

Multi-objective four dimensional imprecise TSP solved with a hybrid multi-objective ant colony optimization-genetic algorithm with diversity

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Abstract. In real world, most of the combinatorial optimization problems are multi-objective and it is difficult to optimize them simultaneously. In the literature, some individual algorithms (ACO, GA, etc.) are available to solve such discrete multi-objective optimization problems (MOOPs), particularly travelling salesman problems (TSPs). Here a hybrid algorithm combining ACO and GA with diversity is developed to solve discrete multi-objective TSPs and named MOACOGAD. Generally in TSP, routes for travel are not considered as lengths of routes remain unaltered. In real life, there may be several routes for travel from one destination to another and conditions of those routes may also be different such as good, rough, bad, etc. In practical, travel costs and travel times are not defined precisely and represented by fuzzy data. When fuzzy travel costs and fuzzy travel times per unit length are involved, the lengths and conditions of the routes along-with the types of conveyances for travel become important. In some cases, risk of travel is also involved. In this paper a four dimensional imprecise TSP including source, destination, conveyances and routes under some risk factors are formulated and solved by the developed MOACOGAD. The model is illustrated numerically. As particular cases three and two dimensional multi-objective imprecise TSPs are derived and solved.

Keywords: Ant colony optimization, Genetic Algorithm, fuzzy travel cost, fuzzy travel time, hybrid algorithm

1. Introduction

Travelling Salesman Problem (TSP) [3] is a NP-hard and also one of the most complex combinatorial optimization problem which cannot be solved exactly in polynomial time. Some investigations with respect to 2-dimensional TSP and 3-dimensional TSP or solid TSP are available in literature. The goal of TSPs is to find a shortest path, exactly once passing through each

city in a given set of cities. When there is only one route and one conveyance for travel between any two cities are known as 2-dimensional TSP [17, 24]. 3-dimensional TSP [10] could be termed when several conveyances at each node/city are available.

Single objective classical TSPs [5, 14] can be solved by Ant Colony Optimization (ACO) algorithm which was introduced by Dorigo and Gambardella [16], inspired by the behaviour of ants in finding paths from nest to food. In 2012, Gaifang Dong et al.[14] proposed a cooperative genetic ant system for solving TSP. In 2013, Bai et al. [5] proposed a model for Asymmetric TSP which includes max-min ant colony optimization.

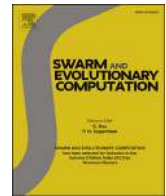
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- ings of the 21st IASTED International Conference on Applied Informatics, Innsbruck, Austria (2003), 97-102.
- [8] L. T. Bui, J. M. Whitacre, H. A. Abbass, Performance analysis of elitism in multi-objective ant colony optimization algorithms, *Congress Evolutionary Computation (CEC2008)*, HongKong, IEEE Service Center (2008), 1633-1640.
- [9] D. Chakraborty, D. K. Jana, T. K. Roy, A new approach to solve multi-objective multi-choice multi-item Atanassov's intuitionistic fuzzy transportation problem using chance operator. *Journal of Intelligent and Fuzzy Systems* **28**(2)(2015), 843-865.
- [10] C. Changdar, M. K. Maiti AND M. Maiti, A constrained solid TSP in fuzzy Environment: two heuristic approaches, *Iranian Journal of Fuzzy Systems* **10** (2013), 1-28.
- [11] S.H. Chen, C.H. Hsieh, Graded mean integration representation of generalized fuzzy numbers, *Chinese Fuzzy Systems Association* **5**(2) (1999), 1-7.
- [12] G.B. Dantzig, D.R. Fulkerson, S.M. Johnson, Solution of a large-scale travelling salesman, *Operations Research*, **2**, (1954), 393-410.
- [13] K. Deb, *Multi-Objective Optimization Using Evolutionary Algorithms*, Wiley (2001).
- [14] G. Dong, W.W. Guo, K. Tickle, Solving the traveling salesman problem using cooperative genetic ant systems, *Expert Systems with Applications* **39** (2012), 5006-5011.
- [15] K. Doerner, W. Gutjahr, R. Hartl, C. Strauss, C. Stummer, Pareto ant colony optimization with ILP, *preprocessing in multiobjective project portfolio selection* **171**(3) (2006), 830-841.
- [16] M. Dorigo, L.M. Gambardilla, Ant colonies for the traveling salesman problem, *BioSystems* **43** (1997), 73-81.
- [17] F. Focacci, A. Lodi, M. Milano, A hybrid exact algorithm for the TSPTW, *INFORM Journal on Computing* **14**(4) (2002), 403-417.
- [18] J. Gottlieb, G.R. Raidl, Evolutionary computation in combinatorial optimization, 6th European Conference, Hungary (2006), 10-12.
- [19] H.J. Holland, *Adaptation in natural and artificial systems*, University of Michigan (1975).
- [20] I. Kaabachi, D. Jriji, F. Madany, and S. Krichen, A Bi-criteria Ant Colony Optimization for Minimizing Fuel Consumption and Cost of The Traveling Salesman Problem With Time Windows, *Procedia Computer Science* **112** (2017), 886-895.
- [21] A. Khanra, M. Maity, M. Maity, Profit maximization of TSP through a hybrid algorithm, *Computers & Industrial Engineering* **88** (2015), 229-236.
- [22] A. Khanra, M. Maity, M. Maity, A hybrid heuristic algorithm for single and multi-objective imprecise traveling salesman problems, *Journal of Intelligent & fuzzy system* **30** (2016), 1987-2001.
- [23] T. Lust, and J. Teghan, "Two-phase pareto local search for bi objective travelling salesman problem", *Journal of Heuristics* **16**(3) (2010), pp. 475-510.
- [24] Y.H. Liu, Different initial solution generators in genetic algorithms for solving the probabilistic traveling salesman problem, *Applied Mathematics and Computation* **21**(6) (2010), 125-137.
- [25] M. Mahi, O. K. Baykan and H. Kodaz, A new hybrid method based on Particle Swarm. Optimization, Ant Colony Optimization and 3-Opt algorithms for Traveling Salesman Problem, *Applied Soft Computing* **30** (2015), 484-490.
- [26] M.K. Maiti, M.Maiti, Utilization of Multi-Objective Genetic Algorithm for One-item multi-level inventory distribution system, *International journal of information and management sciences* **20** (2009), 291-304.
- [27] J. Majumdar, A. K. Bhunia. Genetic algorithm for asymmetric traveling salesman problem with imprecise travel time, *Computational and Applied Mathematics* **235** (2011), 3063-3078.
- [28] M. Michalewicz, *Genetic algorithms + data structures = evolution programs*, Berlin: Springer, (1992).
- [29] K. Miettinen, *Nonlinear multi-objective optimization*. Kluwer, Boston (1999).
- [30] Y. Nagata, D. Soler, A new genetic algorithm for the asymmetric traveling salesman problem, *Expert Systems with Applications* **39** (2012), 8947-8953.
- [31] A. Rabanimotlagh, An efficient ant colony optimization algorithm for multi-objective flow shop scheduling problem, *World Acad. Sci. Eng. Technol* **75** (2011), 127-133.
- [32] G. Reinelt, TspLib95, Available at: <http://www.iwr.uniheidelberg.de/groups/comopt/software/TSPLIB95/tsp/>, (1995).
- [33] R. Shrivastava, S. Singh, G.C. Dubey, Multi-objective optimization of time cost quality quantity using multi colony ant algorithm, *Int. J. Contemp. Math. Sci.* **7** (2012), 773-784.
- [34] G.I.F. Thantulage, *Ant Colony Optimization Based Simulation of 3D Automatic Hose/Pipe Routing* (Ph. D.Thesis), School of Engineering and Design, London, UK (2009).
- [35] W.H. Yang, Y.S. Tarn, Design optimization of cutting parameters for turning operations based on the Taguchi method, *Journal of Materials Processing Technology* **84** (1998), 122-129.
- [36] J. Yang, C. Wu, H.P. Lee, Y. Liang, Solving travelling salesman problems using generalized chromosome genetic algorithm, *Natural Science* **18** (2008), 887-892.
- [37] E. Zitzler, M. Laumanns, L. Thiele, SPEA2 : improving the strength pareto evolutionary algorithm, EUROGEN 2001, Evolutionary Methods for Design, *Optimization and Control with Applications to Industrial Problems, Greece* (2001), 12-21.
- [38] L.A. Zadeh, Fuzzy Sets, *Information and Control* **8**(1965), 338-356.



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A swap sequence based Artificial Bee Colony algorithm for Traveling Salesman Problem

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ABSTRACT

In this research paper, Artificial Bee Colony algorithm is modified with multiple update rules and K-opt operation to solve the Traveling Salesman Problem. Here the features of swap sequences and swap operations on the sequence of cities (solution/path) of the problem are used to create different solution (path) update rules of the algorithm. Eight different rules are proposed to update solutions in the algorithm. Updation of a solution by an employed bee or by an onlooker bee is done by a randomly selected rule from the rule set using Roulette Wheel selection process. In the scout bee phase of the algorithm, the perturbation technique, K-opt operation is applied on any stagnant solution for a fixed number of times for the possible improvement of it. The K-opt operation is again used at the end of the search process to improve the quality of the final solution (if possible). Proposed method is tested with a set of benchmark test problems from TSPLIB and it is observed that the efficiency of the algorithm is adequate with respect to the accuracy and the consistency for solving standard TSPs (Symmetric as well as Asymmetric) compared to the existing algorithms in the literature.

1. Introduction

The Traveling Salesmen Problem (TSP) is one of the standard combinatorial discrete optimization problem. The problem consists of a set of N vertices (nodes/cities) where the distance between any two vertices is known. A salesman starts from a vertex, visits all the vertices exactly once and returned to the starting vertex in such a way that the total distance travelled is a minimum. So the goal of the problem is to find a shortest possible tour through the set of vertices such that each vertex is visited exactly once except for the starting vertex. It is a well known NP-hard problem, can't be solved exactly using any polynomial time algorithm [1,2]. In a TSP, when the distance between any two vertices x_i and x_j is equal to the distance between x_j and x_i then the problem is called Symmetric TSP (STSP) [3,4]. On the other hand, if the distance between the vertices x_i and x_j is not equal to the distance between x_j and x_i , for at least one pair of vertices then the problem belongs to Asymmetric TSP (ATSP) [5]. Generally, there are two approaches to solve a TSP: exact methods and heuristic methods. The exact methods require enormous time for larger N , thus the heuristic methods are typically used to solve a TSP. The exact methods include cutting plane [6], LP relaxation [7], branch and bound [8], branch and cut [9], etc.

Only small size TSPs can be solved by exact methods in a reasonable time window. On the other hand, several TSPs have been solved using heuristics or soft computing based techniques such as Ant Colony Optimization (ACO) [3], local search [10], hybrid algorithm [11], Genetic Algorithm (GA) [12], Particle Swarm Optimization (PSO) [4], Artificial Bee Colony (ABC) [13], etc. There are several well established heuristics for STSP. Wang et al. [4] used concepts of swap operator and swap sequence, and redefined some operators of PSO on the basis of them to solve TSP. Combining the features of PSO, ACO and 3-opt a hybrid algorithm PSO-ACO-3-opt is presented by Mahi et al. [14] to solve standard TSPs. Akhand et al. [15] proposed PSO with partial search algorithm for solving TSPs. Akhand et al. [16] improved this algorithm to find solution of the TSPs and named it velocity tentative PSO. Geng et al. [17] proposed an effective local search algorithm based on Simulated Annealing (SA) and greedy search techniques to solve the TSPs. Jolai and Ghanbari [18] presented an improved Artificial Neural Network (ANN) approach for solving the TSPs. Dorigo et al. [3] proposed an Ant System to solve the TSPs. Dorigo and Gambardella [19] described an ACO capable of solving the TSPs. Bontoux and Feillet [20] proposed a hybrid algorithm to solve the TSPs. Beam-ACO algorithm, which is a hybrid method combining ACO with beam search was used to solve

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- [17] X.T. Geng, Z.H. Chen, W. Yang, D.Q. Shi, K. Zhao, Solving the traveling salesman problem based on an adaptive simulated annealing algorithm with greedy search, *Appl. Soft Comput.* 11 (4) (2011) 3680–3689.
- [18] F. Jolai, A. Ghanbari, Integrating data transformation techniques with Hopfield neural networks for solving traveling salesman problem, *Expert Syst. Appl.* 37 (2010) 5331–5335.
- [19] M. Dorigo, L.M. Gambardella, Ant colonies for the traveling salesman problem, *Biosystems* 43 (1997) 73–81.
- [20] B. Bontoux, D. Feillet, Ant colony optimization for the traveling purchaser problem, *Comput. Oper. Res.* 35 (2) (2008) 628–637.
- [21] M. Lopez-Ibanez, C. Blum, Beam-ACO for the traveling salesman problem with time windows, *Comput. Oper. Res.* 37 (9) (2010) 1570–1583.
- [22] M. Gunduz, M.S. Kiran, E. Ozceylan, A hierarchic approach based on swarm intelligence to solve traveling salesman problem, *Turk. J. Electr. Eng. Comput. Sci.* 23 (2015) 103–117.
- [23] I. Khan, M.K. Maiti, M. Maiti, Coordinating particle swarm optimization ant colony optimization and K-opt algorithm for travelling salesman problem, in: *International Conference on Mathematics and Computing, Communication in Computer and Information Science*, vol. 655, Springer, 2017, pp. 103–119.
- [24] L. Huang, K. Wang, C. Zhou, W. Pang, L. Dong, L. Peng, Particle swarm optimization for traveling salesman problems, *Acta Sci. Nat. Univ. Jilinesis* 4 (2003).
- [25] Sumaiya Iqbal, M. Sohail Rahman, Vehicle routing problems with soft time windows, in: *Electrical & Computer Engineering (ICECE), 2012 7th International Conference on*, IEEE, 2012.
- [26] Q.K. Pan, M. Fatih Tasgetiren, P.N. Suganthan, T.J. Chua, A discrete artificial bee colony algorithm for the lot-streaming flow shop scheduling problem, *Inf. Sci.* 181 (2011) 2455–2468.
- [27] A. Rajasekhar, N. Lynn, S. Das, P.N. Suganthan, Computing with the collective intelligence of honey Bees – a survey, *Swarm Evolut. Comput.* 32 (2017) 25–48.
- [28] M.S. Kiran, H. Hakli, M. Gunduz, H. Uguz, Artificial bee colony algorithm with variable search strategy for continuous optimization, *Inf. Sci.* 300 (2015) 140–157.
- [29] D. Karaboga, B. Akay, A comparative study of artificial bee colony algorithm, *Appl. Math. Comput. Sci.* 214 (2009) 108–132.
- [30] D. Karaboga, B. Basturk, A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm, *J. Global Optim.* 39 (2007) 459–471.
- [31] A. Singh, An artificial bee colony algorithm for the leaf-constrained minimum spanning tree problem, *Appl. Soft Comput.* 9 (2) (March 2009) 625–631.
- [32] Li-Pei Wong, M.Y.H. Low, C.S. Chong, Bee colony optimization with local search for traveling salesman problem, *Int. J. Artif. Intell. Tool.* 19 (03) (2010) 305–334.
- [33] Sumaiya Iqbal, M. Kaykobad, M. Sohail Rahman, Solving the multi-objective vehicle routing problem with soft time windows with the help of bees, *Swarm Evolut. Comput.* 24 (2015) 50–64.
- [34] K. Helsgaun, General k-opt submoves for the Lin Kernighan TSP heuristic, *Mathem. Program. Comput.* 1 (2009), 199–163.
- [35] K.P. Wang, L. Huang, C.G. Zhou, W. Pang, Particle swarm optimization for traveling salesman problem, in: *International Conference on Machine Learning and Cybernetics (2003)*, IEEE Xplore, 2004, ISBN: 0-7803-7865-2, pp. 1583–1585.
- [36] Z. Michalewicz, *Genetic Algorithms+Data Structure = Evolution Programs*, 27. Z. Michalewicz, Springer-Verlag, Berlin Heidelberg, 1992.
- [37] G. Reinelt, TSPLIB -a traveling salesman problem library, *Oper. Res. Soc. Am. J. Comput.* 3 (1991) 376–384.
- [38] A. Khanra, M.K. Maiti, M. Maiti, Profit maximization of TSP through a hybrid algorithm, *Comput. Ind. Eng.* 88 (2015) 229–236.
- [39] D. Karaboga, An Idea Based on Honey Bee Swarm for Numerical Optimization, Technical Report-TR06, Erciyes University, Kayseri, Turkey, 2005.
- [40] G. Sierksma, Hamiltonicity and the 3-Opt Procedure for the traveling salesman problem, *Appl. Math.* 22 (2) (2014) 351–358.
- [41] I. Khan, M.K. Maiti, A novel hybrid algorithm for generalized traveling salesman problems in different environments, *Vietnam J. Comput. Sci.* (2018), <https://doi.org/10.1007/s40595-017-0099-z>, Springer.
- [42] R. Pasti, L.N. De Castro, A neuro-immune network for solving the traveling salesman problem, in: *International Joint Conference on Neural Networks, 2006. IJCNN'06*, IEEE, 2006, pp. 3760–3766.
- [43] T.A.S. Masutti, L.N. de Castro, A self-organizing neural network using ideas from the immune system to solve the traveling salesman problem, *Inf. Sci.* 179 (10) (2009) 1454–1468.
- [44] S.M. Chen, C.Y. Chien, Solving the traveling salesman problem based on the genetic simulated annealing ant colony system with particle swarm optimization techniques, *Expert Syst. Appl.* 38 (2011) 14439–14450.
- [45] Z.A. Othman, A.I. Srour, A.R. Hamdan, P.Y. Ling, Performance water flow-like algorithm for TSP by improving its local search, *Int. J. Adv. Comput. Technol.* 5 (14) (2013) 126.
- [46] W. Deng, R. Chen, B. He, Y. Liu, L. Yin, J. Guo, A novel two-stage hybrid swarm intelligence optimization algorithm and application, *Soft Comput.* 16 (10) (2012) 1707–1722.
- [47] J. Derrac, S. Garcia, D. Molina, F. Herrera, A practical tutorial on the use of nonpara-metric statistical tests as a methodology for comparing evolutionary and swarm intelligence algorithms, *Swarm Evolut. Comput.* 1 (2011) 3–18.

An inventory model with variable demand incorporating unfaithfulness of customers under two-level trade credit

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Abstract: In this research work, an inventory model has been developed under two-level trade credit policy with unfaithful customers. A percentage of the total customers are treated as unfaithful customers. Demand is influenced by customers' credit period, credit amount and selling price. Due to the vagueness of some parameters, the proposed model is formulated in both the crisp and fuzzy environments. The main purpose of this research work is to determine the optimal replenishment policy so that the total profit of the retailer is maximised. The existence of a solution to the problem is discussed theoretically and then some numerical experiments are undertaken. To find the marketing decision of a generalised model (when the number of variables increases) and for the fuzzy objectives, a soft computing technique is used. Some sensitivity analyses are performed to provide some managerial insights. Finally a conclusion is drawn and some future research directions are proposed. [Received: 14 November 2017; Accepted: 2 January 2019]

Keywords: inventory; trade credit; unfaithful customers; particle swarm optimisation; variable demand.

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- Teng, J.T. (2009) 'Optimal ordering policies for a retailer who offers distinct trade credits to its good and bad customers', *International Journal of Production Economics*, Vol. 119, pp.415–423.
- Teng, J.T. and Chang, C.T. (2009) 'Optimal manufacturer's replenishment policies in the EPQ model under two level trade credit policy', *European Journal of Operational Research*, Vol. 195, pp.358–363.
- Teng, J.T., Cheng, C.T., Chern, M.S. and Chan, Y.L. (2007) 'Retailer's optimal ordering policies with trade credit financing', *International Journal of Systems Science*, Vol. 38, pp.269–278.
- Teng, J.T. and Goyal, S.K. (2007) 'Optimal ordering policies for a retailer in a supply chain with up-stream and down-stream trade credits', *Journal of the Operational Research Society*, Vol. 58, pp.1252–1255.
- Teng, J.T., Yang, H.L. and Chern, M.S. (2013) 'An inventory model for increasing demand under two levels of trade credit linked to order quantity', *Applied Mathematical Modelling*, Vol. 37, pp.7624–7632.
- Tiwari, S., Wee, H.M. and Sarkar, S. (2017) 'Lot-sizing policies for defective and deteriorating items with time-dependent demand and trade credit', *European Journal of Industrial Engineering*, Vol. 11, No. 5, pp.683–703.
- Wee, H.M., Lo, C.C. and Hsu, P.H. (2009) 'A multi-objective joint replenishment inventory model of deteriorated items in a fuzzy environment', *European Journal of Operational Research*, Vol. 197, pp.620–631.
- Wu, J., Al-khateeb, F.B., Teng, J.T. and Cardenas-Barron, L.E. (2016) 'Inventory models for deteriorating items with maximum lifetime under downstream partial trade credits to credit-risk customers by discounted cash-flow analysis', *International Journal of Production Economics*, Vol. 171, pp.105–115.
- Zadeh, L.A. (1965) 'Fuzzy sets', *Information and Control*, Vol. 8, pp.338–356.
- Zadeh, L.A. (1978) 'Fuzzy sets as a basic for a theory of possibilities', *Fuzzy Sets and Systems*, Vol. 1, pp.3–28.

ANALYSIS OF LEAD TIME ON PERMISSIBLE DELAY IN PAYMENTS IN AN INVENTORY MODEL INCLUDING THE LEAD TIME CRASHING COST

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Abstract. In this article, the lead time on permissible delay in payments in an inventory model including lead time crashing cost is discussed where lead time and business period are the decision variables. Also, the lead time dependent credit period has been considered which has two parts one being fixed and other being dependent upon lead time. Here supplier offers the credit period to the retailer only when supplier supplies the order before the end of the business period. Here model has been considered in the parlance of infinite time horizon in such a way that the system gets the maximum profit. There are two main cases of inventory models to be studied here. Finally, three different illustrative examples have been added to determine the optimal policy of the model and the sensitivity analysis of some parameters has been added in this model.

Keywords: credit period, crashing cost, lead time, inventory model.

AMS Subject Classification: 90B05.

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1 Introduction

Lead time is the time that elapses between the placement of an order and the receipt of the order into inventory. Lead time may influence customer service and impact inventory costs. From the literature, it is known that productivity of the company and its competitive position in the market depends on lead time. Traditionally, in an inventory models, minimization of total cost or, maximization of total profit has been considered as an objective function from either the supplier's or manufacturer's/retailer's side. In 1975, Das (1975) stated the effect of lead time on inventory and give a static analysis about it. Foote et al. (1988) presented a heuristic policies for inventory ordering problems with long and randomly varying lead times. Ouyang and Wu (1998) established a minimax distribution free procedure for mixed inventory model with variable lead time. Ben-Daya and Raouf (1994) presented an inventory models involving lead time as a decision variable. Glock (2012) discussed the inventory model in which customer service and responsiveness to production schedule changes can be improved by reduced lead time and reduction in safety stocks can be achieved. Hsiao (2008), He et al. (2005), Lan et al. (1999), Yang et al. (2005), Pan et al. (2004) stated that fixed lead time is not always appropriate for all inventory model in business, so they considered lead time as a decision variable. These authors have presented models which can be used to determine the length of lead time that minimizes the expected total relevant cost. Chopra et al. (2004) observed the effects of lead time uncertainty on safety stocks. Ouyang et al. (2004), Chang et al. (2006), and Wu (2004)

- Liao, J.J. (2007a). On an EPQ model for deteriorating items under permissible delay in payments. *Applied Mathematical Modelling*, 31(3), 393-403.
- Liao, J.J. (2007b). A note on an EOQ model for deteriorating items under supplier credit linked to ordering quantity. *Applied Mathematical Modelling*, 31(8), 1690-1699.
- Liao, J.J. (2008). An EOQ model with noninstantaneous receipt and exponentially deteriorating items under two-level trade credit. *International Journal of Production Economics*, 113(2), 852-861.
- Mondal, S. & Maiti, M. (2003). Multi-item fuzzy EOQ models using genetic algorithm. *Computers and Industrial Engineering*, 44(1), 105-117.
- Musa, A. & Sani, B. (2012). Inventory ordering policies of delayed deteriorating items under permissible delay in payments. *International Journal of Production Economics*, 136(1), 75-83.
- Ouyang, L.Y., Wu, K.S. & Ho, C.H. (2004). Integrated vendor-buyer cooperative models with stochastic demand in controllable lead time. *Int. J. Production Economics*, 92(3), 255-266.
- Ouyang, L.Y., & Wu, K.S. (1998). A minimax distribution free procedure for mixed inventory model with variable lead time. *Int. J. Production Economics*, 56-57, 511-516.
- Pan, J.C., Lo, M. & Hsiao, Y. (2004). Optimal reorder point inventory models with variable lead time and backorder discount considerations. *Eur. J. Oper. Res*, 158(2), 488-505.
- Ray, S. & Jewkes, E.M. (2004). Customer lead time management when both demand and price are lead time sensitive. *European Journal of Operational Research*, 153(3), 769-781.
- Uthayakumar, R. & Priyan, S. (2013). Permissible delay in payments in the two-echelon inventory system with controllable setup cost and lead time under service level constraint. *International Journal of Information and Management Sciences*, 24(3), 193-211.
- Vijayashree, M. & Uthayakumar, R. (2016). Inventory models involving lead time crashing cost as an exponential function. *International Journal of Managing Value and Supply Chains (IJMVSC)*, 7(2), 29-39.
- Wu, K. (2004). The effect of time-value of money on continuous review inventory model with controllable lead time. *International Journal of Information and Management Sciences*, 15(2), 11-21.
- Yang, G., Ronald, R.J. & Chu, P. (2005). Inventory models with variable lead time and present value. *European Journal of Operational Research*, 164(2), 358-366.
- Yang, M.F. & Tseng, W.C. (2014). Three-Echelon inventory model with permissible delay in payments under controllable lead time and backorder consideration. *Mathematical Problems in Engineering*, Article ID 809149, 16 pages.


Monte Carlo study with reweighting of uniaxial nematic liquid crystals composed of biaxial molecules

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We present a high accuracy Monte Carlo simulation study of the uniaxial nematic (N_U) to isotropic (I) phase transition of a lattice dispersion model of uniaxial nematics composed of biaxial molecules. The N_U - I coexistence curve terminating at the Landau critical point has been determined using the multiple histogram reweighting technique. A close investigation reveals a sharp departure in the nature of the N_U - I coexistence curve in the temperature-biaxiality parameter phase diagram in comparison to the earlier theoretical (either mean-field or computer simulation) predictions. The coexistence curve shows a change in curvature with increasing value of the degree of molecular biaxiality.

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I. INTRODUCTION

In recent years, a great deal of attention has been devoted to investigations of the phase transformations in thermotropic liquid crystals composed of bent-core molecules [1,2]. Such molecules can be assumed to possess D_{2h} symmetry and are commonly referred to as biaxial molecules, in contrast to the conventional uniaxial molecules having $D_{\infty h}$ symmetry. It is well known from Landau-de Gennes (LDG) [3] and Maier-Saupe mean field (MF) theories that the isotropic to nematic phase transition in thermotropic liquid crystals (LCs) composed of cylindrically symmetric molecules is weakly first order. This has been confirmed by experiments [4,5] as well as by computer simulations [6,7]. In a more recent experimental study, Wiant *et al.* [8] observed that the isotropic (I) to the uniaxial nematic (N_U) transition for LCs composed of biaxial (bent-core) molecules is notably weaker than conventional thermotropic LCs formed from uniaxial molecules. These authors observed [8] that for nematics composed of bent-core molecules $T_{NI} - T^- \approx 0.4^\circ\text{C}$, whereas for typical calamitic (rod-shaped) liquid crystals $T_{NI} - T^- \geq 1^\circ\text{C}$. Here T_{NI} is the nematic-isotropic transition temperature and T^- is the supercooling limit of the nematic phase.

Bent-core molecules possess a high degree of molecular biaxiality. The possible effects of molecular biaxiality on nematic order have been studied theoretically using a number of techniques. These include molecular field treatments [9–16], computer simulation studies of lattice dispersion models [17–20] and the off-lattice biaxial Gay-Berne model [21,22]. All these studies predict sequences of phase transitions, from N_U to I at a higher temperature and from biaxial nematic (N_B) to uniaxial nematic (N_U) at a lower temperature. Also a direct N_B to I transition is predicted at a particular molecular geometry.

Apart from the above observations, molecular field studies [14,16] have shown that the increase in degree of molecular biaxiality influences the N_U - I transition in a number of ways. First, as the molecular biaxiality parameter λ (a measure of the molecular biaxiality and to be defined later) increases, the nematic order parameter S at the phase transition becomes smaller and thus the jump in S at the N_U - I transition decreases. Second, the transition temperature T_{NI} decreases monotonically with increase in λ . Third, the difference between the N_U - I transition temperature and the orientational spinodal temperature (T^-) decreases monotonically with increasing λ and finally these two temperatures merge as λ approaches its critical value $\lambda = \lambda_c = 1/\sqrt{6} = 0.40825$.

More recently, a Monte Carlo (MC) simulation study [23] based on a lattice dispersion model investigated the influences of molecular biaxiality on the N_U - I transition using the multiple histogram reweighting technique [24], and the relevant part of the free energy was generated for two different systems: one composed of uniaxial molecules and the other of biaxial molecules. Although the work reported in Ref. [23] emphasized the effect of an external field on uniaxial and biaxial molecules, from free energy analysis it was pointed out that molecular biaxiality weakens further the weak first-order N_U - I transition. The investigations presented in Ref. [23] were limited to only two values of molecular biaxiality parameter (0 and 0.20) and also the aim of the study was different, namely the effects of an external magnetic field on nematic order.

The fact that the increase in λ leads to weakening of N_U - I transition was also observed in a previous MC study [18] from the plots of order parameter and heat capacity, where the same dispersion model with three different values of λ (0.2, 0.3, and 0.40825) was used. However, to explore the effects of molecular biaxiality on the N_U - I transition and the associated pretransitional behavior, more accurate simulation technique is necessary.

In this paper we present an MC study using the reweighting technique [24] on a lattice dispersion model to investigate

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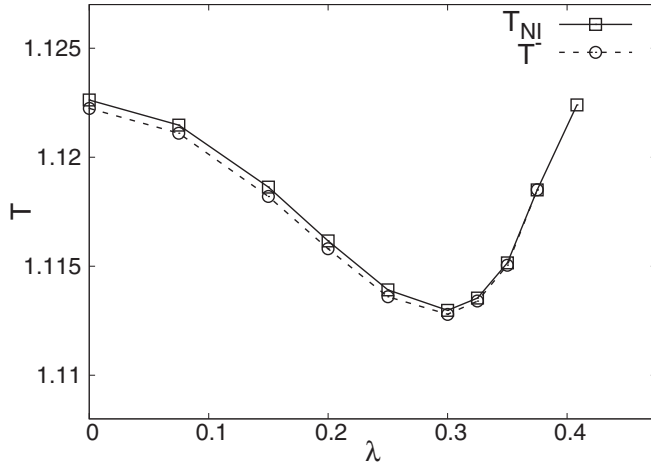


FIG. 4. T_{NI} vs λ phase diagram for the nematic-isotropic transition. The coexistence curve slopes downwards till $\lambda = 0.3$ and then slopes upwards till $\lambda = 1/\sqrt{6}$. The dashed curve represents orientational spinodal line. The error bars are smaller than the point size.

ordinate on the right corresponds to the free energy vs energy curve at T^- . Figures are plotted for λ values 0, 0.25, 0.3, and 0.325. We can see from the curves corresponding to T_{NI} that, as the value of biaxiality parameter increases, the depth of the free energy well decreases, taking the transition closer to being second order. For λ greater than 0.325 the depth of the free energy well at transition becomes so small that the structure of the well becomes nondiscernible from random fluctuations.

Investigators have also used the Lee and Kosterlitz finite size scaling method [34] to obtain the N_U - I temperature for $\lambda = 0$. Priezjev and Pelcovits [36] studied system sizes up to 70^3 using the single histogram reweighting technique [24] and obtained $T_{NI} = 1.1225 \pm 0.0001$ in the thermodynamic limit. This result is very close to what we obtained in the present study, namely $T_{NI} = 1.1226 \pm 0.0001$ for a system size 64^3 . More recently Shekhar *et al.* [37] reported $T_{NI} = 1.1229 \pm 0.00015$ in a study similar to that of Priezjev and Pelcovits [36], but with relatively smaller system sizes (upto 40^3). Perhaps the use of smaller system sizes resulted in a slightly different value of T_{NI} obtained in this work. It may also be noted that, besides the transition temperature, our estimate of the depth in the free energy well (for $\lambda = 0$) is in close agreement with the finding of Priezjev and Pelcovits [36], namely of the order of 1.0ϵ .

Finally, in Fig. 4, we present the coexistence line and the orientational spinodal line in the λ - T plane. We see that both T_{NI} and T^- first decrease with increasing value of the biaxiality parameter and then increase with increasing λ . This

TABLE I. N - I transition temperatures for different values of the biaxiality parameter λ for the biaxial systems. Estimates of orientational spinodal temperature T^- are also listed for the systems having lower λ . The estimated (jackknife) error in each temperature is within ± 0.0001 .

λ	T_{NI} [from χ vs T]	T_{NI} [from $F(E)$ vs T]	T^-
0	1.1227	1.1226	1.1222
0.075	1.1215	1.1214	1.1211
0.150	1.1187	1.1186	1.1182
0.200	1.1163	1.1162	1.1158
0.250	1.1140	1.1139	1.1136
0.300	1.1130	1.1130	1.1128
0.325	1.1136	1.1135	1.1134
0.350	1.1151	1.1151	1.1150
0.375	1.1185	1.1186	1.1185
0.408	1.1224		

observation deviates from the prediction of MF theory, which shows a monotonic nature of the T_{NI} vs λ curve, i.e., no change of curvature. While earlier MC simulations show no perceivable effect of molecular biaxiality upon T_{NI} . It should be noted that the exact nature of T_{NI} vs λ curve is revealed when T_{NI} is computed with sufficiently high temperature resolution Table I.

Another important observation is that the gap between these curves decreases monotonically and finally vanishes as λ approaches λ_C . A similar qualitative feature was found in the molecular-field theory study of To *et al.* [16].

V. CONCLUSION

We have reported the results of a MC study of a uniaxial nematic system composed of biaxial molecules. The temperature resolution used in this work is more than what is available in previous MC studies. The peculiar nature manifested in the change of curvature of the T_{NI} - λ curve exhibited in Fig. 4, to our knowledge not obtained in any previous MC work or MF studies, is the main finding of our work and needs to be explained by rigorous theoretical methods.

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- [1] *Biaxial Nematic Liquid Crystals*, edited by G. R. Luckhurst and T. J. Sluckin (Wiley, Oxford, 2015).
- [2] T. Niori, T. Sekine, J. Watanabe, T. Furukawa, and H. Takezoe, *J. Mater. Chem.* **6**, 1231 (1996).
- [3] P. G. de Gennes and J. Prost, *The Physics of Liquid Crystals* (Oxford Science, Oxford, 1993).

- [4] T. W. Stinson and J. D. Litster, *Phys. Rev. Lett.* **25**, 503 (1970).
- [5] E. F. Gramsbergen, L. Longa, and W. H. de Jeu, *Phys. Rep.* **135**, 195 (1986).
- [6] Z. Zhang, O. G. Mouritsen, and M. J. Zuckermann, *Phys. Rev. Lett.* **69**, 2803 (1992).

- [7] U. Fabbri and C. Zannoni, *Mol. Phys.* **58**, 763 (1986).
- [8] D. Wiant, S. Stojadinovic, K. Neupane, S. Sharma, K. Fodor-Csorba, A. Jáklí, J. T. Gleeson, and S. Sprunt, *Phys. Rev. E* **73**, 030703(R) (2006).
- [9] M. J. Freiser, *Phys. Rev. Lett.* **24**, 1041 (1970).
- [10] R. Alben, *Phys. Rev. Lett.* **30**, 778 (1973).
- [11] J. P. Straley, *Phys. Rev. A* **10**, 1881 (1974).
- [12] G. R. Luckhurst, C. Zannoni, P. L. Nordio, and U. Segre, *Mol. Phys.* **30**, 1345 (1975).
- [13] N. Boccara, R. Mejdani, and L. de Seze, *J. Phys.* **38**, 149 (1977).
- [14] D. K. Remler and A. D. J. Haymet, *J. Phys. Chem.* **90**, 5426 (1986).
- [15] A. M. Sonnet, E. G. Virga, and G. E. Durand, *Phys. Rev. E* **67**, 061701 (2003).
- [16] T. B. T. To, T. J. Sluckin, and G. R. Luckhurst, *Phys. Rev. E* **88**, 062506 (2013).
- [17] G. R. Luckhurst and S. Romano, *Mol. Phys.* **40**, 129 (1980).
- [18] F. Biscarini, C. Chiccoli, P. Pasini, F. Semeria, and C. Zannoni, *Phys. Rev. Lett.* **75**, 1803 (1995).
- [19] S. Romano, *Physica A* **337**, 505 (2004).
- [20] M. A. Bates and G. R. Luckhurst, *Phys. Rev. E* **72**, 051702 (2005).
- [21] R. Berardi and C. Zannoni, *J. Chem. Phys.* **113**, 5971 (2000).
- [22] R. Berardi and C. Zannoni, *Mol. Cryst. Liq. Cryst.* **396**, 177 (2003).
- [23] N. Ghoshal, K. Mukhopadhyay, and S. K. Roy, *Phys. Rev. E* **89**, 042505 (2014).
- [24] A. M. Ferrenberg and R. H. Swendsen, *Phys. Rev. Lett.* **61**, 2635 (1988); **63**, 1195 (1989).
- [25] M. E. Rose, *Elementary Theory of Angular Momentum*, (Wiley, New York, 1957).
- [26] P. A. Lebowitz and G. Lasher, *Phys. Rev. A* **6**, 426 (1972).
- [27] N. Ghoshal, K. Mukhopadhyay, and S. K. Roy, *Liq. Cryst.* **39**, 1381 (2012).
- [28] J. A. Barker and R. O. Watts, *Chem. Phys. Lett.* **3**, 144 (1969).
- [29] N. Madras and A. D. Sokal, *J. Stat. Phys.* **50**, 109 (1988).
- [30] M. E. J. Newman and G. T. Barkema, *Monte Carlo Methods in Statistical Physics* (Clarendon, Oxford, 1999).
- [31] J. Vieillard-Baron, *J. Chem. Phys.* **56**, 4729 (1972).
- [32] P. J. Camp and M. P. Allen, *J. Chem. Phys.* **106**, 6681 (1997).
- [33] P. Peczak, A. M. Ferrenberg, and D. P. Landau, *Phys. Rev. B* **43**, 6087 (1991).
- [34] J. Lee and J. M. Kosterlitz, *Phys. Rev. Lett.* **65**, 137 (1990).
- [35] J. Lee and J. M. Kosterlitz, *Phys. Rev. B* **43**, 3265 (1991).
- [36] N. V. Priezjev and R. A. Pelcovits, *Phys. Rev. E* **63**, 062702 (2001).
- [37] R. Shekhar, J. K. Whitmer, R. Malshe, and J. A. Moreno-Razo, *J. Chem. Phys.* **136**, 234503 (2012).

Pressure-induced phase transitions in liquid crystals: A molecular field approachSudeshna DasGupta,^{1,*} Sabana Shabnam,^{1,†} Soumyajit Pramanick,^{1,‡} Nababrata Ghoshal,^{2,§}
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A rigorous microscopic treatment of a nematic fluid system based on a pairwise interaction potential is immensely complex. For studying such systems molecular field theories are often the standard method of choice. In this paper we have chosen a simple effective potential $U = \frac{u_4}{v^4} - \frac{u_2}{v^2} - \frac{Au_2}{v^2} \langle P_2 \rangle P_2(\cos \vartheta)$ to study an isothermal-isobaric ensemble describing a liquid crystalline system. Using this we have studied in particular the pressure dependence of liquid crystalline phase transitions.

DOI: [10.1103/PhysRevE.98.022701](https://doi.org/10.1103/PhysRevE.98.022701)**I. INTRODUCTION**

Studies of phase transitions in liquid crystalline materials are of extreme importance because of their various important applications. For more than a century different experiments and corresponding theoretical studies have established the existence and behavior of different liquid crystalline phases. These studies involve the measurement of variation of different liquid crystalline properties such as orientational order parameter, dielectric constant, specific heat, isothermal compressibility, isobaric expansivity, etc. with the temperature [1–3]. Most of these thermodynamic measurements have been done on nematics at constant pressure, so that as temperature is varied, the molar volume also varies as a result of thermal expansion. The temperature dependence of orientational order in a nematic liquid crystal at constant molar volume was difficult to measure. This was first carried out by McColl and Shih [4]. They published their results of the temperature and volume variation of the orientational order parameter in para-azoxyanisole (PAA).

One of the first experiments investigating the effect of pressure on mesophase transitions were conducted by Hulett in 1899 [5] just about a decade after the discovery of liquid crystals. Most of the work involving pressure dependence had been done during 1970s [4,6–9]. Then in 1975, Shashidhar and Chandrashekar [6] in their experimental work presented the pressure variation of liquid crystalline materials in detail and generated the phase diagrams, which clearly showed the liquid crystalline phases and the appearance of tricritical points. Horn [2,3], on the other hand, determined the dependence of orientational order parameter with temperature by measuring

refractive index. Later Horn along with Faber explained these experimental data using a mean-field approach [7]. Wallis and Roy [8] again by the proton NMR spectrum study, studied the line width of proton resonance as function of temperature and pressure for the nematogens 5, 6, 7, and 8 CB and also for some other nematogens including PAA. They showed that the value of the orientational order parameter at the nematic-isotropic transition decreases with increasing pressure for 5, 7, and 8 CB but remained constant for 6 CB. The pressure and temperature dependence of the orientational order parameter for different sites in a mesogen were reported by Emsley *et al.* [9]. They showed that the quadrupolar splitting at the nematic isotropic transition temperatures is independent of pressure for different sites of the alkyl chain. In 1980, Luckhurst and Romano [10] considered an anisotropic part of the intermolecular potential along with the isotropic part and carried out computer simulation studies to find the phase diagram for some liquid crystals, but they had not considered any variation in pressure. In 1999, Hess and Su [11] used a generalization of the Lennard-Jones potential to study both the pressure and temperature variation of their liquid crystal model with density and observed a pseudotricritical point.

The stability of the nematic liquid crystal phase arises from the existence of strong interactions between pairs of the constituent molecules. This interaction between molecules leads to a long-range orientational order in the nematic phase. In most realistic situations, a rigorous microscopic treatment of a nematic fluid system based on a pairwise interaction potential becomes immensely complex. For systems of comparable complexity, mean-field theories are often the standard method of choice. The celebrated Maier-Saupe molecular field theory [12] (also referred to as mean-field theory; for a clarification of the terminology being used here see Ref. [13]) of nematic liquid crystals correctly predicts the existence of a first-order phase transition between the nematic and isotropic liquid states. However, there has been no significant molecular field study of the pressure dependence of liquid crystalline phase transitions to date. In the present paper we have presented a

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so that

$$e^{Nf(v)} = e^{Nf(v_*)} e^{\delta^2 f''(v_*)/2} \left(1 + \frac{f'''(v_*)}{6\sqrt{N}} \delta^3 + \dots \right)$$

and hence

$$\int e^{Nf(v)} dv = e^{Nf(v_*)} \int e^{\delta^2 f''(v_*)/2} \left(1 + \frac{f'''(v_*)}{6\sqrt{N}} \delta^3 + \dots \right) \frac{d\delta}{\sqrt{N}}.$$

It is easy to see that this yields

$$\ln \left(\int e^{Nf(v)} dv \right) \approx Nf(v_*) + \ln \left(\sqrt{\frac{2\pi}{N|f'''(v_*)|}} \right) + \dots.$$

Note that for very large values of N , the subleading term in the above expression, which is of order $\ln N$ is completely dominated by the leading term of order N so that we can use

$$\ln \left(\int e^{Nf(v)} dv \right) \approx Nf(v_*).$$

-
- [1] S. Chandrashekar and N. V. Madhusudana, *J. Phys. (Paris) Colloq.* **30**, C4-24 (1969).
- [2] R. G. Horn, *J. Phys.* **39**, 105 (1978).
- [3] R. G. Horn, *J. Phys.* **39**, 167 (1978).
- [4] J. R. McColl and C. S. Shih, *Phys. Rev. Lett.* **29**, 85 (1972).
- [5] G. A. Hulett, *Z. Phys. Chem.* **28**, 629 (1899).
- [6] R. Shashidhar and S. Chandrashekar, *J. Phys. (Paris) Colloq.* **36**, C1-49 (1975).
- [7] R. G. Horn and T. E. Faber, *Proc. R. Soc. Lond. A* **368**, 199 (1979).
- [8] G. P. Wallis and S. K. Roy, *J. Phys.* **41**, 1165 (1980).
- [9] J. W. Emsley, G. R. Luckhurst, and B. A. Timimi, *J. Phys.* **48**, 473 (1987).
- [10] G. R. Luckhurst and S. Romano, *Proc. R. Soc. London A* **373**, 111 (1980).
- [11] S. Hess and B. Su, *Z. Naturforsch. A* **54**, 559 (1999).
- [12] W. Maier and A. Saupe, *Z. Naturforsch. A* **15**, 287 (1960).
- [13] *Biaxial Nematic Liquid Crystals: Theory, Simulation and Experiment*, 1st ed., edited by G. R. Luckhurst and T. J. Sluckin (John Wiley and Sons, New York, 2015), p. 55.
- [14] J. R. McColl, *Phys. Lett. A* **38**, 55 (1972).
- [15] E. B. Priestley, P. J. Wojtowicz, and P. Sheng, *Introduction to Liquid Crystals* (Plenum Press, Berlin, 1974).
- [16] <https://www.chemed.com/cid/21-486-9/octyloxycyanobiphenyl>. (last checked on 20.5.2018). Note that these critical constants are not experimental values, but are rather predictions based on the Joback method [K. G. Joback and R. C. Reid, Estimation of pure-component properties from group-contributions, *Chem. Eng. Commun.* **57**, 233 (1987)].
- [17] S. Chandrasekar, *Liquid Crystals* (Cambridge University Press, Cambridge, 1980), p. 49.



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Fluorescein derived Schiff base as fluorimetric zinc (II) sensor via ‘turn on’ response and its application in live cell imaging

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ABSTRACT

A novel Schiff base **L** composed of fluorescein hydrazine and a phenol functionalized moiety has been designed and prepared via cost-effective condensation reaction. The **L** is utilized for selective sensing of Zn²⁺ over other environmental and biological relevant metal ions in aqueous alcoholic solution under physiological pH range. The binding of Zn²⁺ to the receptor **L** is found to causes ~23 fold fluorescence enhancement of **L**. The 1:1 binding mode of the metal complex is established by combined UV-Vis, fluorescence, and HRMS (high-resolution mass spectroscopy) spectroscopic methods. The binding constant (K_a) for complexation and the limit of detection (LOD) of Zn²⁺ is calculated to be $2.86 \times 10^4 \text{ M}^{-1}$ and 1.59 μM , respectively. Further photophysical investigations including steady-state, time-resolved fluorescence analysis and spectral investigations including NMR (nuclear magnetic resonance), IR (infrared spectroscopy) suggest introduction of CHEF (chelation enhance fluorescence) with the suppression of C=N isomerization and PET (photo-induced electron transfer) mechanism for the strong fluorescent response towards Zn²⁺. Finally, the sensor **L** is successfully employed to monitor a real-time detection of Zn²⁺ by means of TLC (thin layer chromatography) based paper strip. The **L** is used in the cell imaging study using African green monkey kidney cells (Vero cells) for the determination of exogenous Zn²⁺ by Immunofluorescence Assay (IFA) process.

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1. Introduction

Zn (II) ion, the second most abundant transition metal in the human body plays a crucial role in many biological processes. This includes normal human growth and development, an additional signaling role in the central nervous system which contains high levels of zinc, gene transcription, brain function, and mammalian reproduction, co-factor in hundreds of enzymes [1,2]. Recent studies have identified labile zinc as being critically involved in human pathophysiology and neurology [3,4]. For instance, a failure in Zinc homeostasis is linked to development of prostate cancer and Alzheimer's disease. Deficiency of micronutrient zinc leads to impaired cognition, immune dysfunction, diarrhea, and death, particularly in children under the age of 5 years [5]. The human genome encodes two dozen Zn²⁺ specific transporters and many metal-buffering proteins, which are expressed in a tissue-specific manner [6]. Although Zn²⁺ is essential for cell function, accumulation of Zn²⁺

to toxic levels leads to cell death [7–9]. These factors thus trigger us for the detection and development of a new class of Zn (II) sensors. Schiff bases play a crucial role in host-guest chemistry as chemosensors being that the nitrogen atoms present exhibits a strong tendency to bind metal ions and implies its applications in recognition. Fluorescence sensors are powerful tools in the detection of ions/small molecules, because of their high sensitivity, excellent selectivity, and quick response speed. Such type of sensors normally contains two parts viz., a receptor that specially interacts with the target and a fluorophore that translates the molecular recognition to fluorescence signal. Fluorescent sensors based on Schiff base attract special attention owing to their easy synthesis, variable structures, and cheap raw materials. In recent years, the fluorescein and its derivatives were used as excellent fluorescence chemosensor for Zn²⁺ attract interest due to their short synthetic routes, high water solubility, noticeable fluorescence quantum yield and good photo-stability [10–18]. Out of the two distinctive form of fluorescein-based Schiff bases, the spirolactam (close) form is colorless and non-fluorescence. Some metal ions/species are capable to open up the ring-form accompanied with a change of its spectroscopic properties

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Declaration

There are no conflicts to declare.

Appendix A. Supplementary Data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.saa.2018.12.053>.

References

- [1] M.P. Cuajungco, G.J. Lees, Zinc metabolism in the brain: relevance to human neurodegenerative disorders, *Neurobiol. Dis.* 4 (1997) 137–169.
- [2] D. Beyersmann, H. Haase, Functions of zinc in signaling, proliferation and differentiation of mammalian cells, *Biometals* 14 (2001) 331–341.
- [3] P.D. Zalewski, S.H. Millard, I.J. Forbes, O. Kapaniris, A. Slavotinek, W.H. Betts, A.D. Ward, S.F. Lincoln, I. Mahadevan, Video image analysis of labile zinc in viable pancreatic islet cells using a specific fluorescent probe for zinc, *J. Histochem. Cytochem.* 42 (1994) 877–884.
- [4] A.S. Prasad, Discovery and importance of zinc in human nutrition, *Fed. Proc.* 43 (1984) 2829–2834.
- [5] A.S. Prasad, Zinc deficiency in women, infants and children, *J. Am. Coll. Nutr.* 15 (1996) 113–120.
- [6] C. Andreini, L. Banci, I. Bertini, A. Rosato, Counting the zinc-proteins encoded in the human genome, *J. Proteome Res.* 5 (2006) 196–201.
- [7] L.M. Plum, L. Rink, H. Hajo, The essential toxin: impact of zinc on human health, *Int. J. Environ. Res. Public Health* 7 (2010) 1342–1365.
- [8] J. Nriagu, Zinc toxicity in humans, *Encycl. Environ. Heal.* 2011, pp. 801–807.
- [9] C.M. Borkert, F.R. Cox, M.R. Tucker, Zinc and copper toxicity in peanut, soybean, rice, and corn in soil mixtures, *Commun. Soil Sci. Plant Anal.* 29 (1998) 2991–3005.
- [10] T. Li, Z. Yang, Y. Li, Z. Liu, G. Qi, B. Wang, A novel fluorescein derivative as a colorimetric chemosensor for detecting copper(II) ion, *Dyes Pigments* 88 (2011) 103–108.
- [11] L. Jiang, L. Wang, M. Guo, G. Yin, R.Y. Wang, Fluorescence turn-on of easily prepared fluorescein derivatives by zinc cation in water and living cells, *Sensors Actuators B Chem.* 156 (2011) 825–831.
- [12] M.S. Islam, S. Park, C. Song, A.A. Kadi, Y. Kwon, A.F.M.M. Rahman, Fluorescein hydrazones: a series of novel non-intercalative topoisomerase II α catalytic inhibitors induce G1 arrest and apoptosis in breast and colon cancer cells, *Eur. J. Med. Chem.* 125 (2017) 49–67.
- [13] S. Goswami, S. Paul, A. Manna, FRET based selective and ratiometric “naked-eye” detection of CN⁻ in aqueous solution on fluorescein-Zn-naphthalene ensemble platform, *Tetrahedron Lett.* 55 (2014) 3946–3949.
- [14] F.A. Abebe, E. Sinn, Fluorescein-based fluorescent and colorimetric chemosensors for copper in aqueous media, *Tetrahedron Lett.* 52 (2011) 5234–5237.
- [15] P. Jiang, Z. Guo, Fluorescent detection of zinc in biological systems: recent development on the design of chemosensors and biosensors, *Coord. Chem. Rev.* 248 (2004) 205–229.
- [16] B. Vidya, G. Sivaraman, R.V. Sumesh, D. Chellappa, Fluorescein-based “turn on” fluorescence detection of Zn²⁺ and its applications in imaging of Zn²⁺ in apoptotic cells, *Chem. Sel.* 1 (2016) 4024–4029.
- [17] W. Maret, Analyzing free zinc(II) ion concentrations in cell biology with fluorescent chelating molecules, *Metalomics* 7 (2015) 202–211.
- [18] P. Chabosseau, J. Woodier, R. Cheung, G.A. Rutter, Sensors for measuring subcellular zinc pools, *Metalomics* 10 (2018) 229–239.
- [19] J.M. Goldberg, F. Wang, C.D. Sessler, N.W. Vogler, D.Y. Zhang, W.H. Loucks, T. Tzounopoulos, S.J. Lippard, Photoactivatable sensors for detecting mobile zinc, *J. Am. Chem. Soc.* 140 (2018) 2020–2023.
- [20] X.F. Yang, Y. Li, Q. Bai, A highly selective and sensitive fluorescein-based chemodosimeter for Hg²⁺ ions in aqueous media, *Anal. Chim. Acta* 584 (2007) 95–100.
- [21] H.A. Benesi, J.H. Hildebrand, A spectrophotometric investigation of the interaction of iodine with aromatic hydrocarbons, *J. Am. Chem. Soc.* 71 (1949) 2703–2707.
- [22] B. Das, S. Dey, G.P. Maiti, A. Bhattacharjee, A. Dhara, A. Jana, Hydrazinopyrimidine derived novel Al³⁺ chemosensor: molecular logic gate and biological applications, *New J. Chem.* 42 (2018) 9424–9435.
- [23] A. Jana, P.K. Sukul, S.K. Mandal, S. Konar, S. Ray, K. Das, J.A. Golen, A.L. Rheingold, S. Mondal, T.K. Mondal, A.R. Khuda-Bukhsh, S.K. Kar, A novel 2,6-diformyl-4-methylphenol based chemosensor for Zn(II) ions by ratiometric displacement of Cd(II) ions and its application for cell imaging on human melanoma cancer cells, *Analyst* 139 (2014) 495–504.
- [24] J.R. Lakowicz, Principles of Fluorescence Spectroscopy, Plenum, New York, 1999.
- [25] B. Ramachandram, G. Saroja, B. Sankaran, A. Samanta, Unusually high fluorescence enhancement of some 1,8-naphthalimide derivatives induced by transition metal salts, *J. Phys. Chem. B* 104 (2000) 11824–11832.
- [26] S. Banthia, A. Samanta, A new strategy for ratiometric fluorescence detection of transition metal ions, *J. Phys. Chem. B* 110 (2006) 6437–6440.
- [27] P. Bag, D. Chattopadhyay, H. Mukherjee, D. Ojha, N. Mandal, M.C. Sarkar, T. Chatterjee, G. Das, S. Chakraborti, Anti-herpes virus activities of bioactive fraction and isolated pure constituent of *Mallotus peltatus*: an ethnomedicine from Andaman Islands, *J. Virol.* 9 (2012) 98–109.
- [28] P. Bag, D. Ojha, H. Mukherjee, U.C. Halder, S. Mondal, A. Biswas, A. Sharon, L. Van Kaer, S. Chakrabarty, G. Das, D. Mitra, D. Chattopadhyay, A dihydro-pyrido-indole potentially inhibits HSV-1 infection by interfering the viral immediate early transcriptional events, *Antivir. Res.* 105 (2014) 126–134.
- [29] R. Purkait, A. Das Mahapatra, D. Chattopadhyay, C. Sinha, An azine-based carbothioamide chemosensor for selective and sensitive turn-on-off sequential detection of Zn(II) and H₂PO₄⁻, live cell imaging and INHIBIT logic gate, *Spectrochim. Acta A Mol. Biomol. Spectrosc.* 264 (2018) 164–172.
- [30] R. Purkait, C. Patra, A. Das, D. Chattopadhyay, A visible light excitable chromone appended hydrazone chemosensor for sequential sensing of Al³⁺ and F⁻ in aqueous medium and in Vero cells, *Sensors Actuators B Chem.* 257 (2017) 545–552.
- [31] J. Bourson, J. Pouget, B. Valeur, Ion-responsive fluorescent compounds. Effect of cation binding on the photophysical properties of a coumarin linked to monoaza- and diaza-crown ethers, *J. Phys. Chem.* 97 (1993) 4552–4557.
- [32] L.-K. Zhang, G.-F. Wu, Y. Zhang, Y.-C. Tian, Q.-X. Tong, D. Li, A two-in-one fluorescent sensor with dual channels to detect Zn²⁺ and Cd²⁺, *RSC Adv.* 3 (2013), 21409.
- [33] P. Li, X. Zhou, R. Huang, L. Yang, X. Tang, W. Dou, Q. Zhao, W. Liu, A highly fluorescent chemosensor for Zn²⁺ and the recognition research on distinguishing Zn²⁺ from Cd²⁺, *Dalton Trans.* 43 (2014) 706–713.
- [34] S.C. Burdette, G.K. Walkup, B. Spingler, R.Y. Tsien, S.J. Lippard, Fluorescent sensors for Zn²⁺ based on a fluorescein platform: synthesis, properties and intracellular distribution, *J. Am. Chem. Soc.* 123 (2001) 7831–7841.
- [35] Prasanna de Silva, H.Q. Nimal Gunaratne, Thorfinnur Gunnlaugsson, Allen J.M. Huxley, Colin P. McCoy, T.E. Rice, Jude T. Rademacher, Signaling recognition events with fluorescent sensors and switches, *Chem. Rev.* 97 (1997) 1515–1566.
- [36] R.Y. Tsien, A.W. Czarnik, Fluorescent and photochemical probes of dynamic biochemical signals inside living cells, *Am. Chem. Soc. Wash. DC (1993)* 130–146 chapter 9.
- [37] D. Wang, X. Xiang, X. Yang, X. Wang, Y. Guo, W. Liu, W. Qin, Fluorescein-based chromo-fluorescent probe for zinc in aqueous solution: spirolactam ring opened or closed? *Sensors Actuators B Chem.* 201 (2014) 246–254.
- [38] P.G. Mahajan, N.C. Dige, B.D. Vanjare, Y. Han, S.J. Kim, S.K. Hong, K.H. Lee, Intracellular imaging of zinc ion in living cells by fluorescein based organic nanoparticles, *Sensors Actuators B Chem.* 267 (2018) 119–128.
- [39] F. Huo, C. Yin, Y. Yang, J. Su, J. Chao, D. Liu, Ultraviolet-visible light (UV-Vis)-reversible but fluorescence-irreversible chemosensor for copper in water and its application in living cells, *Anal. Chem.* 84 (2012) 2219–2223.
- [40] A. Jana, B. Das, S.K. Mandal, S. Mahai, A.R. Khuda-Bukhsh, S. Dey, Deciphering the CHEF-PET-ESIPT liaison mechanism in a Zn²⁺ chemosensor and its applications in cell imaging study, *New J. Chem.* 40 (2016) 5976–5984.
- [41] Guidelines for drinking-water quality, Zinc in Drinking-Water, 2nd ed., vol. 2, WHO, 1996.
- [42] B. Mondal, S. Lohar, S. Pal, A. Maji, A new chemosensor selective for Cu²⁺ ions through fluorescence quenching approach applicable to real samples, *J. Indian Chem. Soc.* 92 (2015) 1–18 (C.P.).
- [43] Y.-S. Yang, C.-M. Ma, Y.-P. Zhang, Q.-H. Xue, J.-X. Ru, X.-Y. Liu, H.-C. Guo, A highly selective “turn-on” fluorescent sensor for zinc ion based on a cinnamyl pyrazoline derivative and its imaging in live cells, *Anal. Methods* 10 (2018) 1833–1841.
- [44] A. Dhara, N. Guchhait, I. Mukherjee, A. Mukherjee, S. Chandra Bhattacharya, A novel pyrazole based single molecular probe for multi-analyte (Zn²⁺ and Mg²⁺) detection in human gastric adenocarcinoma cells, *RSC Adv.* 6 (2016) 105930–105939.
- [45] S. Erbas-Cakmak, S. Kolemen, A.C. Sedgwick, T. Gunnlaugsson, T.D. James, J. Yoon, E.U. Akkaya, Molecular logic gates: the past, present and future, *Chem. Soc. Rev.* 47 (2018) 2228–2248.
- [46] B. Naskar, R. Modak, Y. Sikdar, D.K. Maiti, A. Banik, T.K. Dangar, S. Mukhopadhyay, D. Mandal, S. Goswami, A simple Schiff base molecular logic gate for detection of Zn²⁺ in water and its bio-imaging application in plant system, *J. Photochem. Photobiol. A Chem.* 321 (2016) 99–109.
- [47] X. Jin, X. Wu, B. Wang, P. Xie, Y. He, H. Zhou, B. Yan, J. Yang, W. Chen, X. Zhang, A reversible fluorescent probe for Zn²⁺ and ATP in living cells and in vivo, *Sensors Actuators B Chem.* 261 (2018) 127–134.
- [48] A. Manna, K. Jana, N. Guchhait, S. Goswami, Discrimination of tabun mimic diethyl cyanophosphonate from sarin mimic diethyl chlorophosphate via Zn(II)-triggered photoinduced electron transfer-decoupled excited state intramolecular proton transfer processes, *New J. Chem.* 41 (2017) 6661–6666.
- [49] K. Chantalkana, N. Choengchan, P. Yingyud, P. Thongyoo, A highly selective “turn-on” fluorescent sensor for Zn²⁺ based on fluorescein conjugates, *Tetrahedron Lett.* 57 (2016) 1146–1149.
- [50] J.M. An, M.H. Yan, Z.Y. Yang, T.R. Li, Q.X. Zhou, A turn-on fluorescent sensor for Zn(II) based on fluorescein-coumarin conjugate, *Dyes Pigments* 99 (2013) 1–5.
- [51] S. Erdemir, O. Kocycigit, A novel dye based on phenolphthalein-fluorescein as a fluorescent probe for the dual-channel detection of Hg²⁺ and Zn²⁺, *Dyes Pigments* 145 (2017) 72–79.

Oxyanion-Binding in a Bioinspired Nanoparticle-Assembled Hybrid Microsphere Structure: Effective Removal of Arsenate/Chromate From Water

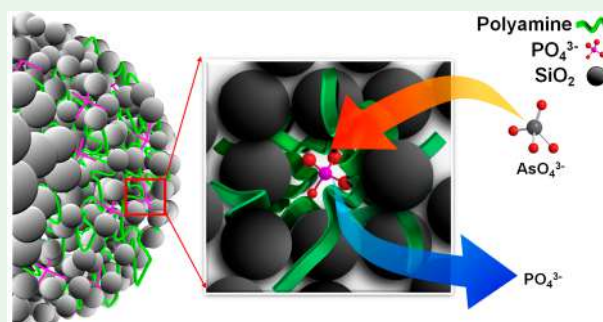
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Supporting Information

ABSTRACT: We demonstrate a bioinspired assembly wherein the specific interaction of polyamines with multivalent anions allows the assembly of silica nanoparticles to generate hybrid microsphere structures while this very phenomenon further provides ways for the microspheres to adsorb oxyanions like arsenate and chromate. In a typical method based on the biomineralization of diatomaceous biosilica structure, thus produced nanoparticle-assembled microspheres with a porous structure and hybrid functionalities exhibit efficient adsorption and separation of these toxic anions from water. The adsorption follows Freundlich isotherm with an inference for stronger interaction between adsorbate and adsorbent with nonuniform distribution of adsorption affinities. The opportunities to tune the composition with respect to the multivalent anion and their interaction with the polyamine, charge ratio, and so forth, illustrate the design of bioinspired robust structures with efficient oxyanion-binding property and recyclability. The consequence of competing anions shows that the binding selectivity follows the Hofmeister series of counterion interaction. Interestingly, in accordance with a molecular imprinting mechanism, the silica nanoparticle-assembled structure stabilizes and preserves the polyamine-anion nanostructure creating cavities/voids complementary to the adsorbing ions in shape, size, and functional groups. As a result, the polyamine with phosphate as the multivalent anion exhibits efficient binding and removal of these toxic contaminants, which is better than most of the other reported adsorbents.

KEYWORDS: biomimetic chemistry, self-assembly, nanostructures, anion-binding, ion-imprinting



INTRODUCTION

Despite the controversial conclusions that certain bacteria can grow in the presence of arsenate instead of phosphate, there has been continuous efforts to find biological or bioinspired solutions for arsenic remediation.^{1,2} This includes investigations using organisms like Microalgae (phytoplankton), which are known to be the key contributors to arsenic cycling in the marine environment.³ Other marine organisms, such as fish and invertebrates, have also been shown to facilitate accumulation of arsenic mainly in the form of organo-arsenicals. This bioaccumulation by a number of marine organisms certainly suggests that they have an affinity for the arsenic containing compounds.⁴ Although the reason underlying this biological process is still a matter of discussion, mimicking these hybrid structures may provide clues not only for the phenomenon but also for the fabrication of advanced materials for the removal of these toxic anions from water.⁵ Therefore, in the present work our focus is to explore the bioinspired structures, particularly those based on the Diatoms, which represent a type of microalgae that dominate the phytoplankton blooms. Via biosilicification processes, these marine species produce shells called frustules composed of silica and long-chain polyamine-

containing proteins (silaffin) assembled together generating intricately designed structures. Thus, formed hybrid structure provides controlled porosity, large surface area, and mechanical protection.^{6–8} Many efforts have been made not only to understand the biosilicification process but also to help develop bioinspired methods for the synthesis of advanced materials for various desirable applications.^{9–13}

In the context of the groundwater contamination, the toxic oxyanions like arsenate and chromate are known to affect millions of people globally.^{14–16} According to WHO (World Health Organization) guidelines, the maximum tolerable concentrations of arsenic and chromium in drinking water are <10 and <50 ppb, respectively. Both of arsenic and chromium exist in water mainly in their tetrahedral oxyanionic form.^{17,18} Therefore, the removal of these oxyanions from drinking water either through natural biogeochemical processes or engineered approaches is imperative to mitigate its potential environmental and health risk. Conventionally, it is done by absorbing the ions

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- (18) Loyaux-Lawnciczak, S.; Lecomte, P.; Ehrhardt, J.-J. Behavior of Hexavalent Chromium in a Polluted Groundwater: Redox Processes and Immobilization in Soils. *Environ. Sci. Technol.* **2001**, *35*, 1350.
- (19) Fryxell, G. E.; Liu, J.; Hauser, T. A.; Nie, Z.; Ferris, K. F.; Mattigod, S.; Gong, M.; Hallen, R. T. Design and Synthesis of Selective Mesoporous Anion Traps. *Chem. Mater.* **1999**, *11*, 2148.
- (20) Tarboush, B. J. A.; Chouman, A.; Jonderian, A.; Ahmad, M.; Hmadeh, M.; Al-Ghoul, M. Metal–Organic Framework-74 for Ultratrace Arsenic Removal from Water: Experimental and Density Functional Theory Studies. *ACS Appl. Nano Mater.* **2018**, *1*, 3283.
- (21) Ali, I. New Generation Adsorbents for Water Treatment. *Chem. Rev.* **2012**, *112*, 5073.
- (22) Sinha, A.; Cha, B. G.; Kim, J. Three-Dimensional Macroporous Alginate Scaffolds Embedded with Akaganeite Nanorods for the Filter-Based High-Speed Preparation of Arsenic-Free Drinking Water. *ACS Appl. Nano Mater.* **2018**, *1*, 1940.
- (23) Loring, J. S.; Sandström, M. H.; Norn, K.; Persson, P. Rethinking Arsenate Coordination at the Surface of Goethite. *Chem. - Eur. J.* **2009**, *15*, 5063.
- (24) Mohan, D.; Pittman, C. U., Jr. Arsenic Removal from Water/Wastewater Using Adsorbents-A Critical Review. *J. Hazard. Mater.* **2007**, *142*, 1.
- (25) Fan, H.-T.; Sun, T.; Xu, H.-B.; Yang, Y.-J.; Tang, Q.; Sun, Y. Removal of arsenic(V) from aqueous solutions using 3-[2-(2-aminoethylamino)ethylamino]propyl-trimethoxysilane functionalized silica gel adsorbent. *Desalination* **2011**, *278*, 238.
- (26) Fan, H.-T.; Fan, X.; Li, J.; Guo, M.; Zhang, D.; Yan, F.; Sun, T. Selective Removal of Arsenic(V) from Aqueous Solution Using A Surface-Ion-Imprinted Amine-Functionalized Silica Gel Sorbent. *Ind. Eng. Chem. Res.* **2012**, *51*, 5216.
- (27) Li, S.; Qi, F.; Xiao, M.; Fan, H.; Shen, Y.; Du, K.; Zhang, Z.; Li, W. In situ synthesis of layered double hydroxides on γ -Al₂O₃ and its application in chromium (VI) removal. *Water Sci. Technol.* **2017**, *75*, 1466.
- (28) Shen, S.; Li, X.-F.; Cullen, W. R.; Weinfeld, M.; Le, X. C. Arsenic Binding to Proteins. *Chem. Rev.* **2013**, *113*, 7769.
- (29) Zhang, J.; Ding, T.; Zhang, Z.; Xu, L.; Zhang, C. Enhanced Adsorption of Trivalent Arsenic from Water by Functionalized Diatom Silica Shells. *PLoS One* **2015**, *10*, No. e0123395.
- (30) Yuan, P.; Liu, D.; Fan, M.; Yang, D.; Zhu, R.; Ge, F.; Zhu, J. X.; He, H. Removal of hexavalent chromium [Cr(VI)] from aqueous solutions by the diatomite-supported/unsupported magnetite nanoparticles. *J. Hazard. Mater.* **2010**, *173*, 614.
- (31) Brunner, E.; Lutza, K.; Sumper, M. Biomimetic Synthesis of Silica Nanospheres Depends on the Aggregation and Phase Separation of Polyamines in Aqueous Solution. *Phys. Chem. Chem. Phys.* **2004**, *6*, 854.
- (32) Vrieling, E. G.; Sun, Q.; Tian, M.; Kooyman, P. J.; Gieskes, W. W. C.; van Santen, R. A.; Sommerdijk, N.; Salinity-Dependent, A. J. M. Diatom Biosilicification Implies an Important Role of External Ionic Strength. *Proc. Natl. Acad. Sci. U. S. A.* **2007**, *104*, 10441.
- (33) Dickerson, M. B.; Sandhage, K. H.; Naik, R. R. Protein- and Peptide-Directed Syntheses of Inorganic Materials. *Chem. Rev.* **2008**, *108*, 4935.
- (34) Porasso, R. D.; Benegas, J. C.; van-den Hoop, M.; Paoletti, S. Chemical Bonding of Divalent Counterions to Linear Polyelectrolytes: Theoretical Treatment within the Counterion Condensation Theory. *Phys. Chem. Chem. Phys.* **2001**, *3*, 1057.
- (35) Fu, J.; Schlenoff, J. B. Driving Forces for Oppositely Charged Polyion Association in Aqueous Solutions: Enthalpic, Entropic, but not Electrostatic. *J. Am. Chem. Soc.* **2016**, *138*, 980.
- (36) Manning, G. S. Counterion Binding in Polyelectrolyte Theory. *Acc. Chem. Res.* **1979**, *12*, 443.
- (37) Bhuiyan, L. B.; Vlachy, V.; Outhwaite, C. Understanding Polyelectrolyte Solutions: Macroion Condensation with Emphasis on the Presence of Neutral Co-solutes. *Int. Rev. Phys. Chem.* **2002**, *21*, 1.
- (38) Manning, G. S. Simple Model for the Binding of a Polyelectrolyte to an Oppositely Charged Curved Surface. *J. Phys. Chem. B* **2003**, *107*, 11485.
- (39) Swann, J. M. G.; Bras, W.; Topham, P. D.; Howse, J. R.; Ryan, A. J. Effect of the Hofmeister Anions Upon the Swelling of a Self-Assembled pH-Responsive Hydrogel. *Langmuir* **2010**, *26*, 10191.
- (40) Kumar, P. A.; Ray, M.; Chakraborty, S. Hexavalent Chromium Removal from Wastewater Using Aniline Formaldehyde Condensate Coated Silica Gel. *J. Hazard. Mater.* **2007**, *143*, 24.
- (41) Bhowmick, S.; Chakraborty, S.; Mondal, P.; Renterghem, W. V.; Berghe, S. V.-D.; Roman-Ross, G.; Chatterjee, D.; Iglesias, M. Montmorillonite-supported Nanoscale Zero-valent Iron for Removal of Arsenic from Aqueous Solution: Kinetics and Mechanism. *Chem. Eng. J.* **2014**, *243*, 14.
- (42) Badruddoza, A. Z. M.; Shawon, Z. B. Z.; Rahman, M. T.; Hao, K. W.; Hidajat, K.; Uddin, M. S. Ionically Modified Magnetic Nanomaterials for Arsenic and Chromium Removal from Water. *Chem. Eng. J.* **2013**, *225*, 607.
- (43) Bulut, Y.; Tez, Z. Removal of Heavy Metals from Aqueous Solution by Sawdust Adsorption. *J. Environ. Sci.* **2007**, *19*, 160.
- (44) Ho, Y.-S.; Chiu, W.-T.; Wang, C.-C. Regression Analysis for the Sorption Isotherms of Basic Dyes on Sugarcane Dust. *Bioresour. Technol.* **2005**, *96*, 1285.
- (45) Chandra, V.; Park, J.; Chun, Y.; Lee, J. W.; Hwang, I.-C.; Kim, K. S. Water-Dispersible Magnetite-Reduced Graphene Oxide Composites for Arsenic Removal. *ACS Nano* **2010**, *4*, 3979.
- (46) Galloway, J. M.; Senior, L.; Fletcher, J. M.; Beesley, J. L.; Hodgson, L. R.; Harniman, R. L.; Mantell, J. M.; Coombs, J.; Rhys, G. G.; Xue, W.-F.; Mosayebi, M.; Linden, N.; Liverpool, T. B.; Curnow, P.; Verkade, P.; Woolfson, D. N. Bioinspired Silicification Reveals Structural Detail in Self-Assembled Peptide Cages. *ACS Nano* **2018**, *12*, 1420.
- (47) Amali, A. J.; Saravanan, P.; Rana, R. K. Tailored Anisotropic Magnetic Chain Structures Hierarchically Assembled from Magneto-responsive and Fluorescent Components. *Angew. Chem., Int. Ed.* **2011**, *50*, 1318.

**ASSESSMENT OF URBANIZATION IN CENSUS-UNITS
THROUGH CONSTRUCTION OF A GENERALIZED
URBANIZATION INDEX: A STUDY FOR ECONOMICALLY
BACKWARD REGIONS OF WEST BENGAL
DURING 1991 TO 2011**

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Sanjoy Kumar Pattanayek**
Debasish Mondal***

Abstract

The Census Authority of India usually provides data regarding the nature of a few urbane characteristics for all the village units and thereby classifies a place as Census Town, which is considered as the lowest unit of urbanization. From the perspective of urbanization, regions of any state, consisting of blocks can be classified as economically advanced or economically backward on the basis of existence of Census Towns in it as urban places are likely to bring more prosperity in terms of standard of living. However, proper assessment of urbanization in a single measurement scale, of all village units of a particular block is not done so far. An attempt in that direction is made in this article through construction of a Generalized Urbanization Index (GUI) for all the village units of some blocks, selected through systematic-stratified sampling, from three major districts of Paschim Medinipur, Bankura and Purulia, which are known as 'so called' backward regions. The proposed GUI for a census-unit is constructed with two components - the town criteria index and the amenities index and the relative weights of both the component-indices and the underlying dimension indices are determined through the application of Iterative Average Correlation Method indicating some movement towards actuality in comparison to prevailing two other methods of weight determination - the Equal Weights Principle and the Principal Component Analysis.

Keywords: *Urbanization, Census Town, Backward Region, Index, Equal Weights, Principal Component Analysis, Average Correlation*

JEL Classification Codes: *C51, H54, O18*

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9. Hotelling, H. (1933): 'Analysis of a Complex of Statistical Variables into Principal Components', *Journal of Educational Psychology*, 24, pp 417 - 441, 498 - 520
10. Manna, S. (1994): 'Mahishadal – A Small Town', *Institute of Social Research & Applied Anthropology*, Calcutta, India
11. Mondal, D. (2004): 'District Development Index of West Bengal 1991 and 2001', Occasional Paper No.16, Department of Economics with Rural Development (under DRS), Vidyasagar University.
12. Mondal, D. (2005): 'Human Development Index-An Essay on Methodology and Implication', FIRMA KLM Private Limited, Kolkata, India.
13. Mondal, D. (2008): 'On the Test of Significance of Linear Multiple Regression Coefficients', *Communication in Statistics- Simulation and Computation, Taylor & Francis Group*, USA, 37(4): 713-730.
14. Mondal, D., S. Mookherjee and S. K. Pattanayek (2017): 'Does the analysis of principal components effectively help in determining actual weights for dimensions of an index? An appraisal in Indian context', *International Journal of Management and Development Studies*, 6(10): 28-36.
15. Mookherjee, S., S. K. Pattanayek and D. Mondal (2017): 'An Appraisal of Urbanization Status of Villages in A Particular Block of West Bengal: An Exploration through Construction of A Generalized Urbanization Index', *ZENITH International Journal of Business Economics & Management Research*, 7 (12): 97-110.
16. Noorbakhsh, F. (1998): 'The Human Development Index: Some Technical Issues and Alternative Indices', *Journal of International Development* 10(5): 589–605.
17. Pattanayek, S. K. and D. Mondal (2016): 'Educational Development in Blocks of Paschim Medinipur District (West Bengal) between 2005-06 and 2012-13: Panel Data Analysis through Education Index', *Artha Vijnana*, 58(1):71-93.

Table AT 4: Computation of AI for the Census-units in **EWP, PCA and IACM** respectively, A Representative Picture with 25 Units under 3 Censuses

Serial No.	DISTRICTS AND BLOCKS	Block-wise Serial No. in Census Years	NAME of the VILLAGE UNITS / NON-MUNICIPAL TOWNS / CENSUS TOWNS	AI (EWP)	AI (PCA)	AI (IACM)
1	Paschim Medinipur KGP 1	2011 1	ABHOYANAGAR	0.179	0.560	0.386
2	KGP 1	2	AGARPARA	0.061	0.170	0.134
3	KGP 1	3	AJABGAR	0.102	0.229	0.210
4	KGP 1	4	AJABPUR	0.106	0.310	0.224
5	KGP 1	5	AJODHYAGAR	0.153	0.548	0.369
6	Bankura BARJORA	2011 1	AMTHIA	0.062	0.160	0.128
7	BARJORA	2	ARJUNI	0.048	0.145	0.092
8	BARJORA	3	ASANSOLA	0.189	0.576	0.405
9	BARJORA	4	ASHURIA MADHABPUR	0.171	0.352	0.253
10	BARJORA	5	BAGULI	0.156	0.345	0.262
11	Purulia KASHIPUR	2011 1	ADALI	0.123	0.228	0.214
12	KASHIPUR	2	ADRA (CT)	0.446	0.726	0.700
13	KASHIPUR	3	AGARDI	0.155	0.209	0.201
14	KASHIPUR	4	AGRABAD	0.107	0.215	0.200
15	KASHIPUR	5	AGUIBAD	0.084	0.186	0.151
16	Paschim Medinipur KGP 1	2001 1	ABHOYANAGAR	0.120	0.216	0.201
17	KGP 1	2	AGARPARA	0.092	0.182	0.129
18	KGP 1	3	AJABGAR	0.048	0.056	0.074
19	KGP 1	4	AJABPUR	0.093	0.102	0.125
20	KGP 1	5	AJODHYAGAR	0.093	0.192	0.158
21	Paschim Medinipur KGP 1	1991 1	ABHOYANAGAR	0.055	0.058	0.097
22	KGP 1	2	AGARPARA	0.019	0.023	0.042
23	KGP 1	3	AJABGAR	0.036	0.035	0.055
24	KGP 1	4	AJABPUR	0.065	0.061	0.104
25	KGP 1	5	AJODHYAGAR	0.055	0.058	0.097

Source: Calculated by the Author on the basis of Selected Census Data



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Surface enhanced Raman scattering: Mechanism and suitable Nanomaterials for detection of trace molecules

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Abstract

SERS is becoming an important tool for detection of molecules in ultra-trace level. In this review, an overview of SERS and different types of SERS active substances are presented. The excessive use of metal and/or metal supported nanostructured materials have been used for making the SERS active substances. Along with pure metal nanoparticles, core-shell or hybrid nanoparticles also made their way as SERS active platform. Notably, unusual shapes such as nanostars or nanoplates have used for such purposes. Further, SERS were used for intracellular detection of biomolecules in different types of cells. It is believed that this review would be useful to further development of advanced SERS platform for various applications especially physiological detection of trace molecules.

Keywords: SERS, mechanism, Nanomaterials, intracellular, trace molecule

1. Introduction

Surface enhanced Raman spectroscopy (SERS) is a powerful vibrational spectroscopy technique that allows for highly sensitive structural detection of low concentration analytes through the amplification of electromagnetic fields generated by the excitation of localized surface plasmons [1]. SERS has progressed from studies of model systems on roughened electrodes to highly sophisticated studies, such as single molecule spectroscopy. We summarize the current state of knowledge concerning the mechanism of SERS and new substrate materials. We highlight recent applications of SERS including sensing, spectro-electrochemistry, single molecule SERS, and real-world applications. We also discuss contributions to the field from the Van Duyne group. This review concludes with a discussion of future directions for this field including biological probing with UV-SERS, tip-enhanced Raman spectroscopy, and ultrafast SERS [2]. A single metal nanoparticle typically offers SERS signal enhancements on the order of 10^2 – 10^6 [3]. However, when two nanoparticles are in close proximity, their dipoles can couple, leading to stronger overall field enhancements, reported to be as high as 10^{10} – 10^{14} [4]. As such, nanoparticle aggregates are often considered an optimum SERS substrate, even though they lack well-defined structure [5]. For intracellular SERS imaging, these nano-particles must self-assemble into aggregates within the cell, since the aggregates are often too large to penetrate the external membrane or wall of the cell. As we shall see, the cells inherently promote this aggregation due to their primary mechanism of nanoparticle uptake; however, this can limit the access that the nanoparticles have to specific regions of the intracellular matrix.

In recent years, purposeful SERS applications have been performed by functionalizing the nanoparticles with antibodies or other bio molecules that have a special receptor [6]. The functionalized nanoparticles that also can be described as SERS targeting nanoprobe always contain Raman reporter molecules to highlight the positions of themselves by their high spectral specificity. More recently, this method has been successfully used in tumor detection on living animals [7]. However, the Raman reporter modified targeting nanoprobe provides only the signature of the reporters and tends to be an imaging instrument rather than a detection probe, like the role of a fluorescent reagent or quantum dot; the application of the latter in targeting research is already proving to be excellent. In fact, delivering molecular structural information from the target analyte is the most important characteristic or advantage of SERS, which until now has not been possible by any other technique.

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Sonia *et al.* synthesized triangular nano-plates and studied their SERS effect on 4-nitrobenzenethiol (4-NBT) (Fig. 6) [17].

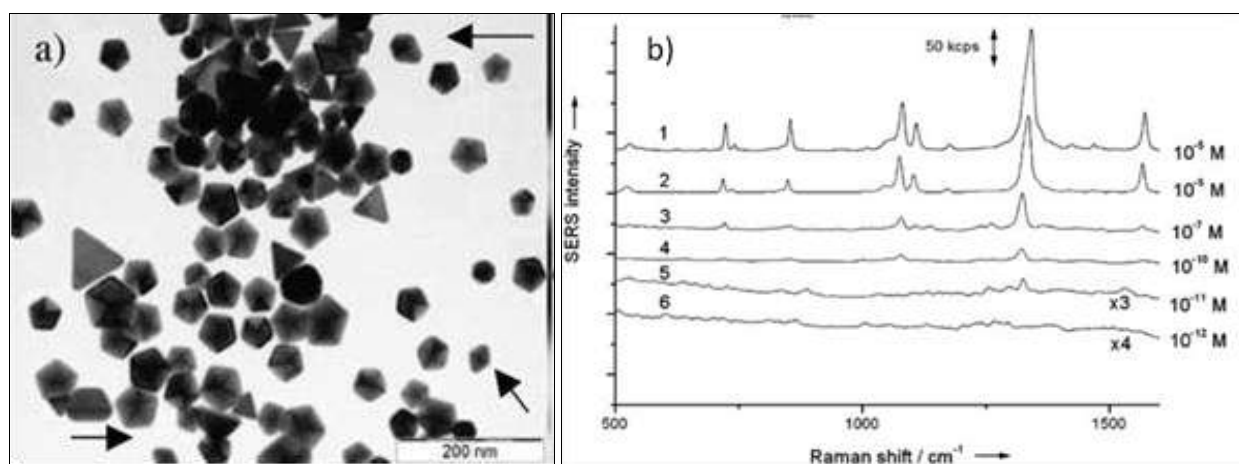


Fig 6: (a) TEM images of Au decahedra synthesized at 80 °C in the presence of 0.8 mM T904, 30 mM citric acid 0.5 mM HAuCl₄ and 1 mM HCl. (b) SERS spectra obtained at different concentrations of 4-NBT in the presence of Au triangular nanoplates (1, 3–6) and Au decahedra (2) upon excitation with a 785 nm laser line [17].

5. Intra-cellular detection

There have been reports for intracellular studies using SERS activity [18, 19]. This study reports on the intracellular detection of cell constituents in mouse fibroblast cells using gold nanoshells. Gold nanoshells were acquired from Nanospectra Biosciences that are based on a silica dielectric core and an outer gold shell layer. They have the unique property of a tunable surface plasmon resonance wavelength from the visible through the near infrared which allows control of the electromagnetic field strength on its surface. Hence gold nanoshells can serve as SERS substrates with plasmonic properties that are not aggregation dependent and thus can be expected to overcome the reproducibility problem that is generally associated with aggregation based colloidal metal nanoparticles. These results represent the first steps in the development of a nano shell-based SERS probe to detect cell organelles and/or intracellular biochemicals with the goal of ultimately improving the ability to monitor intracellular biological processes in real time.

6. Conclusions

In this review, an overview of SERS and different types of SERS active substances are presented. The excessive use of metal and/or metal supported nanostructured materials have been used for making the SERS active substances. Notably, unusual shapes such as nanostars or nanoplates have used for such purposes. Further, SERS were used for intracellular detection of biomolecules in different types of cells. This review will make its use for further development of suitably functionalized SERS materials for detection of physiological trace molecules.

7. References

1. Katherine A. Anal. Bioanal. Chem 2009;394:85-94.
2. Sharma B, Frontiera RR, Henry A-I, Ringe E, Richard PVD. Materials today 2012;15:1-2.
3. Stiles PL, Dieringer JA, Shah NC. Annu. Rev. Anal. Chem 2008;1:601.
4. Dieringer JA, Lettan RB, Scheidt KA. J Am. Chem. Soc 2007;129:16249.
5. Michaels AM, Nirmal M, Brus LE, J Am. Chem. Soc 1999;121:9932.
6. Kim JH, Kim JS, Choi H, Lee SM, Jun BH, Yu KN *et al.* Anal. Chem 2006, 78.

7. Xie W, Su L, Shen A, Maternyc A, Hua J. J Raman Spectrosc 2011;42:1248-1254.
8. Knauer M, Ivleva NP, Liu XJ, Niessner R, Haisch C. Anal. Chem 2010;82:2766.
9. Kukushkin VI, Van'kov AB, Kukushkin IV. JETP Letters 2013;98:64-69.
10. Jeanmaire DL, Suchanski MS, Van Duyne RP, J Amer. Chem. Soc 1975;97:169.
11. Fleischmann M, Hendra PJ, McQuillan AJ. Chemical Physics Letters 1974;26:164-165.
12. Beljebbar A, Sockalingum GD, Morjani H, Manfait M. Proc. SPIE 1999;3608:175.
13. Kazuhiko F, Hidehiro K, Nobuaki OKF, Hidehiro K, Nobuaki O. Analytical Sciences 2009;25:242-243.
14. Chang C-C, Yang K-H, Liu Y-C, Hsu T-C, Mai F-D. ACS Appl. Mater. Interfaces 2012;4:4700-4707.
15. Hardiansyah A, Chen A-Y, Liao H-L, Yang M-C, Liu T-Y, Chan T-Y *et al.* Wang, Nanoscale Research Lett 2015;10:412.
16. Esenturk EN, Walker ARH, Raman J. Spectrosc 2009;40:86-91.
17. Lopez SG, Juarez J, Cambon A, Botana J, Pereiro M, Baldomir D *et al.* Mater. Chem 2010;20:6808-6814.
18. Park J-H, Park J, Dembereldorj U, Cho K, Lee K, Yang SI *et al.* Anal. Bioanal. Chem 2011;401:1631-1639.
19. Aaron J, Travis K, Harrison N, Sokolov K. Nano Lett 2009;9:3612-3618.

EXPLOITATION OF THE NATURE AND THE TRANSFORMATION OF THE WILD IN STEPHEN ALTER'S *IN THE JUNGLES OF THE NIGHT*

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Abstract

*The inclination towards human flesh as part of a daily diet is an 'unnatural' phenomenon for a predatory animal like tiger and leopard. But during the British Raj, the number of man-eaters was drastically increasing in the Kumaon and Garhwal regions of India. Strikingly, this was also the time when the rampant extraction of timber in the Terai forests saw the height of colonial exploitation. It is in this context that Stephen Alter has set his novel, *In the Jungles of the Night* (2016), which is included in this paper as the case-study. Alter's novel is a fictional recounting of Jim Corbett, who is depicted here as a hunter with the impulse of a naturalist and conservationist. Taking Corbett's experience in the account, as narrated by Alter in his novel, this paper would explore how man-eaters are not a natural selection, but a production of human experimentation and interference in the ecological system. How exploitation of the natural resources and encroachment in the vicinity of tigers and leopards threaten ecological balance, would also be the points of discussion for this paper. The paper would consider the colonial policies towards the wild life and investigate its role in the negative transformation of the ecosphere. Finally, the paper would draw its conclusion by reflecting upon the eco-literary consciousness in Alter's novel, suggesting how human beings can still avert ecological crisis by preserving what is left in the bio-diversity.*

Keywords: Man-eater, extraction/ exploitation, encroachment, ecological crisis

In 1907 a man-eater commonly known as the Champawat tigress was shot dead by Jim Corbett. It was his first proclaimed hunting of a man-eater that had been terrorising the

- Dangwal, Dharendra Datt. "Commercialisation of Forests, Timber Extraction and Deforestation in Uttaranchal, 1815-1947." *Conservation and Society* 3.1 (2005): 110-133. Print.
- Ghosh, Amitav. *The Great Derangement: Climate Change and the Unthinkable*. Gurgaon: Penguin Books India, 2016. Print.
- Grove, Richard. *Green Imperialism: Colonial Expansion, Tropical Island Edens, and the Origin of Environmentalism, 1600-1860*. Cambridge: Cambridge University Press, 1995.
- Gupta, Avijit. *Ecology and Development in the Third World*. 2nd. New York: Routledge, 1998. Print.
- Hurd, John and Ian J. Kerr. *India's Railway History: A Research Handbook*. Leiden: Brill, 2012. Print.
- Murphy, Raymond. *Rationality and Nature: A Sociological Inquiry into a Changing Relationship*. Boulder: Westview Press, 1994. Print.



LITERARY STUDIES

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The Mystique Mountain: Nanda Devi in the Eyes of Bill Aitken, Hugh Thomson and Stephen Alter

Asis De and Maitrayee Misra

In literature, mountains usually stand for the supra-mundane. Its vastness, its altitude, the difficulty associated with the art of mountaineering — all contribute to the stature of the mountain as something beyond the ordinary. In English literature, the trend of using mountains as literary metaphors of strength, vastness, height and challenge is a common practice. In ancient Indian (Sanskrit *Kavya* poetry) and Chinese literature (*shan-shui* poetry), mountains and mountainscapes represent mostly religio-philosophical knowledge, spiritual truth and issues transcendental amid the wilderness of nature. It is usually observed that the western treatment of mountains in literary productions chiefly rely on the spatiality of the mountainscapes whereas the oriental attitude rests on the spirituality associated with the mountains and a subtle temporality in a tangent relationship with the consciousness of the transcendental. In European/western literary productions, the crucial truth about the treatment of mountains—whether it was the depiction of Alps or the Andes, was not at all a positive one till the 17th century! Though Marjorie Hope Nicolson, in her book *Mountain Gloom and Mountain Glory: The Development of the Aesthetics of the Infinite* (1959), observes that human “response to mountains has been influenced by inherited conventions of literature and theology” (3), there is no denying that early European literatures—written both in the Classical periods and in the Christian era, had no relation with the depiction of mountains in them. In her book, Nicolson finds the Christian era till 17th century as the period of ‘Mountain Gloom’, when mountains had negative depiction in literary or theological texts:

“During the first seventeen centuries of the Christian era, ‘Mountain Gloom’ so clouded human eyes that never for a moment did poets see mountains in the full radiance to which our eyes have become accustomed. Within a century...all this was changed. The ‘Mountain Glory’ dawned, then shone full splendour. Why? It was not merely a matter of literary language and conventions....The change in human attitudes about mountains involved a reversal of many basic attitudes.” (3)

As Nicolson admits here, there was a certain “change in human attitudes about mountains” in the Eurocentric world of literature and academia after the seventeenth century due to “a reversal of many basic attitudes”. Nicolson also cites a reference to a poem of Alexander Pope, where the poet talks about the heights of Alps and wishes climbing up:

“So pleased at first the tow’ring Alps we try,
Mount o’er the vales, and seem to tread the sky.” (qtd. in Nicolson 4)

Works Cited

- Aitken, Bill. *The Nanda Devi Affair*, Delhi: Penguin Random House India, 1994. Print. "An Introduction to the Literature on Nanda Devi". *The Himalayan Journal*. Ed. Harish Kapadia. Vol. 62 (2006a). Web. 25 Jan. 2018. <<https://www.himalayanclub.org/hj/62/12/an-introduction-to-the-literature-on-nanda-devi/>>
- "Nanda Devi: Vision or Reality?" *The Himalayan Journal*. Ed. Harish Kapadia. Vol. 62 (2006a). Web. 25 Jan. 2018. <<https://www.himalayanclub.org/hj/62/2/nanda-devi-vision-or-reality/>>
- Alter, Stephen. *Becoming a Mountain: Himalayan Journeys in Search of the Sacred and the Sublime*. New Delhi: Aleph Book Company, 2014. Print.
- Griffith, Ralph. T. H. *The Birth of the War-God: A Poem by Kālidāsa*. London: WM.H. Allen & Co, 1853, Digitized by Google (Indiana University Library)
- Heifetz, Hank. *The Origin of the Young God: Kālidāsa's Kumārasambhava*. Delhi: Motilal Banarsidass Publishers. 1990. Print.
- Hinton, David (Trans.). *The Mountain Poems of Hsieh Ling-Yün*. New York: New Directions Books, 2001. Print.
- . *The Mountain Poems of Meng Hao-Jan*. New York: Archipelago Books, 2004. Print.
- Nicolson, Marjorie Hope. *Mountain Gloom and Mountain Glory: The Development of the Aesthetics of the Infinite*. Seattle and London: University of Washington Press, 1997. Print.
- Seaton, J.P (Trans. and Ed.). *Cold Mountain Poems: Zen Poems of Han Shan, Shih Te, and Wang Fan-chih*. Boston & London: Shambhala, 2009, Print.
- Thomson, Hugh. *Nanda Devi: A Journey to the Last Sanctuary*. Gurgaon: Hachette Book Company, 2017. Print.

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Transnational Kinship and Diasporic 'Relatedness' in David Dabydeen's *The Intended*

Asis De

The comparatively recent notion of 'relatedness' (Jallinoja and Widmer, 2011) in family sociology, its core concept of 'relationality' and dimensions like memory and the imaginary could be seen as useful tools in measuring the changing natures of kinship and family during transnational migration. Idea like transnational kinship dwells in constant flux. Issues like ethnicity, 'race', age and language are important vectors which substantially influence both the formation and termination of kinship during transnational dislocation. To elaborate upon this point, I would use David Dabydeen's novel *The Intended* (1991) as case study, which aptly emphasizes the young protagonist's making and remaking of transnational kinship in England alongside his memories of a diasporic Indian family in Guyana and an imaginary ethnic Indian root.

"The ideas of kinship, the kin-based society, the idiom of kinship, and the content of kinship are the received wisdom of today, as they have been almost from the beginnings of anthropology"— Thus begins David Murray Schneider's highly influential volume *A Critique of the Study of Kinship* (1984), which has initiated a rather new way of looking at kinship studies beyond the formalist tradition, by attempting cross-cultural analyses of kinship only three decades back. The propositions of Schneider's new anthropology of kinship, which he finds as "the received wisdom of today", rely heavily on the nature/culture interplay than the biologically determined structuralist way of assessing kinship. The inclusion of 'local' culture/s and community history as no less elemental determinants than the exclusive factors like progeny and ethnology in kinship studies, allowed a broader and more fluid conceptualization of kinship through comparative analyses of 'relationality' of the individual with the society and its culture. Janet Carsten, another key thinker of kinship studies, in her book *After Kinship* (2004) attempts to find out how "kinship is part of the pre-given, natural order of things and the extent to which it is

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[This paper is a revised version of a conference presentation in the Eleventh Biennial MESEA Conference (2018) on "Ethnicity and Kinship: Interdisciplinary Approaches to Family, Community, and Difference" (May 30 – June 2, 2018) hosted by University of Graz, Austria.]

Works Cited:

- Carsten, Janet. *Ghosts of Memory: Essays on Remembrance and Relatedness* (Ed.), Malden and Oxford, Blackwell Publishing Ltd., 2007. Print.
- *After Kinship*, Cambridge and New York: Cambridge University Press, 2004. Print.
- *Cultures of Relatedness: New Approaches to the Study of Kinship*, Cambridge and New York: Cambridge University Press, 2000. Print.
- Dabydeen, David. (1991) *The Intended*, Leeds: Peepal Tree Press, 2005. Print.
- Fee, M. "Resistance and Complicity in David Dabydeen's *The Intended*", in *The Art of David Dabydeen*. Ed. Kevin Grant, Leeds: Peepal Tree, 1997, 67-88. Print.
- Finch, J. and MASON, J. *Passing On: Kinship and Inheritance in England*, London: Routledge, 2000, Print.
- Hareven, Tamara K. (2000). *Families, History, and Social Change: Life-Course and Cross-Cultural Perspectives*, New York: Routledge, 2018, Print.
- Jallinoja, Riitta & E. D. WIDMER (Eds.) *Families and Kinship in Contemporary Europe: Rules and Practices of Relatedness*, New York: Palgrave Macmillan, 2011, Print.
- Mason, Jennifer. 'Tangible Affinities and the Real Life Fascination of Kinship', *Sociology* Sage Publications, February 2008, Volume 42(1): 29-45, DOI: 10.1177/0038038507084824.
- 'Personal Narratives, Relational Selves: Residential Histories in the Living and Telling', *The Sociological Review*, Malden: Blackwell Publishing, 2004, 162-179, Print.
- Schneider, David M. (1984). *A Critique of the Study of Kinship*, Ann Arbor: The University of Michigan Press, 1998, Print.
- Smart, Carol. 'Relationality and Socio-Cultural Theories of Family Life', in Jallinoja & Widmer (Eds.) *Families and Kinship in Contemporary Europe: Rules and Practices of Relatedness*, New York: Palgrave Macmillan, 2011, pp. 13-28, Print.
- Smith, Raymond T. *Kinship and Class in the West Indies: A Genealogical Study of Jamaica and Guyana*, Cambridge and New York: Cambridge University Press (*Cambridge Studies in Social Anthropology*: 65), 1988, Print.
- Strathern, Marilyn. *After nature: English Kinship in the late Twentieth Century*, Cambridge, Cambridge University Press, 1992, Print.

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The Aesthetics of Becoming a Being in Manoranjan Byapari's Bangla Dalit Autobiography *Itibritte Chandal Jivan*

Asis De

Manoranjan Byapari's *Itibritte Chandal Jivan* was published by a less-known Kolkata-based publishing house, 'ab prakashani' quite recently in January 2016. The quintessence of his life was the word that Byapari honours most—'jijibisha', meaning 'an extremely strong urge to live'. The first sentence of the first volume reads as: "Here I am." (*ICJ* 1: 19); the second volume ends with the sentence: "Those unexpressed words make him [the author-narrator] bleed." (*ICJ* 2: 397) [my translation]. Beginning with an emphatic 'I', which is an obvious condition of the genre, and ending with an oblique reference again to that 'I', the narrator-persona's 'bleeding' profusely due to inexpression of suffering and oppression. However, before exploring Manoranjan Byapari's two-volume autobiographical text some deliberations on the emergence of the autobiographical genre in Bengali literature and finally, of the literary space where a few personal narratives written by Dalit writers find their place is imperative.

- iii Manoranjan Byapari's first ever composition, the short autobiographical piece entitled '*Rickshaw Chalai*' ('I Pull Rickshaw'), which was published in Mahasweta Devi's magazine *Bartika* in 1981, was written under a pen-name Madan Dutta.

Work Cited

- Bandopadhyay, Sekhar and Anasua Basu Ray Chaudhury. *In Search of Space: The Scheduled Caste Movement in West Bengal after Partition*, Mahanirban Calcutta Research Group, Policies and Practices 59, 2014.
- Byapari, Manoranjan. *Itibritte Chandal Jivan*. 2012. 2nd Ed. Vol. I. Kolkata Prokashon, 2013.
- . *Itibritte Chandal Jivan*. 2016. 1st Ed. Vol. II. ab Prakasani, 2016.
- Byapari, Manoranjan. Personal interview. 23 Dec 2015.
- Dasgupta, Sayantan. "Dalit Writing in Bangla: Repression and Resistance in Manoranjan Byapari and Manju Bala's Narratives." *Dalit Narratives and the Testimonial Genre in India*, edited by Subha Chakraborty Dasgupta. Spec. issue of *Jadavpur Journal of Comparative Literature*, Vol. 46 (2008-09), pp. 125-38.
- Sen, Dwaipayan. "An absent-minded Casteism?" *The Politics of Caste in West Bengal*, edited by Uday Chandra, Geir Heierstad and Kenneth Bo Nielsen, Routledge, 2016, pp.103-124.
- Singha, S. P. and I. Acharya, editors. Introduction. *Towards Social Change: Essays on Dalit Literature*. By Singha and Acharya, Orient Blackswan, 2014.
- Woerkens, Martine van. "A Life less Ordinary: The Female Subaltern and Dalit Literature in Contemporary India." *Dalit Literatures in India*, edited by Joshil K. Abraham and Judith Misrahi-Barak., Routledge, 2016, pp. 224-237.

Two-level supply chain for a deteriorating item with stock and promotional cost dependent demand under shortages

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Abstract

In this research work, a wholesaler-retailer-customer supply chain model for a deteriorating item is considered, where the retailer's warehouse in the market place has a limited capacity. The retailer can rent an additional warehouse (rented warehouse) if needed, with a higher rent compared to the existing warehouse (own warehouse). The customers' demand of the item is linearly influenced by the stock level and in case of shortages the base demand is partially backlogged. Being the leader of the supply chain, the retailer introduces some promotional cost to boost the base demand of the item. To participate in joint marketing decision, the wholesaler shares a compromise part of this promotional cost. Goal of this research work is to maximize the individual profits (when the retailer is the leader and the wholesaler is the follower) as well as the channel profit (when the retailer and the wholesaler jointly make marketing decision) of the system. It is established that if the wholesaler shares a part of the promotional cost, then the channel profit as well as the individual profits increase. The supply chain model is also considered in imprecise environment, where different inventory parameters are fuzzy/rough in nature. In this case, the individual profits as well as the channel profit become fuzzy/rough in nature. As optimization of fuzzy/rough objective is not well defined, following credibility/trust measure of fuzzy/rough event, an approach is followed for comparison of fuzzy/rough objectives and a Particle Swarm Optimization algorithm is implemented to find the marketing decisions. Efficiency of the algorithm in solving the problem is statistically established. The existence of the joint marketing decision is established analytically and numerically (with illustration) in crisp as well as in imprecise environments.

Keywords: Deteriorating inventory, two-warehouse model, promotional cost, credibility measure, trust measure, particle swarm optimization.

1 Introduction

The classical inventory models on deteriorating items are normally developed with the common assumption that the capacity of the retailer's outlet is sufficient, i.e., the outlet has sufficient space to store the order quantity [2, 3, 30, 37, 43, 44]. However, in several real-life problems, this assumption may not be appropriate. There are a number of factors which influence the marketing decisions in different ways. Sometimes these factors may force the retailer to buy more than his/her own warehouse (OW) capacity. The retailer may overcome the situation using an additional rented warehouse (RW), having sufficient capacity, normally with higher rent relative to the OW [8, 24].

Influence of displayed inventory level on the demand of any item is a well established phenomenon [12, 11]. Due to this reason, a retailer normally uses a decorated outlet at the market place to attract the customers and uses another storehouse near the outlet to stock the excess order quantity [23, 24, 29, 35]. Also inventory modelings of the deteriorating items draw significant attention by the researchers [2, 3, 3, 21, 26, 30, 41, 44]. During last two decades, several researchers on inventory control problems developed their models incorporating the above mentioned

- [35] D. Panda, M. K. Maiti, M. Maiti, *Two warehouse inventory models for single vendor multiple retailers with price and stock dependent demand*, Applied Mathematical Modelling, **34** (2010), 3571-3585.
- [36] P. Pramanik, M. K. Maiti, M. Maiti, *Three level partial trade credit with promotional cost sharing*, Applied Soft Computing, **58** (2017), 553-575.
- [37] K. Prasad, B. Mukherjee, *Optimal inventory model under stock and time dependent demand for time varying deterioration rate with shortages*, Annals of Operations Research, **243**(1-2) (2014), 323-334.
- [38] B. Sarkar, S. Sarkar, *An improved inventory model with partial backlogging, time varying deterioration and stock-dependent demand*, Economic Modelling, **30** (2013), 924-932.
- [39] S. Tiwari, C. K. Jaggi, A. K. Bhunia, A. A. Shaikh, M. Goh, *Two-warehouse inventory model for non-instantaneous deteriorating items with stock-dependent demand and inflation using particle swarm optimization*, Annals of Operations Research, **254**(1-2) (2017), 401-423.
- [40] D. D. Wu, *Bargaining in supply chain with price and promotional effort dependent demand*, Mathematical and Computer Modelling, **58** (2013), 1659-1669.
- [41] H. L. Yang, *Two-warehouse partial backlogging inventory models for deteriorating items under inflation*, International Journal of Production Economics, **103** (2006), 362-370.
- [42] W. H. Yang, Y. S. Tarn, *Design optimization of cutting parameters for turning operations based on the Taguchi method*, Journal of Materials Processing Technology, **84** (1998), 122-129.
- [43] H. L. Yang, J. T. Teng, M. S. Chern, *An inventory model under inflation for deteriorating items with stock-dependent consumption rate and partial backlogging shortages*, International Journal of Production Economics, **123** (2010), 8-19.
- [44] Y. Yu, Z. Wang, L. Liang, *A vendor managed inventory supply chain with deteriorating raw materials and products*, International Journal of Production Economics, **136** (2012), 266-274.



Artificial bee colony optimization-inspired synergetic study of fractional-order economic production quantity model

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Abstract

Inventory control is one of the most widely recognized issues in the reality. This investigation manages the utilization of fractional derivatives and integration on an inventory control problem. The memory of a dynamical model is a highly concerned issue which is commonly neglected by the models described in terms of integer-order differential equation. The memory capturing the power of fractional derivative (in Caputo's sense) is utilized here to describe an economic production quantity model with deterioration when the demand depends on price and stock and production is stock dependent. Also, this study covers the integer-order model with the same assumptions as a memoryless model and a particular case of the fractional model. Due to the complex nature of the model, numerical optimization with the help of a modified artificial bee colony algorithm is done instead of the analytical approach of optimization. Finally, we have performed a sensitivity analysis in order to make a fruitful conclusion.

Keywords Fractional-order differential equation · EPQ model · Laplace transformation · ABC algorithm

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1 Introduction

Fractional calculus (FC) is a branch of mathematics which old enough as the traditional integer-order calculus. In the late seventeenth century, the foundation stone for the establishment of FC was laid by the conversation between two famous mathematicians L'Hospital and Leibnitz. Leibnitz's response to the question of L'Hospital on the existence of derivative of $\frac{1}{2}$ the order was "an apparent paradox from which 1-day useful consequences will be drawn". Surprisingly, the application of FC in the practical field of science and technology is neglected for decades and centuries looking at the concept of FC as an abstract and absurd almost. But, it is proved through recent progress of the subject that the concept is not abstract. Rather, it can describe more accurately the dynamical behaviour of processes in nature and real world in comparison to integer-order calculus. So, these days, global excitement for FC as well as fractional-order system (FOS) has been seemingly exponential. Due to the different nice results of fractional derivatives, FC has attained much attention for modelling of the image processes, various fields of mathematics, economics, physics and engineering (Diethelm et al. 2012;

- Pramanik P, Maity MK (2019b) An inventory model for deterioration items with inflation induced variable demand under two level partial trade credit: a hybrid ABC-GA approach. *Eng Appl Artif Intell* 85:194–207. <https://doi.org/10.1016/j.engappai.2019.06.013>
- Rahaman M, Mondal SP, Shaikh AA et al (2020) Arbitrary-order economic production quantity model with and without deterioration: generalized point of view. *Adv Differ Equ* 2020:16. <https://doi.org/10.1186/s13662-019-2465-x>
- Singh J (2019) A new analysis for fractional rumor spreading dynamical model in a social network with Mittag–Leffler law. *Chaos* 29:013–137
- Singh J, Kumar D, Hammouch Z, Atangana A (2018a) A fractional epidemiological model for computer viruses pertaining to a new fractional derivative. *Appl Math Comput* 316:504–515
- Singh J, Kumar D, Baleanu D, Rathore S (2018b) An efficient numerical algorithm for the fractional Drinfeld–Sokolov–Wilson equation. *Appl Math Comput* 335:12–24
- Singh J, Kumar J, Baleanu D (2018c) On the analysis of fractional diabetes model with exponential law. *Adv Differ Equ.* <https://doi.org/10.1186/s13662-018-1680-1>
- Singh J, Secer A, Swroop R, Kumar D (2018d) A reliable analytical approach for a fractional model of advection–dispersion equation. *Nonlinear Eng.* <https://doi.org/10.1515/nleng-2018-0027>
- Singh J, Kumar D, Baleanu D (2019) New aspects of fractional Biswas–Milovic model with Mittag–Leffler law. *Math Model Nat Phenom* 14(3):303
- Zhu G, Kwong S (2010) Gbest-guided artificial bee colony algorithm for numerical function optimization. *Appl Math Comput* 217(7):3166–3173

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A two-warehouse multi-item supply chain with stock dependent promotional demand under joint replenishment policy: a mixed-mode ABC approach

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ABSTRACT

A multi-item two-level supply chain model under promotional cost sharing is proposed and analysed in this investigation. Here, it is assumed that a retailer purchases different items from a wholesaler under joint replenishment policy and sells the items to its customers. Due to the scarcity of the market place, the retailer uses two rented warehouses to run the business – one with moderate capacity situated at the heart of the market place, namely RW_1 and another with sufficiently large capacity, a little away from the market place, namely RW_2 . Items are ordered jointly using basic period (BP) policy, initially stored at RW_2 and transferred jointly to RW_1 for sale following another BP policy. Demands of the items depend on displayed inventory levels, selling prices as well as the frequencies of the advertisements. Total cost due to the reduced selling prices and the advertisements is considered as the promotional cost. The problem is formulated as a mixed-integer optimisation problem in crisp as well in imprecise environments. To solve such real-life problems, here artificial bee colony algorithm is modified, tested and used. Model is illustrated with some hypothetical test problems and some managerial insights are outlined.

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Two-warehouse; joint replenishment; promotional cost sharing; mixed-mode ABC algorithm

1. Introduction

In any supply chain, profit of each party mostly depends on the market demand of the items involved in the chain. Though every item has some base demand in the market, goal of every supply chain is to improve this base demand to survive in the market. Displayed inventory level always influences the customers and accordingly retailers normally hire a showroom in the market place to attract the customers. This investment is mainly done at the retailer level. Two other factors which highly influence the demand are – advertisement (Maiti & Maiti, 2006a; Manna et al., 2017) and selling price (Maiti & Maiti, 2006a; Pakhira et al., 2017; Paul et al., 2014; Wee, 1997). An item is supposed to be sold in the maximum retail price printed on the packet, but in reality it is observed that different retailers give different discounts to attract their customers. Sometimes packaging is made with some extra amount which basically decreases the unit price. Free gift/extra amount with a purchase is another approach of reducing the selling price. Again different multinationals, as well as small companies, use frequent advertisements to boost the demand of their products to the customers. Though this type of investment reduces the profit from per unit

sale, the resultant profit of each party increases, as total demand improves significantly. But if only one party invests this promotional cost, then, he/she will be the sole decision maker (DM) of the system (Haseli et al., 2019), which may not satisfy the other party's interest. So a coordination is highly required among all the parties in such a manner that all the parties will share the promotional cost and take part in the marketing decision. Some research articles have already been published incorporating promotional cost sharing in supply chain (Cárdenas-Barrón & Sana, 2015; Pakhira et al., 2018a, 2018b, 2019; Pramanik et al., 2017a). In all these studies, it is assumed that a promotional effort influences the demand of an item and promotional cost is a function of this promotional effort. Thus, a research gap from these studies can be identified as follows:

It is neither clear how promotional effort actually improves the demand nor how the promotional cost function is estimated. Moreover, none of these studies considered the influence of displayed inventory on the demand, specially for a supply chain management (SCM) system under retailer's two-warehouse facility.

It has already been mentioned that the displayed inventory has significant role in drawing attention to the

- Production Planning & Control*, 8(5), 494–499. <https://doi.org/10.1080/095372897235073>
- Yang, H.-L. (2004). Two-warehouse inventory models for deteriorating items with shortages under inflation. *European Journal of Operational Research*, 157(2), 344–356. [https://doi.org/10.1016/S0377-2217\(03\)00221-2](https://doi.org/10.1016/S0377-2217(03)00221-2)
- Zhou, Y.-W., & Yang, S.-L. (2005). A two-warehouse inventory model for items with stock-level-dependent demand rate. *International Journal of Production Economics*, 95(2), 215–228. <https://doi.org/10.1016/j.ijpe.2003.12.007>
- Zimmermann, H.-J. (1996). *Fuzzy set theory and its applications*. Springer Science+Business Media.

A supply chain of deteriorating items with variable demand

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Abstract. Here two-level supply chain model is considered for a deteriorating item where the retailer's warehouse in the market place has a limited capacity. Therefore the retailer can rent a warehouse (RW) if needed with a higher cost compared to own warehouse (OW). This model includes one wholesaler and one retailer and our aim is to maximize the total profit. The demand rate in retailer is stock-dependent and in case of any shortages, the demand is partially backlogged. Retailer also introduces some promotional cost to boost the base demand of the item. It is established that if the wholesaler shares a part of promotional cost then channel profit as well as individual profit increase. The supply chain model is also considered for imprecise environment when different inventory parameters are fuzzy/rough in nature. In this case individual profits as well as channel profit become fuzzy/rough in nature. As optimization of fuzzy/rough objective is not well defined, following credibility/trust measure of fuzzy/rough event, an approach is proposed for comparison of fuzzy/rough objectives and a Particle Swarm Optimization (PSO) algorithm is used to find marketing decisions. Models are illustrated with numerical examples.

Keywords: Deterioration, Two-warehouse model, Promotional Cost, Credibility/Trust measure, Particle Swarm Optimization

1. Introduction

In the classical inventory model for deteriorating products, it is usually assumed that the warehouse has no limits in the capacity. However, in the real-life problem the situation is different. There are a number of factors which influence the optimum solution in different ways. Sometimes these factors may suggest retailers to buy more than their own warehouse (OW) capacity. In these situations, the retailers can benefit from a rented warehouse (RW).

Today's globalized and competitive markets drive companies to become more efficient and cost-effective. Usually, supply chain (SC) members

optimize local decisions without considering the impact of their decision on the other member's performance and on the overall performance of SC [33]. Thus, a coordination mechanism may be necessary to motivate the members. SC members are dependent on each other and these members need to be coordinated efficiently by managing dependencies between each other. Jaber and Osman [15] considered a two-level supply chain with delay in payments and profit sharing. The ordering and advertising policies for a single-period commodity was presented by Chen [3] in a two-level supply chain. Wang [32] considered a two-level supply chain with multiple retailers and stochastic demand. Dong et al. [6] developed a model on multi-level supply chain.

Many researchers have discussed on inventory models for deteriorating items. Bhunia and Maiti [2] proposed a deterministic inventory model for

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- [21] M.K. Maiti and M. Maiti, Fuzzy inventory model with two warehouses under possibility constraints, *Fuzzy Sets and Systems* **157**(1) (2006), 52–73.
- [22] Y. Marinakis and M. Marinaki, A hybrid genetic – Particle Swarm Optimization Algorithm for the vehicle routing problem, *Expert Systems with Applications* **37**(2) (2010), 1446–1455.
- [23] V.K. Mishra, Deteriorating inventory model with controllable deterioration rate for time-dependent demand and time-varying holding cost, *Yugoslav Journal of Operations Research* **24**(1) (2014), 87–98.
- [24] S. Mukhopadhyay, R.N. Mukherjee and K.S. Chaudhuri, Joint pricing and ordering policy for a deteriorating inventory, *Computers & Industrial Engineering* **47**(4) (2004), 339–349.
- [25] N. Pakhira, M.K. Maiti and M. Maiti, Uncertain multi-item supply chain with two level trade credit under promotional cost sharing, *Computers & Industrial Engineering* **118** (2018), 451–463.
- [26] B. Pal, S.S. Sana and K. Chaudhuri, Coordination contracts for competitive two-echelon supply chain with price and promotional effort sensitive non-linear demand, *International Journal of Systems Science: Operations & Logistics* **2**(2) (2015), 113–124.
- [27] K. Prasad and B. Mukherjee, Optimal inventory model under stock and time dependent demand for time varying deterioration rate with shortages, *Annals of Operations Research* **243**(1-2) (2016), 323–334.
- [28] B. Sarkar and S. Sarkar, An improved inventory model with partial backlogging, time varying deterioration and stock-dependent demand, *Economic Modelling* **30** (2013), 924–932.
- [29] Q. Wang, A periodic-review inventory control policy for a two-level supply chain with multiple retailers and stochastic demand, *European Journal of Operational Research* **230**(1) (2013), 53–62.
- [30] S. Whang, Coordination in operations: A taxonomy, *Journal of Operations Management* **12**(3-4) (1995), 413–422.
- [31] D.D. Wu, Bargaining in supply chain with price and promotional effort dependent demand, *Mathematical and Computer Modelling* **58**(9-10) (2013), 1659–1669.
- [32] J. Xu and L. Yao, A class of expected value multi-objective programming problems with random rough coefficients, *Mathematical and Computer Modelling* **50**(1-2) (2009), 141–158.
- [33] H.-L. Yang, Two-warehouse partial backlogging inventory models for deteriorating items under inflation, *International Journal of Production Economics* **103**(1) (2006), 362–370.
- [34] H.-L. Yang, J.-T. Teng and M.-S. Chern, An inventory model under inflation for deteriorating items with stock-dependent consumption rate and partial backlogging shortages, *International Journal of Production Economics* **123**(1) (2010), 8–19.
- [35] Y. Yu, Z. Wang and L. Liang, A vendor managed inventory supply chain with deteriorating raw materials and products, *International Journal of Production Economics*, **136**(2)(2012), 266–274.
- [36] L.A. Zadeh, Fuzzy sets, *Information and Control* **8** (1965), 338–353.
- [37] L.A. Zadeh, The concept of linguistic variable and its application to approximate reasoning, *Memorandum ERL-M 411*, Berkeley, 1973.

**NOTE ON: SUPPLY CHAIN INVENTORY MODEL FOR
DETERIORATING ITEMS WITH MAXIMUM LIFETIME AND
PARTIAL TRADE CREDIT TO CREDIT RISK CUSTOMERS**

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ABSTRACT. In the recently published paper [Gour Chandra Mahata and Sujit Kumar De, Supply chain inventory model for deteriorating items with maximum lifetime and partial trade credit to credit-risk customers, International Journal of Management Science and Engineering Management, 2017, DOI:10.1080/17509653.2015.1109482], a supplier-retailer supply chain model of a deteriorating item with maximum lifetime and partial trade credit to credit risk customers is studied. In their study, unfortunately the amount of the payable bank interest due to the deteriorated units is omitted in the retailer's profit function for making the marketing decision. Some other unrealistic studies are also found in the numerical section of the paper. In this study those non-trivial flaws are identified and technically corrected. After correction, the theoretical existence of the optimal solutions of different scenarios are established and the solutions are derived using a soft computing technique.

1. Introduction. In a real life business environment there are several products such as fruits, vegetables, medicines, volatile liquids, blood in blood bank, high-tech products etc., which deteriorate continuously due to evaporation, spoilage, obsolescence, etc. In reality, it is not possible to prevent the deterioration of any deteriorating item fully in any business sector. Due to this reason the maintenance of inventory system of a deteriorating item is a crucial issue for the decision maker of the system. To overcome this difficulty in 1963, Ghare and Schrader[10] first explored an economic order quantity (EOQ) model for deteriorating items. After the novel invention of Ghare and Schrader[10], the researchers and the practitioners of inventory control system/ supply chain management developed various realistic models for deteriorating items considering constant deterioration rate[1, 3, 6, 8, 11,

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- [34] T. Singh and H. Pattanayak, [An EOQ model for deteriorating items with linear demand, variable deterioration and partial backlogging](#), *Journal of Service Science and Management*, **6** (2013), 186–190.
- [35] S. Tayal, S. R. Singh and R. Sharma, Multi Item Inventory Model for Deteriorating Items with Expiration Date and Allowable Shortages, *Indian Journal of Science and Technology*, **7** (2014), 463–471.
- [36] J. T. Teng, [Optimal ordering policies for a retailer who offers distinct trade credits to its good and bad customers](#), *International Journal of Production Economics*, **119** (2009), 415–423.
- [37] J. T. Teng, H. J. Chang, C. Y. Dye and C. H. Hung, [An optimal replenishment policy for deteriorating items with time-varying demand and partial backlogging](#), *Operation Research Letters*, **30** (2002), 387–393.
- [38] J. T. Teng, M. S. Chern, H. L. Yang and Y. J. Wang, [Deterministic lot-size inventory models with shortages and deterioration for fluctuating demand](#), *Operation Research Letters*, **24** (1999), 65–72.
- [39] J. T. Teng and S. K. Goyal, [Optimal ordering policies for a retailer in a supply chain with up-stream and down-stream trade credits](#), *Journal of the Operational Research Society*, **58** (2007), 1252–1255.
- [40] Y. C. Tsao, [Managing multi-echelon multi-item channels with trade allowances under credit period](#), *International Journal Production Economics*, **127** (2010), 226–237.

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An inventory model for deteriorating items with inflation induced variable demand under two level partial trade credit : A hybrid ABC-GA approach [☆]

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ABSTRACT

In this research work an inventory model of a deteriorating item is considered under two level partial trade credit policy incorporating inflation and time value of money in a finite planning horizon. Here it is assumed that a wholesaler offers a partial trade credit to a retailer i.e., trade credit period is offered on a portion of the total purchase amount. In turn the retailer also offers a partial trade credit to its customers. Demand of the item linearly decreases with time and influenced by unit selling price of the item. As selling price is influenced by the inflation and time value of money, so the base demand depends on inflation and bank interest rate also. The retailer also introduces some promotional cost to boost the demand of the item. Under this circumstances, marketing decisions are made to maximize the present value of the total profit. On the other hand combining the features of artificial bee colony (ABC) and genetic algorithm (GA), a hybrid algorithm, artificial bee genetic algorithm (ABGA) has been developed to find the most appropriate business strategies for the proposed model. Efficiency of this algorithm is tested and compared with some ABC variants using a set of benchmark test functions. The model has been illustrated with several numerical examples and some managerial insights are outlined.

1. Introduction and literature review

Due to huge and stiff competition among the business enterprises in the local as well as in the global market, the business enterprises adopt various tolls to sell their products efficiently. Trade credit policy is one of the most effective promotional tools to push a product, which indirectly reduce the selling price of the product. With the novel invention of Goyal (1985), trade credit policy is heavily used in inventory control systems. In Goyal (1985), it is assumed that a supplier offers some delay period in payment to a retailer. From this point of view the researchers and the practitioners of inventory control systems developed various models (Aggarwal and Jaggi, 1995; Chung and Liao, 2004; Huang, 2007a; Ouyang et al., 2009; Pramanik et al., 2017c). From these studies it is seen that a supplier/wholesaler offers a credit period to a retailer but in turn the retailer does not offer any credit opportunity to his/her customers, which is an unrealistic phenomenon. (Huang, 2003) first explore an inventory model under two level trade credit policy, where a supplier offers a credit period for payment to a retailer and in turn the retailer also offers a credit period to the customers. From this point of view there are several research

works developed with different circumstances to make the models more realistic (Chung, 2011, 2013; Guchhait et al., 2014; Huang, 2006, 2007b; Lashgari and Taleizadeh, 2016; Maiti, 2011; Maiti and Maiti, 2007; Taleizadeh et al., 2016; Teng et al., 2013). Also to reduce the default credit risk the researchers of inventory control system develop their models (Huang and Hsu, 2008; Mahata, 2012; Ouyang et al., 2009) with partial credit policy under two level credit policy, where the supplier/wholesaler offers a full credit to the retailer but in turn the retailer offers a credit period to the customers on some portion of the total purchase amount and the remaining portion of the purchase amount has to pay as collateral deposit at the time of receiving the units of the item. Recently Pramanik et al. (2017a) have developed an economic order quantity (EOQ) model under three level trade credit policy with retailer's partial credit policy. Now-a-days, there are so many fake orders are made to the supplier in case of e-business. To mitigate the order cancellation risk, the researchers are devoted in the direction of advance payment scheme (full or partial) for the retailers and offers some credit period on some portion of the total purchase amount (Diabat et al., 2017; Lashgaria et al., 2016, 2018; Taleizadeh et al., 2018; Tavakoli and Taleizadeh; Zia and Taleizadeh, 2015). In

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- Maihami, R., Karimi, B., 2014. Optimizing the pricing and replenishment policy for non-instantaneous deteriorating items with stochastic demand and promotional efforts. *Comput. Oper. Res.* 51, 302–312.
- Maiti, M.K., 2011. A fuzzy genetic algorithm with varying population size to solve an inventory model with credit-linked promotional demand in an imprecise planning horizon. *European J. Oper. Res.* 213, 96–106.
- Maiti, M.K., Maiti, M., 2007. Two-storage inventory model with lot-size dependent fuzzy lead-time under possibility constraints via genetic algorithm. *European J. Oper. Res.* 179, 352–371.
- Michalewicz, Z., 1992. *Genetic Algorithms + Data Structures = Evolution Programs*. Springer, Berlin.
- Min, J., Zhou, Y.W., Zhao, J., 2010. An inventory model for deteriorating items under stock dependent demand and two-level trade credit. *Appl. Math. Model.* 34, 3273–3285.
- Ouyang, L.Y., Ho, C.H., Su, C.H., 2008. Optimal strategy for an integrated system with variable production rate when the freight rate and trade credit are both linked to order quantity. *Int. J. Prod. Econ.* 115, 151–162.
- Ouyang, L.Y., Teng, J.T., Goyal, S.K., Yang, C.T., 2009. An economic order quantity model for deteriorating items with partially permissible delay in payments to order quantity. *European J. Oper. Res.* 194, 418–431.
- Pal, B., Sana, S.S., Chaudhuri, K., 2015. Coordination contracts for competitive two-echelon supply chain with price and promotional effort sensitive non-linear demand. *Int. J. Syst. Sci. Oper. Logist.* 2 (2), 113–124.
- Pramanik, P., Maiti, M.K., Maiti, M., 2017a. A supply chain with variable demand under three level trade credit policy. *Comput. Ind. Eng.* 106, 205–221.
- Pramanik, P., Maiti, M.K., Maiti, M., 2017b. Three level partial trade credit with promotional cost sharing. *Appl. Soft Comput.* 58, 553–575.
- Pramanik, P., Maiti, M.K., Maiti, M., 2017c. An appropriate business strategy for a sale item. *OPSEARCH* <http://dx.doi.org/10.1007/s12597-017-0310-0>.
- Sarkar, B., Mandal, P., Sarkar, S., 2014. An EMQ model with price and time dependent demand under the effect of reliability and inflation. *Appl. Math. Comput.* 231, 414–421.
- Sarkar, B., Saren, S., Wee, H.M., 2013. An inventory model with variable demand, component cost and selling price for deteriorating items. *Econ. Model.* 30, 306–310.
- Sarker, B.R., Jamal, A.M.M., Wang, S., 2000. Supply chain models for perishable products under inflation and permissible delay in payment. *Comput. Oper. Res.* 27, 59–75.
- Shah, N.H., Vaghela, C.R., 2016. Economic order quantity for deteriorating items under inflation with time and advertisement dependent demand. *OPSEARCH* 54, 168–180.
- Taleizadeh, A.A., Lashgari, M., Akram, R., Heydari, J., 2016. An imperfect EPQ model with up-stream trade credit periods linked to raw material order quantity and down-stream trade credit periods. *Appl. Math. Model.* 40, 8777–8793.
- Taleizadeh, A.A., Tavakoli, S., San-José, L.A., 2018. A lot sizing model with advance payment and planned backordering. *Ann. Oper. Res.* <http://dx.doi.org/10.1007/s10479-018-2753-y>.
- Tavakoli, S., Taleizadeh, A.A., An EOQ model for decaying item with full advanced payment and conditional discount, 259 (2017) 415–436.
- Tayal, S., Singh, S.R., Sharma, R., 2014. Multi item inventory model for deteriorating items with expiration date and allowable shortages. *Indian J. Sci. Technol.* 7, 463–471.
- Teng, J.T., Yang, H.L., Chern, M.S., 2013. An inventory model for increasing demand under two levels of trade credit linked to order quantity. *Appl. Math. Model.* 37, 7624–7632.
- Tsao, Y.C., 2010. Managing multi-echelon multi-item channels with trade allowances under credit period. *Int. J. Prod. Econ.* 127, 226–237.
- Wang, S.D., Zhou, Y.W., Min, J., Zhong, Y.G., 2011. Coordination of cooperative advertising models in a one-manufacturer two-retailer supply chain system. *Comput. Ind. Eng.* 61, 1053–1071.
- Wee, H.M., 1999. Deteriorating inventory model with quantity discount pricing and partial backordering. *Int. J. Prod. Econ.* 59, 511–518.
- Yelghi, A., köse, C., 2018. A modified firefly algorithm for global minimum optimization. *Appl. Soft Comput.* 62, 29–44.
- Zhu, G., Kwong, S., 2010. Gbest-guided artificial bee colony algorithm for numerical function optimization. *Appl. Math. Comput.* 217, 3166–3173.
- Zia, N.P., Taleizadeh, A.A., 2015. A lot-sizing model with backordering under hybrid linked-to-order multiple advance payments and delayed payment. *Trans. Res. E.* 82, 19–37.



Trade credit policy of an inventory model with imprecise variable demand: an ABC-GA approach

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Abstract

In this research work, an inventory model with fuzzy promotional effort induced dynamic demand under two level partial trade credit policy has been developed in an imprecise planning horizon. Here, it is assumed that in the planning horizon a retailer completed a finite number full cycles. In each of the retailer's cycle, a wholesaler offers a credit period to the retailer on the full purchased amount and in turn the retailer offers a credit period to its customers on a part of his/her purchased amount. The imprecise marketing demand is influenced by the retailer's fuzzy promotional effort, customers' credit period, customers' credit amount and retail selling price. Goal of this study is to find the optimal business strategy for the retailer with respect to his/her total fuzzy financial gain from the system. Due to imprecise nature of the demand, the problem is mathematically represented following fuzzy differential equation and fuzzy Riemann integration and alpha-cut of the entire fuzzy gain from the system is derived. Its graded mean integration representation is computed and optimized with respect to customer's credit amount credit period, and retailer's order quantity for most appropriate marketing decision. Hence, the problem reduced to a multivariate crisp optimization problem and a heuristic, multichoice artificial bee genetic algorithm (MCABGA) has been proposed for it. The efficiency of MCABGA is tested against some other existing artificial bee colony variants using a list of benchmark test functions available in the literature. The model is illustrated with some hypothetical test problems and some managerial insights are outlined. Finally, a conclusion is drawn and some future research directions are proposed.

Keywords Inventory · Imprecise variable demand · Fuzzy differential equation · Artificial bee colony (ABC) · Genetic algorithm (GA)

1 Introduction

Trade credit policy is an important and effective promotional tool to push a product efficiently. Initiative work on the modelling of inventory problems incorporating trade credit option was made by Goyal (1985) and then the researchers and the practitioners of inventory problems proposed various mod-

els (economic order quantity (EOQ)/economic production quantity (EPQ)) incorporating trade credit options in different levels (customers' level, retailer level, wholesaler level, etc.) of a business chain. Since last two decade, several inventory models are developed by various researchers to maintain the inventory most appropriately in various circumstances under different trade credit policies, like, single level (wholesaler to retailer) credit opportunity (Aggarwal and Jaggi 1995; Chung and Liao 2004; Huang 2007; Ouyang et al. 2009; Pramanik et al. 2017c), two levels of trade option (wholesaler to retailer and retailer to customers) (Chung 2011, 2013; Guchhait et al. 2015; Huang 2003, 2006; Huang and Hsu 2008; Pramanik and Maiti 2019b; Pramanik et al. 2019; Teng 2009) and three levels of trade credit where credit opportunity exists for the wholesaler also from the supplier (Pal et al. 2015; Pramanik et al. 2017a, b). It is a real practice that in a business chain under two level credit opportunity wholesaler offers a credit period on full purchased amount to the retailer (named as

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- Ishii H, Konno T (1998) A stochastic inventory problem with fuzzy shortage cost. *Eur J Oper Res* 106:90–94
- Kandal A, Bytt WJ (1978) Fuzzy differential equation. In: *Proceedings of international conference on cybernetics society*, Tokyo, pp 1213–1216
- Kandal A, Bytt WJ (1980) Fuzzy processes. *Fuzzy Sets Syst* 4:117–152
- Kao C, Hsu WK (2002) A single-period inventory model with fuzzy demand. *Comput Math Appl* 43(6–7):841–848
- Karaboga D (2015) An idea based on honey bee swarm for numerical optimization. Technical report-TR06, Erciyes University, Kayseri, Turkey
- Karaboga D, Akay B (2009) A comparative study of artificial bee colony algorithm. *Appl Math Comput* 214:108–132
- Karaboga D, Basturk B (2007) A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm. *J Glob Optim* 39:459–471
- Karaboga D, Basturk B (2008) On the performance of artificial bee colony (ABC) algorithm. *Appl Soft Comput* 8:687–697
- Katagiri H, Ishii H (2000) Some inventory problems with fuzzy shortage cost. *Fuzzy Sets Syst* 111:87–97
- Katagiri H, Ishii H (2002) Fuzzy inventory problems for perishable commodities. *Eur J Oper Res* 138:545–553
- Kiran MS, Hakli H, Gundaz M, Uguz H (2015) Artificial bee colony algorithm with variable search strategy for continuous optimization. *Inf Sci* 300:140–157
- Kundu A, Guchhait P, Pramanik P, Maiti MK, Maiti M (2017) A production inventory model with price discounted fuzzy demand using an interval compared hybrid algorithm. *Swarm Evol Comput* 34:1–17
- Liu B (2002) *Theory and practice of uncertain programming*. Physica, Heidelberg
- Liu B, Iwamura K (1998) Chance constrained programming with fuzzy parameters. *Fuzzy Sets Syst* 94:227–237
- Mahata GC (2012) An EPQ-based inventory model for exponentially deteriorating items under retailer partial trade credit policy in supply chain. *Expert Syst Appl* 39:3537–3550
- Mahata GC, De SK (2016) An EOQ inventory system of ameliorating items for price dependent demand rate under retailer partial trade credit policy. *OPSEARCH*. <https://doi.org/10.1007/s12597-016-0252-y>
- Maiti MK (2008) Fuzzy inventory model with two warehouses under possibility measure on fuzzy goal. *Eur J Oper Res* 188(3):746–774
- Maiti MK (2011) A fuzzy genetic algorithm with varying population size to solve an inventory model with credit-linked promotional demand in an imprecise planning horizon. *Eur J Oper Res* 213:96–106
- Maiti MK, Maiti M (2006) Fuzzy inventory model with two warehouses under possibility constraints. *Fuzzy Sets Syst* 157(1):52–73
- Maiti MK, Maiti M (2007) Two-storage inventory model with lot-size dependent fuzzy lead-time under possibility constraints via genetic algorithm. *Eur J Oper Res* 179:352–371
- Mandal NK, Roy TK, Maiti M (2005) Multi-objective fuzzy inventory model with three constraints: a geometric programming approach. *Fuzzy Sets Syst* 150(1):87–106
- Michalewicz Z (1992) *Genetic algorithms + data structures = evolution programs*. Springer, Berlin
- Ouyang LY, Ho CH, Su CH (2008) Optimal strategy for an integrated system with variable production rate when the freight rate and trade credit are both linked to order quantity. *Int J Prod Econ* 115:151–162
- Ouyang LY, Teng JT, Goyal SK, Yang CT (2009) An economic order quantity model for deteriorating items with partially permissible delay in payments to order quantity. *Eur J Oper Res* 194:418–431
- Pal B, Sana SS, Chaudhuri K (2015) Coordination contracts for competitive two-echelon supply chain with price and promotional effort sensitive non-linear demand. *Int J Syst Sci Oper Logist* 2(2):113–124
- Pramanik P, Maiti MK (2019a) An inventory model for deteriorating items with inflation induced variable demand under two level partial trade credit: a hybrid ABC-GA approach. *Eng Appl Artif Intell* 85:194–207
- Pramanik P, Maiti MK (2019b) An inventory model with variable demand incorporating unfaithfulness of customers under two-level trade credit. *Eur J Ind Eng* 13(4):461–488. <https://doi.org/10.1504/EJIE.2019.100957>
- Pramanik P, Maiti MK, Maiti M (2017a) An appropriate business strategy for a sale item. *OPSEARCH*. <https://doi.org/10.1007/s12597-017-0310-0>
- Pramanik P, Maiti MK, Maiti M (2017b) A supply chain with variable demand under three level trade credit policy. *Comput Ind Eng* 106:205–221
- Pramanik P, Maiti MK, Maiti M (2017c) Three level partial trade credit with promotional cost sharing. *Appl Soft Comput* 58:553–575
- Pramanik P, Malik Das S, Maiti MK (2019) Note on: supply chain inventory model for deteriorating items with maximum lifetime and partial trade credit to credit risk customers. *J Ind Manag Optim* 15(3):1289–1315
- Raula P, Indrajitsingha SK, Samanta PN, Misra UK (2016) A fuzzy inventory model for constant deteriorating item by using GMIR method in which inventory parameters treated as HFN. *Open J Appl Theor Math (OJATM)* 2(1):13–20
- Roman-Flores H, Barros L, Bassanezi R (2001) A note on the Zadeh's extensions. *Fuzzy Sets Syst* 117:327–331
- Roy A, Maiti MK, Kar S, Maiti M (2007) Two-storage inventory model with fuzzy deterioration over a random time horizon. *Math Comput Model* 46:1419–1433
- Sarkar S, Chakrabarti T (2012) An EPQ model with two-component demand under fuzzy environment and Weibull distribution deterioration with shortages. *Adv Oper Res*. <https://doi.org/10.1155/2012/264182>
- Teng JT (2009) Optimal ordering policies for a retailer who offers distinct trade credits to its good and bad customers. *Int J Prod Econ* 119:415–423
- Vorobiev D, Seikkala S (2002) Towards the fuzzy differential equations. *Fuzzy Sets Syst* 125:231–237
- Wee HM (1999) Deteriorating inventory model with quantity discount, pricing and partial backordering. *Int J Prod Econ* 59:511–518
- Wee HM, Lo CC, Hsu PH (2009) A multi-objective joint replenishment inventory model of deteriorated items in a fuzzy environment. *Eur J Oper Res* 197:620–631
- Wu HC (2000) The fuzzy Riemann integral and its numerical integration. *Fuzzy Sets Syst* 110:1–25
- Zadeh LA (1965) Fuzzy sets. *Inf. Control* 8:338–356
- Zadeh LA (1978) Fuzzy sets as a basis for a theory of possibility. *Fuzzy Sets Syst* 1:3–28
- Zhu G, Kwong S (2010) Gbest-guided artificial bee colony algorithm for numerical function optimization. *Appl Math Comput* 217:3166–3173

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A Hybrid PSO-GA Algorithm for Traveling Salesman Problems in Different Environments

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In this study particle swarm optimization (PSO) is modified and hybridised with genetic algorithm (GA) using one's output as the other's input to solve Traveling Salesman Problem (TSP). Here multiple velocity update rules are introduced to modify the PSO and at the time of the movement of a solution, one rule is selected depending on its performances using roulette wheel selection process. Each velocity update rule and the corresponding solution update rule are defined using swap sequence (SS) and swap operation (SO). K-Opt operation is applied in a regular interval of iterations for the movement of any stagnant solution. GA is applied on the final output swarm of the PSO to search the optimal path of the large size TSPs. Roulette wheel selection process, multi-point cyclic crossover and the K-opt operation for the mutation are used in the GA phase. The algorithm is tested in crisp environment using different size benchmark test problems available in the TSPLIB. In the crisp environment the algorithm gives approximately 100% success rate for the test problems up to considerably large sizes. Efficiency of the algorithm is tested with some other existing algorithms in the literature using Friedman test. Some approaches are incorporated with this algorithm for finding solutions of the TSPs in imprecise (fuzzy/rough) environment. Imprecise problems are generated from the crisp problems randomly, solved and obtained results are discussed. It is observed that the performance of the proposed algorithm is better compared to the some other algorithms in the existing literature with respect to the accuracy and the consistency for the symmetric TSPs as well as the Asymmetric TSPs.

Keywords: Traveling Salesmen Problem; particle swarm optimization; multiple velocity update rules; genetic algorithm; K-Opt operation.

55. X. Yan, C. Zhang, W. Luo, W. Li, W. Chen and H. Liu, Solve traveling salesman problem using particle swarm optimization algorithm, *Int. J. Computer Science Issues* **9**(6) (2012) 264–271.
56. C. Yuan, X. Sun, and R. Lv, Fingerprint liveness detection based on multi-scale LPQ and PCA, *China Communications* **13**(7) (2016) 60–65.
57. L. Zadeh, Fuzzy sets, *Information and Control* **8** (1965) 338–356.
58. S. H. Zhan, J. Lin, Z. J. Zhang and Y. W. Zhong, List-based simulated annealing algorithm for traveling salesman problem, *Computational Intelligence and Neuroscience* **2016** (2016) 1-12.



An integrated imperfect production system with advertisement dependent demand using branch and bound technique

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Abstract

This paper develops an integrated imperfect production-inventory system consisting of a retailer and a manufacturer who produces breakable items. As breakable items are very sensitive to transport, in this paper, to stimulate the retailer, the manufacturer offers (1) free transportation subject to the condition that the retailer must have to order a minimum replenishment quantity specified by the manufacturer and (2) a credit period depending on the replenishment quantity. Moreover, malfunctioning of the production system increases due to several kinds of problem and consequently it produces a mixture of perfect and imperfect quality items. So, to maintain the reliability of the production system, development cost has been incorporated. Also to aware the customer about the reliability of the production system, the manufacturer has paid attention to give a constant amount of advertisement regularly during his/her production period. Henceforth, the advertisement dependent demand has been considered here. Under such circumstances, an integrated profit function has been developed and solved by branch and bound technique to obtain the optimum values of the system. From numerical studies, it is revealed that in case of incorporation of the advertisement, the retailer's average profit, the manufacturer's average profit and the average integrated profit are higher than that in the case without advertisement.

Keywords Branch and bound technique · System reliability parameter · Replenishment quantity · Breakable rate · Credit period

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- Sarkar B, Moon I (2014) Improved quality, set up cost reduction, and variable backorder costs in an imperfect production process. *Int J Prod Econ* 155:204–213
- Sarkar B, Saren S (2016) Product inspection policy for an imperfect production system with inspection errors and warranty cost. *Eur J Oper Res* 248(1):263–271
- Sarkar B, Saren S (2017) Ordering and transfer policy and variable deterioration for a warehouse model. *Hacet J Math Stat* 46(5):985–1014
- Sarkar M, Sarkar B (2013a) An economic manufacturing quantity model with probabilistic deterioration in a production system. *Econ Model* 31:245–252
- Sarkar B, Sarkar S (2013b) Variable deterioration and demand-An inventory model. *Econ Model* 31:548–556
- Sarkar B, Sana SS, Chaudhuri KS (2011) An imperfect production process for time varying demand with inflation and time value of money—an EMQ model. *Expert Sys with Appl* 38(11):13543–13548
- Sarkar B, Cardenas-Barron LE, Sarkar M, Singih ML (2014a) An economic production quantity model with random defective rate, rework process and backorders for a single stage production system. *J Manuf Syst* 33(3):423–435
- Sarkar B, Gupta H, Chaudhuri KS, Goyal SK (2014b) An integrated inventory model with variable lead time, defective units and delay in payments. *Appl Math Comput* 237:650–658
- Sarkar B, Mandal B, Sarkar S (2015a) Quality improvement and backorder price discount under controllable lead time in an inventory model. *J Manuf Syst* 35:26–36
- Sarkar B, Chaudhuri KS, Moon I (2015b) Manufacturing setup cost reduction and quality improvement for the distribution free continuous-review inventory model with a service level constraint. *J Manuf Syst* 34:74–82
- Sarkar B, Sett BK, Sarkar S (2018a) Optimal production run time and inspection errors in an imperfect production system with warranty. *J Ind Manag Opt* 14(1):267–282
- Sarkar B, Majumder A, Sarkar M, Kim N, Ullah M (2018b) Effects of variable production rate on quality of products in a single-vendor multi-buyer supply chain management. *Int J Adv Manuf Technol* 99:567–581
- Sett BK, Sarkar S, Sarkar B (2017) Optimal buffer inventory and inspection errors in an imperfect production system with preventive maintenance. *Int J Adv Manuf Technol* 90:545–560
- Tayyab M, Sarkar B (2016) Optimal batch quantity in a cleaner multi-stage lean production system with random defective rate. *J Cleaner Prod* 139:922–934
- Teng JT, Chang CT (2005) Economic production quantity models for deteriorating items with price- and stock-dependent demand. *Comput Oper Res* 32(2):297–308
- Tiwari S, Cardenas-Barron LE, Goh M, Shaikh AA (2018) Joint pricing and inventory model for deteriorating items with expiration dates and partial backlogging under two-level partial trade credits in supply chain. *Int J Prod Econ* 200:16–36

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IMPERFECT PRODUCTION INVENTORY MODEL WITH UNCERTAIN ELAPSED TIME

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Abstract: *Most of the classical inventory control model assumes that all items received conform to quality characteristics. However, in practice, items may be damaged due to production conditions, transportation and environmental conditions. Modelling such real world problems involve various indeterminate phenomena which can be estimated through human beliefs. The uncertainty theory proposed by Liu (2015) is extensively regarded as an appropriate tool to deal with such uncertainty. This paper investigates the optimum production run time and optimum cost in an imperfect production process, where the rate of imperfect items are different in different states of the process. The process may be shifting from 'in-control' state to the 'out-of-control' state is an uncertain variable with certain uncertainty distribution. Some propositions are derived for the optimal production run time and optimized the expected total cost function per unit time. Finally, numerical examples have been illustrated to study the practical feasibility of the model.*

Keywords: *Inventory, Imperfect production, Uncertain variables, Uncertain distribution, Expected value model.*

1. Introduction

In some real uncertain situation, we have to depend on domain experts to represent the belief degree when no samples are available to estimate a probability distribution. To deal with uncertainty in human belief, which is neither random nor fuzzy, Liu (2009), (2015), (2016) introduced uncertainty theory. It deals with modeling of uncertainty, based on normality, monotonicity, self-duality, countable sub-additivity and product measure axioms. Uncertain variable, uncertain set and uncertain measure are the basic tools to describe the uncertain phenomenon.

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Yeh, R. H., Chen, M. Y., & Lin, C. Y. (2007). Optimal periodic replacement policy for repairable products under free-repair warranty. *European Journal of Operational Research*, 176, 1678-1686.

Yeo, W. M., & Yuan, XueMing. (2009). Optimal warranty policies for systems with imperfect repair. *European Journal of Operational Research*, 199, 187-197.

Yun, Won Young, Murthy, D. N. P. & Jack, N. (2008). Warranty servicing with imperfect repair. *International Journal of Production Economics*, 111, 159-169.

Zhou, C., Tang, W., & Zhao, R. (2014). An uncertain search model for recruitment problem with enterprise performance. *Journal of Intelligent Manufacturing*, 28(3), 695-704.



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Sustainable recycling in an imperfect production system with acceptance quality level dependent development cost and demand

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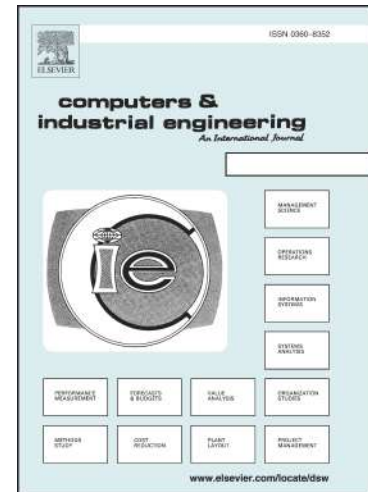
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Sustainable recycling in an imperfect production system with acceptance quality level dependent development cost and demand.

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Sustainable recycling in an imperfect production system with acceptance quality level dependent development cost and demand.

Abstract: This paper considers a closed-loop supply chain production inventory model consisting of a virgin raw material supplier, a manufacturer, a retailer and a collector who collects the used product from consumers at a return rate depending on acceptance quality level of the used product. Here, two types of products are produced : manufactured product using virgin raw materials and remanufactured product using used manufactured product. So, to make the model more realistic, here, the manufacturer incorporates two separate remanufacturing and manufacturing infrastructures to process simultaneously to produce remanufactured and manufactured items due to overcome the lost sale situation arisen in several published model. Again, since the quality of a product from a remanufacturing process mostly depends upon the acceptance quality level of the used product, hence an acceptance quality level dependent development cost has been considered in remanufacturing process. Also, both demand of the remanufactured products and procurement cost of the used products from collector to manufacturer have been considered as a function of acceptance quality level of returned items. Moreover, remanufacturing and manufacturing processes produce some defective items which are reworked within the same cycle. With these considerations, a mathematical model has been developed (i) to find out optimum acceptance quality level of the used manufactured product for recycling, (ii) to overcome the lost sale situation due to unsatisfied demand of remanufactured (manufactured) product at the time of manufacturing (remanufacturing) process and (iii) to obtain optimum number of deliveries from supplier to manufacturer, from manufacturer to retailer and from collector to manufacturer that maximize total integrated profit. To get the optimum solutions of the proposed model, sequential and global optimizations methods have been used. Finally, the

- Taleizadeh, A. A., Noori-daryan, M. (2016). Pricing, inventory and production policies in a supply chain of pharmacological products with rework process: a game theoretic approach. *Operational Research, An International Journal* , 16, 89-115.
- Taleizadeh, A. A., Moshtagh, M. S., & Moon, I. (2017). Optimal decisions of price, quality, effort level and return policy in a three-level closed-loop supply chain based on different game theory approaches. *European Journal of Industrial Engineering*, 11(4), 486-525.
- Taleizadeh, A. A., Pourreza, P., & Moon, I. (2018a). Hybrid for an imperfect production system considering product quality and returns under two warranty policies. *Applied Soft Computing*, 75, 333-348.
- Taleizadeh, A. A., & Moshtagh, M. S. (2019). A consignment stock scheme for closed loop supply chain with imperfect manufacturing processes, lost sales, and quality dependent return: Multi Levels Structure. 217, 298-316
- Taleizadeh, A. A., Hazarkhani, B., & Moon, I. (2018b). Joint pricing and inventory decisions with carbon emission considerations, partial backordering and planned discounts. *Annals of Operations Research*, <https://doi.org/10.1007/s10479-018-2968-y>.
- Taleizadeh, A. A., Alizadeh-Basban, N., Niaki, S.T.A (2019a). A closed-loop supply chain considering carbon reduction, quality improvement effort, and return policy under two remanufacturing scenarios. *Journal of Cleaner Production*, 232, 1230-1250.
- Taleizadeh, A. A., Haghghi, F., & Niaki, S. T. A. (2019b). Modeling and solving a sustainable closed loop supply chain problem with pricing decisions and discounts on returned products. *Journal of Cleaner Production*, 207, 163-181.
- Yang, P. C., Wee, H. M., Chung, S. L., & Ho, P. C. (2010). Sequential and global optimization for a closed loop deteriorating inventory supply chain. *Mathematical and Computer Modelling*, 52, 161-176.
- Zerang, E.S., Taleizadeh, A. A., Razmi, J. (2018). Analytical comparisons in a three-echelon closed-loop supply chain with price and marketing effort-dependent demand: game theory approaches. *Environ Dev Sustain*, 20, 451-478.

Highlights:

- **An integrated closed-loop supply chain production inventory model has been developed.**
- **The remanufacturing and manufacturing processes have been considered simultaneously to overcome the lost sale situation.**
- **Acceptance quality level dependent development cost and demand has been constructed.**

Effects of product reliability dependent demand in an EPQ model considering partially imperfect production

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Abstract: In this article, an economic production quantity (EPQ) model with partially imperfect production system has been considered where both perfect and imperfect quality items are produced and demand of the product has been assumed as a function of selling price, reliability of the product and advertisement. Perfect quality items are ready for sale but imperfect quality items are reworked at a cost to become perfect one. Reworking cost, reliability of the product and reliability parameter of the manufacturing system can be improved by introducing the time dependent development cost and also by improving the quality of the raw material used in the production system. Under such circumstances, a profit function has been developed and maximised by optimising the reliability parameter of the manufacturing system, reliability of the product and duration of production. Finally, the model has been illustrated with some numerical examples.

Keywords: inventory; imperfect production; production time; reliability parameter; product reliability; development cost; rework; screening cost; raw material cost; advertisement; selling price.

- Taleizadeh, A.A., Khanbaglo, M.P.S. and Cardenas-Barron, L.E. (2016) 'An EOQ inventory model with partial backordering and reparation of imperfect products', *International Journal of Production Economics*, Vol. 182, pp.418–434.
- Taleizadeh, A.A., Kalantari, S.S. and Cardenas-Barron, L.E. (2016) 'Pricing and lot sizing for an EPQ inventory model with rework and multiple shipments', *TOP*, Vol. 24, pp.143–155.
- Teng, J.T. and Chang, C.T. (2005) 'Economic production quantity models for deteriorating items with price- and stock-dependent demand', *Computers & Operations Research*, Vol. 32, pp.297–308.
- Trevino-Garza, G., Castillo-Villar, K.K. and Cardenas-Barron, L.E. (2015) 'Joint determination of the lot size and number of shipments for a family of integrated vendor-buyer systems considering defective products', *International Journal of Systems Science*, Vol. 46, No. 9, pp.1705–1716.
- Yoo, S.H., Kim, D. and Park, M.S. (2009) 'Economic production quantity model with imperfect-quality items, two-way imperfect inspection and sales return', *International Journal of Production Economics*, Vol. 121, pp.255–265.
- Wang, W.T., Wee, H.M. Cheng, Y.L., Wen, C.L. and Cardenas-Barron, L.E. (2015) 'EOQ model for imperfect quality items with partial backorders and screening constraint', *European Journal of Industrial Engineering*, Vol. 9, No. 6, pp.744–773.

REALIZATION OF NONCLASSICAL EFFECTS OF LIGHT AND TOTAL NOISE IN COHERENT ANTI-STOKES RAMAN AND HYPER-RAMAN SCATTERINGS UP TO THE FIRST-ORDER HAMILTONIAN INTERACTION

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Abstract

In this paper, we give an overview of nonclassical effects, such as squeezing and sub-Poissonian states, of an optical field in coherent anti-Stokes Raman scattering and coherent anti-Stokes hyper-Raman scattering under the short time scale. We establish the coupled Heisenberg equations of motion of quadrature operators in terms of real and imaginary parts. We investigate the photon statistics of the pump mode in these processes and find that they are sub-Poissonian in nature. We demonstrate that squeezing and sub-Poissonian photon statistics are greater in coherent anti-Stokes hyper-Raman scattering (CAHRS) than in coherent anti-Stokes Raman scattering (CARS). The effect of the sub-Poissonian nature of an optical field in terms of total noise is also incorporated. We show that the depth of nonclassicality directly depends on the amount of total noise present in the system. This suggests that the more squeezed the state, the greater its total noise in the system.

Keywords: nonclassical light, squeezing of radiation, sub-Poissonian photon statistics, coherent anti-Stokes Raman scattering, coherent anti-Stokes hyper-Raman scattering, photon number operator, total noise.

1. Introduction

Squeezing [1–3] and sub-Poissonian [4–6] behavior of light has recently attracted considerable attention owing to its low-noise property [7–9] with applications in high-quality telecommunication [9, 10] and cryptography [11, 12]. Squeezing means that the fluctuation in one of the two conjugate components (amplitude or phase) is suppressed while it is enhanced in the other. It is a purely quantum-mechanical

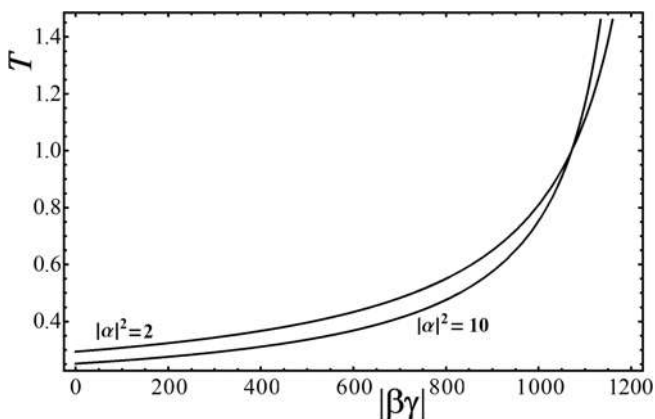


Fig. 7. Variation of total noise T in the quantum state with $|\beta\gamma|$ and $|\alpha|^2 = 2, 10$ in CARS process at $\theta_1 = \pi/4$, $\theta_2 + \theta_3 = \pi/2$, and $|gt| = 10^{-4}$.

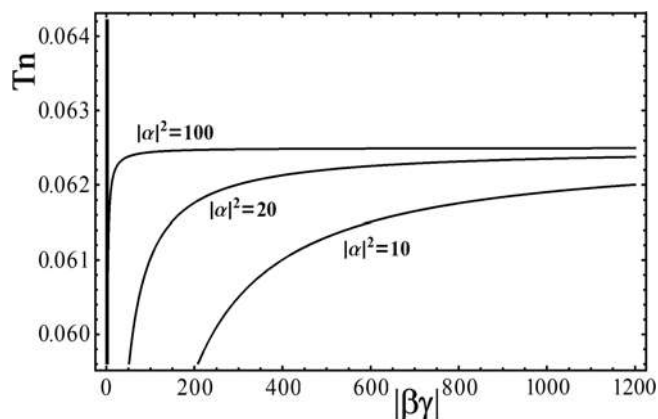


Fig. 8. Variation of total noise T_n in the quantum state with $|\beta\gamma|$ and $|\alpha|^2 = 10, 20, 100$ in the CAHRS process at $\theta_1 = \pi/4$, $\theta_2 + \theta_3 = \pi/2$, and $|gt| = 10^{-4}$.

statistics of light increase with increasing $|\alpha|^2$ and $|\beta\gamma|$, i.e., the increase is directly proportional to the number of photons.

Comparing Figs. 5 and 6, we found that the depth of nonclassicality is greater in the CAHRS than in the CARS. Thus, the degree of nonclassicality of light increases with the photon numbers in the Stokes and anti-Stokes modes. This also confirms that the sub-Poissonian statistics are associated with a large number of photons and with a higher degree of nonlinearity.

To study the variation of first-order squeezing in terms of the total noise with $|\alpha|^2$, we plot a graph of Eqs. (32) and (59) versus T and T_n in Figs. 7 and 8 for CARS and CAHRS, respectively.

The steady increase in the curves shows that the total noise increases with increase in the number of photons $|\alpha|^2$ and $|\beta\gamma|$. This infers that the depth of nonclassicality directly depends on the large number of photons. This also suggests that the more squeezed the state, the greater its total noise. From Eqs. (33) and (60), it is obvious that, for fixed $\langle N \rangle$, as $[\Delta N(t)]^2$ decreases, the total noise must increase; therefore, as the state becomes more sub-Poissonian with decreasing $(\Delta N(t)/\langle N \rangle)$, its total noise increases.

A comparison of Figs. 7 and 8 shows that the greater the total noise, the greater the squeezing having the same number of photons in CAHRS than CARS processes. The results of the present study agree with the result of Hillery [26] that a maximum total noise is available in higher-order squeezing.

5. Conclusions

In this study, we showed that the presence of squeezing is greater in the CAHRS due to higher nonlinearity than the corresponding squeezing in the CARS. We observed that, when the value of the Stokes and anti-Stokes modes is higher, the squeezing increases in the pump mode and lowers the depth of classicality of the field amplitude. This fact confirmed that the degree of normal squeezing directly depends upon the photon number in the pump, Stokes, and anti-Stokes modes. Also we found that the sub-Poissonian statistics are associated with a large number of photons.

We conclude that the total noise increases with increase in the number of pump photons and with the value of the Stokes and anti-Stokes modes. We show that the more squeezed the state, the greater its total noise. Therefore, as the state becomes more sub-Poissonian, its total noise increases.

Also we observed that a maximum total noise is available in higher-order squeezing. Hence it is inferred that a higher photon absorption process is suitable for generating optimum squeezed light.

Our results suggest that the desired degree of squeezing, sub-Poissonian statistics, and total noise are obtained using a short interaction time and having a number of photons present in the field before initiating the interaction in the system. Hence, the total noise of a quantum state can be considered as a measure of the depth of nonclassicality, i.e., a more nonclassical state (squeezing and the sub-Poissonian condition) of the field in any system is observed. Finally, we conclude that the CARS and CAHRS processes can be used for high-quality telecommunications and quantum cryptography owing to the multiphoton version of the sub-Poissonian state.

References

1. D. F. Walls, *Nature*, **306**, 141 (1983).
2. R. Loudon and P. L. Knight, *J. Mod. Opt.*, **34**, 709 (1987).
3. M. C. Teich and B. E. A. Saleh, *Quantum Opt.*, **1**, 153 (1989).
4. J. Perina, *Quantum Statistics of Linear and Nonlinear Optical Phenomena*, Kluwer, Dordrecht (1991), Chs. 9 & 10.
5. V. V. Dodonov, *J. Opt. B: Quantum Semiclass. Opt.*, **4**, R1 (2002).
6. J. Perina, V. Perinova, and J. Kodousek, *Opt. Commun.*, **49**, 210 (1984).
7. B. E. A. Saleh and M. C. Teich, *Phys. Rev. Lett.*, **58**, 2656 (1987).
8. H. J. Kimble and D. F. Walls, *J. Opt. Soc. Am.*, **B 4**, 1450 (1987).
9. H. P. Yuen and J. H. Shapiro, *IEEE Trans. Inf. Theor.*, **24**, 657 (1978).
10. L. Mandel, *Phys. Scr. T*, **12**, 34 (1986).
11. C. H. Bennett, G. Brassard, and N. D. Mermin, *Phys. Rev. Lett.*, **68**, 557 (1992).
12. J. Kempe, *Phys. Rev. A*, **60**, 910 (1999).
13. J. Perina, V. Perinova, C. Sibilila, and M. Bertolotti, *Opt. Commun.*, **49**, 285 (1984).
14. M. S. K. Razmi and J. H. Eberly, *Opt. Commun.*, **76**, 265, (1990).
15. C. K. Hong and L. Mandel, *Phys. Rev. Lett.*, **54** 323-325 (1985);
16. C. K. Hong and L. Mandel, *Phys. Rev. A*, **32**, 974 (1985).
17. D. K. Giri and P. S. Gupta, *J. Opt. B: Quantum Semiclass. Opt.*, **6**, 91 (2004);
18. D. K. Giri and P. S. Gupta, *Opt. Commun.*, **221**, 135 (2003).
19. L. Mandel, *Opt. Commun.*, **42**, 437 (1982).
20. M. Hillery, *Opt. Commun.*, **62**, 135 (1987).
21. M. Hillery, *Phys. Rev. A*, **36**, 3796 (1987).
22. S. Rani, J. Lal, and N. Singh, *Opt. Commun.*, **281**, 341 (2008).
23. R. Pratap, D. K. Giri, and A. Prasad, *Optik*, **125**, 1065 (2014).
24. You-bang Zhan, *Phys. Lett. A*, **160**, 498 (1991).
25. D. K. Giri and P. S. Gupta, *J. Mod. Opt.*, **51**, 1705 (2004).
26. M. Hillery, *Phys. Rev. A*, **39**, 2994 (1989).
27. P. Gupta and A. Pathak, *Optik: Int. J. Light Electron Opt.*, **121**, 1507 (2010).
28. S. Gill, S. Rani, and N. Singh, *Int. J. Opt.*, **2012**, 1 (2012).
29. B. K. Choudhary and D. K. Giri, *Acta Phys. Pol. A*, **134**, 1108 (2018).



Internet of Health Things (IoHT) for personalized health care using integrated edge-fog-cloud network

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Abstract

This paper proposes a mobile healthcare framework based on edge-fog-cloud collaborative network. It uses edge and fog devices for parameterized health monitoring, and cloud for further health data analysis in case of abnormal health status. The continuous location change of users is a critical issue, and the connection interruption and delay in delivering health related data may be fatal in case of emergency. In this direction, in the proposed framework, mobility information of the users is considered and the users' mobility pattern detection is performed inside the cloud for advising the user regarding nearby health centre. From the theoretical analysis, it is observed that the proposed framework reduces the delay and energy consumption of user device by $\sim 28\%$ and $\sim 27\%$ respectively than the cloud only health care model. The proposed healthcare framework has been implemented in the laboratory and health data of few student volunteers are analyzed to predict their health status. The experimental analysis also shows that the proposed mobility prediction model has better precision, recall value and time-efficiency than the existing models.

Keywords Health monitoring · Edge-fog-cloud network · Mobility prediction · Internet of Health Things (IoHT)

1 Introduction

The rapid advances in sensor-based systems and Internet technologies have enabled a new dimension of health care technology namely Internet of Health Things (IoHT). IoHT

is the exchange and processing of the data for health status monitoring of individuals by integrating sensor or IoT devices with advanced mobile technologies (da Costa et al. 2018). IoHT can become a demanding application for personalized health care leveraging on fog, edge and cloud computing. In a cloud based health care system, the health data are collected using body area network (BAN) or body sensor network (BSN) and then stored and processed inside the cloud servers. In BAN, there are several sensors attached with human body and varied health data e.g. body temperature, blood pressure etc are collected by these sensors.

With availability of several body sensors, it is possible to design and develop a low-cost wearable system to capture values of various health parameters of human body (e.g. blood pressure, heart/pulse rate, oxygen level, body temperature etc.) and to predict the health status of individuals based on the collected data and contextual information (e.g. atmospheric condition, user's location, activity etc.). These sensor nodes collect health parameter values and transmit to the connected smart phone. Next, the data is processed and health status is predicted by the smartphones. But smart phones are resource hungry. Therefore, the computationally complex applications are difficult to execute in the resource-limited smart phones.

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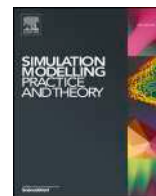
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- Ghosh S, Mukherjee A, Ghosh SK, Buyya R (2019b) Mobi-iost: mobility-aware cloud-fog-edge-iot collaborative framework for time-critical applications. *IEEE Trans Netw Sci Eng*
- Ghosh S, Das J, Ghosh SK (2020) Locator: A cloud-fog-enabled framework for facilitating efficient location based services. In: 2020 International Conference on COMMunication Systems & NET-workS (COMSNETS), IEEE, pp 87–92
- Ghosh SK, Ghosh S (2018b) Modeling individual's movement patterns to infer next location from sparse trajectory traces. In: IEEE International conference on systems, man, and cybernetics (SMC), IEEE, pp 693–698
- Gong YJ, Chen E, Zhang X, Ni LM, Zhang J (2017) Antmapper: an ant colony-based map matching approach for trajectory-based applications. *IEEE Trans Intell Transp Syst* 19(2):390–401
- Hassanalieragh M, Page A, Soyata T, Sharma G, Aktas M, Mateos G, Kantarci B, Andreescu S (2015) Health monitoring and management using internet-of-things (iot) sensing with cloud-based processing: Opportunities and challenges. In: 2015 IEEE International conference on services computing, IEEE, pp 285–292
- Karatzoglou A, Schnell N, Beigl M (2018) A convolutional neural network approach for modeling semantic trajectories and predicting future locations. In: International conference on artificial neural networks, Springer, pp 61–72
- Kaur PD, Chana I (2014) Cloud based intelligent system for delivering health care as a service. *Comput Methods Progr Biomed* 113(1):346–359
- Kim SY, Koo HJ, Song HY (2018) A study on estimation of human personality from location visiting preference. *J Ambient Intell Humaniz Comput* 9(3):629–642
- Krakiwsky EJ, Harris CB, Wong RV (1988) A kalman filter for integrating dead reckoning, map matching and gps positioning. In: IEEE PLANS'88., Position Location and Navigation Symposium, Record.'Navigation into the 21st Century', IEEE, pp 39–46
- Liu Q, Wu S, Wang L, Tan T (2016) Predicting the next location: a recurrent model with spatial and temporal contexts. In: Thirtieth AAAI conference on artificial intelligence
- Lv M, Chen L, Chen G (2012) Discovering personally semantic places from gps trajectories. In: Proceedings of the 21st ACM international conference on information and knowledge management, pp 1552–1556
- Mukherjee A, De D (2014) Femtocell based green health monitoring strategy. In: 2014 XXXIth URSI general assembly and scientific symposium (URSI GASS), IEEE, pp 1–4
- Mukherjee A, De D, Ghosh SK (2020) Fogioht: a weighted majority game theory based energy-efficient delay-sensitive fog network for internet of health things. *Internet of Things*, p 100181
- Papandrea M, Giordano S (2014) Location prediction and mobility modelling for enhanced localization solution. *J Ambient Intell Humaniz Comput* 5(3):279–295
- Salomón S, Tîrnăucă C, Duque R, Montaña JL (2018) User identification from mobility traces. *J Ambient Intell Humaniz Comput* 11:1–10
- Solanas A, Patsakis C, Conti M, Vlachos IS, Ramos V, Falcone F, Postolache O, Pérez-Martínez PA, Di Pietro R, Perrea DN et al (2014) Smart health: a context-aware health paradigm within smart cities. *IEEE Commun Mag* 52(8):74–81
- Tuli S, Mahmud R, Tuli S, Buyya R (2019) Fogbus: a blockchain-based lightweight framework for edge and fog computing. *J Syst Softw* 154:22–36
- Verma P, Sood SK (2018) Fog assisted-iot enabled patient health monitoring in smart homes. *IEEE Internet Things J* 5(3):1789–1796
- Vlachos M, Kollios G, Gunopulos D (2002) Discovering similar multidimensional trajectories. In: Proceedings 18th international conference on data engineering, IEEE, pp 673–684
- Yang J, Sun Y, Shang B, Wang L, Zhu J (2019) Understanding collective human mobility spatiotemporal patterns on weekdays from taxi origin-destination point data. *Sensors* 19(12):2812
- Ye Y, Zheng Y, Chen Y, Feng J, Xie X (2009) Mining individual life pattern based on location history. In: 2009 tenth international conference on mobile data management: systems, services and middleware, IEEE, pp 1–10
- Zhang C, Zheng Y, Ma X, Han J (2015) Assembler: Efficient discovery of spatial co-evolving patterns in massive geo-sensory data. In: Proceedings of the 21th ACM SIGKDD international conference on Knowledge discovery and data mining, pp 1415–1424
- Zhang J, Zheng Y, Qi D (2017) Deep spatio-temporal residual networks for citywide crowd flows prediction. In: Thirty-first AAAI conference on artificial intelligence
- Zhang J, Zheng Y, Sun J, Qi D (2019) Flow prediction in spatio-temporal networks based on multitask deep learning. *IEEE Trans Knowl Data Eng*
- Zheng Y (2015) Trajectory data mining: an overview. *ACM Trans Intell Syst Technol (TIST)* 6(3):1–41

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Spatio-Fog: A green and timeliness-oriented fog computing model for geospatial query resolution

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ABSTRACT

Geospatial data analysis is an emerging area of research today. Systems need to respond to user requests in a timely manner. In this paper we have proposed a fog computing framework namely Spatio-Fog, where the fog devices contain the geospatial data of their current region and process geospatial queries using resources in the proximity. The geospatial query resolution is performed by the fog device either itself or using cloud servers or fog device of other region depending on the geographical region related to the geospatial query. We have performed both empirical study and experimental analysis to demonstrate feasibility of our proposed approach. The empirical study illustrates that the proposed architecture Spatio-Fog reduces the power consumption and delay by approximately 43–47% and 47–83% respectively over the use of existing geospatial query resolution system. The experimental analysis demonstrates that the proposed framework reduces the power consumption and delay by 30–60% approximately than the existing geospatial query resolution system.

1. Introduction

Geospatial information storage, processing, and query resolution is a promising research area [1]. There are several industrial applications of geospatial data analysis such as mapping, telecom and network services, hot spot analysis, urban planning, transport services, environmental impact analysis, health and human services, disaster management, resource management, geology. Google Maps is a popular application of a web-based mapping solution on geospatial data, which is used for navigation services. Geospatial data analysis also helps in road traffic management, transport and urban planning. For risk assessment and disaster management geospatial data analysis is also important. Usually, cloud servers are used to store and process the geospatial information [2]. However, as geospatial information is related to geographical regions, storing and processing large volume geospatial data inside the remote cloud servers can suffer from delay and energy consumption. Geospatial query processing involves geospatial data analysis along with different geospatial services, which have been discussed later in Section 3. While mobile devices request for any geospatial information, then to process the respective geospatial queries geospatial big data analysis is required. However, accessing geospatial data inside the remote cloud servers may degrade the quality of user experience by enhancing delay [3] and energy. Moreover,

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- Electrical, Computer and Electronics Engineering (UPCON), 2016 IEEE Uttar Pradesh Section, IEEE, 2016, pp. 613–618.
- [16] R.K. Barik, A. Tripathi, H. Dubey, R.K. Lenka, T. Pratik, S. Sharma, K. Mankodiya, V. Kumar, H. Das, MistGIS: optimizing geospatial data analysis using mist computing, *Progress in Computing, Analytics and Networking*, Springer, 2018, pp. 733–742.
- [17] M. Das, S.K. Ghosh, V. Chowdary, A. Saikrishnaveni, R. Sharma, A probabilistic nonlinear model for forecasting daily water level in reservoir, *Water Resour. Manag.* 30 (9) (2016) 3107–3122.
- [18] S. Bhattacharjee, M. Das, S.K. Ghosh, S. Shekhar, Prediction of meteorological parameters: an a-posteriori probabilistic semantic kriging approach, *Proceedings of the 24th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems*, ACM, 2016, p. 38.
- [19] F. Gu, On-demand data assimilation of large-scale spatial temporal systems using sequential monte carlo methods, *Simul. Model. Pract. Theory* 85 (2018) 1–14.
- [20] A. Dasgupta, S.K. Ghosh, P. Mitra, A technique for assessing the quality of volunteered geographic information for disaster decision making, *International Conference on Computational Science and Its Applications*, Springer, 2018, pp. 589–597.
- [21] O. Chakraborty, J. Das, A. Dasgupta, P. Mitra, S.K. Ghosh, A geospatial service oriented framework for disaster risk zone identification, *International Conference on Computational Science and Its Applications*, Springer, 2016, pp. 44–56.
- [22] S. Pal, S. Ghosh, A large-scale data-oriented intelligent system for urban growth simulation, *Geospatial Infrastructure, Applications and Technologies: India Case Studies*, Springer, 2018, pp. 143–154.
- [23] S. Ghosh, S.K. Ghosh, Modeling of human movement behavioral knowledge from GPS traces for categorizing mobile users, *Proceedings of the 26th International Conference on World Wide Web Companion*, International World Wide Web Conferences Steering Committee, 2017, pp. 51–58.
- [24] S. Ghosh, A. Mukherjee, S.K. Ghosh, R. Buyya, Mobi-IoST: mobility-aware cloud-fog-edge-iot collaborative framework for time-critical applications, *IEEE Trans. Netw. Sci. Eng.* (2019), <https://doi.org/10.1109/TNSE.2019.2941754>.
- [25] S.M. Vicente-Serrano, S. Beguería, L. Gimeno, L. Eklundh, G. Giuliani, D. Weston, A.E. Kenawy, J.I. López-Moreno, R. Nieto, T. Ayenew, et al., Challenges for drought mitigation in africa: the potential use of geospatial data and drought information systems, *Appl. Geogr.* 34 (2012) 471–486.
- [26] A.H. Weerts, J. Schellekens, F.S. Weiland, Real-time geospatial data handling and forecasting: examples from delft-fews forecasting platform/system, *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.* 3 (3) (2010) 386–394.
- [27] N.N. Kussul, B.V. Sokolov, Y.I. Zelyk, V.A. Zelentsov, S.V. Skakun, A.Y. Shelestov, Disaster risk assessment based on heterogeneous geospatial information, *J. Autom. Inf. Sci.* 42(12) 32–45.
- [28] C.-R. Shyu, M. Klaric, G.J. Scott, A.S. Barb, C.H. Davis, K. Palaniappan, GeoIRIS: geospatial information retrieval and indexing system content mining, semantics modeling, and complex queries, *IEEE Trans. Geosci. Remote Sens.* 45 (4) (2007) 839–852.
- [29] J.-H. Hong, Z.L.-T. Su, E.H.C. Lu, A recommendation framework for remote sensing images by spatial relation analysis, *J. Syst. Softw.* 90 (2014) 151–166.
- [30] D. Warren, Method and apparatus for providing location based data services, 2003, US Patent 6,611,751.
- [31] L. Qi, X. Zhang, W. Dou, Q. Ni, A distributed locality-sensitive hashing-based approach for cloud service recommendation from multi-source data, *IEEE J. Sel. Areas Commun.* 35 (11) (2017) 2616–2624.
- [32] S. Nishimura, S. Das, D. Agrawal, A.E. Abbadi, MD-HBase: a scalable multi-dimensional data infrastructure for location aware services, 2011 IEEE 12th International Conference on Mobile Data Management, 1, IEEE, 2011, pp. 7–16.
- [33] S. Nishimura, S. Das, D. Agrawal, A.E. Abbadi, MD-HBase: design and implementation of an elastic data infrastructure for cloud-scale location services, *Distrib. Parallel Databases* 31 (2) (2013) 289–319.
- [34] A. González, C. Aliagas, M. Valero, A data cache with multiple caching strategies tuned to different types of locality, *International Conference on Supercomputing*, Citeseer, 1995, pp. 338–347.
- [35] M. Kandemir, A. Choudhary, J. Ramanujam, N. Shenoy, P. Banerjee, Enhancing spatial locality via data layout optimizations, *European Conference on Parallel Processing*, Springer, 1998, pp. 422–434.
- [36] P. Gerolymatos, S. Sioutas, N. Nodarakis, A. Panaretos, K. Tsakalidis, SMaRT: a novel framework for addressing range queries over nonlinear trajectories, *J. Syst. Softw.* 105 (2015) 79–90.
- [37] G. Roumelis, M. Vassilakopoulos, A. Corral, Y. Manolopoulos, Efficient query processing on large spatial databases: a performance study, *J. Syst. Softw.* 132 (2017) 165–185.
- [38] H. Samet, The quadtree and related hierarchical data structures, *ACM Comput. Surv. (CSUR)* 16 (2) (1984) 187–260.
- [39] I. Kamel, C. Faloutsos, Hilbert R-tree: an improved R-tree using fractals, *Tech. rep.* (1993).
- [40] T. Sellis, N. Roussopoulos, C. Faloutsos, The R+ -Tree: A dynamic index for multi-dimensional objects, *Tech. rep.* (1987).
- [41] N. Beckmann, H.-P. Kriegel, R. Schneider, B. Seeger, The R⁺-tree: an efficient and robust access method for points and rectangles, *ACM Sigmod Record*, ACM, 1990, pp. 322–331. 19
- [42] G.R. Hjaltason, H. Samet, Speeding up construction of PMR quadtree-based spatial indexes, *Int. J. Very Large Data Bases* 11 (2) (2002) 109–137.
- [43] T. Dokeroglu, M.A. Bayir, A. Cosar, Robust heuristic algorithms for exploiting the common tasks of relational cloud database queries, *Appl. Soft Comput.* 30 (2015) 72–82.
- [44] M. Malensek, S. Pallickara, S. Pallickara, Analytic queries over geospatial time-series data using distributed hash tables, *IEEE Trans. Knowl. Data Eng.* 28 (6) (2016) 1408–1422.
- [45] K. Karantzas, D. Bliziotis, A. Karmas, A scalable geospatial web service for near real-time, high-resolution land cover mapping, *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.* 8 (10) (2015) 4665–4674.
- [46] K. Evangelidis, K. Ntoulos, S. Makridis, C. Papatheodorou, Geospatial services in the cloud, *Comput. Geosci.* 63 (2014) 116–122.
- [47] A. Rezgui, Z. Malik, C. Yang, High-resolution spatial interpolation on cloud platforms, *Proceedings of the 28th Annual ACM Symposium on Applied Computing*, ACM, 2013, pp. 377–382.
- [48] J. Wenjue, C. Yumin, G. Jianya, Implementation of OGC web map service based on web service, *Geo-Spatial Inf. Sci.* 7 (2) (2004) 148–152.
- [49] P.A. Vretanos, Web feature service implementation specification, *Open Geospatial Consort. Specif.* 1325 (2005) 04–094.
- [50] P. Schut, A. Whiteside, OpenGIS web processing service, Version 1.0. 0, OGC 05-007r7, Open Geospatial Consortium, Inc 87.
- [51] R. Barik, H. Dubey, S. Sasane, C. Misra, N. Constant, K. Mankodiya, Fog2fog: augmenting scalability in fog computing for health GIS systems, *Proceedings of the Second IEEE/ACM International Conference on Connected Health: Applications, Systems and Engineering Technologies*, IEEE Press, 2017, pp. 241–242.
- [52] G. Buehrer, B.W. Weide, P.A. Sivilotti, Using parse tree validation to prevent SQL injection attacks, *Proceedings of the 5th international workshop on software engineering and middleware*, ACM, 2005, pp. 106–113.
- [53] R.P. Haining, R. Haining, *Spatial Data Analysis: Theory and Practice*, Cambridge University Press, 2003.
- [54] T. Brinkhoff, H.-P. Kriegel, B. Seeger, Efficient Processing of Spatial Joins Using R-Trees, *ACM*, 1993. Vol. 22
- [55] J. Das, A. Dasgupta, S.K. Ghosh, R. Buyya, A learning technique for VM allocation to resolve geospatial queries, *Recent Findings in Intelligent Computing Techniques*, Vol. 1, Springer, 2019, pp. 577–584.
- [56] A. Mukherjee, D. De, R. Buyya, E2R-F2N: energy-efficient retailing using a femtolet-based fog network, *Software* 49 (3) (2019) 498–523.



Power and Delay Efficient Multilevel Offloading Strategies for Mobile Cloud Computing

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Abstract

Mobile cloud computing has introduced offloading to save the battery life of mobile devices. In mobile cloud computing optimization of power and delay for offloading has become a vital research scope. However, migration of the storage and computation from the mobile device to the remote cloud server enhances the delay and power consumption. To overcome this difficulty, cloudlet comes which is located nearby the mobile device. Since the cloudlet may not be able to fulfill all the offloading requests, sometimes remote public cloud server is used for the same. As a result the power and delay consumptions are increased. For solving this difficulty, private cloud server is used in our scheme along with the cloudlet and public cloud server. In this paper multilevel full and partial offloading strategies are proposed based on cloudlet, private and public cloud servers. The power and delay consumption in the proposed methods are determined and compared with the existing offloading methods. The theoretical and experimental analyses demonstrate that the proposed multilevel offloading methods are power and delay efficient. The simulation results show that the proposed multilevel full and partial offloading strategies reduce the power consumption by approximately 8–9% and 20% respectively than the existing methods.

Keywords Cloudlet · Delay aware · Multilevel · Offloading · Power optimization · Private cloud · Public cloud

Debashis De and Deepsubhra Guha Roy: Formerly, West Bengal University of Technology.

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22. Mahmud, R., Kotagiri, R., & Buyya, R. (2018). Fog computing: A taxonomy, survey and future directions. In *Internet of everything* (pp. 103–130). Singapore: Springer.
23. Yi, S., Li, C., & Li, Q. (2015, June). A survey of fog computing: concepts, applications and issues. In *Proceedings of the 2015 workshop on mobile big data* (pp. 37–42). ACM.
24. Yi, S., Hao, Z., Qin, Z., & Li, Q. (2015, November). Fog computing: Platform and applications. In *2015 third IEEE workshop on hot topics in web systems and technologies (HotWeb)* (pp. 73–78). IEEE.
25. Vaquero, L. M., & Rodero-Merino, L. (2014). Finding your way in the fog: Towards a comprehensive definition of fog computing. *ACM SIGCOMM Computer Communication Review*, 44(5), 27–32.
26. Orsini, G., Bade, D., & Lamersdorf, W. (2015, October). Computing at the mobile edge: Designing elastic android applications for computation offloading. In *2015 8th IFIP wireless and mobile networking conference (WMNC)* (pp. 112–119). IEEE.
27. Mach, P., & Becvar, Z. (2017). Mobile edge computing: A survey on architecture and computation offloading. *IEEE Communications Surveys & Tutorials*, 19(3), 1628–1656.
28. Chang, Z., Zhou, Z., Ristaniemi, T., & Niu, Z. (2017, December). Energy efficient optimization for computation offloading in fog computing system. In *GLOBECOM 2017–2017 IEEE global communications conference* (pp. 1–6). IEEE.
29. Du, J., Zhao, L., Feng, J., & Chu, X. (2018). Computation offloading and resource allocation in mixed fog/cloud computing systems with min-max fairness guarantee. *IEEE Transactions on Communications*, 66(4), 1594–1608.
30. Ning, Z. et al. (2018). A cooperative partial computation offloading scheme for mobile edge computing enabled Internet of Things. *IEEE Internet of Things Journal*, 6(3), 4804–4814.
31. Mukherjee, A., Deb, P., De, D., & Buyya, R. (2018). C2OF2N: a low power cooperative code offloading method for femtolet-based fog network. *The Journal of Supercomputing*, 74(6), 2412–2448.
32. Rao, X., Zhao, L., Liang, K., & Wang, K. (2019). Edge caching and computation offloading for fog-enabled radio access network. *Wireless Personal Communications*, 109(1), 297–313.
33. Zhang, J., Xia, W., Yan, F., & Shen, L. (2018). Joint computation offloading and resource allocation optimization in heterogeneous networks with mobile edge computing. *IEEE Access*, 6, 19324–19337.
34. Chen, M., & Hao, Y. (2018). Task offloading for mobile edge computing in software defined ultradense network. *IEEE Journal on Selected Areas in Communications*, 36(3), 587–597.

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Functions of interleukin-6 in ovulation of female climbing perch, *Anabas testudineus*



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ABSTRACT

In mammals, interleukin 6 (IL-6) has an important function during ovulation, however, the functions of IL-6 in fish have not been elucidated. In the present study, there was quantification of *de novo* synthesis of ovarian IL-6 and tumor necrosis factor-alpha (TNF α) in control and hCG-treated fish and results were compared with those from an *in vitro* study where there was evaluation of the regulatory functions of gonadotropins and TNF α of IL-6 secretions. Relatively greater concentrations of ovarian IL-6 at the post-GVBD (post-germinal vesicle breakdown) stage indicates IL-6 modulates ovulatory processes. The hCG-induced increase in relative abundance of IL-6 (*in vitro*) mRNA transcript and secretion from the ovary were attenuated when there was administration of the inhibitor of TNF α secreting enzyme, TAPI-I, which indicates TNF α modulates IL-6 secretion. Treatments with IL-6 induced a marked increase in ovulation rate *in vitro* when there was induction of activating matrix metalloproteinase (MMP). Furthermore, treatment with IL-6 resulted in production of prostaglandin as indicated by the IL-6 induced increase in the abundance of *ptgs2* mRNA transcript in the ovary of *Anabas testudineus*. Furthermore, results indicate the source of IL-6 in the ovary is the granulosa cells with secretion of IL-6 being induced by the additions of hCG and TNF α in the medium. There was also an IL-6-induced increase in abundance of receptors (IL-6 R α and gp130) to which it binds indicating IL-6 autoregulates this population of receptors. Results from this study, for the first time, elucidate the reproductive functions of IL-6 in a teleost fish.

1. Introduction

In teleost, the process of reproduction not only depends on the gonadotropins and steroids, but different cytokines also have important functions in regulation of the ovarian functions (Hoek et al., 1998; Salmassi et al., 2001; Richards et al., 2008; Liu et al., 2009; Sirotkin, 2011; Sauté et al., 2014; Stassi et al., 2017). It is well established that the ovulatory process is similar to the inflammatory responses (Xu et al., 2010; Wissing et al., 2014; Liu et al., 2017) and in the ovary, gonadotropins are the primary regulatory factors of ovulation (Richards et al., 2008; Smolikova et al., 2012). After the pre-ovulatory surge release of gonadotropins, ovarian cytokines have important functions in cumulus oocyte complex (COC) expansion (Liu et al., 2009) or prostaglandin (PG) production (Brannstrom and Norman, 1993).

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- Walters, K.A., Allan, C.M., Handelsman, D.J., 2008. Androgen actions and the ovary. *Biol. Reprod.* 78 (3), 380–389.
- Wang, L.J., Brännström, M., Robertson, S.A., Norman, R.J., 1992. Tumor necrosis factor α in the human ovary: presence in follicular fluid and effects on cell proliferation and prostaglandin production. *Fertil. Steril.* 58, 934–940.
- Wei, L., Jiao, P., Song, Y., Cao, L., Yuan, R., Gong, L., Cui, J., Zhang, S., Qi, W., Yang, S., Liao, M., 2013. Host immune responses of ducks infected with H5N1 highly pathogenic avian influenza viruses of different pathogenicities. *Vet. Microbiol.* 166, 386–393.
- Wissing, M.L., Kristensen, S.G., Andersen, C.Y., Mikkelsen, A.L., Høst, T., Borup, R., Grøndahl, M.L., 2014. Identification of new ovulation-related genes in humans by comparing the transcriptome of granulosa cells before and after ovulation triggering in the same controlled ovarian stimulation cycle. *Hum. Reprod.* 29, 997–1010.
- Xu, F., Stouffer, R.L., Muller, J., Hennebold, J.D., Wright, J.W., Bahar, A., Leder, G., Peters, M., Thorne, M., Sims, M., Wintermantel, T., Lindenthal, B., 2010. Dynamics of the transcriptome in the primate ovulatory follicle. *Mol. Hum. Reprod.* 17, 152–165.
- Zhu, Y., Liu, D., Shaner, Z.C., Chen, S., Hong, W., Stellwag, E.J., 2015. Nuclear progesterin receptor (pgr) knockouts in zebrafish demonstrate role for pgr in ovulation but not in rapid nongenomic steroid mediated meiosis resumption. *Front. Endocrinol.* 6, 1–10.
- Zolti, M., Meïrom, R., Shemesh, M., Wollach, D., Mashiach, S., Shore, L., Rafael, Z.B., 1990. Granulosa cells as a source and target organ for tumor necrosis factor alpha. *FEBS Lett.* 26, 1253–1255.
- Zou, J., Secombes, C.J., 2016. The function of fish cytokines. *Biology* 5, 1–35.



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AN ASSESSMENT OF MACROPHYTE AND WATER CHARACTERISTICS OF PAHAR DIGHI, PURBA MEDINIPUR, WEST BENGAL

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ABSTRACT

A preliminary survey of macrophytic plant species and water quality of Pahar Dighi wetland of Mahishadal Raj Garh area, Purba Medinipur, West Bengal is conducted. Altogether 38 plant species belonging to 27 families have been documented and different physico-chemical parameters of water studied are reported.

Key words: *Macrophytes diversity, Water characteristics, Pahar Dighi, Mahishadal.*

INTRODUCTION

Mahishadal Raj Garh area is a place of historical importance and hence this preliminary work was undertaken to document macrophytic plant species and water characteristics of Pahar Dighi of Mahishadal Raj Garh area, Purba Medinipur, West Bengal in post monsoon season.

MATERIALS AND METHODS

Study site: Pahar Dighi situated in between 22.1814° N and 87.9898° E, is a manmade stagnant water body of about 0.137 ha in area, 162 ft. in length and 70 ft. in diameter under the mouza Garkamalpur, created by King Satis Prasad Gargh. It is an extended part of central canal system (the Raj *Parikha*), isolated from the main water body. The water body is surrounded by Madha Hingli in south, Khagra in west, Jagannathpur in east and Basulya in the north (Fig. 1).

Study methods: Several field surveys have been conducted during September to December, 2019. The phyto-resources have been documented with field notes and the herbarium sheets made for identification following standard literature (Cook, 1996; <http://www.theplantlist.org>; <http://www.ipni.org>) and kept in the Department of

Dighi wetland of Cooch Behar District, West Bengal. There are other important works

Table 2. Water characteristics of Pahar Dighi, Mahishadal, West Bengal

Parameters	Postmonsoon
pH	8.5
Dissolve oxygen (DO)	6.8 mg/lit.
CO ₂ content	44 mg/lit.
Hardness	150 mg/lit. in CaCo ₃
Alkalinity	140 mg/lit.
Ammonia	0.25 mg/lit.
Phosphate	2.5 mg/lit
Chloride	160 mg/lit
Nitrate	0.05 mg/lit
NaCl/Salinity	263.68 mg/lit.

on macrophytic composition of wetlands in different districts of West Bengal (Bala and Mukherjee in 2007, 2010; Palit and Mukherjee, 2012; Chowdhury and Das, 2013; Gupta and Palit, 2014; Parveen *et al.*, 2014; Singh and Rajan, 2015)

The present wetland, Pahar Dighi, is an isolated part of the central canal system of Mahishadal Raj Garh (the Raj *Parikha*). The water source is limited here, but present throughout the year. However, being stagnant, the water quality parameters may need to be monitored for different bio-resource productive purposes.

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REFERENCES

- Bala, G. and Mukherjee, A. 2007. A census of wetland macrophytes in Nadia district, West Bengal. *Environ. & Ecol.*, **25**: 287-290.
- Bala, G. and Mukherjee, A. 2010. Inventory of wetlands of Nadia district, West Bengal, India and their characterization as natural resources. *J. Environ & Sociobiol.* **7**(2): 93-106.
- Cook, C. D. K. 1996. *Aquatic and Wetland Plants of India*. Oxford University Press, Oxford, 385 pp.
- Chowdhury, M. and Das, A. P. 2013. Present status of flora, fauna and vegetation structure in the wetlands of Maldah district of West Bengal. *NBU J. Pl. Sci.*, **7**(1): 29-34.
- Goswami, G., Pal, S., Palit, D. 2010. Studies on the physico-chemical characteristics, macrophyte diversity and their economic prospect in Rajmata Dighi: a wetland in Cooch Behar District, West Bengal, India. *NeBIO.*, **1**(3): 21-27.
- Gupta, S. and Palit, D. 2014. Biosurveillance of wetlands in eastern India (Birbhum, West Bengal) for wise use. *Int. J. Sci. Environ. Technol.* **3**(6): 2136-2144.
- Palit, D. and Mukherjee, A. 2012. Studies on water quality and macrophyte composition in wetlands of Bankura district, West Bengal, India. *Ind. J. Pl. Sci.*, **1**(2-3): 97-115.
- Parveen, M., Chatterjee, N. C. and Tah, J. 2014. Study of macrophyte diversity with reference to their phyto-sociological study in Chupisar, West Bengal. *Int. J. Pure App. Biosci.*, **2**(2): 131-136.
- Singh, D. M. and Rajan, S. G. D. 2015. Survey of wetland macrophytes from wetlands of Haliyal Taluk. *Int. J. Pure App. Biosci.*, **3**(4): 166-172.



Lost years of a nomad: Exploring Indian experience in Nuruddin Farah's oeuvre

Asis De

Lost years of a nomad: Exploring Indian experience in Nuruddin Farah's oeuvre


To honor Nuruddin Farah's fifty-year-long writing journey, this article explores his time in India (1966–69) and the influence it had on making him a leading postcolonial writer. My approach is largely biographical. I begin with his decision to turn down a scholarship at an American University, which some critics view as immature or even eccentric. I challenge this view of his choice instead to enroll for a degree in philosophy, literature and sociology at the Government College of Panjab University at Chandigarh in 1966 and to make what was then a country of poverty and even famine his first diasporic destination. I argue that this was a well-thought-out, politically correct and wise decision in the global context of international relationships in the 1960s. I also explore Farah's brief association with Indian culture and the knowledge he acquired of Indian philosophy and literature to explain his decision to adopt a feminist perspective to write on injustice against women and the powerless and religious intolerance rather than focus on issues such as independence realpolitik like leading African writers at the time. His first manuscript, published in 1970 as *From a Crooked Rib*, was a Penguin modern classic by 2004. I argue that this novel was importantly shaped by his Indian experience. I also explore the influence of two novels on the young Farah, on his personal life, ideology and writing even before he went to India: W. Somerset Maugham's novel *The Razor's Edge* (1944) and Thakazhi Sivasankara Pillai's classic *Chemmeen* (1956). This is the first substantial investigation of the effect of Farah's Indian experience. **Keywords:** biographical criticism, Indian experience, nomad, cosmopolitan.

When he was a schoolboy, long before Somalia gained its political independence from Britain and Italy, Nuruddin Farah Hasan (1945–) dreamt of becoming a writer. He is now about to celebrate the golden jubilee of his career as a writer. To date, Farah has published fourteen novels, a non-fiction book and several plays. He was named after a prince in *One Thousand and One Nights*. When he was being interviewed by Ahmed I. Samatar in 2001, he revealed that he used to delight in cutting out the name "Nuruddin" from pages in *One Thousand and One Nights* and gluing the small pieces of paper onto the cover pages of his exercise books (Samatar 87). He also enjoyed giving the animal characters in his English language textbooks human names and attributes. His linguistic talent was evident from an early age. As is well known, Farah assisted his mother to compose *buraanbur* or Somali oral poetry that is sung during social celebrations and community rituals. By the time he was a teenager, he was able to converse equally well in five languages: Somali, Arabic, Amharic, Italian and English. However, Farah found the local education system disappointingly alien. He comments sadly that "the textbooks we were taught from, belonged in the mind and culture of other people" ("Why I Write" 3). Though the mind and culture of "other people" initially shaped the vision of Somalia's first Anglophone writer, Farah has written about Somalia and Somali characters for most of his career. Several decades of diasporic separation have not weakened Farah's bond with Somalia and its people, just as almost fifty years of being away from Indian soil has not dimmed his memory of the people there.

His time as a graduate student at the Government College of Panjab University might have gone unnoticed had he not written his debut novel during his stay on this campus and later become one of the leading African writers of his generation. Those who knew him at the time would probably not have guessed that he would return to the campus at the age of seventy-two to receive an honorary doctorate from Panjab University in 2017. His success as a writer is often ascribed to two 'immature' decisions that he made. The first decision concerns his choice to enroll at Panjab University in India rather than take up a scholarship to study at the University of Wisconsin-Madison

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I remember from university is that I was doing English literature at one point and taking a novel exam—there was a course [...] ‘The English Novel’” (35).

2. An interesting similarity between Pillai and Farah: the story goes that the Indian novelist Pillai wrote *Chemmeen* in just 8 days, while Farah took 28 days to write *From a Crooked Rib*, from 19 March to 15 April, 1968. (Vetticad)
3. The “wooden comb” on the head of the ‘savant’ resembling “an Indian Sikh” in *From a Crooked Rib* is one of the five articles of faith (Five ‘K’s: *Kesh* [uncut hair], *Kara* [steel bracelet], *Kanga* [wooden comb], *Kachera* [cotton underwear] and *Kirpan* [ceremonious steel sword]) according to the religio-cultural practice of the Khalsa Sikhs in India.
4. When Farah was staying in India, the Fourth Five-Year Development Plan (1969–74) accelerated family planning efforts by establishing a separate Department of Family Planning within the Ministry of Health and Family Welfare. Naturally, new campaign strategies were adopted to bring the target of family planning to fruition. During my recent trip to Chandigarh in March, 2019, I visited the Chandigarh office of the All India Radio (now called Prasar Bharti), which purportedly had archival material on Farah’s works. To my astonishment, the responsible officer informed me that documents related to the production and broadcasting history of a time fifty years back were not there. The explanation given was that the papers, which dated back to a pre-cyber age, had been burnt as useless rubbish that was taking up office space.
5. Padmini Ramachandran (1932–2006) was a famous Indian actress and dancer who performed in more than 250 Indian films. Later she settled in New Jersey with her physician husband and started a school of Indian classical dance known as the Padmini School of Fine Arts.
6. Padmini Ramachandran (1932–2006) was a famous Indian actress and dancer who performed in more than 250 Indian films. Later she settled in New Jersey with her physician husband and started a school of Indian classical dance known as the Padmini School of Fine Arts.

Works Cited

- Alden, Patricia & Louis Tremaine. “How Can We Talk of Democracy? An Interview with Nuruddin Farah.” *Emerging Perspectives on Nuruddin Farah*, edited by Derek Wright. Africa World Press, 2002, pp. 25–46.
- Appiah, Kwame Anthony. “For Nuruddin Farah.” *World Literature Today*. vol. 72, no. 4, 1998. p. 703. DOI: <https://doi.org/10.2307/40154254>.
- _____. “Princeton Professor K. Anthony Appiah interviewed African novelist Nuruddin Farah about his recently released novel, *Knots*.” *YouTube*. 21 Feb. 2007, www.youtube.com/watch?v=jY1Xh9hHK-E. Accessed 24 Apr. 2019.
- Bardolph, Jacqueline. “Dreams and Identity in the Novels of Nuruddin Farah.” *Research in African Literatures* vol. 29, no. 1, 1998, pp. 163–73.
- Farah, Nuruddin. *From a Crooked Rib*. Penguin, 2006.
- _____. *Hiding in Plain Sight*. Riverhead, 2014.
- _____. “Ibsen, In Other Words.” *Nordlit* vol. 34, 2015, pp. 15–22. DOI: <https://doi.org/10.7557/13.3350>.
- _____. “Why I Write.” *Emerging Perspectives on Nuruddin Farah*, edited by Derek Wright. Africa World Press, 2002. pp. 1–13.
- Farah, Nuruddin & F. Fiona Moolla. “Reflecting back, projecting forward: A conversation with Nuruddin Farah.” *Tydskrifvir Letterkunde* vol. 57, no. 1, 2020, pp. 19–25.
- Gray, Stephen. “Interview with Nuruddin Farah.” *English in Africa* vol. 27, no. 1, 2000, pp. 131–9. www.jstor.org/stable/40238895.
- Jaggi, Maya. “Nuruddin Farah: A Life in Writing.” *The Guardian*. 21 Sep. 2012, <https://www.theguardian.com/culture/2012/sep/21/nuruddin-salah-life-in-writing>. Accessed 24 Apr. 2019.
- Hawley, John C. “Nuruddin Farah—Tribalism, Orality, and Postcolonial Ultimate Reality and Meaning in Contemporary Somalia.” *Ultimate Reality and Meaning* vol. 19, no. 3, 1996, pp. 189–205. DOI: <https://doi.org/10.3138/uram.19.3.189>.
- Hitchcock, Peter. *The Long Space: Transnationalism and Postcolonial Form*. Stanford U P, 2010.
- Metz, Helen Chapin. *Somalia: A Country Study*. Federal Research Division Library of Congress, 1993.
- Moolla, F. Fiona. *Reading Nuruddin Farah: The Individual, the Novel & the Idea of Home*. James Currey, 2014.
- Moore, Gerald. H. “Nomads and Feminists: The Novels of Nuruddin Farah.” *The International Fiction Review* vol. 11, no. 1, 1984, pp. 3–12.
- Samatar, Ahmed I. “Interview with Nuruddin Farah.” *Bildhaan: An International Journal of Somali Studies* vol. 1, 2001, pp. 87–106.
- Sethi, Rumina. “Rumina Sethi in conversation with Nuruddin Farah, Department of English, Panjab University.” *YouTube*. 27 Apr. 2017. www.youtube.com/watch?v=LNxxpcDY00A. Accessed 21 May 2019.
- Vettica, Anna M. M. “Golden milestone.” *The Hindu BusinessLine*. www.thehindubusinessline.com/blink/watch/golden-milestone/article7899728.ece
- Wright, Derek. “Parenting the Nation: Some Observations on Nuruddin Farah’s *Maps*.” *College Literature* vol. 19, no. 10, 1993, pp. 176–84.

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Transnationality, Multiculturalism and 'New' Cosmopolitanism: Indo-Australian Interface in *of Sadhus and Spinners: Australian Encounters with India*

Asis De

At the beginning of the final decade of the twentieth century, the world has witnessed two very significant events shaping the politico-economic environment both in the West and in the East: the end of the Cold War (1947-1991) and the introduction of Globalization, or, in other words, 'economic liberalization'. In the post-Cold War era (following the collapse of the Soviet Union on 31 December 1991), precisely in the mid-nineties of the last century, Australia started adopting the policy of 'Look West' with a particular interest in the Indian Ocean Region (IOR)—specifically with India and South Africa expecting a rapid development in the economic relationship. India complements this Australian policy by opening windows for bilateral cooperation in the field of trade and investment, on the issue of military and political security, on collaborative educational activities and cultural exchange in the 1990s after adopting economic liberalization. On the issue of academic and cultural exchange, the formation of the *Indian Association for the Study of Australia* in the year 2000 is precisely an important step towards making different “facets of Australian society including culture, humanities, social sciences, international studies, media and literature” (cf. *Webpage of IASA*) familiar to the people in India. The IASA and the AIC (Australia-India Council), working in close association with India's premier Universities like Jawaharlal Nehru University, IGNOU in Delhi, the University of Madras in Chennai, or even Mohanlal Sukhadia University in Udaipur, have taken crucial roles in shaping the forums for the discussion of the cultural and literary interrelationship between India and Australia. So, it is undeniable that in the last twenty-five years, the Indo-Australian interface has taken a remarkably positive turn and a

- Elizabeth Webby, CUP, 2010, pp. 183-208.
- Dasgupta, Sanjukta. "The Two Way Flow: Connecting Cultures, Understanding Others" in *Landscape, Place and Culture: Linkages between Australia and India*, edited by Deb Narayan Bandopadhyay, Paul Brown and Christopher Conti, Cambridge Scholars Publishing, 2011, pp. 2-13.
- Delanty, Gerard. "Introduction: The Emerging Field of Cosmopolitanism Studies" in *Routledge Handbook of Cosmopolitanism Studies*, Edited by Gerard Delanty, Routledge, 2012, pp. 1-8.
- Earnshaw, John. "Lang, John (1816–1864)", *Australian Dictionary of Biography*, National Centre of Biography, Australian National University, <http://adb.anu.edu.au/biography/lang-john-3985/text6301>. Accessed on 24 October 2018.
- Huggan, Graham. *Australian Literature: Postcolonialism, Racism, Transnationalism*. Oxford University Press, 2007.
- Bandopadhyay, Deb Narayan, Paul Brown and Christopher Conti, eds. *Landscape, Place and Culture: Linkages between Australia and India*. Cambridge Scholars Publishing, 2011.
- Singh, Supriya. *Money, Migration and Family: India to Australia*. Palgrave Macmillan (Springer Nature), 2016.
- Strydom, Piet. "Modernity and Cosmopolitanism: From a Critical Social Theory Perspective," in *Routledge Handbook of Cosmopolitanism Studies*, edited by Gerard Delanty, Routledge, 2012, pp. 25-37.

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INDIA

Cultural Ecotone and Transformation of the Human Geography in Mahasweta Devi's *Chotti Munda and His Arrow*

Asis De

It is by now a well-accepted historico-cultural reality that the imperial and mercantile aggression of European colonial enterprise has ruthlessly altered not only the bioregions of the colonized countries, but made substantial changes in the human geography on the planet as well. With the end of the twentieth century, more specifically saying, with the end of the European colonialism, the world has witnessed several historical changes in the value-systems, perceptions, thoughts and attitudes, which one may fairly assemble under the single umbrella term: 'postcolonialism'. Ecological consciousness could probably be seen as one of the major products of the post-colonial time. Apart from the scientific study of the relationship between the bio-organism and the environment, ecology now-a-days includes new disciplines like 'social ecology' or 'human ecology' which insist mostly on the changes in the 'human' environment. In his book *The Ecological Thought* (2010), Timothy Morton argues:

Ecology isn't just about global warming, recycling and solar power—and also not just to do with everyday relationships between humans and nonhumans... It has to do with capitalism and with what might exist after capitalism.... It has to do with concepts of space and time.... It has to do with society. It has to do with coexistence. (2)

Taking this view as the basic premise I would like to argue that an ecological consciousness affects numerous aspects of human life, culture and community. Morton's opinion sounds quite proverbial when he says: "Human beings *are* each others' environment" (4; original emphasis). The interconnectedness and coexistence of human communities and cultures produce diverse landscapes, which can well be compared with the diversity of human geography and the notion of the 'ecotone' in ecology.

The idea of an 'ecotone' is primarily inspired by an ecological consciousness that tends to see the earthly paradigm as a cluster of 'biomes'¹ or specific climatic regions with particularly unique sets of living organisms and their biotic and abiotic environments. Environmental scientists like to see an 'ecotone' as a space that exists on the very 'border-edge' of two or more ecosystems. So, an ecotone is essentially an ecological frontier, where the most crucial reality is that of the border. But at the same time it should be equally clear that an ecotone is not only a space

Morton, Timothy. *The Ecological Thought*. Cambridge, MA: Harvard University Press, 2010.

Sharma, Vandhana and kaurQ. "Articulating Tribal History: The Fallouts of Caste in Mahasweta Devi's *Chotti Munda and His Arrow*". *European Academic Research*. Vol. I, Issue 12(March 2014): 5875-5904.

Sreelatha, R. "Tribal Perceptions of the Forest: A Study of Mahasweta Devi's *Chotti Munda and His Arrow*". *Essays in Ecocriticism*. Eds., Nirmal Selvamony et al. OSLE-India, Chennai and Sarup & Sons: New Delhi, 2007. Print.

Sutton, Mark Q and E. N. Anderson. *Introduction to Cultural Ecology* (3rd edition). Lanham/ Maryland: Alta Mira Press (A Division of Rowman & Littlefield), 2014. Print.



Food, Festivals and Sweets: Creating Cultural Identity of Bengal in the 21st Century

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Abstract

Food is an important part of culture and creates our identity. The term multiculturalism is also associated with food. Food has some social significance also. Food is important for understandings our society and has deep impact on different rituals. It creates relationships between people and strengthens bonds. Modernization, nationalism is important while we discuss ritualistic food. We cannot get the real picture of the Bengali dishes if we don't give any description of sweets. From ancient times Bengalis prepared sweets and offered to Gods. On every occasion we prepare sweets. It creates our identity and differs us from others. From ancient period to modern times there are mention of preparing and consuming sweets by the Bengalis. Sweets are part of our different religious practises. In ancient or medieval times sweets were not prepared from channa or curdled milk. It was the Portuguese who first introduced channa in Bengal and sweets were prepared from it after that. We are grateful to Nabin Chandra Das who invented rosogolla in Bengal. Apart from that sandesh, pantua, makha sandesh, kalojam, kanchagolla etc are made and consumed by the sweet lovers of Bengal. 19th century is regarded as the golden age of Bengali sweets and from this time sweet creates the identity of the people of Bengal.

Food is not just to satiate our appetite but it is the expression of our cultural identity. We share our cultural tradition, identity, practices and customs with each other and create a new cultural identity and food is the medium of creating the identity. Like language food has the power to interact with each other belong to different cultural zones. It strengthens social bonds by expressing cultural identity. Sociologist Robin Fox pointed out that our religion, ethnicity and social classes all these are reflected in our food habits. Sometimes food creates 'forge alliances' with others because sometimes we are compelled to stay in a situation and consume that kind of food with which we are not habituated with. Fox said "Food is almost always shared; people eat together; mealtimes are events when the whole family or settlement or village comes together. Food is an occasion for sharing- for the expression of altruism."¹

Food creates multiculturalism, not only food but sometimes ritualistic

cultural identity in a very exclusive way. It is the expression of friendship and hospitality. It is an integral part of our religious rituals. In this way, different types of sweets on different occasions and their process of making have been discussed to prove the fact that how sweet influences the Bengali mind and sentiment. In this way a deep and rich culture developed in Bengal. It strengthens the bonds between different people and brings them very close together. It has some symbolic meaning which creates a platform for association for people belong to different or same group. Many times, people make different and special kind of sweets to make the occasions very special and memorable. It will not be wrong to say that sweet marks the cultural identity of Bengal and makes our culture rich and colourful.

References

- 1 Fox, Robin, "Food and Eating: An Anthropological Perspective" in *Social Issues*, Centre, La Trobe University, 2014, Vol. 12, pp. 1-22.
- 2 Ibid.
- 3 Kothari, Geeta, "If You Are What You Eat, Then What Am I?" in *Kenyon*, Kenyon College, Gambier, 1999, vol. XXI, No. I, pp 1-17.
- 4 Cwiertka, J., Katarzyna, *Food and war in Mid-Twentieth Century East Asia*, Publishing Limited, 2013, p.409.
- 5 Allen Matthew and Rumi Sakamoto, *Popular Culture, Globalization and* Routledge, 2006.
- 6 Ibid.
- 7 *Food and Identity: A Global Approach*, found in www.foodandidentity.wordpress.com, date of access 08/05/2019.
- 8 Ibid.
- 9 Sen, Sukumar, *History of Bengali literature*, Sahitya Academy, 1960.
- 10 Achaya, K.T., *The Illustrated Food of India: A-Z*, Oxford University Press, 2008.
- 11 Dey, Ishita, "Crafting Sweets in Bengal: Practices and Rituals," in *Overview*, 5 February 2017, found in <https://www.sahapedia.org>, date of access, 10/09/2019.
- 12 Kaviraj, Krishnadas, *Chaitanyacharitamrita*, Sri Sukumar Sen (ed), Sahitya Akademi, New Delhi, 1963.
- 13 Haldar, J., *Bengal Sweets: Revised and Enlarged*, Facsimile Publisher, Kolkata, 2015.
- 14 Ibid.
- 15 Roy, Pratap Kumar, "Food of Calcutta-Past and Present," www.geocities.ws/cuisines-past, date of access, 11/09/2019.
- 16 "The Poi la Baisakh Sweet Platter" found in <https://m.telegraphindia.com>, date of access, 02/04/2019.
- 17 Roy, Pratap Kumar, "Food of Calcutta-Past and Present".



A random-permutation based GA for generalized traveling salesman problem in imprecise environments

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Abstract

A random-permutation technique and the features of the genetic algorithm (GA) are combined together to develop a novel heuristic for solving generalized travelling salesman problem. Here, the random-permutation technique is used to find the sequence of clusters of a probable solution in which a complete tour to be commenced. The features of GA are used to select the cities from different clusters of the sequence. The algorithm has the ability to solve the problems in both the crisp as well as in the imprecise environments. A fuzzy membership-based selection process is proposed to select a solution for the mating pool. A general comparison rule of the solutions is proposed to rank the potential solutions of the population in imprecise environments. In the crisp environment, the efficiency of the proposed approach is tested against a set of different benchmark test problems from GTSP LIB having sizes up to 226 cities with 26 clusters. It is observed from the experimental results that the algorithm produces 100% accurate results for all the benchmark test problems under consideration. Imprecise test problems are generated from different benchmark crisp test problems of TSPLIB and are used to test the algorithm in the imprecise environments. It is also observed from the experimental results that the proposed approach finds multiple optimal paths (i.e., more than one path), if exists, for the problems in the crisp as well as in the imprecise environments.

Keywords Traveling salesmen problem · Genetic algorithm · Randomness · Triangular fuzzy number · Rough set

1 Introduction

A generalized form of the classical Traveling Salesman Problem (TSP), the generalized TSP (GTSP) was introduced by Henry-Labordere [11], Saksena [31], and Srivastava [33] in the context of computer record balancing and of visit sequencing through welfare agencies in 1960s. The problem consists of a set of n cities and a cost matrix $(c_{ij})_{n \times n}$, where,

c_{ij} is the cost of travelling from city i to city j . The n cities are grouped into several clusters- cl_1, cl_2, \dots, cl_k , where k is the number of clusters. Every city must belongs to at least one cluster. So, a city may belongs to more than one clusters. A salesman starts from a city of a cluster, visits one and only one city of every cluster and returns to the starting city with the minimum expenditure. So, the goal of the problem is to find the path/route of the salesman with the minimum cost covering all the clusters exactly once. There are several real-life applications of GTSP, such as, mail delivery [17], welfare agency routing [31], material flow system design [17], vehicle routing [17], and computer file sequencing [11], etc. The GTSP belongs to the class of NP-hard problems.

In most of the above-mentioned studies it is implicitly assumed that the travel cost, c_{ij} between any two cities i and j , is fixed and crisp in nature. But c_{ij} depends on the several factors, like, the quality of the vehicle used, condition of the roadways, duration of the travel, weather condition, etc. The travelling cost between any two cities mainly depends on the quality of transport used for the purpose. Sometimes it depends on the availability of the vehicle, condition of the road ways, etc., though its value normally lies in an interval.

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35. Wu CG, Liang YC, Lee HP, Lu C (2004) A generalized chromosome genetic algorithm for generalized traveling salesman problems and its applications for machining. *Phys Rev E* 70:016701
36. Yang J, Shi X, Marchese M, Liang Y (2008) An ant colony optimization method for generalized TSP problem. *Prog Nat Sci* 18:1417–1422
37. Zadeh L (1965) Fuzzy sets. *Inf Control* 8:338–356
38. Zhao X, Zhu XP (2010) Innovative genetic algorithm for solving GTSP. In: Second international conference on modeling,

simulation and visualization methods. College of Computer Science and Engineering, Guangdong Institute of Science and Technology

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Multi-objective traveling salesman problem: an ABC approach

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Abstract

Using the concept of swap operation and swap sequence on the sequence of paths of a Traveling Salesman Problem(TSP) Artificial Bee Colony (ABC) algorithm is modified to solve multi-objective TSP. The fitness of a solution is determined using a rule following the dominance property of a multi-objective optimization problem. This fitness is used for the selection process of the onlooker bee phase of the algorithm. A set of rules is used to improve the solutions in each phase of the algorithm. Rules are selected according to their performance using the roulette wheel selection process. At the end of each iteration, the parent solution set and the solution sets after each phase of the ABC algorithm are combined to select a new solution set for the next iteration. The combined solution set is divided into different non-dominated fronts and then a new solution set, having cardinality of parent solution set, is selected from the upper-level non-dominated fronts. When some solutions are required to select from a particular front then crowding distances between the solutions of the front are measured and the isolated solutions are selected for the preservation of diversity. Different standard performance metrics are used to test the performance of the proposed approach. Different sizes standard benchmark test problems from TSPLIB are used for the purpose. Test results show that the proposed approach is efficient enough to solve multi-objective TSP.

Keywords Multi-objective traveling salesmen problem · Artificial bee colony algorithm · Swap operation · Pareto optimal solution · Performance metric

1 Introduction

Most of the real-life problems involve multiple conflicting goals, which leads to multi-objective optimizations, e.g., optimization of the profit of a company as well as the customer satisfaction; optimization of transportation time as well as transportation cost of a transport company; etc. In a multi-objective optimization problem (MOOP), as the

objective functions are generally conflicting in nature, the concept of optimality does not hold; rather the concept of pareto optimality takes place. Two solutions are called pareto optimal if each solution is better than the other with respect to at least one objective. One solution is said to be better than another one if it is better or equal with respect to all the objectives and strictly better with respect to at least one objective. Different multi-objective evolutionary algorithms (MOEAs) are proposed by several researchers [7, 9, 12, 40, 48] in the past decades. For a complete survey on MOEAs please see [44].

The Traveling Salesmen Problem (TSP) is one of the standard combinatorial optimization problems and is a familiar NP-hard problem [28, 29]. The problem consists of a complete graph of n vertices (node/ cities) where each edge is associated with a parameter having known value (the distance /the travel time/ the travel risk etc., between the associated nodes). The aim of the problem is to find a Hamiltonian circuit having minimum value (the distance /the travel time/ the travel risk etc.). When there is only one parameter associated with each edge, then the problem is called single-objective TSP (SOTSP) [24–26]. On the other hand, when more than one parameters are associated with each edge, the problem is called Multi-Objective

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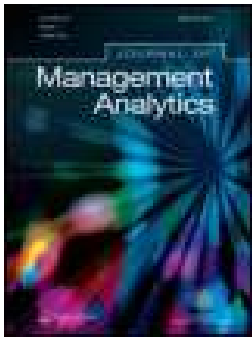
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21. Karaboga D, Gorkemli B, Ozturk C, Karaboga N (2014) A comprehensive survey: artificial bee colony (ABC) algorithm and applications. *Artif Intell Rev* 42(1):21–57
22. Karaboga D, Gorkemli B (2011) A combinatorial artificial bee colony algorithm for traveling salesman problem. In: 2011 international symposium on innovations in intelligent systems and applications. IEEE, pp 50–53
23. Khanra A, Pal T, Maiti MK, Maiti M (2019) Multi-objective four dimensional imprecise TSP solved with a hybrid multi-objective ant colony optimization-genetic algorithm with diversity. *Journal of Intelligent & Fuzzy Systems* 36(1):47–65
24. Khan I, Pal S, Maiti MK (2019) A hybrid PSO-GA algorithm for traveling salesman problems in different environments. *International Journal of Uncertainty Fuzziness and Knowledge-Based Systems* 27(05):693–717
25. Khan I, Maiti MK (2019) A swap sequence based artificial bee colony algorithm for traveling salesman problem. *Swarm and Evolutionary Computation* 44:428–438
26. Khan I, Maiti MK, Maiti M (2017) Coordinating particle swarm optimization, ant colony optimization and K-Opt algorithm for traveling salesman problem. In: *International conference on mathematics and computing*. Springer, Singapore, pp 103–119
27. Khan I, Maiti MK (2018) A novel hybrid algorithm for generalized traveling salesman problems in different environments. *Vietnam Journal of Computer Science* 5(1):27–43
28. (1985) *The traveling salesman problem: a guided tour of combinatorial optimization*. Wiley-Interscience Series in Discrete Mathematics
29. Lin S, Kernighan BW (1973) An effective heuristic algorithm for the traveling-salesman problem. *Operations Research* 21(2):498–516
30. Li H, Zhang Q (2008) Multi-objective optimization problems with complicated Pareto sets, MOEA/d and NSGA-II. *IEEE Transactions on Evolutionary Computation* 13(2):284–302
31. Maity S, Roy A, Maiti M (2016) An imprecise multi-objective genetic algorithm for uncertain constrained multi-objective solid travelling salesman problem. *Expert Systems With Applications* 46:196–223
32. Moraes DH, Sanches DS, da Silva Rocha J, Garbelini JMC, Castoldi MF (2019) A novel multi-objective evolutionary algorithm based on subpopulations for the bi-objective traveling salesman problem. *Soft Comput* 23(15):6157–6168
33. Martin-Moreno R, Vega-Rodriguez MA (2018) Multi-objective artificial bee colony algorithm applied to the bi-objective orienteering problem. *Knowl-Based Syst* 154:93–101
34. Michalewicz Z, Hartley SJ (1996) Genetic algorithms+ data structures= evolution programs. *Math Intell* 18(3):71
35. Pan QK, Tasgetiren MF, Suganthan PN, Chua TJ (2011) A discrete artificial bee colony algorithm for the lot-streaming flow shop scheduling problem. *Information sciences* 181(12):2455–2468
36. Psychas ID, Delimpasi E, Marinakis Y (2015) Hybrid evolutionary algorithms for the multiobjective traveling salesman problem. *Expert Syst Appl* 42(22):8956–8970
37. Reinelt G (1991) TSPLIB—a traveling salesman problem library. *ORSA Journal on Computing* 3(4):376–384
38. Samanlioglu F, Ferrell WG Jr, Kurz ME (2008) A memetic random-key genetic algorithm for a symmetric multi-objective traveling salesman problem. *Computers & Industrial Engineering* 55(2):439–449
39. Singh A (2009) An artificial bee colony algorithm for the leaf-constrained minimum spanning tree problem. *Appl Soft Comput* 9(2):625–631
40. Srinivas N, Deb K (1994) Multi-objective optimization using non dominated sorting in genetic algorithms. *Evolutionary Computation* 2(3):221–248
41. Tang L, Zhou Y, Xiang Y, Lai X (2016) A multi-objective artificial bee colony algorithm combined with a local search method. *International Journal on Artificial Intelligence Tools* 25(03):1650009
42. Wong LP, Low MYH, Chong CS (2010) Bee colony optimization with local search for traveling salesman problem. *International Journal on Artificial Intelligence Tools* 19(03):305–334
43. Wang KP, Huang L, Zhou CG, Pang W (2003) Particle swarm optimization for traveling salesman problem. In: *Proceedings of the 2003 international conference on machine learning and cybernetics*, vol 3. IEEE, pp 1583–1585
44. Zhou A, Qu BY, Li H, Zhao SZ, Suganthan PN, Zhang Q (2011) Multi-objective evolutionary algorithms: a survey of the state of the art. *Swarm and Evolutionary Computation* 1(1):32–49
45. Zou W, Zhu Y, Chen H, Zhang B (2011) Solving multiobjective optimization problems using artificial bee colony algorithm. *Discrete dynamics in nature and society*
46. Zitzler E, Laumanns M, Thiele L (2001) SPEA2: improving The strength Pareto evolutionary algorithm. TIK-report, 103
47. Zitzler E (1999) *Evolutionary algorithms for multi-objective optimization: methods and applications* (vol 63). Ithaca: Shaker
48. Zitzler E, Thiele L (1998) Multi-objective optimization using evolutionary algorithms—a comparative case study. In: *International conference on parallel problem solving from nature*. Springer, Berlin, pp 292–301
49. Zitzler E, Thiele L (1999) Multi-objective evolutionary algorithms: a comparative case study and the strength Pareto approach. *IEEE Transactions on Evolutionary Computation* 3(4):257–271

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An EOQ model with backordering for perishable items under multiple advanced and delayed payments policies

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An EOQ model with backordering for perishable items under multiple advanced and delayed payments policies

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This study investigated an economic order quantity (EOQ) model with complete backorder for fixed lifetime perishable items under multiple advance and delayed payments policies. Here, a new type of business policy is considered where supplier offers the retailer to pay a fraction of the purchasing cost before the order delivery by multiple equal installments starting from the ordering time and the rest amount after the delivery by multiple equal installments. Here, some theoretical results are illustrated to determine the conditions of existence and uniqueness of the optimal solutions. A closed form solution is determined to solve the proposed model under approximation. Some numerical examples are provided to examine the validity of the proposed model. Finally, sensitivity analyses are presented to obtain the effect of optimal policy and provide some managerial insights of the model.

Keywords: inventory; perishable item; expiry date; advance payment; delayed payment

1. Introduction

Payment policies of purchasing price for the items ordered and customer's reaction effect on out of stock of an item is the significant factor in the economic order quantity model. In 1913, F.W. Harris developed an EOQ (Economic Order Quantity) model, by considering with the assumption that the retailer or customer pays the whole amount of purchasing the item just when received the items. After that, many researcher and practitioners made their efforts to adjust the assumption to more realistic in inventory management. Based on the nature of payment of the purchase cost, there are three basic possibilities which are the following types: (i) payment before the receiving of delivery of the order quantity which is known as advance payment or prepayment. Several researchers, viz. Gupta, Bhunia, and Goyal (2009), Taleizadeh, Pentico, Jabalameli, and Aryanezhad (2013), Teng, Cárdenas-Barrón, Chang, Wu, and Hu (2016), Wu, Teng, and Chan (2017), Manna, Das, and Tiwari (2020) and others were reported interesting works in this area. (ii) payment just on the time of delivery (Ghosh, Manna, & Dey, 2017; Mallick, Manna, & Mondal, 2018; Shah & Cárdenas-Barrón, 2015), (iii) payment after the

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- Yang, M.-F., & Tseng, W.-C. (2015). Deteriorating inventory model for chilled food. *Mathematical Problems in Engineering*, 2015, 1–10. doi:10.1155/2015/816876
- Zhou, Y. W., Zhong, Y. G., & Wahab, M. I. M. (2013). How to make the replenishment and payment strategy under flexible two-part trade credit. *Computers and Operations Research*, 40, 1328–1338.

AN IMPERFECT PRODUCTION INVENTORY MODEL WITH ADVANCE PAYMENT AND CREDIT PERIOD IN A TWO-ECHELON SUPPLY CHAIN MANAGEMENT

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Abstract. This paper presents an integrated imperfect production inventory model under two layer supply chain management. To ensure the orders, manufacturer convinces the retailer to pay a percentage of the purchasing cost prior to replenish the products and offers the facilities such as (i) delay in payment on the remaining part of the purchasing cost and (ii) free transportation on the basis of advance payment amount. Time dependent development cost is incurred to maintain the reliability of the production system and as a result it reduces the imperfectness of the product during production. Under such circumstances, an integrated profit function has been developed to find the optimum number of production cycle, optimum number of replenishment cycle and hence reliability parameter of the manufacturing system, replenishment quantity for the retailer which maximize the integrated profit. Branch and Bound technique is used to obtain the integer solutions. Furthermore, we derived some useful lemmas and algorithms to obtain the optimum solution. Finally, the model has been illustrated with some numerical examples exploring the sensitivity analysis with respect to some parameters and obtains some managerial insights.

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1. INTRODUCTION

In present's competitive situation, supply chain management (SCM) plays a vital role in economy because it makes an integrated networking system among supplier, manufacturer, retailer and customer and learns how to survive in the present's competitive market through the co-operation among supplier, manufacturer, retailer and customer. It also co-ordinates a system of inter-related business process in order to procurement of raw materials, transportation of raw-materials, production of items, transportation of the finished product to the retailer for sale to satisfy their customers' demand. Along this direction, some previous research works to build an integrated SCM dates back to Bookbinder, Cachon and Zipkin [5], Agarwal *et al.* [1] and others. They have presented a production, distribution and inventory (PDI) planning system that integrated three supply

Keywords. Imperfect production, advance payment, replenishment cycle time, system reliability, credit period, branch and bound technique.

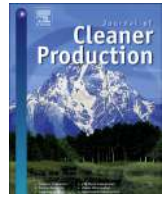
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- [8] B.C. Das, B. Das and S.K. Mondal, An integrated production-inventory model with defective item dependent stochastic credit period. *Comput. Ind. Eng.* **110** (2017) 255–263.
- [9] S.K. De and G.C. Mahata, A production inventory supply chain model with partial backordering and disruption under triangular linguistic dense fuzzy lock set approach. *Soft Comput.* **24** (2020) 5053–5069.
- [10] S.K. De and G.C. Mahata, An EPQ model for three-layer supply chain with partial backordering and disruption: triangular dense fuzzy lock set approach. *Sadhana* **44** (2019) 177.
- [11] S.K. De and G.C. Mahata, A cloudy fuzzy economic order quantity model for imperfect-quality items with allowable proportionate discounts. *J. Ind. Eng. Int.* **15** (2019) 571–583.
- [12] S.K. De and G.C. Mahata, A comprehensive study of an economic order quantity model under fuzzy monsoon demand. *Sadhana, Indian Acad. Sci.* **44** (2019) 89.
- [13] S.K. De and S.S. Sana, Two-layer supply chain model for cauchy type stochastic demand under fuzzy environment. *Int. J. Intell. Comput. Cybern.* **11** (2018) 285–308.
- [14] S.K. Goyal, Economic order quantity under conditions of permissible delay in payments. *J. Oper. Res. Soc.* **36** (1985) 335–338.
- [15] S.K. Goyal, A joint economic-lot-size model for purchaser and vendor: a comment. *Decis. Sci.* **19** (1988) 236–241.
- [16] R.K. Gupta, A.K. Bhunia and S.K. Goyal, An application of Genetic Algorithm in solving an inventory model with advance payment and interval valued inventory costs. *Math. Comput. Modell.* **49** (2009) 893–905.
- [17] M.A. Khan, A.A. Shaikh, G.C. Panda and I. Konstantaras, Two-warehouse inventory model for deteriorating items with partial backlogging and advance payment scheme. *RAIRO:OR* **53** (2019) 1691–1708.
- [18] M.A. Khan, A.A. Shaikh, G.C. Panda, I. Konstantaras and L.E. Cardenas-Barron, The effect of advance payment with discount facility on supply decisions of deteriorating products whose demand is both price and stock dependent. *Int. Trans. Oper. Res.* **27** (2020) 1343–1367.
- [19] B. Khara, J.K. Dey and S.K. Mondal, An inventory model under development cost dependent imperfect production and reliability dependent demand. *J. Manage. Anal.* **4** (2017) 258–275.
- [20] B. Khara, J.K. Dey and S.K. Mondal, Sustainable recycling in an imperfect production system with acceptance quality level dependent development cost and demand. *Comput. Ind. Eng.* **142** (2020) 106300.
- [21] B. Khara, J.K. Dey and S.K. Mondal, An integrated imperfect production system with advertisement dependent demand using branch and bound technique. To appear in: *Flexible Serv. Manuf. J.* (2020). DOI: [10.1007/s10696-020-09377-5](https://doi.org/10.1007/s10696-020-09377-5).
- [22] M. Khouja and A. Mehrez, An economic production lot size model with imperfect quality and variable production rate. *J. Oper. Res. Soc.* **45** (1994) 1405–1417.
- [23] M. Lashgari, A.A. Taleizadeh and A. Ahmadi, Partial up-stream advanced payment and partial down-stream delayed payment in a three-level supply chain. *Ann. Oper. Res.* **238** (2016) 329–354.
- [24] M. Lashgari, A.A. Taleizadeh and S.J. Sadjadi, Ordering policies for non-instantaneous deteriorating items under hybrid partial prepayment, partial trade credit and partial backordering. *J. Oper. Res. Soc.* **69** (2018) 1167–1196.
- [25] R. Li, Y.L. Chan, C.T. Chang and L.E. Cárdenas-Barron, Pricing and lot-sizing policies for perishable products with advance-cash-credit payments by a discounted cash-flow analysis. *Int. J. Prod. Econ.* **193** (2017) 578–589.
- [26] Y. Liang and F. Zhou, A two-warehouse inventory model for deteriorating items under conditionally permissible delay in payment. *Appl. Math. Modell.* **35** (2011) 2221–2231.
- [27] S. Ma, J. Lin, W. Xing and X. Zhao, Advance booking discount in the presence of spot market. *Int. J. Prod. Res.* **53** (2015) 2921–2936.
- [28] S. Maity, A. Chakraborty, S.K. De, S.P. Mondal and S. Alam, A comprehensive study of a backlogging EOQ model with nonlinear heptagonal dense fuzzy environment. *RAIRO:OR* **54** (2020) 267–286.
- [29] A.K. Manna, J.K. Dey and S.K. Mondal, Three-layer supply chain in an imperfect production inventory model with two storage facilities under fuzzy rough environment. *J. Uncertainty Anal. App.* **2** (2014) 17.
- [30] A.K. Manna, B. Das, J.K. Dey and S.K. Mondal, Multi-item EPQ model with learning effect on imperfect production over fuzzy-random planning horizon. *J. Manage. Anal.* **4** (2016) 80–110.
- [31] A.K. Manna, J.K. Dey and S.K. Mondal, Imperfect production inventory model with production rate dependent defective rate and advertisement dependent demand. *Comput. Ind. Eng.* **104** (2017) 9–22.
- [32] M.J. Rosenblatt and H.L. Lee, Economic production cycles with imperfect production processes. *IIE Trans.* **18** (1986) 48–55.
- [33] M. Salameh and M.Y. Jaber, Economic production quantity model for items with imperfect quality. *Int. J. Prod. Econ.* **64** (2000) 59–64.
- [34] S.S. Sana, A production-inventory model of imperfect quality products in a three-layer supply chain. *Decis. Support Syst.* **50** (2011) 539–547.
- [35] A.A. Shaikh, S.C. Das, A.K. Bhunia, G.C. Panda and M.A. Khan, A two-warehouse EOQ model with interval-valued inventory cost and advance payment for deteriorating item under particle swarm optimization. *Soft Comput.* **23** (2019) 13531–13546.
- [36] Y. Shi, Z. Zhang, S.C. Chen, L.E. Cardenas-Barron and K. Skouri, Optimal replenishment decisions for perishable products under cash, advance, and credit payments considering carbon tax regulations. *Int. J. Prod. Econ.* **223** (2020) 107514.
- [37] A.A. Taleizadeh, An EOQ model with partial backordering and advance payments for an evaporating item. *Int. J. Prod. Econ.* **155** (2014) 185–193.
- [38] A.A. Taleizadeh, Lot-sizing model with advance payment pricing and disruption in supply under planned partial backordering. *Int. Trans. Oper. Res.* **24** (2017) 783–800.
- [39] A.A. Taleizadeh, D.W. Pentico, M.S. Jabalameli and M. Aryanezhad, An economic order quantity model with multiple partial prepayments and partial backordering. *Math. Comput. Modell.* **57** (2013) 311–323.

- [40] S. Tavakoli and A.A. Taleizadeh, An EOQ model for decaying item with full advanced payment and conditional discount. *Ann. Oper. Res.* **259** (2017) 415–436.
- [41] A. Thangam, Optimal price discounting and lot-sizing policies for perishable items in a supply chain under advance payment scheme and two-echelon trade credits. *Int. J. Prod. Econ.* **139** (2012) 459–472.
- [42] Q.H. Zhang, Y.C. Tsao and T.H. Chen, Economic order quantity under advance payment. *Appl. Math. Modell.* **38** (2014) 5910–5921.
- [43] Q. Zhang, D. Zhang, Y.C. Tsao and J. Luo, Optimal ordering policy in a two-stage supply chain with advance payment for stable supply capacity. *Int. J. Prod. Econ.* **177** (2016) 34–43.
- [44] N.P. Zia and A.A. Taleizadeh, A lot-sizing model with backordering under hybrid linked-to-order multiple advance payments and delayed payment. *Transp. Res. Part E* **82** (2015) 19–37.



Supply chain coordination model for green product with different payment strategies: A game theoretic approach



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ABSTRACT

In our world, pollution arising from various sources like factories and vehicles, threaten the very environment we live in. We should become more and more aware of the products that pose a threat to our environment because otherwise through our lack of awareness, we will ourselves contribute towards the distractions of our beloved and beautiful world. In this paper, we have brought into focus a work regarding making the supply chain of a product as green as we possibly can. We have developed a strategy based on the manufacturer's advanced payment policy as well as trade credit facility to the retailer. We have assumed that for any particular retailer, the customers' demand for his goods is a direct consequence of how green the goods are, along with the selling price and the effort put into the environment friendliness of a product. To this effect, the manufacturer also allows the retailer a credit period for the goods as also a discount that can imposed on the selling price. We have provided a model that optimizes the retailer's sales effort, the wholesale price demanded by the manufacturer, the green level of the product as well as the selling price effected by the retailers. This model is exemplified numerically of its practicality. We also perform some sensitivity analyses of the model by varying market demand, price elasticity coefficient, greening awareness level and sales effort and the corresponding performance shown by the model are also recorded.

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1. Introduction

In recent times most of the world is under a threat from environmental pollution. Numerous researchers have dedicated their research time on green supply chain system (GSCS) to reduce the pollution in the environment. The concept of green supply chain system (GSCS) has been derived from traditional supply chain system (SCS) by embroilment of green activities in the supply chain. The aim of GSCS is sustainability on environmental front from suppliers to customer and manufacturer. Yadav and Pathak (2016) reported that most of the young customers will buy green (eco-friendly) products, which has been manufactured in an environmentally friendly fashion, and to create minimum havoc on the environment. To accommodate this situation manufacturers give

attention to producing green products. Recently, Sana (2020) pointed out that the authorities in developed countries collect lower tax from green product manufacturers than non-green product manufacturers. He also considered green technology investment to reduce carbon emission of the firm. As such, many researchers, viz. Chan and Lau (2002), Zhu et al. (2005), Zhang and Liu (2013), Wood et al. (2016), Manna et al. (2017), Jamali and Rasti-Barzoki (2018), Panja and Mondal (2019), Zhang et al. (2020) and others have been working on green supply chain system (GSCS) that reduce environment pollution and earn maximum profit for the supply chain members.

In a competitive market, delay-in-payment scheme is a very important strategy to run the business smoothly. Generally, the supplier offers the retailer the opportunity for paying partial an

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- solving an inventory model with advance payment and interval valued inventory costs. *Math. Comput. Model.* 49 (5–6), 893–905.
- Gurnani, H., Erkoc, M., 2008. Supply contracts in manufacturer, retailer interactions with manufacturer, quality and retailer effort, induced demand. *Nav. Res. Logist.* 55 (3), 200–217.
- He, Y., Zhao, X., Zhao, L., He, J., 2009. Coordinating a supply chain with effort and price dependent stochastic demand. *Appl. Math. Model.* 33 (6), 2777–2790.
- Heydari, J., Asl-Najafi, J., 2018. A revised sales rebate contract with effort-dependent demand: a channel coordination approach. *Int. Trans. Oper. Res.* <https://doi.org/10.1111/itor.12556>.
- Jamali, M.B., Rasti-Barzoki, M., 2018. A game theoretic approach for green and non-green product pricing in chain-to-chain competitive sustainable and regular dual-channel supply chains. *J. Clean. Prod.* 170, 1029–1043.
- Khan, M.A.A., Shaikh, A.A., Konstantaras, I., Bhunia, A.K., Cárdenas-Barrón, L.E., 2020. Inventory models for perishable items with advanced payment, linearly time-dependent holding cost and demand dependent on advertisement and selling price. *Int. J. Prod. Econ.* 107804.
- Lou, W., Ma, J., 2018. Complexity of sales effort and carbon emission reduction effort in a two-parallel household appliance supply chain model. *Appl. Math. Model.* 64, 398–425. <https://doi.org/10.1016/j.apm.2018.07.042>.
- Lu, C.-J., Yang, C.-T., Yen, H.-F., 2020. Stackelberg game approach for sustainable production-inventory model with collaborative investment in technology for reducing carbon emissions. *J. Clean. Prod.* 121–963. <https://doi.org/10.1016/j.jclepro.2020.121963>.
- Mahata, G.C., 2012. An EPQ-based inventory model for exponentially deteriorating items under retailer partial trade credit policy in supply chain. *Expert Syst. Appl.* 39 (3), 3537–3550.
- Manna, A.K., Das, B., Dey, J.K., Shyamal, S.K., 2017. Two layers green supply chain imperfect production inventory model under bi-level credit period. *TKHNE - Review of Applied Management Studies* 15 (2), 124–142.
- Manna, A.K., Das, B., Tiwari, S., 2020. Impact of carbon emission on imperfect production inventory system with advance payment base free transportation. *Rairo Oper. Res.* 54, 1103–1117.
- Mishra, U., Wu, J.Z., Tseng, M.L., 2019. Effects of a hybrid-price-stock dependent demand on the optimal solutions of a deteriorating inventory system and trade credit policy on re-manufactured product. *J. Clean. Prod.* 241, 118282.
- Ogilvie, J., Rapp, A., Agnihotri, R., Bachrach, D.G., 2017. Translating sales effort into service performance: it's an emotional ride. *J. Personal Sell. Sales Manag.* 37 (2), 100–112.
- Panja, S., Mondal, S.K., 2019. Analyzing a four-layer green supply chain imperfect production inventory model for green products under type-2 fuzzy credit period. *Comput. Ind. Eng.* 129, 435–453.
- Panja, S., Mondal, S.K., 2020. Exploring a two-layer green supply chain game theoretic model with credit linked demand and mark-up under revenue sharing contract. *J. Clean. Prod.* <https://doi.org/10.1016/j.jclepro.2019.119491>.
- Petersen, M.A., Rajan, R.G., 1997. Trade credit: theories and evidence. *Rev. Financ. Stud.* 10 (3), 661–691.
- Rajagopal, Pitt, M., Price, S., 2010. Measuring sales performance of home dcor products. *J. Retail Leisure Property* 9 (2), 105–124.
- Roy, A., Sana, S.S., Chaudhuri, K., 2018. Optimal Pricing of competing retailers under uncertain demand—a two layer supply chain model. *Ann. Oper. Res.* 260 (1–2), 481–500.
- Roy, A., Sana, S.S., Chaudhuri, K., 2016. Joint decision on EOQ and pricing strategy of a dual channel of mixed retail and e-tail comprising of single manufacturer and retailer under stochastic demand. *Comput. Ind. Eng.* 102, 423–434.
- Saha, S., Modak, N.M., Panda, S., Sana, S.S., 2019. Promotional coordination mechanisms with demand dependent on price and sales efforts. *Journal of Industrial and Production Engineering* 1–19. <https://doi.org/10.1080/21681015.2019.1565451>.
- Sana, S.S., 2012. Price sensitive demand with random sales price a newsboy problem. *Int. J. Syst. Sci.* 43 (3), 491–498.
- Sana, S.S., 2020. Price competition between green and non green products under corporate social responsible firm. *J. Retailing Consum. Serv.* 55, 102–118.
- Sane-Zerang, E., Razmi, J., Taleizadeh, A.A., 2019. Coordination in a closed-loop supply chain under asymmetric and symmetric information with sales effort-dependent demand. *J. Bus. Econ.* <https://doi.org/10.1007/s11573-019-00955-0>.
- Taleizadeh, A.A., 2014. An economic order quantity model for deteriorating item in a purchasing system with multiple prepayments. *Appl. Math. Model.* 38 (23), 5357–5366.
- Taleizadeh, A.A., Pourmohammad-Zia, N., Konstantaras, I., 2019. Partial linked-to-order delayed payment and life time effects on decaying items ordering. *Operational Research* 1–23.
- Teng, J.T., Chang, C.T., 2009. Optimal manufacturer's replenishment policies in the EPQ model under two levels of trade credit policy. *Eur. J. Oper. Res.* 195 (2), 358–363.
- Thangam, A., Uthayakumar, R., 2009. Two-echelon trade credit financing for perishable items in a supply chain when demand depends on both selling price and credit period. *Comput. Ind. Eng.* 57 (3), 773–786.
- Tiwari, S., Cárdenas-Barrón, L.E., Goh, M., Shaikh, A.A., 2018. Joint pricing and inventory model for deteriorating items with expiration dates and partial backlogging under two-level partial trade credits in supply chain. *Int. J. Prod. Econ.* 200, 16–36.
- Tsao, Y.-C., 2013. A piecewise nonlinear optimization for a production-inventory model under maintenance, variable setup costs, and trade credits. *Ann. Oper. Res.* 233 (1), 465–481.
- Wang, X., Liu, Z., Chen, H., 2018. A composite contract for coordinating a supply chain with sales effort-dependent fuzzy demand. *International Journal of Machine Learning and Cybernetics.* <https://doi.org/10.1007/s13042-017-0774-5>.
- Wang, D., Du, G., Jiao, R.J., Wu, R., Yu, J., Yang, D., 2016. A Stackelberg game theoretic model for optimizing product family architecting with supply chain consideration. *Int. J. Prod. Econ.* 172, 1–18.
- Wood, L.C., Wang, C., Abdul-Rahman, H., Abdul-Nasir, N.S.J., 2016. Green hospital design: integrating quality function deployment and end-user demands. *J. Clean. Prod.* 112, 903–913.
- Wu, J., Chang, C.-T., Teng, J.-T., Lai, K.-K., 2017a. Optimal order quantity and selling price over a product life cycle with deterioration rate linked to expiration date. *Int. J. Prod. Econ.* 193, 343–351.
- Wu, C., Zhao, Q., Xi, M., 2017b. A retailer-supplier supply chain model with trade credit default risk in a supplier-Stackelberg game. *Comput. Ind. Eng.* 112, 568–575.
- Xing, D., Liu, T., 2012. Sales effort free riding and coordination with price match and channel rebate. *Eur. J. Oper. Res.* 219 (2), 264–271.
- Yadav, R., Pathak, G.S., 2016. Young consumers' intention towards buying green products in a developing nation: extending the theory of planned behavior. *J. Clean. Prod.* 135, 732–739.
- Zhang, A.X., 1996. Optimal advance payment scheme involving fixed per-payment costs. *Omega* 24 (5), 577–582.
- Zhang, X., Jin, Y., Shen, C., 2020. Manufacturers' green investment in a competitive market with a common retailer. *J. Clean. Prod.* 276, 123164.
- Zhang, C.T., Liu, L.P., 2013. Research on coordination mechanism in three-level green supply chain under non-cooperative game. *Appl. Math. Model.* 37 (5), 3369–3379.
- Zhang, Q., Zhang, D., Tsao, Y.-C., Luo, J., 2016. Optimal ordering policy in a two-stage supply chain with advance payment for stable supply capacity. *Int. J. Prod. Econ.* 177, 34–43.
- Zhou, Y.W., Zhou, D., 2013. Determination of the optimal trade credit policy: a supplier-Stackelberg model. *J. Oper. Res. Soc.* 64 (7), 1030–1048.
- Zhu, Q., Sarkis, J., Geng, Y., 2005. Green supply chain management in China: pressures, practices and performance. *Int. J. Oper. Prod. Manag.* 25 (5), 449–468.

EFFECT OF INSPECTION ERRORS ON IMPERFECT PRODUCTION INVENTORY MODEL WITH WARRANTY AND PRICE DISCOUNT DEPENDENT DEMAND RATE

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Abstract. This paper deals with selling price-discount and warranty period dependent demand in an imperfect production inventory model under the consideration of inspection errors and time dependent development cost. Normally, due to long-run, a production process deteriorates with time and here we assume that the process shifts from “in-control” to “out-of-control” state at any random time. A time dependent development cost has been constructed to increase the reliability of the production system *i.e.*, to decrease the deterioration of the system during the production process. As a result, a few items are rejected. Here, two types of inspection errors such as Type-I error and Type-II error, have been considered during the period of product inspection process. In Type-I error, an inspector may choose falsely a defective item as non-defective and in Type-II error an inspector may choose falsely a non-defective item as defective. Due to these phenomena, the inspection process would consist of the following costs: cost of inspection, cost of inspection errors. The purpose of this paper is to investigate the effects of time dependent development cost on the defective items, selling price-discount and warranty policy on the market demand and finally optimize the expected average profit under consideration of such inspection costs in infinite time horizon. Some numerical examples along with graphical illustrations and sensitivity analysis are provided to test the feasibility of the model.

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1. INTRODUCTION

In a real manufacturing system, a long-run production process shifts from “in-control” to “out-of-control” state due to different machinery problems, labor problems, etc. On the other hand, the production of defective units is a natural phenomenon to be occurred due to different difficulties arisen in a long-run production process. Normally, it is seen that a production process is initiated from “in-control” state, because every factors associated with the system are in well condition. Then due to continuous running of system, these factors gradually lose their perfectness. So, after some time, the production process may shift from “in-control” state to “out-of-control” state. For this reason, some imperfect items along with perfect items are produced in every

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- [15] A.K. Manna, B. Das, J.K. Dey and S.K. Mondal, Two layers green supply chain imperfect production inventory model under bi-level credit period. *TÉKHNE – Rev. Appl. Manage. Stud.* **15** (2017) 124–142.
- [16] A.K. Manna, J.K. Dey and S.K. Mondal, Controlling GHG emission from industrial waste perusal of production inventory model with fuzzy pollution parameters. *Int. J. Syst. Sci.: Oper. Logistics* **6** (2019) 368–393.
- [17] A.K. Manna, J.K. Dey and S.K. Mondal, Two layers supply chain in an imperfect production inventory model with two storage facilities under reliability consideration. *J. Ind. Prod. Eng.* **35** (2018) 57–73.
- [18] A.H. Nobil, A.H. Afshar Sedigh, S. Tiwari and H.M. Wee, An imperfect multi-item single machine production system with shortage, rework, and scrapped considering inspection, dissimilar deficiency levels, and non-zero setup times. *Sci. Iran.* **26** (2019) 557–570.
- [19] S. Panja and S.K. Mondal, Analyzing a four-layer green supply chain imperfect production inventory model for green products under type-2 fuzzy credit period. *Comput. Ind. Eng.* **129** (2019) 435–453.
- [20] E.L. Porteus, Optimal lot sizing, process quality improvement and setup cost reduction. *Oper. Res.* **34** (1986) 137–144.
- [21] A. Raouf, J.K. Jain and P.T. Sathe, A cost-minimization model for multi characteristic component inspection. *IIE Trans.* **15** (1983) 187–194.
- [22] T. Raz and D. Bricker, Sequencing of inspection operations subject to errors. *Eur. J. Oper. Res.* **68** (1993) 251–264.
- [23] A.H. Rentoul, G. Mullineux and A.J. Medland, Interpretation of errors from inspection results. *Comput. Integr. Manuf. Syst.* **7** (1994) 173–178.
- [24] M.J. Rosenblatt and H.L. Lee, Economic production cycles with imperfect production process. *IIE Trans.* **18** (1986) 48–55.
- [25] M.K. Salameh and M.Y. Jaber, Economic production quantity model for items with imperfect quality. *Int. J. Prod. Econ.* **64** (2000) 59–64.
- [26] S.S. Sana, An economic production lot size model in an imperfect production system. *Eur. J. Oper. Res.* **201** (2010) 158–170.
- [27] B. Sarkar, B.K. Sett and S. Sarkar, Optimal production run time and inspection errors in an imperfect production system with warranty. *J. Ind. Manage. Optim.* **14** (2018) 267–282.
- [28] S. Tiwari, L.E. Cárdenas-Barrón, A. Khanna and C.K. Jaggi, Impact of trade credit and inflation on retailer's ordering policies for non-instantaneous deteriorating items in a two-warehouse environment. *Int. J. Prod. Econ.* **176** (2016) 154–169.
- [29] S. Tiwari, C.K. Jaggi, A.K. Bhunia, A.A. Shaikh and M. Goh, Two-warehouse inventory model for non-instantaneous deteriorating items with stock-dependent demand and inflation using particle swarm optimization. *Ann. Oper. Res.* **254** (2017) 401–423.
- [30] S. Tiwari, H.M. Wee and S. Sarkar, Lot-sizing policies for defective and deteriorating items with time-dependent demand and trade credit. *Eur. J. Ind. Eng.* **11** (2017) 683–703.
- [31] S. Tiwari, C.K. Jaggi, M. Gupta and L.E. Cárdenas-Barrón, Optimal pricing and lot-sizing policy for supply chain system with deteriorating items under limited storage capacity. *Int. J. Prod. Econ.* **200** (2018) 278–290.
- [32] S. Tiwari, L.E. Cárdenas-Barrón, M. Goh and A.A. Shaikh, Joint pricing and inventory model for deteriorating items with expiration dates and partial backlogging under two-level partial trade credits in supply chain. *Int. J. Prod. Econ.* **200** (2018) 16–36.
- [33] S. Tiwari, Y. Daryanto and H.M. Wee, Sustainable inventory management with deteriorating and imperfect quality items considering carbon emission. *J. Cleaner Prod.* **192** (2018) 281–292.
- [34] S. Tiwari, W. Ahmed and B. Sarkar, Multi-item sustainable green production system under trade-credit and partial backordering. *J. Cleaner Prod.* **204** (2018) 82–95.
- [35] C.H. Wang and S.H. Sheu, Optimal lot size for products under free-repair warranty. *Eur. J. Oper. Res.* **149** (2003) 131–141.
- [36] C.H. Wang and S.H. Sheu, Determining the optimal production-maintenance policy with inspection errors: using Markovchain. *Comput. Oper. Res.* **30** (2003) 1–17.
- [37] R.H. Yeh, W.T. Ho and S.T. Teng, Optimal production run length for products sold with warranty. *Eur. J. Oper. Res.* **120** (2005) 575–582.



Nonclassical states and total noise in five-wave interaction process

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Abstract We investigated theoretically the squeezing, sub-Poissonian, and total noise of a quantum state in spontaneous and stimulated five-wave interaction process under short-time approximation. It has been found that the squeezing occurs in field amplitude, amplitude-squared in the fundamental mode in the process. It is shown that higher-order squeezing allows a much larger fractional noise reduction than lower-order squeezing. We observed that the squeezed states are associated with a large number of photons. It is shown that squeezing is greater in the stimulated interaction than the corresponding squeezing in the spontaneous interaction. The photon statistics of the fundamental mode in the process is investigated and found to be sub-Poissonian in nature. The effect of the sub-Poissonian nature of an optical field in terms of total noise is also incorporated. We showed that the depth of non-classicality directly depends on the amount of total noise present in the system. This suggests that the more squeezed the state is, the greater is its total noise in the system. It is found that a higher multi-photon absorption process is suitable for the generation of optimum squeezed light.

Keywords Multi-photon process · Squeezing · Sub-poissonian · Photon number · Total noise

Introduction

The idea of squeezing of the electromagnetic field was introduced by Hollenhorst [1] and Caves [2]. After that, D. F. Walls [3] has given a detailed review of squeezed states of light including the generation and detection of squeezed states as well as proposed potential applications. The concept of squeezing [4–10] in the quantized electromagnetic field has gained a great deal of importance in view of the possibility of reducing the noise of an optical signal below the shot-noise limit. R. E. Slusher et al. [11] have generated squeezed states of the electromagnetic field by non-degenerate four-wave mixing process and have measured with a balanced homodyne detector. Ling-Au Wu et al. [12] have generated squeezed states of light by parametric down-conversion in an optical cavity. Garraway et al. [13] have presented a simple scheme that allows the generation and detection of nonclassical states of the electromagnetic field with controllable photon number and phase distributions. Squeezing of radiation is a purely quantum mechanical phenomenon, and its low-noise property [14–16] has many attractive applications such as high-quality telecommunication [17] quantum cryptography [18, 19], and so on. The experimental detections and applications approve the importance of the theoretical investigations into various nonlinear optical processes such as Raman [20–22], Hyper-Raman [23], Harmonic Generation [24, 25], Multiwave-mixing processes [26–29], and so on. A squeezed state may exhibit sub-Poissonian photon statistics. The conversion of higher-order squeezed light into nonclassical light with higher-order sub-Poissonian

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It is concluded that greater total noise and hence greater squeezing exist in second order than in first order, having the same number of photons. It is inferred that the more squeezed the state is, the greater is its total noise in the system. Therefore, as the state becomes more sub-Poissonian, and its total noise increases.

These results suggest that the total noise of a quantum state can be measured the depth of nonclassicality i.e. more nonclassical state (squeezing and sub-Poissonian) of the field in any system.

References

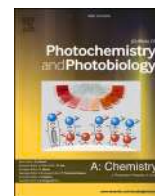
- J.N. Hollenhorst, Quantum limits on resonant-mass gravitational-radiation detectors. *Phys. Rev. D* **19**, 1669–1679 (1979)
- C.M. Caves, Quantum-mechanical noise in an interferometer. *Phys. Rev. D* **23**, 1693–1708 (1981)
- D.F. Walls, Squeezed states of light. *Nature* **306**, 141–146 (1983)
- R.E. Slusher, L.W. Hollberg, B. Yurke, J.C. Mertz, J.F. Valley, Observation of squeezed states generated by four-wave mixing in an optical cavity. *Phys. Rev. Lett.* **55**, 2409–2412 (1985)
- R.M. Shelby, M.D. Levenson, S.H. Perlmutter, R.G. DeVoe, D.F. Walls, Broad-band parametric deamplification of quantum noise in an optical fiber. *Phys. Rev. Lett.* **57**, 691–694 (1986)
- R. Loudon, P.L. Knight, Squeezed light. *J. Mod. Opt.* **34**, 709–759 (1987)
- M.C. Teich, B.E.A. Saleh, Squeezed states of light. *Quant. Opt.* **1**, 153–191 (1989)
- J. Perina, *Quantum Statistics of Linear and Nonlinear Optical Phenomena*. Kluwer, Dordrecht, Chapters 9 and 10 (1991)
- L. Mandel, Nonclassical states of the electromagnetic field. *Phys. Scr. T.* **12**, 34–42 (1986)
- V.V. Dodonov, Nonclassical states in quantum optics: a squeezed review of the first 75 years. *J. Opt. B Quant. Semiclass. Opt.* **4**, R1–R33 (2002)
- R.E. Slusher, B. Yurke, J. Mertz, Experimental progress in intracavity generation of squeezed light using resonant atomic nonlinearities. *J. Mod. Opt.* **34**, 761–773 (1987)
- L.A. Wu, H.J. Kimble, J.L. Hall, H. Wu, Generation of squeezed states by parametric down conversion. *Phys. Rev. Lett.* **57**, 2520–2523 (1986)
- B.M. Garraway, B. Sherman, H. Moya-Cessa, P.L. Knight, G. Kurizki, Generation and detection of nonclassical field states by conditional measurements following two-photon resonant interactions. *Phys. Rev. A* **49**, 535–547 (1994)
- B.E.A. Saleh, M.C. Teich, Can the channel capacity of a light-wave communication system be increased by the use of photon-number-squeezed light? *Phys. Rev. Lett.* **58**, 2656–2659 (1987)
- K. Wódkiewicz, On the Quantum Mechanics of Squeezed States. *J. Mod. Opt.* **34**, 941–948 (1987)
- H.J. Kimble, D.F. Walls, Squeezed states of the electromagnetic field: introduction to feature issue. *J. Opt. Soc. Am. B* **4**, 1450–1741 (1987)
- H.P. Yuen, J.H. Shapiro, Optical communication with two-photon coherent states—part I: quantum-state propagation and quantum-noise reduction. *IEEE Trans. Inf. Theory* **24**, 657–668 (1978)
- C.H. Bennett, G. Brassard, N.D. Mermin, Quantum cryptography without Bell’s theorem. *Phys. Rev. Lett.* **68**, 557–559 (1992)
- J. Kempe, Multipartite entanglement and its applications to cryptography. *Phys. Rev. A* **60**, 910–916 (1999)
- J. Perina, J. Krepelka, Stimulated Raman scattering of squeezed light with pump depletion. *J. Mod. Opt.* **38**, 2137–2151 (1991)
- A. Kumar, P.S. Gupta, Short-time squeezing in spontaneous Raman and stimulated Raman scattering. *Quant. Semiclass. Opt.* **7**, 835–841 (1995)
- D.K. Giri, P.S. Gupta, Higher-order squeezing of the electromagnetic field in spontaneous and stimulated Raman process. *J. Mod. Opt.* **52**, 1769–1781 (2005)
- A. Kumar, P.S. Gupta, Higher-order amplitude squeezing in hyper-Raman scattering under short-time approximation. *Quant. Semiclass. Opt.* **8**, 1053–1060 (1996)
- L. Mandel, Squeezing and photon antibunching in harmonic generation. *Opt. Commun.* **42**, 437–439 (1982)
- S. Kielich, R. Tanas, R. Zawodny, Squeezing in the third-harmonic field generated by self-squeezed light. *J. Opt. Soc. Am B* **4**, 1627–1632 (1987)
- J. Perina, V. Perinova, C. Sibilila, M. Bertolotti, Quantum statistics of four-wave mixing. *Opt. Commun.* **49**, 285–289 (1984)
- M.S.K. Razmi, J.H. Eberly, Degenerate four-wave mixing and squeezing in pumped three-level atomic systems. *Opt. Commun.* **76**, 265–267 (1990)
- D.K. Giri, P.S. Gupta, The squeezing of radiation in four-wave mixing processes. *J. Opt. B: Quant. Semiclass. Opt.* **6**, 91–96 (2004)
- D.K. Giri, P.S. Gupta, Short-time squeezing effects in spontaneous and stimulated six-wave mixing process. *Opt. Commun.* **221**, 135–143 (2003)
- J. Perina, V. Perinova, J. Kodousek, On the relations of antibunching, sub-poissonian statistics and squeezing. *Opt. Commun.* **49**, 210–214 (1984)
- K. Kim, Higher order sub-Poissonian. *Phys. Lett. A* **245**, 40–42 (1998)
- H. Prakash, D.K. Mishra, Higher order sub-Poissonian photon statistics and their use in detection of Hong and Mandel squeezing and amplitude-squared squeezing. *J. Phys. B: At. Mol. Opt. Phys.* **39**, 2291–2297 (2006)
- H. Prakash, D.K. Mishra, Corrigendum to Higher order sub-Poissonian photon statistics and their use in detection of Hong and Mandel squeezing and amplitude-squared squeezing. *J. Phys. B: At. Mol. Opt. Phys.* **40**, 2531–2532 (2007)
- H. Prakash, D.K. Mishra, Enhancement and generation of sum squeezing in two-mode light in mixing with coherent light using a beam splitter. *Eur. Phys. J. D* **45**, 363–367 (2007)
- H. Prakash, D.K. Mishra, Quantum analysis of a beam splitter with second-order nonlinearity and generation of nonclassical light. *J. Opt. Soc. Am. B* **33**, 1552–1557 (2016)
- D.K. Mishra, Study of higher order non-classical properties of squeezed Kerr state. *Opt. Commun.* **283**, 3284–3290 (2010)
- D.K. Mishra, Vikram Singh, Hong and Mandel fourth-order squeezing generated by the beam splitter with third-order nonlinearity from the coherent light. *Opt. Quant. Elect.* **52**, 68 (2020)
- B.L. Schumaker, Quantum mechanical pure states with gaussian wave functions. *Phys. Rep.* **135**, 317–408 (1986)
- M. Hillery, Total noise and nonclassical states. *Phys. Rev. A* **39**, 2994–3002 (1989)
- P. Gupta, A. Pathak, Minimum total noise is a measure of higher order squeezing. *Optik-Int. J. Light and Elect. Opt.* **121**, 1507–1510 (2010)
- S. Gill, Sunil Rani, Nafa Singh, Minimum total noise in wave-mixing processes. *Int. J. Opt.* **2012**, 1–4 (2012)
- S. Gill, Sunil Rani, Nafa Singh, Squeezing and photon statistics in five-wave mixing process. *Mod. Phys. Letts.* **23**, 2681–2693 (2009)

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A cell-compatible red light-emitting multianalyte chemosensor via three birds, one stone strategy

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ABSTRACT

The design and synthesis of red light-emitting multianalyte chemosensors have always been a challenging task because of its specific requirement of coordination pocket and selective fluorescence mechanism. Herein, we develop a chemosensor via “three birds, one stone” strategy in which we can detect three metal ions with one ligand. A highly sensitive new azo functionalized rhodamine based luminescent sensor is synthesized for selective fluorogenic recognition of Al³⁺, Cr³⁺, and chromogenic recognition of Cu²⁺ in ethanol : H₂O medium in the red light-emitting zone. Among the guest metals, Cu²⁺ efficiently quenches the emission whereas Al³⁺ and Cr³⁺ induce increased luminescent 4.76 fold for Al³⁺ and 2.47 fold for Cr³⁺ through chelation-enhanced fluorescence (CHEF) and photo-induced electron transfer (PET) regulated mechanism with the formation of 1:1 complex. The restricted imine isomerization through complex formation inhibits ongoing PET process with the instantaneous onset of CHEF. The mechanism is in good consonance with NMR (¹H & ¹³C), FT-IR, elemental analysis, DFT, TCSPC, and pH-dependent studies. Micromolar range detection of 1.1 μM, 1.3 μM, and 1.5 μM for Cu²⁺, Al³⁺, and Cr³⁺ respectively, easy penetration into HLCs cells and higher imaging resolution increase its potentiality to assess Al³⁺ and Cr³⁺ in vitro. Moreover, paper strip application increases its viability as an onsite naked-eye portable solid probe.

1. Introduction

Besides natural sources, various industrial activities and anthropogenic activity enrich the amount of Cu²⁺, Al³⁺, and Cr³⁺ in the environment. A living body requires a very low concentration of Cu²⁺. Its toxicity through excessive accumulation brings the loss of activity in various Cu-dependent enzymes viz. tyrosinase co-oxidase, cytochrome, and superoxide dismutase which is responsible for the generation of in vivo reactive oxygen regulation by iron and causes Menkes disease by disturbing the development of the brain [1]. Wilson's disease, a Cu²⁺

related disease, is grown up by the excessive deposition of Cu²⁺ in the liver and brain through irregular transport [2]. Among the different oxidation state trace element chromium is less harmful in its trivalent (Cr³⁺) state [3]. Balance concentration of chromium regulates the metabolism of fat lipids and carbohydrates by activating certain enzymes whereas insufficient dietary intake increases blood sugar by deactivating insulin, increases the risk of cardiovascular disease, and stops the formation of haemoglobin in the red blood cell [4]. Again diversified application of alumina includes not only industries like packaging, pharmaceuticals, food, and medicine but also in our daily life

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- [15] Z.Q. Hu, M. Du, L.F. Zhang, F.Y. Guo, M.D. Liu, M. Li, A novel colorimetric and fluorescent chemosensor for cyanide ion in aqueous media based on a rhodamine derivative in the presence of Fe^{3+} ion, *Sens. Actuators B Chem.* 192 (2014) 439–443.
- [16] A. Mohammadi, Z. Dehghan, M. Rassa, N. Chaibakhsh, Colorimetric probes based on bioactive organic dyes for selective sensing of cyanide and fluoride ions, *Sens. Actuators B Chem.* 230 (2016) 388–397.
- [17] J. Griffiths, II. Photochemistry of azobenzene and its derivatives, *Chem. Soc. Rev.* 1 (1972) 481–493.
- [18] A. Bafana, S.S. Devi, T. Chakrabarti, Azo dyes: past, present, and the future, *Environ. Rev.* 19 (2011) 350–370.
- [19] S. Paul, A. Manna, S. Goswami, A differentially selective molecular probe for detection of trivalent ions (Al^{3+} , Cr^{3+} , and Fe^{3+}) upon single excitation in a mixed aqueous medium, *Dalton Trans.* 26 (2015) 11805–11810.
- [20] R.G. Parr, W. Yang, *Density Functional Theory of Atoms and Molecules*, Oxford Univ. Press, 1989.
- [21] V. Barone, M. Cossi, Conductor solvent model, *J. Phys. Chem. A* 102 (1998) 1995–2001.
- [22] J.B. Anderson, Comment on “An exact quantum Monte Carlo calculation of the helium-helium intermolecular potential” [*J. Chem. Phys.* 115, 4546 (2001)], *J. Chem. Phys.* 120 (2004) 9886–9887.
- [23] M. Cossi, N. Rega, G. Scalmani, V. Barone, Energies, structures, and electronic properties of molecules in solution with the C-PCM solvation model, *J. Comput. Chem.* 24 (2003) 669–681.
- [24] A.D. Becke, Density-functional thermochemistry. III. The role of exact exchange, *J. Chem. Phys.* 98 (1993) 5648–5652.
- [25] R.G. Parr, C. Lee, W. Yang, Development of the Colic-Salvetti correlation-energy formula into a functional of the electron density, *Phys. Rev. B* 37 (1988).
- [26] R.E. Stratmann, G.E. Scuseria, M.J. Frisch, An efficient implementation of time-dependent density-functional theory for the calculation of excitation energies of large molecules, *J. Chem. Phys.* 109 (1998) 8218–8224.
- [27] R. Bauernschmitt, R. Ahlrichs, Treatment of electronic excitations within the adiabatic approximation of time-dependent density functional theory, *Chem. Phys. Lett.* 256 (1996) 454–464.
- [28] M.E. Casida, C. Jamorski, K.C. Casida, D.R. Salahub, Molecular excitation energies to high-lying bound states from time-dependent density-functional response theory: characterization and correction of the time-dependent local density approximation ionization threshold, *J. Chem. Phys.* 108 (1998) 4439–4449.
- [29] M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov, J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J. Dannenberg, S. Dapprich, A. D. Daniels, Ö. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski, and D. J. Fox, Gaussian, Inc. Wallingford CT, 2009.
- [30] Karol M. Langner Noel, M. O’Boyle, L. Adam, TENDERHOLT software news and updates gabedit — A graphical user interface for computational chemistry softwares, *J. Comput. Chem.* 29 (2007) 839–845.
- [31] J.R. Lakowicz, *Principles of Fluorescence Spectroscopy*, 3rd edition, 1999. New York.
- [32] S. Banthia, A. Samanta, A new strategy for ratiometric fluorescence detection of transition metal ions, *J. Phys. Chem. B* 110 (2006) 6437–6440.
- [33] B. Ramachandram, G. Saroja, N.B. Sankaran, A. Samanta, Unusually high fluorescence enhancement of some 1,8-naphthalimide derivatives induced by transition metal salts, *J. Phys. Chem. B* 104 (2000) 11824–11832.
- [34] A. Pradhan, M. Bepari, P. Maity, S.S. Roy, S. Roy, S.M. Choudhury, Gold nanoparticles from indole-3-carbinol exhibit cytotoxic, genotoxic and antineoplastic effects through the induction of apoptosis, *RSC Adv.* 6 (2016) 56435–56449.
- [35] Y. Xiang, A. Tong, P. Jin, Y. Ju, New fluorescent rhodamine hydrazone chemosensor for Cu(II) with high selectivity and sensitivity, *Org. Lett.* 8 (2006) 2863–2866.
- [36] L.Q. Yan, M.F. Cui, Y. Zhou, Y. Ma, Z.J. Qi, A simplified and turn-on fluorescence chemosensor based on coumarin derivative for detection of aluminium(III) ion in pure aqueous solution, *Anal. Sci.* 31 (2015) 1055–1059.
- [37] D. Maity, T. Govindaraju, Conformationally constrained (Coumarin-Triazolyl-Bipyridyl) click fluoroionophore as a selective Al^{3+} sensor, *Inorg. Chem.* 49 (2010) 7229–7231.
- [38] J.H. Hildebrand, H.A. Benesi, Interaction of iodine with aromatic hydrocarbons, *Nature* 164 (1949) 963.
- [39] M. Dolai, U. Saha, A.K. Das, G. Suresh Kumar, Single sensors for multiple analytes employing fluorometric differentiation for Cr^{3+} and Al^{3+} in semi-aqueous medium with bio-activity and theoretical aspects, *Anal. Methods* 10 (2018) 4063–4072.
- [40] J. Cheng, X. Zhou, H. Xiang, Fluorescent metal ion chemosensors via cation exchange reactions of complexes, quantum dots, and metal-organic frameworks, *Analyst* 140 (2015) 7082–7115.
- [41] A. Sikdar, S. Roy, K. Haldar, S. Sarkar, S.S. Panja, Rhodamine-based Cu^{2+} -selective fluorosensor: synthesis, mechanism, and application in living cells, *J. Fluoresc.* 23 (2013) 495–501.
- [42] S. Mahbai, A. Jana, S. Dey, A novel rhodamine-based colorimetric and fluorometric chemosensor for selective detection of Al^{3+} ion in $\text{CH}_3\text{CN-H}_2\text{O}$ solution, *J. Indian Chem. Soc.* 92 (2015) 1647–1656.
- [43] L.Y. Qin, L.J. Hou, J. Feng, J. Bin Chao, Y. Wang, W.J. Jin, A reversible turn-on colorimetric and fluorescent sensor for Al^{3+} in fully aqueous media and its living cell imaging, *Synth. Met.* 221 (2016) 206–213.
- [44] J.S. Bae, S.Y. Gwon, Y.A. Son, S.H. Kim, A benzothiazole-based semisquarylium dye suitable for highly selective Hg^{2+} sensing in aqueous media, *Dyes Pigm.* 83 (2009) 324–327.
- [45] H. Lee, R.D. Hancock, H.S. Lee, Role of fluorophore-metal interaction in photoinduced electron transfer (PET) sensors: time-dependent density functional theory (TDDFT) study, *J. Phys. Chem. A* 117 (2013) 13345–13355.
- [46] J. Berrones-Reyes, B.M. Muñoz-Flores, A. Gómez-Treviño, M.A. Treto-Suárez, D. Páez-Hernández, E. Schott, X. Zarate, V.M. Jiménez-Pérez, Novel fluorescent Schiff bases as Al^{3+} sensors with high selectivity and sensitivity, and their bioimaging applications, *Mater. Chem. Phys.* 233 (2019) 89–101.
- [47] C. Yi, W. Tian, B. Song, Y. Zheng, Z. Qi, Q. Qi, Y. Sun, A new turn-off fluorescent chemosensor for iron (III) based on new diphenylfluorenes with phosphonic acid, *J. Lumin.* 141 (2013) 15–22.
- [48] J.Q. Wang, L. Huang, M. Xue, Y. Wang, L. Gao, J.H. Zhu, Z. Zou, Architecture of a hybrid mesoporous chemosensor for Fe^{3+} by covalent coupling bis-Schiff base PMBA onto the CPTEs-functionalized SBA-15, *J. Phys. Chem. C* 112 (2008) 5014–5022.
- [49] A.F. Zheng, J.L. Chen, G. Wu, G. Wu, Y.G. Zhang, H.P. Wei, A novel fluorescent distinguished probe for Cr (VI) in aqueous solution, *Spectrochim. Acta – Part A Mol. Biomol. Spectrosc.* 74 (2009) 265–270.
- [50] Y. Liang, L. Diao, R. Wang, N. Wang, S. Pu, A bifunctional probe for Al^{3+} and Zn^{2+} based on diarylethene with an ethylimidazo[2,1-b]thiazole-6-hydrazone unit, *Tetrahedron Lett.* 60 (2019) 106–112.
- [51] B. jie Pang, C. rui Li, Z. yin Yang, Design of a colorimetric and turn-on fluorescent probe for the detection of Al(III), *J. Photochem. Photobiol. A: Chem.* 356 (2018) 159–165.
- [52] A. Sahana, A. Banerjee, S. Lohar, B. Sarkar, S.K. Mukhopadhyay, D. Das, Rhodamine-based fluorescent probe for Al^{3+} through time-dependent PET-CHEF-FRET processes and its cell staining application, *Inorg. Chem.* 52 (2013) 3627–3633.
- [53] P. Mahato, S. Saha, E. Suresh, R. Di Liddo, P.P. Parnigotto, M.T. Conconi, M. K. Kesharwani, B. Ganguly, A. Das, Ratiometric detection of Cr^{3+} and Hg^{2+} by a naphthalimide-rhodamine based fluorescent probe, *Inorg. Chem.* 51 (2012) 1769–1777.
- [54] T. Mistri, R. Alam, M. Dolai, S. Kumar Mandal, P. Guha, A. Rahman Khuda-Bukhsh, M. Ali, Rhodamine-based chromo-/fluorogenic dual signaling probe for selective recognition of HgII with potential applications in INHIBIT logic devices and cell-imaging studies, *Eur. J. Inorg. Chem.* (2013) 5854–5861.
- [55] S. Sinha, B. Chowdhury, P. Ghosh, A highly sensitive ESIPT-based ratiometric fluorescence sensor for selective detection of Al^{3+} , *Inorg. Chem.* 55 (2016) 9212–9220.
- [56] A. Dhara, A. Jana, S.K. Mandal, A.R. Khuda-Bukhsh, N. Guchhait, S.K. Kar, A unique rhodamine-based “off-on” molecular spy for selective detection of trivalent aluminum and chromium ions: synthesis, crystal structure, and spectroscopic properties along with living cell imaging, *Inorganica Chim. Acta* 423 (2014) 454–461.
- [57] T. Mistri, R. Alam, R. Bhowmick, A. Katarkar, K. Chaudhuri, M. Ali, A rhodamine embedded bio-compatible smart molecule mimicking a combinatorial logic circuit and “key-pad lock” memory device for defending against information risk, *New J. Chem.* 40 (2016) 330–339.

Solvent-Regulated Fluorimetric Differentiation of Al³⁺ and Zn²⁺ Using an AIE-Active Single Sensor

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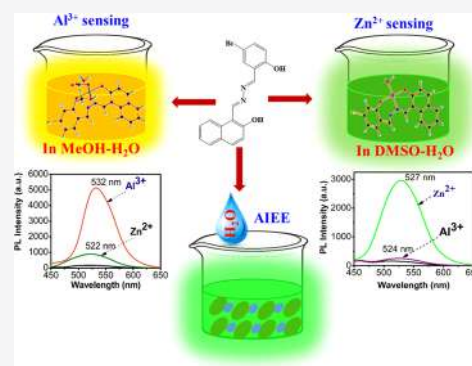


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Supporting Information

ABSTRACT: The absence of d-orbital electrons or presence of full-filled d-orbital electrons in metal ions is a well-known Achilles' heel problem for the detection of these metal ions by a simple UV-visible study. For this reason, detection of metal ions such as Al³⁺ with no d-orbital electrons or Zn²⁺ with filled d-orbital electrons is a challenging task. Herein, we report a 2-naphthol-based fluorescent probe [1-((*E*)-((*E*)-(5-bromo-2-hydroxybenzylidene)hydrazono)methyl)naphthalen-2-yl] (H₂L) that has been used to sense and discriminate Al³⁺ and Zn²⁺ via solvent regulation. The probe exhibits excellent selectivity and swift sensitivity toward Al³⁺ in MeOH–water (9:1, v/v) and toward Zn²⁺ in dimethyl sulfoxide (DMSO)–water (9:1, v/v) among various metal ions. The respective detection limit is found to be 9.78 and 3.65 μM. The sensing mechanism is attributed to multiple processes, viz., the inhibition of photo-induced electron transfer (PET) along with the introduction of chelation-enhanced emission (CHEF) and excited-state intramolecular proton transfer (ESIPT) inhibition, which are experimentally well verified by UV–vis absorption spectroscopy, emission spectroscopy, and NMR spectroscopy. The probe shows aggregation-induced emissive (AIE) response in ≥70% aqueous media as well as in the solid state. The experimental results are well corroborated by time-resolved photoluminescence (TRPL) and density functional theory (DFT) calculations. An advanced-level OR-AND-NOT logic gate has been constructed from a different chemical combinational input and emission output. The reversible recognition of both Al³⁺ in MeOH–water (9:1, v/v) and Zn²⁺ in DMSO–water (9:1, v/v) is also ascertained in the presence of Na₂EDTA, enabling the construction of a molecular memory device. The probe H₂L also detects intracellular Al³⁺/Zn²⁺ ions in Hela cells. Altogether, our fundamental findings will pave the way for designing and synthesis of unique chemosensors that could be used for cell imaging studies as well as constructing molecular logic gates.



INTRODUCTION

Multitasking application of materials is an important and emerging field of science in the modern world. Such types of materials make a product cheap and user-friendly, and the time management issue provides an endeavor toward sustainable development.^{1,2} A Schiff base is an example of such type of materials due to its versatile application in different applied fields of science including medicine and pharmacy (because of its properties, viz., antitumor, antiviral, antifungal, antibacterial, biocidal, and antimalarial properties), chemical synthesis and analysis, modern technological imaging systems, molecular memory storage, photochromic materials, and in colorimetric and fluorimetric ion/molecule sensors.^{3–6} The sensing of ions/small molecules by a Schiff base has useful applications in several interdisciplinary sciences. Several analytical scientific strategies including chromatography, spectrometry, titrimetry, spectrophotometry, and electrochemical techniques have been developed for the detection of metal ions.^{7,8} As the method mentioned above is complicated and time- and cost-consuming, simple but reliable methods for qualitative and quantitative as well as rapid and sensitive detection of metal

ions are in extreme need. Among various strategies utilized, fluorescence signaling is one of the first choices as it is simpler and rapid, convenient, and profoundly sensitive for the recognition of biologically and environmentally relevant metal ions.^{9,10}

The concentration of aluminum, which is the third most abundant element present in the earth's furthest layer, in soil or water increases during rain, which is perilous for growing plants.^{11,12} The far-reaching uses of aluminum in our everyday life, for example, aluminum foil, vessels, and treat sheets; medications; the paper industry; food additives; and aluminum-based pharmaceutical antiperspirants, antiulcer agents, and antacids, result in its exposure to the environment.¹³ Adverse effects of Al³⁺ influence the central nervous

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Diagnosis of Pick's Disease from Urine and Bio-Mimetic Cells Exocytosis. *ACS Appl. Biomater.* **2018**, *1*, 683–692.

(63) Shekari, Z.; Younesi, H.; Heydari, A.; Tajbakhsh, M.; Chaichi, M.; Shahbazi, A.; Saberi, D. Fluorescence Chemosensory Determination of Cu^{2+} Using a New Rhodamine–Morpholine Conjugate. *Chemosensors* **2017**, *5*, 26.

(64) Brunner, J.; Kraemer, R. Copper (II) -Quenched Oligonucleotide Probes for Fluorescent DNA Sensing. *J. Am. Chem. Soc.* **2004**, *1*, 13626–13627.

(65) Akkaya, E. U.; Huston, M. E.; Czarnik, A. W. Chelation-Enhanced Fluorescence of Anthrylazamacrocyclic Conjugate Probes in Aqueous Solution. *J. Am. Chem. Soc.* **1990**, *112*, 3590–3593.

(66) Paquin, F.; Rivnay, J.; Salleo, A.; Stingelin, N.; Silva, C. Multi-Phase Semicrystalline Microstructures Drive Exciton Dissociation in Neat Plastic Semiconductors. *J. Mater. Chem. C* **2015**, *3*, 10715–10722.

(67) Kumar, V.; Sk, B.; Kundu, S.; Patra, A. Dynamic and Static Excimer: A Versatile Platform for Single Component White-Light Emission and Chelation-Enhanced Fluorescence. *J. Mater. Chem. C* **2018**, *6*, 12086–12094.

(68) De Silva, A. P.; Moody, T. S.; Wright, G. D. Fluorescent PET (Photoinduced Electron Transfer) Sensors as Potent Analytical Tools. *Analyst* **2009**, *134*, 2385–2393.

(69) Budzák, S.; Jacquemin, D. Mechanism of Fluorescence Switching in One ESIPT-Based Al^{3+} Probe. *J. Phys. Chem. B* **2016**, *120*, 6730–6738.

(70) Treto-Suárez, M. A.; Hidalgo-Rosa, Y.; Schott, E.; Zarate, X.; Páez-Hernández, D. Understanding the Selective-Sensing Mechanism of Al^{3+} Cation by a Chemical Sensor Based on Schiff Base: A Theoretical Approach. *J. Phys. Chem. A* **2019**, *123*, 6970–6977.

(71) Dolai, M.; Saha, U.; Das, A. K.; Kumar, G. S. Single Sensors for Multiple Analytes Employing Fluorometric Differentiation for Cr^{3+} and Al^{3+} in Semi-Aqueous Medium with Bio-Activity and Theoretical Aspects. *Anal. Methods* **2018**, *10*, 4063–4072.

(72) Bourson, J.; Pouget, J.; Valeur, B. Ion-Responsive Fluorescent Compounds. 4. Effect of Cation Binding on the Photophysical Properties of a Coumarin Linked to Monoaza- and Diaza-Crown Ethers. *J. Phys. Chem. A* **1993**, *97*, 4552–4557.

(73) Wang, J.; Pang, Y. A Simple Sensitive ESIPT On-off Fluorescent Sensor for Selective Detection of Al^{3+} in Water. *RSC Adv.* **2014**, *4*, 5845–5848.

(74) Li, R.; Yang, W.; Su, Y.; Li, Q.; Gao, S.; Shang, J. K. Ionic Potential: A General Material Criterion for the Selection of Highly Efficient Arsenic Adsorbents. *J. Mater. Sci. Technol.* **2014**, *30*, 949–953.

(75) Karnati, C.; Ji, H.-F. Molecular Logic Gates. In *Micro-manufacturing and Nanotechnology*; Springer: Berlin, Heidelberg, 2006; pp 275–297.

(76) Gunnlaugsson, T.; Dónail, D.; Mac; Parker, D. Luminescent Molecular Logic Gates: The Two-Input Inhibit (INH) Function. *Chem. Commun.* **2000**, 93–94.

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Acetate ion augmented fluorescence sensing of Zn²⁺ by Salen-based probe, AIE character, and application for picric acid detection

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Abstract

Counter anion-triggered metal ion detection has been rarely reported by fluorimetric method. To address this challenging issue, a fluorescent probe (**H₂L**) has been synthesized from bromo-salicylaldehyde and hydrazine hydrate, and structurally characterized by single crystal X-ray diffraction. The probe shows very weak fluorescence itself. However, its emission intensity increases in the presence of Zn²⁺ over other metal ions. Surprisingly, the emission profile of this probe in presence of Zn²⁺ is augmented only when acetate anion (OAc⁻) is present as counter anion, that allows for precise quantitative analysis by spectroscopic studies. The compositions and complexation among the probe, Zn²⁺ ion, and OAc⁻ are supported by ESI-MS, ¹H-NMR, and Job's plot. Based on these studies, it is confirmed that the binding ratio between probe: metal is 1:2 and the detection limit (LOD) for the Zn²⁺ is 2.18 μM. The probe is capable of recognizing Zn²⁺ ion in the wide range of pH~6.5-9.5, and it could be efficiently recycled by EDTA. Furthermore, the combinatorial molecular logic gate and memory device have been constructed from the fluorescent behavior of **H₂L** with Zn²⁺, OAc⁻, and EDTA input as based on NOT and AND gates. Interestingly, the aggregation-induced emission (AIEE) phenomenon is also perceived with greater than 50% water content in organic water mixtures, which are then useful for the detection of picric acid often used as explosive.

KEYWORDS

AIEE, counter anion, molecular logic gate, PET and CHEF, Picric acid, Schiff base, zinc sensor

1 | INTRODUCTION

Performing multiple tasks useful material is a significant and developing field of science in the cutting edge world. Such kind of materials makes an item modest, easy to use, and the time executives issue pro-

vides an endeavor and influence towards sustainable developments.^{1,2} Schiff base is a reasonable example of such type of materials because of its versatile application in different field of applied science including medicine and pharmacy (viz., antifungal, antibacterial, biocidal, antitumor, antiviral, and antimalarial properties), chemical synthesis

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51. Dolai M, Saha U, Das AK, Kumar GS. Single sensors for multiple analytes employing fluorometric differentiation for Cr³⁺ and Al³⁺ in semi-aqueous medium with bio-activity and theoretical aspects. *Anal Methods*. 2018;10:4063-4072.
52. Saha U, Dolai M, Suresh Kumar G. Adaptable sensor for paying fluorometric detection of methanol molecules: theoretical aspects and DNA binding studies. *New J Chem*. 2019;43:8982-8992.
53. Qin J-C, Fan L, Yang Z-Y. A small-molecule and resumable two-photon fluorescent probe for Zn²⁺ based on a coumarin Schiff-base. *Sens Actuators, B*. 2016;228:156-161.
54. Pannipara M, Al-Sehemi AG, Irfan A, Assiri M, Kalam A, Al-Ammari YS. AIE active multianalyte fluorescent probe for the detection of Cu²⁺, Ni²⁺ and Hg²⁺ ions. *Spectrochim Acta - Part A Mol Biomol Spectrosc*. 2018;201:54-60.
55. Martinho JMG. Heavy-atom quenching of monomer and excimer pyrene fluorescence. *J Phys Chem*. 1989;93:6687-6692.
56. Pandey R, Kumar P, Singh AK, et al. Fluorescent zinc(II) complex exhibiting "on-off-on" switching toward Cu²⁺ and Ag⁺ ions. *Inorg Chem*. 2011;50:3189-3197.
57. Paquin F, Rivnay J, Salleo A, Stingelin N, Silva C. Multi-phase semicrystalline microstructures drive exciton dissociation in neat plastic semiconductors. *J Mater Chem C*. 2015;3:10715-10722.
58. Gogoi A, Samanta S, Das G. A benzothiazole containing CHEF based fluorescence turn-ON sensor for Zn²⁺ and Cd²⁺ and subsequent sensing of H₂PO₄⁻ and P₄O₇⁴⁻ in physiological pH. *Sensors Actuators, B Chem*. 2014;202:788-794.
59. Du K, Niu S, Qiao L, et al. A highly selective ratiometric fluorescent probe for the cascade detection of Zn²⁺ and H₂PO₄⁻ and its application in living cell imaging. *RSC Adv*. 2017, 7, 40615-40620.
60. *Guidelines for drinking-water quality, Zinc in Drinking-Water*. WHO 1996 Vol. 2.
61. Wu JS, Liu WM, Zhuang XQ, et al. Fluorescence turn on of coumarin derivatives by metal cations: a new signaling mechanism based on C = N isomerization. *Org Lett*. 2007;9:33-36.
62. De Silva AP, Moody TS, Wright GD. Fluorescent PET (Photoinduced Electron Transfer) sensors as potent analytical tools. *Analyst*. 2009;134:2385-2393.
63. Santra S, Krishnamoorthy G, Dogra SK. Excited-state intramolecular proton transfer in 2-(2'-Acetamidophenyl)benzimidazole. *J Phys Chem A*. 2000;104:476-482.
64. Abou-Zied OK, Jimenez R, Thompson EHZ, Millar DP, Romesberg FE. Solvent-dependent photoinduced tautomerization of 2-(2'-hydroxyphenyl)benzoxazole. *J Phys Chem A*. 2002;106:3665-3672.
65. Kim J, Kim S, Park SY, Joo T. Excited State Intramolecular Proton Transfer Dynamics of Oxadiazole-based Dyes. *Bull Korean Chem Soc*. 2015;36:855-861.
66. Shahid M, Misra A. Photoenolization via excited state proton transfer and ion sensing studies of hydroxy imidazole derivatives. *J Photochem Photobiol A Chem*. 2017;335:190-199.
67. Jana A, Das B, Mandal SK, Mabhai S, Khuda-Bukhsh AR, Dey S. Deciphering the CHEF-PET-ESIPT liaison mechanism in a Zn²⁺ chemosensor and its applications in cell imaging study. *New J Chem*. 2016;40:5976-5984.
68. Bhalla V, Roopa; Kumar M. Fluoride triggered fluorescence "turn on" sensor for Zn²⁺ ions based on pentaquinone scaffold that works as a molecular keypad lock. *Org Lett*. 2012;14:2802-2805.
69. Dong Y, Li J, Jiang X, Song F, Cheng Y. Nap Triggered Fluorescence Sensors for Mg²⁺ Detection Based on a Coumarin Salen Moiety. *Org Lett*. 2011;13:2252-2255.
70. Wang J, Miao X, Fengzhao Q, Ren C, Yang Z, Wang L. Enzymatic and reductive triggered hydrogelation of peptide-based gelators combined with alginate gel. *Anal Methods*. 2013(5):5584-5588.
71. Jin CC, Fukuda M, Wu C, et al. A pyrene-armed hexahomotrioxacalix[3]arene as a multi-sensor via synergistic and demetallation effects. *Tetrahedron*. 2015;71:9593-9597.
72. Kowser Z, Rayhan U, Rahman S, Georghiou PE, Yamato T. A fluorescence "turn-on" sensor for multiple analytes: oAc⁻ and F⁻ triggered fluorogenic detection of Zn²⁺ in a co-operative fashion. *Tetrahedron*. 2017;73:5418-5424.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Polyaniline and sulfonated graphene oxide supported bimetallic manganese cobalt oxides as an effective and non-precious cathode catalyst in air-cathode microbial fuel cells

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ABSTRACT

This study examines the feasibility of the use of nanocomposite of polyaniline (PAni) grafted sulfonated graphene oxide (SGO) supported manganese cobalt oxide as a novel and effective cathode catalyst for single chamber microbial fuel cell (SC-MFC). The graphene oxide (GO) was sulfonated to SGO for the development of a significant increase in the hydrophilicity of GO to enhance the nano-catalyst dispersion. The structural properties of the prepared nanocomposite were studied by X-ray diffraction, X-ray photoelectron spectroscopy, and Raman spectroscopy. Morphological studies of the nanocomposite revealed a wrinkled paper-like structure of SGO and a spherical type structure of Mn-Co. Both cyclic voltammetry and electrochemical impedance spectroscopy showed a reduction current value of -1.04 mA, and charge-transfer resistance of 52.4 ohm, which exhibited a higher oxygen reduction reaction activity and good conductivity compared to Mn-Co/GO-PAni, Mn-Co/rGO-PAni and Pt/C catalyst. Electrochemical tests also suggest that the Mn-Co/SGO-PAni nanocomposite exhibited excellent durability among the other three cathodes. Furthermore, the MFCs equipped with Mn-Co/SGO-PAni nanocomposite modified electrode achieved power density of 1392.68 mW m⁻² which is 2.89 times higher than state-of-art Pt/C (481.3 mW m⁻²). The Electrochemical studies also displayed a similar result. The significant increase in power generation with Mn-Co/SGO-PAni nanocomposite as a cathode catalyst indicates that it can be used as a promising, inexpensive electrocatalyst for the long-term operation for MFC.

1. Introduction

Microbial fuel cell (MFC) is a novel, environmentally friendly and promising alternative energy source that produces bioelectricity from wastewater or biomass in which bacteria are used as catalysts to oxidize organic matter [1,2]. The bacteria in anode chamber produce protons, electrons, and CO₂ from the biodegradation of organic fuel by catabolic metabolism. The electron is transferred from the anode to the cathode through an external wire and then reduces oxygen in the air to form water and electric current [2,3]. The overall MFC performance is affected by several factors such as cell design, electrode materials, bacterial inoculum, substrate, and ion-selective membrane [4]. Unfortunately, the sluggish kinetics of the oxygen reduction reaction (ORR) has become the bottleneck of power generation in MFC. Hence, a

number of studies have been employed to accelerate the sluggish kinetics of the ORR at the cathode [5]. Generally, high surface area, excellent electrical conductivity, high catalytic activity, good stability, and low cost are very necessary to enhance the ORR kinetics.

The most commonly employed cathode catalyst is platinum (Pt) and its alloys as they have good catalytic activity, stability, and resistance to corrosion [6–8]. Noble metal Pt is rare and expensive and has poor availability along with sensitivity to catalyst poisoning and these are the major hindrances to its commercial acceptance. Therefore, developing an alternative cost-effective non-platinum catalyst for ORR has stimulated wide research interests [9,10]. Several metal-based catalyst, i.e. CoO_x/FePc [11], Spinel-type Cu/Co [12], Co/Fe/N [13], α -Fe₂O₃/polyaniline [14], Ni-Co/SPANi [15], Cu₂O/RGO [16], Zn-Co/ZnO [17], V₂O₅/GO [18], δ -MnO₂ [19] and SGO-TiO₂-PAni

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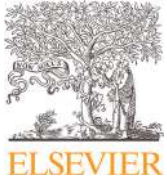
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- [34] N. Zhao, Z. Ma, H. Song, D. Wang, Y. Xie, Polyaniline/reduced graphene oxide-modified carbon fiber brush anode for high-performance microbial fuel cells, *Int. J. Hydrog. Energy* 43 (2018) 17867–17872.
- [35] X. Zhou, Y. Xu, X. Mei, N. Du, R. Jv, Z. Hu, S. Chen, Polyaniline/ β -MnO₂ nanocomposites as cathode electrocatalyst for oxygen reduction reaction in microbial fuel cells, *Chemosphere* 198 (2018) 482–491.
- [36] M. Vinothkannan, A.R. Kim, D.J. Yoo, Sulfonated graphene oxide/Nafion composite membranes for high temperature and low humidity proton exchange membrane fuel cells, *RSC Adv.* 8 (2018) 7494–7508.
- [37] H. Begum, M.S. Ahmed, S. Jeon, δ -MnO₂ nanoflowers on sulfonated graphene sheets for stable oxygen reduction and hydrogen evolution reaction, *Electrochim. Acta* 296 (2019) 235–242.
- [38] R. Bolagam, R. Boddula, P. Srinivasan, Design and synthesis of ternary composite of polyaniline-sulfonated graphene oxide-TiO₂ nanorods: a highly stable electrode material for supercapacitor, *J. Solid State Electrochem* 22 (2018) 129–139.
- [39] M. Vinothkannan, R. Kannan, A.R. Kim, G.G. Kumar, K.S. Nahm, D.J. Yoo, Facile enhancement in proton conductivity of sulfonated poly (ether ether ketone) using functionalized graphene oxide—Synthesis, characterization, and application towards proton exchange membrane fuel cells, *Colloid Polym. Sci.* 294 (2016) 1197–1207.
- [40] F. Papiya, S. Das, P. Pattanayak, P.P. Kundu, The fabrication of silane modified graphene oxide supported Ni–Co bimetallic electrocatalysts: a catalytic system for superior oxygen reduction in microbial fuel cells, *Int. J. Hydrog. Energy* 44 (2019) 25874–25893.
- [41] Q. Hao, H. Wang, X. Yang, L. Lu, X. Wang, Selective expression of S100A11 in lung cancer and its role in regulating proliferation of adenocarcinomas cells, *Mol. Cell. Biochem.* 359 (2012) 323–332.
- [42] K.N. Jung, S.M. Hwang, M.S. Park, K.J. Kim, J.G. Kim, S.X. Dou, J.H. Kim, J.W. Lee, One-dimensional manganese-cobalt oxide nanofibres as bi-functional cathode catalysts for rechargeable metal-air batteries, *Sci. Rep.* 5 (2015) 7665.
- [43] R. Miao, J. He, S. Sahoo, Z. Luo, W. Zhong, S.Y. Chen, C. Guild, T. Jafari, B. Dutta, S.A. Cetegen, M. Wang, Reduced graphene oxide supported nickel–manganese–cobalt spinel ternary oxide nanocomposites and their chemically converted sulfide nanocomposites as efficient electrocatalysts for alkaline water splitting, *ACS Catal.* 7 (2017) 819–832.
- [44] J. Zhang, X.S. Zhao, Conducting polymers directly coated on reduced graphene oxide sheets as high-performance supercapacitor electrodes, *J. Phys. Chem. C* 116 (2012) 5420–5426.
- [45] J. Yin, X. Wang, R. Chang, X. Zhao, Polyaniline decorated graphene sheet suspension with enhanced electrorheology, *Soft Matter* 8 (2012) 294–297.
- [46] B. Ou, R. Huang, W. Wang, H. Zhou, C. He, Preparation of conductive polyaniline grafted graphene hybrid composites via graft polymerization at room temperature, *RSC Adv.* 4 (2014) 43212–43219.
- [47] V. Saadattalab, A. Shakeri, H. Gholami, Effect of CNTs and nano ZnO on physical and mechanical properties of polyaniline composites applicable in energy devices, *Prog. Nat. Sci.: Mater. Int.* 26 (2016) 517–522.
- [48] L.J. Ghil, T.Y. Youn, N.R. Park, H.W. Rhee, Proton conductive nano-channel membranes based on polyaniline with phosphonic acid moieties for low relative humidity, *J. Nanosci. Nanotechnol.* 13 (2013) 7912–7915.
- [49] Z. Awan, K.S. Nahm, J.S. Xavier, Nanotubular MnO₂/graphene oxide composites for the application of open air-breathing cathode microbial fuel cells, *Biosens. Bioelectron.* 53 (2014) 528–534.
- [50] R.K. Gautam, H. Bhattacharjee, S.V. Mohan, A. Verma, Nitrogen doped graphene supported α -MnO₂ nanorods for efficient ORR in a microbial fuel cell, *RSC Adv.* 6 (2016) 110091–110101.
- [51] Y. Xu, S. Zhou, M. Li, Enhanced bioelectricity generation and cathodic oxygen reduction of air breathing microbial fuel cells based on MoS₂ decorated carbon nanotube, *Int. J. Hydrog. Energy* 44 (2019) 13875–13884.
- [52] T.S. Song, D.B. Wang, H. Wang, X. Li, Y. Liang, J. Xie, Cobalt oxide/nanocarbon hybrid materials as alternative cathode catalyst for oxygen reduction in microbial fuel cell, *Int. J. Hydrog. Energy* 40 (2015) 3868–3874.
- [53] A. Valipour, S. Ayyaru, Y. Ahn, Application of graphene-based nanomaterials as novel cathode catalysts for improving power generation in single chamber microbial fuel cells, *J. Power Sources* 327 (2016) 548–556.
- [54] R. Kumar, L. Singh, A.W. Zularisam, Enhanced oxygen reduction reaction in air-cathode microbial fuel cells using flower-like Co₃O₄ as an efficient cathode catalyst, *Int. J. Hydrog. Energy* 42 (2017) 19287–19295.
- [55] S. Rout, A.K. Nayak, J.L. Varanasi, D. Pradhan, D. Das, Enhanced energy recovery by manganese oxide/reduced graphene oxide nanocomposite as an air-cathode electrode in the single-chambered microbial fuel cell, *J. Electroanal. Chem.* 815 (2018) 1–7.
- [56] S.A. Ansari, N. Parveen, T.H. Han, M.O. Ansari, M.H. Cho, Fibrous polyaniline@manganese oxide nanocomposites as supercapacitor electrode materials and cathode catalysts for improved power production in microbial fuel cells, *Phys. Chem. Chem. Phys.* 18 (2016) 9053–9060.
- [57] R. Kumar, L. Singh, A.W. Zularisam, Mesoporous Co₃O₄ nanoflakes as an efficient and non-precious cathode catalyst for oxygen reduction reaction in air-cathode microbial fuel cells, *J. Taiwan Inst. Chem. Eng.* 78 (2017) 329–336.
- [58] M. Yang, Q. Cai, C. Liu, R. Wu, D. Sun, Y. Chen, Y. Tang, T. Lu, Monodispersed hollow platinum nanospheres: facile synthesis and their enhanced electrocatalysis for methanol oxidation, *J. Mater. Chem. A* 2 (2014) 13738–13743.
- [59] J. Yang, J. Tao, T. Isomura, H. Yanagi, I. Moriguchi, N. Nakashima, A comparative study of iron phthalocyanine electrocatalysts supported on different nanocarbons for oxygen reduction reaction, *Carbon* 145 (2019) 565–571.
- [60] S. Mahalingam, S. Ayyaru, Y.H. Ahn, Enhanced cathode performance of Fe₂O₃, boron nitride-doped rGO nanosheets for microbial fuel cell applications, *Sustain. Energy Fuels* 4 (2020) 1454–1468.
- [61] B. Bera, T. Kar, A. Chakraborty, M. Neergat, Influence of nitrogen-doping in carbon on equivalent distributed resistance and capacitance – implications to electrocatalysis of oxygen reduction reaction, *J. Electroanal. Chem.* 805 (2017) 184–192.
- [62] C. Cao, L. Wei, M. Su, G. Wang, J. Shen, Enhanced power generation using nano cobalt oxide anchored nitrogen-decorated reduced graphene oxide as a high-performance air-cathode electrocatalyst in biofuel cells, *RSC Adv.* 6 (2016) 52556–52563.
- [63] M. Kodali, S. Herrera, S. Kabir, A. Serov, C. Santoro, I. Ieropoulos, P. Atanassov, Enhancement of microbial fuel cell performance by introducing a nano-composite cathode catalyst, *Electrochim. Acta* 265 (2018) 56–64.



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Research article

FogIoT: A weighted majority game theory based energy-efficient delay-sensitive fog network for internet of health things

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ABSTRACT

Internet of Health Things (IoHT) has become a demanding application of Internet of Things and cloud computing. In IoHT, the exchange and processing of health data are performed for monitoring the health status of patients. The health data collected using a body area network are stored and processed inside the cloud servers. The users can access the health data using their mobile devices as well as can receive health care advice. To reduce energy consumption and delay over the remote cloud servers, fog computing has been introduced. The health care system using fog computing is emerging due to the increasing need of energy and latency optimized health service provisioning. This article focuses on fog based Internet of Health Things for indoor as well as outdoor scenarios. In the proposed system the weighted majority game theory is used for selecting fog device in indoor and outdoor regions. Simulation results demonstrate that the proposed fog computing based system reduces the average delay, average jitter and energy consumption by approximately 15%, 20% and 15% respectively than the existing cloud only health care system.

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1. Introduction

Electronic health (e-health) monitoring has become an emerging research field in the last few years [1]. The exponential growth in the number of smart phone users has made a remarkable change in the traditional e-health system and mobile health (m-health) monitoring has been introduced. Nowadays most of the smart phones have health related applications, which can detect user activity and predict health condition based on pulse rate, BMI etc. Samsung S Health, Apple Healthkit, Google Fit, Microsoft Health etc. are some of the popular applications. Health sensor devices are also available which can detect several health parameters like blood sugar level, pressure level, ECG etc. [1]. After collecting respective health parameter values these sensor nodes transmit the same to the connected smart phone. The smart phone can process the data and predict the health status. However, execution of exhaustive applications for processing health data may not be possible inside the smart phones due to resource constraints. Mobile cloud computing may resolve these challenges [2]. By executing

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- [48] S. Ghosh, D. De, P. Deb, A. Mukherjee, 5g-zoom-game: small cell zooming using weighted majority cooperative game for energy efficient 5g mobile network, *Wireless Networks* Article in press (2018).
- [49] H. Hartenstein, K.P. Laberteaux, et al., A tutorial survey on vehicular ad hoc networks, *IEEE Communications magazine* 46 (6) (2008) 164.
- [50] F.A. Silva, A. Boukerche, T.R. Silva, L.B. Ruiz, E. Cerqueira, A.A. Loureiro, Vehicular networks: A new challenge for content-delivery-based applications, *ACM Computing Surveys (CSUR)* 49 (1) (2016) 11.
- [51] A. Mukherjee, S. Bhattacharjee, S. Pal, D. De, Femtocell based green power consumption methods for mobile network, *Computer Networks* 57 (1) (2013) 162–178.
- [52] A. Tripathi, P. Yadav, Enhancing security of cloud computing using elliptic curve cryptography, *International Journal of Computer Applications* 57 (1) (2012) 26–30.
- [53] L. Yan, C. Rong, G. Zhao, Strengthen cloud computing security with federal identity management using hierarchical identity-based cryptography, in: *IEEE International Conference on Cloud Computing*, Springer, 2009, pp. 167–177.
- [54] E.B. Fernandez, N. Yoshioka, H. Washizaki, Cloud access security broker (casb): A pattern for accessing secure cloud services, *Proceedings of the 4th AsianPLOP (Pattern Languages of Programs)* (2015) 1–8.
- [55] S. Khan, S. Parkinson, Y. Qin, Fog computing security: a review of current applications and security solutions, *Journal of Cloud Computing* 6 (1) (2017) 19.
- [56] M. Richardson, S. Wallace, *Getting started with raspberry PI*, " O'Reilly Media, Inc.", 2012.



Full length article

Fractional frequency reuse based frequency allocation for 5G HetNet using master–slave algorithm

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ABSTRACT

Frequency allocation in small cell-based green heterogeneous mobile networks is a demanding research domain nowadays. Femtocells are the essential components of small cell networks. In this paper, we propose a low power micro-femtocell network using the master–slave algorithm. In the master–slave algorithm, the master node allocates work to the slave nodes. When a slave ends its task given by a master node, it informs the master node, and it is being assigned a new workload. Slave nodes do not communicate with each other. In our approach, the microcell is divided into three sectors, and each sector is further categorized into three regions: inner region, outer region, and most-outer region. Femtocells are allocated in these three regions. According to the duty cycle, several femtocells are chosen as master femtocells. The rest of the femtocells are assigned under the supervision of the master femtocells. These femtocells are referred to as slave femtocells. The master femtocells communicate with the microcell, and the slave femtocells communicate with the corresponding master femtocell. Frequency allocation for this micro-femtocell network is proposed based on Fractional Frequency Reuse (FFR). The power consumption, signal-to-interference-plus-noise ratio (SINR), and spectral efficiency for the proposed network are calculated. The simulation results exemplify that the proposed scheme reduces the power consumption of the network by approximately 44%–80% than the conventional heterogeneous network. The simulation results also demonstrate that the proposed network has better SINR and spectral efficiency than the existing micro-femtocell network. For experimental analysis, vector signal generator (VSG) and vector signal analyzer (VSA) are used. The experimental results also show that the proposed network is greener compared to the existing micro-femtocell network.

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1. Introduction

The increasing use of smartphones has elevated the requirement of introducing new approaches for giving good signal strength at the outdoor as well as an indoor area. Long Term Evolution (LTE) network has come into the scenario to enhance the speed of data communication and to boost the capability of the mobile network [1]. For better, indoor and outdoor coverage LTE network is followed by LTE-Advanced (LTE-A) network. LTE-A is primarily for small cell-based heterogeneous networks. Small cell serves as a critical component for low power cellular network [1–4]. Heterogeneous cellular network (HCN) or heterogeneous network (HetNet) is a combination of macrocell base

station (MBS), microcell base station (MiBS), picocell base station (PBS) and femtocell base station (FBS) [2]. The HetNet is not only for third and fourth generation mobile networks but for the fifth-generation mobile network also. FBSs are allocated for giving better signal strength in the indoor region. FBS is a small cell base station, which can be deployed in a plug and play manner. The transmission power of an MBS or an MiBS is higher than that of an FBS. Deployment of several FBSs inside a macrocell or a microcell improves coverage [1]. An MiBS has lower transmission power than an MBS [4].

Hence, in this article, we use MiBS instead of MBS, where FBSs are allocated inside the microcell based on the master–slave algorithm. In the master–slave algorithm, the master node allocates work to the slave nodes. When a slave ends its task given by a master node, it informs the master node, and it is being assigned a new workload. Slave nodes do not communicate with each other. In our approach, FBSs are deployed under an MiBS. From these FBSs based on duty cycle, master FBSs are chosen,

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existing micro-femtocell network. The results also demonstrate that the proposed algorithms improve the spectral efficiency and the SINR. Hence we can conclude that the master-slave algorithm based proposed micro-femtocell network is a green cellular network. In the future, we wish to extend our method for micro-pico-femtocell based three-tier cellular networks.

CRedit authorship contribution statement

Priti Deb: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing - original draft, Writing - review & editing. **Anwasha Mukherjee:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Debashis De:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.phycom.2020.101158>.

References

- [1] A. Mukherjee, D. De, P. Deb, Interference management in macro-femtocell and micro-femtocell cluster-based long-term evaluation-advanced green mobile network, *IET Commun.* 10 (5) (2016) 468–478.
- [2] A. Mukherjee, P. Deb, D. De, M.S. Obaidat, WmA-MiFN: A weighted majority and auction game based green ultra-dense micro-femtocell network system, *IEEE Syst. J.* 14 (1) (2020) 353–362.
- [3] B. Reddaiah, K.S. Rao, B.S. Kumar, A novel approach on the role of femto small cells for effective energy consumption in 5G networks, in: *Advances in Data Science and Management*, Springer, Singapore, 2020, pp. 333–344.
- [4] A. Mukherjee, S. Bhattacharjee, S. Pal, D. De, Femtocell based green power consumption methods for mobile network, *Comput. Netw.* 57 (1) (2013) 162–178.
- [5] P. Lin, J. Zhang, Y. Chen, Q. Zhang, Macro-femto heterogeneous network deployment and management: from business models to technical solutions, *IEEE Wirel. Commun.* 18 (3) (2011).
- [6] M. Fereydooni, M. Sabaei, M. Dehghan, G.B. Eslamlou, M. Rupp, Analytical evaluation of heterogeneous cellular networks under flexible user association and frequency reuse, *Comput. Commun.* 116 (2018) 147–158.
- [7] H. Marshoud, H. Otrok, H. Barada, Macrocell-femtocells resource allocation with hybrid access motivational model, *Phys. Commun.* 11 (2014) 3–14.
- [8] D. De, A. Mukherjee, Group handoff management in low power microcell-femtocell network, *Digit. Commun. Netw.* 3 (1) (2017) 55–65.
- [9] Z. Liu, S. Li, H. Yang, K.Y. Chan, X. Guan, Approach for power allocation in two-tier femtocell networks based on robust noncooperative game, *IET Commun.* 11 (10) (2017) 1549–1557.
- [10] H. Tran, G. Kaddoum, F. Gagnon, Power allocation for cognitive underlay networks with spectrum band selection, *Phys. Commun.* 21 (2016) 41–48.
- [11] A. Mukherjee, D. De, User velocity based handoff prediction in micro-femtocell clustered network, *Comput. Electr. Eng.* 72 (2018) 732–751.
- [12] A. Ijaz, S.A. Hassan, D.N.K. Jayakody, A multiple region reverse frequency allocation scheme for downlink capacity enhancement in 5G HetNets, in: *Consumer Communications & Networking Conference (CCNC), 2017 14th IEEE Annual*, January, IEEE, 2017, pp. 905–910.
- [13] Z.L.X. Wang, M.D.Y. Ji, H.Z.Y. Tanaka, User-oriented intercell interference coordination in heterogeneous networks (HetNets), in: *Resource Allocation in Next-Generation Broadband Wireless Access Networks*, vol. 145, 2017.
- [14] E. Yousefi, M. Eslami, Energy efficiency of joint base station and relay sleeping in heterogeneous networks, *IET Commun.* 11 (18) (2017) 2721–2728.
- [15] W. Jiao, G. Liu, Performance analysis and power allocation for the unsaturated two-user interference channel, *IET Commun.* 11 (2) (2017) 282–291.
- [16] M. Webb, L.I. Zhaojun, P. Bucknell, T. Mouldsley, U.S. Patent No. 9, 560, 675. Washington, DC, U.S. Patent and Trademark Office, 2017.
- [17] C. Han, L. Chen, H. Yin, G. Wei, A new scheme of dynamic power allocation in wireless powered communication, *Phys. Commun.* (2018).
- [18] S. Wu, Z. Zeng, H. Xia, Coalition-based sleep mode and power allocation for energy efficiency in dense small cell networks, *IET Commun.* 11 (11) (2017) 1662–1670.
- [19] R. Thakur, S.N. Swain, C.S.R. Murthy, Cell selection and resource allocation for sleep mode enabled femtocells with backhaul link constraint, *Comput. Commun.* 105 (2017) 105–115.
- [20] S.C. Lam, K. Sandrasegaran, Performance analysis of fractional frequency reuse in uplink random cellular networks, *Phys. Commun.* 25 (2017) 469–482.
- [21] G. Shao, F. Berman, R. Wolski, Master/slave computing on the grid, in: *Heterogeneous Computing Workshop, 2000. (HCW 2000) Proceedings*, 9th, IEEE, 2000, pp. 3–16.
- [22] P. Xu, X. Fang, M. Chen, Y. Xu, A stackelberg game-based spectrum allocation scheme in macro/femtocell hierarchical networks, *Comput. Commun.* 36 (14) (2013) 1552–1558.
- [23] A. Mukherjee, P. Deb, D. De, Small cell zooming based green congestion control in mobile network, *CSI Trans. ICT* 5 (1) (2017) 35–43.
- [24] W.U. Khan, Z. Ali, M. Waqas, G.A.S. Sidhu, Efficient power allocation with individual qos guarantees in future small-cell networks, *AEU-Int. J. Electron. Commun.* 105 (2019) 36–41.
- [25] S. Ghosh, D. De, P. Deb, A. Mukherjee, 5G-ZOOM-Game: small cell zooming using weighted majority co-operative game for energy efficient 5G mobile network, *Wirel. Netw.* (2018) 1–24.
- [26] K. Davaslioglu, C.C. Coskun, E. Ayanoglu, Energy-efficient resource allocation for fractional frequency reuse in heterogeneous networks, *IEEE Trans. Wireless Commun.* 14 (10) (2015) 5484–5497.
- [27] P. Cao, W. Liu, J.S. Thompson, C. Yang, E.A. Jorswieck, Semidynamic green resource management in downlink heterogeneous networks by group sparse power control, *IEEE J. Sel. Areas Commun.* 34 (5) (2016) 1250–1266.
- [28] A. Alexiou, C. Bouras, V. Kokkinos, A. Papazois, G. Tsiichritzis, Spectral efficiency performance of MBSFN-enabled LTE networks, in: *2010 IEEE 6th International Conference on Wireless and Mobile Computing, Networking and Communications*, October, IEEE, 2010, pp. 361–367.



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REVIEW

Critical analysis of biophysicochemical parameters for qualitative improvement of phyto-genic nanoparticles

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Abstract

Conventional chemical approaches for synthesizing nanoparticles (NPs) may restrict their applicability as they are not eco-friendly, energetically efficient and often involve toxic reducing/capping agents; but phytonanotechnology enabled the synthesis of safe, inexpensive, highly biocompatible NPs. In this regard, thorough understanding of green components and the modulatory effects of different reaction conditions on the physicochemical parameters of green synthesized NPs would be a prerequisite, which is not depicted elsewhere. This review critically analyzes the relevant reaction conditions from their mechanistic viewpoints in plant-based synthesis of NPs arising fundamental issues which need to be determined carefully. The size, stability and surface chemistry of phyto-genic NPs may be fabricated as a function of multiple interconnected reaction parameters and the plant species used. The therapeutic potential of phyto-genic NPs may depend on the plant species used; and so the meticulous understanding of physicochemical parameters and the family wise shorting of elite plant species may potentially benefit the theranostic future of plant-based NPs.

KEYWORDS

green-synthesis, nanotechnology, phytochemicals, phytonanotechnology, plant-based nanoparticles, reducing/capping agents

1 | INTRODUCTION

Cancer is an emerging health concern due to its high rate of global occurrence in every year and associated therapeutic complications.¹⁻⁴ The waned enhanced permeability and retention (EPR) effects of chemotherapeutic agents, underdeveloped drug delivery systems for tissue/organs/organelles specific targeting and the deficit of original bioavailability would be the major technological limitations subduing the therapeutic efficiency of chemotherapeutants.

The advent of nanotechnology has opened up a new horizon to the treatment of many deadly ailments including cancer.⁵⁻⁷ The present physical and chemical methods (including both top-down and bottom-up approaches) for nanoparticles (NP) synthesis still have to depend on the use of a lot of toxic and environmentally hazardous

reagents, which might impose severe detrimental effects on the environment, ecosystem and public health; and are labor intensive, energetically inefficient and expensive.⁸⁻¹⁵ These hurdles compelled researchers to think another way and to make use of biomolecules for NPs synthesis aiming to develop facile, inexpensive, energetically efficient and eco-friendly technologies (green technology) for biocompatible NPs synthesis (Figure 1).

The phytomining approach of NPs recovery depends on the sequestration of biocompatible NPs from the plants which can bioaccumulate the metals ions and are able to reduce them making NPs *in vivo*; but this process is time consuming and cannot monitor the size and shape of synthesized NPs.¹⁶ In this way, the *in vitro* approach for plant-based synthesis of NPs (bottom-up approach) has been developed. The green synthesis of NPs involves the biomolecules of plants,

191. Erdogan O, Abbak M, Demirbolat GM, et al. Green synthesis of silver nanoparticles via *Cynara scolymus* leaf extracts: the characterization, anticancer potential with photodynamic therapy in MCF7 cells. *PLoS One*. 2019;14(6):e0216496. <https://doi.org/10.1371/journal.pone.0216496>.
192. Pei J, Fu B, Jiang L, Sun T. Biosynthesis, characterization, and anticancer effect of plant-mediated silver nanoparticles using *Coptis chinensis*. *Int J Nanomed*. 2019;14:1969-1978. <https://dx.doi.org/10.2147/IJN.S188235>.
193. Wang L, Xu J, Yan Y, Liu H, Karunakaran T, Li F. Green synthesis of gold nanoparticles from *Scutellaria barbata* and its anticancer activity in pancreatic cancer cell (PANC-1). *Artif Cells Nanomed Biotechnol*.

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Functional interplay between plastic polymers and microbes: a comprehensive review

Sukhendu Maity · Sambuddha Banerjee · Chayan Biswas · Rajkumar Guchhait · Ankit Chatterjee · Kousik Pramanick

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Abstract Escalated production of plastic, their worldwide distribution and persistent nature finally results into their environmental accumulation causing severe threats to the ecological environment and biotic health. Thus, development of suitable measurements for environmental remediation of plastic may be an urgent issue in this plastic age. Some recent reviews have categorized the microbial species able to degrade different plastic polymers and the different factors effecting bio-degradation of plastic are poorly understood. This review comprehensively discusses bio-degradation of traditional and biodegradable plastic polymers both in natural and biological environment (gut microbes and fungi) to understand different factors regulating their degradation, and also shows how degradation of plastic polymers under abiotic factors influence subsequent biological degradation. Different physicochemical modifications like - breaking large polymers into small fragments

by pre-treatment, functional groups enrichment, identifying potent microbial species (consortia) and engineering microbial enzymes might be crucial for bio-degradations of plastic. Effects of micro/nanoplastic and other chemical intermediates, formed during the bio-degradation of plastic, on species composition, abundance, growth, metabolism and enzymatic systems of microbes involved in the bio-degradation of plastic should be determined in future research.

Keywords Bio-degradation · Pre-treatment · Functional groups · Biotic-abiotic factors · Microbial enzymes · Composting

Introduction

Global production rate of plastic production is increasing every year since 1950 s due to their wide range of applications in different sectors such as agriculture, packaging, construction, automotive industry, biomedicine etc. Increasing annual production of plastic and their improper waste management collectively results in higher environmental accumulation. The global production of plastic reached 368 million tons in 2019 and 51% of this total production was contributed by Asia (Plastics—the facts 2020 by Plastic Europe). Eriksen et al. (2014) showed the improper waste management system to be accounted for floating of >5 trillion plastic pieces

Sukhendu Maity, Sambuddha Banerjee and Chayan Biswas have contributed equally to this work.

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Review

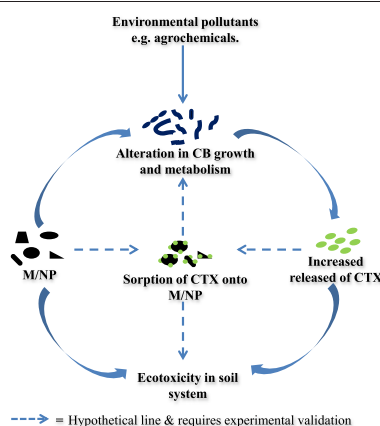
Co-occurrence of co-contaminants: Cyanotoxins and microplastics, in soil system and their health impacts on plant – A comprehensive review

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HIGHLIGHTS

- Cyanotoxin and micro/nanoplastics may be emerging co-contaminants in soils.
- Phytotoxic effects of cyanotoxin and its mixture are poorly understood.
- Co-occurrence in soil suggests sorption of cyanotoxin onto micro/nanoplastics.
- Distinct lack of combined effects of cyanotoxin & micro/nanoplastics.
- Ecotoxicity should be measured using environmentally relevant doses.

GRAPHICAL ABSTRACT



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ABSTRACT

Cyanotoxins (CTX) and micro/nanoplastics (M/NP) are ubiquitously distributed in every environmental compartment. But the distribution, abundance and associated ecological risks of CTX are still poorly understood in soil system. On the other hand, M/NP could serve as vectors for persistent organic/inorganic pollutants in the natural environment through the sorption of pollutants onto them. Thus, co-occurrence of CTX and M/NP in soils suggests the sorption of CTX onto M/NP. So, major aim of this review is to understand the relevance of CTX and M/NP in soils as co-contaminants, possible interactions between them and ecological risks of CTX in terms of phytotoxicity. In this study, we comprehensively discuss different sources and fate of CTX and the sorption of CTX onto M/NP in soil system, considering the partition coefficient of different phases of soil and mass balance. Phytotoxicity of CTX, CTX mixture and co-contaminants has also been discussed with insights on the mechanism of action. This study indicates the need for the evaluation of sorption between co-contaminants, especially CTX and M/NP, and their phytotoxicity assessment using environmentally relevant concentrations.

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- Song, Y., Cao, C., Qiu, R., Hu, J., Liu, M., Lu, S., Shi, H., Raley-Susman, K.M., He, D., 2019. Uptake and adverse effects of polyethylene terephthalate microplastics fibers on terrestrial snails (*Achatina fulica*) after soil exposure. *Environ. Pollut.* 250, 447–455.
- Summers, S., Henry, T., Gutierrez, T., 2018. Agglomeration of nano-and microplastic particles in seawater by autochthonous and de novo-produced sources of exopolymeric substances. *Mar. Pollut. Bull.* 130, 258–267.
- Svircev, Z., Lalic, D., Savic, G.B., Tokodi, N., Backovic, D.D., Chen, L., Meriluoto, J., Codd, G.A., 2019. Global geographical and historical overview of cyanotoxin distribution and cyanobacterial poisonings. *Arch. Toxicol.* 93 (9), 2429–2481.
- Tang, S., Lin, L., Wang, X., Feng, A., Yu, A., 2020. Pb (II) uptake onto nylon microplastics: interaction mechanism and adsorption performance. *J. Hazard. Mater.* 386, 121960.
- Thirumavalavan, M., Hu, Y.L., Lee, J.F., 2012. Effects of humic acid and suspended soils on adsorption and photo-degradation of microcystin-LR onto samples from Taiwan reservoirs and rivers. *J. Hazard. Mater.* 217, 323–329.
- Tlili, S., Jemai, D., Brinis, S., Regaya, I., 2020. Microplastics mixture exposure at environmentally relevant conditions induce oxidative stress and neurotoxicity in the wedge clam *Donax trunculus*. *Chemosphere* 258, 127344.
- Tourinho, P.S., Kočí, V., Loureiro, S., van Gestel, C.A., 2019. Partitioning of chemical contaminants to microplastics: sorption mechanisms, environmental distribution and effects on toxicity and bioaccumulation. *Environ. Pollut.* 252, 1246–1256.
- Velzeboer, I., Kwadijk, C.J.A.F., Koelmans, A.A., 2014. Strong sorption of PCBs to nanoplastics, microplastics, carbon nanotubes, and fullerenes. *Environ. Sci. Technol.* 48 (9), 4869–4876.
- Wang, T., Yu, C., Chu, Q., Wang, F., Lan, T., Wang, J., 2020a. Adsorption behavior and mechanism of five pesticides on microplastics from agricultural polyethylene films. *Chemosphere* 244, 125491.
- Wang, F., Zhang, M., Sha, W., Wang, Y., Hao, H., Dou, Y., Li, Y., 2020b. Sorption behavior and mechanisms of organic contaminants to nano and microplastics. *Molecules* 25 (8), 1827.
- Wu, P., Cai, Z., Jin, H., Tang, Y., 2019. Adsorption mechanisms of five bisphenol analogues on PVC microplastics. *Sci. Total Environ.* 650, 671–678.
- Xu, B., Liu, F., Cryder, Z., Huang, D., Lu, Z., He, Y., Wang, H., Lu, Z., Brookes, P.C., Tang, C., Gan, J., 2020. Microplastics in the soil environment: occurrence, risks, interactions and fate—a review. *Crit. Rev. Environ. Sci. Technol.* 50 (21), 2175–2222.
- Yokota, K., Waterfield, H., Hastings, C., Davidson, E., Kwietniewski, E., Wells, B., 2017. Finding the missing piece of the aquatic plastic pollution puzzle: interaction between primary producers and microplastics. *Limnol. Oceanogr. Lett.* 2 (4), 91–104.
- Yu, F., Yang, C., Zhu, Z., Bai, X., Ma, J., 2019. Adsorption behavior of organic pollutants and metals on micro/nanoplastics in the aquatic environment. *Sci. Total Environ.* 694, 133643.
- Zanchett, G., Oliveira-Filho, E.C., 2013. Cyanobacteria and cyanotoxins: from impacts on aquatic ecosystems and human health to anticarcinogenic effects. *Toxins* 5 (10), 1896–1917.
- Zerrifi, S.E.A., El Khalloufi, F., Oufdou, K., Oudra, B., Lahrouni, M., Campos, A., Vasconcelos, V., 2019. Mode of action and fate of microcystins in the complex soil-plant ecosystems. *Chemosphere* 225, 270–281.
- Zhang, Y., Whalen, J.K., Sauv e, S., 2020a. Phytotoxicity and bioconcentration of microcystins in agricultural plants: meta-analysis and risk assessment. *Environ. Pollut.* 115966.
- Zhang, Y., Whalen, J.K., Duy, S.V., Munoz, G., Husk, B.R., Sauv e, S., 2020b. Improved extraction of multiclass cyanotoxins from soil and sensitive quantification with on-line purification liquid chromatography tandem mass spectrometry. *Talanta* 216, 120923.
- Zhou, C.Q., Lu, C.H., Mai, L., Bao, L.J., Liu, L.Y., Zeng, E.Y., 2021. Response of rice (*Oryza sativa* L.) roots to nanoplastic treatment at seedling stage. *J. Hazard. Mater.* 401, 123412.



Solvato(fluoro)chromism, investigation of quenching mechanism and thermodynamic binding parameter of two azine based chemosensor for Cu²⁺ ion, application in onsite detection

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Two solvatochromic fluorescent azine derivative 1-((*E*)-((*Z*)-(4-(diethylamino)-2-hydroxybenzylidene)hydrazono)methyl)naphthalen-2-yl (L1) and (*E*)-2-((4-(diethylamino)-2-hydroxybenzylidene)amino)-3',6'-dihydroxyspiro[isindoline-1,9'-xanthen]-3-one (L2) was synthesized via Schiff base condensation. The introduction of an electron-donating diethylamino group and an electron-accepting fluorophore unit into the pi-conjugated system of L1 and L2 endowed a prominent solvatochromic emission property. In contrast with the very little changes of absorption spectra in the different solvents, the emission was strongly dependent on the solvent polarity and could be tuned from blue region to red region by changing the solvent from less polar tetrahydrofuran to highly polar water. Both the ligand L1 and L2 were able to binds Cu²⁺ ion selectively via fluorescence turn-off process. The limit of detection (LOD) for Cu²⁺ was found to be 1.9 μM and 1.62 μM with L1 and L2, respectively. The photophysical experimental results reveal that the Cu²⁺ ions quenched the intrinsic fluorescence of both L1 and L2 by forming the ligand-metal complexes, but the quenching process different (static or dynamic) for the two probes. In addition, the binding spontaneity was mainly entropy-driven. Again both ligands successfully detect Cu²⁺ by means of TLC paper as well as simple filter paper based strips and hence, they would be very useful for onsite detection purpose.

Keywords: Solvato(fluoro)chromism, Cu²⁺ ion, quenching, LOD, thermodynamic spontaneity, paper strips.

Introduction

Luminescent materials derived from Schiff base compounds have attracted great attention in the past few decades owing to their potential applications in the fields of organic electronics, optoelectronics, sensors and informational displays¹. It is well known that the absorption and emission spectral responses of chemical compounds may be influenced by the surrounding medium and that medium can bring about a change in the position, intensity, and shape of absorption and/or emission bands. Hantzsch later termed this phenomenon solvatochromism^{2,3}. The term often solvatofluorochromism was defined for the emission position change upon solvent polarity variation. Obviously, this phenomenon is caused by differential solvation of the ground and first excited state of the light-absorbing molecule (or its chromophore). Differential solvation of these two states is

responsible for the solvent influence on emission spectra⁴. In general, molecules with a large change in their permanent dipole moment upon excitation exhibit a strong solvatochromic behaviour⁵. Besides the dipole moment change on excitation, the ability of a solute to donate or to accept hydrogen bonds to or from surrounding solvent molecules in its ground and Franck-Condon excited state determines further the extent and sign of its solvatochromism^{4,6,7}.

Fluorescent molecules possessing solvatochromic properties display different emission spectra depending on solvent polarity whose fluorescence intensity, color, and wavelength are sensitive to the environment^{5,8}. The absolute value of the red shift depends, usually linearly, on the solvent polarity. The more polar solvent with a higher static dipole moment polarizes molecules more strongly, the stronger the red shift. Due to their sensitivity to polarity and hydration,

for Cu²⁺ was found to be 1.9 μM and 1.62 μM with **L1** and **L2**, respectively. The thermodynamic parameter reveals the binding of metal ion is associated with entropy favorable path. The complete quenching of the emission intensity was observed with Cu²⁺ ions in paper strips unravel the efficiency of the probe **L1** and **L2** to detect Cu²⁺ ions as an onsite sensor.

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References

1. T. L. Mako, J. M. Racicot and M. Levine, *Chem. Rev.*, 2018, **119**, 322.
2. A. Hantzsch, *Ber. Dtsch. Chem. Ges.*, 1922, 953.
3. E. S. Dodsworth, M. Hasegawa, M. Bridge and W. Linert, *Compr. Coord. Chem. II*, 2004, **2**, 351.
4. A. S. Klymchenko, *Acc. Chem. Res.*, 2017, **50**, 366.
5. A. Marini, A. Muñoz-Losa, A. Biancardi and B. Mennucci, *J. Phys. Chem. B*, 2010, **114**, 17128.
6. S. Nigam and S. Rutan, *Appl. Spectrosc.*, 2001, **55**, 362A.
7. A. A. Edwards and B. D. Alexander, "UV-Visible absorption spectroscopy, organic applications", Elsevier Ltd., 3rd ed., 2016.
8. C. Reichardt, *Chem. Rev.*, 1994, **94**, 2319.
9. J. M. V. Ngororabanga, C. Moyo, E. Hosten, N. Mama and Z. R. Tshentu, *Anal. Methods*, 2019, **11**, 3857.
10. A. T. Afaneh and G. Schreckenbach, *J. Phys. Chem. A*, 2015, **119**, 8106.
11. Y. Yang, F. Huo, C. Yin, Y. Chu, J. Chao, Y. Zhang, J. Zhang, S. Li, H. Lv, A. Zheng and D. Liu, *Sensors Actuators B: Chem.*, 2013, **177**, 1189.
12. R. Yadav, A. Rai, A. K. Sonkar, V. Rai, S. C. Gupta and L. Mishra, *New J. Chem.*, 2019, **43**, 7109.
13. M. Calvin and K. W. Wilson, *J. Am. Chem. Soc.*, 1945, **67**, 2003.
14. K. S. Siddiqi, S. Bano, A. Mohd and A. A. P. Khan, *Chinese J. Chem.*, 2009, **27**, 1755.
15. S. Samanta, S. Goswami, M. N. Hoque, A. Ramesh and G. Das, *Chem. Commun.*, 2014, **50**, 11833.
16. B. Das, A. Jana, A. Das Mahapatra, D. Chattopadhyay, A. Dhara, S. Mabhai and S. Dey, *Spectrochim. Acta - Part A: Mol. Biomol. Spectrosc.*, 2019, **212**, 222.
17. S. Banthia and A. Samanta, *J. Phys. Chem. B*, 2006, **110**, 6437.
18. B. Ramachandram and A. Samanta, *J. Phys. Chem. A*, 1998, **102**, 10579.
19. J. R. Lakowicz, "Principles of Fluorescence Spectroscopy", Plenum, New York, 1999.
20. J. T. Yeh, W. C. Chen, S. R. Liu and S. P. Wu, *New J. Chem.*, 2014, **38**, 4434.
21. P. S. Subramanian, E. Suresh and D. Srinivas, *Inorg. Chem.*, 2000, **39**, 2053.
22. N. Kato, M. Nakamura and T. Uchiyama, *J. Inorg. Biochem.*, 1999, **75**, 117.
23. K. Campbell, A. Zappas, U. Bunz, Y. S. Thio and D. G. Bucknall, *J. Photochem. Photobiol. A: Chem.*, 2012, **249**, 41.
24. H. Cho, J. B. Chae and C. Kim, *ChemistrySelect*, 2019, **4**, 2795.
25. E. Ciotta, P. Proposito and R. Pizzoferrato, *J. Lumin.*, 2019, **206**, 518.
26. F. Wang, Z. Gu, W. Lei, W. Wang, X. Xia and Q. Hao, *Sensors Actuators, B: Chem.*, 2014, **190**, 516.
27. W. E. Acree, *Zeitschrift fur Naturforsch. - Sect. A: J. Phys. Sci.*, 1993, **48**, 1265.
28. R. Giri, *Spectrochim. Acta - Part A: Mol. Spectrosc.*, 1992, **48**, 843.
29. S. Bano, A. Mohd, A. A. P. Khan and K. S. Siddiqi, *J. Chem. Eng. Data*, 2010, **55**, 5759.
30. M. Kasha, *J. Chem. Phys.*, 1952, **20**, 71.
31. M. Wang, K. Li, J. Hou, M. Wu, Z. Huang and X. Yu, *J. Org. Chem.*, 2012, **77**, 8350.
32. H. Liu, F. X. Li, Y. Pi, D. J. Wang, Y. J. Hu and J. Zheng, *Spectrochim. Acta - Part A: Mol. Biomol. Spectrosc.*, 2015, **145**, 588.



RESEARCH ARTICLE

WILEY

Mafic volcanic rocks of western Iron Ore Group, Singhbhum Craton, eastern India: Geochemical evidence for ocean–continent convergence

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Precambrian mafic magmatism is an important global episode which played a significant role in the crustal evolution. In India, Singhbhum Craton being the oldest craton, witnessed significant occurrences of Precambrian geological activity, marked by several episodes of volcanism, plutonism, sedimentation spanning from Palaeoarchean to Mesoproterozoic age. Here we present petrological and geochemical characteristics of Precambrian mafic volcanic rocks (occurring in western Iron Ore Group (IOG), Singhbhum Craton, eastern India) to evaluate their petrogenetic aspects, tectonic setting, and magma generation. The mafic volcanic rocks are porphyritic in nature with the phenocrysts of plagioclase and groundmass composed of clinopyroxene, plagioclase, ilmenite, and volcanic glass. These rocks are mostly tholeiitic, sometimes with a transitional behaviour towards calc-alkaline nature and display basalt-basaltic andesite affinity. These mafic volcanic rocks also preserve geochemical signatures (high Nb/U, Nb/La, [Nb/Th]_{pm} ratios) in support of Nb-enriched basalts and are classified as Nb-enriched basalts (NEB; Nb > 7 ppm) and high-Nb basalts (HNB; Nb > 20 ppm) on the basis of Nb concentrations and mantle normalized Nb/La ratios (>0.5). The NEBs and HNBS are marked by lesser magnitude of negative Nb anomalies with high (Nb/Th)_{pm}, (Nb/La)_{pm}, and Nb/U ratios as compared to normal arc basalts. Several major element oxides, trace elements, and selected element ratios (like SiO₂, CaO/Al₂O₃, Y, V/Cr, Zr/Nb, and \sum REE) show systematic variations with MgO which suggests role of magmatic fractionation. Chondrite-normalized REE patterns for NEB and HNB rocks exhibit uniform LREE enrichment with distinct Eu negative anomalies while primitive mantle-normalized incompatible trace element patterns reflect enrichment in LILE and LREE with prominent Nb-Ta anomalies. Different HFSE ratios corroborate a subduction related setting for magma generation formed by ~10%–20% melting in the domain of garnet lherzolite. Relative enrichment of LILE and LREE with depleted HFSE characteristics attest a garnet-bearing mantle source and melt extraction with garnet in the residue. Geochemical signatures suggest that the genesis of NEB and HNB is attributable to slab-melting and wedge hybridization processes

- Santosh, M. (2013). Evolution of continents, cratons and supercontinents: Building the habitable Earth. *Current Science*, 104, 871–879.
- Sarkar, S. N., & Saha, A. K. (1962). A revision of the Precambrian stratigraphy and tectonics of Singhbhum and adjacent region. *Quarterly Journal, Geological Mining and Metallurgical Society of India*, 34, 97–136.
- Sarkar, S. N., & Saha, A. K. (1963). On the occurrence of two intersecting Precambrian orogenic belts in Singhbhum and adjacent areas, India. *Geological Magazine*, 100, 69–92.
- Sengupta, S., Acharyya, S. K., & Deshmeth, J. B. (1997). Geochemistry of Archaean volcanic rocks from Iron Ore Supergroup, Singhbhum, eastern India. *Proceedings of the Indian Academy of Sciences (Earth Planetary Science)*, 106, 327–342.
- Sengupta, S., Corfu, F., McNutt, R. H., & Paul, D. K. (1996). Mesoarchaean crustal history of the eastern Indian craton: Sm-Nd and U-Pb isotopic evidence. *Precambrian Research*, 77, 17–22.
- Shankar, R., Srinivasa Sarma, D., Ramesh Babu, N., & Parashuramulu, V. (2018). Palaeomagnetic study of 1765 Ma dyke swarm from Singhbhum Craton: Implications to the palaeogeography of India. *Journal of Asian Earth Sciences*, 157, 235–244.
- Sharma, R. S. (2009). *Cratons and fold belts of India*. Heidelberg, Germany: Springer Verlag 322p.
- Singh, M. R., Manikyamba, C., Ray, J., Ganguly, S., Santosh, M., Saha, A., ... Sawant, S. S. (2016). Major, trace and platinum group element (PGE) geochemistry of Archean Iron Ore Group and Proterozoic Malangtoli metavolcanic rocks of Singhbhum Craton, Eastern India: Inferences on mantle melting and sulphur saturation history. *Ore Geology Reviews*, 72, 1263–1289.
- Smithies, R. H., Champion, D. C., Van Kranendonk, M. J., Howard, H. M., & Hickman, A. H. (2005). Modern-style subduction processes in the Mesoarchaean. Geochemical evidence from the 3.12 Ga Whundo intra-oceanic arcs. *Earth and Planetary Science Letters*, 231, 221–237.
- Soderlund, U., Elmings, S.-A., Ernst, R. E., & Schissel, D. (2006). The Central Scandinavian Dolerite Group: Protracted hotspot activity or back-arc magmatism? Constraints from U-Pb baddeleyite geochronology and Hf isotope data. *Precambrian Research*, 150, 136–152.
- Sreenivas, B., Dey, S., Bhaskar Rao, Y. J., Vijaya Kumar, T., Babu, E. V. S. K., & Williams, I. S. (2019). A new cache of Eoarchaean detrital zircons from the Singhbhum Craton, eastern India and constraints on early Earth geodynamics. *Geoscience Frontiers*, 10(4), 1359–1370.
- Srivastava, R. K., & Ahmad, T. (2008). Precambrian mafic magmatism in the Indian Shield: An introduction. *Journal of Geological Society of India*, 72, 9–13.
- Srivastava, R. K., Söderlund, U., Ernst, R. E., Mondal, S. K., & Samal, A. K. (2016). Neoarchaean-Palaeoproterozoic mafic dyke swarms from the Singhbhum Granite Complex, Singhbhum Craton, eastern India: Implications for identification of large igneous provinces and their possible continuation on other formerly adjacent crustal blocks. *Acta Geologica Sinica (English Edition)*, 90(supp. 1), 17–18.
- Stern, C. R., & Kilian, R. (1996). Role of the subducted slab, mantle wedge and continental crust in the generation of adakites from the Austral Volcanic zone. *Contribution to Mineralogy and Petrology*, 123, 263–281.
- Sun, S. S., & McDonough, W. F. (1989). Chemical and isotopic systematics of oceanic basalts: Implications for mantle composition and processes. In A. D. Saunders & M. J. Norry (Eds.), *Magmatism in the Ocean Basins* (Vol. 42, pp. 313–345). London: Geological Society of London Special Publication <https://doi.org/10.1144/GSL.SP.1989.042.01.19>
- Suominen, V. (1991). The Chronostratigraphy of Southwestern Finland with special reference to Postjotnian and Subjotnian diabbases. *Geological Survey of Finland, Bulletin*, 356 106p.
- Sylvester, P. J., Campbell, I. H., & Bowyer, D. A. (1997). Niobium/Uranium evidence for early formation of the continental crust. *Science*, 275, 521–523.
- Tait, J., Zimmermann, U., Miyazaki, T., Presnyakov, S., Chang, Q., Mukhopadhyay, J., & Sergeev, S. (2011). Possible juvenile Palaeoarchaean TTG magmatism in eastern India and its constraints for the evolution of the Singhbhum Craton. *Geological Magazine*, 148, 340–347.
- Tatsumi, Y. (2006). High-Mg andesites in the Setouchi volcanic belt, southwestern Japan: Analogy to Archean magmatism and continental crust formation? *Annual Reviews, Earth and Planetary Sciences*, 34, 467–499.
- Thomson, A. R., Walter, M. J., Kohn, S. C., & Brooker, R. A. (2016). Slab melting as a barrier to deep carbon subduction. *Nature*, 529, 76–79.
- Thornton, C. P., & Tuttle, O. F. (1960). Chemistry of igneous rocks: Pt. 1. Differentiation index. *American Journal of Science*, 258, 664–684.
- Thurston, P. C. (1990). Early Precambrian basic rocks of the Canadian Shield. In R. P. Hall & D. J. Hughes (Eds.), *Early Precambrian basic magmatism* (pp. 221–247). Springer, Dordrecht: Blackie and Son Limited.
- Turkina, O. M., & Nozhkin, A. D. (2003). Genesis of Archean tonalite-trondhjemite suites: Plume or subduction related? *Russian Journal of Earth Sciences*, 5, 93–100.
- Upadhyay, D., Chattopadhyay, S., Kooijman, E., Mezger, K., & Berndt, J. (2014). Magmatic and metamorphic history of Palaeoarchaean tonalite-trondhjemite-granodiorite (TTG) suites from the Singhbhum Craton, Eastern India. *Precambrian Research*, 252, 180–190.
- Upton, B. G. J., Emeleus, C. H., Heaman, L. M., Goodenough, K. M., & Finch, A. A. (2003). Magmatism of the mid-Proterozoic Gardar Province, South Greenland: Chronology, petrogenesis and geological setting. *Lithos*, 68, 43–65.
- Walowski, K. J., Wallace, P. J., Hauri, E. H., Wada, I., & Clyne, M. A. (2015). Slab melting beneath the Cascade Arc driven by dehydration of altered oceanic peridotite. *Nature Geoscience*, 8, 404–408.
- Weaver, B. L. (1991). The origin of ocean island basalt end-member compositions: Trace element and isotopic constraints. *Earth and Planetary Science Letters*, 104, 381–397.
- Wilde, S. A., Zhou, X. H., Nemchin, A. A., & Sun, M. (2003). Mesozoic crust–mantle interaction beneath the North China Craton: A consequence of the dispersal of Gondwanaland and accretion of Asia. *Geology*, 31(9), 817–820.
- Wilson, M. (1989). *Igneous Petrogenesis*. London, UK: Unwin Hyman 466p.
- Wingate, M. T. D. (1999). Ion microprobe baddeleyite and zircon ages for Late Archaean mafic dykes of the Pilbara Craton, Western Australia. *Australian Journal of Earth Sciences*, 46, 493–500.
- Wood, D. A. (1980). The application of a Th-Hf-Ta diagram to problems of tectonomagmatic classification and to establish the nature of crustal contamination of basaltic lavas of the Tertiary Volcanic Province. *Earth and Planetary Science Letters*, 50, 11–30.
- Wyman, D. (2018). Do cratons preserve evidence of stagnant lid tectonics? *Geoscience Frontiers*, 9, 3–17.
- Wyman, D. A., Ayer, J. A., & Devaney, J. R. (2000). Niobium-enriched basalts from the Wabigoon subprovince, Canada: Evidence for adakitic metasomatism above an Archean subduction zone. *Earth and Planetary Science Letters*, 179, 21–30.
- Zhai, M. (2014). Multi-stage crustal growth and cratonization of the North China Craton. *Geoscience Frontiers*, 5(4), 457–469.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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Homes across the Water: Dislocation and Transcultural Kinship in Amitav Ghosh's *The Glass Palace*

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Abstract:

*Kinship studies, a key area of anthropology since the late nineteenth century, implies human relationships based on consanguinity and biological affinity, where blood-relationships play an essential role in the social grouping of people and identity formation. The essentialist idea of kinship insists on a universal assumption—'Blood is thicker than water'. However, this idea has been challenged by modern cultural anthropologists in the late twentieth century (David M. Schneider and Marilyn Strathern) and early twenty-first century (Janet Carsten) since it does not take into consideration multiple cultural factors in the formation of kinship in this modern age of transnational migration and dislocation. Setting the 'blood-related', 'natural' or biological kinship aside, they advocated for the 'cultural' dimensions of kinship configured by regional specificity, community, ethno-nationality, language, marriage and even diasporic dislocation. In this article, we attempt an exploration of transcultural kinship concerning diasporic individuals and their families constituted by members with different ethno-cultural identities. Taking Amitav Ghosh's *The Glass Palace* (2000) as case-study, this essay would examine how dislocation beyond the familiar cultural space opens up avenues for re-imagining kinship beyond the bonds of community and often leads to the establishment of families across the "water" (metaphoric of diasporic mobility). We also attempt to investigate how cultural hybridity and transculturality reconfigure family-ties situating an individual in a newer pattern of kinship; how a relationship like close friendship or mentorship turns into strong kinship bonds resembling family-ties.*

Keywords: *Migration, Dislocation, Identity, Borders, Negotiation, Kinship, Family-ties*

"The ideas of kinship, the kin-based society, the idiom of kinship, and the content of kinship are the received wisdom of today, as they have been almost from the beginnings of anthropology."

A Critique of the Study of Kinship (1984): David Murray Schneider

-With this proposition, Schneider's influential volume *A Critique of the Study of Kinship* (1984) initiates a relatively new way of looking at kinship studies beyond the formalist tradition, by attempting cross-cultural analyses of kinship only three decades back. The inception of kinship studies is attributed to Lewis Henry Morgan and his 'magnum opus' *Systems of Consanguinity and Affinity of the Human Family* (1871) which centres around the essentialist idea of kinship based on blood relationships and biological affinity. The propositions of Schneider's new anthropology of kinship, which he finds as "the received wisdom of today" (3), rely heavily on nature/culture interplay than the biologically determined structuralist way of assessing kinship. The inclusion of 'local' culture/s and community history as no less essential determinants than the exclusive factors like progeny and ethnology in kinship studies, has allowed a broader and more fluid conceptualization of

the eventual birth of Ilongo is a strong example of transcultural kinship in dislocation. The ending of the novel is significant since it shows how lack of wealth, homelessness and dislocation transform people. Despite their mutual antipathy, the redemptive love brings Rajkumar and Uma together to dissolve the borders between them. The crossing of borders not only liberates the 'self' from a confined space but also situates it in a global network of kinship that paves the way for re-imagining community and a home across the water.

End Note:

¹ Ghosh's narrator indulges in a fanciful reference to botanical kinship while reflecting over the relationship between teak and mint: "Teak is a relative of mint, *tectona grandis*, born of the same genus" (70), and "there was an unmistakable kinship, a palpably familial link" (71).

Works Cited:

- Carsten, Janet. Ed. Introduction. *Ghosts of Memory: Essays on Remembrance and Relatedness*. Blackwell Publishing Ltd., 2007.
- . *After Kinship*. Cambridge University Press, 2004.
- De, Asis. "Empire and Exile: Representation of the Burmese Royal Family across the Border in Amitav Ghosh's *The Glass Palace* and Sudha Shah's *The King in Exile*". *Beyond Borders and Boundaries: Diasporic Images and Re-presentations in Literature and Cinema*. Edited by Nilufer Bharucha, Sreedhar Rajeswaran and Klaus Stierstorfer. Indian Diaspora Centre, 2018, pp.132-147.
- Ghosh, Amitav. *The Glass Palace* (2000). HarperCollins Publishers India, 2005.
- Jallinoja, Riitta & E. D. Widmer. Eds. *Families and Kinship in Contemporary Europe: Rules and Practices of Relatedness*. Palgrave Macmillan, 2011.
- Schneider, David M. *A Critique of the Study of Kinship* (1984). The University of Michigan Press, 1998.
- Smart, Carol. "Relationality and Socio-Cultural Theories of Family Life." *Families and Kinship in Contemporary Europe: Rules and Practices of Relatedness*. Edited by Riitta Jallinoja & E. D. Widmer. Palgrave Macmillan, 2011, pp. 13-28.
- Strathern, Marilyn. *After Nature: English Kinship in the late Twentieth Century*. Cambridge University Press, 1992.
- Thieme, John. "Amitav Ghosh." *A Companion to Indian Fiction in English*. Edited by Pier Paolo Piciuccio. Atlantic, 2004. pp. 251-275.

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চরকসংহিতায় সাংখ্যের প্রভাব : একটি সমীক্ষা

বিভাস মিত্তী

সাংখ্যদর্শন মূলতঃ দ্বৈতবাদী দর্শন, কেননা সাংখ্যমতে জগতের মূল তত্ত্ব দুটি — পুরুষ (আত্মা) ও প্রকৃতি (জড় সত্তা)। পুরুষ নিত্য শুদ্ধ বুদ্ধ মুক্ত চৈতন্যস্বরূপ। প্রকৃতি ত্রিগুণাত্মিকা — সত্ত্ব রজঃ ও তমঃ গুণের সাম্যাবস্থা। মঙ্গলাচরণ কারিকায় এই তত্ত্বদুটির সূচনা করা হয়েছে —

অজামেকাং লোহিতশুক্লকৃষ্ণাং বহ্বীঃ প্রজাঃ সৃজমানাং নমামঃ
অজা যে তাং জুষমাণাং ভজন্তে জহত্যেনাং ভুক্তভোগাং নুমস্তান্ ৷^১

শুধুমাত্র যে মঙ্গলাচরণ কারিকার প্রথম চরণে প্রকৃতিকে নমস্কার করে দ্বিতীয় চরণে পুরুষকে নমস্কার করা হয়েছে তাই নয়, সাংখ্যকারিকার তৃতীয় কারিকায় সাংখ্যশাস্ত্রের যে চারটি প্রতিপাদ্য বিষয়ের কথা বলা হয়েছে, তার মধ্যে সর্বপ্রথমে প্রকৃতিতত্ত্বের ও সর্বশেষে পুরুষতত্ত্বের উল্লেখ করা হয়েছে —

মূল প্রকৃতিরবিকৃতির্মহাদ্যায়াঃ প্রকৃতিবিকৃতয়ঃ সপ্ত
ষোড়শকস্তু বিকারো ন প্রকৃতিবিকৃতয়ঃ পুরুষঃ ৷^২

চরকসংহিতা অরতীয় আয়ুর্বেদ চিকিৎসাশাস্ত্রের আকর গ্রন্থ। বিশাল এই গ্রন্থে চরক বিভিন্ন রোগের কারণ, লক্ষণ, ঔষধতৈরি এবং রোগের চিকিৎসা-নির্ণয়ের কথা উল্লেখ করেছেন। চরকসংহিতায় আটটি স্থান আছে এবং ১২০ টি অধ্যায় আছে। এই আটটি স্থান হল — সূত্রস্থান, নিদানস্থান, বিমানস্থান, শারীরস্থান, ইন্দ্রিয়স্থান, চিকিৎসাস্থান, কল্পস্থান এবং সিদ্ধিস্থান। ভারতীয় চিকিৎসাবিজ্ঞানের ইতিহাসে চরকসংহিতা এত বড় ও বিষয়বহুল যে, এই সংহিতাটিকে মহাভারতের মতো বলা হয়েছে — চিকিৎসা বহিবেশস্য স্বস্থাতুরহিতং প্রতি, যদিহাস্তি তদন্যত্র যন্নেহাস্তি ন তৎ ক্চিৎ ৷^৩

চরকসংহিতা যে এককালে বহুল সমাদৃত হয়েছিল তার প্রমাণ এই গ্রন্থের উপর অসংখ্য টীকা। চরকসংহিতার টীকাকারদের মধ্যে বিশেষ উল্লেখযোগ্য হলেন চক্রপাণি দত্ত, তাঁর টীকার নাম আয়ুর্বেদ-দীপিকা, শিবদাসেনের চরকতত্ত্বদীপিকা, গঙ্গাধরকৃত কল্পতরু প্রভৃতি। চরকসংহিতার সূত্রস্থানের প্রথম অধ্যায়ে বলা হয়েছে শরীর, মন ও আত্মার মিলিতরূপই হচ্ছে পুরুষ। সেখানে একটি উপমার সাহায্যে দেখানো হয়েছে যে — তিনটি দণ্ডের সংযোগের ফলে যেমন একটি ত্রিদণ্ড প্রস্তুত হয়, যার উপর সব দ্রব্য রাখা যায়। তেমনি শরীর, মন ও আত্মার মিলিতরূপের দ্বারা যে-পুরুষ গঠিত হয়, সেই পুরুষেতেই সুখ,

দুঃখ, বিষয়, বাসনা, জ্ঞান, অজ্ঞান সব কিছু থাকে। শরীর, মন ও আত্মা এই তিনটি যতদিন পরস্পর থেকে বিচ্ছিন্ন না হয় ততদিন লোক জীবিত থাকে, চেতন এই পুরুষকে লক্ষ্য করেই আয়ুর্বেদশাস্ত্রের যা কিছু উপদেশ।

সত্ত্বমায়া শরীরঃ ত্রয়মেতদ্রিদমবত্, লোকস্তিষ্ঠতি সংযোগাত্ তত্র সর্বং প্রতিষ্ঠিতম্।

স পুমাংশ্চেতনং তচ্চ তচ্চাধিকরণং স্মৃতম্, বিদেস্যাস্য, তদর্থং হি বেদোহয়ং সম্প্রকাশিতঃ।^{১৫}

চেতন শব্দের ব্যাখ্যা করতে গিয়ে চক্রপাণি দত্ত আয়ুর্বেদ-দীপিকা টীকায় চেতনাকে জ্ঞানবান্ বলে উল্লেখ করেছেন। চেতনমিতি জ্ঞানবত্।^{১৬} সাংখ্যপ্রবচনসূত্রে বলা হয়েছে — এই পুরুষ ভোক্তা অর্থাৎ সকলের দ্রষ্টা, পুরুষ শরীর প্রভৃতির ব্যতিরিক্ত — শরীরাদিব্যতিরিক্তঃ পুমান্।^{১৭}

চরকসংহিতায় পুরুষতত্ত্বের প্রভাব: চরকসংহিতার সূত্রস্থানের ২৫তম অধ্যায়ের ৮ থেকে ২০ সংখ্যক শ্লোক পর্যন্ত পুরুষের উৎপত্তির কথা বলা হয়েছে। এও বলা হয়েছে, আত্মাই কর্ম করেন এবং আত্মাই কর্মের ফল ভোগ করেন। চেতনাস্বরূপ আত্মা ছাড়া সুখ-দুঃখের প্রবৃত্তি হতে পারে না- আত্মাজঃ পুরুষো রোগাশ্চাত্মজাঃ কারণং হি সঃ।^{১৮} শরীরব্যতিরেকে শারীরিক রোগের এবং মনের স্থিতি হতে পারে না। চরকসংহিতায় বলা হয়েছে, রস থেকেই প্রাণী ও তাদের রক্ত উৎপন্ন হয়ে থাকে। আবার জল থেকেই রস উৎপন্ন হয়। অতএব জলই পুরুষের ও রোগের উৎপত্তির কারণ —

নর্থে শরীরাচ্ছরীররোগো ন মনসঃ স্থিতিঃ।

রসজানি তু ভূতনি ব্যাধেয়শ্চ পৃথগ্বিধাঃ

আপো হি রসবতস্তাঃ স্মৃতা নিবৃত্তিনিবৃত্তিহেতবঃ।^{১৯}

চরকসংহিতায় পুরুষকে ষড়্-ধাতুজ বলা হয়েছে — ষড়্ধাতুজস্ত পুরুষো রোগাঃ ষড়্ধাতুজস্তথা, রাশিঃ ষড়্ধাতুজো হ্যেষ সাংখ্যৈরাদ্যৈঃ পরীক্ষিতঃ।^{২০}

পুরুষ ক্ষিতি, অপ, তেজ, মরুৎ ও ব্যোম এই পঞ্চ ধাতু এবং আত্মা — এই ছয় ধাতু থেকে উৎপন্ন হয়েছে এবং রোগ সকলও এই ছয় ধাতু হতে জন্মেছে। এই পুরুষের ছয় ধাতুর সমষ্টিমাত্র প্রাচীন সংখ্যশাস্ত্রে ঋষিরা বলেছেন। ষড়্-ধাতুজ বলা হলেও মাতাপিতা ছাড়া পুরুষের উৎপত্তি সম্ভব নয়। একটি ন্যায়ের সাহায্যে চরকসংহিতায় তা বোঝানো হয়েছে। যেমন পুরুষ থেকে পুরুষ, গরু থেকে গরু, গরু থেকে অশ্ব জন্মায়, সেরূপ মাতা-পিতা থেকে পুরুষের, রোগসমূহও উৎপন্ন হয়। অতএব মাতা-পিতাই পুরুষের ও রোগসমূহের কারণ — পুরুষঃ পুরুষাদ্ গোর্গোরশ্বাদশ্বঃ প্রজায়তে, মাতাপিতৃভবাশ্চোক্তা গান্তাবত্র কারণম্।^{২১} আবার বলা হয়েছে, কর্ম থেকেই পুরুষের উদ্ভব। সৃষ্টির প্রথমে মাতা-পিতার অভাব। অতএব মাতা-পিতা কখনো জন্মের কারণ নয়। পূর্বজন্মার্জিত কর্মকে এক্ষেত্রে কারণ বলা হয়েছে। হতেই পুরুষের উৎপত্তি, কর্ম হতেই রোগেরও উৎপত্তি। পুরুষের জন্ম বা রোগ কর্ম ছাড়া সম্ভব হয়

মাতাপিত্রোশ্চ পূর্বমুৎপত্তিনোপদ্যতে ।
 কর্মজন্তু মতো যন্তুঃ । কর্মজাতস্য চাময়াঃ ।
 নহ্যতে কর্মণো জন্ম রোগাণাং পুরুষস্য বা ।
 চরকসংহিতার শারীরস্থানে কর্ম থেকে যে পুরুষের উৎপত্তির কথা বলা হয়েছে, সেখানে বলা হয়েছে, যেহেতু পরমাত্মা অনাদি, অতএব তাকে কোনো কিছুর উৎপত্তির কারণ বলা চলে না । মোহ, ইচ্ছা ও দ্বেষকৃতকর্ম থেকেই রাশিসজ্জক পুরুষ অর্থাৎ চতুর্বিংশতি পুরুষ উৎপন্ন হয় — পুরুষে রাশিসজ্জন্তু মোহেচ্ছাদ্বেষকর্মজঃ ।
 পুরুষের স্বরূপ: পুরুষের স্বরূপ প্রসঙ্গে চরকসংহিতার শারীরস্থানে উল্লেখ পাওয়া যায়, সেখানে বলা হয়েছে — এই পুরুষ নিত্য, অনাদি । কিন্তু হেতুজাত পুরুষ অনিত্য-অনাদিঃ পুরুষো নিত্য বিপরীতস্ত হেতুজঃ ।
 নিত্য আত্মার স্বরূপ হচ্ছে বিভূ, অব্যয়, ক্ষেত্রজ, শাশ্বত, অব্যর্থ ও অচিন্ত্য —
 ...তদব্যক্তমচিন্ত্যং ব্যক্তমন্যাথা, অব্যক্তাত্মা ক্ষেত্রজঃ শাশ্বতো বিভূরব্যয়ঃ ।
 তস্মাদ্ যদন্যৎ তদ্ব্যক্তং, বন্ধতে চাপরং দ্বয়ম্, ব্যক্তমৈন্দ্রিয়কণ্ঠৈব গৃহ্যতে তদ্ যদিদ্ভিয়েঃ ।
 অতোহন্যৎ পুনরব্যক্তং লিঙ্গগ্রাহ্যমতীন্দ্রিয়ম্ ।
 এখানে অব্যক্ত বলতে যা ইন্দ্রিয়ের সাহায্যে গ্রহণ করা যায় সেগুলো ভিন্ন যা কিছু অতীন্দ্রিয় লিঙ্গ গ্রাহ্য । আত্মা অব্যক্ত, শাশ্বত, বিভূ ও অব্যয় । অনাদি পুরুষের স্বরূপ হল—সৎ এবং নিত্যধর্মবিশিষ্ট । হেতুজাত পুরুষ অসৎ ।
 অব্যক্ত থেকে পুরুষ কিভাবে ব্যক্ত হয় সে সম্পর্কেও চরকসংহিতার শারীরস্থানের প্রথম অধ্যায় নির্দেশ পাওয়া যায় । সেখানে বলা আছে অব্যক্ত থেকে বুদ্ধির জন্ম হয়, আর এই বুদ্ধির সাহায্যেই অব্যক্ত নিজে মনে করে আমি কর্তা । অর্থাৎ বুদ্ধি হতেই অহঙ্কার উৎপন্ন হয়, অহঙ্কার থেকেই যথাক্রমে আকাশ প্রভৃতি পঞ্চভূতের উৎপত্তি । এইভাবে পুরুষ সম্পূর্ণ হলে তাকে জাতি বা অভ্যুদিত বলা হয় । প্রলয়কালে পুরুষ এইসকল ইষ্টভাব থেকে বিযুক্ত হয়ে পড়েন । এইভাবে পুরুষ রজঃ তমোগুণ সংযুক্ত হয়ে অব্যক্ততা থেকে ব্যক্ততা এবং ব্যক্ততা থেকে আবার প্রলয় অব্যক্ততা হয়ে চক্রবৎ বারবার পরিবর্তিত হতে থাকে । যারা রজঃ ও তমোগুণযুক্ত দ্বন্দ্ব লিঙ হন এবং অহঙ্কারপ মোহে আবিষ্ট হন, তাঁদেরই জন্ম ও মৃত্যু বারবার হতে থাকে, কিন্তু যারা অনাসক্ত এবং অহঙ্কার বুদ্ধিশূন্য তাঁদের বার বার জন্ম ও মৃত্যু হয় না, তাঁরাই মুক্তি লাভ করেন ।
 জায়তে বুদ্ধিরব্যক্তাদ্ বুদ্ধ্যাহমিতি মন্যতে, পরং খাদীন্যহঙ্কারাদুৎপদ্যন্তে যথাক্রমম্ ।
 ততঃ সম্পূর্ণসর্বাস্তো জাতোহভ্যুদিত উচ্যতে, পুরুষঃ প্রলয়ে চেষ্টী পুনর্ভাবৈর্ধিযুজ্যতে ।
 অব্যক্তাদ্ব্যক্ততাং যাতি ব্যক্তাদব্যক্ততাং পুনঃ, রজস্তমোগুণাবিষ্টচক্রবৎ পরিবর্ততে ।
 যেমাং দন্দ্বৈ পরা সঞ্জিরহঙ্কারপরাস্চ যে, উদয়প্রলয়ো তেষাং নি তেষাং যে ততোহন্যাথা ।

পুরুষ, রজঃ তমোগুণের সঙ্গে সংযুক্ত হলে এই সংযোগ হয় অনেকপ্রকার এবং এদের দ্বারা পুরুষ নিরাকৃত হলে একমাত্র সত্ত্ববুদ্ধি দ্বারা এই সংযোগের নিবৃত্তি হতে পারে। অর্থাৎ রজঃ ও তমোগুণের সংযোগ হলে চতুর্বিংশতি পুরুষের সৃষ্টি হয় এবং রজঃ তমোগুণের অভাব হলে সত্ত্ববুদ্ধি দ্বারা পুরুষের মুক্তি হয়ে থাকে — রজস্তমোগুণ যুক্তস্য সংযোগোহয়মনস্তবান্। তাভ্যাং নিরাকৃতাত্যাস্ত সত্ত্ববুদ্ধ্যা নিবর্ততে।^{১৬} সাংখ্যকারিকায় বলা হয়েছে ত্রিগুণাদি অর্থাৎ সত্ত্ব, রজঃ ও তমোগুণের বিপরীত পুরুষ হচ্ছেন সাক্ষী অর্থাৎ দুঃখ প্রভৃতি ছাড়া নিত্যমুক্ত, উদাসীন, দ্রষ্টা ও অকর্তা — তস্মাচ্চ বিপর্যাসাৎ সিদ্ধং সাক্ষিত্বমস্য পুরুষস্য। কৈবল্যং মাখ্যাহ্যং দ্রষ্টৃত্বমকভূতাবশ্চ।^{১৭} সাংখ্যপ্রবচনসূত্রেও বলা হয়েছে পুরুষ জন্ম প্রভৃতি ব্যবস্থার জন্য বহু — জন্মদিব্যবহাতঃ পুরুষবহুত্বম্।^{১৮} এবং ব্যবস্থাদিজন্য পুরুষ বহু বলা হয়েছে — পুরুষবহুত্বম্ ব্যবস্থাতঃ।^{১৯}

চরকসংহিতায় পুরুষ সম্পর্কে বিভিন্ন মতবাদ: চরকসংহিতায় পুরুষ সম্পর্কে বিভিন্ন স্থানে বিভিন্ন মতবাদ দেখা যায় — কোথাও বলা হয়েছে চতুর্বিংশতিপুরুষ, কোথাও বা ষড়্ধাতু পুরুষ এবং কোথাও বা পুরুষ এক প্রকার বলে উল্লেখ করা হয়েছে — ষড়্ধাতুক একধাতুকচতুর্বিংশতিধাতুকশ্চেতি ধাতুভেদেন ত্রিবিধঃ পুরুষো ভবতীতি।^{২০}

চতুর্বিংশতি পুরুষ: চরকসংহিতায় ধাতুভেদের কল্পনানুসারে পুরুষকে চব্বিশ প্রকার বলা হয়েছে। মন, দশটি ইন্দ্রিয় ও পাঁচটি ইন্দ্রিয়ের অর্থ অর্থাৎ শব্দতন্মাত্র, স্পর্শতন্মাত্র, রূপতন্মাত্র, রসতন্মাত্র ও গন্ধতন্মাত্র এবং আটটি ধাতু বিশিষ্ট প্রকৃতি — এই চতুর্বিংশতি ধাতুর সমষ্টিকে চতুর্বিংশতিক পুরুষ বলে — পুনশ্চ ধাতুভেদেন চতুর্বিংশতিকঃ স্মৃতঃ, মনো দর্শেন্দ্রিয়াণ্যর্থাঃ প্রকৃতিশ্চাষ্টধাতুকী।^{২১} এই চব্বিশ প্রকার ধাতুর সমবায়কে চতুর্বিংশতি পুরুষ বলা হয়েছে। আটটি ধাতু বিশিষ্ট প্রকৃতি হল- আকাশ, জল, তেজ, বায়ু ও পৃথিবী—এই পঞ্চমহাভূত, বুদ্ধি অহঙ্কার ও অব্যক্ত এই আটটি— খাদীনি বুদ্ধিরব্যক্তমহঙ্কারস্তথাষ্টমঃ।^{২২} চক্ষু, কর্ণ, নাসিকা, জিহ্বা ও ত্বক্— এই পাঁচটি বুদ্ধীন্দ্রিয়। বাক্, পাণি, পাদ, পায়ু ও উপস্থ— এই পাঁচটি কর্মেন্দ্রিয়। মনঃ এবং শব্দ, স্পর্শ, রূপ, রস ও গন্ধ এই পাঁচটি পঞ্চতন্মাত্র। এই ষোলটিকে প্রকৃতির বিকৃতি বলে গণ্য করা হয়। অব্যক্ত ছাড়া অন্যগুলোকে ক্ষেত্র এবং অব্যক্তকে ক্ষেত্রের ক্ষেত্র বলা হয়েছে—অব্যক্তমস্য ক্ষেত্রস্য ক্ষেত্রস্তম্বয়ো বিদুঃ।^{২৩}

সাংখ্যদর্শনে পঞ্চবিংশতিতত্ত্বের উল্লেখ দেখা যায়। জড়বর্গের আদি কারণ প্রকৃতি, এটি কার্য নয় কেবল কারণ। সাংখ্যদর্শনে কার্য-কারণতত্ত্ব সংকার্যবাদ নামে খ্যাত। সংকার্যবাদানুসারে কার্যোৎপত্তির পূর্বে কার্যকারণের মধ্যে প্রচ্ছন্নভাবে থাকে, কাজেই সাংখ্যমতে উৎপত্তির পূর্বে জগৎ জড়প্রকৃতির মধ্যে প্রচ্ছন্নভাবে ছিল। মূলপ্রকৃতি বা অব্যক্ত থেকে উদ্ভূত মহৎ, অহংকার ও পঞ্চতন্মাত্র—এরা সকলেই কার্যকারণ তত্ত্বের কারণ। পুরুষ সকলের উর্ধ্বে। এটি কার্যও নয়, কারণও নয়— মূলপ্রকৃতিরবিকৃতির্মহাদায়াঃ প্রকৃতি-কৃতয়ঃ সপ্তঃ। ষোড়শকস্ত বিকারো ন প্রকৃতিরবিকৃতিঃ পুরুষঃ।^{২৪}

ষড়্ধাতুজ পুরুষ: ক্ষেত্রবিশেষে পুরুষকে ষড়্ধাতুজ বলা হয়েছে। আকাশাদি পঞ্চমহাভূত অর্থাৎ আকাশ, জল, তেজ, বায়ু, পৃথিবী এই পঞ্চমহাভূত এবং চেতনা ধাতু—এই ষড়্ধাতুর সমষ্টিকেও চরকসংহিতায় পুরুষ বলে অভিহিত করা হয়েছে — খাদয়শ্চেতনাষষ্ঠা ধাতবঃ পুরুষঃ স্মৃতঃ।^{২৫} চক্রপাণি চরকসংহিতার টীকায় চেতনা বলতে ‘মনসংযুক্ত আত্মাকে’ বুঝিয়েছেন। চক্রপাণির এই ব্যাখ্যানানুসারে,

যে আত্মা পুরুষ শব্দের দ্বারা উক্ত হয় তাকেই চেতনা বলে।^{২৬} এই চেতনাকে স্থান বিশেষে ব্রহ্মা বা অব্যক্ত ব্রহ্মরূপে অভিহিত করা হয়েছে। এজন্য চরকসংহিতায় আমরা দেখতে পাই — পৃথিবী, জল, তেজ, বায়ু, আকাশ ও অব্যক্ত ব্রহ্ম একত্রে মিলিত হলে পুরুষ বলে অভিহিত করা হয় — পৃথিব্যাপ্যন্তেজো বায়ুরাকাশং ব্রহ্ম চাব্যক্তমিতি এত এব চ ষড়্-ধাতুবঃ সমুদিতাঃ 'পুরুষ' ইতি শব্দং লভন্তে।^{২৭} এই পুরুষের মূর্তি হচ্ছে পৃথিবী, ক্লেদ হচ্ছে জল, সন্তান হচ্ছে তেজ, প্রাণ হচ্ছে বায়ু, ছিদ্রসমূহ হচ্ছে আকাশ এবং অন্তরাত্মা হচ্ছে ব্রহ্মা-পুরুষস্য পৃথিবী মূর্তিরূপঃ ক্লেদঃ, তেজোহভিসস্তাপঃ, বায়ু প্রাণঃ, রিয়ৎ সুবিরাপি, ব্রহ্মা অন্তরাত্মা।^{২৮} এই ছয় ধাতুর সমন্বয়ে গঠিত পুরুষ সাংখ্যদর্শনেও অনুমোদিত, একথা চরকের উক্তি থেকে পাওয়া যায়। তাই ষড়্-ধাতুর সমন্বয়ে গঠিত পুরুষকেও রাশিপুরুষ বলা হয়ে থাকে—

ষড়্-ধাতুজস্ত, পুরুষো রোগাঃ ষড়্-ধাতুজাস্তথা
রাশিঃ ষড়্-ধাতুজো হ্যেষ সাংখ্যৈরাদ্যৈঃ পরীক্ষিতঃ।^{২৯}

একক পুরুষ: অনেকে পুরুষকে চতুর্বিংশতি ধাতুজ ও ষড়্-ধাতুজ পুরুষ বলে গণ্য করা ছাড়াও এককভাবে চেতনাধাতুকেও পুরুষ বলে গণ্য করেছেন—চেতনাধাতুরপ্যেকঃ স্মৃত পুরুষসঙ্ককঃ।^{৩০} চরকসংহিতার টীকাকার চক্রপাণি দত্ত কিন্তু ভিন্নমত পোষণ করেন। তার মতে কেবলমাত্র চেতনা ধারণ করে রয়েছে যে পুরুষ সে পুরুষ দর্শনের পুরুষ হতে পারে কিন্তু সে পুরুষের তো চিকিৎসা করা যাবে না। চিকিৎসাবোগ্য হতে পারে একমাত্র ষড়্ধাতুবিশিষ্ট পুরুষ—তেন ন চেতনাধাতুরূপঃ পুরুষচিকিৎসায়ামনভিপ্রেতঃ কিন্তু শাস্ত্রানু তরব্যবহারানুরোধাদিহাপ্যয়ং পুরুষশব্দো সঞ্জিত ইতি দর্শয়তি, চিকিৎসা বিষয়বস্তু ষড়্ধাতুক এব পুরুষঃ।^{৩১}

চরকসংহিতায় প্রকৃতি তত্ত্বের প্রভাব: চরকসংহিতায় প্রকৃতির স্বরূপ সম্পর্কে একটাই কথা বলা হয়েছে — বিকারো ধাতুবৈষম্যং সাম্যং প্রকৃতিরুচ্যতে, সুখসংজ্ঞকমারোগ্যং বিকারো দুঃখমেব চ।^{৩২} অর্থাৎ ধাতুদের মধ্যে যে বৈষম্য দেখা যায়, তার নাম হচ্ছে বিকার বা রোগ। এদের যখন সমভাবে অবস্থান করতে দেখা যায়, তখন তার নাম হলো প্রকৃতি বা আরোগ্য। আরোগ্য নামই সুখ এবং রোগের নামই দুঃখ। টীকাকার চক্রপাণি দত্ত আয়ুর্বেদ-দীপিকা টীকায় বলেছেন যে—বায়ু প্রভৃতি এবং রস প্রভৃতির সাম্যাবস্থায়ই হলো প্রকৃতি।^{৩৩} অব্যক্ত হচ্ছে মূল প্রকৃতি। অহংকার হচ্ছে বুদ্ধির বিকার। এই বিকার হচ্ছে তিন প্রকার-ভূতপ্রকৃতি, তৈজস্ এবং বৈকারিক। প্রাণীদের স্থাবর জঙ্গম প্রকৃতি হলো ভূতপ্রকৃতি এবং সেখানে অব্যক্ত প্রকৃতিই শ্রেষ্ঠ। বুদ্ধি প্রভৃতি নিজকারনে বিকৃতিরূপা হলেও এবং নিজকার্যের অপেক্ষায় প্রকৃতিরূপে বিবেচিত হয় বলে তাকেও প্রকৃতি বলে। সাংখ্যদর্শনের তৃতীয় কারিকার ব্যাখ্যায় মূলপ্রকৃতি শব্দের অর্থ নিরূপণ প্রসঙ্গে বাচস্পতি বলেছেন।^{৩৪}

এই আলোচনা শেষে বলা যায়, সাংখ্যমতে পুরুষ সত্য ও বহু। প্রকৃতি ও সত্য। জগৎ সেই প্রকৃতির পরিণাম। সুতরাং সাংখ্যমতে জ্ঞানের কর্তা ও জ্ঞেয়পদার্থ উভয়ই সত্য, মিথ্যা নয়। চরকসংহিতায়ও পুরুষ বহুত্বের বর্ণনা সরাসরি না হলেও একের অধিক পুরুষের বর্ণনা পরিলক্ষিত হয়। সাংখ্যদর্শনে আমরা জানি যে, জন্ম-মরণ-করণ প্রভৃতির ভিত্তিতে সেখানে পুরুষবহুত্ব স্বীকৃত হয়েছে- জন্মমরণকরণানাং প্রতিনিয়মাদয়গপত প্রবক্তেশ্চ পুরুষবহুত্বং সিদ্ধং ত্রৈগুণ্য বিপর্যয়াচ্ছেব।^{৩৫} কিন্তু নিত্য শুদ্ধ বুদ্ধ মুক্ত

পুরুষের জন্মমরণাদি কিছুই নেই। উপাধিভেদেই পুরুষের বহুত্ব হয়েছে।^{৩৬} আকাশ এক হলেও ঘট, পট, প্রভৃতি উপাধিভেদে ঘটাকাশ, পটাকাশ ইত্যাদি বলা হয়। তেমনি স্বরূপতঃ পুরুষ এক হলেও দেহাদি উপাধিভেদেই তার ভেদ। সাংখ্যদর্শনে যেমন — পুরুষের অধিষ্ঠান ছাড়া প্রকৃতি ক্রিয়া করতে সক্ষম হয় না, পুরুষের অধিষ্ঠান বশতঃই মহাদিক্রমে প্রকৃতির পরিণাম ক্রিয়া শুরু হয়। অনুরূপভাবেই চরকসংহিতায় অভিব্যক্তিক্রিয়ার পুরুষের অধিষ্ঠান স্বীকৃত হয়েছে। সাংখ্যদর্শনের মতোই মহাদিক্রমে সৃষ্টিতত্ত্বের বর্ণনা চরকসংহিতায় পাওয়া যায়। সেখানে বলা হয়েছে—অব্যক্তং মূলপ্রকৃতিঃ অহঙ্কারো বুদ্ধিবিকারঃ, স চ ত্রিবিধো ভূতাদিস্তৈজসো বিকারিকশ্চ ভূতানাং স্থাবরজঙ্গমানাং প্রকৃতিভূতপ্রকৃতিঃ। তত্র চাব্যক্তং প্রকৃতিরৈব পরম্।^{৩৭} প্রকৃতির এই অভিব্যক্তিক্রিয়া সাংখ্যদর্শনে বর্ণিত অভিব্যক্তি ক্রিয়ার অনুরূপ। এই আলোচনা থেকে সিদ্ধান্ত করা যায় যে, সাংখ্যের পুরুষত্ব ও প্রকৃতিতত্ত্ব চরকসংহিতায় যথাযথভাবে প্রতিফলিত হয়েছে।

সংকেতসূচি :

সা. কা.—সাংখ্যকারিকা, চ. সি. — চরকসংহিতা সিদ্ধিস্থান, চ. সূ. — চরকসংহিতা সূত্রস্থান, জ. ক. — জল্পকল্পতরুটীকা
 আ. দী.—আয়ুর্বেদদীপিকাটীকা, সা. প্র. সূ. — সাংখ্য প্রবচনসূত্র, চ. শা. — চরকসংহিতা শারীরস্থান।

উল্লেখপঞ্জি :

১. সা. কা. (মঙ্গলাচরণ শ্লোক)।
২. সা. কা., কারিকা নম্বর ৩।
৩. চ. সি. ১২/৫৩-৫৪।
৪. চ. সূ. ১/৪৬-৪৭।
৫. আ. দী., চ. সূ. ১।
৬. সা. প্র. সূ. ১/১৩৯।
৭. চ. সূ. ২৫/৮।
৮. তদেব, ২৫/১২-১৩।
৯. তদেব, ২৫/১৫।
১০. তদেব, ২৫/১৬-১৭।
১১. তদেব, ২৫/১৮-১৯।
১২. চ. শা., ১/৫৩।
১৩. তদেব, ১/৫৯।
১৪. তদেব, ১/৬০-৬২।
১৫. তদেব, ১/৬৬-৬৯।
১৬. তদেব, ১/৩৬।
১৭. সা. কা, কারিকা নম্বর ১৯।
১৮. সা. প্র. সূ., ১/১৪৯।
১৯. তদেব, ৬/৪৫।

২০. জ. ক., চ. শা., ১।

২১. চ. শা., ১/১৭।

২২. তদেব, ১/৬৩।

২৩. তদেব, ১/৬৫।

২৪. সা. কা., কারিকা নম্বর ৩।

২৫. চ. শা., ১/১৬।

২৬. চেতনাযষ্ঠা ইত্যত্রৈব চেতনাশব্দেন চেতনাধারঃ সমনাস্ক আখ্যা গৃহ্যতে। আ. দী., চ. শা., ১।

২৭. চ. শা., ৫/৪।

২৮. তদেব, ৫/৫।

২৯. চ. সূ., ২৫/১৫।

৩০. চ. শা., ১/১৬।

৩১. আ. দী., চ. শা., ১।

৩২. চ. সূ., ৯/৩।

৩৩. প্রকৃতিং বাতাদীনাং রসাদীনাঞ্চ সাম্যাবস্থাম্। শাস্ত্রসক লিঙ্গম্ প্রকৃত্যন্তরু চরম চ লিঙ্গ জ্যেষ্ঠান্যন্তরম্। কলিকাতা

৩৪. মূলপ্রকৃতিরবিকৃতিঃ ইতি। প্রকারোত্তীতি প্রকৃতিঃ প্রধানন্ সম্বুরজন্তমসাং সাম্যাবস্থা। সা অবিকৃতিঃ প্রকৃতিরবেতার্থঃ।

৩৫. সা. কা., কারিকা নম্বর ১০।

৩৬. উপাধিভেদেৎপোকস্য নানাযোগ আকাশস্যেব ঘটাদিভিঃ।

৩৭. আ. দী., চ. শা., ১।

নির্বাচিত গ্রন্থপঞ্জি : কলিকাতাঃ ॥ শ্রীমতী চরু চক্রাচার্য চক্রু। চক্রাচার্য চরু চক্রাচার্য চক্রু। চক্রাচার্য চরু চক্রাচার্য চক্রু। চক্রাচার্য চরু চক্রাচার্য চক্রু।

ঈশ্বরকৃষ্ণ। সাংখ্যকারিকা। সম্পা. পূর্ণচন্দ্র বেদান্ত চক্ৰু। কলিকাতা: পশ্চিমবঙ্গ রাজ্য পুস্তক পর্ষদ, ১৯৮৩।

চরক। চরকসংহিতা। সম্পা. হরিদত্ত শাস্ত্রী। চক্রপাণিদত্ত প্রণীত আয়ুর্বেদ-দীপিকা এবং জেজট বিরচিত

নিরন্তরপদব্যাখ্যা সমন্বিত। বোম্বে (অধুনা মুম্বাই): মতিলাল বানারসীদাস, ১৯৪৬ (২য় সং.)।

—। সম্পা. যাদবজী ত্রিকমজী আচার্য। চক্রপাণিকৃত আয়ুর্বেদ-দীপিকা সহ। বারাণসী: চৌখাম্বা সংস্কৃত সংস্থান,

১৯৮৪।

—। সম্পা. নরেন্দ্রনাথ সেনগুপ্ত এবং বলাইচাঁদ সেনগুপ্ত। চক্রপাণিদত্ত প্রণীত আয়ুর্বেদ-দীপিকা টীকা এবং

গঙ্গাধর বিরচিত জল্পকল্পতরু টীকা। বারাণসী: চৌখাম্বা ওরিয়েন্টালিয়া, ১৯৯১।

—। সম্পা. সহ বাংলা অনুবাদ ব্রজেন্দ্রচন্দ্র নাগ। কলিকাতা: নবপত্র প্রকাশন, ১৯৯১ (প্রথম সং. ১৯৮৪)।

ত্রিপাঠি, যোগেন্দ্র কুমার। ন্যায়সূত্র ও চরকসংহিতা। বারাণসী: ত্রিবিধা প্রকাশন, ১৯৮৭।

বাচস্পতিমিশ্র। সাংখ্যতত্ত্বকৌমুদী। সম্পা. নারায়ণ চন্দ্র গোস্বামী। কলিকাতা: সংস্কৃত পুস্তক ভান্ডার, ১৯৯৯।

গুড়ু, বাগীশ্বর। আয়ুর্বেদ কা ইতিহাস। বারাণসী: চৌখাম্বা অমর ভারতী, ১৯৭৭।

(... would have to be considered a new kind of substance)

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Indigenous People: Evolution of Concept and Rights in Post-Colonial International Phenomena

Prakash Bisui*

Abstract: In the post-colonial era, democratic pluralistic societies and nation-states developed, along with the concept of human rights. Holding hands of postmodern thinkers, international organizations such as the International Labour Organization and the United Nations continued to be driven by the notion of pluralistic human rights. As a result, issues such as international law, human rights, protection of marginalized people, etc., have become international issues, in which the protection of tribes and their rights became one of the issues in the international arena. In this research paper, I shall discuss how the protection of the rights of the people, who were accustomed to a somewhat primitive and natural way of life and maintained their own characteristics across the region, became important in the international arena and what were their rights. On the other hand, environmentalist thinkers felt the urge to protect their way of life, keeping in mind the protection of the environment because the tribes have been protecting the environment for a long time in pursuit of their own way of life and in the mainstream society and state system, whenever they wanted to violate their way of life and rights, they have become protesters. thus the tribal environmentalist movement has developed.

Methodology: In composing this article, a comparative discussion of various research papers and various declarations of the international laws, the United Nations and the International Labour Organization regarding the tribes have been intensively tried and evaluated.

Objective: The principal objective of this study is to create an idea in the readership about the tribes and their rights, to create the model of a society that is in harmony with the pluralistic society and environment. In today's society, human rights violations, environmental destruction, marginalization of surfaced people, etc. are becoming common phenomena all over the world, then the more the researchers and academicians discuss such issues, the more the issues like protection of rights, respect for citizens, protection of marginalized people, protection of environment will increase.

Interdiction: Debating tribes and tribal beings have attained quite significant in today's discussions of social science. They are referred to by varied nomenclature

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created political pressure in favour of these demands. These demands were raised in the conference of the International Human Rights Commission in 1993. Countries, whose interests may be harmed by this law (specially the colonial countries), claimed it to be unfair and they protested against it.²⁷

The principal demands of these movements were of self-control and self-determination. Because they had been incurred in the trap of colonialism for many days and the colonial rulers were constantly violating their self-control. The tribes are socially, culturally and politically a completely new race. Continuing this system of governance based on the idea of another nation violates their human rights. However, their demand for self-determination is not consistent with their demand for a new nation-state. Woodrow Wilson was the first to talk about the subject as the Right to Self-Control in 1918. After this, the issue had been discussed in the 1st and 55th Section of the San Francisco Conference of the United Nations in 1945.²⁸ But the conference did not say who were entitled to self-determination. In later period, a discussion was conducted in the Human Rights Conference of the United Nations elaborately in 1941. 'The General Assemblies on Declaration on the Greeting of Independent Countries to Colonial Countries and Peoples' was established in 1966, which worked a great deal respecting this issue.

Notes and References

- ¹ The Human Rights Fact Sheet No. 9. (Geneva : Centre for Human Rights, UN, 1990) p. 3
- ² *Girish Chandrav Gour, Trade-Related Intellectual Property Rights (TRIPR) With Reference to Indian Medicinal Plants/ Harbs and Indigenous Systems of Medicines used by Tribals, Bhupinder, Sing, & Neeti, Mahanti, (Ed), Intellectual Property Rights and the Tribals, (New Delhi : Inter India Publications, 1977) p. 104.*
- ³ International Labour Office Indigenous Peoples; *Living and Working Conditions of Aboriginal Populations in Independent Countries*, Geneva : UN, 1953, p. 23
- ⁴ Concerning Indigenous and Tribal Peoples in Independent Countries was adopted by the International Labour Conference, ILO Convention No- 169, 76th Session, 7th Geneva : June, 1989
- ⁵ *Herman Santa Cruz, Measures Taken in Connection with the Protection of Indigenous People, H. S., Cruz, Racial Discrimination (Report)*, UN Doc-E/CN.4/Sub.2/322, (New York : United Nations Publication, 1971), p. 344-345
- ⁶ *Jose R. Martenez, Cobo, Study of the Problem of Discrimination Against Indigenous Population, (Report)*, E/CN.4/Sub.2/ L.566 at Para 34, (New York : United Nations Publication, 1982)
- ⁷ *World Bank Operational Manual: Operational Directive 4.20, Sept 1991, Para-4-5.*
- ⁸ Conventions and Recommendations Adopted by the International Labour Conference, 1919-1966, (Geneva : Department of International Labour Organisations, 1966)
- ⁹ *Natan Lerner, The 1989 ILO Convention on Indigenous Populations: New Standards*, Y H R, 20, 1990, p. 223-241
- ¹⁰ UN Fact Sheet, No-9, The Rights of Indigenous People, Programme of Activities for the International Decade of the Worlds Indigenous People (1995-2004) (Para-4), General Assembly Resolution 50/157 of 21 December, 1995, annex, p. 2



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শ্রীশিক্ষা: নারীমুক্তি ও ঈশ্বরচন্দ্র বন্দোপাধ্যায়-একটি পর্যালোচনা

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Abstract:

women in India were deprived for education privileges for centuries, but there were always some expectations to this general condition. It is difficult to determine the exact extent of education imparted to women during the early Vedic period in India. Uponayana ritual was obligatory for girls, and this must have ensured the imparting of a certain amount of Vedic and literary education to the girls of all classes. But female education received a great setback during later vedic period primarily owing to the deterioration of religious status of women. During the Medieval period women education was constrained because Muslim men were also subjected to low educational attainment in general. The reawakening of India was started with the efforts of Ram Mohan Roy. After that Iswarchandra vidyasagar also took a leading role in that field. At the outset Christian missionary had started English education in India. Systematic female education was started in India with the efforts of Baptist Mission Society in 1819. Vidyasagar was also a fully supporter of female education by improving the condition of Indian. He took an important role to spread education among women with the help of Sir J.E. Drinkwater Bethune. He established 35 female schools with an average total attendance of 1300 girls in four districts. Besides, Vidyasagar was appointed as Honorary Secretary of Bethune School Committee for the progress of this school. Miss Mary Carpenter also helped vidyasagar to spread education among women in India. After Independence of India, government has taken various measures to provide education to women. As a result, women's literacy rate has grown over the three decades and the growth of female literacy has in fact been higher than that of male literacy rate.

Keyword: Renaissance, Intellectual, Systematic, Supervision, Vedanta, Compound, Missionaries, Idealism, Moderity, Vernacular, Superstitions, Emancipation, Enegetic, Impulse, Inspector, Committee, Philanthropic, Acquaintance, Superintendent, Lieutenant.

ভূমিকা: সৃষ্টির উষালগ্ন থেকেই ক্রিয়াকলাপ, পোশাক-পরিচ্ছদ, বিবাহ প্রভৃতি ক্ষেত্রে নারী ও পুরুষ -উভয়ের মধ্যে সুস্পষ্ট বিভাজন পরিলক্ষিত হয়। মাতৃতান্ত্রিক সভ্যতা রূপে পরিচিত সিন্দু সভ্যতায় নারীর প্রাধান্য থাকলেও বৈদিক ও বেদোত্তর যুগ থেকে (পিতৃতান্ত্রিক সমাজে) পুরুষের প্রাধান্য স্থাপিত হলে নারী ক্রমশ অন্তঃপুরবাসী হয়ে পড়ে। বৈদিক ও বেদোত্তর যুগ থেকে স্মৃতিশাস্ত্রকারগণ পুরুষ ও নারীর মধ্যে সম্পর্ক, বিবাহ সম্পর্কিত রীতিনীতি, শিক্ষা, সম্পত্তির অধিকার প্রভৃতি বিষয়ে বিধান দিয়েছেন এবং বিভিন্ন যুগে সমকালীন সমাজে বাস্তব পরিস্থিতি অনুযায়ী

বিধানগুলি ক্রমশ পরিবর্তিত হয়েছে।¹ প্রাচীন ও মধ্যকালীন ভারতে বালিকাদের গুরুগৃহে পাঠিয়ে অনেকেংশে শিক্ষাদানের রীতি প্রচলিত না থাকলেও প্রাচীনকালে গাণী, মৈত্রী, অপালা, লোপামুদ্রা প্রমুখ বিদুষী রমণীর কথা জানা যায়; যারা স্বচেষ্টায় জ্ঞানতাপস পিতা, মাতা ও স্বামীর সহযোগিতায় বাড়িতে বসে জ্ঞান অর্জন করেছেন। মধ্যযুগেও নারীদের স্বাধীনতা এবং অধিকার ক্রমশ সংকুচিত হয়েছে। প্রাচীন ও মধ্যকালীন ভারতে সমাজপতিরা স্ব স্বার্থে একের পর এক বিধি নিষেধ দ্বারা নারীজাতিকে কুসংস্কারের জালে আবদ্ধ করেছে।²

ঔপনিবেশিক শাসনে পাশ্চাত্য সভ্যতার সংস্পর্শে এসে বাঙালি মধ্যবিত্ত সমাজে এক আধুনিক দৃষ্টিভঙ্গির উদ্ভব ঘটে এবং এর প্রধান ভিত্তি ছিল যুক্তি ও মানবতাবাদ-যা সমকালীন শিক্ষা, সাহিত্য, ধর্ম ও সমাজকে গভীরভাবে প্রভাবিত করে। নবসৃষ্ট বঙ্গ সমাজে পাশ্চাত্য সভ্যতা ও শিক্ষা প্রসারের মাধ্যমে নারীশিক্ষা ও নারীর অধিকার প্রতিষ্ঠার আন্দোলন ধীরে ধীরে গড়ে ওঠে।³

ভারত পৃথক রাজা রামমোহন রায়ের আবির্ভাবের (১৭৭২ মতান্তরে ১৭৭৪ খৃষ্টাব্দে) প্রায় অর্ধশতাব্দী পর যুক্তিবাদী, বিজ্ঞানমনস্ক, মানবতাবাদী ঈশ্বরচন্দ্র বিদ্যাসাগরের জন্ম হয় ১৮২০ সালের ২৬ সেপ্টেম্বর তৎকালীন ছগলী জেলার এবং বর্তমানে পশ্চিম মেদিনীপুর জেলার বীরসিংহ গ্রামে ঠাকুরদাস বন্দোপাধ্যায় ও ভগবতী দেবীর সন্তান রূপে।⁴ এই সময় নব্যবঙ্গনদের প্রচেষ্টায় বাংলা তথা ভারতে ইংরেজি সাহিত্য, দর্শন, বিজ্ঞান, এবং রাজনীতিতে এক নতুন যুগের সূচনা হয়। মহর্ষি দেবেন্দ্র নাথ ঠাকুর, কেশবচন্দ্র সেন, শিবনাথ শাস্ত্রী নিজ নিজ ক্ষেত্রে অবদান রাখেন। ইউরোপ থেকে আগত আলেকজান্ডার ডাফ, মেরি কারপেন্টার, বেথুন প্রমুখ সংস্কারকণণ সমাজের সর্বাঙ্গীণ উন্নতির ক্ষেত্রে আত্মবিকশিত নারীর অসামান্য ভূমিকার গুরুত্ব সম্পর্কে সচেতন ছিলেন। তাঁদের প্রচেষ্টায় সমগ্র ঊনবিংশ শতাব্দী ধরে বাংলায় নারীকেন্দ্রিক বিভিন্ন সামাজিক আন্দোলন সংগঠিত হয়। এই সময় নিজস্ব গুনে উজ্জ্বল ছিলেন বাংলার অমর সন্তান ঈশ্বরচন্দ্র বিদ্যাসাগর। তাঁর শিক্ষা ও কর্ম জীবনের সূচনায় বাংলার ধর্ম ও সমাজ এক যুগসন্ধিক্ষণের মধ্য দিয়ে চলে। হিন্দু ধর্ম খ্রিষ্টান মিশনারিদের প্রবল বিরোধীতার সম্মুখীন হয়। রামমোহন রায় যুক্তি ও মানবতাবাদের উপর হিন্দুধর্মকে প্রতিষ্ঠা করেন ও সকল ধর্ম সমন্বয়ের চেষ্টা করে এর যোগ্য জবাব দেন। রামমোহন রায়ের প্রগতিশীল সংস্কারগুলি রাধাকান্তদেবের নেতৃত্বাধীন রক্ষণশীল হিন্দু সমাজ মেনে নেয়নি। খ্রিষ্টান মিশনারির পাশাপাশি ডিরোজিওর অনুগামী নব্যবঙ্গনও হিন্দুধর্মের কুপ্রথা ও কুসংস্কারগুলির বিরুদ্ধে আন্দোলন শুরু করে। বিদ্যাসাগর যখন সমাজ সংস্কারে প্রবৃত্ত হন তখন বাঙালি সমাজ সম্পূর্ণরূপে কুসংস্কারে আচ্ছন্ন ছিল। ব্রাহ্মসমাজ ও নববঙ্গ-উভয় গোষ্ঠীর সঙ্গে তার সুসম্পর্ক ছিল এবং অনেক ক্ষেত্রে তিনি তাদের সহায়তা করলেও কাদেরও সাথে কখনো ঘনিষ্ঠ হননি। নিজে বিবেক ও বিবেচনা অনুযায়ী তিনি সর্বদা লক্ষ্য ও পথ নির্ধারণ করেন।⁵

রাজা রামমোহন রায় সতীদাহ প্রথা নিবারনে আন্দোলন শুরু করেন। ফলস্বরূপ স্বামী মারা যাওয়ার পর স্ত্রীর বাঁচার অধিকার আছে -এ ধারণায় বশবর্তী হয় নারী সমাজ যদিও এর দ্বারাই নারীর সর্বময় মুক্তি হয়নি। নারীকে কুসংস্কারের বন্ধন থেকে মুক্ত করার জন্য প্রয়োজন ছিল শ্রীশিক্ষা। বাঙালী মেয়েদের মধ্যে পাশ্চাত্য শিক্ষা প্রসারে প্রথম এগিয়ে এসেছিল খ্রিষ্টান মিশনারিগুলি। লন্ডন মিশনারি সোসাইটির সদস্য রবার্ট মে উল্লেখ করেছেন যে, ১৮১৮ খ্রি. লন্ডন মিশনারি চিনসুরাতে একটি বালিকা বিদ্যালয় স্থাপন করে। ১৮১৯ খ্রি. ব্যাপটিস্ট মিশনারি সোসাইটি ভারতে নারী শিক্ষায় অগ্রণী ভূমিকা নেয়। ব্যাপটিস্ট মিশনারি সোসাইটি ১৮১৯ খ্রি. কলকাতায় প্রতিষ্ঠা করে "The Female Juvenile Society"; যার লক্ষ্য ছিল বাঙালি নারী শিক্ষার প্রসার ঘটানো। ১৮২৩ খ্রি. এই সোসাইটি ৮টি বালিকা বিদ্যালয় পরিচালনা করে। ১৮২৮ খ্রিষ্টাব্দের মধ্যে এই প্রতিষ্ঠানটি ১২টি স্কুল পরিচালনা করতে সক্ষম হয়। চার্চ মিশনারি সোসাইটি বাঙালী মেয়েদের শিক্ষার জন্য "Ladies Society" প্রতিষ্ঠা করে এবং ১৮২৪ খ্রি. মধ্যে কলকাতা এবং তৎসংলগ্ন অঞ্চলে ২৪ টি স্কুল পরিচালনা করে। ১৮২৯ খ্রিষ্টাব্দের চার্চ মিশনারির তত্ত্বাবধানে কলকাতা ও শ্রীরামপুর এলাকায় ৪৪৮ জন, ঢাকায় ১৯০ জন, চিটাংগাওতে ১০০ জন এবং বীরভূমে ৯০ জন ছাত্রী অধ্যয়ন করে।⁶

অভিযান আন্দোলন শুরু হয়েছিল তার প্রয়োজনীয়তা আজও ফুরায়নি। নারী শিক্ষা সম্প্রসারণে সরকার অনেকাংশে সফল। আমরা আশাবাদী যে আগামী দিনে নারীরা শিক্ষিত ও সচেতন হয়ে নিজেরাই নিজেদের মুক্তির পথ বেছে নেবে।

সূত্র নির্দেশ:

1. নরেন্দ্রনাথ ভট্টাচার্য, প্রাচীন ভারতীয় সমাজ,পশ্চিমবঙ্গ রাজ্য পুস্তক পর্ষদ, কলকাতা, ২০০১ (প্রথম প্রকাশ), পৃ.৪১-৪৪.
2. প্রাগুক্ত,পৃ.১৮৬-৮৭.
3. .রাখাল চন্দ্র নাথ, উনিশ শতক ভাব-সংঘাত ও সমন্বয়, কে পি বাগচি অ্যান্ড কোম্পানি, কলকাতা, ২০১৬, পৃ.xi-xxviii.
4. .Aparna chatterjee, Iswar chandra Vidyasagar-A Profile of the Philanthropic Protagonist,http://ezinear-ticles.com.
5. .Amallesh Tripathi, Vidyasagar: The Traditional Moderniser,Orient longman,Calcutta,1974,pp.-65-66.
6. .প্রাগুক্ত,পৃ.৬৬।
7. .প্রাগুক্ত,পৃ.-৬৭।
8. .Santosh Kumar Adhikary, Vidyasagar and the Regeneration of Bengal, Subarnarekha, Calcutta, 1980, p.-43.
9. .Gopal Halder,Vidyasagar-A Reassessment,People's Publishing House,New Delhi,July 1972,p.-51.
10. .Manik Mukhopadhyay &et.al.The Golden Book of Vidyasagar a commreorative Volume, calcutta, p.-364.
11. .Syamal Chakrabarti, Vidyasagar, National Council of Education Research and Training, New Delhi, 1971, p.-51.
12. .এস. কে. বসু, ঈশ্বর চন্দ্র বিদ্যাসাগর,ন্যাশানাল বুক ট্রাস্ট,নতুন দিল্লী,১৯৭২,পৃ.২৭-২৮.
13. .Manik Mukhopadhyay & et.al, op.cit.,p.-367.
14. .Amallesh Tripathi, op.cit.,p.71.
15. .Manik Mukhopadhyay & et.al.,p.-369.
16. .Amallesh Tripathi, op.cit.,p.-72. & এস.কে.বসু, .প্রাগুক্ত,পৃ.-৩৩।
17. .Manik Mukhopadhyay & et.al., op.cit.,p.-371.
18. যোগেশ চন্দ্র বাঙ্গাল, বিদ্যাসাগর পরিচয়, রঞ্জন পাব্লিশিং হাউস,কলকাতা,১৯৬০,পৃ.৫২।
19. .Manik mukhopadhyay &et.al.,op. cit.,p.-372.

শ্রীশিক্ষা: নারীমুক্তি ও ঈশ্বরচন্দ্র বন্দোপাধ্যায়-একটি পর্যালোচনা

সুজিত মণ্ডল

20. .Subhal Chandra Mitra,Isvar Chandra Vidyasagar:A Story of his life and work,Sarat Chandra Mitra,Calcutta,1920,
21. .www.bn.w.wikipedia.org.
22. .https.bn.m.wikipedia.org.
23. .www.bbc.com.
24. .https://biplobparbatipur.blogspot.com.

International Migration of Women from Darjeeling District: The Question of Empowerment

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ABSTRACT The phenomenon of migration flows is not a new process in Darjeeling district. It has evolved time and again with diversified patterns in terms of class, caste and gender specifics. Historical evidences addressed in hill studies show that the pattern of migration from Darjeeling district was mainly dominant by the male migrants who were migrating to the metropolitan cities to work in private sectors. But the recent trends in migration from this region are of women migrating independently to work in informal sectors mostly as a domestic worker to countries like Gulf countries, Middle East countries and South East Asian countries. They have become active economic agents as well as inspiration for aspirant migrants in the home country. Thus, on the basis of this context, exploratory research has been conducted in Darjeeling district in an attempt to study the patterns and impact of women's international migration and examine socio-cultural implications that caters towards the empowerment of women in Darjeeling district.

INTRODUCTION

Migration is a universal phenomenon concerning people's movement from one place to another for multiple reasons and having manifold connotations. International Organisation for Migration defines migration as, "the movement of a person, whatever its length, composition and causes, and it includes migration of refugees, displaced persons, economic migrants and persons moving for other purposes, including family reunification" (Bhardwaj and Sawant 2015). Donald (1979) defines migration as a "rationally planned action, which is the result of conscious decisions taken after a consideration or calculation of the advantages and disadvantages of moving and staying". In the simplest form, international migration can be defined as the movement of people across borders and staying in the host country on a temporal or permanent basis.

Conceptualising the historical trend of migration, the phrase "migrants" was used only as a code for male migrants while women migrants have always been linked with marriage and other associational reasons. While, with the oil boom in Gulf countries, the emergence of newly industrialising economies, expansion of the service economy, high demand of skilled and unskilled labour in the developed regions has intensified a much broader pattern of international

migration incorporating women migrants as well. Apparently, females represent half of the international migrants in developed regions whereby "the phrase feminisation of migration" is gaining prominence in the field of research studies.

Of the above issues of significance, international migration from Darjeeling District is a topic worth studying. International migration from this region is readily enforced and reshaped by the radical changes in the demographic pattern during the last one hundred and fifty years. The structural changes of the region are concomitant with the historic migration between and from neighbouring countries with the resultant effect of colonial regime during the early and mid-nineteenth century¹. The widespread influx of Nepalese of Nepal has not only affected the socio-economic profile of the region but also constantly blurred their (Indian Nepalese) national identities and thwarted their protracted demand of autonomy (Gorkhaland Movement), which has been a controversial issue till date. By the time of the second Census of India in 1881, the Nepalese formed the absolute majority not only in the three hill sub-divisions but also in the whole district of Darjeeling" (Dasgupta 1999).

Moreover, if one looks at the socio-economic profile of Darjeeling district, half of the population is agriculturist and majority of them are engaged in tea plantation works. Since its in-

- Bhardwaj KV, Sawant NN 2015. *Human Migration in South Asia: Prospects and Constraints*. New Delhi: G.B Books.
- Bhunia Sherap 2014. Economic development and environmental issues in Darjeeling Himalaya of West Bengal, India: A theoretical perspectives. *International Journal of Humanities and Social Science Invention*, 3(7): 42-47.
- Chanda Ipsita 2017. *Selfing the City: Single Women Migrants and Their Lives in Kolkata*. New Delhi: Sage Publications India.
- Chatterjee Rajib, Monda SR 2011. *Cloud Stone and the Mind, the People and Environment of Darjeeling Hill Area*. Kolkata: K.P Bagchi and Company.
- Charmes J, Wieringa S 2003. Measuring women's empowerment: An assessment of the Gender-related Development Index and the Gender Empowerment. *Journal of Human Development*, 4(3): 419-435.
- Dasgupta Atis 1999. Ethnic problems and movements for autonomy in Darjeeling. *Social Scientist*, 27(11): 47-68.
- Donald JB 1979. *A Migrant's Eye View of the Costs and Benefits of Migration to a Metropolis*. New York: Academic Press.
- Gaye Amie, Jha Shreyasi 2011. Measuring women's empowerment through migration. *Diversities*, 13(1): 49-61.
- Ghosh Jayati 2009. Migration and Gender Empowerment: Recent Trends and Emerging Issues. United Nations Development Programme. *Human Development Reports Research Paper*: 1-52.
- Hashemi MS, Schuler RS, Riley PA 1996. Rural credit programs and women's empowerment in Bangladesh. *World Development*, 24: 635-653.
- Kweun YT 2007. An Empowerment Approach to Female Migration: A Case study of China's Manufacturing Industry. Development Studies Institute. London School of Economics and Political Science, London. *Working Paper Series*, 1-40.
- Kabeer Naila 1999. Resources, agency, achievements: Reflections on the measurement of women's empowerment. *Development and Change*, 30: 435-464.
- Mahapatro R Sandhya 2013. Gender relations and its influence on female migration decision in India. *The Pakistan Development Review*, 52(1): 69-88.
- Nijbroek Mieke 2016. *Migration as a Tool for Empowerment? The Effect of Migration and Return on the Empowerment Levels of Filipina International Migrant Workers*. MSc Thesis. Netherlands: International Development Studies, Utrecht University.
- Oishi Nana 2002. Gender and Migration: An Integrative Approach. *Working Paper* 49. Centre for Comparative Immigration Studies, University of California, San Diego.
- Platanova A, Geny RL 2017. Women's Empowerment and Migration in the Caribbean. International Organization for Migration. *Studies and Perspectives Series*. United Nations Publication.
- Pakhrin Kalyani 2013. Challenging the Hegemonies: The unheard story of Brave Women, Putalimaya Devi Podder. *IOSR Journal of Humanities and Social Science*, 10: 53-60.
- Rai MS 2005. Equal Participation of Women and Men in Decision Making Processes with Particular Emphasis on Political Participation and Leadership. *Paper Prepared for Expert Group Meeting*. United Nations Division for the Advancement of Women (DAW): 3-27.
- Rawat Sunny 2016. Causes and effects of rural-urban migration in Darjeeling. *Academia*, (8021523): 1-5.
- Rosulnik KK, Hladnik MM, Licen Nives 2016. Women's narratives on learning through migration. *Journal of Ethnic Studies*, 29-47.
- Sharma Gopal 2014. Socio-economic condition of the people of Darjeeling: Out migration as a survival strategy. *International Journal of Innovative Research and Development*, 3(5): 6-18.
- Sinha Babita, Jha Smita, Negi SN 2012. Migration and empowerment: The experience of women in households in India where migration of a husband has occurred. *Journal of Gender Studies*, 21(1): 61-76.
- Soco Andrea 2008. Changing the discourse on return migrants: Cosmopolitanism and the reintegration of return Filipino migrant domestic workers. *Philippine Sociological Review* Published by Philippine Sociological Society, 56: 1-19.
- Subba TB 2010. Migration and Agrarian Change in Darjeeling. From <http://dSPACE.nyu.ac.in/handle/1/2496> (Retrieved on 6 September 2019).
- Sundas Binu 2011. *HIV and AIDS in Darjeeling: Emerging Socio-Political Challenge*. New Delhi: Concept Publishing Company Pvt. Ltd.
- Suksomboon Panitee 2008. Remittances and social remittances: Their impact on livelihoods of Thai women in the Netherlands and non migrant in Thailand. *Gender Technology and Development*, SAGE Publications Los Angeles/London/New Delhi/Singapore, 12(3): 461-482.
- Thapan Meenakshi, Singh Anshu, Sreekumar Nidhitha 2014. Women's mobility and migration: Muslim women migrants in Jamia Nagar, Delhi. *Economic and Political Weekly*, XLIX(23): 96-104.
- Yngvesson Andreas 2017. *The Social Impact of Remittances on Gender Roles in Kosovo: A Catalyst for Women Empowerment?* Bachelor Thesis. Sweden: Bachelor in Development Studies, Department of Sociology Lund University. Bachelor in Development Studies.

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সমতা ও বৈষম্য : নৈতিক সমীক্ষা

বরুণ কুমার ঘোষ

বর্তমান শতাব্দীর সবচেয়ে আলোড়ন সৃষ্টিকারী নৈতিক সমস্যাগুলির মধ্যে একটি হল মানুষে মানুষে বৈষম্য। যদিও নৈতিক সমস্যাগুলির অধিকাংশ আজও বিতর্কিত। ভারতীয় সংবিধানে 'সমতার অধিকারকে' একটি মৌলিক অধিকার বলা হয়েছে এবং এও বলা হয়েছে এই অধিকার প্রত্যেক নাগরিকের অবশ্যই উপভোগ করা উচিত। এর অর্থ হল জাতি, ধর্ম, লিঙ্গ, বর্ণ ও শ্রেণীগত কারণে কোন বৈষম্য ছাড়াই আইনের চোখে সবাই সমান। তারপরও যদি আমরা আমাদের চারপাশে তাকাই তাহলে আমরা দেখতে পাব যে আমাদের সমাজে প্রকট বৈষম্য রয়েছে। 'সমতার অধিকার' নীতিটি বর্তমানে রাজনৈতিক, সামাজিক ও অর্থনৈতিক গোঁড়ামির অংশ বিশেষে পরিণত হয়েছে। কিন্তু আমরা জানি মানবাধিকারের অধিকারত্বের প্রদে 'সকল মানুষ সমান'। তাই অধিকারের দিক থেকে যে সকল মানুষ সমান এবং মানুষের মধ্যে যে বৈষম্য রয়েছে এবং সেই বৈষম্য দূর করবার প্রয়োজন আছে কি না - এটি একটি নৈতিক আলোচনার বিষয় হতে পারে।

'মানবাধিকার' কথাটি সাম্প্রতিককালে প্রচলিত। এই কথাটি পূর্বে 'প্রাকৃতিক অধিকার' এবং 'সুশীল সমাজের অধিকার' নামে পরিচিত ছিল। প্রাচীন গ্রিক যুগে মানবাধিকারের আদিরূপ প্রাকৃতিক বিধি থেকে নিঃসৃত প্রাকৃতিক অধিকারের পদচিহ্ন হিসাবে পাওয়া গেলেও মূলত টমাস হবস, জন লক ও টমাস পেইন - এর লেখায় প্রাকৃতিক অধিকারের স্বপক্ষে জোরালো যুক্তির উল্লেখ পাওয়া যায়। প্রাকৃতিক অধিকার পরম্পরার শেষের দিকে ১৭৮৯ সালে ফরাসি বিপ্লবের পর 'Declaration of the Rights of Man and the Citizen' জারি হয়, যেখানে টমাস পেইন - এর ঘোষিত অধিকারগুলি স্থান পায় যা পরে সার্বজনীন মানবাধিকার ঘোষণা পত্রের স্থান পায়।

মানুষ হিসাবে যে প্রাণী জন্মগ্রহণ করেছে সে তার মনুষ্যত্বের অধিকারে কতকগুলি অধিকার নিয়েই জন্মগ্রহণ করেছে। যে অধিকারগুলি তার জন্মসূত্রে প্রাপ্ত এবং এই অধিকার থেকে কোনভাবেই তাকে বঞ্চিত করা সম্ভব নয়। কারণ সমস্ত মানুষই জন্মসূত্রে সমান মর্যাদা ও অধিকারসম্পন্ন। এই প্রসঙ্গে Recharad Wasserstorm তাঁর 'Rights-Human Rights' নামক নিবন্ধে মানুষের অধিকারের

চারটি বৈশিষ্ট্যের উল্লেখ করেছেন। যথা - (১) 'মানুষের অধিকার' সব মানুষের সাধারণ অধিকার এবং কেবলমাত্র মানুষেরই অধিকার। (২) সাধারণ অধিকার হওয়ায় 'মানুষের অধিকারের' প্রতি সব মানুষের সমান অধিকার। (৩) পদাধিকারের জন্য, সমাজে ব্যক্তির বিশেষ ভূমিকার জন্য মানুষ কতকগুলি বিশেষ বিশেষ সুবিধার দাবীদার হলেও 'মানুষের অধিকার' থেকে তাদের কেউ বঞ্চিত হয় না। (৪) পদমর্যাদা বা প্রতিষ্ঠার ওপর নির্ভরশীল না হওয়ায় 'মানুষের অধিকার' অপরের ইচ্ছা-অনিচ্ছার ওপর, সম্মতি-অসম্মতির ওপর নির্ভরশীল নয়। অপরের ইচ্ছা ও সম্মতির বিরুদ্ধেও 'মানুষের অধিকারের' প্রতি প্রত্যেক মানুষের দাবী চূড়ান্ত। অর্থাৎ অধিকারগুলির দিক থেকে প্রত্যেক মানুষ সমান। কিন্তু আমরা লক্ষ্য করছি যে বর্তমান সভ্য সমাজে জাতি-ধর্ম-লিঙ্গ ও বর্ণ ভেদে মানুষের মধ্যে নানাভাবে বৈষম্য করা হচ্ছে, যা নৈতিক দিক থেকে সমর্থনযোগ্য নয়।

বর্তমান সভ্য সমাজে মানবাধিকার রক্ষার জন্য অনেক আইন প্রণীত হয়েছে। ইংল্যান্ডে ১২১৫ সালে 'Magna Carta', অষ্টাদশ শতাব্দীতে আমেরিকায় 'Bill of Rights' এবং উনিবিংশ শতাব্দীতে বিভিন্ন স্বাধীন রাষ্ট্র আইনের দ্বারা মানবাধিকার সংরক্ষণের চেষ্টা করেছে। সম্মিলিত জাতিপুঞ্জই সর্বপ্রথম ঘোষণা করেছে মানুষের সমতার কথা। পরবর্তীকালে মানবাধিকারের বিশেষ বিশেষ দিকের উপর গুরুত্ব দিয়ে কয়েকটি আনুষ্ঠানিক ঘোষণাপত্র গৃহীত হয়। যেমন অর্থনৈতিক, সামাজিক ও সাংস্কৃতিক অধিকার বিষয়ে ১৯৬৬ সালে আন্তর্জাতিক ঘোষণাপত্র গৃহীত হয়। এই ঐতিহাসিক দলিলগুলি সারা বিশ্বে মানবাধিকার রক্ষা ও মানবাধিকারের দাবি পূরণের মৌলিক ভিত্তি। সমস্ত মানুষই যদি জন্মসূত্রে সমান হয় তাহলে সকলেরই - জীবনের অধিকার, স্বাধীনতার অধিকার, মতপ্রকাশের অধিকার, আইনের সামনে সমবিচারের অধিকার, শিক্ষার অধিকার ইত্যাদি - এই সমস্ত অধিকার থাকা উচিত। অর্থাৎ অধিকারের দিক থেকে প্রত্যেক মানুষ সমান এটি একটি নৈতিক দাবী বলে গণ্য হতে পারে।

অনেকে এখানে আপত্তি করতে পারেন যে সকল মানুষ কোন অর্থে সমান এবং কোন মানদণ্ডের ভিত্তিতে আমরা সকল মানুষের সমতা প্রমাণ করতে পারি? কারণ বর্ণভেদ, লিঙ্গভেদ, সামর্থ্য বা যোগ্যতা ভেদে সকল মানুষ কখনো সমান হতে পারে না। কোন মানুষ দীর্ঘ, কোন মানুষ খাটো, কোন মানুষের বুদ্ধি বেশী, কোন মানুষের বুদ্ধি কম, কোনো মানুষ কৃষিতে পারদর্শী আবার কোন মানুষ শিল্পসৃষ্টিতে দক্ষ ইত্যাদি।

এই প্রসঙ্গে Peter Singer তাঁর 'Practical Ethics' গ্রন্থে রলস - এর বস্তুব্যবহার উল্লেখ করেছেন। সকল মানুষের সমতাকে রলস এক ধরণের পরিবৃত্তিমণ্ডলের পরিপ্রেক্ষিতে ব্যাখ্যা করেছেন। একটি বৃত্তের অভ্যন্তরে যত বিন্দু আঁকা যায় সেই সমস্ত বিন্দুকেই পরিবৃত্তি ও বলা যাবে। "কিছু কিছু বিন্দু কেন্দ্রের

সংবেদনশীল বিষয় তাই এটিকে যত্নসহকারে এবং সতর্কতার দ্বারা আরোহিত করা উচিত। সংরক্ষণ নীতির সুযোগ কাউকে দেওয়ার আগে বিশেষভাবে মনোনেওয়া প্রয়োজন যে যাকে অগ্রাধিকার দেওয়া হচ্ছে সে বাস্তবিক বৈষম্য নীতির প্রয়োগ হওয়ার ফলে বঞ্চিত হয়েছিল কি না। যাইহোক বর্তমান পরিস্থিতিতে সমাজের কিছু শ্রেণী সংরক্ষণ নীতির সুযোগ লাভের বিপক্ষে মতামত প্রকাশ করছেন। কারণ সংরক্ষণ নীতি প্রত্যেক ব্যক্তির কাছে প্রধানত দেশের যুব শক্তির কাছে একটা বাধা হয়ে দাঁড়িয়েছে তাদের নিজেদের উৎকর্ষতা অর্জনে। রাজনৈতিক দলগুলি এই নীতিকে অস্ত্র হিসাবে ব্যবহার করছে ভোট পাওয়ার জন্য। এই দরকষাকষিতে সংখ্যাগরিষ্ঠরা সুযোগ সুবিধা থেকে বঞ্চিত হচ্ছে। এটি এমন একটা নীতি যেখানে একজন যোগ্য ছাত্র সংরক্ষণের কারণে তার সুযোগ হারাচ্ছে। এজন্য সাম্প্রতিক মহামান্য সুপ্রীম কোর্ট সংখ্যাগরিষ্ঠদের জন্য, যারা আর্থিকভাবে পিছিয়ে, তাদের জন্য ১০% সংরক্ষণের ব্যবস্থা করেছে। তাই আমার মনে হয় বর্তমানে পরিবেশের উপযোগী করে তোলার জন্য সংরক্ষণ নীতির পুনর্মূল্যায়ন প্রয়োজন।

তথ্যসূত্র :

- ১) বেনুলাল ধর - মানবাধিকার কী ও কেন ? - প্রগতিশীল প্রকাশক - কোলকাতা - ৭০০০৭৩।
- ২) Richard Wasserstorm -- Reprinted in Moral Problems, J. Rachels, Page - 114.
- ৩) ডঃ প্রদীপ কুমার রায় - ব্যবহারিক নীতিবিদ্যা - বাংলা একাডেমী - ঢাকা - পৃষ্ঠা - ১৮।
- ৪) ডঃ দীক্ষিত গুপ্ত - নীতিবিদ্যা ও ফলিত নীতিবিদ্যা - সোমা বুক এজেন্সী - কোলকাতা - ৭০০ ০০৯, পৃষ্ঠা - ৮৯।
- ৫) ডঃ সমরেন্দ্র ভট্টাচার্য - তত্ত্বগত নীতিবিদ্যা ও ব্যবহারিক নীতিবিদ্যা - বুক সিঙ্ক্রিকিট প্রাইভেট লিমিটেড - কোলকাতা - ৭০০ ০০৯, পৃষ্ঠা - ১৮০।
- ৬) AmartyaSen -- Inequality Reexamined -- Harvard University Press -- Harvard.
- ৭) Berry R. Gross -- Reverse Discrimination -- New York Press -- New York -- 1978.
- ৮) পায়েল রায় চৌধুরী - মানব অধিকার ও মানব উন্নয়ন - প্রোগ্রেসিভ পাবলিশার্স - কোলকাতা - ৭০০০৭৩।

REPRESENTATION OF TRIBAL WOMEN, MARGINALITY AND TRANSFORMATION IN HANSDA SOWVENDRA SHEKHAR'S *THE MYSTERIOUS AILMENT OF RUPI BASKEY*

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Abstract

India, being a culturally diverse country, treasures numerous ethno-cultural communities. Santhal community is one of them, due to their sizeable population. Santhals of Chotanagpur region, like any other tribal community believes in numerous myths and legends, often these beliefs consider 'mysterious' and beyond the border of reason, 'dahni-bidya' or witchcraft is one of them. This eerie knowledge of spirits is practiced by few Santhal women to gain benefit from others by causing them harm. The damaging nature of such knowledge made Santhals avoid those women who participate in it, thus making them socially marginalized in their own community. On the other hand Santhals have their own set of socio-cultural and religious practices which considered under-civilized by main-stream Indians, consequently making them unequal 'other' and marginalized.

*Both the socio-ethnic marginalization of the tribals due to cultural difference outside the border of the community, and the marginalization of the women empowered by the knowledge of witchcraft inside the community find sharp literary representation in Hansda Sowvendra Shekhar's debut novel *The Mysterious ailment of Rupi Baskey* (2014). The present paper will focus on the portrayal of the Santhal women who are the victims and practitioners of 'dahni-bidya' and marginalization as well as those who are benefitted by such practices. The paper will further convey how globalization has influenced the lives Santhals women and the future of 'dahni-bidya' in the age of 'modern' medical sciences as represented in the novel.*

Key words: Ethno-cultural difference, Tribal culture, Marginality, Transformation etc.

Tribal culture treasures numerous myths, legends and folklores. Epistemologically, the socio-cultural practices in tribal are often shaped by so-called 'mysterious' beliefs which seem to be rooted beyond the border of logic and reason. People of the Santhal tribal community, like

issue of marginality becomes less severe as it was earlier. As Rupi, with the assurance of the ending of witchcraft over her family, curls up to sleep and then slips into a dream of wish fulfillment and prosperity, Hansda's narrative excels in creating a space where ailment could only be replaced by happiness and a dream of peace.

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Acronym used:

MARB – *The Mysterious Ailment of Rupi Baskey*

Works Cited:

- Bodding, P.O. *Traditions and Institutions of the Santhals*. Gyan Publishing House: New Delhi, 2016. Print.
- Chakraborty, Amitayu. "Problematising 'Indigeneity' through Hansda Sowvendra Shekhar's *The Mysterious Ailment of Rupi Baskey*". *Rupkatha Journal on Interdisciplinary Studies in Humanities*, Vol. 11, No. 3, October-December, 2019. 1-9. Doi: <https://dx.doi.org/10.21659/rupkatha.v11n3.19>
- De, Asis. "Natural Supernaturalism and Tribal Eco-theology in Hansda Sowvendra Shekhar's *The Mysterious Ailment of Rupi Baskey*" in *Rethinking Environment: Literature, Ethics and Praxis*, Ed. Shruti Das, Delhi: Author Press: 2017. 235-242, Print.
- Hadder, Hans. "Moving Identities: The Jadopatia, the Santals and Myth of Creation." Web. Sept. 2015. https://www.researchgate.net/publication/282247501_Moving_Identities_The_Jadopatia_the_Santals_and_the_Myth_of_Creation.
- Hansda, Sowvendra Shekhar. *The Mysterious Ailment of Rupi Baskey*. Aleph: New Delhi, 2014. Print.
- Hansda, Sowvendra Shekhar. Interview by Anumeha Yadav. *The Hindu*, 28 Nov. 2014. <https://www.thehindu.com/features/magazine/writer-hansda-sowvendra-shekar-talks-to-anumeha-yadav/article6574437.ece>
- Hembram, Ratan et al. "A Visual Journey into Santhal Village Life". Web. Feb. 2016. <http://intangibleheritage.intach.org/wp-content/uploads/2016/07/2.-A-Visual-Journey-into-Santhal-Village-Life-17-36.pdf>
- Tamslyche, Marine Carrin. "The Impact of Cultural Diversity and Globalization in Developing a Santhal Peer Culture in Middle India". Web. 2013. <https://core.ac.uk/download/pdf/13322115.pdf>

The Sacred and the Secular: Post-Colonial Mythopoeia and Cultural Identity in R. K. Narayan's *The Man-eater of Malgudi*

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ABSTRACT

In the post-colonial Indian Anglophone literary scenario, the urge to represent a distinctly Indian cultural identity is the effect of both modernist experimentation and a nationalist assertion. Mythopoeia, mainly a post-religious literary aesthetic, becomes a favourite trope for certain Indian litterateurs, as it conveys an intermediate perspective between the doctrinal sacred and the liberal secular. The retelling of ancient Indian myths in the context of contemporary post-colonial reality becomes trendy in literary imagination and functional in asserting an Indian cultural identity in the second half of the previous century. To bring home the point, I would consider R.K. Narayan's *The Man-eater of Malgudi* as a case study, which, in the words of John Thieme, is the "most mythic novel" (120) among all the fourteen novels he has written. This paper would explore Narayan's dexterous and subtle use of religio-cultural references from ancient Indian mythology as found in the epics and the Puranas, and establish the point that Narayan's mythopoeic treatment is essentially secular. This paper attempts to challenge the superficial reception of the character of Vasu as archetypally "demonic," as Nataraj's assistant Sastri finds him. Even Vasu's death at the end of the novel, which Sastri finds resembling the destruction of the mythical Bhasmasura in the 'Shiva Purana', may be seen from a post-religious perspective: justifying the death of the despicable. This paper finally aims to establish that Narayan's representation of Indian cultural identity relies more on the minute delineation of the Malgudi society, its culture and people rather than on Nataraj's campaign of the 'sacred'.

Keywords: Sacred, Secular, Mythopoeia, Post-colonial, Cultural Identity

Thieme, John. *R. K. Narayan* (Contemporary World Writers), New Delhi: Viva Books, 1st Indian Edition, 2010.

Volná, Ludmila. 'Commodification against Indianness: Symbolism of Things in R. K. Narayan's *The Man-Eater of Malgudi*' in *The Silent Life of Things: Reading and Representing Commodified Objecthood*, Eds. by Daniela Rogobete, Jonathan P. A. Sell and Alan Munton, Newcastle upon Tyne: Cambridge Scholars Publishing, 2015, 153-161.

Walsh, William. *R. K. Narayan: A Critical Appreciation*. London: Heinemann, 1962.

Walther, Sundhya. 'The Nation's Taxidermist: Ungovernable Bodies in R.K. Narayan's *The Man-Eater of Malgudi*.' *University of Toronto Quarterly*, 84 (4), 2015, pp. 74-89. Doi: 10.3138/utq.84.4.06.

Woodcock, George. 'Two Great Commonwealth Novelists: R. K. Narayan and V. S. Naipaul.' *The Sewanee Review*, 87 (1979): 1-28.



A modified ACO with K-Opt for restricted covering salesman problems in different environments

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Abstract

In this study, the ant colony optimization (ACO) algorithm is modified with the K-Opt operation to solve the covering salesman problem (CSP) under one restriction in crisp and imprecise (fuzzy, rough) environments. A CSP involves two phases—the division of cities into groups with the selection of the visiting cities and searching of the Hamiltonian circuit through the visiting cities. But, none of the studies in the literature is made following the direct approach. Also, none of the studies in the literature gives attention to reduce the total travel distance of the unvisited cities from the visited city of a group. Moreover, there is no algorithm in the literature which provides the solution of a CSP with the specified coverage range r . Also, none has introduced any algorithm to solve CSPs in imprecise environments. Though algorithms are available to solve the Traveling Salesman Problems in the imprecise environments, the approach cannot deal with the problems involving fuzzy data with nonlinear membership functions or the problems involving rough data where the rough estimation can not be done using Lebesgue measure. The well-established algorithm for any routing problem is the ACO, but not much attention has been paid to solve the CSP using ACOs. To overcome these limitations on the studies of the ACO on the CSPs, here, an algorithm is proposed for the division of groups of the set of cities depending upon the maximum number of cities in a group and the total number of groups. Then, ACO is used to find the shortest/minimum-cost path of the problem by selecting only one visiting city from each group without violating the restriction of the specified coverage range r of the location of the unvisited cities. K-Opt operation is applied periodically at the end of ACO operation to improve the quality of the best found solution so far by the ACO algorithm and to arrest any premature convergence. For the restricted problems, paths are searched in such a manner that the total distance/travel cost of different unvisited cities of a group from the visited city of the group should not exceed a predefined upper limit. To solve the problem in an imprecise environment, some approach is followed so that the tour is searched without transferring the imprecise optimisation problem into an equivalent crisp optimisation problem. Also, the simulation approaches in fuzzy and rough environments are proposed to deal with the CSPs with any type of estimation of the imprecise data set. Algorithm is tested with the standard benchmark crisp problems available in the literature. To test the algorithm in the imprecise environments, the imprecise instances are derived randomly from the standard crisp instances using a specified rule. Test results imply that the proposed algorithm is efficient enough in solving the CSPs in the crisp as well as in the imprecise environments.

Keywords Covering salesmen problem · Ant colony optimization · K-Opt operation · Fuzzy simulation · Rough simulation

1 Introduction

A covering salesman problem (CSP) is a complete weighted graph, consists of a set of vertices, called cities, and a weight matrix, called distance (cost) matrix which consists of the distance (travelling cost) between any two cities. The goal of the problem is to find the different clusters (groups) of the cities and then find a minimum cost Hamiltonian circuit visiting only one city in each cluster so that each unvisited city in a cluster should be located in a predefined cover-

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- Lin S, Kernighan B (1973) An effective heuristics algorithm for travelling salesman problem. *Oper Res* 21:498–516
- Labbe M, Laporte G, Martin I, Salzar G (2004) The ring star problem: polyhedral analysis and exact algorithm. *Networks* 43(3):177–189
- Labbe M, Laporte G, Martin I, Salzar G (2005) Locating median cycles in networks. *Eur J Oper Res* 160:457–470
- Liu B (2002) Theory and practice of uncertain programming. Physica-Verlag, Heidelberg
- Liu B, Iwamura K (1998) A note on chance constrained programming with fuzzy coefficients. *Fuzzy Sets Syst* 100:229–233
- Maurya AK, Kumar N (2017) Localization problem in disaster management smartphone application. *Int J Adv Res Comput Sci* 8(9):177–180
- Pandiri V, Singh A, Rossi A (2020) Two hybrid metaheuristic approaches for the covering salesman problem. *Neural Comput Appl* 32(19):15643–15663
- Pramanik P, Maiti MK, Maiti M (2017) Three level partial trade credit with promotional cost sharing. *Appl Soft Comput* 58:553–575
- Salari M, Naji-Azimi Z (2012) An integer programming-based local search for the covering salesman problem. *Comput Oper Res* 39:2594–2602
- Salari M, Reihaneh M, Sabbagh MS (2015) Combining ant colony optimization algorithm and dynamic programming technique for solving the covering salesman problem. *Comput Ind Eng* 83:244–251
- Sierksma G (2014) Hamiltonicity and the 3-Opt procedure for the travelling salesman problem. *Appl Math* 22(2):351–358
- Tripathy S, Tulshyan A, Kar S, Pal T (2017) A metameric genetic algorithm with new operator for covering salesman problem with full coverage. *Int J Control Theory Appl* 10(7):245–252
- Ungureanu V (2006) Traveling salesman problem with transportation. *Comput Sci J Moldova* 14(2):41
- Venkatesh P, Srivastava G, Singh A (2019) A multi-start iterated local search algorithm with variable degree of perturbation for the covering salesman problem. *Harmony search and nature inspired optimization algorithms*. Springer, Singapore, pp 279–292
- Zadeh L (1965) Fuzzy sets. *Inf Control* 8:338–356
- Zang Z, Jiang L, Ratli M, Ding B (2020) A parallel variable neighborhood search for solving covering salesman problem. *Optim Lett* 16:175–190

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Multi-objective generalized traveling salesman problem: A decomposition approach

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Abstract

Using the features of shuffle, re-generation, and 4-opt operation, a novel heuristic has been proposed based on the decomposition approach for the multi-objective generalized traveling salesman problems. A three-layer solution updating mechanism, namely, a shuffle layer, a layer for re-generation, and a layer for 4-opt operation, has been designed for the same. The shuffle and re-generation operations are specially designed to solve this problem. The shuffle operation is applied to a solution sequence (complete path/tour) to improve the corresponding objectives. The re-generation operation consists of two phases- in the first phase, the objectives are improved by interchanging a few portions of the groups/clusters sequence, and in the second phase, the same is done by replacing some cities from the corresponding groups. Finally, the solution and the corresponding groups are rearranged using the 4-opt operation for the betterment of the same. Problems with varying sizes from the generalized traveling salesman problem library are solved using the proposed approach to verify its performance and for the illustration. Some widely used performance metrics for multi-objective solution methodologies have been applied to the proposed heuristic to measure its performance. Various well-established heuristics have been modified according to this problem and are implemented to compare the efficiency of the proposed heuristic. Based on the performance metrics values of the computational outputs, a conclusion can be drawn that the proposed heuristic, named SR4-MOEA/D, is the best compared to the other heuristics implemented for the same. Also, every test instance of the proposed algorithm provides the best pareto optimal front, which is distributed over the whole true pareto front of the respective problem.

Keywords Multi-objective generalized traveling salesmen problem · Shuffle operation · Re-generation operation · 4-Opt operation · Decomposition approach on multi-objective heuristics

1 Introduction

A significant portion of the research work on NP-hard combinatorial optimization problems is captured by the

Traveling Salesman Problem (TSP) due to its applicability in the areas of applied sciences [22]. An extension of TSP, the generalized traveling salesman problem (GTSP), was proposed by Henry-Labordere [1], Saksena [36], and Srivastava [40] in the 1960s and has received gradual attention in the social welfare services, like, rural health care, disaster management, rationing system, etc. A standard GTSP involves a node set that is divided into some disjoint subsets, and a weight is associated with each pair of nodes. The objective of the problem is to search a Hamiltonian circuit with minimum weight by visiting one and only one node of each subset. Normally, a node represents a destination or city, and weight represents the travel length between the two associated cities. So, a GTSP can be described as a complete weighted graph (V, E, W) , where a member of $V = \{1, 2, \dots, N\}$ defines a destination/city, the member $e_{ij} \in E$ is associated with the destination i and the destination j indicates the path between the destination i and the destination j , the member $d_{ij} \in W = (d_{ij})_{N \times N}$ is associated with e_{ij} and indicates

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25. Khan MMK, Indadul, Kreshnendu B (2020) Multi-objective traveling salesman problem: an abc approach. *Applied Intelligence*
26. Knowles J, Corne D (1999) The pareto archived evolution strategy: a new baseline algorithm for pareto multiobjective optimization. In: *Proceedings of the 1999 Congress on Evolutionary Computation-CEC99* (Cat. No. 99TH8406), vol 1. IEEE, pp 98–105
27. Knowles JD, Corne DW (2000) Approximating the nondominated front using the pareto archived evolution strategy. *Evolution Comput* 8(2):149–172
28. Korhonen PJ, Laakso J (1986) A visual interactive method for solving the multiple criteria problem. *Eur J Oper Res* 24(2):277–287
29. Lancia G, Dalpasso M (2019) Algorithmic strategies for a fast exploration of the tsp 4-opt neighborhood. In: *Advances in optimization and decision science for society, services and enterprises*. Springer, pp 457–470
30. Laporte G, Asef-Vaziri A, Sriskandarajah C (1996) Some applications of the generalized travelling salesman problem. *J Oper Res Soc* 47(12):1461–1467
31. Laporte G, Nobert Y (1983) Generalized travelling salesman problem through n sets of nodes: an integer programming approach. *INFOR: Inform Syst Oper Res* 21(1):61–75
32. Maity S, Roy A, Maiti M (2016) An imprecise multi-objective genetic algorithm for uncertain constrained multi-objective solid travelling salesman problem. *Expert Syst Appl* 46:196–223
33. Pintea C, Pop P, Chira C (2006) Reinforcing ant colony system for the generalized traveling salesman problem. *Proc. BIC-TA. Evolutionary Computing* 245–252
34. Reinelt G (1991) Tsplib—a traveling salesman problem library. *ORSA J Comput* 3(4):376–384
35. Renaud J, Boctor FF (1998) An efficient composite heuristic for the symmetric generalized traveling salesman problem. *Eur J Oper Res* 108(3):571–584
36. Saskena J (1970) Mathematical model of scheduling clients through welfare agencies. *J Canadian Oper Res Soc* 8:185–200
37. Schaffer JD (1985) Multiple objective optimization with vector evaluated genetic algorithms. In: *Proceedings of the first international conference on genetic algorithms and their applications*. Lawrence Erlbaum Associates. Inc. Publishers, New Jersey, p 1985
38. Snyder LV, Daskin MS (2006) A random-key genetic algorithm for the generalized traveling salesman problem. *Europ J Oper Res* 174(1):38–53
39. Srinivas N, Deb K (1994) Multiobjective optimization using nondominated sorting in genetic algorithms. *Evolution Comput* 2(3):221–248
40. Srivastava S, Kumar S, Garg R, Sen P (1969) Generalized traveling salesman problem through n sets of nodes. *CORS J* 7(2):97
41. van Pinxten J, Geilen M, Basten T, Waqas U, Somers L (2016) Online heuristic for the multi-objective generalized traveling salesman problem. In: *2016 Design, automation & test in europe conference & exhibition (DATE)*. IEEE, pp 822–825
42. Van Veldhuizen DA, Lamont GB (2000) On measuring multiobjective evolutionary algorithm performance. In: *Proceedings of the 2000 Congress on Evolutionary Computation. CEC00* (Cat. No. 00TH8512), vol 1. IEEE, pp 204–211
43. Wierzbicki AP (1980) The use of reference objectives in multiobjective optimization. In: *Multiple criteria decision making theory and application*. Springer, pp 468–486
44. Wu C, Liang Y, Lee HP, Lu C (2004) Generalized chromosome genetic algorithm for generalized traveling salesman problems and its applications for machining. *Phys Rev E* 70(1):016701
45. Zhang Q, Li H, Moea D (2007) A multiobjective evolutionary algorithm based on decomposition. *IEEE Trans Evolution Comput* 11(6):712–731
46. Zhao Y, Liu H-L (2013) Multi-objective particle swarm optimization algorithm based on population decomposition. In: *International conference on intelligent data engineering and automated learning*. Springer, pp 463–470
47. Zhou A, Qu B-Y, Li H, Zhao S-Z, Suganthan PN, Zhang Q (2011) Multiobjective evolutionary algorithms: a survey of the state of the art. *Swarm Evolution Comput* 1(1):32–49
48. Zitzler E (1999) *Evolutionary algorithms for multiobjective optimization: Methods and applications*, vol 63. Citeseer, Pennsylvania
49. Zitzler E, Thiele L (1999) Multiobjective evolutionary algorithms: a comparative case study and the strength pareto approach. *IEEE Trans Evolution Comput* 3(4):257–271

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A random-permutation based GA for generalized traveling salesman problem in imprecise environments

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Abstract

A random-permutation technique and the features of the genetic algorithm (GA) are combined together to develop a novel heuristic for solving generalized travelling salesman problem. Here, the random-permutation technique is used to find the sequence of clusters of a probable solution in which a complete tour to be commenced. The features of GA are used to select the cities from different clusters of the sequence. The algorithm has the ability to solve the problems in both the crisp as well as in the imprecise environments. A fuzzy membership-based selection process is proposed to select a solution for the mating pool. A general comparison rule of the solutions is proposed to rank the potential solutions of the population in imprecise environments. In the crisp environment, the efficiency of the proposed approach is tested against a set of different benchmark test problems from GTSP LIB having sizes up to 226 cities with 26 clusters. It is observed from the experimental results that the algorithm produces 100% accurate results for all the benchmark test problems under consideration. Imprecise test problems are generated from different benchmark crisp test problems of TSPLIB and are used to test the algorithm in the imprecise environments. It is also observed from the experimental results that the proposed approach finds multiple optimal paths (i.e., more than one path), if exists, for the problems in the crisp as well as in the imprecise environments.

Keywords Traveling salesmen problem · Genetic algorithm · Randomness · Triangular fuzzy number · Rough set

1 Introduction

A generalized form of the classical Traveling Salesman Problem (TSP), the generalized TSP (GTSP) was introduced by Henry-Labordere [11], Saksena [31], and Srivastava [33] in the context of computer record balancing and of visit sequencing through welfare agencies in 1960s. The problem consists of a set of n cities and a cost matrix $(c_{ij})_{n \times n}$, where,

c_{ij} is the cost of travelling from city i to city j . The n cities are grouped into several clusters- cl_1, cl_2, \dots, cl_k , where k is the number of clusters. Every city must belongs to at least one cluster. So, a city may belongs to more than one clusters. A salesman starts from a city of a cluster, visits one and only one city of every cluster and returns to the starting city with the minimum expenditure. So, the goal of the problem is to find the path/route of the salesman with the minimum cost covering all the clusters exactly once. There are several real-life applications of GTSP, such as, mail delivery [17], welfare agency routing [31], material flow system design [17], vehicle routing [17], and computer file sequencing [11], etc. The GTSP belongs to the class of NP-hard problems.

In most of the above-mentioned studies it is implicitly assumed that the travel cost, c_{ij} between any two cities i and j , is fixed and crisp in nature. But c_{ij} depends on the several factors, like, the quality of the vehicle used, condition of the roadways, duration of the travel, weather condition, etc. The travelling cost between any two cities mainly depends on the quality of transport used for the purpose. Sometimes it depends on the availability of the vehicle, condition of the road ways, etc., though its value normally lies in an interval.

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35. Wu CG, Liang YC, Lee HP, Lu C (2004) A generalized chromosome genetic algorithm for generalized traveling salesman problems and its applications for machining. *Phys Rev E* 70:016701
36. Yang J, Shi X, Marchese M, Liang Y (2008) An ant colony optimization method for generalized TSP problem. *Prog Nat Sci* 18:1417–1422
37. Zadeh L (1965) Fuzzy sets. *Inf Control* 8:338–356
38. Zhao X, Zhu XP (2010) Innovative genetic algorithm for solving GTSP. In: Second international conference on modeling,

simulation and visualization methods. College of Computer Science and Engineering, Guangdong Institute of Science and Technology

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Journal Pre-proofs

A multi-item supply chain with multi-level trade credit policy under inflation:
A mixed mode ABC approach

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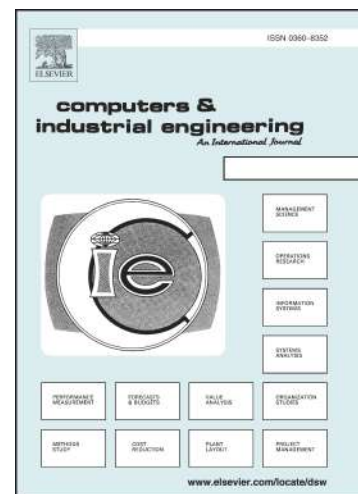
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A MULTI-ITEM SUPPLY CHAIN WITH MULTI-LEVEL TRADE CREDIT POLICY UNDER INFLATION: A MIXED MODE ABC APPROACH

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A MULTI-ITEM SUPPLY CHAIN WITH MULTI-LEVEL TRADE CREDIT POLICY UNDER INFLATION: A MIXED MODE ABC APPROACH

ABSTRACT. In this study, a multi-item supplier-wholesaler-retailer-customers supply chain with partial trade credit policy at each level under inflationary effect for a fixed planning horizon is developed and analysed. Here the wholesaler receives a partial credit period from the supplier, i.e., a credit period on a portion of the amount of units purchased. Wholesaler also offers a partial credit period to its retailer and in turn the retailer also offers a partial credit period to its customers to boost the base demand of any item. Here, credit period induced base demand of any item decreases linearly with time. Demand of the items are also influenced by the respective selling prices. The retailer introduces some promotional cost against advertisement and price discount to improve the demand of the items. Here, it is established that if the wholesaler shares a portion of this promotional cost then the profits of both the retailer and the wholesaler improve. Model is formulated as a mixed-integer profit maximization problem and is analysed in crisp as well as in imprecise (fuzzy/rough) environment and some managerial insights are outlined. To find the marketing decision of such a real-life supply chain model, here, a new variant of ABC is proposed for mixed-integer optimization problems. The algorithm is tested against a set of benchmark test problems available in the literature and its efficiency to solve such problems is well established.

Key words : Supply chain; Partial trade credit period; Inflation; Promotional cost sharing; Artificial Bee Colony.

1. Introduction

In any supply chain, profit of each party mostly depends on the market demand of the items involved in the chain, though, each party offers some sort of credit period to its purchaser to improve his/her sale amount. In reality, sale of each party mainly depends on the base demand of the item to the customers. This phenomenon as well as the credit opportunity from the wholesaler influences the retailer to offer some sort of credit facility to its customers. But the customers are basically floating in nature and there is no guarantee that all the customers will obey the business ethics. A portion of the customers may not pay the credit amount at the end of the credit period. This credit risk forces the retailer to offer only partial credit period to its customers, i.e., credit opportunity is offered on a portion of the amount purchased by any customer. On the other hand, to improve the demand, the retailer uses some promotional activities, like, local advertisement, offering price discount, free gift, etc., and the cost of these activities is known as the promotional cost. During the last decade, several research papers have been published reflecting

- [43] Sarkar, B., Mandal, P., Sarkar, S., 2014. An EMQ model with price and time dependent demand under the effect of reliability and inflation. *Applied Mathematics and Computation*, 231, 414-421.
- [44] Subotic, M., Tuba, M., 2014. Parallelized Multiple Swarm Artificial Bee Colony Algorithm (MS-ABC) for Global Optimization. *Studies in Informatics and Control*, 23(1), 117-126.
- [45] Tsao, Y.-C., 2010. Managing multi-echelon multi-item channels with trade allowances under credit period. *International Journal of Production Economics*, 127(2), 226-237.
- [46] Tsao, Y.-C., Sheen, G.-J., 2012. Effects of promotion cost sharing policy with the sales learning curve on supply chain coordination. *Computers & Operations Research*, 39(8), 1872-1878.
- [47] Yaghin, R.G., 2018. Integrated multi-site aggregate production-pricing planning in a two-echelon supply chain with multiple demand classes. *Applied Mathematical Modelling*, 53, 276-295.
- [48] Yang, H.-L., 2006. Two-warehouse partial backlogging inventory models for deteriorating items under inflation. *International Journal of Production Economics*, 103(1), 362-370.
- [49] Zimmermann, H.-J., 1996. *Fuzzy Set Theory and Its Applications*. Springer, Science+Business Media, New York.

A DETERIORATING FOOD PRESERVATION SUPPLY CHAIN MODEL WITH DOWNSTREAM DELAYED PAYMENT AND UPSTREAM PARTIAL PREPAYMENT

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Abstract. This paper investigates a food supply chain model consisting of the supplier, food producer and multi-retailer of a deteriorating item under fully delay-in-payment and partial advance payment scheme. The deterioration rate of raw material is dependent on temperature and other environmental factors with respect to time. Here, the food producer prepares food after collecting the raw material from the supplier and then storing it in cold storage. The refrigeration cost is dependent on the occupied volume in the cold storage (where the products are preserved for freshness) and power consumption. The supplier offers delay-in-payment to stimulate the food producer to buy more raw material (which minimizes the holding cost and earns more revenues), whereas the food producer takes the partial advance payment on purchase cost from the retailers to ensure the order quantity. A mathematical model is developed to obtain optimal production time and the optimal number of deliveries so that the average profit of the food producer is maximum. Finally, a numerical example and sensitivity analysis of the key parameters are provided to illustrate and test the feasibility of the proposed model.

Mathematics Subject Classification. 90B05, 90B15, 90B25, 90B30, 90B50.

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1. INTRODUCTION

In this world, food deterioration is a common phenomenon in developing countries and may cause economic loss. In many countries, food supply chain management affronts a huge challenge of food quality, food safety, public health, demand, price variability and weather-related variability etc. On the other hand, perishable products are important in inventory management because customers strive for quality. According to Ferguson and Katzenberg [11], 15% (approximately) of foods deteriorates in the food retailing sector. Also, more than 25% of fruit and vegetables are deteriorated in China during transportation, at wholesale markets and in shops (*cf.* [22]). Food products are the most delicate goods on the market due to insufficient storage, the wrong

Keywords. Supply chain, deteriorating items, delay-in-payment, advance payment.

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- [18] M.A.A. Khan, A.A. Shaikh, G.C. Panda and I. Konstantaras, Two-warehouse inventory model for deteriorating items with partial backlogging and advance payment scheme. *RAIRO-Oper. Res.* **53** (2019) 1691–1708.
- [19] R. Li, Y.-L. Chan, C.-T. Chang and L.E. Cárdenas-Barrón, Pricing and lot-sizing policies for perishable products with advance-cash-credit payments by a discounted cash flow analysis. *Int. J. Prod. Econ.* **193** (2017) 578–589.
- [20] G.C. Mahata, An EPQ-based inventory model for exponentially deteriorating items under retailer partial trade credit policy in supply chain. *Expert Syst. App.* **39** (2012) 3537–3550.
- [21] A.K. Manna, J.K. Dey and S.K. Mondal, Effect of inspection errors on imperfect production inventory model with warranty and price discount dependent demand rate. *RAIRO-Oper. Res.* **54** (2020) 1189–1213.
- [22] R. Martin, China must improve its cool supply chain to keep pace with demand for fresh food. <http://theloadstar.co.uk/coolstar/china-mustimprove-its-cool-supply-chain-to-keep-pace-with-demand-for-fresh-food> (2015).
- [23] G.D. Orris and A.J. Whitehead, Hazard analysis and critical control point (HACCP) as a part of an overall quality assurance system in international food trade. *Food Control* **11** (2000) 345–351.
- [24] Y. Qin, J. Wang and C. Wei, Joint pricing and inventory control for fresh produce and foods with quality and physical quantity deteriorating simultaneously. *Int. J. Prod. Econ.* **152** (2014) 42–48.
- [25] H. Ronald, G. Schmidt and E. Rodrick, Definition of food safety. In: *Food Safety Handbook*. Wiley-IEEE3-7 (2005).
- [26] N.H. Shah, M.Y. Jani and U. Chaudhari, Optimal replenishment time for retailer under partial upstream prepayment and partial downstream overdue payment for quadratic demand. *Math. Comput. Model. Dyn. Syst.* **24** (2017) 1–11.
- [27] K. Skouri and S. Papachristos, A continuous review inventory model with deteriorating items time varying demand linear replenishment cost partially time varyingbacklogging. *Appl. Math. Model.* **26** (2002) 603–617.
- [28] K. Skouri, I. Konstantaras, S. Papachristos and I. Ganas, Inventory models with ramp type demand rate, partial backlogging and Weibull deterioration rate. *Eur. J. Oper. Res.* **192** (2009) 79–92.
- [29] D. Smith, Design and management concepts for high care food processing. *Br. Food J.* **108** (2006) 54–60.
- [30] A.A. Taleizadeh, D.W. Pentico, M.S. Jabalameli and M. Aryanezhad, An economic order quantity model with multiple partial prepayments and partial backordering. *Math. Comput. Model.* **57** (2013) 311–323.
- [31] A.A. Taleizadeh, An economic order quantity model for deteriorating items in a purchasing system with multiple prepayments. *Appl. Math. Model.* **38** (2014) 5357–5366.
- [32] J.T. Teng, J. Min and Q. Pan, Economic order quantity model with trade credit financing for non-decreasing demand. *Omega* **40** (2012) 328–335.
- [33] J.T. Teng, L.E. Cárdenas-Barrón, H.J. Chang, J. Wu and Y. Hu, Inventory lot-size policies for deteriorating items with expiration dates and advance payments. *Appl. Math. Model.* **40** (2016) 8605–8616.
- [34] A. Thangam and R. Uthayakumar, Two-echelon trade credit financing for perishable items in a supply chain when demand depends on both selling price and credit period. *Comput. Ind. Eng.* **57** (2009) 773–786.
- [35] S. Tiwari, L.E. Cárdenas-Barrón, M. Goh and A.A. Shaikh, Joint pricing and inventory model for deteriorating items with expiration dates and partial backlogging under two-level partial trade credits in supply chain. *Int. J. Prod. Econ.* **200** (2018) 16–36.
- [36] Y.-C. Tsao, A piecewise nonlinear optimization for a production-inventory model under maintenance, variable setup costs, and trade credits. *Ann. Oper. Res.* **233** (2015) 465–481.
- [37] M.-F. Yang and W.-C. Tseng, Deteriorating inventory model for chilled food. *Math. Prob. Eng.* **2015** (2015) 1–10.
- [38] A.X. Zhang, Optimal advance payment scheme involving fixed per-payment costs. *Omega* **24** (1996) 577–582.

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Article

A Fuzzy Imperfect Production Inventory Model Based on Fuzzy Differential and Fuzzy Integral Method

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Abstract: In the inventory theory, to treat the uncertainty, the fuzzy set concept is used in order to provide a feasible approach to deal with the uncertainty problem. In this research work, a fuzzy economic production quantity model with interactive fuzzy demands is proposed. In a production process, in the beginning, the system is assumed to be in a controlled state in which only perfect items are manufactured. Later, the manufacturing production process shifts to be an out-of-control-state system; producing both perfect and imperfect items simultaneously, this is considered as a fuzzy state. The defective production rate is also taken into account as a fuzzy state. Here, the selection process of produced items is realized during the production period. With the aim of studying the practical feasibility of the fuzzy economic production inventory model along with a sensitivity analysis of some parameters, different numerical examples are illustrated.

Keywords: fuzzy economic production quantity; fuzzy imperfect production process; fuzzy integral method; fuzzy demand; fuzzy programming technique



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1. Introduction

It is well known that the fuzzy set concept is applied into the inventory models to treat the uncertainty. The fuzzy set theory was introduced by (Zadeh 1965) with the aim of providing a feasible approach to deal with the fuzzy uncertainty problem. In the literature, the fuzzy set theory, also known as uncertain sets, has attracted attention for treating uncertainty in a variety of circumstances. For example, fuzzy inventory costs in the economic order quantity model are used in (Park 1987; Priyan and Uthayakumar 2016). Obtaining the economic production quantity when the quantity of demand is uncertain is analyzed in (Chang 1999). To treat the inventory problem considering all the parameters and variables being fuzzy numbers, a fuzzy economic production model is established by (Chen and Hsieh 2000). Different types of production inventory models for fuzzy environments are proposed by studies such as (Dey et al. 2005; Hsieh 2002; Lee and Yao 1998; Lin and Yao 2000; Manna et al. 2014, 2017a). Furthermore, other, different research works solve uncertainty issues using fuzzy set theory, such as (Das et al. 2015; Soni and Joshi 2015). Bera and Jana (2017) developed an imperfect production inventory model for multi-items under bi-fuzzy environments. (Dey 2019) introduced an imperfect production inventory problem under a fuzzy random environment. Recently, (Maiti 2021) incorporated the demand-dependent production rate into an inventory model with imperfect production process under a cloudy fuzzy environment.

Traditional economic production quantity (EPQ) models assume that in manufacturing systems, all items are made of perfect quality. However, in the real world, due to many

- Moghdani, Reza, Shib Sankar Sana, and Hamid Shahbandarzadeh. 2020. Multi-item fuzzy economic production quantity model with multiple deliveries. *Soft Computing* 24: 10363–87. [\[CrossRef\]](#)
- Park, Kyung S. 1987. Fuzzy set theoretic interpretation of economic order quantity. *IEEE Transactions on Systems, Man, and Cybernetics* 17: 1082–84. [\[CrossRef\]](#)
- Pasandideh, Seyed Hamid Reza, Seyed Taghi Akhavan Niaki, Amir Hossein Nobil, and Leopoldo Eduardo Cárdenas-Barrón. 2015. A multiproduct single machine economic production quantity model for an imperfect production system under warehouse construction cost. *International Journal of Production Economics* 169: 203–14. [\[CrossRef\]](#)
- Petrovic, Dobrila, Radivoj Petrovic, and Mirko Vujosevic. 1996. Fuzzy models for the newsboy problem. *International Journal of Production Economics* 45: 435–41. [\[CrossRef\]](#)
- Porteus, Evan L. 1986. Optimal lot-sizing process quality improvement and setup cost reduction. *Operations Research* 34: 137–44. [\[CrossRef\]](#)
- Priyan, S., and R. Uthayakumar. 2016. Economic design of multi-echelon inventory system with variable lead time and service level constraint in a fuzzy cost environment. *Fuzzy Information and Engineering* 8: 465–511. [\[CrossRef\]](#)
- Román-Flores, Heriberto, Laécio C. Barros, and Rodney C. Bassanezi. 2001. A note on Zadeh's extensions. *Fuzzy Sets and Systems* 117: 327–31. [\[CrossRef\]](#)
- Rosenblatt, Meir J., and Hau L. Lee. 1986. Economic production cycles with imperfect production processes. *IIE Transactions* 18: 48–55. [\[CrossRef\]](#)
- Salameh, Mouen K., and Mohamad Y. Jaber. 2000. Economic production quantity model for items with imperfect quality. *International Journal of Production Economics* 64: 59–64. [\[CrossRef\]](#)
- Sarkar, Biswajit, Leopoldo Eduardo Cárdenas-Barrón, Mitali Sarkar, and Moses Laksono Singgih. 2014. An EPQ inventory model with random defective rate, rework process and backorders for a single stage production system. *Journal of Manufacturing Systems* 33: 423–35. [\[CrossRef\]](#)
- Seikkala, Seppo. 1987. On the fuzzy initial value problem. *Fuzzy Sets and Systems* 24: 319–30. [\[CrossRef\]](#)
- Shao, Zhen, and Xiaoyu Ji. 2006. Fuzzy multi-product constraint newsboy problem. *Applied Mathematics and Computation* 180: 7–15. [\[CrossRef\]](#)
- Shaikh, Ali Akbar, Asoke Kumar Bhunia, Leopoldo Eduardo Cárdenas-Barrón, Laxminarayan Sahoo, and Sunil Tiwari. 2018. A fuzzy inventory model for a deteriorating item with variable demand, permissible delay in payments and partial backlogging with shortage follows inventory (SFI) policy. *International Journal of Fuzzy Systems* 20: 1606–23. [\[CrossRef\]](#)
- Shaikh, Ali Akbar, Leopoldo Eduardo Cárdenas-Barrón, Amalesh Kumar Manna, and Armando Cespedes-Mota. 2020. An economic production quantity (EPQ) model for a deteriorating item with partial trade credit policy for price dependent demand under inflation and reliability. *Yugoslav Journal of Operations Research* 31: 139–51.
- Shah, Nita H., and Chetansinh R. Vaghela. 2018. Imperfect production inventory model for time and effort dependent demand under inflation and maximum reliability. *International Journal of Systems Science: Operations & Logistics* 5: 60–68.
- Soni, Hardik N., and Manisha Joshi. 2015. A periodic review inventory model with controllable lead time and backorder rate in fuzzy-stochastic environment. *Fuzzy Information and Engineering* 7: 101–14. [\[CrossRef\]](#)
- Taleizadeh, Ata Allah, Saman Nikpour, and Mahmoud Zarei. 2009. Constraint joint-replenishment inventory control problem with fuzzy rough demand. *Journal of Applied Sciences* 9: 627–38. [\[CrossRef\]](#)
- Taleizadeh, Ata Allah, Mahshid Yadegari, and Shib Sankar Sana. 2019. Production models of multiple products using a single machine under quality screening and reworking policies. *Journal of Modelling in Management* 14: 232–59. [\[CrossRef\]](#)
- Wang, Chih-Hsiung, and Shey-Heui Sheu. 2001. Simultaneous determination of the optimal production inventory and product inspection policies for a deteriorating production system. *Computers and Operations Research* 28: 1093–110. [\[CrossRef\]](#)
- Wang, Chih-Hsiung. 2005. Integrated production and product inspection policy. *International Journal of Production Economics* 95: 123–34. [\[CrossRef\]](#)
- Wu, Hsien-Chung. 2000. The fuzzy Riemann integral and its numerical integration. *Fuzzy Sets and Systems* 110: 1–25. [\[CrossRef\]](#)
- Yoo, Seung Ho, DaeSoo Kim, and Myung-Sub Park. 2009. Economic production quantity model with imperfect quality items, two-way imperfect inspection and sales return. *International Journal of Production Economics* 121: 255–65. [\[CrossRef\]](#)
- Zadeh, Lotfi Asker. 1965. Fuzzy sets. *Information and Control* 8: 338–56. [\[CrossRef\]](#)
- Zimmermann, Hans-Jürgen. 1996. *Fuzzy Set Theory and Its Applications*, 2nd ed. Allied: New Delhi.

HIGHER-ORDER ANTIBUNCHING OF LIGHT IN SEVEN-PHOTON INTERACTION PROCESS

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Abstract

We study higher-order antibunching of light and the possibility of observing it in all modes in two and three-photon absorption seven-photon interaction processes. We solve the generalized interaction Hamiltonian for several particular cases in the Heisenberg picture and investigate the possibility of observing antibunching using the short-time approximation technique. We demonstrate that the antibunching of light in the initial pump field is directly dependent on coupling of the field between the modes and short-time interaction, as well as the quantity of photons. With the same number of photons, we find that the third-order antibunching is more prominent, followed by the second-and-first-order antibunching. In these systems, we discover that antibunching is not observed for the Stokes and signal modes in this process. We show that a higher-multiphoton-absorption technique is the best for producing optimum antibunched light.

Keywords: higher-order antibunching, seven-photon interaction process, photon number operator, short-time approximation.

1. Introduction

A nonclassical phenomenon [1, 2], such as photon antibunching [3–12] of the field, is currently of great interest in the context of quantum teleportation [13, 14], quantum computation [15–19], and quantum cryptography [20–22], using a single-photon source as unconditional security [23–25]. Single-photon sources are light sources that emit light as single particles or photons and give rise to an effectively one-photon number state, i.e., the probability of emitting a single photon is larger than the probability of emitting two, three, four, or more photons simultaneously. The rate of simultaneous emission of two or more photons is lower in the antibunched state than it is in the single-photon state, indicating that the likelihood of detecting a single-photon source is larger than the probability of detecting a two or more-photon source in a bunch. Antibunching arises in pump modes, which lose energy, while bunching appears in signal modes, which absorb energy from the pump. In other words, as energy increases, more noise increases, and vice versa, as energy decreases, noise decreases [26–29].

As a result, we found that a higher multiphoton absorption method is the best for producing optimum antibunched light.

6. Summary and Conclusions

In this paper, we investigated antibunching of light in two and three-photon absorption seven-photon interaction processes.

The quantity of pump photons and the coupling of the field between the modes and interaction time were demonstrated to be strongly related to the first, second, and third-order antibunching of light of the initial pump field. As a result, the maximum degree of antibunching that can be achieved is determined by the interaction time, which is limited by short interaction times. When comparing the first, second, and third-order antibunching of light, we deduced that the third-order antibunching had the most antibunching, followed by the second and first-order antibunching; all with the same amount of pump photons. Higher-order antibunching (photon number squared and photon number cubed) is thought to be more effective than ordinary antibunching in terms of achieving the depth of nonclassicality. We showed that the number of photons present in the pump mode appeared to be a good way to regulate the depth of nonclassicality.

It is inferred that in both two and three-photon absorption seven-photon interaction processes, ordinary and higher-order antibunching of light is absent for the Stokes mode over the pump mode and for the Stokes mode over the Stokes mode and the signal mode, respectively. We found that the three-photon absorption seven-photon interaction process had more antibunching than the two-photon absorption seven-photon interaction process, despite the fact that both processes had the same amount of photons. As a result, it is clear that a higher multiphoton absorption technique is the best for producing optimum antibunched light.

The findings of this paper are simple and straightforward to replicate in most physical systems in laboratories, paving the way for the experimental observation of higher-order antibunching and the development of suitable probabilistic single-photon sources for quantum teleportation and quantum cryptography. Finally, in addition to these important conceptual and foundational aspects, the realization of larger and better multiphoton nonclassical states should open up new possibilities and perspectives for quantum optic realizations of quantum information and communication processes, which are currently underexplored [39].

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References

1. P. Meystre and M. Sargent III, *Elements of Quantum Optics*, 4th ed., Springer Verlag, Berlin (1991).
2. V. V. Dodonov, *J. Opt. B: Quantum Semiclass. Opt.*, **4**, R1 (2002).
3. H. Paul, *Rev. Mod. Phys.*, **54**, 1061 (1982).
4. D. Stoler, *Phys. Rev. Lett.*, **33**, 1397 (1974).
5. R. Tanas, *Optik*, **40**, 109 (1974).
6. R. Loudon, *Phys. Bull.*, **27**, 21 (1976).

7. M. Koziarowski and R. Tanas, *Opt. Commun.*, **21**, 229 (1977).
8. H. J. Kimble, M. Dagenais, and L. Mandel, *Phys. Rev. Lett.*, **39**, 691 (1977).
9. L. Mandel, *Opt. Commun.*, **42**, 437 (1982).
10. S. Kielich, M. Koziarowski, and R. Tanas, *Optica Acta: Int. J. Opt.*, **32**, 1023 (1985).
11. X. T. Zou and L. Mandel, *Phys. Rev. A*, **41**, 475 (1990).
12. A. Pathak and S. Mandal, *Mod. Phys. Lett. B*, **17**, 225 (2003).
13. C. H. Bennett, G. Brassard, C. Crépeau, et al., *Phys. Rev. Lett.*, **70**, 1895 (1993).
14. A. Furusawa, J. L. Sørensen, S. L. Braunstein, et al., *Science*, **282**, 706 (1998).
15. D. Gottesman and I. Chuang, *Nature*, **402**, 390 (1999).
16. P. Benioff, *J. Stat. Phys.*, **22**, 563 (1980).
17. R. P. Feynman, *Int. J. Theor. Phys.*, **21**, 467 (1982).
18. D. Deutsch, *Proc. R. Soc. A*, **400**, 97 (1985).
19. M. Raginsky and P. Kumar, *J. Opt. B: Quantum Semiclass. Opt.*, **3**, L1 (2001).
20. C. H. Bennett and G. Brassard, *IBM Tech. Discl. Bull.*, **28**, 3153 (1985).
21. A. K. Ekert, *Phys. Rev. Lett.*, **67**, 661 (1991).
22. M. Hillery, *Phys. Rev. A*, **61**, 022309 (2000).
23. M. Matsuoka and T. Hirano, *Phys. Rev. A*, **67**, 042307 (2003).
24. M. J. Stevens, S. Glancy, Sae Woo Nam, and R. P. Mirin, *Opt. Exp.*, **22**, 3244 (2014).
25. E. Meyer-Scott, C. Silberhorn, and A. Migdall, *Rev. Sci. Instrum.*, **91**, 041101 (2020).
26. N. B. Grosse, T. Symul, M. Stobinska, et al., *Phys. Rev. Lett.*, **98**, 153603 (2007).
27. H. Seifoory, S. Doutre, M. Dignam, and J. E. Sipe, *J. Opt. Soc. Am. B*, **34**, 1587 (2017).
28. S. Mandal, M. Alam, M. Kora, and M. R. Wahiddin, *J. Phys.*, **95**, 82 (2021).
29. Y. Inui, and Y. Yamamoto, *Entropy*, **23**, 624 (2021).
30. C. T. Lee, *Phys. Rev. A*, **41**, 1721 (1990).
31. C. T. Lee, *Phys. Rev. A*, **41**, 1569 (1990).
32. Nguyen Ba An, *J. Opt. B: Quantum Semiclass. Opt.*, **4**, 222 (2002).
33. A. Pathak and M. E. Garcia, *Appl. Phys. B*, **84**, 484 (2006).
34. P. Gupta, P. Pandey, and A. Pathak, *J. Phys. B: At. Mol. Opt. Phys.*, **39**, 1137 (2006).
35. H.-A. Bachor, *A Guide to Experiments in Quantum Optics*, 2nd ed., Wiley-VCH, Weinheim (1998), Chs. 8; 10.
36. W. Vogel, D. Welsch, and S. Wallentowitz, *Quantum Optics: An Introduction*, 2nd ed., Wiley-VCH, Berlin (2001), Ch. 6.
37. D. Erenso, R. Vyas, and S. Singh, *J. Opt. Soc. B*, **19**, 1471 (2002).
38. R. Vyas and S. Singh, *Phys. Rev. A*, **40**, 5147 (1989).
39. A. Verma, N. K. Sharma, and A. Pathak, *Phys. Lett. A*, **372**, 5542 (2008).
40. B. Sen, S. Mandal, and J. Perina, *J. Mod. Opt.*, **59**, 555 (2012).
41. T. M. Duc, H. T. X. Nguyen, and An Ba Nguyen, *Int. J. Theor. Phys.*, **53**, 899 (2014).
42. A. Mukhopadhyay, S. K. Giri, T. Sinha, and P. C. Jana, *J. Phys. Sci.*, **22**, 151 (2017).
43. F. Dell'Anno, S. De Siena, and F. Illuminati, *Phys. Rep.*, **428**, 53 (2006).
44. R. Tanas, *Phys. Lett. A*, **141**, 217 (1989).
45. R. Tanas, A. Miranowicz, and S. Kielich, *Phys. Rev. A*, **43**, 4014 (1991).
46. J. Perina, *Quantum Statistics of Linear and Nonlinear Optical Phenomena*, 2nd ed., Kluwer, Dordrecht, The Netherlands (1991), Chs. 9; 10.
47. A. Sinatrat, F. Castellit, L. A. Lugiato, et al., *Quantum Semiclass. Opt.*, **7**, 405 (1995).
48. Liu Yu-Xi and Sun Chang-Pu, "Antibunching effect of the radiation field in a microcavity with a mirror undergoing heavily damping oscillation," arXiv.org/abs/quant-ph/0001036v1, 12 Jan. 2000.
49. C. C. Gerry and S. Rodrigues, *Phys. Rev. A*, **36**, 5444 (1987).
50. D. K. Giri and P. S. Gupta, *J. Opt. B: Quantum Semiclass. Opt.*, **5**, 158 (2003).
51. G. M. Latha, M. Sripriya, and N. Ramesh, *Opt. Photonics J.*, **7**, 139 (2017).



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A naphthalene-based azo armed molecular framework for selective sensing of Al³⁺†

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An azo armed Schiff base chemosensor was synthesized based on a naphthalene fluorophore, which transduces greenish-yellow emission by complexing with Al³⁺. It emits greenish-yellow fluorescence through restricted C=N isomerization, chelation-enhanced fluorescence, and the photo-induced electron transfer mechanism. The clear visible transformation of the achromatic ligand to a chromatic ligand by the 1:1 complexation with Al³⁺ is substantiated by ESI-MS spectra. ¹H NMR, ¹³C NMR, and FTIR spectroscopies are used to characterize the **HL**. The selectivity of the **HL** for Al³⁺ in the presence of other metal ions was investigated through absorbance and fluorescence spectroscopies. The average lifetimes of **HL** and **L–Al³⁺** have been evaluated using a time-resolved photoluminescence experiment to explore the sensing mechanism. The Al³⁺ sensing mechanism was also established by density functional theory calculations. A reversibility experiment was performed, demonstrating that Al³⁺ binding to **HL** is reversible. The pH variation on luminescence affirms that the **HL** can survive in physiological pH. Finally, the lower limit of detection of 5.4 × 10^{−7} and a good response in a cytotoxicity and cell imaging study confirm the usability of the ligand as an indelible signature of an effective biosensor for target Al³⁺.

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Introduction

In supramolecular chemistry, one of the challenging areas of development is developing a photochromic compound that can detect ions under the influence of external stimuli *via* photo-induced switching.¹ Although there are many analytical techniques for detecting ions, their operation demands skilled operators, high equipment costs, and complex preparatory processes.^{2–6} A transition metal is an integral part of an enzyme that regulates biological activity, yet it can be detrimental to the environment and human life; thus, it is a real paradox of the

environment.⁷ Aluminium, when absorbed in our body from various sources such as aluminium-based utensils and medicines, circulates to almost all tissue, reaches plasma through iron-binding protein, and is stored in the brain. Alzheimer's disease due to aluminium-induced oxidative deterioration in the CNS (central nervous system) can happen even with a minimum dose of chronic exposure to aluminium from drinking water.⁸ It is also believed to be the causative factor of smoking-related diseases, bone softening, chronic renal failure, and Parkinson's disease.⁹ Therefore, to understand the mechanism of aluminium-induced adverse effects and to determine the concentration of Al³⁺ according to the WHO, researchers have been spurred to track aluminium more efficiently.¹⁰ Because of their operational simplicity in detecting metal ions *via* chromogenic and fluorogenic sensing, chemosensors based on Schiff bases have piqued the interest of researchers in environmental and biomedical fields.¹¹ The most common mode of sensing operation in a chemosensor is that the photon interacting fluorophore site forms a communication with the receptor site after being attached with a metal ion and produces a 'turn-on' signal. Azomethine (CH=N) Schiff base derivatives armed with a suitable fluorophore moiety are considered classical ligands for detecting metal ions due to their elite coordination toward target metal ions, and ease of synthesis in combination with good photophysical properties.^{12,13} A large number of sensory probes have been developed, taking

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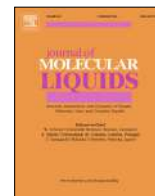
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- 71 B. In, G. W. Hwang and K. H. Lee, *Bioorg. Med. Chem. Lett.*, 2016, **26**, 4477–4482.
- 72 A. W. Czarnik, *Fluorescent Chemosensors for Ion and Molecule Recognition*, 1992.
- 73 J. R. Lakowicz, *Principles of Fluorescence Spectroscopy*, 1983.
- 74 X. Chen, X. Tian, I. Shin and J. Yoon, *Chem. Soc. Rev.*, 2011, **40**, 4783–4804.
- 75 A. P. De Silva, H. Q. N. Gunaratne, T. Gunnlaugsson, A. J. M. Huxley, C. P. McCoy, J. T. Rademacher and T. E. Rice, *Chem. Rev.*, 1997, **97**, 1515–1566.
- 76 X. Chen, T. Pradhan, F. Wang, J. S. Kim and J. Yoon, *Chem. Rev.*, 2012, **112**, 1910–1956.
- 77 M. Sadia, J. Khan, R. Naz, M. Zahoor, E. Khan, R. Ullah and A. Bari, *J. Sens.*, 2020, **2020**, 2192584.
- 78 S. Alghool, H. F. Abd El-Halim, M. S. Abd El-Sadek, I. S. Yahia and L. A. Wahab, *J. Therm. Anal. Calorim.*, 2013, **112**, 671–681.
- 79 V. K. Gupta, S. K. Shoor, L. K. Kumawat and A. K. Jain, *Sens. Actuators, B*, 2015, **209**, 15–24.
- 80 W. Cao, X. J. Zheng, J. P. Sun, W. T. Wong, D. C. Fang, J. X. Zhang and L. P. Jin, *Inorg. Chem.*, 2014, **53**, 3012–3021.
- 81 J. Cheng, X. Zhou and H. Xiang, *Fluorescent metal ion chemosensors via cation exchange reactions of complexes, quantum dots, and metal-organic frameworks*, Royal Society of Chemistry, 2015, vol. 140.
- 82 R. J. P. Williams, *J. Chem. Soc.*, 1953, 3192–3210.
- 83 H. Xiang, J. Cheng, X. Ma, X. Zhou and J. J. Chruma, *Near-Infrared Phosphorescence: Mater. Appl.*, 2013, **42**, 6128–6185.
- 84 M. Venkateswarulu, S. Sinha, J. Mathew and R. R. Koner, *Tetrahedron Lett.*, 2013, **54**, 4683–4688.
- 85 G. Tamil Selvan, C. Varadaraju, R. Tamil Selvan, I. V. M. V. Enoch and P. Mosae Selvakumar, *ACS Omega*, 2018, **3**, 7985–7992.
- 86 C. Yi, W. Tian, B. Song, Y. Zheng, Z. Qi, Q. Qi and Y. Sun, *J. Lumin.*, 2013, **141**, 15–22.
- 87 V. Kumar, B. Sk, S. Kundu and A. Patra, *J. Mater. Chem. C*, 2018, **6**, 12086–12094.
- 88 E. U. Akkaya, M. E. Huston and A. W. Czarnik, *J. Am. Chem. Soc.*, 1990, **112**, 3590–3593.
- 89 F. Paquin, J. Rivnay, A. Salleo, N. Stingelin and C. Silva-Acuña, *J. Mater. Chem. C*, 2015, **3**, 10715–10722.
- 90 S. Doose, H. Neuweiler and M. Sauer, *ChemPhysChem*, 2009, **10**, 1389–1398.
- 91 A. Dhara, A. Jana, S. K. Mandal, A. R. Khuda-Bukhsh, N. Guchhait and S. K. Kar, *Inorg. Chim. Acta*, 2014, **423**, 454–461.
- 92 H. S. Kim, S. Angupillai and Y. A. Son, *Sens. Actuators, B*, 2016, **222**, 447–458.
- 93 S. S. Razi, R. Ali, R. C. Gupta, S. K. Dwivedi, G. Sharma, B. Koch and A. Misra, *J. Photochem. Photobiol., A*, 2016, **324**, 106–116.
- 94 S. Banerjee, P. Brandão and A. Saha, *RSC Adv.*, 2016, **6**, 101924–101936.



Multiple ion (Al^{3+} , Cr^{3+} , Fe^{3+} , and Cu^{2+}) sensing using a cell-compatible rhodamine-phenolphthalein-derived Schiff-base probe

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ABSTRACT

In this study, a novel rhodamine-phenolphthalein derivative (**RBPF**) was designed, synthesized, and characterized. **RBPF** exhibited the selective and sensitive colorimetric detection of Cu^{2+} and Fe^{3+} and fluorometric detection of Al^{3+} and Cr^{3+} , thus functioning as a multiple-channel probe in MeOH-H₂O ($v/v = 9/1$, 5 μM HEPES, pH 7.2) in the presence of other cations. A strong enhancement of the absorbance at around 555 nm was observed for the four mentioned cations. In contrast, in the presence of Al^{3+} and Cr^{3+} , emissions were intensified within the red region of the spectra (583 and 586 nm, respectively). The **RBPF** sensor was found to bind to the metal ions at a 1:2 stoichiometric ratio. The proposed mechanism for the observed sensing behavior is the opening of the spiroactam ring of the rhodamine core in the presence of the four mentioned metal ions. The detection limits for Cu^{2+} , Fe^{3+} , Al^{3+} , and Cr^{3+} were calculated to be 1.21 μM , 1.75 μM , 2.27 μM , and 1.29 μM , respectively. To test the practical use of the probe, TLC-based paper strips were fabricated. In addition, cell-imaging analysis of Al^{3+} and Cr^{3+} ions in the A549 cancer cell line produced promising concentration and time-dependent detection results.

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1. Introduction

Ions are required for the development, growth, and functioning of living systems [1,2], but the presence of high levels of non-biodegradable ions can have deleterious effects [3]. For example,

Abbreviations: P, Phenolphthalein; R, Rhodamine B; PF, Phenolphthalein-dialdehyde; RBPF, Phenolphthalein-rhodamine dye derivative; WHO, World Health Organization; CNS, Central Nervous System; TLC, Thin layer chromatography; PET, Photoinduced electron transfer; ESIP, Excited-state intramolecular proton transfer; HEPES, (4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid); LOD, Limit of detection; AIEE, Aggregation-induced emission enhancement; DFT, Density functional theory; TDDFT, Time-dependent density functional theory; EDTA, Ethylene diamine tetraacetic acid; TCSPC, Time-correlated single-photon counting; MTT, Methyl thiazolyltetrazolium; FBS, Fetal bovine serum; DMEM, Dulbecco's Modified Eagle's Medium.

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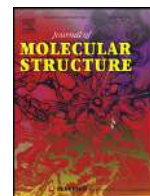
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when the ion balance in living cells is disturbed, the electrolytic equilibrium is disrupted, individual organs can be damaged, and essential enzymatic mechanisms are affected. Trivalent cations, including Al^{3+} , Cr^{3+} , and Fe^{3+} , and divalent Cu^{2+} have a particularly strong impact on the body [4-7]. Al^{3+} is a common pollutant of drinking water and at high levels is toxic to humans in the long term. Aluminum damages the central nervous system (CNS) and is known to cause Alzheimer's disease, Parkinson's disease, neurodegeneration, encephalopathy, and breast cancer [8,9]. In contrast, Fe^{3+} plays several crucial roles in processes such as cellular metabolism and enzyme catalysis, including electron transfer reactions [10,11]. Fe^{3+} also conjointly transports oxygen within all tissues via haemoprotein [12,13]. However, Al^{3+} and Fe^{3+} interact competitively, and iron-binding proteins can transfer Al^{3+} to the brain and other organs, while the dysregulation of Fe^{3+} contributes to Huntington's disease [14,15]. In addition, although Cr^{3+} deficiency is not biologically detrimental, it increases the risk of diabetes, cardiovascular disease, and malignancy [16-18], while Cr toxicity in

- [38] H.A. Benesi, J.H. Hildebrand, A spectrophotometric investigation of the interaction of iodine with aromatic hydrocarbons, *J. Am. Chem. Soc.* 71 (8) (1949) 2703–2707.
- [39] B. Das, M. Dolai, A. Dhara, S. Mabhai, A. Jana, S. Dey, A. Misra, Acetate ion augmented fluorescence sensing of Zn²⁺ by Salen-based probe, AIE character, and application for picric acid detection, *Anal. Sci. Adv.* 1 (2021) 1–21.
- [40] B. Das, A. Jana, A.D. Mahapatra, D. Chattopadhyay, A. Dhara, S. Mabhai, S. Dey, Fluorescein derived Schiff base as fluorimetric zinc (II) sensor via 'turn on' response and its application in live cell imaging, *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.* 212 (2019) 222–231.
- [41] S. Banthia, A. Samanta, A new strategy for ratiometric fluorescence detection of transition metal ions, *J. Phys. Chem. B.* 110 (13) (2006) 6437–6440.
- [42] J.R. Lakowicz (Ed.), *Principles of Fluorescence Spectroscopy*, 3rd., Springer US, Boston, MA, 2006.
- [43] R.G. Parr, W. Yang, Density-functional theory of the electronic structure of molecules, *Annu. Rev. Phys. Chem.* 46 (1) (1995) 701–728.
- [44] N.M. O'boyle, A.L. Tenderholt, K.M. Langner, cclib: a library for package-independent computational chemistry algorithms, *J. Comput. Chem.* 29 (2008) 839–845.
- [45] M.J. Frisch, G.W. Trucks, H.B. Schlegel, G.E. Scuseria, M.A. Robb, J.R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G.A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H.P. Hratchian, A.F. Izmaylov, J. Bloino, G. Zheng, J.L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J.A. Montgomery, Jr., J.E. Peralta, F. Ogliaro, M. Bearpark, J.J. Heyd, E. Brothers, K.N. Kudin, V.N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J.C. Burant, S.S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J.M. Millam, M. Klene, J.E. Knox, J.B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R.E. Stratmann, O. Yazyev, A.J. Austin, R. Cammi, C. Pomelli, J.W. Ochterski, R.L. Martin, K. Morokuma, V.G. Zakrzewski, G.A. Voth, P. Salvador, J.J. Dannenberg, S. Dapprich, A.D. Daniels, Ö. Farkas, J.B. Foresman, J.V. Ortiz, J. Cioslowski, D.J. Fox, *Gaussian 09* (Gaussian, Inc., Wallingford CT, 2009).
- [46] M. Cossi, G. Scalmani, N. Rega, V. Barone, New developments in the polarizable continuum model for quantum mechanical and classical calculations on molecules in solution, *J. Chem. Phys.* 117 (1) (2002) 43–54.
- [47] C. Lee, W. Yang, R.G. Parr, Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density, *Phys. Rev. B.* 37 (2) (1988) 785–789.
- [48] M. Cossi, N. Rega, G. Scalmani, V. Barone, Energies, structures, and electronic properties of molecules in solution with the C-PCM solvation model, *J. Comput. Chem.* 24 (6) (2003) 669–681.
- [49] S. Guria, A. Ghosh, P. Upadhyay, M.K. Das, T. Mishra, A. Adhikary, S. Adhikari, Small-molecule probe for sensing serum albumin with consequential self-assembly as a fluorescent organic nanoparticle for bioimaging and drug-delivery applications, *ACS Appl. Bio Mater.* 3 (5) (2020) 3099–3113.
- [50] S. Guria, A. Ghosh, K. Manna, A. Pal, A. Adhikary, S. Adhikari, Rapid detection of aspartic acid and glutamic acid in water by BODIPY-Based fluorescent probe: live-cell imaging and DFT studies, *Dye. Pigment.* 168 (2019) 111–122.
- [51] Y. Guo, F. Huo, C. Yin, J. Kang, J. Li, A highly selective and sensitive turn-on fluorescent probe for the detection of holmium ion and its bioimaging, *RSC Adv.* 5 (14) (2015) 10845–10848.
- [52] Y.-S. Zhang, R. Balamurugan, J.-C. Lin, S. Fitriyani, J.-H. Liu, A. Emelyanenko, Pd²⁺ fluorescent sensors based on amino and imino derivatives of rhodamine and improvement of water solubility by the formation of inclusion complexes with β -cyclodextrin, *Analyst* 142 (9) (2017) 1536–1544.
- [53] T.-T. Liu, J. Xu, C. Liu, S. Zeng, Z.-Y. Xing, X.-J. Sun, J.-L. Li, A novel dual-function probe for recognition and differentiation of Zn²⁺ and Al³⁺ and its application, *J. Mol. Liq.* 300 (2020) 112250.
- [54] B.Z. Tang, Y. Geng, J.W.Y. Lam, B. Li, X. Jing, X. Wang, F. Wang, A.B. Pakhomov, X.X. Zhang, Processible nanostructured materials with electrical conductivity and magnetic susceptibility: preparation and properties of maghemite/polyaniline nanocomposite films, *Chem. Mater.* 11 (1999) 1581–1589.
- [55] S. Kagitkar, D. Sunil, Aggregation-induced emission of azines: An up-to-date review, *J. Mol. Liq.* 292 (2019) 111371.
- [56] K. Li, Y.u. Xiang, X. Wang, J.i. Li, R. Hu, A. Tong, B.Z. Tang, Reversible photochromic system based on rhodamine B salicylaldehyde hydrazone metal complex, *J. Am. Chem. Soc.* 136 (4) (2014) 1643–1649.
- [57] V.V. Volchkov, V.L. Ivanov, B.M. Uzhinov, Induced intersystem crossing at the fluorescence quenching of laser dye 7-amino-1,3-naphthalenedisulfonic acid by paramagnetic metal ions, *J. Fluoresc.* 20 (1) (2010) 299–303.
- [58] S. Suganya, J.W. Namgoong, A.K. Mutyala, S. Velmathi, J.P. Kim, J.S. Park, A new perylene diimide with NH functionality as a colorimetric and fluorescent probe for the selective detection of trivalent Fe³⁺ and Al³⁺ ions, *J. Photochem. Photobiol. A Chem.* 344 (2017) 36–41.
- [59] S. Hou, Z. Qu, K. Zhong, Y. Bian, L. Tang, A new Rhodamine-based visual and fluorometric probe for selective detection of trivalent cations, *Tetrahedron Lett.* 57 (24) (2016) 2616–2619.
- [60] J. Sun, T. Li, Z. Yang, A novel fluorescent probe based on 7,8-benzochromone-3-carbaldehyde-(rhodamine B carbonyl) hydrazone for detection of trivalent cations and Zn²⁺ in different systems, *J. Photochem. Photobiol. A Chem.* 411 (2021) 113207.
- [61] R. Alam, R. Bhowmick, A.S.M. Islam, A. katarkar, K. Chaudhuri, M. Ali, A rhodamine based fluorescent trivalent sensor (Fe³⁺, Al³⁺, Cr³⁺) with potential applications for live cell imaging and combinational logic circuits and memory devices, *New J. Chem.* 41 (16) (2017) 8359–8369.
- [62] Y. Wang, C. Wang, S.u. Xue, Q. Liang, Z. Li, S. Xu, Highly selective and sensitive colorimetric and fluorescent chemosensor of Fe³⁺ and Cu²⁺ based on 2,3,3-trimethylnaphtho[1,2-d] squaraine, *RSC Adv.* 6 (8) (2016) 6540–6550.
- [63] A. Finelli, V. Chabert, N. Hérault, A. Crochet, C. Kim, K.M. Fromm, Sequential multiple-target sensor: In³⁺, Fe²⁺, and Fe³⁺ discrimination by an anthracene-based probe, *Inorg. Chem.* 58 (2019) 13796–13806.
- [64] X. Chen, T. Pradhan, F. Wang, J.S. Kim, J. Yoon, Fluorescent chemosensors based on spiroring-opening of xanthenes and related derivatives, *Chem. Rev.* 112 (3) (2012) 1910–1956.
- [65] S. Dey, S. Sarkar, D. Maity, P. Roy, Rhodamine based chemosensor for trivalent cations: synthesis, spectral properties, secondary complex as sensor for arsenate and molecular logic gates, *Sensors Actuators, B Chem.* 246 (2017) 518–534.
- [66] N. Kitamura, N. Sakata, H.-B. Kim, S. Habuchi, Energy gap dependence of the nonradiative decay rate constant of 1-anilino-8-naphthalene sulfonate in reverse micelles, *Anal. Sci.* 15 (5) (1999) 413–419.
- [67] M. Shyamal, P. Mazumdar, S. Maity, S. Samanta, G.P. Sahoo, A. Misra, Highly selective turn-on fluorogenic chemosensor for robust quantification of Zn(II) based on aggregation induced emission enhancement feature, *ACS Sensors* 1 (6) (2016) 739–747.
- [68] S. Mabhai, M. Dolai, S.K. Dey, A. Dhara, S.M. Choudhury, B. Das, S. Dey, A. Jana, D.R. Banerjee, A cell-compatible red light-emitting multianalyte chemosensor via three birds, one stone strategy, *J. Photochem. Photobiol. A Chem.* 404 (2021) 112889.



A cell-compatible phenolphthalein-aminophenol scaffold for Al³⁺ sensing assisted by CHEF phenomenon

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ABSTRACT

Monitoring of excess Al³⁺ and its selective detection in biological and environmental samples are important tasks for researcher due to its harmful effects. Herein, we present a phenolphthalein-aminophenol derived sensor (**PFAP**) for the selective fluorescent response of Al³⁺ in an "OFF-ON" mode over a pool of analytes including eighteen cations with striking greenish emission. It has a prominent limit of detection (LOD) value (1.5 μM), fast response time (10 s) for Al³⁺ detection. The complexation properties of **PFAP** with Al³⁺ ions were clarified by UV-vis, ¹H & ¹³C NMR, HRMS, and FTIR spectroscopic experiments. The recognition mechanism of **PFAP** for Al³⁺ working with chelation enhanced fluorescence (CHEF) and is verified with two model compounds **PF** and **PFAN** in the light of UV-vis, PL, TRPL, and NMR experiment. To check its applicability, easily prepared test paper and TLC strip of **PFAP** was produced for rapid and selective onsite detection of Al³⁺ ions. Bio-imaging application of **PFAP** in human lung cancer cell lines A549 demonstrated excellent results with negligible cytotoxicity and as an excellent marker to detect traces of Al³⁺ ion in a time-dependent as well as concentration-dependent manner. Actual sample analysis for Al³⁺ with the probe **PFAP** produces fruitful result.

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1. Introduction

The sensing and recognition of cationic analytes have attracted much attention due to their environmental and biological important role [1–3]. Aluminum is imperatively a significant ion which assumes to play essential role in biochemical processes [4]. It is regularly found in nature as silicate, hydroxide, sulfate, and cry-

olite. It has the biggest offer after iron on the planet's economy. However, high quantities of aluminum can generate a variety of biological and environmental issues [5]. Central nervous system, skeletal-muscle system, and hematopoietic framework may go through harmfulness with over exposure to aluminum [6]. Particularly, Alzheimer and Parkinson's dementia are the case of aluminum toxicity [5,7,8]. Aluminum-rich meals, foods stored in aluminum containers, drinking water, and pharmaceutical products are the most common dietary sources of aluminum. Potable water is one of the most major uses for aluminum [9]. According to the World Health Organization (WHO), aluminum compounds used in drinking water treatment should be used in moderation and should not surpass 0.2 ppm after treatment [10,11]. Accordingly, the foundation of new strategies for the fast, simple, and precise monitoring of Al³⁺ is profoundly significant for biological and ecological investigations.

Various methods such as titrimetry, voltammetry, chromatography, and electrochemistry have been developed for metal ions de-

LOD, Limit of detection; PET, Photoinduced electron transfer; CHEF, Chelation enhanced fluorescence; ESIP, Excited state intramolecular proton transfer; RET, Resonance energy transfer; ICT, Intermolecular charge transfer; AIE, Aggregation induced emission enhancement; WHO, World health organisation; HEPES, 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid; DFT, Density functional theory; TDDFT, Time-dependent density functional theory; TRPL, Time-resolved photoluminescence; TLC, Thin layer chromatography; BODIPY, 4,4-difluoro-4-bora-3a,4a-diaza-s-indacene.

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- [11] J. Lyons-Weiler, R. Ricketson, Reconsideration of the immunotherapeutic pediatric safe dose levels of aluminum, *J. Trace Elem. Med. Biol.* 48 (2018) 67–73.
- [12] F. Scholz, Voltammetric techniques of analysis: the essentials, *ChemTexts* 1 (2015) 17.
- [13] A. Shrivastava, J. Sharma, V. Soni, Various electroanalytical methods for the determination of uranium in different matrices, *Bull. Fac. Pharm. Cairo Univ.* 51 (2013) 113–129.
- [14] J. Docherty, S. Mabbott, W.E. Smith, J. Reglinski, K. Faulds, C. Davidson, D. Graham, Determination of metal ion concentrations by SERS using 2,2'-bipyridyl complexes, *Analyst* 140 (2015) 6538–6543.
- [15] M. Pesavento, G. Alberti, R. Biesuz, Analytical methods for determination of free metal ion concentration, labile species fraction and metal complexation capacity of environmental waters: a review, *Anal. Chim. Acta* 631 (2009) 129–141.
- [16] K.P. Carter, A.M. Young, A.E. Palmer, Fluorescent sensors for measuring metal ions in living systems, *Chem. Rev.* 114 (2014) 4564–4601.
- [17] I.I. Ebralidze, N.O. Laschuk, J. Poisson, O.V. Zenkina, Chapter 1 - colorimetric sensors and sensor arrays, in: *Micro and Nano Technologies*, Elsevier, 2019, pp. 1–39.
- [18] B. Liu, J. Zhuang, G. Wei, Recent advances in the design of colorimetric sensors for environmental monitoring, *Environ. Sci. Nano* 7 (2020) 2195–2213.
- [19] Z. Gryczynski, I. Gryczynski, J.R.B. TM, E. Lakowicz, in: *Fluorescence-sensing Methods, Biophotonics*, Part A, Academic Press, 2003, pp. 44–75.
- [20] S. Suganya, S. Naha, S. Velmathi, A critical review on colorimetric and fluorescent probes for the sensing of analytes via relay recognition from the year 2012–17, *ChemistrySelect* 3 (2018) 7231–7268.
- [21] Y. Tong, X. Jiao, H. Yang, Y. Wen, L. Su, X. Zhang, Reverse-bumpy-ball-type-nanoreactor-loaded nylon membranes as peroxidase-mimic membrane reactors for a colorimetric assay for H₂O₂, *Sensors* 16 (2016) 465.
- [22] A. Gupta, N. Kumar, A review of mechanisms for fluorescent “turn-on” probes to detect Al³⁺ ions, *RSC Adv.* 6 (2016) 106413–106434.
- [23] H.N. Kim, M.H. Lee, H.J. Kim, J.S. Kim, J. Yoon, A new trend in rhodamine-based chemosensors: application of spirolactam ring-opening to sensing ions, *Chem. Soc. Rev.* 37 (2008) 1465–1472.
- [24] P. Kaur, K. Singh, Recent advances in the application of BODIPY in bioimaging and chemosensing, *J. Mater. Chem. C* 7 (2019) 11361–11405.
- [25] A.N. Kursunlu, E. B. E. Guler, Importance of BODIPY-based chemosensors for cations and anions in Bio-imaging applications, *Curr. Anal. Chem.* 17 (2021) 1–13.
- [26] H. Lu, Z. Shen, Editorial: BODIPYs and their derivatives: the past, present and future, *Front. Chem.* 8 (2020) 290.
- [27] S. Kim, J.Y. Noh, K.Y. Kim, J.H. Kim, H.K. Kang, S.W. Nam, S.H. Kim, S. Park, C. Kim, J. Kim, Salicylimine-based fluorescent chemosensor for aluminum ions and application to bioimaging, *Inorg. Chem.* 51 (2012) 3597–3602.
- [28] D. Diamond, M.A. Mc Kervey, Calixarene-based sensing agents, *Chem. Soc. Rev.* 25 (1996) 15–24.
- [29] R. Ludwig, N.T. Dzung, Calixarene-based molecules for cation recognition, *Sensors* 2 (2002) 397–416.
- [30] Z. Kowser, U. Rayhan, T. Akther, C. Redshaw, T. Yamato, A brief review on novel pyrene based fluorometric and colorimetric chemosensors for the detection of Cu²⁺, *Mater. Chem. Front.* 5 (2021) 2173–2200.
- [31] X. Meng, S. Wang, M. Zhu, Quinoline-based fluorescence sensors, molecular photochemistry - various aspects, *Satyen Saha IntechOpen* (2012), doi:10.5772/31771.2012.
- [32] Y. Chen, T. Wei, Z. Zhang, T. Chen, J. Li, J. Qiang, J. Lv, F. Wang, X. Chen, A benzothiazole-based fluorescent probe for ratiometric detection of Al³⁺ in aqueous medium and living cells, *Ind. Eng. Chem. Res.* 56 (2017) 12267–12275.
- [33] C. Chang, F. Wang, T. Wei, X. Chen, Benzothiazole-based fluorescent sensor for ratiometric detection of Zn(II) ions and secondary sensing PPI and Its applications for biological imaging and PPase catalysis assays, *Ind. Eng. Chem. Res.* 56 (2017) 8797–8805.
- [34] B.K. Momidi, V. Tekuri, D.R. Trivedi, Selective detection of mercury ions using benzothiazole based colorimetric chemosensor, *Inorg. Chem. Commun.* 74 (2016) 1–5.
- [35] S. Das, M. Dutta, D. Das, Fluorescent probes for selective determination of trace level Al³⁺: recent developments and future prospects, *Anal. Methods* 5 (2013) 6262–6285.
- [36] O. Alici, D. Aydin, A Schiff-base receptor based on phenolphthalein derivate appended 2-furoic hydrazide: highly sensitive fluorogenic “turn on” chemosensor for Al³⁺, *J. Photochem. Photobiol. A Chem.* 404 (2021) 112876.
- [37] S. Erdemir, S. Malkondu, Dual-emissive fluorescent probe based on phenolphthalein appended diaminomaleonitrile for Al³⁺ and the colorimetric recognition of Cu²⁺, *Dye. Pigment.* 163 (2019) 330–336.
- [38] A. Gul, M. Oguz, A.N. Kursunlu, M. Yilmaz, A novel colorimetric/fluorometric dual-channel sensor based on phenolphthalein and Bodipy for Sn (II) and Al (III) ions in half-aqueous medium and its applications in bioimaging, *Dye. Pigment.* 176 (2020) 108221.
- [39] X. yu Kong, L.J. Hou, X. qing Shao, S.M. Shuang, Y. Wang, C. Dong, A phenolphthalein-based fluorescent probe for the sequential sensing of Al³⁺ and F⁻ ions in aqueous medium and live cells, *Spectrochim. Acta Part A Mol. Biomol. Spectrosc.* 208 (2019) 131–139.
- [40] D. Aydin, S. Dinckan, S.N. Karuk Elmas, T. Savran, F.N. Arslan, I. Yilmaz, A novel phenolphthalein-based fluorescent sensor for Al³⁺ sensing in drinking water and herbal tea samples, *Food Chem.* 337 (2021) 127659.
- [41] B. Das, M. Dolai, A. Dhara, A. Ghosh, S. Mabbai, A. Misra, S. Dey, A. Jana, Solvent-regulated fluorimetric differentiation of Al³⁺ and Zn²⁺ using an AIE-active single sensor, *J. Phys. Chem. A* 125 (2021) 1490–1504.
- [42] H.A. Benesi, J.H. Hildebrand, A spectrophotometric investigation of the interaction of iodine with aromatic hydrocarbons, *J. Am. Chem. Soc.* 71 (1949) 2703–2707.
- [43] B. Das, M. Dolai, A. Dhara, S. Mabbai, A. Jana, S. Dey, A. Misra, Acetate ion augmented fluorescence sensing of Zn²⁺ by Salen-based probe, AIE character, and application for picric acid detection, *Anal. Sci. Adv.* 2 (2021) 447–463.
- [44] G. Weber, F.W.J. Teale, Determination of the absolute quantum yield of fluorescent solutions, *Trans. Farad. Soc.* 53 (1957) 646–655.
- [45] J.B. Birks, Fluorescence quantum yield measurements, *J. Res. Natl. Bur. Stand. Sect. A Phys. Chem.* 80A (1976) 389–399.
- [46] V. Shcheslavskiy, P. Morozov, A. Divochiy, Y. Vakhtomin, K. Smirnov, W. Becker, Ultrafast time measurements by time-correlated single photon counting coupled with superconducting single photon detector, *Rev. Sci. Instrum.* 87 (2016) 53117.
- [47] J.R. Lakowicz, Principles of Fluorescence Spectroscopy, 3rd ed., Springer, Boston, MA, 2006.
- [48] M.Y. Berezin, S. Achilefu, Fluorescence lifetime measurements and biological imaging, in: *Chem. Rev.* 110, 2010, pp. 2641–2684.
- [49] V. Kumar, S. Schlücker, E. Hasselbrink, Chapter 16 - Ultrafast time-resolved molecular spectroscopy, in: V.P. Gupta, Y.B.T.-M. and L.S. Ozaki (Eds.), Elsevier, 2020: pp. 563–594.
- [50] R.G. Parr, Density-functional theory of atoms and molecules, *Horiz. Quantum Chem.* (1980) 5–15.
- [51] V. Barone, M. Cossi, Conductor solvent model, *J. Phys. Chem. A* 102 (2001) 1995–2001.
- [52] M. Cossi, N. Rega, G. Scalmani, V. Barone, Energies, structures, and electronic properties of molecules in solution with the C-PCM solvation model, *J. Comput. Chem.* 24 (2003) 669–681.
- [53] A.D. Becke, Density-functional thermochemistry. III. The role of exact exchange, *J. Chem. Phys.* 98 (1993) 5648–5652.
- [54] C. Lee, W. Yang, R.G. Parr, Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density, *Phys. Rev. B* 37 (1988) 785–789.
- [55] M.E. Casida, C. Jamorski, K.C. Casida, D.R. Salahub, Molecular excitation energies to high-lying bound states from time-dependent density-functional response theory: characterization and correction of the time-dependent local density approximation ionization threshold, *J. Chem. Phys.* 108 (1998) 4439–4449.
- [56] M.J. Frisch, G.W. Trucks, H.B. Schlegel, G.E. Scuseria, M.A. Robb, J.R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G.A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H.P. Hratchian, A.F. Izmaylov, J. Bloino, G. Zheng, J.L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J.A. Montgomery, J.E. Peralta, F. Ogliaro, M. Bearpark, J.J. Heyd, E. Brothers, K.N. Kudin, V.N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J.C. Burant, S.S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J.M. Millam, M. Klene, J.E. Knox, J.B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R.E. Stratmann, O. Yazyev, A.J. Austin, R. Cammi, C. Pomelli, J.W. Ochterski, R.L. Martin, K. Morokuma, V.G. Zakrzewski, G.A. Voth, P. Salvador, J.J. Dannenberg, S. Dapprich, A.D. Daniels, Ö. Farkas, J.B. Foresman, J.V. Ortiz, J. Cioslowski, D.J. Fox, Gaussian 09, Revision D.01, Gaussian Inc, Wallingford CT, 2009.
- [57] N.M. O'boyle, A.L. Tenderholt, K.M. Langner, CHARMM: the biomolecular simulation program B, *J. Comput. Chem.* 29 (2008) 839–845.
- [58] S. Guria, A. Ghosh, K. Manna, A. Pal, A. Adhikary, S. Adhikari, Rapid detection of aspartic acid and glutamic acid in water by BODIPY-based fluorescent probe: live-cell imaging and DFT studies, *Dye. Pigment.* 168 (2019) 111–122.
- [59] S. Guria, A. Ghosh, P. Upadhyay, M. kumar Das, T. Mishra, A. Adhikary, S. Adhikari, Small-molecule probe for sensing serum albumin with consequential self-assembly as a fluorescent organic nanoparticle for bioimaging and drug-delivery applications, *ACS Appl. Bio Mater.* 3 (2020) 3099–3113.
- [60] Y. Guo, F. Huo, C. Yin, J. Kang, J. Li, A highly selective and sensitive turn-on fluorescent probe for the detection of holmium ion and its bioimaging, *RSC Adv.* 5 (2015) 10845–10848.
- [61] X. Hu, C. Li, X. Song, D. Zhang, Y. Li, A new Cu²⁺-selective self-assembled fluorescent chemosensor based on thiocalix[4]arene, *Inorg. Chem. Commun.* 14 (2011) 1632–1635.
- [62] A. Kumar, V. Kumar, K.K. Upadhyay, An Al³⁺ and H₂PO₄⁻/HSO₄⁻ selective conformational arrest and bail to a pyrimidine-naphthalene anchored molecular switch, *Analyst* 138 (2013) 1891–1897.
- [63] B. Sen, M. Mukherjee, S. Banerjee, S. Pal, P. Chattopadhyay, A rhodamine-based ‘turn-on’ Al³⁺ ion-selective reporter and the resultant complex as a secondary sensor for F⁻ ion are applicable to living cell staining, *Dalton Trans.* 44 (2015) 8708–8717.
- [64] D. Zhang, J.R. Cochrane, A. Martinez, G. Gao, Recent advances in H₂PO₄⁻ fluorescent sensors, *RSC Adv.* 4 (2014) 29735–29749.



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Combined theoretical and experimental investigation of a DNA interactive poly-hydroxyl enamine tautomer exhibiting “turn on” sensing for Zn²⁺ in pseudo-aqueous medium†‡

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Crystallographically established (solid state structure at 150 K temperature) enamine ligand 2-((1,3-dihydroxy-2-(hydroxymethyl)propan-2-ylamino)methyl)-4-bromo-6-methoxyphenol (**H₄L**) was prepared, which showed interconvertible equilibrium ($\Delta E = 7.37$ kcal) of its tautomers and also found to exhibit DNA binding activity at the minor groove of double-stranded (ds) DNA. Spectroscopic and calorimetric methods were employed to explore the interaction of **H₄L** with DNA. Further, the competitive Hoechst 33258 displacement assay indicated the specific binding site of **H₄L** to be at the minor grooves of DNA. Thermodynamic evaluation from isothermal titration calorimetry (ITC) experiments suggested the association of **H₄L** with DNA to be an enthalpy driven process with an equilibrium binding affinity (K) of $(2.50 \pm 0.11) \times 10^4$ M⁻¹. Molecular docking studies were found to be in good agreement with the experimental results of the DNA interaction of the probe in groove binding mode. The poor emission of **H₄L** in the excited state was due to excited state induced proton transfer (ESIPT), but in the presence of Zn²⁺, the ESIPT was blocked and chelation-enhanced fluorescence (CHEF) was initiated to exhibit ‘turn on’ fluorescence upon the coordination of Zn²⁺. The **H₄L** probe was found to detect Zn²⁺ selectively among various metal ions and the LOD was calculated to be ~ 1.13 μ M. The coordination of the Zn(II) bound complex and the relative stability of the tautomers of **H₄L** were investigated in detail via spectroscopic and computational studies.

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Introduction

As a well-established phenomenon, the Schiff bases prepared from salicylaldehydes and aromatic/aliphatic amines exist in different tautomeric forms, *i.e.*, (i) enamine or keto tautomer¹ (ii) imine or enol² and (iii) zwitterionic forms.³ However, it is very difficult to consider the particular structures of Schiff base adducts where they may exist in the enamine form in the solid state and convert to the imine form in the solution state, although the complication in assessing tautomeric structures can be removed by knowing the exact structures of the compounds. Many research studies have involved determining the structures of the same compounds in recent years using ¹⁵N and ¹³C solid-state nuclear magnetic resonance (NMR) spectroscopy.⁴ However, the phase-to-phase inter-conversion of structures is so rapid that it cannot be unequivocally determined in this way. Moreover, single-crystal X-ray structures can give an accurate solution to the puzzling problems in the solid state. Again, there is a possibility of the temperature-dependent interconversion of tautomers in the solid state, known as thermochromism,⁵ which adds some extra complications in perfectly assigning structures in this context.

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† Dedicated to Professor Ashutosh Ghosh, University of Calcutta on the Occasion of his 62nd birthday.

‡ Electronic supplementary information (ESI) available: The supporting Information includes further synthetic details, experimental details including DFT calculations and information concerning X-ray structure analysis, ¹H-NMR spectra, IR spectra and other physical properties studies. CCDC 2092531. For ESI and crystallographic data in CIF or other electronic format see DOI: 10.1039/d1nj03510j

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- 7 F. Anam, A. Abbas, K. M. Lo, H. S. Zia-ur-Rehman and M. M. Naseer, *New J. Chem.*, 2014, **38**, 5617–5625.
- 8 C. Bargossi, M. C. Fiorini, M. Montalti, L. Prodi and N. Zaccheroni, *Coord. Chem. Rev.*, 2000, **208**, 17–32.
- 9 L. Prodi, F. Bolletta, M. Montalti and N. Zaccheroni, *Coord. Chem. Rev.*, 2000, **205**, 59–83.
- 10 B. Valeur and I. Leray, *Coord. Chem. Rev.*, 2000, **205**, 3–40.
- 11 J. Wu, W. Liu, J. Ge, H. Zhang and P. Wang, *Chem. Soc. Rev.*, 2011, **40**, 3483–3495.
- 12 D. Wu, A. C. Sedgwick, T. Gunnlaugsson, E. U. Akkaya, J. Yoon and T. D. James, *Chem. Soc. Rev.*, 2017, **46**, 7105–7123.
- 13 J. P. Desvergne and A. W. Castle in Springer Science & Business Media, *ACS Symposium Series*, American Chemical Society; p. 2012.
- 14 J. Anastassopoulou, T. T. (1995), NATO ASI Series (Series C: Mathematical and Physical Sciences), vol 459, Springer, Dordrecht.
- 15 N. Kaznina, N. Dubovets, Y. Batova, A. Ignatenko, O. Orlovskaya and N. Repkina, *Agronomy*, 2021, **11**(6), 1057.
- 16 C. M. Borkert, F. R. Cox and M. R. Tucker, *Commun. Soil Sci. Plant Anal.*, 1998, **29**, 2991–3005.
- 17 M. J. Jackson and N. M. Lowe, *Food Chem.*, 1992, **43**, 233–238.
- 18 R. Bartzatt, *Eur. J. Nutr. Food Saf.*, 2017, **7**, 155–160.
- 19 L. Marger, C. R. Schubert and D. Bertrand, *Biochem. Pharmacol.*, 2014, **91**, 426–435.
- 20 E. Mocchegiani, J. Romeo, M. Malavolta, L. Costarelli, R. Giacconi, L.-E. Diaz and A. Marcos, *Age*, 2013, **35**, 839–860.
- 21 M. J. Jackson and N. M. Lowe, *Food Chem.*, 1992, **43**, 233–238.
- 22 T. Fukada, S. Yamasaki, K. Nishida, M. Murakami and T. Hirano, *J. Biol. Inorg. Chem.*, 2011, **16**, 1123–1134.
- 23 W. J. Bettger and B. L. O'Dell, *Life Sci.*, 1981, **28**, 1425–1438.
- 24 L. M. Plum, L. Rink and H. Haase, *Int. J. Environ. Res. Public Health*, 2010, **7**(4), 1342–1365.
- 25 A. S. Prasad, *Fed. Proc.*, 1984, **43**, 2829–2834.
- 26 A. S. Prasad, *J. Am. Coll. Nutr.*, 1996, **15**, 113–120.
- 27 M. Dolai, U. Saha, A. K. Das and G. Suresh Kumar, *Anal. Methods*, 2018, **10**, 4063–4072.
- 28 Y. M. Chumakov, V. I. Tzapkov, G. Bocelli, B. Y. Antosyak and A. P. Gulya, *J. Struct. Chem.*, 2006, **47**, 346–351.
- 29 Z. Cungen, Z. Peizi, W. Dan and Y. Kaibei, *J. Chem. Res.*, 2000, **2000**, 402–403.
- 30 H. Y. Odabaşoğlu, O. Büyükgüngör, O. O. Avinç and M. Odabaşoğlu, *Acta Crystallogr., Sect. C: Cryst. Struct. Commun.*, 2003, **59**, 616–619.
- 31 Y. M. Chumakov, B. Y. Antosyak, M. D. Mazus, V. I. Tsapkov and N. M. Samus, *Crystallogr. Rep.*, 2000, **45**, 945–950.
- 32 M. Odabasoglu, V. I. Tsapkov, G. Bocelli, B. Y. Antosyak and A. P. Gulya, *J. Mol. Struct.*, 2007, **840**, 71–89.
- 33 A. Gómez, P. Borrachero and J. Bellanato, *Carbohydr. Res.*, 1984, **135**, 101–116.
- 34 U. Saha, A. Y. Khan, S. Bhuiya, S. Das, G. Fiorillo, P. Lombardi and G. Suresh Kumar, *J. Biomol. Struct. Dyn.*, 2019, **37**, 1375–1389.
- 35 U. Saha, S. Chatterjee, M. Dolai and G. Suresh Kumar, *ACS Appl. Bio Mater.*, 2020, **3**, 7810–7820.
- 36 M. Dolai, U. Saha, G. Suresh Kumar and M. Ali, *Chemistry-Select*, 2018, **3**, 6935–6941.
- 37 U. Saha, M. Dolai and G. Suresh Kumar, *J. Mol. Struct.*, 2020, **1220**, 128690.
- 38 H. A. Benesi and J. H. Hildebrand, *J. Am. Chem. Soc.*, 1949, **71**, 2703–2707.
- 39 P. E. Pjura, K. Grzeskowiak and R. E. Dickerson, *J. Mol. Biol.*, 1987, **197**, 257–271.
- 40 U. Saha, B. Das, M. Dolai, R. J. Butcher and G. Suresh Kumar, *ACS Omega*, 2020, **5**, 18411–18423.
- 41 A. Y. Khan, U. Saha, G. Fiorillo, P. Lombardi and G. Suresh Kumar, *J. Therm. Anal. Calorim.*, 2018, **132**, 623–630.
- 42 U. Saha, M. Dolai, G. Suresh Kumar, R. J. Butcher and S. Konar, *J. Chem. Eng. Data*, 2020, **65**, 5393–5404.
- 43 U. Saha, M. Dolai and G. Suresh Kumar, *New J. Chem.*, 2019, **43**, 8982–8992.
- 44 Z. Zhao, J. Zhang, S. Zhi, W. Song and J. Zhao, *J. Inorg. Biochem.*, 2019, **197**, 110696.
- 45 M. Dolai, U. Saha, S. Biswas, S. Chatterjee and G. Suresh Kumar, *CrystEngComm*, 2020, **22**, 8374–8386.
- 46 A. Jana, B. Das, S. K. Mandal, S. Mabhai, A. R. Khuda-Bukhsh and S. Dey, *New J. Chem.*, 2016, **40**, 5976–5984.
- 47 S. Mabhai, M. Dolai, S. K. Dey, A. Dhara, S. M. Choudhury, B. Das, S. Dey and A. Jana, *Spectrochim. Acta, Part A*, 2019, **219**, 319–332.
- 48 B. Das, A. Jana, A. Mahapatra, D. Chattopadhyay, A. Dhara, S. Mabhai and S. K. Dey, *Spectrochim. Acta, Part A*, 2019, **212**, 222–231.
- 49 B. Das, S. Dey, G. P. Maiti, A. Bhattacharjee, A. Dhara and A. Jana, *New J. Chem.*, 2018, **42**, 9424–9435.
- 50 M. Shahid and A. Misra, *J. Photochem. Photobiol., A*, 2017, **335**, 190–199.

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A bio-compatible pyridine–pyrazole hydrazide based compartmental receptor for Al³⁺ sensing and its application in cell imaging†

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For practical applications, the development of bio-compatible organic molecules as p-block ion chemosensors is critical. Herein, we report the single crystal (SC) of new pyridine–pyrazole derived Al³⁺ sensor H₂PPC [(Z)-N'-(2,3-dihydroxybenzylidene)-5-methyl-1-(pyridin-2-yl)-1H-pyrazole-3-carbohydrazide] as well as its Cu-complex SC. The probe exhibits an “off–on” fluorescence response towards Al³⁺ ions, and this has been modulated with different solvents. For selective detection of Al³⁺ ions, a special coordination pocket in the structural backbone is advantageous. The chemosensor exhibits a submicromolar detection level (LOD = 4.78 μM) for Al³⁺. The density functional theory (DFT) and time-dependent DFT (TD-DFT) calculations of H₂PPC and [Al(HPP)₂]⁺ (**1**) reveal that a change of the structural conformation of probe H₂PPC upon complexation causes the pyrazole and pyridine units to create a specific cavity to tether Al³⁺, and consequently H₂PPC proves to be a promising molecule for Al³⁺ detection. Furthermore, the probe has been successfully used to evaluate Al³⁺ as a low-cost kit using filter paper strips, and the *in situ* Al³⁺ ion imaging in Vero cells as well as A549 cell lines shows the sensor's nuclear envelope penetrability, indicating that it has great potential for biological and environmental applications.

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1. Introduction

Aluminum compounds are used in various items, including household appliances, construction materials, transportation systems, and communication, and advanced medical devices.¹ Aluminum has a high level of exposure due to its widespread

use in everyday life. Aluminum is well-known to be highly harmful to human health as well as the plant kingdom.^{2,3} Because of the possible connection to the brain, doctors refer to Al³⁺ as the “silent killer” in the human body. Dementia, myopathy, Alzheimer's disease, and Parkinson's disease are all neurodegenerative disorders caused by it.^{4–8} Overexposure to aluminum dust has a detrimental effect on dialysis encephalopathy, lung functions, tumors, cough, and asthma in industry staff.⁹ Due to aluminum toxicity, studies on aluminum (Al³⁺) detection are crucial for controlling its concentration levels in the biosphere and have attracted more attention from researchers. In this context, sensitive and dependable fluorescent molecular sensors appear to be the most appropriate tool, as they have advantages in terms of selectivity, sensitivity, response time, and cost, and thus have piqued the interest of chemists.^{10–12} The non-transition metal ion Al³⁺ lacks spectroscopic characteristics because it lacks d electrons. As a result, the d–d electronic transition for colorful, complex generation is an ambiguous way to detect Al³⁺ ions with the naked eye. Instead, an alternative route involving appropriate ligand design that results in a successful LMCT (ligand–metal charge transfer) will solve the problem. To fit the coordination preferences of the metal ion, suitable donor atoms should be positioned at strategic positions in the ligand cavity. It should be noted that, in comparison to other transition metal ions, Al³⁺

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- 14 D. Maity and T. Govindaraju, *Inorg. Chem.*, 2010, **49**, 7229–7231.
- 15 D. Maity and T. Govindaraju, *Chem. Commun.*, 2010, **46**, 4499–4501.
- 16 D. Maity and T. Govindaraju, *Eur. J. Inorg. Chem.*, 2011, **2011**, 5479–5485.
- 17 D. Maity and T. Govindaraju, *Chem. Commun.*, 2012, **48**, 1039–1041.
- 18 A. Ansari, A. Ali, M. Asif and Shamsuzzaman, *New J. Chem.*, 2016, **41**, 16–41.
- 19 K. Karrouchi, S. Radi, Y. Ramli, J. Taoufik, Y. N. Mabkhot, F. A. Al-Aizari and M. Ansar, *Molecules*, 2018, **23**, 134.
- 20 A. W. Brown, *Recent Developments in the Chemistry of Pyrazoles*, Elsevier Inc., 1st edn, 2018, vol. 126.
- 21 R. Mukherjee, *Coord. Chem. Rev.*, 2000, **203**, 151–218.
- 22 A. Rajput and R. Mukherjee, *Coord. Chem. Rev.*, 2013, **257**, 350–368.
- 23 A. M. Abu-Dief and I. M. A. Mohamed, *Beni-Suef Univ. J. Basic Appl. Sci.*, 2015, **4**, 119–133.
- 24 W. Qin, S. Long, M. Panunzio and S. Biondi, *Molecules*, 2013, **18**, 12264–12289.
- 25 A. Kajal, S. Bala, S. Kamboj, N. Sharma and V. Saini, *J. Catal.*, 2013, **2013**, 1–14.
- 26 U. Pischel and J. Andreasson, *Chem. Soc. Rev.*, 2015, **44**, 1053–1069.
- 27 T. Gunnlaugsson, D. a. Mac Dónail and D. Parker, *Chem. Commun.*, 2000, 93–94.
- 28 A. P. de Silva, I. M. Dixon, H. Q. Nimal Gunaratne, T. Gunnlaugsson, Pamela R. S. Maxwell and T. E. Rice, *J. Am. Chem. Soc.*, 1999, **121**(6), 1393–1394.
- 29 A. P. de Silva and N. D. McClenaghan, *Chem.–Eur. J.*, 2004, **10**, 574–586.
- 30 N. Adhikari and N. Saha, *J. Chem. Res.*, 2006, 645–648.
- 31 SMART (V 5.628), SAINT (V 6.45a), XPREP, SHELXTL, Bruker AXS Inc., Madison, WI, 2004.
- 32 G. M. Sheldrick, *Acta Crystallogr., Sect. C: Struct. Chem.*, 2015, **71**, 3–8.
- 33 B. Das, A. Jana, A. Das Mahapatra, D. Chattopadhyay, A. Dhara, S. Mabhai and S. Dey, *Spectrochim. Acta, Part A*, 2019, **212**, 222–231.
- 34 J. R. Lakowicz, *Principles of Fluorescence Spectroscopy*, Plenum, New York, 1999.
- 35 S. Banthia and A. Samanta, *J. Phys. Chem. B*, 2006, **110**, 6437–6440.
- 36 B. Ramachandram and A. Samanta, *J. Phys. Chem. A*, 1998, **102**, 10579–10587.
- 37 R. G. Parr, *Horizons Quantum Chem.*, 1980, pp. 5–15.
- 38 V. Barone and M. Cossi, *J. Phys. Chem. A*, 2001, **102**, 1995–2001.
- 39 M. Cossi, N. Rega, G. Scalmani and V. Barone, *J. Comput. Chem.*, 2003, **24**, 669–681.
- 40 A. D. Becke, *J. Chem. Phys.*, 1993, **98**, 5648–5652.
- 41 C. Lee, W. Yang and R. G. Parr, *Phys. Rev. B: Condens. Matter Mater. Phys.*, 1988, **37**, 785–789.
- 42 R. E. Stratmann, G. E. Scuseria and M. J. Frisch, *J. Chem. Phys.*, 1998, **109**, 8218–8224.
- 43 R. Bauernschmitt and R. Ahlrichs, *Chem. Phys. Lett.*, 1996, **256**, 454–464.
- 44 M. E. Casida, C. Jamorski, K. C. Casida and D. R. Salahub, *J. Chem. Phys.*, 1998, **108**, 4439–4449.
- 45 M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov, J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A. Montgomery Jr, J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J. Dannenberg, S. Dapprich, A. D. Daniels, Ö. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski and D. J. Fox, *Gaussian Inc.*, 2009, Wallingford CT.
- 46 A. L. Tenderholt, K. M. Langner and N. M. O'Boyle, *J. Comput. Chem.*, 2008, **29**, 839–845.
- 47 S. Guria, A. Ghosh, K. Manna, A. Pal, A. Adhikary and S. Adhikari, *Dyes Pigm.*, 2019, **168**, 111–122.
- 48 P. Bag, D. Chattopadhyay, H. Mukherjee, D. Ojha, N. Mandal, M. C. Sarkar, T. Chatterjee, G. Das and S. Chakraborti, *Virol J.*, 2012, **9**, 1–12.
- 49 R. Purkait, C. Patra, A. Das and D. Chattopadhyay, *Sens. Actuators, B*, 2017, **257**, 545–552.
- 50 S. Guria, A. Ghosh, P. Upadhyay, M. K. Das, T. Mishra, A. Adhikary and S. Adhikari, *ACS Appl. Bio Mater.*, 2020, **3**, 3099–3113.
- 51 M. Dolai, U. Saha, A. K. Das and G. Suresh Kumar, *Anal. Methods*, 2018, **10**, 4063–4072.
- 52 U. Saha, M. Dolai and G. Suresh Kumar, *New J. Chem.*, 2019, **43**, 8982–8992.
- 53 E. R. Nightingale, *J. Phys. Chem.*, 1959, **63**, 1381–1387.
- 54 T. M. Goodman, *Colour Design: Theories and Applications*, Woodhead Publishing, 2nd edn, 2012, pp. 417–452.
- 55 A. Dhara, N. Guchhait, I. Mukherjee, A. Mukherjee and S. Chandra Bhattacharya, *RSC Adv.*, 2016, **6**, 105930–105939.
- 56 B. Das, S. Dey, G. P. Maiti, A. Bhattacharjee, A. Dhara and A. Jana, *New J. Chem.*, 2018, **42**, 9424–9435.
- 57 M. Andrade, C. Sousa, J. E. Borges and C. Freire, *J. Phys. Org. Chem.*, 2005, **18**, 935–940.
- 58 H. Amiri Rudbari, M. R. Iravani, V. Moazam, B. Askari, M. Khorshidifard, N. Habibi and G. Bruno, *J. Mol. Struct.*, 2016, **1125**, 113–120.
- 59 S. Dutta Gupta, B. Revathi, G. I. Mazaira, M. D. Galigniana, C. V. S. Subrahmanyam, N. L. Gowrishankar and N. M. Raghavendra, *Bioorg. Chem.*, 2015, **59**, 97–105.
- 60 S. Tamburini, P. Tomasin, P. A. Vigato, A. Casnati and L. Domiano, *Inorg. Chim. Acta*, 1997, **254**, 209–212.

AgriStick: An IoT-Enabled Agricultural Appliance to Measure Growth of Jackfruit Using 2-Axis JoyStick

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In the field of agriculture, growth monitoring and measurement are two important factors used specifically to evaluate the influence of the environmental conditions on productivity. The change of circumference of parts of plants like their trunks, branches and fruits is one way to monitor plant growth. In this paper, we developed an Internet of Things (IoT)-based growth measurement and monitoring system using a 2-Axis joystick. In the case study, we measured the growth of Jackfruit which is a tropical fruit and widely cultivated in tropical areas like India, Bangladesh, Thailand, Brazil, and Malaysia. The developed appliance is referred to as *AgriStick*. The IoT appliance utilizes a 16-bit ultra-low power consuming microcontroller. We used RS485 protocol to make our appliance work for long distance range. The sensor was utilized for the purpose of monitoring the growth of horticulture crops as well as natural ecosystem plants.

Measuring Agricultural Indicators

Real-time information collection and analysis are essential in recent agricultural systems to properly use fertilizer, pesticide, water, etc. The growth rate monitoring or growth measurement is a significant attribute of the horticulture and regular ecosystem. The crop growth depends on various factors like environmental and physiological conditions and a plant's genetic endowment. The growth monitoring is significant for timely harvesting of crops for better yield, from the economical perspective of the farmers. We generally use the radius-wise growth of stems or tree branches as pointers of the vigor of a plant, while the growth of fruit gives us an essential functional factor in gardening production. Usually, in growth measurement, strain gauges and Linear Variable Differential Transformers (LVDT) are used [1]. Though the LVDT-based systems are more expensive than the strain gauge-based systems, the former provide information with better accuracy and resolution.

The storage of growth-related information is also vital for analysis. In [2], multispectral images were collected for higher output phenotyping of tomato spot wither disease confrontation among 20 peanut genotypes. For growth measurement of

tree parts and fruits, there are tools like dendrometers [3], [4]. Though they offer benefits such as temperature compensation and fine resolution, there are few disadvantages such as cost, large size, and additional support required for the sensors, and recalibration of the sensor when moved from one tree to another. The disadvantages led to the development of an alternative sensor which is an optoelectronic sensor-based measurement tool [5]. Practically, this appliance is cost-effective and has proven as an alternative solution for growth measurement. Our research is based on the development of an IoT-based appliance that can perform the monitoring and measurement in an adjusting manner for both remote places and test areas using the Internet.

The authors in [6] have highlighted the use of IoT in smart precision agriculture and farming. The researchers have proposed in [7], an IoT device for monitoring fruit growth. In [8], the authors have discussed the application of Radio Frequency Identification sensing technology in environmental monitoring, soil monitoring, plant growth monitoring, and harvest quality monitoring. The use of IoT in growth monitoring has several advantages, such as the surveillance is continuous even in real-time, and the data fetched through the sensor node can be stored in the cloud for future use. Growth monitoring of crops is a significant area of research interest in the field of smart agriculture. In [9], the authors have developed a system to monitor the growth of apple plantations. In that work, the authors have used a deep learning-based edge network, and performed the remote estimation of apple size during the entire growth period.

The existing growth measurement systems [1], [5] used the mouse or sensor as the sensing unit, Bluetooth as the communication protocol, and stored the collected data inside the SD card. However, there are two major issues: Bluetooth provides short-distance communication, and the SD card is not able to contain a huge volume of data. To deal with these challenges, a system is required that will be able to provide comparatively long-distance communication, and can store high volume of data for further analysis. In this paper, we propose an IoT-based growth measurement system named as *AgriStick*, that

the cloud. This will help to reduce the network traffic and storage overhead of the cloud. Blockchain plays an important role in agriculture and food supply chain management [12] and is especially for security purposes. In our system, we also could use blockchain for security purposes and in crop supply chain management. Therefore, the use of blockchain is another future research scope of AgriStick.

Conclusions

We developed the Internet of Growth Measuring Things AgriStick using a 2-Axis joystick and used it to measure and monitor the growth of Jackfruit. We installed the developed sensor node in the field for 24 days, during which time, the sensor node showed good performance, indicated with high accuracy of ~99%, with low power consumption and battery life of approximately two months. We use this IoT appliance for monitoring and measurement of the radial growth of plants in the agricultural industry. The system will give a new dimension to the modern-day IoT-based precision agriculture. The developed system will help to understand the right time to harvest the fruit from the tree, depending upon the radial growth data analysis.

References

- [1] S. Das, S. Nayak, B. Chakraborty and S. Mitra, "Continuous radial growth rate monitoring of horticultural crops using an optical mouse," *Sensors and Actuators A: Physical*, vol. 297, 2019.
- [2] A. Patrick, S. Pelham, A. Culbreath, C. C. Holbrook, I. J. De Godoy and C. Li, "High throughput phenotyping of tomato spot wilt disease in peanuts using unmanned aerial systems and multispectral imaging," *IEEE Instrum. Meas. Mag.*, vol. 20, no. 3, pp. 4–12, 2017.
- [3] D. M. Drew and G. M. Downes, "The use of precision dendrometers in research on daily stem size and wood property variation: a review," *Dendrochronologia*, vol. 27, no. 2, pp. 159–172, 2009.
- [4] D. Sheil, "Growth assessment in tropical trees: large daily diameter fluctuations and their concealment by dendrometer bands," *Canadian J. Forest Res.*, vol. 33, no. 10, pp. 2027–2035, 2003.
- [5] M. Thalheimer, "A new optoelectronic sensor for monitoring fruit or stem radial growth," *Computers and Electronics in Agriculture*, vol. 123, pp. 149–153, 2016.
- [6] N. Ahmed, D. De and I. Hussain, "Internet of Things (IoT) for smart precision agriculture and farming in rural areas," *IEEE Internet of Things J.*, vol. 5, no. 6, pp. 4890–4899, Dec. 2018.
- [7] A. Sengupta, A. Mukherjee, A. Das and D. De, "GrowFruit: an IoT based radial growth rate monitoring device for fruit," *IEEE Consumer Electronics Mag.*, 2021.
- [8] R. Rayhana, G. Xiao and Z. Liu, "RFID sensing technologies for smart agriculture," *IEEE Instrum. Meas. Mag.*, vol. 24, no. 3, pp. 50–60, 2021.
- [9] D. Wang, C. Li, H. Song, H. Xiong, C. Liu and D. He, "Deep learning approach for apple edge detection to remotely monitor apple growth in orchards," *IEEE Access*, vol. 8, pp. 26911–26925, 2020.
- [10] M. Bor, J. E. Vidler and U. Roedig, "LoRa for the Internet of Things," pp. 361–366, 2016.
- [11] M. J. O'Grady, D. Langton and G. M. P. O'Hare, "Edge computing: a tractable model for smart agriculture?" *Artificial Intell. Agriculture*, vol. 3, pp. 42–51, 2019.
- [12] A. Kamilaris, A. Fonts and F. X. Prenafeta-Boldú, "The rise of blockchain technology in agriculture and food supply chains," *Trends in Food Science Technol.*, vol. 91, pp. 640–652, 2019.

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STROVE: spatial data infrastructure enabled cloud–fog–edge computing framework for combating COVID-19 pandemic

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Abstract

The outbreak of 2019 novel coronavirus (COVID-19) has triggered unprecedented challenges and put the whole world in a parlous condition. The impacts of COVID-19 is a matter of grave concern in terms of fatality rate, socio-economical condition, health infrastructure. It is obvious that only pharmaceutical solutions (vaccine) cannot eradicate this pandemic completely, and effective strategies regarding lockdown measures, restricted mobility, emergency services to users—in brief data-driven decision system is of utmost importance. This necessitates an efficient data analytics framework, data infrastructure to store, manage pandemic related information, and distributed computing platform to support such data-driven operations. In the past few decades, Internet of Things-based devices and applications have emerged significantly in various sectors including healthcare and time-critical applications. To be specific, health-sensors help to accumulate health-related parameters at different time-instances of a day, the movement sensors keep track of mobility traces of the user, and helps to assist them in varied conditions. The smartphones are equipped with several such sensors and the ability of low-cost connected sensors to cover large areas makes it the most useful component to combat pandemics such as COVID-19. However, analysing and managing the huge amount of data generated by these sensors is a big challenge. In this paper we have proposed a unified framework which has three major components: (i) Spatial Data Infrastructure to manage, store, analyse and share spatio-temporal information with stakeholders efficiently, (ii) Cloud–Fog–Edge-based hierarchical architecture to support preliminary diagnosis, monitoring patients' mobility, health parameters and activities while they are in quarantine or home-based treatment, and (iii) Assisting users in varied emergency situation leveraging efficient data-driven techniques at low-latency and energy consumption. The mobility data analytics along with SDI is required to interpret the movement dynamics of the region and correlate with COVID-19 hotspots. Further, Cloud–Fog–Edge-based system architecture is required to provision healthcare services efficiently and in timely manner. The proposed framework yields encouraging results in taking decisions based on the COVID-19 context and assisting users effectively by enhancing accuracy of detecting suspected infected people by $\sim 24\%$ and reducing delay by $\sim 55\%$ compared to cloud-only system.

Keywords Health service provisioning · Health data analysis · Cloud–Fog–Edge framework · COVID-19

1 Introduction

The widespread of infectious coronavirus disease (COVID-19) due to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus has affected more than 150 million people (positive case) and resulting over 35,00,000 deaths all over the world (as of last week of May, 2021). This pandemic has brought substantial changes in all aspects of our lifestyle. The healthcare sector of all countries were significantly affected and several strategies such as restricted mobility, isolating regions, lockdown measures have been adapted. All though these measures have reduced the spread of the disease, however, there is a great impact on socio-

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36. Ghosh S, Ghosh SK (2019) Traj-cloud: a trajectory cloud for enabling efficient mobility services. In: 2019 11th International conference on communication systems and networks (COM-SNETS) 2019. IEEE, pp 765–770
37. Ghosh S, Mukherjee A, Ghosh SK, Buyya R (2019) Mobi-iost: mobility-aware cloud–fog–edge-iot collaborative framework for time-critical applications. *IEEE Trans Netw Sci Eng*
38. Ghosh S, Ghosh SK, Buyya R (2020) MARIO: a spatio-temporal data mining framework on Google Cloud to explore mobility dynamics from taxi trajectories. *J Netw Comput Appl* 15(164):102692
39. Whaiduzzaman M, Hossain MR, Shovon AR, Roy S, Laszka A, Buyya R, Barros A (2020) A privacy-preserving mobile and fog computing framework to trace and prevent covid-19 community transmission. *IEEE J Biomed Health Inform* 24(12):3564–75
40. Mukherjee A, Ghosh S, Behere A, Ghosh SK, Buyya R (2020) Internet of health things (IoHT) for personalized health care using integrated edge–fog–cloud network. *J Ambient Intell Humaniz Comput* 8:1–7
41. Ghosh S, Ghosh SK, Buyya R (2019) Movcloud: a cloud-enabled framework to analyse movement behaviors. In: *IEEE International Conference on Cloud Computing Technology and Science (Cloud-Com)*, pp 239–246. IEEE Computer Society

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LETTER

OrangeMusic: An orange computing-inspired recommender framework in internet of music things

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Abstract

Recent computational analytics in the domain of the Internet of Things provides crowd-sourced reviews for decision assistance for innumerable aspects of our living standards and socio-entertainments. However, one of the most significant tasks for obtainable online music libraries and websites is the demand for personalized and professionalized courses of action for music listeners and composers to elect suitable musical performances. In this paper, we illustrate a hybrid matrix factorization-based content-sensitive music recommender schema on the Internet of Music Things. Emerging orange computing technology offers a harmonic fusion framework for psychological care and happiness-concerned computing. We elucidate the projected music recommender paradigm in the domain of Internet of Music Things, titled as OrangeMusic. The OrangeMusic schema differs from the earlier contributions in the following aspects: (a) Orange computing-based information fusion framework is applied on the Internet of Music Things; (b) Provided musical content revisions can be exposed by listeners' rating metrics and be exploited to amend original listener-provided ratings; (c) Music listeners' preferences and musical items are incorporated into the standard matrix factorization mechanism. The performance metrics flourish that our proposed OrangeMusic presents a proficient rating prediction and intensifies the accuracy of content-sensitive music recommendation expressively.

KEYWORDS

hybrid matrix factorization, internet of music things, music recommender system, Orange computing

1 | INTRODUCTION

Musicians can compose knowledge-based music for listeners and can circulate worldwide through Internet-driven live-streamed performances. Internet of Things (IoT) in Music has provided an evolving schema that enables remotely accessible musicians, multiple instruments, and music-making technologies into a solitary platform. In,¹ the authors have provided the opportunistic crowdsensing-oriented Internet of Music Things (IoMT) system architecture and evaluated the system performances in terms of the time for data transmission, power dissipation, and energy consumption. IoMT has been elucidated in diverge contexts to fix music composition and generation perspectives, such as ubiquitous music retrieval, remote performance monitoring, and auto-tuning of musical instruments. Acceptance of the IoT-inspired musical performances depends on the audiences: how they feel according to their present emotion and recommend to the future listeners.^{2,3}

Numerous strategies exist for movies recommendation, product recommendations, etc. In,⁴ the authors illustrated an Ensemble-based system with the Particle Swarm Optimization that boosts towards intelligent recommendation frameworks. In,⁵ emerging Capsule Network and

of EVS, MAE, and RMSE. The OrangeMusic has conceivable applications in the real world which comprise the wide-network interactive and distributed music performances, wearable smart instruments, dynamic rhythmic tuning, and multi-user-based virtual music composition and reconstruction systems. As Orange computing refers to a humanistic care-inspired framework, the association of Orange computing and Internet of Music Things, that is, OrangeMusic has the potential impacts on the music-therapeutic applications. Music therapy is yet unscathed by the emerging technologies of OrangeMusic. However, this schema recommends impressive capability for the devices that may perhaps be concerned with the assistive-living consequences that offer a non-invasive, individually accustomed, outline of psychological and humanistic treatment which is forever accessible. In future work, we shall try to incorporate multifaceted multiple intelligent computing strategies to enhance the music recommendation efficiency and to design more humanized and personalized humanistic care frameworks in the contexts of the IoT and Orange technology convergence.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Mendeley at <https://doi.org/10.17632/9v76rdd4gz.2>.

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REFERENCES

1. Roy S, Sarkar D, Hati S, De D. Internet of music things: an edge computing paradigm for opportunistic crowdsensing. *J Supercomput.* 2018;74(11):6069-6101.
2. Roy S, Biswas M, De D. iMusic: a session-sensitive clustered classical music recommender system using contextual representation learning. *Multimed Tools Appl.* 2020;79(33):24119-24155.
3. Wen X. Using deep learning approach and IoT architecture to build the intelligent music recommendation system. *Soft Comput.* 2021;25(4):3087-3096.
4. Gupta G, Katarya R. EnPSO: an AutoML technique for generating ensemble recommender system. *Arab J Sci Eng.* 2021;46:8677-8695.
5. Katarya R, Arora Y. Capsmf: a novel product recommender system using deep learning-based text analysis model. *Multimed Tools Appl.* 2020;79(47):35927-35948.
6. Gupta G, Katarya R. Recommendation analysis on item-based and user-based collaborative filtering. In *2019 International Conference on Smart Systems and Inventive Technology (ICSSIT)* 2019; pp. 1-4, IEEE.
7. Katarya R. Reliable recommender system using improved collaborative filtering technique. In: Anand A, Ram M, eds. *System Reliability Management*. Boca Raton, FL: CRC Press; 2018:113-119.
8. Katarya R, Verma N. Automatically detection and recommendation in collaborative groups. In *2017 International Conference on Intelligent Sustainable Systems (ICISS)*. IEEE; 2017; pp. 218-222.
9. Katarya R, Verma OP. Recommender system with grey wolf optimizer and FCM. *Neural Comput Appl.* 2018;30(5):1679-1687.
10. Katarya R, Verma OP. Efficient music recommender system using context graph and particle swarm. *Multimed Tools Appl.* 2018;77(2):2673-2687.
11. Wang J-F, Chen B-W, Fan W-K, Li C-H. Emotion-aware assistive system for humanistic care based on the Orange computing concept. *Appl Comput Intell Soft Comput.* 2012;2012:1-8.
12. Wang HY, Chen BW, Bharanitharan K, Wu JS, Tseng SP, Wang JF. Human-centric technology based on orange computing. In: *ICOT 2013 - 1st International Conference on Orange Technologies*, IEEE, 2013; pp. 250-251.
13. Zhang Y, Chen M, Huang D, Wu D, Li Y. iDoctor: personalized and professionalized medical recommendations based on hybrid matrix factorization. *Fut Generat Comput Syst.* 2017;66:30-35.
14. Koren Y, Bell R, Volinsky C. Matrix factorization techniques for recommender systems. *Computer.* 2009;42(8):30-37.
15. Dutta A, Sil D, Chandra A, Palit S. CNN based musical instrument identification using time-frequency localized features. *Internet Technol Lett.* 2021;e191:1-6. <https://doi.org/10.1002/itl2.191>
16. Mangla P, Arora S, Bhatia MPS. Intelligent audio analysis techniques for identification of music in smart devices. *Internet Technol Lett.* 2021;e268:1-6. <https://doi.org/10.1002/itl2.268>
17. Pedregosa F, Varoquaux G, Gramfort A, et al. Scikit-learn: machine learning in Python. *J Mach Learn Res.* 2011;12:2825-2830.
18. Roy S, Mukherjee A, De D. Data for: contextual music rating prediction. Mendeley Data V2 2021.

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RESEARCH ARTICLE

RESCUE: Enabling green healthcare services using integrated IoT-edge-fog-cloud computing environments

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Abstract

Internet of Things (IoT) has a pivotal role in developing intelligent and computational solutions to facilitate varied real-life applications. To execute high-end computations and data analytics, IoT and cloud-based solutions play the most significant role. However, frequent communication with long distant cloud servers is not a delay-aware and energy-efficient solution while providing time-critical applications such as healthcare. This article explores the possibilities and opportunities of integrating cloud technology with fog and edge-based computing to provide healthcare services to users in exigency. Here, we propose an end-to-end framework named *RESCUE* (enabling green healthcare services using integrated iot-edge-fog-cloud computing environments), consisting efficient spatio-temporal data analytics module for efficient information sharing, spatio-temporal data analysis to predict the path for users to reach the destination (healthcare center or relief camps) with minimum delay in the time of exigency (say, natural disaster). This module analyzes the collected information through crowd-sourcing and assists the user by extracting optimal path post-disaster when many regions are nonreachable. Our work is different from the existing literature in varied aspects: it analyses the context and semantics by augmenting real-time volunteered geographical information (VGI) and refines it. Furthermore, the novel path prediction module incorporates such VGI instances and predicts routes in emergencies avoiding all possible risks. Also, the design of development of a latency-aware, power-aware data-driven analytics system helps to resolve any spatio-temporal query more efficiently compared to the existing works for any time-critical application. The experimental and simulation results outperform the baselines in terms of accuracy, delay, and power consumption.

KEYWORDS

cloud computing, edge computing, geospatial query processing, green computing, healthcare service, internet of things, spatio-temporal data

50. Vales R, Moura J, Marinheiro R. Energy-aware and adaptive fog storage mechanism with data replication ruled by spatio-temporal content popularity. *J Netw Comput Appl.* 2019;135:84-96.
51. Ghosh S, Das J, Ghosh SK. Locator: a cloud-fog-enabled framework for facilitating efficient location based services. Proceedings of the 2020 International Conference on COMMunication Systems & NETWORKS (COMSNETS); 2020:87-92.
52. Rajavel R, Ravichandran SK, Harimoorthy K, Nagappan P, Gobichettipalayam KR. IoT-based smart healthcare video surveillance system using edge computing. *J Ambient Intell Humaniz Comput.* 2021;1-13.
53. Chelladurai U, Pandian S. A novel blockchain based electronic health record automation system for healthcare. *J Ambient Intell Humaniz Comput.* 2021;1-11.
54. Ghosh S, Ghosh SK, Buyya R. MARIO: a spatio-temporal data mining framework on Google cloud to explore mobility dynamics from taxi trajectories. *J Netw Comput Appl.* 2020;164:1-17.
55. Gupta H, Vahid Dastjerdi A, Ghosh SK, Buyya R. iFogSim: a toolkit for modeling and simulation of resource management techniques in the Internet of Things, edge and fog computing environments. *Softw Pract Exper.* 2017;47(9):1275-1296.

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Femtolet Based Low Power Hetnet Using Soft Fractional Frequency Reuse

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Abstract

This paper addresses three prime issues of fifth generation mobile network: frequency allocation, power efficiency and communication while computing. This paper proposes a power-efficient micro-femtolet/macro-femtolet network based on soft fractional frequency reuse. Macrocell/microcell base stations are used in the network, and for providing good signal strength and offloading facilities to indoor and edge region users' femtolets are allocated inside the macrocell/microcell. The power transmission in the proposed heterogeneous network (HetNet) is estimated. The analytical evaluation presents that use of SFFR reduces the power transmission of the network by 10.87% approximately. This is also observed that the signal-to-interference-plus-noise ratio (SINR) of the network is improved using the proposed strategy. For experimental evaluation we have used vector signal generator (VSG) and vector signal analyzer (VSA). The simulation analyses performed using network simulator Qualnet shows that femtolet provides $\sim(2-34)\%$ reduction in energy consumption than the cloud based offloading.

Keywords Soft fractional frequency reuse · Femtolet based HetNet · Power reduction · SINR improvement

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13. Mukherjee, Anwasha, Deb, Priti, De, Debashis, & Obaidat, Mohammad S. (2019). Wma-mifn: A weighted majority and auction game based green ultra-dense micro-femtocell network system. *IEEE Systems Journal*, 14(1), 353–362.
14. Tseng, Chih-Cheng., & Peng, Ching-Shun. (2018). Co-tier uplink interference management by stackelberg game with pricing in co-channel femtocell networks. *Wireless Personal Communications*, 100(1), 7–23.
15. Attia, Eman S., El-Dolil, Sami A., & Abd-Elnaby, Mohammed. (2018). Spectrum allocation for enhanced cross-tier interference mitigation with throughput improvement for femtocells in a heterogeneous lte cellular network. *Wireless Personal Communications*, 101(3), 1671–1683.
16. Chandrasekhar, Vikram, Andrews, Jeffrey G., & Gatherer, Alan. (2008). Femtocell networks: A survey. *IEEE Communications Magazine*, 46(9), 59–67.
17. Wang, Xiaofei, Vasilakos, Athanasios V., Chen, Min, Liu, Yunhao, & Kwon, Ted Taekyoung. (2012). A survey of green mobile networks: Opportunities and challenges. *Mobile Networks and Applications*, 17(1), 4–20.
18. Mukherjee, Anwasha, Bhattacharjee, Srimoyee, Pal, Sucheta, & De, Debashis. (2013). Femtocell based green power consumption methods for mobile network. *Computer Networks*, 57(1), 162–178.
19. Mhiri, F., Reguiga, KSB., Bouallegue, R., Pujolle, G., (2011). A power management algorithm for green femtocell networks. In: 2011 The 10th IFIP Annual Mediterranean Ad Hoc Networking Workshop, IEEE. pp. 45–49.
20. Al Haddad, M., & Bayoumi, M., (2015). Green novel power control framework for dense femtocell grids. In: International Conference on Computer Vision and Image Analysis Applications, IEEE, pp. 1–6.
21. Lee, P., Lee, T., Jeong, J., & Shin, J. (2010). Interference management in lte femtocell systems using fractional frequency reuse. In: 2010 The 12th international conference on advanced communication technology (ICACT), IEEE, vol 2 (pp. 1047–1051).
22. Kang, Xin, Zhang, Rui, & Motani, Mehul. (2012). Price-based resource allocation for spectrum-sharing femtocell networks: A stackelberg game approach. *IEEE Journal on Selected areas in Communications*, 30(3), 538–549.
23. Saquib, Nazmus, Hossain, Ekram, Le, Long Bao, & Kim, Dong In. (2012). Interference management in ofdma femtocell networks: Issues and approaches. *IEEE Wireless Communications*, 19(3), 86–95.
24. Sharma, Nitin, Badheka, Divyakumar, & Anpalagan, Alagan. (2014). Multiobjective subchannel and power allocation in interference-limited two-tier ofdma femtocell networks. *IEEE Systems Journal*, 10(2), 544–555.
25. Chai, Xiaomeng, Zhang, Zhongshan, & Long, Keping. (2015). Joint spectrum-sharing and base station sleep model for improving energy efficiency of heterogeneous networks. *IEEE Systems Journal*, 12(1), 560–570.
26. Ghosh, J., & Jayakody, D. N. K. (2018). An analytical view of ase for multicell ofdma networks based on frequency-reuse scheme. *IEEE Systems Journal*, 14(1), 645–648.
27. Ghosh, Subha, De, Debashis, & Deb, Priti. (2019). Energy and spectrum optimization for 5g massive mimo cognitive femtocell based mobile network using auction game theory. *Wireless Personal Communications*, 106(2), 555–576.
28. Othman, Mazliza, Khan, Abdul Nasir, Shuja, Junaid, Mustafa, Saad, et al. (2017). Computation offloading cost estimation in mobile cloud application models. *Wireless Personal Communications*, 97(3), 4897–4920.
29. Pandey, Vikas, Singh, Shashank, & Tapaswi, Shashikala. (2015). Energy and time efficient algorithm for cloud offloading using dynamic profiling. *Wireless Personal Communications*, 80(4), 1687–1701.
30. Mukherjee, A., De, D., & Buyya, R. (2019). E2r–f2n: Energy-efficient retailing using a femtolet-based fog network. *Software: Practice and Experience*, 49(3), 498–523.
31. Deb, P., Mukherjee, A., & De, D. (2019). Design of green smart room using fifth generation network device femtolet. *Wireless Personal Communications*, 104(3), 1037–1064.
32. Mukherjee, Anwasha, Deb, Priti, De, Debashis, & Buyya, Rajkumar. (2018). C2of2n: A low power cooperative code offloading method for femtolet-based fog network. *The Journal of Supercomputing*, 74(6), 2412–2448.
33. Roy, D. G., Mukherjee, A., De, D., & Srirama, S. N. (2019). Practical implementation of femtolet based peer-to-peer network. *Wireless Personal Communications*, 108(4), 2477–2498.



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GrowFruit: An IoT based Radial Growth Rate Monitoring Device for Fruit

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Abstract—GrowFruit is an Internet of Things (IoT)-based low-cost real-time radial growth-rate measurement device for fruit or stem. The working principle is measuring the growth of multiple crops up to 128 different inputs utilizing a single Texas Instrument-based 32-bit ultra-low-power microcontroller. The system utilizes Flex sensors, each of 4.5 inches to measure the change of circumference of the crop. The bending angle of the Flex sensor generates voltage, and via Analog to Digital Converter (ADC), is fed to the microcontroller in the form of a digital signal. With the help of the Quectel M95 GSM modem, the microcontroller sends the signal to the cloud for storage and analysis of the growth rate data. As the system measures the perimeter changes of fruits or stems, more precise growth information is obtained.

I. INTRODUCTION

The recent agricultural aspects require a real-time crop growth rate monitoring system. The crop growth rate depends on various factors such as the plant's genetic endowment and physiological and environmental conditions. The growth rate monitoring is an essential factor in plant studies for horticulture and natural ecosystem-grown crops. The growth measuring systems usually are supported by direct contact with the test sample and the mechanical structure that has to be updated depending on the size and shape of the sample [1]. In the growth measurement systems, Linear Variable Differential Transformers (LVDT) and strain gauges are used [1]. The strain gauge-based systems are economical compared to the LVDT-based systems. However, the LVDT-based systems provide precise, accurate, and high-resolution information regarding growth rate, whereas in strain gauge-based systems, specific electronic circuitry and flexible frames are required. The crop

growth-related information storage is also significant for proper monitoring. This paper aims to design a device that will collect growth-related information and store the collected data for better growth monitoring. Our research work has designed an IoT-based device that utilizes a 32-bit ultra-low-power-consuming microcontroller that will process up to 128 inputs. The device utilizes the RS485 protocol for long-distance communication. We have used 4.5-inch Flex sensors to monitor the growth of horticulture crops and natural ecosystem plants. The bending angle of the Flex sensor, which has an analog output, is fed to the microcontroller via ADC for processing the data. Our system stores the processed data inside the EPROM and, after every one hour, sends the data to the cloud using the Quectel M95 GSM modem and the Rest API protocol. We plot the data in the X-Y plane in the form of the day and circumference of the crop, trunk, or branches, measured using the sensor. The proposed system obtains the sleep mode through Real-Time Clock. The proposed low-power consuming system works in a 12V, 1A rating. We may deploy solar panels for natural ecosystem radial growth measurement to power the cell, thus, making it a green or energy-efficient device.

II. RELATED WORK

Improving the productivity and growth rate of fruits is an emerging and significant research trend. In [2], the authors have discussed a low-cost fruit diameter monitoring device. The authors have discussed on multi-color driving algorithm concerning Pulse Width Modulation duty cycles and spectral power distributions [2]. To optimize the color correlation temperature and index for color rendering, multi-colour plant-growing light signals can significantly exploit photosynthetic radiant effectiveness [2]. On the other hand, in [3], the authors have discussed fabrication, calibration,

- [6] M. Thalheimer, "A new optoelectronic sensor for monitoring fruit or stem radial growth," *Computers and Electronics in Agriculture*, vol. 123, pp. 149-153, 2016.
- [7] W. Slamet, N. M. Irham, and M. S. A. Sutan, "IoT based growth monitoring system of Guava (*psidiumguajava* l.) fruits," *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, vol. 147, no. 1, pp. 012048, 2018.
- [8] S. K. Ram, B. B. Das, K. Mahapatra, S. P. Mohanty, U. Choppali, "Energy Perspectives in IoT Driven Smart Villages and Smart Cities," *IEEE Consumer Electronics Magazine*, September 2020, Available: 10.1109/MCE.2020.3023293
- [9] A. Sengupta, B. Debnath, A. Das, D. De, "FarmFox: A Quad-Sensor based IoT box for Precision Agriculture," *IEEE Consumer Electronics Magazine*, 2021, DOI: 10.1109/MCE.2021.3064818
- [10] D. Das, V. Udutalapally and S. P. Mohanty, "Consumer Technologies for Smart Agriculture," *IEEE Consumer Electronics Magazine*, vol. 10, no. 4, pp. 49-50, 2021.
- [11] P. K. Tripathy, A. K., Tripathy, A. Agarwal, and S. P. Mohanty, "MyGreen: An IoT-Enabled Smart Greenhouse for Sustainable Agriculture," *IEEE Consumer Electronics Magazine*, 2021, DOI: <https://doi.org/10.1109/MCE.2021.3055930>.
- [12] A. Sengupta, T. Mallick, and A. Das, "A Cost-Effective Design and Implementation of Arduino Based Sign Language Interpreter," *2019 Devices for Integrated Circuits (DevIC), IEEE*, pp. 12-15, 2019.

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Toxicological impacts of nanopolystyrene on zebrafish oocyte with insight into the mechanism of action: An expression-based analysis

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ABSTRACT

Many studies have investigated the negative impacts of microplastics on teleost fishes with very little or no evidence of their mechanism of action. This scenario entreats us to investigate the toxicities of nanopolystyrene in zebrafish oocyte with emphasis on the mechanism of action. In the present study, the cellular levels of mRNA transcripts of different genetic markers (such as: *sod*, *gpx*, *nr1h2*, *inos*, *ucp2*, and *atp6* (redox-sensitive markers); *nfκβ*, *tnfα*, *il-10*, *ikβ*, *gdf9*, and *bmp15* (immune markers); *gadd45*, *rad51*, *p53* and *bcl2* (DNA damage and apoptotic)) have been quantified by real-time PCR after 6 h of incubation of isolated oocyte with different doses of nanopolystyrene viz. P0 (control i.e. no polystyrene in culture medium), P1 (100 ng/ml), and P2 (400 ng/ml). Results showed that both the treatment concentrations of nanopolystyrene induce oxidative stress with % DPPH = 30.75, 31.61, and 32.43% for P0, P1, and P2, respectively. Increase in oxidative stress in oocytes with increasing doses of nanopolystyrene was also observed in TBARS assay with MDA content 0.12 and 0.21 μM for P1 and P2, respectively as compared to the control 0.08 μM. This increased oxidative stress can regulate the expression pattern (upregulation/downregulation) of selected genes leading to different toxic effects like – oxidative stress, immunotoxicity, and apoptosis in oocytes, which suggests the impairment of reproductive functions by nanopolystyrene.

1. Introduction

Plastic pollution represents a major global concern due to their elevated production and environmental disposal with a low rate of recycling. Regular monitoring of micro/nanoplastics into the environmental samples and their toxicity assessment is important for their environmental risk assessment. Polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), and polyvinyl chloride (PVC) are some most widely used forms of thermoplastics. Plastic waste can impose severe negative impacts on the wildlife in an aquatic system (Vegter et al., 2014). Micro/nanoplastics, formed by the biotic and abiotic degradation of large plastic waste, are ubiquitously distributed in all ecosystems (Besseling et al. 2013; Obbard et al., 2014). The aquatic system may serve as a large sink for the environmental accumulation of

nanoplastics, where they can induce severe toxicities to the aquatic organisms.

Recently, many studies have reported the negative impacts of microplastics in fishes such as - oxidative stress (Zhao et al. 2013, Brun et al., 2019), reproductive impairments (Sharifinia et al., 2020; Sarasamma et al., 2020; Yin et al., 2021), disrupted glucose metabolism (Brun et al., 2019), neurotoxicity (Kim et al., 2021), DNA breakage, and the increased mortality rate (Zhou et al. 2013). Microplastics can bioaccumulate into different organs like - liver, kidney, gut, gills, brain, and gonads. Different anti-oxidants provide the first line of defense against oxidative stress (Jin et al., 2010) and therefore play a pivotal role in the regulation of oxidative stress (Dong et al., 2018). Zhou et al. (2013) reported the oxidative damage with increased SOD (superoxide

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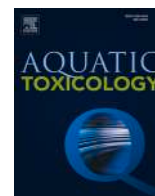
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- the transcription of cell damage-related genes in zebrafish embryos. *J. Appl. Toxicol.* 32 (9), 654–661.
- Kedare, S.B., Singh, R.P., 2011. Genesis and development of DPPH method of antioxidant assay. *J. Food Sci. Technol.* 48 (4), 412–422.
- Kim, J.H., Yu, Y.B., Choi, J.H., 2021. Toxic effects on bioaccumulation, hematological parameters, oxidative stress, immune responses and neurotoxicity in fish exposed to microplastics: a review. *J. Hazard. Mater.* 413, 125423.
- Kondoh, H., Leonart, M.E., Bernard, D., Gil, J., 2007. Protection from oxidative stress by enhanced glycolysis; a possible mechanism of cellular immortalization. *Histol. Histopathol.* 22 (1) 22 (1), 85–90.
- Liebermann, D.A., Hoffman, B., 2008. Gadd45 in stress signaling. *J. Mol. Signal.* 3 (1), 1–8.
- Lima, F.E.O., Bezerra, F.T.G., Souza, G.B., Matos, M.H.T., Van Den Hurk, R., Silva, J.R.V., 2018. Influence of interleukin 1 beta and tumour necrosis factor alpha on the in vitro maturation, maturation and mitochondrial distribution of bovine oocytes from small antral follicles. *Zygote* 26 (5), 381–387.
- Liu, Y., Wang, J., Wei, Y., Zhang, H., Xu, M., Dai, J., 2008. Induction of time-dependent oxidative stress and related transcriptional effects of perfluorododecanoic acid in zebrafish liver. *Aquat. Toxicol.* 89 (4), 242–250.
- Maity, S., Chatterjee, A., Guchhait, R., De, S., Pramanick, K., 2020. Cytogenotoxic potential of a hazardous material, polystyrene microparticles on *Allium cepa* L. *J. Hazard. Mater.* 385, 121560.
- Mammalian Gene Collection (MGC) Program Team, 2002. Generation and initial analysis of more than 15,000 full-length human and mouse cDNA sequences. *Proc. Natl. Acad. Sci.* 99 (26), 16899–16903.
- Moore, K.W., de Waal Malefyt, R., Coffman, R.L., O'Garra, A., 2001. Interleukin-10 and the interleukin-10 receptor. *Annu. Rev. Immunol.* 19 (1), 683–765.
- Niture, S.K., Jain, A.K., Jaiswal, A.K., 2009. Antioxidant-induced modification of I κ N β cysteine 151 and PKC- δ -mediated phosphorylation of Nrf2 serine 40 are both required for stabilization and nuclear translocation of Nrf2 and increased drug resistance. *J. Cell Sci.* 122 (24), 4452–4464.
- Obbard, R.W., Sadri, S., Wong, Y.Q., Khitun, A.A., Baker, I., Thompson, R.C.C.E.F., 2014. 429 Global warming releases microplastic legacy frozen in Arctic Sea ice. *Earth's Future* 2 (6).
- Otsuka, F., Yamamoto, S., Erickson, G.F., Shimasaki, S., 2001. Bone morphogenetic protein-15 inhibits follicle-stimulating hormone (FSH) action by suppressing FSH receptor expression. *J. Biol. Chem.* 276 (14), 11387–11392.
- Pi, J., Zhang, Q., Woods, C.G., Wong, V., Collins, S., Andersen, M.E., 2008. Activation of Nrf2-mediated oxidative stress response in macrophages by hypochlorous acid. *Toxicol. Appl. Pharmacol.* 226 (3), 236–243.
- Pramanick, K., Kundu, S., Paul, S., Mallick, B., Moulik, S.R., Pal, P., Mukherjee, D., 2014. Steroid-induced oocyte maturation in indian shad *Tenulosa ilisha* (Hamilton, 1822) is dependent on phosphatidylinositol 3 kinase but not MAP kinase activation. *Mol. Cell. Endocrinol.* 390 (1–2), 26–33.
- Qiang, L., Cheng, J., 2021. Exposure to polystyrene microplastics impairs gonads of zebrafish (*Danio rerio*). *Chemosphere* 263, 128161.
- Rao, X., Huang, X., Zhou, Z., Lin, X., 2013. An improvement of the 2⁻ $\Delta\Delta$ CT method for quantitative real-time polymerase chain reaction data analysis. *Bioinform. Biomath.* 3 (3), 71.
- Sarasamma, S., Audira, G., Siregar, P., Malhotra, N., Lai, Y.H., Liang, S.T., Chen, J.R., Chen, K.H.C., Hsiao, C.D., 2020. Nanoplastics cause neurobehavioral impairments, reproductive and oxidative damages, and biomarker responses in zebrafish: throwing up alarms of wide spread health risk of exposure. *Int. J. Mol. Sci.* 21 (4), 1410.
- Seo, B.B., Marella, M., Yagi, T., Matsuno-Yagi, A., 2006. The single subunit NADH dehydrogenase reduces generation of reactive oxygen species from complex I. *FEBS Lett.* 580 (26), 6105–6108.
- Sharifinia, M., Bahmanbeigloo, Z.A., Keshavarzifard, M., Khanjani, M.H., Lyons, B.P., 2020. Microplastic pollution as a grand challenge in marine research: a closer look at their adverse impacts on the immune and reproductive systems. *Ecotoxicol. Environ. Saf.* 204, 111109.
- Sheikh, M.S., Fornace, Jr., A.J., 2000. Role of p53 family members in apoptosis. *J. Cell. Physiol.* 182 (2), 171–181.
- Shen, Q., Zhang, B., Xu, R., Wang, Y., Ding, X., Li, P., 2010. Antioxidant activity in vitro of the selenium-containing protein from the se-enriched bifidobacterium *animalis* 01. *Anaerobe* 16 (4), 380–386.
- Shi, X., Zhou, B., 2010. The role of Nrf2 and MAPK pathways in PFOS-induced oxidative stress in zebrafish embryos. *Toxicol. Sci.* 115 (2), 391–400.
- Spence, R., Gerlach, G., Lawrence, C., Smith, C., 2008. The behaviour and ecology of the zebrafish, *Danio rerio*. *Biol. Rev.* 83 (1), 13–34.
- Sugiura, K., Eppig, J.J., 2005. Society for Reproductive Biology Founders' Lecture 2005. Control of metabolic cooperativity between oocytes and their companion granulosa cells by mouse oocytes. *Reprod. Fertil. Dev.* 17 (7), 667–674.
- Thisse, C., Degraeve, A., Kryukov, G.V., Gladyshev, V.N., Obrecht-Pflumio, S., Krol, A., Thisse, B., Lescure, A., 2003. Spatial and temporal expression patterns of selenoprotein genes during embryogenesis in zebrafish. *Gene Expr. Patterns* 3 (4), 525–532.
- van Wijk, R.C., Krekels, E.H., Hankemeier, T., Spaik, H.P., van der Graaf, P.H., 2016. Systems pharmacology of hepatic metabolism in zebrafish larvae. *Drug Discov. Today Dis. Model.* 22, 27–34.
- Vegter, A.C., Barletta, M., Beck, C., Borrero, J., Burton, H., Campbell, M.L., et al., 2014. Global research priorities to mitigate plastic pollution impacts on marine wildlife. *Endang. Species Res.* 25, 225–247.
- Xu, H., Yang, M., Qiu, W., Pan, C., Wu, M., 2013. The impact of endocrine-disrupting chemicals on oxidative stress and innate immune response in zebrafish embryos. *Environ. Toxicol. Chem.* 32 (8), 1793–1799.
- Yin, K., Wang, Y., Zhao, H., Wang, D., Guo, M., Mu, M., Liu, Y., Nie, X., Li, B., Li, J., Xing, M., 2021. A comparative review of microplastics and nanoplastics: toxicity hazards on digestive, reproductive and nervous system. *Sci. Total Environ.* 145758.
- Zhang, D.C., Shao, Y.Q., Huang, Y.Q., Jiang, S.G., 2005. Cloning, characterization and expression analysis of interleukin-10 from the zebrafish (*Danio rerio*). *BMB Rep.* 38 (5), 571–576.
- Zhao, K., Huang, Z., Lu, H., Zhou, J., Wei, T., 2010. Induction of inducible nitric oxide synthase increases the production of reactive oxygen species in RAW264. 7 macrophages. *Biosci. Rep.* 30 (4), 233–241.
- Zhao, X., Wang, S., Wu, Y., You, H., Lv, L., 2013. Acute ZnO nanoparticles exposure induces developmental toxicity, oxidative stress and DNA damage in embryo-larval zebrafish. *Aquat. Toxicol.* 136, 49–59.
- Zheng, J.L., Yuan, S.S., Wu, C.W., Lv, Z.M., 2016. Acute exposure to waterborne cadmium induced oxidative stress and immunotoxicity in the brain, ovary and liver of zebrafish (*Danio rerio*). *Aquat. Toxicol.* 180, 36–44.
- Zheng, J.L., Yuan, S.S., Wu, C.W., Lv, Z.M., Zhu, A.Y., 2017. Circadian time-dependent antioxidant and inflammatory responses to acute cadmium exposure in the brain of zebrafish. *Aquat. Toxicol.* 182, 113–119.
- Zou, J., Clark, M.S., Secombes, C.J., 2003. Characterisation, expression and promoter analysis of an interleukin 10 homologue in the puffer fish, *Fugu rubripes*. *Immunogenetics* 55 (5), 325–335.



Toxic effects of cyanotoxins in teleost fish: A comprehensive review

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ABSTRACT

The phenomenon of eutrophication leads to the global occurrence of algal blooms. Cyanotoxins as produced by many cyanobacterial species can lead to detrimental effects to the biome due to their stability and potential biomagnification along food webs. Therefore, understanding of the potential risks these toxins pose to the most susceptible organisms is an important prerequisite for ecological risks assessment of cyanobacteria blooms. Fishes are an important component of aquatic ecosystems that are prone to direct exposure to cyanotoxins. However, relatively few investigations have focused on measuring the toxic potentials of cyanotoxins in teleost fishes. This review comprehensively describes the major toxicological impacts (such as hepatotoxicity, neurotoxicity, immune toxicity, reproductive toxicity and cytogenotoxicity) of commonly occurring cyanotoxins in teleost fishes. The present work encompasses recent research progresses with special emphasis on the basic molecular mechanisms by which different cyanotoxins impose their toxicities in teleost fishes. The major research areas, which need to be focused on in future scientific investigations, have also been highlighted. Protein kinase inhibition, transcriptional dysregulation, disruption of redox homeostasis and the induction of apoptotic pathways appear to be the key drivers of the toxicological effects of cyanotoxins in fish. Analyses also showed that the impacts of cyanotoxins on specific reproductive processes are relatively less described in teleosts in comparison to mammalian systems. In fact, as compared to other toxicological effects of cyanotoxins, their reproductive toxicity (such as impacts on oocyte development, maturation and their hormonal regulation) is poorly understood in fish, and thus requires further studies. Furthermore, additional studies characterizing the molecular mechanisms responsible for the cellular uptake of cyanotoxins need to be investigated.

Abbreviations: MC-LR, Microcystin LR; CYN, Cylindrospermopsin; NOD, Nodularin; ANTX-a, Anatoxin-a; ANTX-a(s), Anatoxin-a(s); BMAA, β -N-methylamino-L-alanine; STX, Saxitoxin; Oatp, Organic Anion Transporter Protein; PP1, Protein Phosphatase 1; PP2A, Protein Phosphatase 2A; PP2C, Protein Phosphatase 2C; LPS, Lipopolysaccharide; *xbp-1 s*, X-box Binding Protein 1 s; *chop*, C/EBP Homologous Protein; *btp*, β -Trace Protein; *atf4*, Activating Transcription Factor 4; *tnfa*/TNF α , Tumor Necrosis Factor α ; *dusp5*, Dual Specificity Phosphatase 5; ERK, Extracellular Signal-Regulated Kinase; MAPK, Mitogen-activated Protein Kinase; JNK, c-Jun N-terminal Kinase; ROS, Reactive Oxygen Species; RNS, Reactive Nitrogen Species; *sod*/SOD, Superoxide Dismutase; *cat*/CAT, Catalase; *gst*/GST, Glutathione S-transferase; *gpx*/GPx, Glutathione Peroxidase; GSH, Reduced Glutathione; LPO, Lipid Peroxidation; MDA, Malondialdehyde; G6PDH, Glucose 6-Phosphate Dehydrogenase; DW, Dry weight; LC-MS, Liquid Chromatography-Mass Spectroscopy; DPF, Days Post fertilization; BAF, Bioaccumulation Factor; ACh, Acetyl Choline; nAChR, Nicotinic Acetyl Choline Receptor; AChE, Acetyl Cholinesterase; *elavl3*, ELAV-like Protein 3; *gap43*, Growth Associated Protein 43; *gfap*, Glial Fibrillary Acidic Protein; *syn2a*, Synapsin IIa; *shha*, Sonic Hedgehog Protein A; *nkx2.2a*, NK2 Transcription Factor Related 2a; *mbp*, Myelin Basic Protein; *ngn1*, Neurogenin-1; *bcl2*, B-cell Lymphoma 2; *bax*, BCL2 Associated X; *vtg1*/VTG, Vitellogenin; E2, 17 β -Estradiol; T, Testosterone; *cyp19a1a*, Cytochrome P450 Aromatase-a1a; *cyp19a1b*, Cytochrome P450 Aromatase-a1b; *17 β -hsd*, 17 β -hydroxysteroid Dehydrogenase; *hmgra*, HMG-CoA Reductase a; *gnrh3*, Gonadotropin Releasing Hormone 3; *gnrh2*, Gonadotropin Releasing Hormone 2; *gnrh1*, Gonadotropin Releasing Hormone Receptor 1; *gnrh2*, Gonadotropin Releasing Hormone Receptor 2; *fsh β* , Follicle Stimulating Hormone β ; *lh β* , Luteinizing Hormone β ; *fshr*, Follicle Stimulating Hormone Receptor; *lhr*, Luteinizing Hormone Receptor; *bmp15*, Bone Morphogenic Protein 15; *era*, Estrogen Receptor α ; *pacap1*, Pituitary Adenylate Cyclase-Activating Polypeptide 1; *gh*, Growth Hormone; *igf*, Insulin-like Growth Factor; DHP, 17 α ,20 β -dihydroxy-4-pregnen-3-one; MPF, Maturation Promoting Factor..

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- Wu, Q., Yan, W., Cheng, H., Liu, C., Hung, T.C., Guo, X., Li, G., 2017. Parental transfer of microcystin-LR induced transgenerational effects of developmental neurotoxicity in zebrafish offspring. *Environ. Pollut.* 231, 471–478. <https://doi.org/10.1016/j.envpol.2017.08.038>.
- Wu, Q., Yan, W., Liu, C., Li, L., Yu, L., Zhao, S., Li, G., 2016. Microcystin-LR exposure induces developmental neurotoxicity in zebrafish embryo. *Environ. Pollut.* 213, 793–800. <https://doi.org/10.1016/j.envpol.2016.03.048>.
- Xiao, W., Zou, Z., Li, D., Zhu, J., Yue, Y., Yang, H., 2020. Effect of dietary phenylalanine level on growth performance, body composition, and biochemical parameters in plasma of juvenile hybrid tilapia, *Oreochromis niloticus* × *Oreochromis aureus*. *J. World Aquacult. Soc.* 51, 437–451.
- Xie, L., Xie, P., Guo, L., Li, L., Miyabara, Y., Park, H.D., 2005. Organ distribution and bioaccumulation of microcystins in freshwater fish at different trophic levels from the eutrophic Lake Chaohu, China. *Environ. Toxicol.* 20, 293–300. <https://doi.org/10.1002/tox.20120>.
- You, D.S., Lee, Y.W., Choi, D., Chang, Y.C., Cho, H., 2017. Algicidal effects of thiazolidine derivatives against *Microcystis aeruginosa*. *Korean J. Chem. Eng.* 34, 139–149. <https://doi.org/10.1007/s11814-016-0234-z>.
- Zhan, C., Zhang, F., Liu, W., Zhang, X., 2020a. Microcystin-LR promotes zebrafish (*Danio rerio*) oocyte (in vivo) maturation by activating ERK1/2-MPF signaling pathways, and cAMP is involved in this process. *Environ. Pollut.* 259, 113843.
- Zhan, C., Zhang, F., Liu, W., Zhang, X., 2020b. Microcystin-LR promotes zebrafish (*Danio rerio*) oocyte (in vivo) maturation by activating ERK1/2-MPF signaling pathways, and cAMP is involved in this process. *Environ. Pollut.* 259, 113843.
- Zhang, H., Shao, D., Wu, Y., Cai, C., Hu, C., Shou, X., Dai, B., Ye, B., Wang, M., Jia, X., 2012. Apoptotic responses of *Carassius auratus* lymphocytes to nodularin exposure in vitro. *Fish Shellfish Immunol* 33, 1229–1237. <https://doi.org/10.1016/j.fsi.2012.08.016>.
- Zhang, S., Du, X., Liu, H., Losiewicz, M.D., Chen, X., Ma, Y., Wang, R., Tian, Z., Shi, L., Guo, H., Zhang, H., 2020. The latest advances in the reproductive toxicity of microcystin-LR. *Environ. Res.* 192, 110254 <https://doi.org/10.1016/j.envres.2020.110254>.
- Zhao, Y.Y., Xie, L.Q., Yan, Y.J., 2015. Microcystin-LR impairs zebrafish reproduction by affecting oogenesis and endocrine system. *Chemosphere* 120, 115–122.
- Zheng, X., Yuan, Y., Li, Y., Liu, X., Wang, X., Fan, Z., 2020. Polystyrene nanoplastics affect growth and microcystin production of *Microcystis aeruginosa*. *Environmental Science and Pollution Research*, pp. 1–10.
- Zhong, Y., Shen, L., Ye, X., Zhou, D., He, Y., Li, Y., Ding, Y., Zhu, W., Ding, J., Zhang, H., 2020. Neurotoxic anatoxin-a can also exert immunotoxicity by the induction of apoptosis on *Carassius auratus* lymphocytes in vitro when exposed to environmentally relevant concentrations. *Front. Physiol.* 11, 316.

Occurrence and distribution of micro/nanoplastics in soils and their phytotoxic effects: A review

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Abstract

Some recent studies have reviewed the occurrence and phytotoxicity of micro/nanoplastics, but their distribution in the soil environment, mechanisms of uptake by roots and the mode of action are unclear. Thus, this review comprehensively represents the relative abundance of micro/nanoplastics in different soil types and their toxicities in plants with insights into their partitioning to different soil matrices, uptake mechanisms, and the mode of action. Partitioning of micro/nanoplastics to different soil matrices (like—soil particles, naturally occurring soil organic matters, pore waters and soil fauna) could modify their bioavailability to plants. The small micro/nanoplastic particles can be taken up by roots through the apoplastic and symplastic pathways. In this regard, cellular endocytosis and aquaporin might play a significant role. The shape of the polymers can also regulate their uptake, and the polymers with spherical shapes are more easily absorbed by roots than the polymers with other shapes. Bioaccumulation of micro/nanoplastic induces oxidative stress, which, in turn, causes alterations of gene expressions and different metabolic pathways responsible for plant growth, biomass production and synthesis of secondary metabolites.

KEYWORDS

bioavailability, oxidative stress, partitioning, plant uptake, toxicity

1 | INTRODUCTION

Since the 1950s, the worldwide production of different plastic polymers has been increasing very rapidly. According to Plastic Europe (2020), ~370 million tonnes and ~58 million tonnes of plastics have been produced in 2019 as total global and European production, respectively. Packaging, construction, building, and automotive industries are some of the important sectors heavily liable for the consumption of a large fraction (viz. 39.6%, 20.4% and 9.6%, respectively) of total European production. Polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polystyrene (PS) and polyvinylchloride (PVC) are the most common forms of thermoplastic to be used widely.

Based on the size of plastic particles, they can be categorised as macroplastic (>25 mm), mesoplastic (5–25 mm), large microplastic (1–5 mm), small microplastic (1 µm–1 mm), and nanoplastic (<1 µm) (Kim et al., 2021). But it is generally accepted that the plastic particles with diameter <5 mm are microplastics and those with diameter <100 nm are nanoplastics (He et al., 2018; Song et al., 2017). Plastics in the environment can exist in various forms including fibres, films, beads and foams. Micro/nanoplastics may have two types of origin in the natural environment. Firstly, they can be directly released from manufactured products (Guo et al., 2020); and secondly, different environmental processes such as: photo-oxidation (UV mediated), thermo-oxidation (temperature mediated), mechanical forces, biodegradation, and hydrolysis can break up the large plastic fragments

- Zhao, T., Lozano, Y.M. & Rillig, M.C. (2021) Microplastics increase soil pH and decrease microbial activities as a function of microplastic shape, polymer type, and exposure time. *Frontiers in Environmental Science*, 9, 235–548.
- Zhou, C.Q., Lu, C.H., Mai, L., Bao, L.J., Liu, L.Y. & Zeng, E.Y. (2021) Response of rice (*Oryza sativa* L.) roots to nanoplastic treatment at seedling stage. *Journal of Hazardous Materials*, 401, 123412.
- Zhou, Q. & Hu, X. (2017) Systemic stress and recovery patterns of rice roots in response to graphene oxide nanosheets. *Environmental Science & Technology*, 51(4), 2022–2030.
- Zhou, Q., Zhang, H., Fu, C., Zhou, Y., Dai, Z., Li, Y. et al. (2018) The distribution and morphology of microplastics in coastal soils adjacent to the Bohai Sea and the Yellow Sea. *Geoderma*, 322, 201–208.
- Zhu, F., Zhu, C., Wang, C. & Gu, C. (2019) Occurrence and ecological impacts of microplastics in soil systems: a review. *Bulletin of Environmental Contamination and Toxicology*, 102(6), 741–749.
- Ziajahromi, S., Neale, P.A., Silveira, I.T., Chua, A. & Leusch, F.D. (2021) An audit of microplastic abundance throughout three Australian wastewater treatment plants. *Chemosphere*, 263, 128294–128749.
- Zimmerman, R.P. & Kardos, L.T. (1961) Effect of bulk density on root growth. *Soil Science*, 91(4), 280–288.

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Interaction of plastic particles with heavy metals and the resulting toxicological impacts: a review

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Abstract

Interactions of plastic particles with different organic/inorganic pollutants including heavy metals impact their ecotoxicological potential, and proper understanding in this regard is important for their ecological risk assessment. However, many studies have reported the interactions between micro-/nanoplastics (MNPs) and heavy metals (HMs), but the most prevalent interactive forces and factors monitoring their interactions are still not clear. So, the present review represents the mechanisms of interactions with special emphasis on major interactive forces and biophysicochemical and environmental factors influencing trace element's adsorption onto the surface of MNPs. Electrostatic interaction and pore-filling mechanism can best explain the HMs adsorption to MNPs. A number of biophysicochemical factors (such as biofilm, size, crystallinity, and surface charge) and environmental factors (such as pH, salt, and temperature) act together for mediating interactions and ecotoxicities of MNPs and HMs in the real environment. From a toxicological point of view, the synergistic mode of action may be more active in animals, whereas the antagonistic activity may be prevalent in plants. Besides polymer density, biofilm formation and agglomeration property of MNPs can control the vertical distribution of MNPs along the water column. Finally, the ecotoxicological potential of MNPs in the natural environment can be considered as a function of spatiotemporal variation in abiotic (including MNPs and heavy metals) and biotic components. This review will be helpful in the detail understanding of ecotoxicological risk assessment of MNPs in relation to their interaction with heavy metals.

Keywords Micro-/nanoplastic · Interactions · Heavy metals · Ecotoxicity · Biophysicochemical factors · Spatiotemporal variation

Introduction

Since last few decades, the concern of plastic pollution has been growing up very rapidly (Browne et al. 2007; Eerkes-Medrano et al. 2015; Galloway et al. 2017; Campanale et al. 2020) due to their scaled-up global production, inadequate

waste management, and toxic behaviors. The ubiquitous distribution of MNPs in every environmental compartment and their trophic level transfer can impose threats to the ecosystem and public health (Eerkes-Medrano et al. 2015; Thompson 2015; Vethaak and Leslie 2016; Horton et al. 2017; Chae and An 2017; Hodson et al. 2017; Chae and An 2018; Zhang and Liu 2018). Many studies have already reported different toxicological effects of MNPs including developmental toxicity, reproductive toxicity, neurotoxicity, immunotoxicity, cytotoxicity, and phytotoxicity (Supplementary table 1). MNPs induce toxic effects by disrupting redox homeostasis (oxidative stress) and modulating gene expression (Alomar et al. 2017; Espinosa et al. 2017; Yu et al. 2018). The increased surface area of MNPs and surface chemistry enable them to interact with organic/inorganic pollutants (Turner and Holmes 2015; Wang et al. 2019; Tang et al. 2020; Mao et al. 2020; Singh et al. 2020). Thus, MNPs can act as vectors for a large number of organic/inorganic pollutants including HMs due to their sorption

Chayan Biswas, Sambuddha Banerjee and Rajkumar Guchhait contributed equally to this work.

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Overview on Anorexia Nervosa: An eating disorder

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ABSTRACT

Anorexia nervosa is a serious mental disorder with a characteristic appearance. It can affect people of all ages, genders, sexual orientations, races, and ethnicities, but it is especially dangerous for adolescent girls and young adult women. Anorexia is caused by a combination of psychological, societal, and biological variables, and there is no single cause. Anorexia nervosa affects about 0.5–1.0 percent of women over the world. Previous research suggested that anorexia nervosa is a condition that exclusively affects women in Western countries; however, recent research has showed that it is more common in boys than previously assumed. The higher rate of anorexia nervosa in western countries compared to non-western countries was explained by cultural differences, as western culture places a high priority on thinness in young women. Being skinny, on the other hand, is socially unacceptable in most non-western cultures. Although anorexia nervosa is primarily a problem in Western countries, current data suggests that it is spreading to non-Western countries in both genders. This phenomenon was explained by a number of factors, including Western media attention, social and parental pressure, genetic and biochemical variables, and other psychological problems including such sexual abuse and poor self are also contributors.

KEYWORDS: eating disorder, Western media attention, social and parental pressure, genetic and biochemical variables, Depression, anxiety

1. INTRODUCTION

Eating disorder is a psychological condition characterised by food avoidance, excessive consumption, or purging. It's also been stated that eating disorders are a form of dependency. Eating becomes a source of reliance, disrupting everyday life's equilibrium (Arcelus et al., 2011). Others define eating disorders as a disease that leads to the adoption of unhealthy eating behaviours. Teenage girls and young women are more likely to suffer from these diseases.

Psychologists define an eating disorder as a psychiatric condition that interferes with normal eating behaviour (Smith, 2012).

Characteristics of Eating Disorder

Extremes characterise this illness. It appears when a person's eating behaviour is severely disrupted, such as intense distress or concern over body weight or shape. Unlike hysteria, an eating disorder involves manipulating one's food intake and being obsessive about one's own body's shape and weight (Attia,

It is evident that luteinizing hormone (LH) secretion pattern slows down which ultimately leads to reduced ovarian stimulation, cessation of menstruation and amenorrhea(Steinhausen, 2002).

Thus, patients having anorexia nervosa exhibits a wide range of symptoms, associated with hypothyroidism, cold intolerance, hypothermia, constipation, reduced basal metabolic rate (BMR), bradycardia, and hypercholesterolemia(Mitchell & Crow, 2006).

3. CONCLUSIONS:

Although, anorexia nervosa is the issue of Western-countries; however recent evidence suggests its spread in both genders among non-Western countries. Many factors explained this phenomenon, of which Western media exposure, peer and family pressure, genetic and molecular factors and other psychological factors as sexual abuse and low self-esteem.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

- [1] Abraham, S. F., & Beumont, P. J. V. (1982). How patients describe bulimia or binge eating. *Psychological medicine*, 12(3), 625-635.
- [2] Agras, W. S., Barlow, D. H., Chapin, H. N., Abel, G. G., & Leitenberg, H. (1974). Behavior modification of anorexia nervosa. *Archives of General Psychiatry*, 30(3), 279-286.
- [3] American Psychiatric Association. (2003). *Diagnostic and Statistical Manual of Mental Disorders DSM 4 TR (Text Revision)*. American Psychiatric Association.
- [4] American Psychiatric Association. *Diagnostic and statistical manual of mental disorders: DSM-5*. Washington, DC: American Psychiatric Association; 2013.
- [5] Arcelus, J., Mitchell, A. J., Wales, J., & Nielsen, S. (2011). Mortality rates in patients with anorexia nervosa and other eating disorders: a meta-analysis of 36 studies. *Archives of general psychiatry*, 68(7), 724-731.
- [6] Attia, E. (2010). Anorexia nervosa: current status and future directions. *Annual review of medicine*, 61, 425-435.
- [7] Gonsalves, D., Hawk, H., & Goodenow, C. (2014). Unhealthy weight control behaviors and related risk factors in Massachusetts middle and high school students. *Maternal and child health journal*, 18(8), 1803-1813.
- [8] Kaye, W. H., Wierenga, C. E., Bailer, U. F., Simmons, A. N., & Bischoff-Grethe, A. (2013). Nothing tastes as good as skinny feels: the neurobiology of anorexia nervosa. *Trends in neurosciences*, 36(2), 110-120.
- [9] Khalua, R. K., Mondal, R., & Tewari, S. (2019). Comparative evaluation of anti-inflammatory activities of three Indian medicinal plants (*Alstoniascholaris* Linn, *Swertia chirata*, *Swietenia macrophylla* Linn.). 8(8): 396-400.
- [10] Khalua, R. K., Tewari, S., & Mondal, R. (2019). Review on effect of nutrient on anxiety and depression during pregnancy and its management by foods. *Journal of*. 6 (5), 33-41
- [11] Makino, M., Tsuboi, K., & Dennerstein, L. (2004). Prevalence of eating disorders: a comparison of Western and non-Western countries. *Medscape general medicine*, 6(3).
- [12] Mitchell, J. E., & Crow, S. (2006). Medical complications of anorexia nervosa and bulimia nervosa. *Current Opinion in Psychiatry*, 19(4), 438-443.
- [13] Mustelin, L., Silén, Y., Raevuori, A., Hoek, H. W., Kaprio, J., & Keski-Rahkonen, A. (2016). The DSM-5 diagnostic criteria for anorexia nervosa may change its population prevalence and prognostic value. *Journal of psychiatric research*, 77, 85-91.
- [14] Smink, F. R., Van Hoeken, D., & Hoek, H. W. (2012). Epidemiology of eating disorders: incidence, prevalence and mortality rates. *Current psychiatry reports*, 14(4), 406-414.
- [15] Smith, H. (2012). Anorexia nervosa and eating disorders. *SA Pharmaceutical Journal*, 79(6), 34-36.
- [16] Steinhausen, H. C. (2002). The outcome of anorexia nervosa in the 20th century. *American journal of Psychiatry*, 159(8), 1284-1293.
- [17] Tewari, S., (2019). *Therapeutic diet to control diseases*, AkiNik Publications, 1-79.
- [18] Tewari, S., Das, S. K., Parida, S., & Gosh, T. (2019). A comparative study on alcoholic and non-alcoholic person with RDA in our locality (Kapasaria, West Bengal). *Journal of the Pharma Innovation*, 8(3), 183-187.
- [19] Tewari, S., Ramkrishna, K. S., & Dhiman, T. (2020). A review on nutraceutical: the combination of nutrition and pharmaceutical. *World Journal Of Pharmacy And Pharmaceutical Sciences*, 9(5), 33-41.
- [20] Tozzi, F., Sullivan, P. F., Fear, J. L., McKenzie, J., & Bulik, C. M. (2003). Causes and recovery in anorexia nervosa: The patient's perspective. *International Journal of Eating Disorders*, 33(2), 143-154.
- [21] Want, S. C. (2009). Meta-analytic moderators of experimental exposure to media portrayals of women on female appearance satisfaction: Social comparisons as automatic processes. *Body image*, 6(4), 257-269.
- [22] Widiger, T. A., & Samuel, D. B. (2005). Diagnostic categories or dimensions? A question for the Diagnostic and statistical manual of mental disorders--. *Journal of abnormal psychology*, 114(4), 494.
- [23] Woerwag-Mehta, S., & Treasure, J. (2008). Causes of anorexia nervosa. *Psychiatry*, 7(4), 147-151.



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Malnutrition and immunity: A review

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Abstract

Malnutrition, which includes both lack and overnutrition, is a major cause of disease and mortality around the world. Malnutrition is caused by dietary absorption problems, but it is also marked by recurring infections and persistent inflammation, signaling an underlying immunological problem. Defects arise in the immunopigenome of impoverished parents before birth, and these may lead to intergenerational malnutrition cycles. Immune dysfunction is both a cause and a consequence of starvation, according to this review, which includes major recent data from experimental animals, *in vitro* models, and human cohorts. We emphasize gaps in existing understanding of immune-physiological dysfunction in malnutrition, with the goal of therapeutically addressing immunological pathways as a novel strategy to reduce morbidity and death in children.

Keywords: Immunoepigenome, low of protein diet, malnutrition cycles, immune dysfunction, dietary absorption

Introduction

Malnutrition as an Immunodeficiency Syndrome

Malnutrition, which includes both under- and over-nutrition, causes a huge health burden worldwide (Rahman and Adjero, 2015; Black *et al.*, 2013) [35, 6]. Nutritional aspects have always found to be very instrumental with the physiological attributes not only that various nutritional changes input various physiological changes projecting the deficiency and sufficiency of the key factors responsible for the particular nutrient markers.

Despite being usually described as poor nutritional digestion, malnutrition is not solely caused by a lack of food intake. Obesity can develop without a poor diet and continue even if a healthy diet is adopted (Clemente *et al.*, 2012; DeBoer *et al.*, 2012; Godfrey *et al.*, 2011; Gregor and Hotamisligil, 2011; van der Klaauw and Farooqi, 2015) [8, 11, 17, 19, 48], while intensive feeding therapies only marginally reduce stunting prevalence (Bhutta, 2008). Despite the fact that under- and overnutrition manifest as separate physical defects, several studies suggest that they share etiological pathways: early-life undernutrition increases the risk of obesity later in life (DeBoer *et al.*, 2012; Roseboom, 2006) [11, 38], altered metabolism (Bartz *et al.*, 2014; Kong *et al.*, 2014; O'Keefe *et al.*, 2015) [3, 24, 29], chronic inflammation (Kong *et al.*, 2014; Prendergast *et al.*, 2014; Kosek *et al.*, 2013) [24, 32, 25], and gut dysfunction (enteropathy) (Kong *et al.*, 2014; O'Keefe *et al.*, 2015; Subramanian *et al.*, 2014) [24, 29, 46], in overweight people, excessive calorie and macronutrient intake is commonly linked to micronutrient deficiencies. Malnutrition is increasingly being recognized as a complex condition with overlapping and poorly understood comorbidities (Humphrey, 2009; Prendergast *et al.*, 2014; Ahmed *et al.*, 2014) [21, 33, 2]. In order to create novel therapeutic diet (Therapeutic diet is a diet which is given to the patient who is suffering from any type of disease condition (Tewari, 2019) [47] to support international aims to increase nutrition, health, and well-being, pathogenesis across the malnutrition spectrum must be characterized.

Malnutrition affects immunity

A primary immunodeficiency is an immune system condition caused by a genetic or developmental defect. Secondary or acquired immunodeficiency is the loss of immunological function caused by a range of external factors. Although infection with the human immunodeficiency virus (HIV) is the most well-known cause of secondary immunodeficiency, acute malnutrition is the most prevalent cause of immunodeficiency worldwide, affecting up to 50% of the population in some underprivileged communities (Geraix *et al.*, 2008) [15]. Both innate and adaptive immunity are affected by immune system abnormalities.

- 2001;106(3):255-258.
29. O'Keefe SJ, Li JV, Lahti L, Ou J, Carbonero F, Mohammed K, *et al.* Fat, fibre and cancer risk in African Americans and rural Africans. *Nature communications*. 2015;6(1):1-14.
 30. Pereira-Santos M, Costa PDF, Assis AD, Santos CDS, Santos DD. Obesity and vitamin D deficiency: a systematic review and meta-analysis. *Obesity reviews*. 2015;16(4):341-349.
 31. Petro TM, Schwartz KM, Chen SSA. Production of IL2 and IL3 in syngeneic mixed lymphocyte reactions of BALB/c mice are elevated during a period of moderate dietary protein deficiency. *Immunological investigations*. 1994;23(2):143-152.
 32. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. *Paediatrics and international child health*. 2014;34(4):250-265.
 33. Prendergast AJ, Rukobo S, Chasekwa B, Mutasa K, Ntozini R, Mbuya MN, *et al.* Stunting is characterized by chronic inflammation in Zimbabwean infants. *PloS one*. 2014;9(2):e86928.
 34. Prendergast AJ. Malnutrition and vaccination in developing countries. *Philos. Trans. R. Soc. Lond. B Biol. Sci*, 2015, 370pp.
 35. Rahman SA, Adjeroh D. Surface-based body shape index and its relationship with all-cause mortality. *PLoS One*. 2015;10(12):e0144639.
 36. Redmond HP, Shou J, Kelly CJ, Schreiber S, Miller E, Leon P, Daly JM. Immunosuppressive mechanisms in protein-calorie malnutrition. *Surgery*. 1991;110(2):311-317.
 37. Reyes A, Blanton LV, Cao S, Zhao G, Manary M, Trehan I, *et al.* Gut DNA viromes of Malawian twins discordant for severe acute malnutrition. *Proceedings of the National Academy of Sciences*. 2015;112(38):11941-11946.
 38. Roseboom T, de Rooij S, Painter R. The Dutch famine and its long-term consequences for adult health. *Early human development*. 2006;82(8):485-491.
 39. Rytter MJH, *et al.* The immune system in children with malnutrition—a systematic review. *PLoS ONE*. 2014;9:e105017.
 40. Sánchez A, Rojas P, Basfi-Fer K, Carrasco F, Inostroza J, Codoceo J, *et al.* Micronutrient deficiencies in morbidly obese women prior to bariatric surgery. *Obesity surgery*. 2016;26(2):361-368.
 41. Savino W. The thymus gland is a target in malnutrition. *European journal of clinical nutrition*. 2002;56(3):S46-S49.
 42. Savy M, *et al.* Landscape analysis of interactions between nutrition and vaccine responses in children. *J Nutr*. 2009;139:2154s-2218s
 43. Smith MI, Yatsunencko T, Manary MJ, Trehan I, Mkakosya R, Cheng J, *et al.* Gut microbiomes of Malawian twin pairs discordant for kwashiorkor. *Science*. 2013;339(6119):548-554.
 44. Souza ME. Evaluation of the intestinal microbiota of individuals injured by biological materials in occupational accidents and subjected to antiretroviral prophylaxis. *Journal of Venomous Animals and Toxins including Tropical Diseases*. 2007;13:694-694.
 45. Stapleton PP, Fujita J, Murphy EM, Naama HA, Daly JM. The influence of restricted calorie intake on peritoneal macrophage function. *Nutrition*. 2001;17(1):41-45.
 46. Subramanian S, Huq S, Yatsunencko T, Haque R, Mahfuz M, Alam MA, *et al.* Persistent gut microbiota immaturity in malnourished Bangladeshi children. *Nature*. 2014;510(7505):417-421.
 47. Tewari S. *Therapeutic diet to control diseases*, AkiNik Publications, 2019, 1-79.
 48. Van der Klaauw AA, Farooqi IS. The hunger genes: pathways to obesity. *Cell*. 2015;161(1):119-132.
 49. Veldhoen M, Ferreira C. Influence of nutrient-derived metabolites on lymphocyte immunity. *Nature medicine*. 2015;21(7):709-718.
 50. Xavier JG, Favero ME, Vinolo MAR, Rogero MM, Dagli MLZ, Arana-Chavez VE, *et al.* Protein-energy malnutrition alters histological and ultrastructural characteristics of the bone marrow and decreases haematopoiesis in adult mice. *Histology and histopathology*, 2007.



Human/Non-human Interface and the Affective Uncanny in Amitav Ghosh's *Gun Island*

Asis Deⁱ

Abstract

Postcolonial fiction depicting transnational human mobility across landscapes and cultural spaces often represents the variable “structure of feeling” in a human being with continuous ‘de-’ and ‘re-territorialization’ (Grossberg 313) from the familiar space to the unfamiliar. Experiences of lived realities and relationships alter with time and space, simultaneously affecting human understanding of logic and thereby leaving a scope to interpret newer experiences on multiple levels such as the mysterious, uncanny, or the exotic. It is not just the fictional character/s in literary narratives but also the reader/s who feel affected by the relationality between the rational and the mysterious as emotional affect “arises in the midst of in-between-ness” (Seigworth and Gregg 1). The epistemic lens of affect theory has been used in this essay to explore the human/non-human relationships in Amitav Ghosh’s novel *Gun Island* (2019). I would show how, in Ghosh’s narrative, the human/non-human interface has been perceived by inventories of belonging and migration, and often represented with an interplay of the corporeal and the uncanny, mainly aiming at emotional affect sandwiched between anxiety and hope— both conditions of postcoloniality and ecological engagement. The representation of the human/non-human relationships in literary narratives depends heavily on imaginative correspondence, where the affective exceptional may find its easy place. Examining several episodes in the novel, I would discuss how the corporeality of a snake, spider, shipworm, or even a wildfire affects the incorporeal cognitive dimensions like trauma or anxiety in Dinanath— the central character, and reshapes his “structure of feeling.”

Keywords

human/non-human interface, affect, uncanny, corporeal, sensorial

Introduction

One of the exclusive twenty-first-century cultural phenomena is the ever-increasing use of digital and computational technology and devices, where space for the imaginative and the emotional requires, quite naturally, a new reconfiguration. The visible emergence of the interdisciplinary research network of affect studies in the last two decades can be seen as a part of this process of cultural reconfiguration. While the application of digital and computational technology demonstrates the *relatedness* of corporeal organic matters with logical and mathematical precision, the critical lens of Affect theory “*accumulates* across both relatedness and interruptions in relatedness” (Seigworth and Gregg 2). In the ‘Introduction’ to *The Affect*

Seigworth, Gregory J. and Melissa Gregg. "An Inventory of Shimmers." *The Affect Theory Reader*, edited by Melissa Gregg and Gregory J. Seigworth, Duke University Press, 2010, pp. 1-25.

Stewart, Kathleen. "Worlding Refrains," *The Affect Theory Reader*, edited by Melissa Gregg and Gregory J. Seigworth, Duke University Press, 2010, pp. 339-353.

Trigg, Dylan. *The Memory of Place: A Phenomenology of the Uncanny*. Ohio University Press, 2012.

Williams, Raymond. *Culture and Materialism* (1980). Verso, 2005.

Notes

¹ In the book launch event of *Gun Island* in Delhi on 19 June 2019, Ghosh admits that the novel is not just about climate change, it's much more: "I wouldn't say it's climate change, it's not just that...it's something much more complicated, it's the reality that we live in, and the reality that we live in today is so fractured, is so sort of strange that there's something so uncanny about the way the world is changing." See the full interview here: <https://www.youtube.com/watch?v=r5RbdChKMv4> (accessed 25 January 2021).

² In both the post-publication book launch events in Delhi and Kolkata, Ghosh claims that in no way, *Gun Island* should be seen as the sequel of *The Hungry Tide*, which he wrote fifteen years back in 2004. However, there are some conceptual connections between the two novels. The Delhi book launch event could be accessed here: <https://www.youtube.com/watch?v=r5RbdChKMv4> (accessed 25 January 2021); For the Kolkata event, see: <https://www.youtube.com/watch?v=lr41o6qN1lg> (accessed 25 January 2021).

³ In the medieval Bengali literature entitled *Manasamangal Kāvya* authored by Khemananda and in some other Bengali folkloric legends, one may notice such merchant figures that stand as powerful and ruthless men, mostly Shaivaites by religion and without any reverence for the "subaltern" deities like Manasa. Like the Gun Merchant in Ghosh's *Gun Island*, the most well-known of such traders is Chandradhar or Chand Sadagar. See *Manasamangal Kāvya* for details.

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28. *গার্হস্থ্যশ্রাম-নির্ভর প্রাচীন-ভারতীয় অর্থনীতি—একটি বিশেষ সমীক্ষা* 227
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বৈশেষিকসূত্রের আঙ্গিকে প্রত্যক্ষপ্রমাণের প্রামাণ্য

বিভাস গিন্টী

সারসংক্ষেপ

বৈশেষিক মতে প্রত্যক্ষ ও অনুমান এই দুটি প্রমাণ স্বীকৃত। প্রত্যক্ষকে বলা হয় প্রমাণজ্যেষ্ঠ, অর্থাৎ সমস্ত প্রমাণের মধ্যে প্রত্যক্ষ সর্বাপেক্ষা গুরুত্বপূর্ণ। প্রত্যক্ষ প্রমাণ সমস্ত সম্প্রদায়ে স্বীকৃত। প্রত্যক্ষের প্রামাণ্য বিষয়ে কোন বিবাদ নেই। বৈশেষিকদর্শনের প্রাচীনতম মূলগ্রন্থ হল কণাদ রচিত বৈশেষিকসূত্র। বৈশেষিকসূত্রে প্রত্যক্ষ প্রমাণের স্বরূপ সম্পর্কে প্রায় কিছুই পাওয়া যায় না। প্রত্যক্ষকে একটি বিষয়রূপে নির্দিষ্ট করে কোন আলোচনা করা হয়নি। তবে একথা ঠিক যে, কোন কোন প্রসঙ্গে অবশ্যই প্রত্যক্ষপ্রমাণ বা তার কারণ সম্পর্কে উল্লেখ রয়েছে। যেমন তৃতীয় অধ্যায়ের প্রথম আঙ্গিকে আত্মার অস্তিত্ব প্রমাণের প্রসঙ্গে একটি সূত্রে বলা হয়েছে আত্মা ও ইন্দ্রিয়ার্ধ সন্নিকর্ষ থেকে জ্ঞান উৎপন্ন হয়। এখানে প্রত্যক্ষ শব্দের উল্লেখ না থাকলেও ইন্দ্রিয়ার্ধ সন্নিকর্ষের উল্লেখ থাকায় বোঝা যাচ্ছে যে, প্রত্যক্ষের কথাই বলা হয়েছে। প্রত্যক্ষ এমন একপ্রকার জ্ঞান যা চতুষ্ঠয়সন্নিকর্ষ থেকে উৎপন্ন হয়। টিকাকাররা তাই বলেছেন, আত্মার সঙ্গে মনের সংযোগ হয়, মনের সঙ্গে ইন্দ্রিয়ের সংযোগ হয় এবং ইন্দ্রিয়ের সঙ্গে বিষয়ের সংযোগ হলে প্রত্যক্ষ উৎপন্ন হয়। বৈশেষিকসূত্রের প্রাচীন কোন ব্যাখ্যা পাওয়া যায় না। কণাদ প্রদত্ত প্রত্যক্ষের লক্ষণসূত্রটি উল্লেখ করে বৌদ্ধ দার্শনিক দিগ্‌নাগের মন্তব্য এখানে আমি আলোচনা করছি। পূর্বপক্ষীর যুক্তি উল্লেখ করে প্রত্যক্ষ বিষয়ে গৌতমের মতও আলোচনা করছি আমার এই প্রবন্ধে।

শব্দসংকেত : প্রত্যক্ষ, ইন্দ্রিয়ার্ধসন্নিকর্ষ, স্বর্ণক, উদ্ভূতত্ব, অনভিত্তত্ব, রসত্ব।

বৈশেষিকসূত্রের আঙ্গিকে প্রত্যক্ষপ্রমাণের প্রামাণ্য :

বৈশেষিক মতে প্রত্যক্ষ ও অনুমান এই দুটি প্রমাণ স্বীকৃত। প্রত্যক্ষকে বলা হয় প্রমাণজ্যেষ্ঠ, অর্থাৎ সমস্ত প্রমাণের মধ্যে প্রত্যক্ষ সর্বাপেক্ষা গুরুত্বপূর্ণ। প্রত্যক্ষ প্রমাণ সমস্ত সম্প্রদায়ে স্বীকৃত। প্রত্যক্ষের প্রামাণ্য বিষয়ে কোন বিবাদ নেই। এমনকি চর্চাকর্যও প্রত্যক্ষকে প্রমাণরূপে স্বীকার করেন। দ্বিতীয়তঃ প্রত্যক্ষ ভিন্ন প্রমাণগুলি প্রত্যক্ষের উপর নির্ভরশীল হয়। প্রত্যক্ষ প্রমাণের গুরুত্ব আরো কারণ হলো যে, প্রত্যক্ষ প্রমাণের দ্বারা জ্ঞান উৎপন্ন হলে সে বিষয়ে কোন প্রকার সংশয়ের অবকাশ থাকে না। এইসব যুক্তিতে প্রত্যক্ষকে সবার উপরে স্থান দেওয়া হয়।^১

বৈশেষিকসূত্রে প্রত্যক্ষ :

বৈশেষিকদর্শনের প্রাচীনতম মূলগ্রন্থ হল কণাদ রচিত বৈশেষিকসূত্র। বৈশেষিকসূত্রে প্রত্যক্ষ প্রমাণের স্বরূপ সম্পর্কে প্রায় কিছুই পাওয়া যায় না। প্রত্যক্ষকে একটি বিষয়রূপে নির্দিষ্ট করে কোন আলোচনা করা হয়নি। তবে একথা ঠিক যে, কোন কোন প্রসঙ্গে অবশ্যই প্রত্যক্ষপ্রমাণ বা তার কারণ সম্পর্কে উল্লেখ রয়েছে। যেমন তৃতীয় অধ্যায়ের প্রথম আঙ্গিকে আত্মার অস্তিত্ব প্রমাণের প্রসঙ্গে একটি সূত্রে বলা হয়েছে আত্মা ও ইন্দ্রিয়ার্ধসন্নিকর্ষ থেকে জ্ঞান উৎপন্ন হয়।^২ এখানে প্রত্যক্ষ শব্দের উল্লেখ না থাকলেও

ইন্দ্রিয়াধর্মনিকর্ষের উল্লেখ থাকায় বোঝা যাচ্ছে যে, প্রত্যক্ষের কথাই বলা হয়েছে। আবার তৃতীয় অধ্যায়ের দ্বিতীয় আদিক্কে মনের অনুমান প্রসঙ্গে একটি সূত্রে বলা হয়েছে, আত্মা ও বিায়ের সম্পদ সত্ত্বেও জ্ঞানের উৎপত্তি ও অনুৎপত্তি মনের অনুমাপক হয়।^৩ পঞ্চম অধ্যায়ের দ্বিতীয় আদিক্কে একটি সূত্র পাওয়া যায়, সেই সূত্রে বলা হয়েছে, আত্মা, ইন্দ্রিয়, মন ও অর্ধের সন্নিকর্ষ থেকে সুখ ও দুঃখ উৎপন্ন হয়। সূত্রটির যাাযায় শঙ্করমিশ্র বলেছেন শুধু সুখ ও দুঃখই নয়, জ্ঞান এবং প্রযত্ন এই চারটির সম্পদ থেকে উৎপন্ন হয়।^৪ আলোচিত প্রসঙ্গ যাই হোক না কেন একথা স্পষ্ট যে, প্রত্যক্ষ এমন একপ্রকার জ্ঞান যা চতুষ্ঠিসন্নিকর্ষ থেকে উৎপন্ন হয়। টীকাকাররা তাই বলেছেন, আত্মার সঙ্গে মনের সংযোগ হয়, মনের সঙ্গে ইন্দ্রিয়ের সংযোগ হয় এবং ইন্দ্রিয়ের সঙ্গে বিায়ের সংযোগ হলে প্রত্যক্ষ উৎপন্ন হয়। বৈশেষিকসূত্রের প্রতিনি কেন ব্যাখ্যা পাওয়া যায় না। শঙ্কর মিশ্র প্রভৃতি টীকাকাররা অনেক পরবর্তীকালের, ততদিনে নানা রকম মতবাদ প্রচলিত হয়ে গেছে। টীকাকাররা ঐ সব মতবাদের দ্বারা প্রভাবিত হয়ে কণাদের সংশ্লিষ্ট সূত্রের মধ্যে নানা রকম তাৎপর্ষ উদ্ভাবন করেন। কিন্তু এইসব ব্যাখ্যা ঐতিহাসিকভাবে এবং যুক্তিগতভাবে কতখানি গ্রহণযোগ্য সে বিষয়ে সংশয়ের অবকাশ থেকেই যায়।

সাধারণতঃ বলা হয়, চতুষ্ঠয়সন্নিকর্ষ থেকে প্রত্যক্ষ জ্ঞান উৎপন্ন হয়। কিন্তু প্রত্যক্ষজ্ঞানের ক্ষেত্রে করণ কি? প্রত্যক্ষ প্রমাণ বলতে ঠিক কোনটিকে বোঝায় এ বিষয়ে স্পষ্ট নির্দেশ কণাদের সূত্রে পাওয়া যায় না। এই প্রসঙ্গে বৌদ্ধ দার্শনিক দিঙ্নাগের মতব্য থেকে সাহায্য পাওয়া যায়। তাঁর বিখ্যাত গ্রন্থ ‘প্রমাণসমুচ্চয়ের’ প্রত্যক্ষ পরিচ্ছেদে বৈশেষিক মতের সমালোচনায় প্রত্যক্ষের করণ বিষয়ে দুটি মত প্রচলিত ছিল, এই রকম তথ্য পাওয়া যায়। কণাদ প্রদত্ত প্রত্যক্ষের লক্ষণ সূত্রটি উল্লেখ করে দিঙ্নাগ বলেছেন :

‘কেচিৎ প্রমাণেৎ ফলমর্থাত্তরমিচ্ছতোভসাধারণকারণত্বাদিন্দ্রিয়াধর্মনিকর্ষঃ প্রমাণমিত্যাহুঃ।’^৫

প্রমাণ ও প্রমাণের ফল ভিন্ন না কি অভিন্ন এ বিষয়ে ভারতীয়দর্শনে ভিন্ন ভিন্ন মত পাওয়া যায়। বৈশেষিকরা প্রমাণ ও তার ফলকে ভিন্ন বলে মনে করেন। একদল মনে করেন, ইন্দ্রিয়াধর্মনিকর্ষকে প্রমাণ অর্থাৎ করণ স্বীকার করা উচিত। কারণ সন্নিকর্ষই প্রত্যক্ষের ক্ষেত্রে অসাধারণ কারণ। কারণ বলতে অসাধারণ কারণকেই বোঝায়। এই মত প্রায় সকলেই স্বীকার করেন। প্রত্যক্ষের ক্ষেত্রে অন্যান্য যে সন্নিকর্ষের কথা বলা হয়েছে সেগুলি স্মৃতি প্রভৃতি অন্যান্য জ্ঞানের ক্ষেত্রেও কারণ হওয়া সাধারণ কারণরূপে গণ্য হয়। অসাধারণ ধর্মকে উল্লেখ করে লক্ষণ করাই নিয়ম। সাধারণ ধর্মকে লক্ষণরূপে উল্লেখ করা ঠিক নয়। কারণ তাহলে অতিব্যাপ্তির আশঙ্কা দেখা দেয়। প্রত্যক্ষ ভিন্ন অন্য জ্ঞানের ক্ষেত্রে ইন্দ্রিয়সন্নিকর্ষ কারণ হয় না। প্রমাণসমুচ্চয়ের বিখ্যাত টীকাকার জিনেন্দ্রবুদ্ধি মনে করেন শায়স্ক প্রভৃতি এই মতের সমর্থক ছিলেন।^৬ কিন্তু অন্যান্য মনে করেন আত্মনঃসন্নিকর্ষই প্রধান, এই সন্নিকর্ষকেই করণের মর্যাদা দেওয়া উচিত। জিনেন্দ্রবুদ্ধির মতে রাবণ প্রভৃতি এই মত পোষণ করতেন। জ্ঞানের ক্ষেত্রে আত্মা ও মন এই দুটি পদার্থই প্রধান। ফলে তাদের সন্নিকর্ষও প্রধান হওয়া উচিত। আত্মার প্রাধান্যের কারণ হলে আত্মাই জ্ঞানের কর্তা। দ্বিতীয়তঃ জ্ঞানই হয় আত্মার অনুমাপক লিঙ্গ। বৈশেষিক মতে জ্ঞান গুণপদার্থ। প্রত্যেকটি গুণ কোন না কোন দ্রব্যে সমবায় সম্বন্ধে বিদ্যমান হয়। পৃথিবী প্রভৃতি অন্য কোন দ্রব্য জ্ঞানের আশ্রয় হতে পারে না। সেক্ষেত্রে জ্ঞানের আশ্রয় হয় এমন দ্রব্যরূপে আত্মাকে স্বীকার করা হয়। তৃতীয়তঃ আত্মা ফলের ভোক্তা। অদৃষ্টের দ্বারা সুখ দুঃখ ইত্যাদি যে ফল উৎপন্ন হয়, সেগুলি আত্মাতেই বিদ্যমান হয়। অন্য কোন দ্রব্য ভোক্তা হয় না। অতএব আত্মা প্রধান। মনেরও প্রাধান্য

আছে। কারণ মন হচ্ছে সববিষয়ক। মন ভিন্ন চক্ষু প্রভৃতি যে পাঁচটি হৃদয়ের স্বীকার করা হয়েছে সেগুলির বিষয় নিয়ত বা নির্দিষ্ট। যেমন চক্ষু কেবল রূপকে গ্রহণ করে, গন্ধকে গ্রহণ করে না। নাসিকা কেবল গন্ধকে গ্রহণ করে, কিঙ্ক রূপকে গ্রহণ করে না। মনের ক্ষেত্রে এইরকম নির্দিষ্ট নিয়ম নেই। যে কোন প্রত্যক্ষ অবশ্যই মনের ভূমিকা থাকে। জ্ঞান ইচ্ছা প্রভৃতি সমস্ত আত্মার বিশেষ গুণের উৎপত্তিতে আত্মান-সংযোগ সমব্যয়িকারণ হয়। সুতরাং অন্যান্য হৃদয়ের অপেক্ষায় মনকেই প্রধান বলা যায়। এই যুক্তিতে আত্মানঃ সংযোগকে প্রত্যক্ষের কারণ বলা উচিত।^৭

এখানে উল্লেখযোগ্য যে, ষাটিনকালে এই বিষয়ে যে বিবাদ ছিল তার পরিচয় গৌতমের *ন্যায়সূত্র* ও পাণ্ডা যায়। *ন্যায়সূত্র* এর প্রথম অধ্যায়ের প্রথম আহ্নিকের চতুর্থ সূত্রে গৌতম প্রত্যক্ষের লক্ষণ বলেছেন।^৮ সেখানে তিনি বলেছেন প্রত্যক্ষ এমন একপ্রকার জ্ঞান যা হৃদয়মাধ্বস্নিকর্ষ থেকে উৎপন্ন হয়। এই সূত্রের ভাষ্য বাৎস্যায়ন প্রথমেই একটি পূর্বপক্ষের উত্থাপন করেছেন যে, গৌতমের প্রত্যক্ষ লক্ষণটি সংগত হয়নি। কারণ শুধুমাত্র হৃদয় ও অর্ধের স্নিকর্ষ হলেই প্রত্যক্ষ উৎপন্ন হয় না। আত্মা ও মন এবং মন ও হৃদয়ের সংযোগও অপেক্ষিত হয়। সুতরাং গৌতমের ঐ স্নিকর্ষগুলিকেও উল্লেখ করা উচিত ছিল।^৯ বাৎস্যায়ন চতুর্থ সূত্রের ভাষ্য এই পূর্বপক্ষ উত্থাপন করলেও সূত্রাকার গৌতম কিন্তু নিজেই দ্বিতীয় অধ্যায়ে এই আপত্তির আলোচনা করেছেন এবং উত্তর দিয়েছেন। *ন্যায়সূত্র* গৌতম প্রমাণ প্রভৃতি ষোলটি পদার্থের উদ্দেশ্য, লক্ষণ ও পরীক্ষা এই তিনটি ধাপে স্বরূপ নির্ণয় করেছেন। তিনটি সূত্রে তিনি পূর্বপক্ষীদের বক্তব্য উপস্থাপিত করেছেন।^{১০} পূর্বপক্ষীদের দাবী, প্রত্যক্ষের লক্ষণে সমস্ত প্রয়োজনীয় কথা বলা হয়নি, লক্ষণটি অসম্পূর্ণ। আত্মা ও মনের স্নিকর্ষ না হলে প্রত্যক্ষ উৎপন্ন হয় না। প্রত্যক্ষ পূর্বে বিদ্যমান থাকে শুধুমাত্র এই যুক্তিতে যদি হৃদয়মাধ্বস্নিকর্ষকে কারণ বলা হয়, তাহলে দিক, দেশ, কাল এবং আকাশের ক্ষেত্রেও সেকথা প্রয়োজ্য হতে পারে। দিক ইত্যাদি পদার্থগুলি নিত্য এবং বিদ্যুৎ। তারা সর্বদা সর্বত্র বিদ্যমান থাকে। তারা সমস্ত কার্যের পূর্ববর্তী হয়, প্রত্যক্ষেরও পূর্ববর্তী হয়। ফলে তাদেরও প্রত্যক্ষ কারণ হওয়ার আপত্তি হয়।^{১১}

পূর্বপক্ষীর যুক্তি উল্লেখ করার পর গৌতম তার নিজের মতে বলেছেন। প্রত্যক্ষের লক্ষণে আত্মানঃ সংযোগের উল্লেখ নেই, একথা ঠিক। তবে এর অর্থ এই নয় যে, প্রত্যক্ষ এই সংযোগের গুরুত্ব গৌতম স্বীকার করেন না। আত্মানঃসংযোগ যে প্রত্যক্ষের কারণ হয়, একথা বোঝা যায় গৌতমের অন্য একটি সূত্রের ভাষ্য থেকে^{১২} গৌতমের মতে আত্মা দেহাতিরিক্ত পদার্থ এবং প্রত্যক্ষের অন্তর্ভুক্ত। আত্মার অস্তিত্বের প্রমাণ হল অনুমান এবং সেই অনুমানে হেতু হয় জ্ঞান। অর্থাৎ জ্ঞানের আশ্রয় হল আত্মা। আত্মা একটি দ্রব্য এবং জ্ঞান তার গুণ। সুতরাং আত্মা জ্ঞান মাত্রের কারণ হয়। কিন্তু আত্মা নিত্য, সর্বকালে বিদ্যমান হয়। তবু বাস্তব ঘটনা হল সর্বকালে আত্মাতে জ্ঞান জন্মে না। কাজেই স্বীকার করতে হয় আত্মা জ্ঞানের উৎপত্তিতে কোন সংযোগবিশেষের উপর নির্ভর করে। ঐ বিশেষ সংযোগ হল আত্মানঃসংযোগ। এজন্য আলাদা করে এই সংযোগের কথা প্রত্যক্ষসূত্রে বলা হয়নি।

আত্মানঃসংযোগের মতো হৃদয়মনঃসংযোগও প্রত্যক্ষের কারণ। তবুও প্রত্যক্ষসূত্রে তার উল্লেখ নেই। কিন্তু এতে কোন অসংগতি হয় না। কারণ অন্যতম প্রত্যক্ষ মন সম্পর্কে গৌতম একটি সূত্রে বলেছেন, একই ক্ষণে অনেকগুলি জ্ঞান জন্মে না, এ থেকে মনের অনুমান হয়।^{১৩} *ন্যায়বৈশেষিক*দের একটি নিজস্ব মত হল যে, বিভিন্ন হৃদয়ের নিজ নিজ বিষয়ের সঙ্গে যুগপৎ সম্বন্ধ হলেও একই ক্ষণে জ্ঞানগুলি উৎপন্ন

হয় না। এর কারণ হল মন অণুপরিমাণ হওয়ায় একই ক্ষণে অনেক ইন্দ্রিয়ের সঙ্গে মনের সংযোগ সম্ভব হয় না। একটি ক্ষণে যে ইন্দ্রিয়ের সঙ্গে মনের সম্বন্ধ হয়, সেই ক্ষণে সেই ইন্দ্রিয়ের দ্বারা প্রত্যক্ষ উৎপন্ন প্রত্যক্ষসূত্রে তার উল্লেখ না থাকলেও কোন দোষ হয় না।

ইন্দ্রিয়াধর্ষনিকর্ষকই নাম করে উল্লেখ করে কোন প্রত্যক্ষের লক্ষণ বলা হয়েছে এ বিষয়ে গৌতম যুক্তি উপস্থাপিত করেছেন। আত্মমনঃসংযোগ সর্বপ্রকার জ্ঞানের প্রতি কারণ হয়, কিন্তু ইন্দ্রিয়াধর্ষনিকর্ষ শূন্যাত্ম প্রত্যক্ষ জ্ঞানের প্রতি কারণ হয়। আবার ইন্দ্রিয়মনঃসংযোগ প্রত্যক্ষের প্রতি কারণ হলেও সর্বপ্রকার প্রত্যক্ষের প্রতি কারণ হয় না। সুখ-দুঃখ ইত্যাদি গুণের প্রত্যক্ষে বহির্বিদ্রয়ের প্রয়োজন না থাকায় সেখানে ইন্দ্রিয়মনঃসংযোগ সম্ভব নয়। একমাত্র ইন্দ্রিয়মনঃসংযোগই প্রত্যক্ষের অসাধারণ কারণ হয়। এই কারণকে উল্লেখ করে লক্ষণ করাই সম্ভব হয়েছে।^{১৪}

প্রত্যক্ষে ইন্দ্রিয়াধর্ষনিকর্ষের প্রাধান্য প্রতিপাদন করার জন্য গৌতম দুটি দৃষ্টান্তের উল্লেখ করেছেন। কোন নিদ্রিত ব্যক্তি যখন তীব্র শব্দ শুনেন হঠাৎ জাগরিত হয়, তখন যে জ্ঞানটি তার জাগরণের কারণ হয়, সেই জ্ঞানটির প্রতি প্রধান কারণ হয় অবগোচ্রিয় এবং ঐ শব্দের সম্বন্ধ। আবার যখন কোন অন্যমনস্ক ব্যক্তির সম্মুখে হঠাৎ কোন পদার্থ উপস্থিত হলে সে ঐ পদার্থটিকে প্রত্যক্ষ করতে বাধ্য হয়, তখন ঐ জ্ঞানের প্রতি ঐ পদার্থটি এবং চক্ষুরিন্দ্রিয়ের সম্বন্ধই প্রধান কারণ। এখানে আত্মমনঃসংযোগ থাকলেও তার কিছু প্রাধান্য হয় না। অতএব ইন্দ্রিয়াধর্ষনিকর্ষেরই উল্লেখ সম্ভব হয়। অন্যান্য সম্বন্ধের তুলনায় ইন্দ্রিয়াধর্ষনিকর্ষ যে প্রধান এ বিষয়ে আরও একটি যুক্তি হলো প্রত্যক্ষ জ্ঞানগুলির নামকরণ। যেমন চক্ষুরিন্দ্রিয়ের দ্বারা ঘটের প্রত্যক্ষ হলে সেই জ্ঞানটিকে বলা হয় চাক্ষুষজ্ঞান বা ঘটজ্ঞান। এইভাবে সর্বত্রই ইন্দ্রিয়ের দ্বারা অধবা বিষয়ের দ্বারা প্রত্যক্ষে ব্যাপদেশ করা হয়।^{১৫}

প্রত্যক্ষের উৎপত্তি বিষয়ে এইসব সংক্ষিপ্ত মন্তব্য ছাড়া প্রত্যক্ষ কোথায় কোথায় সম্ভব হয় এ সম্পর্কেও কিছু মন্তব্য কণাদের সূত্রে পাওয়া যায়। যেমন, দ্রব্যপ্রত্যক্ষের সর্ব উল্লেখ করে চতুর্থ অধ্যায়ের প্রথম অঙ্কিকে কণাদ বলেছেন—*মহত্ত্বেনেকদ্রব্যবত্বাদ রূপাচ্ছোপলঙ্ঘিঃ*^{১৬} অর্থাৎ যে দ্রব্য মহৎ পরিমাণ বিশিষ্ট হয়, অনেক কণাদ বললেই গঠিত হয় এবং রূপের আশ্রয় হয়, তার প্রত্যক্ষ হতে পারে। যেমন ঘটের প্রত্যক্ষ হয়, অবয়বের দ্বারা গঠিত হয় এবং রূপের আশ্রয় হয়, তার প্রত্যক্ষ হতে পারে। যেমন ঘটের প্রত্যক্ষ হয়, কিন্তু পরমাণুর প্রত্যক্ষ হয় না, যেহেতু পরমাণুতে মহৎ পরিমাণ থাকে না। শঙ্করমিশ্র প্রথম দুটি সর্বের প্রত্যেকটিই আবশ্যিক কি না এ বিষয়ে বিচার করেছেন। কেউ কেউ মনে করেন, মহৎ পরিমাণের বিদ্যমানতাই যথেষ্ট, অনেক অবয়বের সম্বন্ধে গঠিত এ কথাটি না বললেও চলে, কারণ যে দ্রব্য মহৎ পরিমাণ বিশিষ্ট হয় সেই দ্রব্য অবশ্যই বহু অবয়বের সম্বন্ধে গঠিত হয়। কিন্তু শঙ্করমিশ্রের মতে দুটি সর্বই সমানভাবে প্রয়োজনীয়। যেমন দূরে অতিসূক্ষ্ম সূতোর দ্বারা নির্মিত একখণ্ড বস্ত্রের উপর যদি একটি ক্ষুদ্র মুদ্রের স্থাপিত হয়, তবে মুদ্রেরটির প্রত্যক্ষ হয়, কিন্তু বস্ত্রের প্রত্যক্ষ হয় না, যদিও বস্ত্রটিতে মহত্ত্বের পরিমাণ বিদ্যমান আছে। এর দ্বারা সূচিত হয় যে, প্রত্যক্ষে অবয়ববহুত্বেরও উপযোগিতা আছে।

আবার কোন অবস্থায় রূপের প্রত্যক্ষ হয় তা বোঝাতে একটি সূত্রে কণাদ বলেছেন যে, রূপ অনেক অবয়বের দ্বারা গঠিত দ্রব্যে সমবায় সম্বন্ধে থাকে এবং যে রূপেতে বিশেষ ধর্ম থাকে, সেই রূপের প্রত্যক্ষ হয়।^{১৭} টিকাকারদের মতে রূপেতে বিদ্যমান বিশেষ ধর্মগুলি হল তিনটি—উত্ত্বত্ব, অনভিত্ত্বত্ব এবং রূপত্ব।

যে রূপে এই তিনটি বিশেষ ধর্ম থাকে সেই রূপের প্রত্যক্ষ হয়। পরমাণুরূপের প্রত্যক্ষ হয় না। স্পর্শগুণের প্রত্যক্ষ হয় না, কারণ ঐ গুণে রূপত্ব নেই। চক্ষুর রশ্মি বা তার রূপের প্রত্যক্ষ হয় না, যেহেতু ঐ রূপে উদ্ভূতত্ব নেই।

এই প্রসঙ্গে উল্লেখযোগ্য যে, ঠিক একই আকারের একটি সূত্র ন্যায়সূত্রের তৃতীয় অধ্যায়ের প্রথম আঙ্কিকে পাওয়া যায়। সূত্রটিতে বলা হয়েছে, যে দ্রব্যের বহু অবয়ব থাকে এবং যার মধ্যে বিশেষ ধরনের একটি রূপ থাকে সেই দ্রব্যের এবং তার রূপের প্রত্যক্ষ হয়।^{১৮} ন্যায়সূত্রের ভাষ্যকার বাৎস্যয়ান উদাহরণ দিয়ে সূত্রটির ব্যাখ্যা করেছেন। ছাগুক নামে একপ্রকার অতিক্ষুদ্র দ্রব্য আছে যার উপাদান বা অবয়ব হয় দুটি পরমাণু। অবয়ব বহু না হওয়ায় ছাগুক প্রত্যক্ষ হয় না। রূপ, রস, স্পর্শ ইত্যাদি গুণ আবার দূরকম হয়, উদ্ভূত এবং অনুদ্ভূত। উদ্ভূতরূপ ইত্যাদির প্রত্যক্ষ হয়, অনুদ্ভূত হলে ঐ সব গুণের প্রত্যক্ষ হয় না। যেমন ধরা যাক, সূর্যের রশ্মি। তার রূপ উদ্ভূত। অতএব সূর্যরশ্মি চোখেও দেখা যায় এবং তার উষ্ণতাও অনুভব করা যায়। আবার ধরা যাক প্রদীপের রশ্মি। তার রূপ উদ্ভূত, চোখে দেখা যায় কিন্তু তার স্পর্শ অনুদ্ভূত, উষ্ণতা অনুভব করা যায় না। আবার ধরা যাক গরম জলে মিশে থাকা অগ্নিকণা। তার রূপ অনুদ্ভূত কিন্তু স্পর্শ উদ্ভূত। আবার ধরা যাক, চক্ষুর রশ্মি। তার রূপ এবং স্পর্শ দুইই অনুদ্ভূত। এইভাবে তেজ পদার্থ নানাপ্রকারের হতে পারে এবং তাদের গুণের প্রত্যক্ষ বা অপ্রত্যক্ষও অনুরূপভাবে বুঝে নিতে হবে।^{১৯}

কণাদের সূত্রে আরও বলা হয়েছে, রস, গন্ধ এবং স্পর্শের প্রত্যক্ষেও এইভাবে বিশেষ বিশেষ ধর্মের প্রয়োজনীয়তা আছে। যেমন রসের প্রত্যক্ষের সর্ভ হল—উদ্ভূতত্ব, অনভিভূতত্ব এবং রসত্ব। সাধারণ সর্ভ হিসাবে অনেকে অবয়বের সমন্বয়ে গঠিত দ্রব্যে বিদ্যমানতাকেও গ্রহণ করতে হবে। যেমন স্রাণেদ্রিয়ে বিদ্যমান গন্ধের প্রত্যক্ষ হয় না, কারণ ঐ গন্ধ উদ্ভূত নয়। একটি ক্ষুদ্র প্রস্তরখণ্ডে বিদ্যমান গন্ধের প্রত্যক্ষ হয় না, যেহেতু ঐ গন্ধ অভিভূত। উষ্ণ জলে তেজের ভাস্বর রূপ এবং জলের শীতস্পর্শ অভিভূত হওয়ায় প্রত্যক্ষ হয় না। সুবর্ণের ক্ষেত্রে রূপ উদ্ভূত হলেও তার ঞ্জুরতা ও ভাস্বরতা মিশ্রিত পাণ্ডিৰ উপাদানের পীতবর্ণের দ্বারা অভিভূত হওয়ায় প্রত্যক্ষ হয় না।

গুণ, কর্ম ও সামান্যের প্রত্যক্ষ বিষয়ে সংক্ষেপে সর্বের উল্লেখ করা হয়েছে। যদি এই পদার্থগুলি প্রত্যক্ষযোগ্য কোন দ্রব্যে বিদ্যমান হয় এবং যদি সেই দ্রব্যটির সঙ্গে চক্ষুরিন্দ্রিয়ের সন্নির্কর্ষ হয়, তবে ঐ গুণ ইত্যাদির প্রত্যক্ষ হয়। ঐ সব পদার্থের সঙ্গে সাক্ষাৎভাবে ইন্দ্রিয়ের সম্বন্ধ হয় না, সম্বন্ধ হয় আশ্রয় দ্রব্যের মাধ্যমেই। আশ্রয় প্রত্যক্ষ হয় কিনা এই বিষয়ে মতভেদ দেখা যায়। অনেকে মনে করেন আশ্রয় প্রত্যক্ষ হয় না, অনুমানের দ্বারাই আশ্রয় অস্তিত্ব সিদ্ধ হয়। সাধারণতঃ বলা হয় প্রত্যেকের নিজ নিজ আশ্রয় প্রত্যক্ষ হয়, কিন্তু পরদেহে বিদ্যমান আশ্রাকে অনুমানের দ্বারাই কেবল জানা যায়। তবে বৈশেষিকসূত্রে অন্ততঃ একটি সূত্র পাওয়া যায়, সেখানে আশ্রয় প্রত্যক্ষের কথা বলা হয়েছে। অবশ্য এই প্রত্যক্ষ একপ্রকার মানস প্রত্যক্ষ এবং বিশেষ একপ্রকার আশ্রয়মানঃসংযোগের দ্বারা উৎপন্ন হয়। শঙ্করমিশ্র মনে করেন এই প্রত্যক্ষ শুধুমাত্র যোগীদের পক্ষে সম্ভব এবং কদাচিৎ সাধারণ ব্যক্তির পক্ষে সম্ভব, যদিও সেক্ষেত্রে অবিদ্যার দ্বারা তিরস্কৃত হওয়ায় সেই প্রত্যক্ষ অসম্ভব। দ্বিতীয়তঃ এই আশ্রয়মানঃসংযোগের বৈশিষ্ট্য হল যোগজন্য ধর্মের দ্বারা অনুগ্রহ।

তথ্যসূত্র :

- ১ ন্যায়সূত্র, ১/১/৩।
- ২ বৈশেষিকসূত্র, ৩/১/১৮।
- ৩ হ্রী, ৩/২/১।
- ৪ হ্রী, ৫/২/২৫।
- ৫ হ্রী, চন্দ্রানন্দস্বরচিত বৃত্তিসহ, সং মুনি জম্বুবিজয়, পৃঃ ১৬৯।
- ৬ হ্রী, পৃঃ ১৭৪।
- ৭ হ্রী।
- ৮ ন্যায়সূত্র, ১/১/৪।
- ৯ হ্রী।
- ১০ হ্রী, ২/১/২১ - ২/১/২২।
- ১১ হ্রী, ২/১/১৩।
- ১২ হ্রী, ২/১/২৪।
- ১৩ হ্রী, ১/১/৬।
- ১৪ হ্রী, ২/১/২৬।
- ১৫ হ্রী, ২/১/২৭।
- ১৬ বৈশেষিকসূত্র, ৪/১/১৬।
- ১৭ হ্রী, ৪/১/৭।
- ১৮ ন্যায়সূত্র, ৩/১/৩৮।
- ১৯ হ্রী।

গ্রন্থগঞ্জী :

- কণাদ, বৈশেষিকদর্শনম্, জয়নারায়ণ তর্কপঞ্চানন (সম্পা.), কলিকাতা : ১৮৬১ (বঙ্গাব্দ)।
- কণাদ, বৈশেষিকদর্শনম্, অমিত ভট্টাচার্য (সম্পা.), কলিকাতা : সংস্কৃত বুক ডিপো, ২০১২।
- কণাদ, বৈশেষিকসূত্র, নারায়ণ মিশ্র (সম্পা.), বারাণসী : ১৯৬৯।
- কণাদ, বৈশেষিকসূত্র, চন্দ্রানন্দবৃত্তিসহ, জম্বুবিজয়ী মুনি (সম্পা.), বরোদা : এরিয়েন্টাল ইনস্টিটিউট, ১৯৮২।
- গৌতম, ন্যায়দর্শনম্, ভাষ্য-বাক্তিক-তাৎপর্যটিকাসহ, অনন্তলাল ঠাকুর (সম্পা.), বৈশালী : প্রাকৃত জৈন ইনস্টিটিউট, ১৯৬৭।
- গৌতম, ন্যায়দর্শন, ফণিভূষণ তর্কবাণীশ (সম্পা.), কলিকাতা : পশ্চিমবঙ্গ রাজ্য পুস্তক পর্ষদ, ১৩২৪ (পুনঃ সং.), ১ম-৫ম খণ্ড।
- গৌতম, ন্যায়সূত্র, বাৎস্যায়নভাষ্যাদি সহ, তারনাথ ন্যায়তর্কতীর্থ এবং অমরেন্দ্রমোহন তর্কতীর্থ (সম্পা.), নিউ দিল্লী : ২০০৩।
- বল্লাভাচার্য, ন্যায়লীলাবতী, হরিশ্বর শাস্ত্রী (সম্পা.), নিউ দিল্লী : ২০১২।
- প্রশস্তপাদ, প্রশস্তপাদভাষ্যম্, বোম্বাই টিকাসহ, গৌরীনাথ শাস্ত্রী (সম্পা.), বারাণসী : ১৯৮৩।
- প্রশস্তপাদ, প্রশস্তপাদভাষ্যম্, কিরণাবতী টিকাসহ, শিবচন্দ্র সার্বভৌম (সম্পা.), কলিকাতা : ১৯৮৯।
- প্রশস্তপাদ, প্রশস্তপাদভাষ্যম্, ন্যায়কন্দলী টিকাসহ, জেটলি ও পারিধ (সম্পা.), বনোদরা : ১৯১১।
- প্রশস্তপাদ, প্রশস্তপাদভাষ্যম্, ন্যায়কন্দলী টিকাসহ, গঙ্গানাথ ঝাঁ (সম্পা.), বারাণসী : সম্পর্গবিনোদ সংস্কৃত বিশ্ববিদ্যালয়, ১৯৬৩ (পুনঃ সং)।
- বিখনাথ; ভাষ্যপরিচ্ছেদ, অনামিকা রায়চৌধুরী (সম্পা.), কলিকাতা : সংস্কৃত পুস্তক ভাণ্ডার, ২০০৪।
- বিখনাথ, ভাষ্যপরিচ্ছেদ, পঞ্চানন ভট্টাচার্য (সম্পা.), কলিকাতা : সংস্কৃত পুস্তক ভাণ্ডার, ১৩৭৭ (বঙ্গাব্দ)।
- সায়নমাধব, সর্বদর্শনসংগ্রহঃ, বাবুসুন্দর শাস্ত্রী (সম্পা.), পুনা : দি ভাণ্ডারকার এরিয়েন্টাল রিসার্চ ইনস্টিটিউট, ১৯৫১।



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SUBJECTIVITY, TRANSGRESSION AND RESISTANCE: RETHINKING THE IDEA OF FEMALE DOMESTIC SPACE OF INDEPENDENT BENGAL

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Abstract:

Subjectivity, Transgression and resistance are the perpetual conditions in human existence. The construction of individual identity as a defense mechanism to get a space in patriarchal hegemony is vividly portrayed by Mahasweta Devi in her renowned seminal work Mother of 1084 (Hazard Churasir Maa). In this Independent system, Virginia Wolf's A Room of One's Own has become 'No Room of One's Own' where any attempt to break it, challenge it, question it, or speak the truth against the status quo is violently suppressed, dominated and subdued. Importantly Foucault's idea of Transgression establishes a scenario for the analysis of the oppressive and transgressive women under a patriarchal hegemony in the literary text, Mother of 1084. Mahasweta Devi's Mother of 1084 sets the situation with transgression and its representation in theatrical performance and in Indian English literature.

Keywords: Subjectivity, Transgression, Indigenous Identity, and Hegemony.

Introduction

“The history of men's opposition to women's emancipation is more interesting perhaps than the story of that emancipation itself.”. (P- 46)

The modernist twentieth century prolific writer Virginia Wolf does not hesitate to talk about woman's emancipation in her seminal extended essay 'A Room of One's Own'. Actually the idea of uprising of the subjugated woman is crystal clearly portrayed in the writings from all over the world- in the writings of once colonized nations like Africa, the Carribeans, south east part of Asia and of colonizing nation's like England (Virginia Wolf, Emily Bronte) France (Simon De Beauvoir) and America (Judith Butler). They have consistently showed through the lens of unimpeachable realism the status of woman as a questioning subjects. In this established power structure of gender binary system, Virginia Wolf's A Room Of One's Own has become a 'No Room Of One's Own' where any attempt to break it, challenge it, question it or speak against the status quo is violently suppressed, and dominated. The historical, social and existential questions of woman is represented not only in the western Culture and literature but in Indian/Bengali Literature as well. The works of Bankimchandra, Tagore, Sarat Chandra have established the convention of portraying woman in literature as a Self sacrificing Devi or 'Other' and the witch or dinner. Asapurna Devi focuses on one the common Indian phenomenon in the 19th century- widowhood. The Hindu widow now occupies a crucial place in the canonical texts of modern Indian Literature. Similarly, Mahasweta Devi picturizes the Indian politics of domesticity and the social attitudes towards women with their extraordinary literary effort. In my paper I would like to reconceptualize the idea of Female Domestic space in Independent Bengal through Mahasweta Devi's watershed literary work Mother of 1084.

The issues of power, identity and the female domestic space and the history of gender injustice are efficiently expressed in Mahasweta Devi's Mother of 1084. In September 1973 for the October issue of the Periodical 'Prasad' Devi wrote the first version of Hajar Churasir Maa (Mother of 1084). The narrative predominantly points out the psychological and emotional trauma of a mother who gets a horrible news in the morning that her beloved son Brati is lying dead in the police morgue, reduced to a mere number: corpse no -1084. This situation moves her to a journey of discovery in the course of which she tries to understand her Naxalite son's revolutionary commitment and her own alienation as a woman, wife and mother in the so called bourgeoisie 'bhadralok' society.

Women's subjectivity, Transgression and resistance are the perpetual condition in human existence. It is quite evident in the construction of individual identity as a defense mechanism to get a space in the patriarchal middle class society may be seen a beginning of a social revolution. In the story, Sujata Chatterjee, mother of Brati, is a traditional apolitical upper middle class educated lady. She starts the revolution by educating herself and pursuing B.A. degree in a conservative family. Interestingly the members of the family thinks that education benefits her marriage proposal and finally married to Dibyanath Chatterjee, a chartered accountant belonging to a 'bhadralok' bourgeois Calcutta family. In the 34 years of marriage life, Sujata becomes mother of four children, two sons (Jyoti and Brati) and two daughters (Nipa and Tuli). So women in a domestic household of Independent Bengal is fit only for marriage and reproduction. The only aim of mother of a mother is to look after the household and bring up children efficiently. But after Brati's death, Sujata goes on to discover her life again with a vision of new Ideology. She emerges throwing all the pretensions to hypocritical social respectability and challenging the hegemonic notions of 'bhadralok' domestic family and she claims a space for her own. According to



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As she returns from her day long Odyssey and confronts Dibyanath for the first time courageously breaking the silence, ' Her Words hit him like a whiplash. Dibyanath went out tamely wiping the nope of his neck"(P-16) . The idea of breaking the silence is reminiscent of a great Postcolonial writer's canonical text, 'Can The Subaltern Speak'? where Spivak presents a complex concept of the subaltern woman who are unable to utter words for themselves. Here Sujata becomes brave enough to talk about her dead son and for herself. Nadini's political and ideological commitment and analytic understanding give her encourage to face the harsh reality of 'bhadralok' consciousness. The ideas of rebellion, power, betrayal and also revolutionary optimism have become obvious to Sujata only because of another rebellious and transgressive woman, Nandini. In this context, it is necessary to mention Foucault's idea of Transgression in " A Preface to Transgression" in the book Language, Counter-memory, Practice: Selected Essays and Interviews (1977). He writes,

“ Transgression is an action which involves the limit, that narrow zone of line where it displays the flash of its passages, but perhaps also it's entire trajectory, even it's origin; it is likely that Transgression has its entire space in the line it crosses.... Transgression incessantly crosses and re-crosses a line which close up behind it in a short duration, and thus. It is made to return one more right to horizon of the un-crossable".(P-33-34)

Foucault points out that limit and Transgression are related to each other for if the limit was not crossable it would not be a transgressive act and vice versa. Transgression is an affirmation of the existence of limitless zone where an individual can get freedom to move ahead.

Yes, Sujata moves ahead to get her freedom of inner self. But unfortunately she loses all her hope to live a domestic life due to tragic death of Brati. She says, "Now Brati is dead, I too wouldn't like go on living."(P-127) The moment she screams and collapses on the ground, Dibyanath simply says that her " appendix has burst"(128). It is the death that unites Sujata and Brati who stands against the complacent hypocritical bourgeois society and it's rituals, customs, and thoughtless social tyranny.

Mahasweta Devi's social realism and observation of Sujata as She-hero is significantly noteworthy because she represents Sujata's emancipation from a suppressed, marginalized and mechanical woman in a domestic household to one who desires to have a voice amidst the silences of the voiceless women and their world.

References

- Devi, Mahasweta Mother of 1084, trans. Samik Bandyopadhyay, Calcutta; Seagulls book, 1997
- Butler, Judith, Gender Trouble, feminism and the Subversion of Identity. New York; Routledge, 1990
- Adichie Ngozi Chimamanda, We Should All Be Feminists. London; Fourth Easte,2014.
- Irigaray, Luce. This Sex is Not One, New York; Cornell University Press, 1981.
- Kundu, Tanmoy and Srirupa Mahalanabis. Off the Line Transgression and it's Representation in Literature and Culture, New Delhi; Atlantic, 2020.
- Wolf, Virginia. A Room of One's Own. New York: Harcourt, Brace and Company, 1929.



A Discourse on Patachitra Art with narratives and songs in religious and cultural Scenario of West Bengal.

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Abstract: India, with its colonial history and contemporary postcolonial culture offers an elaborate arena for the interpretation of the Patachitra art form of different states- Odisha, Bihar, Jharkhand and most importantly west Bengal. Although through the rise of Edward Said's "Orientalism", it was India which first exercised literary influence on the west, similarly Indian Rural Cultures like patachitra, miniature painting, pottery and other crafts have spread on a global scale. Especially the patachitra of west Bengal with its ethnographic reflections is like to leave a permanent and positive mark on the world. In some historical narratives, miscellaneous studies are conceptualized to reveal the significance of the Patachitra art of Bengal, particularly the Patachitra of East and West Medinipur.

Keywords: Postcolonial culture, ethnographic, orientalism and Patachitra

" Culture is a means of communication, language carries culture and culture carries , particularly through orature and literature, the entire body of values by which we come to perceive ourselves and places in the world." (Thiongo P-16)

The kenyan writer Ngugi wa Thiongo in his canonical essay ' *Decolonising the Mind: the politics of Language in African Literature (1986)* precisely explains the co-existence of language, culture and communication. Culture and language are intimately connected to each other. Patachitra art form is supposed to be the byproduct of the indistinguishable relationship of language and culture. Patachitra tradition in Indian socio-cultural scenario is the most significant platform where various modes of communication have merged including visual messages, oral traditions and music. It portrays nature, society and culture with narratives of social transformation, migrations and socio-political and religious reflections through the folk songs. And their identity as Pataus belongs to

one particular culture and ethnicity. In this discourse of identity formation, it is often associated with the idea of self conception and self perception. So the term cultural identity obviously refers to an individual sense of self derived from formal or informal membership in a group which transmit and inculcate knowledge, beliefs, values, attitudes and ways of life.

In this perspective, it is noteworthy to mention the ideas expressed in " *Modernity An Introduction To Modern Societies*" edited by the Jamaica-born British Marxist sociologist, cultural theorist Stuart Hall who explores some questions about the cultural identity and a crisis of identities. Cultural identity is passing through some transformations. It is shifting from the individual consciousness to collective identity and social identity. The concept of collective identity was first introduced by Freud in his essay *Group Psychology and the Analysis of the Ego* (1921). Freud argues that the individual is always a part of a group. It is also important to note that when a given group is formed , no matter whether it is an ethnic group , a nation or just a crowd the individuals behave uniformly to tolerate the peculiarities of the members of the group and feel themselves to be equal. The difference between social and cultural identity could be made much easier, if the first is related to society while the second is used to refer to culture. So the artists of Patachitra art form consists of a collective identity of a specific culture in West Bengal. The 'Pataus' together form a cultural identity that is highly significant to prove existence in the world of globalization and commercialization.

Therefore, language as culture is the collective memory bank of a people's experiences in history, values and aesthetics that is quite interestingly visible in the creative works of Paatachitra art form. The choice of language and the use of language is important to identify the definition in relation to the entire universe. Thiongo



- _md7D8pc1spOZJUF0WZySEZQ&sig2=uA
IIMZORd0CrUP4sIJo0Ng
- [16]. 2011. Oral traditions reaching beyond peripheries in modern era of mass communication- A case study of Radh region of West Bengal (India). In LOUKIK (bilingual journal in English and Bengali) – Volume- 4, Issue No. 1 & 2, 2011. Kolkata.

Websites Only

- [1] <http://www.thehindubusinessline.com/features/dying-folk-art-of-patachitra-getsdigitalised/article4286520.ece>
- [2] PoojaSarkar ‘Deft strokes’. Business Standard, November 06, 2011
- [3] <http://www.businessstandard.com/india/news/deft-strokes/454636/>
- [4] <http://www.theworld.org/2009/12/patua-scroll-book/>



THE DISTINCT CULTURE OF MATUYA: A HISTORICAL PERSPECTIVE AND ANALYSIS

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Abstract

One of most imperative revolutions among the Namasudra was the instigation of the new religious sect Matuaism in the middle of the 19th century. Harichand Thakur; a Hindu votary and founder of the Matuya sects of Hinduism, felt that the bakward Hindus were victimized not only socially, economically and educationally but also exploited religiously in Bengal. According to him, the social customs and order were the main barriers before the upliftment of the down-trodden and their freedom of mind. Matuya movement was adopted by Namashudra (chandal). His doctrine is based on three basic principles- 'truth', 'love', and 'sanctity' and it treats all people as equal. Harichand Thakur left 12 instructions for matuyas; known as Dvadash Ajva. Cultural aspects of Matuaism are related with ideas, customs and social behavior of the Matuya society. The cultural atmosphere of Matuya developed in association with existing social activities, lifestyle, social customs, rules and regulation. The culture of Matuya is independent from the traditional culture of India.

Keywords: Distinct, Dvadash Ajva, Abatars, Incarnation, Gurugiri, Hari Sabha, Kirtan, Gonsai 'Matam, Kabigan, Haribol, Swayam-Dikshiti, Darshan.

INTRODUCTION

One of most imperative revolutions among the Namasudra was the instigation of the new religious sect Matuaism in the middle of the 19th century. Harichand Thakur; a Hindu votary and founder of the Matuya sects of Hinduism (the son of Jasabanta Thakur and Annapurna Devi) was born in a Namasudra family of Safala Danga village in the district of Gopalgunj (Greater faridpur; now in Bangladesh), on the auspicious day of Madhukrishna Traodashi Tithi in 1812 A.D. (the day is logical and reasonable to Bengalee; 1218 Bengali year). He for the first time, felt that the bakward Hindus were victimized not only socially, economically and educationally but also exploited religiously in Bengal. In these circumstances, he took an initiative step for protest against social injustice at first, he did not protest against social injustice directly but introduced a new religious sect for religious liberty for the down-trodden Hindu in Bengal. He realised the imperativeness of religious reformation for the down-trodden people who were deprived of various rights for centuries due to the existence of traditional social customs and order based on social inequality in Hinduism. According to him, the social customs and order were the main barriers before the upliftment of the down-trodden and their freedom of mind.

Different types of works performed and developed with the help of 'Matuya Religion' for Namashudra and other downtrodden people of society. It performed social and cultural reformation, establishment of a newly distinct religion, development in agriculture, economy, familial lives, human moralities, reservation in educations, services and in elections etc and development of social status, respect, position and honour. These become very essential for different types social positions and because of classification of society and professions. In every caste, there are distinction and have restriction about food habits, customs and cultures as well as social marriage system, social rituals.¹

According to the Yajurveda, the worked and dignity of four castes or classes explained. The Brahmins set up at the highest position of the society on the basis of their work and dignity. The distinction started with in cultures of social arrangement according to the basis of colour or class and it led to create their own culture of every class. After that, these started to appear as distinct categories. As the Brahmins were the highest position in society, lots of rule's regulations and customs depended on them because Brahmins only the main creators of highly cultures, customs and advisers as well as maintainer. As a result of inter-caste marriage, there were formed newly mixtures classes with in social arrangement. In India, there could found another one class who were original inhabitants or natives, known as Santal, Adibashi, Koal Munda, Chandalas. Their social customs, rules and regulations of living cultures, food, habits and social arrangements were totally distinction and we could not find out similarities with them.ⁱⁱ

Namasudra, also known as Namassej or Namassut, is an avarna community originating from Southern and Central Bengal. The community was earlier known as Chandala or Chandal, a term usually considered as a slur. As per the Hindu's religious books, the Manusanghita and the Brihadharma Purana, the chandala is the descendants of illegal sexual union of the Shudra male and the Brahmin female. The term is also used in modern times for a specific caste of agriculturists, fishermen and boatmen, more usually referred to as Namasudra.ⁱⁱⁱ



In the occasion of birthday anniversary of Harichand Thakur at Orakandi in East Bengal erstwhile East Pakistan the Matuyas from different part of India used to throng being divided into many groups of different sizes under the leadership of a Matuya, known as Dalpati (leader) in every group. After the partition of India Thakurbari of Thakurnagar has been organising also such festival in this occasion. Guruchand Thakur felt the necessity of bringing them together on a common platform by which a big group comprising the small ones can be formed to gain adequate strength capable of fighting out all the devils and evils. This big group was termed later 'Matuya Mahasangha'. Matuya Mahasangha believe in 'Swayam-Dikshiti' (Self-Realisation). Therefore, anyone who has faith in the Darshan or Philosophy of Harichand belongs to Matuya Mahasangha. At first Matuyas formed an organisation at Orakandi district in Faridpur district of Bengal Presidency (now in Bangladesh). After partition, followers formed a second organisation at Thakurnagar in West Bengal. The temple was initially looked after by Thakur's family, but as of 2011 A.D. it was managed by trustee chosen by the followers.^{xv}

CONCLUSION

The cultural atmosphere of Matuya developed in association with all the above existing social activities, lifestyle, social customs, rules and regulation. The culture of Matuya are independent from the traditional culture of India. There exists both similarities and disparities among the inherited culture and the culture developed by the Matuya through their own philosophy. Matuya sangeet containing praises of the God Hari and their gurus Harichand Thakur and Guruchand Thakur. The baul songs are predominantly about love and bhakti. Matuyas ring a trumpet at the time of uttering the name of Hari. They use a red flag with white border to symbolise equalities of social, economic and political. They use a long stick (religious stick) and keep long cotted hairs for their desireless love and the power of devotions. In Matuya religion men and women have equal right in the field of religion as well as in society. They think that all human being are sacred within this religion. In this religion there is only one name: Lord Hari.

References

- ⁱ . Nandadulal Mohanto, "Matuya Andolon O Dalit Andolon", Annapurna prakashoni, kolkata, pp.-4-29.
- ⁱⁱ . Narendra Nath Bhattacharya, "Prachin Bharatiya Samaj", Paschim Banga Rajya Puatak parsad, Kolkata, 2001, pp. 186-187.
- ⁱⁱⁱ . Oneil Biswas, "The Namah Shudras: Origin and Development", Jyoti Printers, Kolkata, 2004, pp. -1-35.
- ^{iv} . Manohar Mouli Biswas, "Prabandhe Prantajan: Authoba Aspriyer Dairi", Bibhuti Printing Works, Kolkata, pp.-28-41.
- ^v . Interview, Nandadulal Mohanto, on 6th sept. at 4.40 P.M., 2012, Chandpara, Bangaon, W.B.
- ^{vi} . Kapil Krishna Thakur, "Life History of Hari-Guru Chand Thakur, Their philosophy and Activities in Brief", Sridham Thakurnagar, North 24 pargana, 2009, p.-5.
- ^{vii} . <https://www.livescience.com>
- ^{viii} . H.H. Risley, "The Tribes and caste of Bengal", vol.-1, London, 1891. Reprinted, Calcutta, 1981, pp.-186-188..
- ^{ix} . Nandadulal Mohanto, op.cit., pp.-47-57.
- ^x . Interview, Binapani Devi (Baroma), on 11 Sept. 2012, at 3.35 P.M. Thakurnagar.
- ^{xi} . Interview, Kapil Biswas, on 12th Nov., at 4.40 P.M. 2013, Bamungachi, North 24 parganas.
- ^{xii} . Kapil Krishna Thakur, op.cit., pp.-5-13.
- ^{xiii} . Interview, Sailendranath Biswas, Nagerbazar, on 12th Oct., 2013, at 2.45 P.M.
- ^{xiv} . Interview, Binapani Devi, op.cit.
- ^{xv} . Ibid.
- ^{xvi} . Field observation, on 3 April, 2019, at Thakurnagar.
- ^{xvii} . Interview, Nandadulal Mohanto .op.cit.
- ^{xix} . Monosanta Biswas, "Banglar Matuya Andolon Samaj Somoskriti Rajniti", Setu, Kolkata, 2016, pp.49-72.
- ^{xx} . Debdas Pandey, "An Approach to Matuicism", Matuya Mahasangha, Thakur Nagar, 2008, pp.-105-127.

নীতিবিদ্যা ও নৈতিকতা :

Corruption

বরুণ কুমার ঘোষ

অতি সাম্প্রতিককালে আমরা টেলিভিশন, রেডিও, পেপার-পত্রিকা প্রভৃতিতে প্রায়ই দেখতে পাচ্ছি যে পশ্চিমবঙ্গ তথা ভারতবর্ষ তথা সমগ্র বিশ্বে 'Corruption' নামক একটি বিষয় আলোচনার কেন্দ্র বিন্দু হয়ে উঠেছে। এই 'Corruption' হল একটি বিশ্বব্যাপী সমস্যা এবং বিশ্বের কোম দেশ সম্পূর্ণরূপে এই ভয়প্রদর্শনকারী গ্রাস থেকে মুক্ত হতে পারে নি। যাইহোক, একদিক থেকে যেমন এই Corruption-এর ব্যাপকতা দিন দিন বাড়ছে এবং তেমনই অন্যদিক থেকে সং, নির্ভীক লোকজন দিন দিন এর সঙ্গে যুক্ত হচ্ছে। এর ফলে বিভিন্ন দেশে বিভিন্নভাবে এই Corruption অনুধাবিত হচ্ছে। ভারতবর্ষের রাজনীতিতে, শিক্ষায়, স্বাস্থ্যে, সভ্য সমাজে, সার্বজনীন, এবং ব্যক্তিগত ব্যবসা-বাণিজ্যে Corruption ওতোঃপ্রতোভাবে জড়িয়ে পড়ছে। আমাদের শিক্ষা ব্যবস্থা, নির্বাচন ব্যবস্থা এবং সামাজিক-অর্থনৈতিক ব্যবস্থাপনা ধীরে ধীরে Corruption-এ দুর্গন্ধপূর্ণ হয়ে পড়েছে। ভারতবর্ষের প্রত্যেক ক্ষেত্রে গভীরভাবে Corruption-এর সংস্কৃতি আবিষ্ট হচ্ছে। তাই ভবিষ্যতে ভারতবর্ষ বিশ্বের Corruption-গ্রস্ত দেশগুলির মধ্যে অন্যতম হয়ে উঠতে পারে।

আমরা প্রায়ই এই Corruption গুলিতে বিদ্রোহিতভাবে মুখোমুখি প্রভাবিত হই। আমরা প্রায়ই এগুলি দেখি যে Corruption-কারীরা আমাদের রাজ্যে রাস্তাঘাট, হাসপিটাল, স্কুলের পরিকাঠামো গঠন থেকে শুরু করে সর্বত্র অপরাধের ঢেউ ছড়িয়ে দিচ্ছে। দুঃখের সহিত বলতে হচ্ছে সেখানে অপরাধ দমন করার জন্য কোন তৎপরতা বা প্রতিজ্ঞাবদ্ধতা নেই অথবা কোন শাস্তিবিধানের ব্যবস্থা নেই। আমাদের অনেক Corruption বিরোধী স্লোগান, উদ্যোগ এবং বিভিন্ন প্রতিষ্ঠানের মহতি প্রচেষ্টা হয়ে পড়ে সম্পূর্ণ শূন্য এবং বন্ধা। তাই আমার লেখাটির মূল লক্ষ্য হল নীতিবিদ্যা ও নৈতিকতার আবহে Corruption - নামক কাজটি নৈতিক না অনৈতিক ?

নীতিবিদ্যা ও নৈতিকতার আবহে Corruption - নামক কাজটি আলোচনা করতে গেলে প্রথমেই আমাদের নীতিবিদ্যা ও নৈতিকতা সম্বন্ধে প্রাথমিক ধারণা লাভ এবং সমাজে নীতিবিদ্যা ও নৈতিকতার ভূমিকা সম্বন্ধে প্রাথমিক আলোচনা করা প্রয়োজন। ইংরাজী 'Ethics' শব্দটি এসেছে গ্রীক শব্দ 'Ethos' থেকে যার অর্থ 'রীতি-নীতি'।

আমাদের 'Ethics' এবং 'Moral'-এই শব্দ দুটিকে সমার্থক বলে মনে করেন। 'Moral' একটি ল্যাটিন শব্দ যা 'Mores' থেকে উৎপন্ন হয়েছে। 'Mores' শব্দের অর্থ 'রীতি-নীতি' বা 'অভ্যাস'। তাই ব্যুৎপত্তিগতভাবে বলা যায় যে এই দুটি শব্দের অর্থ হল মানুষের রীতি-নীতি, প্রথা ও অভ্যাস সম্পর্কিত আলোচনা। এজন্য ম্যাকেন্জি (Mackenzie) নীতিবিদ্যার সংজ্ঞায় বলেছেন - 'Ethics may be defined as the study of what is right or good in Conduct' অর্থাৎ "নীতিবিদ্যা হল আচরণের উচিত্য বা ভালত্ব সম্বন্ধীয় বিজ্ঞান"।.. নীতিবিদ্যা সম্পর্কে অধ্যাপক লিলির (Lillie) সংজ্ঞাটি বিশেষভাবে উল্লেখযোগ্য, কেননা সংজ্ঞাটিতে নীতিবিদ্যার মূল বৈশিষ্ট্যগুলির উল্লেখ আছে। লিলির মতে, 'নীতিবিদ্যা হল সমাজে বসবাসকারী মানুষের আচরণ সম্বন্ধীয় এমন এক আদর্শনিষ্ঠ বিজ্ঞান যেখানে মানুষের আচরণ উচিত কি অসুচিত, ভাল কি মন্দ বা অনুকূল বিচার করা হয়'।^১ এছাড়াও নীতিবিদ্যাকে বলা হয় নীতিদর্শন। কারণ ইহা মানুষের নৈতিক সমস্যা, নৈতিক বিচার এবং মানুষের নৈতিক ক্রিয়া নিয়ে আলোচনা করে। তাই নীতিবিদ্যা সম্পর্কে Uduigwomen বলেছেন "the regulation of the behavior and conduct of man as it affects the overall wellbeing of the state or society in which he lives"^২

আমরা নীতিবিদ্যা ও নৈতিকতার মধ্যে প্রায়ই কিছু শব্দ দেখতে পাই যেমন- নৈতিক, অনৈতিক, নীতিবিগর্হিত। এছাড়াও আমরা দেখতে পাই - নৈতিক ক্রিয়া, ভাল, মন্দ, নৈতিক কর্তা, মূল্য, পছন্দ, অপছন্দ, মানবিক ক্রিয়া ইত্যাদি। আবার নীতিবিদ্যার মধ্যে আমরা দেখতে পাই উপরলক্ষ শব্দগুলির মধ্যে সুন্দর সুন্দর পার্থক্য খুব সুস্পষ্টভাবে উল্লেখ করা হয়েছে। আমি এখানে কেবল নৈতিক ক্রিয়া, অনৈতিক ক্রিয়া এবং নীতিবিগর্হিত ক্রিয়া নিয়ে আলোচনা করব। কারণ আমার আলোচ্য বিষয়টি যেহেতু নৈতিক না অনৈতিক তা বিবেচনা করা। যে ক্রিয়ার ক্ষেত্রে নৈতিক বিশেষণ ভাল-মন্দ ইত্যাদি প্রয়োগ করা যায় তা নৈতিক ক্রিয়া। মানুষের কেবল স্বেচ্ছাকৃত কর্মই নৈতিক। যে ক্রিয়ার ক্ষেত্রে নৈতিক বিশেষণ ভাল, মন্দ ইত্যাদি প্রয়োগ করা যায় না, তা অনৈতিক ক্রিয়া। আবার নীতিবিগর্হিত ক্রিয়া বলতে বোঝায় যা মন্দ, অনুচিত কাজ। মানুষের বাধ্যতামূলক ক্রিয়া অনৈতিক ক্রিয়া।

উক্ত আলোচনার পরিপ্রেক্ষিতে বলা যায় যে নীতিবিদ্যা ও নৈতিকতা প্রত্যেকটি সমাজের জীবনকে প্রতিফলিত করে। ইহার কারণ হল সমাজ সবসময় গঠিত হতে চায় নৈতিক গুণসম্পন্ন ব্যক্তিত্বকে নিয়ে, যারা প্রত্যহ ইচ্ছা, রুচি এবং পছন্দ, ভালোত্ব এই গুণগুলি নিয়ে জীবনকে পরিচালিত করে। এই রকম নীতিশাস্ত্র ও নৈতিকতা ছাড়া মনুষ্য সমাজ চালিত হলে তা হবে হবস-এর কল্পিত রাজ্যের মতো, যেখানে একজন মানুষ আর একজন মানুষের পেছনে ধাওয়া হয়েছিল নেকড়ের মতো। সেইজন্য মানুষ হয়ে পড়েছিল জঘন্য, অত্যাচারী এবং নির্ভর, তাই মানুষের জীবনের প্রত্যেকটি কাজকর্ম মুখোমুখি হয়ে পড়ে নৈতিকতায়, কারণ মানুষের কাজকর্ম শুধুমাত্র নৈতিক মূল্যকে প্রভাবিত

উদ্দেশ্যমুখী নৈতিক মতবাদ অনুসারে, কোন কর্ম বা কর্মনীতি নৈতিকভাবে ঠিক বা খোঁটিক তা নির্ধারণ করার মানদণ্ড হল নীতিসম্পর্কিত অনৈতিক কোন মূল্য, যাকে ঐ কর্ম বা কর্মনীতি অনুসরণ করে ফলস্বরূপ পাওয়া যেতে পারে, অর্থাৎ মানুষের ক্ষেত্রকৃত কর্ম বা কর্মনীতির ফল যদি ভাল হয় তাহলেই ঐ কর্ম বা কর্মনীতির নৈতিক ভালোত্ব স্বীকার করা যাবে। তাই হুসপদগুণস বলেছেন- 'An act ought to be done if and only if it or the rule under which it falls produces a greater balance of good over evil than any available alternative'.^১ আবার "কোন কর্ম বা কর্মনীতিকে 'নৈতিক ভালো' বলা যাবে যদি এবং কেবল যদি ঐ কর্ম বা কর্মনীতি অনুসরণ করে অকল্যাণ অপেক্ষা কল্যাণের পরিমাণ বেশী হয়, যদি তা না হয় তাহলে ঐ কর্ম বা কর্মনীতি নৈতিক দিক থেকে মন্দ"। ফলাফল বা পরিণতির জন্য কোন কর্ম বা কর্মনীতি ভালো বা মন্দ হয়, কর্মের বা কর্মনীতির স্বকীয় মূল্যের জন্য নয়। Corruption নামক কর্মটির ফলাফল বা পরিণতি মন্দ হয় অর্থাৎ সমাজে কল্যাণ অপেক্ষা অকল্যাণ বাশী পরিমাণে হয়, তাই কর্মটি অনৈতিক বা মন্দ।

তথাপি খুব সহজভাবে লক্ষ্যনীয় যে, কিভাবে Corruption নৈতিক নিয়মের বিরুদ্ধে যায়? আমরা দেখতে পাই যে সমাজের উপর Corruption এর একটা খারাপ প্রভাব রয়েছে। বিশেষ করে সমাজের একটা বেশী সংখ্যক মানুষের উপর এটা শেষ পর্যন্ত একটা যন্ত্রণা আরোপ করে। আমরা জানি ভালোর ধারণার মধ্যে আপেক্ষিকতা আছে। আমরা কোন কিছুকে ভালো বলছি শুধু এইজন্য যে তার দ্বারা উদ্দেশ্য সিদ্ধ হবে। সেই উদ্দেশ্য সিদ্ধির পরিপ্রেক্ষিতেই তাকে 'ভালো' বলা হয়। একটি গুণ্ডু ভালো কারণ তা রোগ নিরাময়ের সহায়ক। রোগের নিরাময় স্বাস্থ্যের সহায়ক। স্বাস্থ্য সুখের সহায়ক। এইভাবে যা ভালো তা সর্বদাই একটি উদ্দেশ্যকে অপেক্ষা করে। এর সঙ্গে তুলনা করে ভালোর আর একটি ধারণা গঠন করা যায় 'Absolute Good' যাকে নিরপেক্ষভাবে ভালো বলা যাবে। যাকে এই অর্থে ভালো বলা যায় তা কোন উদ্দেশ্য সিদ্ধ করে না। তা স্বরূপতঃই ভালো। আমরা তাকে কামনা করি কোন উদ্দেশ্য সিদ্ধির জন্য নয়। তাকে পাবার জন্যই আমরা তাকে কামনা করি।^২ এই দৃষ্টিভঙ্গিতে এটা প্রাসঙ্গিক যে, Corruption স্বরূপতঃ ভালো নয়। এটি একটি সাময়িক লাভজনক বিষয়। এটা ব্যক্তিগতভাবে বা সামগ্রিকভাবেও কখনো মানুষকে ভাল কিছু করতে বা ঘটতে সাহায্য করতে পারে না। Corruption গ্রন্থ মানুষেরা কখনো তাদের ধনসম্পত্তি নিয়ে সম্পূর্ণভাবে সন্তুষ্ট বা সুখী হয় না। ধনী ব্যক্তির আরো সম্পত্তি বাড়ানোর কামনায় সবসময় উদ্বিগ্ন থাকে। তাদের যে পরিমাণ ধনসম্পত্তি রয়েছে তাতে সন্তুষ্ট নয়। তাদেরকে যদি সুযোগ দেওয়া যায় তাহলে তারা আরো বেশী পরিমাণ আত্মসাৎ করবে। এই ঘটনার পরিপ্রেক্ষিতে Corruption হল একটি নৈতিকভাবে চরিত্রহীন ও নিন্দনীয় নীতি। এমনকি এটা মানুষকে তার সর্বোচ্চ ভাল কাজ করা থেকে বিরত করতে পারে। আমরা জানি যে নৈতিকতার দিক থেকে Corruption খুবই খারাপ কাজ।

এটি আমাদের খুব গভীরে প্রবেশ করেছে, যেটি আমাদের বিপদগামী করে ফুলেছে এবং আমাদের ভুল পথে চালিত করেছে। আমরা সহজেই Corruption গ্রন্থ মানুষকে এবং মহৎ মানুষকে পছন্দ করতে পারি। যদি আমরা সহজভাবে Corruption গ্রন্থ মানুষকে পছন্দ করি তাহলে আমরা শীঘ্রই বিপদগামী হব এবং খারাপ কাজে নিজেদেরকে নিয়োজিত করবো। সেই সময় আমরা দেখতে পাব Corruption এর বিষয় ফল এবং নৈতিকতার মধ্যে একটা টানা পোড়েন।

সবশেষে বলা যেতে পারে যে আমরা সভ্য সমাজের মানুষ হিসাবে যখন কোন কাজ করছি তখন আমাদের লক্ষ্য রাখা দরকার যে আমার কাজটি নৈতিকভাবে সমর্থনযোগ্য কিনা। যে কাজগুলি সমাজের পক্ষে ক্ষতিকারক বা অন্যায় কাজ সেই কাজগুলি সম্পাদন করা থেকে যেন আমরা বিরত থাকি। আমরা প্রত্যেকেই যদি সচেতনভাবে আমাদের কাজকর্মগুলি সম্পাদন করি তাহলে ভবিষ্যতে আমাদের সমাজ বিশ্বের একটি অন্যতম সভ্য সমাজে পরিণত হবে। কিন্তু তা না করে যদি আমরা আমাদের মতো করে কাজ করি তাহলে এই দেশ তথা ভারতবর্ষ ধীরে ধীরে কিছু অসাধু মানুষের কৃষ্ণগত হয়ে পড়বে এবং ধীরে ধীরে সমাজের অবক্ষয় হতে থাকবে। এর ফলে এই ভারতবর্ষ বসবাসের অযোগ্য হয়ে যাবে।

তথ্যসূত্র:

- ১) Mackenzie, J.S. 'A Manual of Ethics' (London: University Tutorial Press Ltd.), Page - 1.
- ২) ডক্টর চার্লস, সমরেন্দ্র - তত্ত্বগত নীতিবিদ্যা ও ব্যবহারিক নীতিবিদ্যা, বুক সিডিকিট প্রাইভেট লিমিটেড, অধ্যায় - ৫ ও ৬।
- ৩) Uduigwomen, A. F. (2006). Introducing Ethics: Trends, Problems and Perspectives. Calabar: Jochrissam Publishers.
- ৪) Frankena, W. K. Ethics (Englewood Cliffs), Ch - II, Page - 15.
- ৫) Kant, Immanuel. (1984). The Foundations of the Metaphysics of Morals. Tr. H.J. Paton In his book 'The Moral Law'. London: Hutchinson. Page - 19.
- ৬) Frankena, W. K. Ethics (Englewood Cliffs), Ch - II, Page - 14.
- ৭) গুপ্ত, ডঃ দীক্ষিত - নীতিবিদ্যা, লেভান্ত বুকস, অধ্যায় - ১।



Multi-dimensional transportation problems in multiple environments: a simulation based heuristic approach

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Abstract

Here, a general methodology is proposed to formulate and solve any multidimensional balanced/unbalanced, constrained/unconstrained transportation problems (TP) in different environments (crisp/fuzzy/rough). To understand the general model easily, here, at first, a multi-item 5-dimensional fixed charge profit maximization TP under budget and time constraint is presented. A potential solution of the problem is coded as a permutation of the different cells of the allocation matrix. A general decoding rule is proposed to determine the actual allocation from this coded solution. A heuristic approach is applied on a set of randomly generated coded solution of the target problem to determine the marketing decision. Applying swap operations on the coded solutions, the perturbation rules of the heuristic Particle Swarm Optimization (PSO) are modified to solve the problem. In a particular case, the problem is analysed as a bi-criteria decision making problem with the maximization of the total profit as well as the minimization of the total shipment time under a budget constraint. The bi-criteria TP is formulated as a single objective optimisation problem using a proposed rule and the same heuristic is run for a finite number of times to determine the pareto optimal front. To formulate the problem in the fuzzy (rough) environment an approach is proposed using credibility (trust) measure of fuzzy (rough) events. Proper fuzzy (rough) simulation algorithms are also proposed to solve the problem for any type of fuzzy (rough) estimation. Using this approach no crisp equivalent of any imprecise parameters is used for the marketing decision. Due to the unavailability of the test data in the literature, different hypothetical data sets are used for the illustration of the models.

Keywords Multi-dimensional profit maximization transportation problem · Imprecise environment · Swap sequence based PSO · Fuzzy simulation · Rough simulation

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1 Introduction

Most of the supply chain systems involves transportation operations where the company purchases different items at different depots (sources) of the company distributed over the country. The items are then transported to different outlets/franchises (demand points) using various conveyances, e.g., motor vehicles, cargo flights, goods trains etc., through different routes. Costs and times for the shipment of the units of different items from different depots to the different outlets through different vehicles through different routes are different and known. This type of transportation problem belongs to 5-dimensional transportation problem (TP). This is generalization of 2-dimensional (basic) (Hitchcock 1941; Schell 1955) TP and 3-dimensional (solid) (Haley 1962) TP. Initial impetus on multi-index TP was made by Haley (1962). But he analysed the model for three indexes, i.e., for solid transportation problem (STP). After that, extensive research

- Ojha A, Das B, Mondal S, Maiti M (2010) A Solid Transportation Problem for an item with fixed charge vehicle cost and price discounted varying charge using Genetic Algorithm. *Appl Soft Comput* 10:100–110
- Ojha A, Das B, Mondal S, Maiti M (2011) Transportation policies for single and multi-objective transportation problem using fuzzy logic. *Math Comput Model* 53:1637–1646
- Ojha A, Das B, Mondal SK, Maiti M (2013) A multi-item transportation problem with fuzzy tolerance. *Appl Soft Comput* 13(8):3703–3712
- Pramanik P, Maiti MK, Maiti M (2017) A supply chain with variable demand under three level trade credit policy. *Comput Indu Eng* 106:205–221
- Pramanik P, Maiti MK, Maiti M (2017) Three level partial trade credit with promotional cost sharing. *Appl Soft Comput* 58:553–575
- Pramanik P, Maiti MK (2019) An inventory model for deteriorating items with inflation induced variable demand under two level partial trade credit: a hybrid ABC-GA approach. *Eng Appl Artif Intell* 85:194–207
- Pramanik P, Maiti MK (2020) Trade credit policy of an inventory model with imprecise variable demand: an ABC-GA approach. *Soft Comput* 24:9857–9874
- Schell ED (1955) Distribution of a product by several properties, in: *Proceedings of 2nd Symposium in Linear Programming*, DCS/comptroller, HQ US Air Force, Washington, DC, 615–642
- Sun M, Aronson JE, Mckeown PG, Dennis D (1998) A tabu search heuristic procedure for fixed charge transportation problem. *Eur J Oper Res* 106:411–456
- Tao Z, Xu J (2012) A class of rough multiple objective programming and its application to solid transportation problem. *Inf Sci* 188:215–235
- Wang KP, Huang L, Zhou CG, Pang W (2003) Particle swarm optimization for travelling salesman problem, In: *Proc. International Conference on Machine Learning and Cybernetics*, pp. 1583–1585
- Yan X, Zhang C, Luo W, Li W, Chen W, Liu H (2012) Solve travelling salesman problem using particle swarm optimization algorithm. *Int J Comput Sci Issues* 9:264–271
- Yang L, Liu L (2007) Fuzzy fixed charge solid transportation problem and algorithm. *Appl Soft Comput* 7:879–889
- Yang L, Yuan F (2007) A bi-criteria solid transportation problem with fixed charge under stochastic environment. *Appl Math Model* 31:2668–2683
- Zadeh LA (1965) Fuzzy Sets. *Inform Control* 8:338–353
- Zadeh LA (1978) Fuzzy Set as a basis for a theory of possibility. *Fuzzy Sets Syst* 1:3–28
- Zimmermann H-J (1978) Fuzzy programming and linear programming with several objective functions. *Fuzzy Sets Syst* 1:45–55

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Multi-objective covering salesman problem: a decomposition approach using grey wolf optimization

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Abstract

In this study, the basic grey wolf optimization (GWO) algorithm is modified along with K -bit exchange, K -opt operation, and integrated with the structure of multi-objective evolutionary algorithm with decomposition approach (MOEA/D) to solve multi-objective covering salesman problem(MOCSP). The algorithm is named a “multi-objective evolutionary algorithm with decomposition using Grey Wolf optimization (MOEA/D-GWO).” The K -opt operation with $K = 3$ and $K = 4$ is used to generate the initial solution set. The GWO algorithm is modified with a set of newly introduced perturbation rules. A two-stage updating mechanism has been introduced to improve the quality of a potential solution. The first stage of the process is done by the modified GWO algorithm, and in the second stage, a perturbation technique using K -bits exchange operation is applied. The MOEA/D-GWO algorithm is a two-phase algorithm where in the first phase, the clustering/grouping of cities is done, and in the next phase one city from each cluster/group is selected to search pareto-optimal Hamiltonian cycles in such a way that each cycle maintains the pre-define covering distance. Here, for the first time a heuristic approach is proposed for MOCSP. Different sizes of standard benchmark MOCSP test instances are used to test the performance of the MOEA/D-GWO algorithm. The instances are generated from TSPLIB. Different traditional multi-objective optimization algorithms, like NSGA-II, SPEA2, MOEA/D, MR-ABCWCD, SMPSO, SR4-MOEA/D for MOOP, have been modified according to MOCSP and implemented to compare the efficiency of the proposed approach. Nine standard well-known performance metrics/indicators have been used to analyse the performance of the MOEA/D-GWO algorithm for MOCSP. Differ-

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49. Trivedi V, Varshney P, Ramteke M (2020) A simplified multi-objective particle swarm optimization algorithm. *Swarm Intell* 14:83–116
50. Van Veldhuizen DA (1999) Multiobjective evolutionary algorithms: classifications, analyses, and new innovations. Technical report, AIR FORCE INST OF TECH WRIGHT-PATTERSONAFB OH SCHOOL OF ENGINEERING
51. Van Veldhuizen DA, Lamont GB (2000) On measuring multiobjective evolutionary algorithm performance. In: Proceedings of the 2000 congress on evolutionary computation. CEC00 (Cat. No. 00TH8512), vol 1. IEEE, pp 204–211
52. Yang C, Liu K, Jiao X, Wang X, Chen Ruihu, You Sixiong (2022) An adaptive firework algorithm optimization-based intelligent energy management strategy for plug-in hybrid electric vehicles. *Energy* 239:0360–5442
53. Zhang Q, Li H (2007) MOEA/D: a multiobjective evolutionary algorithm based on decomposition. *IEEE Trans Evol Comput* 11(6):712–731
54. Zhang Z, Yang J (2022) A discrete cuckoo search algorithm for traveling salesman problem and its application in cutting path optimization. *Comput Ind Eng* 169:108157
55. Zhu Z, Zhou X (2020) An efficient evolutionary grey wolf optimizer for multi-objective flexible job shop scheduling problem with hierarchical job precedence constraints. *Comput Ind Eng* 140:106280
56. Zitzler E (1999) Evolutionary algorithms for multiobjective optimization: methods and applications, vol 63
57. Zitzler E, Thiele L (1998) Multiobjective optimization using evolutionary algorithms—a comparative case study. In: International conference on parallel problem solving from nature. Springer, Berlin, pp 292–301
58. Zitzler E, Thiele L (1999) Multiobjective evolutionary algorithms: a comparative case study and the strength pareto approach. *IEEE Trans Evol Comput* 3(4):257–271

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A perturbation based modified BAT algorithm for priority based covering salesman problem

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Abstract. In this study, Bat algorithm (BA) is modified along with K -opt operation and one newly proposed perturbation approach to solve the well known covering salesman problem (CSP). Here, along with the restriction of the radial distances of the unvisited cities from the visited cities another restriction is imposed where a priority is given to some cities for the inclusion in the tour, i.e., some clusters to be created where the prioritised cities must be the visiting cities and the corresponding CSP is named as Prioritised CSP (PCSP). In the algorithm, 3-opt and 4-opt operations are used for two different purposes. The 4-opt operation is applied for generating an initial solution set of CSP for the BA and the 3-opt operation generates some perturbed solutions of a solution. A new perturbation approach is proposed for generating neighbour solutions of a potential solution where the exchange of some cities in the tour is made and is named as K -bit exchange operation. The proposed solution approach for the CSP and PCSP is named as the modified BA embedded with K -bit exchange and K -opt operation (MBAKEKO). It is a two-stage algorithm where in the first stage of the algorithm the clustering of the cities is done with respect to a fixed visiting city of each cluster in such a manner that the distances of the other cities of the cluster must lie within the fixed covering distance of the problem and in the second stage the BA is applied to find the minimum cost Hamiltonian circuit by passing through the visiting cities of the clusters. MBAKEKO is tested with a set of benchmark test problems with significantly large sizes from the TSPLIB. To measure the performance of MBAKEKO, its results are compared with the results of different well-known approaches for CSPs available in the literature. It is observed from the comparison studies that MBAKEKO searches the minimum cost tour for any of the considered instances compared to all other well-known algorithms in the literature. It can be concluded from the numerical studies that the performance of MBAKEKO is better with respect to the state-of-the-art algorithms available in the literature.

Keywords: Combinatorial optimization, covering salesmen problem, priority based covering salesman problem, K -bit exchange operation, K -opt, Bat Algorithm

1. Introduction

The covering salesman problem (CSP) [2] is a complete weighted graph where the vertices are analogous to the cities, the edges are analogous to the connecting path between the corresponding cities, and the weights are analogous to the travel cost or

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- [18] S. Lin and B.W. Kernighan, An effective heuristic algorithm for the traveling-salesman problem, *Oper Res* **21**(2) (1973), 498–516.
- [19] Q. Luo, Y. Zhou, J. Xie, M. Ma and L. Li, Discrete bat algorithm for optimal problem of permutation flow shop scheduling, *The Scientific World Journal*, 2014, 2014.
- [20] E. Osaba, X.-S. Yang, F. Diaz, P. Lopez-Garcia and R. Carballo, An improved discrete bat algorithm for symmetric and asymmetric traveling salesman problems, *Engineering Applications of Artificial Intelligence* **48** (2016), 59–71.
- [21] R.S. Parpinelli and H.S. Lopes, New inspirations in swarm intelligence: a survey, *International Journal of Bio-Inspired Computation* **3**(1) (2011), 1–16.
- [22] G. Reinelt, TspLib—a traveling salesman problem library, *ORSA journal on computing* **3**(4) (1991), 376–384.
- [23] Y. Saji, M.E. Riffi and B. Ahiod, Discrete bat-inspired algorithm for travelling salesman problem, In *2014 Second World Conference on Complex Systems (WCCS)*, pages 28–31. IEEE, 2014.
- [24] M. Salari and Z. Naji-Azimi, An integer programming-based local search for the covering salesman problem, *Computers & Operations Research* **39**(11) (2012), 2594–2602.
- [25] M. Salari, M. Reihaneh and M.S. Sabbagh, Combining ant colony optimization algorithm and dynamic programming technique for solving the covering salesman problem, *Computers & Industrial Engineering* **83** (2015), 244–251.
- [26] R. Shuttleworth, B.L. Golden, S. Smith and E. Wasil, Advances in meter reading: Heuristic solution of the close enough traveling salesman problem over a street network, In *The Vehicle Routing Problem: Latest Advances and New Challenges*, pages 487–501. Springer, 2008.
- [27] X.-S. Yang, A new metaheuristic bat-inspired algorithm, In *Nature inspired cooperative strategies for optimization (NICSO 2010)*, pages 65–74. Springer, 2010.
- [28] X.-S. Yang and A.H. Gandomi, Bat algorithm: a novel approach for global engineering optimization, *Engineering Computations*, 2012.
- [29] X.-S. Yang and X. He, Bat algorithm: literature review and applications, *International Journal of Bio-Inspired Computation* **5**(3) (2013), 141–149.



Profit maximization fuzzy 4D-TP with budget constraint for breakable substitute items: a swarm based optimization approach

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Abstract

The concept of breakable substitute items and budget constraints is to be used in decision-making problems. For demonstration, a fixed charge multi-item four-dimensional transportation problem (4D-TP) with budget constraint as profit maximization, the problem for breakable substitute items is considered under a fuzzy environment. The items are purchased from distinct depots at different prices. The different types of breakable substitute items are supplied to separate destination points from a distinct type of supply points with a different type or capacity of vehicles via a different road. The parameters of the transportation problem like direct transportation charges, fixed charges, market prices, procuring costs, sources of origins, requirements at destination points, conveyance's volume, or size are assumed to be deterministic or imprecise. Budget restrictions are applied on-demand points where the available budget amounts are fuzzy. Requirement restrictions at destinations are on the number of items having some minimum demands for each substitutable item. The imprecise constraints are reduced to equivalent deterministic constraints using credibility measures. The reduced fuzzy optimization problem under deterministic constraints is solved by swap-based particle swarm optimization (SPSO) and credibility-based genetic algorithm (CBGA), where a comparison of fuzzy objectives is made using the credibility measure of fuzzy events. For deterministic objectives, the same SPSO algorithm is used, where a simple comparison makes a comparison of an objective of deterministic numbers. The obtained results are compared using CBGA and SPSO for 4D-TP. As a particular demonstration, the results of solid transportation problems (3D-TPs) and conventional transportation problems (2D-TPs) are also presented in this paper. Statistical analysis is demonstrated to analogize the algorithms.

Keywords Fuzzy 4D-TP · Budget constraints · Breakable substitute items · Credibility measure · SPSO.

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32. Ojha, A., Das, B., Mondal, S., Maiti, M.: A Solid Transportation Problem for an item with fixed charge vehicle cost and price discounted varying charge using Genetic Algorithm. *Appl. Soft Comput.* **10**, 100–110 (2010)
33. Schell, E. D.: Distribution of a product by several properties, In: Proceedings of 2nd symposium in linear programming, DCS/comptroller, HQ US Air Force, Washington DC, 615-642 (1955)
34. Sun, M., Aronson, J.E., Mckeown, P.G., Dennis, D.: A tabu search heuristic procedure for fixed charge transportation problem. *Euro. J. Oper. Res.* **106**, 411–456 (1998)
35. Wang, K.P., Huang, L., Zhou, C.G., Pang, W.: Particle swarm optimization for travelling salesman problem. *Proc. Int. Conf. Mach. Learn. Cyber.* **3**, 1583–1585 (2003)
36. Yan, X., Zhang, C., Luo, W., Li, W., Chen, W., Liu, H.: Solve traveling salesman problem Using particle swarm optimization algorithm. *Int. J. Comp. Sci.* **9**, 264–271 (2012)
37. Yang, L., Liu, L.: Fuzzy fixed charge solid transportation problem and algorithm. *Appl. Soft Comput.* **7**, 879–889 (2007)
38. Zadeh, L.A.: Fuzzy Set as a basis for a theory of possibility. *Fuzzy Sets Syst.* **1**, 3–28 (1978)

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CREDIT POLICY FOR AN INVENTORY MODEL OF A DETERIORATING ITEM HAVING VARIABLE DEMAND CONSIDERING DEFAULT RISK

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ABSTRACT. In this study, a supplier-retailer-customer supply chain has been proposed for a deteriorating item with expiration time and dynamic deterioration rate. Here, the supplier adopt full credit policy for the retailer to enhance the retailer's order volume. This facility influences the retailer to provide some partial credit opportunity to the customers to boost the demand. For this credit policy, the retailer always faces a risk due to defaulters, which is termed as default credit risk. The default credit risk is considered in more realistic manner, which depends on the customers' partial credit period and credit amount. The market demand is influenced by customers' credit amount, customers' credit period and retail price of the item. Optimal decision is searched by maximizing the average profit of the system. For the search process, an artificial bee colony algorithm is implemented, tested and used. Illustration of the model is done with some hypothetical examples.

Key words : Expiration time; Dynamic deterioration; Credit policy; Credit amount; Default credit risk.

1. Introduction

In any supply chain, among different parameters, market demand is the key factor as revenue of the system fully comes from the sell revenue of the item. This phenomenon influences both the supplier and retailer to adopt different promotional activities to improve their sales. Trade credit is one of the important strategies to improve the demand of each player involved in the system. To increase the retailer's order size, the supplier offers a credit period to the retailer. This opportunity promotes the retailer to adopt some credit policy for his/her customers. Pioneering work in this direction was made by Goyal[1] incorporating credit policy. Afterwards, there are several research works done incorporating full credit policy[2, 3, 4, 5, 6, 7] and partial credit policy[8, 9, 10, 11, 12, 13].

Though credit policy is a good promotional tool for the enhancement of the market demand of any item, any credit policy involves credit risk. In fact, in any business transaction under trade credit policy, there are some business bonding between the supplier and the retailer, but there is no such bonding between the retailer and the customers. In reality customers are floating in nature and so some of the customers normally do not follow business ethics and move to another shop without paying the credit amount. For that, researchers developed their models[8, 12] considering partial credit policy in retailer-customers level to decrease the default credit risk. However, partial credit policy is an excellent attempt to decrease the credit risk, but still it is very critical to draw the optimal decision for the decision maker(DM) as the number of defaulters is not known. To overcome this difficulty, Pramanik *et al.*[14] considered a percentage of total customers as defaulters. But in reality, it is impossible to predict the amount of defaulters at the beginning. So it is more appropriate to consider the default credit risk as a function of customers' credit period and credit amount as the number of defaulters increases/decreases with customers credit amount and credit period proportionally. According to the authors best knowledge, there is only one article[15], considered the default risk as a function of customers' credit period. But number of defaulters may vary with the customers' credit amount also. So default risk must be a function of credit amount and the

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Optimal production run in an imperfect production process with maintenance under warranty and product insurance

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Abstract

In the business world, product warranty and insurance plays an important role by increasing the demand of the product to maximizing the average profit or minimizing the average cost in a manufacturing system. Also, the customers' demand depends on several factors, viz. quality, selling price, payment strategies, warranty and insurance of the product. This paper develops an imperfect production inventory model with preventive machine maintenance, rework, warranty and insurance coverage on the accidentally damaged part(s) of the product. The concerned production system can randomly shift from an in-control state to an out-of-control state at any time during a production run, and the time elapsed while the production process stays in the in-control state is assumed to be exponentially distributed. The rates of producing reworkable defective items in the in-control state and out-control states are different. The demand rate of the customers is considered as the product's selling price and warranty period dependent. To attract customers and increase the demand for the product, the manufacturer offers an insurance policy on the damageable part(s) of the product within the warranty period. The main aim of this study is to find the optimal production time, selling price for the different warranty periods of the product, which maximizes the profit per unit business period. To examine the validity of the proposed model, two numerical examples are considered and solved with the help of MATHEMATICA software. Finally, the effects of warranty and insurance policies on the products are analyzed, based on the numerical examples.

Keywords Imperfect production · Reworked · Machine maintenance · Warranty · Insurance policy

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Two-mode difference-squeezing in CARS and CAHRS processes

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Abstract: In this manuscript, we studied two-mode difference-squeezing in coherent anti-Stokes Raman scattering (CARS) and coherent anti-Stokes hyper Raman scattering (CAHRS) processes. We established that for uncorrelated modes, the difference (higher-order) squeezing of the fundamental and Stokes fields can be turned into the normal squeezing of the anti-Stokes field. We showed that the second-order (amplitude-squared) squeezing and the fourth-order (amplitude fourth-power) squeezing of the fundamental (pump) mode are directly converted into the normal squeezing of the anti-Stokes mode in CARS and CAHRS processes, respectively. We investigated that the difference-squeezing responds nonlinearly to the number of pump photons and found it greater in the CAHRS process than in the CARS process. We established the concept of detection of difference-squeezing and normal squeezing in these processes. It is inferred that difference-squeezing exists only in certain domains of pump photons. We demonstrated that the multi-photon absorption approach is ideal for the generation of optimal squeezed light, which results in a larger reduction of noise in any optical system.

Keywords: Squeezed states; Second-order squeezing; Amplitude-squared; Fourth-order (amplitude fourth-power) squeezing; Difference-squeezing; CARS; CAHRS; Multi-photon process; Photon number operator

1. Introduction

Squeezing of the electromagnetic field [1] is a special feature of non-classical states of light. It has sparked considerable interest in the possibility of reducing the quantum noise of an optical signal below the vacuum limit [2, 3], with potential applications in optical telecommunication [4, 5], quantum cryptography [6, 7], and the development of techniques for performing higher-order correlation measurements [8–13]. In their past research, Prakash and Mishra have looked into higher-order squeezing as a way to improve the performance of a number of optical devices and networks [14–16]. Mishra et al. [17] and Yadav et al. [18] have studied the enhancement of higher-order squeezing with different parameters using beam splitters. Garcia Fernandez et al. [19] as well as Mishra et al. [20] have investigated higher-order nonclassical states in single-mode and their utility in

detecting nonclassical light. Apart from the present work, we [21, 22] have worked out in earlier times the possibilities of co-existence of the higher-order squeezing with lower-order squeezing in pumps, Stokes and anti-Stokes modes, up to the interaction of second-order coupling of the field in CARS and CAHRS processes. Later, Kumar et al. [23] reported the existence of nonclassical nature and enumerated total noise in CARS and CAHRS processes up to first-order Hamiltonian interaction. In addition to the possibilities for the enhanced sensitivity of the measurements, there are several higher-order versions like higher-order amplitude squeezing, sum-squeezing, difference-squeezing, higher-order antibunching, and entanglement that fulfil various aspects of quantum optics [24, 25]. Out of these things, sum-and difference-squeezing is a multi-mode non-classical state of light that was first proposed by Hillery [26]. In the past few decades, many people have been able to get sum-and-difference-squeezing states both theoretically and experimentally in a number of nonlinear optical processes [27–31]. To generalize, three modes [32] as well as an arbitrary number of modes for sum and

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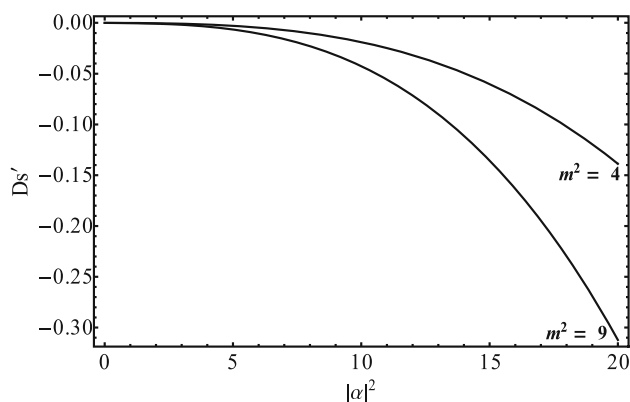


Fig. 8 Variation of the squeezing ($D_{S'}$) in the anti-Stokes mode with $|\alpha|^2$ in degenerate CAHRS process

pump photons $|\alpha|^2$ increases. This confirms that the squeezed states are associated with the large number of pump photons [42, 43]. It also showed that the higher-order squeezing is directly associated with the coupling of the field and interaction time.

A comparison between Figs. 5 and 6 shows greater noise reduction in the fourth-order (amplitude fourth-power) squeezing in the CAHRS process than the second-order squeezing in the CARS process, having the same number of photons. Hence, fourth-order (amplitude fourth-power) will produce more pronounced squeezed laser light than second-order.

Now taking $|\text{gt}|^2 = 10^{-6}$ and draw Figs. 7 and 8 of Eqs. (44) and (74) respectively by D_S and $D_{S'}$ with $|\alpha|^2$ having Stokes mode as constant value $m^2 = 4$ and 9 (arbitrary value taken).

Figures 7 and 8 show that the squeezing increases with the increase in the number of pump photons $|\alpha|^2$ as well as with the increase in the constant value of Stokes mode. It is also inferred that squeezing occurs more in the CAHRS process than in the corresponding CARS process.

6. Conclusions

In this manuscript, we observed that difference-squeezing of optical fields can be converted into normal squeezing in degenerate CARS and CAHRS processes. It is shown that the difference-squeezing responds nonlinearly to the pump photons and is found to be dependent on the coupling of the field and short interaction time. It is found that the squeezing increases with the increase in the number of pump photons as well as with the increase in the constant value of the Stokes mode. It is shown that squeezing is more pronounced in the stimulated process than in the spontaneous process having the same number of photons.

This also confirms that the squeezed states are associated with a large number of photons [42, 43].

It is found that when the number of pump photons is increasing, the degree of difference-squeezing gets more negative until a critical value of pump photon is reached, but subsequently, it decreases and finally disappears. Hence, difference-squeezing exists only in certain domains of pump photons. It is found that there is greater noise reduction in fourth-order (amplitude fourth-power) squeezing in the CAHRS process than in the second-order (amplitude squared) squeezing in the CARS process, having the same number of photons. Hence, the fourth-order (amplitude fourth-power) of the field amplitude results in more pronounced squeezed laser light than the second-order. It is inferred that difference-squeezing is more prominent in the CAHRS process than in the CARS process.

When an amplitude-squared (second-order) squeezing or fourth-order (amplitude fourth-power) squeezing in the fundamental mode propagates through a nonlinear medium, then normal squeezing will be generated in the anti-Stokes mode of the degenerate CARS process or CAHRS process, respectively. Thus, it is inferred that a process that absorbs more multiphotons produces the best squeezed light.

Difference-squeezing, second-order (amplitude-squared) squeezing, and fourth-order (amplitude fourth-power) squeezing are the family of higher-order squeezing effects. A nonlinear interaction that relates the relevant quadratic variable to the amplitude of a mode can turn each member of the family into a normal (lower-order) squeezing. As a result, this family of higher-order squeezing effects may be used to generate squeezing in CARS and CAHRS. They are also of greater fundamental relevance since they are all direct expressions of the electromagnetic field's quantum-mechanical nature. These findings suggest that processes with higher-order nonlinearity are more suitable for the generation of optimum squeezed light, and the results also suggest ways of selecting suitable processes for obtaining greater noise reduction in optical systems, which can be useful in high-quality optical telecommunication [44].

References

- [1] D F Walls *Nature* **306** 141 (1983)
- [2] R Loudon and P L Knight *J. Mod. Opt.* **34** 709 (1987)
- [3] V V Dodonov *J. Opt. B: Quant. Semiclass. Opt.* **4** R1 (2002)
- [4] B E A Saleh and M C Teich *Phys. Rev. Lett.* **58** 2656 (1987)
- [5] H P Yuen and J H Shapiro *IEEE Trans. Inf. Theory.* **24** 657 (1978)
- [6] C H Bennett *Lett.* **68** 557 (1992)
- [7] J Kempe *Phys. Rev. A* **60** 910 (1999)
- [8] C K Hong and L Mandel *Phys. Rev. Lett.* **54** 323 (1985)

- [9] C K Hong and L Mandel *Phys. Rev. A* **32** 974 (1985)
- [10] L A Wu and H J Kimble *Rev. Lett.* **57** 2520 (1986)
- [11] H Prakash and D K Mishra *J. Phys. B: At. Mol. Opt. Phys.* **39** 2291 (2006)
- [12] H Prakash and D K Mishra *J. Phys. B: At. Mol. Opt. Phys.* **40** 2531 (2007)
- [13] K Thapliyal and A Pathak *Commun.* **444** 111 (2019)
- [14] H Prakash and D K Mishra *J. Phys. B: At. Mol. Opt. Phys.* **38** 665 (2005)
- [15] H Prakash and D K Mishra *Opt. Lett.* **35** 2212 (2010)
- [16] H Prakash and D K Mishra *J. Opt. Soc. Am. B* **33** 1552 (2016)
- [17] D K Mishra and V Singh *Opt. Quant. Elect.* **52:68** 1 (2020)
- [18] D Yadav, K K Mishra, G Shukla and D K Mishra *Opt. Quant. Elect.* **53:133** 1 (2021)
- [19] P G Fernandez and L S D L Terreros *Lett. A* **118** 400 (1986)
- [20] D K Mishra *Opt. Commun.* **283** 3284 (2010)
- [21] D K Giri and P S Gupta *J. Mod. Opt.* **51** 1705 (2004)
- [22] D K Giri and P S Gupta *Quant. Electron.* **42** 215 (2010)
- [23] S Kumar and D K Giri *J. Russ. Las. Res.* **41** 235 (2020)
- [24] K Mukherjee and P C Jana *Optica Applicata* **47** 651 (2017)
- [25] D M Truong *J. Theor. Phys.* **53** 899 (2014)
- [26] M Hillery *Phys. Rev. A* **40** 3147 (1989)
- [27] H Prakash and D K Mishra *Eur. Phys. J. D* **45** 363 (2007)
- [28] A V Chizhov and J W Haus *J. Opt. Soc. Am. B* **14** 1541 (1997)
- [29] M Hillery and M S Zubairy *Phys. Lett. A* **103** 259 (1984)
- [30] Y Fang and J Jing *New J. Phys.* **17** 023027 (2015)
- [31] K K Mishra and D Yadav *Scr.* **96** 045102 (2021)
- [32] A Kumar and P S Gupta *Quant. Semiclass. Opt.* **10** 485 (1998)
- [33] D K Giri and P S Gupta *Mod. Phys Lett. B* **19** 1261 (2005)
- [34] M K Olsen and R J Horowicz *Opt. Commun.* **168** 135 (1999)
- [35] N B An and V Tinh *Phys Lett. A* **270** 27 (2000)
- [36] S Wang *Commun.* **335** 108 (2015)
- [37] A Mukherjee and A Giri *Res. J. Basic Appl. Sci.* **1** 39 (2016)
- [38] D K Giri and B K Choudhary *Int. J. Opt.* **2020** 1 (2020)
- [39] K K Mishra, G Shukla, D Yadav and D K Mishra *Opt. Quant. Electron.* **52:186** 1 (2020)
- [40] M Hillery *Phys. Rev. A* **45** 4944 (1992)
- [41] D K Giri and P S Gupta *J. Opt. B: Quant. Semiclass. Opt.* **5** 158 (2003)
- [42] A Kumar and P S Gupta *Quantum Semiclass. Opt.* **7** 835 (1995)
- [43] N B An *Phys. Lett. A* **234** 45 (1997)
- [44] D K Giri *Quant. Electron.* **46** 1127 (2014)

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Review

Insight on the choice of sensitizers/dyes for dye sensitized solar cells: A review

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ABSTRACT

In this review, a discussion on renewable sources of energy with clear focus on solar cell applications is presented. Especially, possible future directions for development of dye-sensitized solar cells (DSSCs) are discussed. Dye-sensitized solar cells have become an important topic of research due to its high importance in energy conversion. Current DSSCs are based on metal dye sensitizers, metal-free organic dyes or natural dyes. They have been extensively studied due to their low cost, simple preparation methodology, low toxicity, and ease of production. Still there is a need to find more abundant DSSC materials that at the same time exhibit long-term stability. Computational studies have been an important ally for developing/designing new dye sensitizers. They are reviewed here with a special emphasis on the benefit of such studies. The conceptual understanding of development and working principle of photoactive DSSC materials is the primary feature of the review followed by examples of studies on different dye sensitizers using scarce to abundant metal based dyes and metal free organic dyes with donor- π -acceptor geometries for both n- and p-type DSSCs. The proper choice of organic dyes including donor, spacer, or acceptor is discussed and a prospective on dual donor based dyes is presented.

1. Introduction

With the increase in the population and the advancement of the civilization, the demand of energy is escalating, raising major concerns for the adverse effects of conventional energy sources like natural gas, coal, fossil fuels etc. on the environment of the earth. Furthermore, the fast depletion of the natural resources like fossil fuels reserves is also an important motivation for many researchers worldwide to search for alternative and renewable sources of energy associated with no or low pollution of the environment.

Renewable energy sources are sustainable and can be regarded to provide an endless source of energy. In recent years, a growing amount of important household demands such as electricity, air and water heating/cooling, transportation and rural (off-grid) energy services are being provided in many countries based on renewable energy sources. The most popular renewable energies are.

a. Solar Energy

b. Wind energy

c. Hydro energy

d. Tidal energy

e. Geothermal energy

f. Biomass energy

According to a report of REN21 (Renewable Energy Policy Network for the 21st Century) in the years 2017, a total of 19.3% of the total energy consumed in the human population was provided from renewable energy sources for the year 2015–2016. The total contribution is divided into 8.9% from traditional biomass; 4.2% from geothermal and solar energy sources, 3.9% from hydroelectricity and the remaining 2.2% from wind, solar, geothermal. Investments and jobs associated with renewable energy are increasing every year, and the efficiency of its generation is also increasing along with a decrease in the cost. Out of the five different renewable systems as given in Fig. 1, the most abundant and freely and globally available source of energy is the sun providing solar energy. With respect to the other energies one can note

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- [388] Guo F, Liu X, Ding Y, Kong F, Chen W, Zhou L, Dai S. Broad spectral-response organic D-A- π -A sensitizer with pyridine-diketopyrrolopyrrole unit for dye-sensitized solar cells. *RSC Adv* 2016;6:13433–41.
- [389] Patil DS, Sonigara KK, Jadhav MM, Avhad KC, Sharma S, Soni SS, Sekar N. Effect of structural manipulation in hetero-tri-aryl amine donor-based D-A'- π -A sensitizers in dye-sensitized solar cells. *New J Chem* 2018;42:4361–71.
- [390] Huang H, Chen H, Long J, Wang G, Tan S. Novel D-A- π -A organic dyes based on 3-dimensional triarylamine and benzothiadiazole derivatives for high-performance dye-sensitized solar cells. *J Power Sources* 2016;326:438–46.
- [391] Shen Z, Zhang X, Giordano F, Hu Y, Hua H, Zakeeruddin SM, Tian H, Grätzel M. Significance of π -bridge contribution in pyrido[3,4-b]pyrazine featured D-A- π -A organic dyes for dye-sensitized solar cells. *Mater Chem Front* 2016;1:181–9.
- [392] Dessi A, Chalkias DA, Balancia S, Sinicropi A, Calamante M, Mordini A, Karavioti A, Stathatos E, Zani L, Reginato G. D-A- π -A organic dyes with tailored green light absorption for potential application in greenhouse-integrated dye-sensitized solar cells. *Sustain. Energ.Fuels*. 2021;5:1171–83.
- [393] Tian L, Wang Y, Zhang Y, Li X, Wu W, Liu B. Molecular engineering of indoline dyes and their application in dye-sensitized solar cells: effect of planarity and side chain on interfacial charge-transfer processes. *ACS Appl Energy Mater* 2021;4:242–8.
- [394] Yao Z, Zhang M, Wu H, Yang L, Li R, Wang P. Donor/acceptor indenoperylene dye for highly efficient organic dye-sensitized solar cells. *J Am Chem Soc* 2015;137:3799–802.
- [395] Yao Z, Zhang M, Li R, Yang L, Qiao Y, Wang P. A metal-free N-annulated thienocyclopentaperylene dye: power conversion efficiency of 12 % for dye-sensitized solar cells. *Angew Chem* 2015;54:5994–8.
- [396] Ren Y, Sun D, Cao Y, Tsao HN, Yuan Y, Zakeeruddin SM, Wang P, Grätzel M. A stable blue photosensitizer for color palette of dye-sensitized solar cells reaching 12.6% efficiency. *J Am Chem Soc* 2018;140:2405–8.
- [397] Li M, Kou L, Diao L, Zhang Q, Li Z, Wu Q, Lu W, Pan D, Wei Z. Theoretical study of W-9-Based organic sensitizers for unusual vis/NIR absorption and highly efficient dye-sensitized solar cells. *J Phys Chem C* 2015;119:9782–90.
- [398] Xu Y, Xu X, Li M, Lu W. Prediction of photoelectric properties, especially power conversion efficiency of cells, of IQ1 and derivative dyes in high-efficiency dye-sensitized solar cells. *Sol Energy* 2020;195:82–8.
- [399] Mao L, Dun S, Ren H, Jiang J, Guo X, Huang F, Heng P, Wang L, Zhang J, Ågren H. Introducing chenodeoxycholic acid coadsorbent and strong electron-withdrawing group in indoline dyes to design high-performance solar cells: a remarkable theoretical improvement. *J Mater Chem C* 2021;9:5800–7.
- [400] Zhang J, Zhu H-C, Zhong R-L, Wang L, Su Z-M. Promising heterocyclic anchoring groups with superior adsorption stability and improved IPCE for high-efficiency noncarboxyl dye sensitized solar cells: a theoretical study. *Org Electron* 2018;54:104–13.
- [401] Hua Y, Chang S, Huang D, Zhou X, Zhu X, Zhao J, Chen T, Wong WY, Wong WK. Significant improvement of dye-sensitized solar cell performance using simple phenothiazine-based dyes. *Chem Mater* 2013;25:2146–53.
- [402] Ren X, Jiang S, Cha M, Zhou G, Wang ZS. Thiophene-bridged double D- π -A dye for efficient dye-sensitized solar cell. *Chem Mater* 2012;24:3493–9.
- [403] Hong Y, Iqbal Z, Yin X, Cao D. Synthesis of double D-A branched organic dyes employing indole and phenoxazine as donors for efficient DSSCs. *Tetrahedron* 2014;70:6296–302.
- [404] Hong Y, Liao JY, Fu J, bin Kuang D, Meier H, Su CY, Cao D. Performance of dye-sensitized solar cells based on novel sensitizers bearing asymmetric double D- π -A chains with arylamines as donors. *Dyes Pigments* 2012;94:481–9.
- [405] Cao D, Peng J, Hong Y, Fang X, Wang L, Meier H. Enhanced performance of the dye-sensitized solar cells with phenothiazine-based dyes containing double D-A branches. *Org Lett* 2011;13:1610–3.
- [406] Hong Y, Liao JY, Cao D, Zang X, bin Kuang D, Wang L, Meier H, Su CY. Organic dye bearing asymmetric double donor- π -Acceptor chains for dye-sensitized solar cells. *J Org Chem* 2011;76:8015–21.
- [407] Ning Z, Zhang Q, Wu W, Pei H, Liu B, Tian H. Starburst triarylamine based dyes for efficient dye-sensitized solar cells. *J Org Chem* 2008;73:3791–7.
- [408] Jungstuiwong S, Tarsang R, Sudyoadsuk T, Promarak V, Khongpracha P, Namuangruk S. Theoretical study on novel double donor-based dyes used in high efficient dye-sensitized solar cells: the application of TDDFT study to the electron injection process. *Org Electron* 2013;14:711–22.
- [409] Wang S, Wang H, Guo J, Tang H, Zhao J. Influence of the terminal electron donor in D-D- π -A phenothiazine dyes for dye-sensitized solar cells. *Dyes Pigments* 2014;109:96–104.
- [410] Balanay MP, Enopia CMG, Lee SH, Kim DH. Theoretical design of triphenylamine-based derivatives with asymmetric D-D- π -A configuration for dye-sensitized solar cells. *Spectrochim Acta Mol Biomol Spectrosc* 2015;140:382–91.
- [411] Han F, Wang Y, Wan Z, Jia C, Luo J, Yao X. Enhanced photovoltaic performances of dye-sensitized solar cells sensitized with D-D- π -A phenothiazine-based dyes. *Synth Met* 2016;221:95–102.
- [412] Saritha G, Mangalaraja RV, Anandan S. High-efficiency dye-sensitized solar cells fabricated using D-D- π -A (Donor-Donor/ π -Spacer-Acceptor) architecture. *Sol Energy* 2017;146:150–60.
- [413] Dai P, Yang L, Liang M, Dong H, Wang P, Zhang C, Sun Z, Xue S. Influence of the terminal electron donor in D-D- π -A organic dye-sensitized solar cells: dithieno [3,2-b:2',3'-d]pyrrole versus bis(amine). *ACS Appl Mater Interfaces* 2015;7:22436–47.
- [414] Yang Z, Shao D, Li J, Tang L, Shao C. Design of butterfly type organic dye sensitizers with double electron donors: the first principle study, *Spectrochim. Acta Part A* 2018;196:385–91.
- [415] Chai Q, Li W, Zhu S, Zhang Q, Zhu W. Influence of donor configurations on photophysical, electrochemical, and photovoltaic performances in D- π -A organic sensitizers. *ACS Sustainable Chem Eng* 2013;2:239–47.
- [416] Jiang S, Chen Y, Li Y, Han L. Novel D-D- π -A indoline-linked coumarin sensitizers for dye-sensitized solar cells. *J Photochem Photobiol, A* 2019;384:112031.
- [417] Lee YH, Chitumalla RK, Jang BY, Jang J, Thogiti S, Kim JH. Alkyl chain length dependence of the charge-transfer, recombination and electron diffusion length on the photovoltaic performance in double donor-acceptor-based organic dyes for dye sensitized solar cells. *Dyes Pigments* 2016;133:161–72.
- [418] Qian X, Wang X, Shao L, Li H, Yan R, Hou L. Molecular engineering of D-D- π -A type organic dyes incorporating indoloquinoline and phenothiazine for highly efficient dye-sensitized solar cells. *J Power Sources* 2016;326:129–36.
- [419] Saritha G, Mangalaraja RV, Anandan S. High-efficiency dye-sensitized solar cells fabricated using D-D- π -A (Donor-Donor/ π -Spacer-Acceptor) architecture. *Sol Energy* 2017;146:150–60.
- [420] Sharmoukh W, Cong J, Gao J, Liu P, Daniel Q, Kloos L. Molecular engineering of D-d- π -A-based organic sensitizers for enhanced dye-sensitized solar cell performance. *ACS Omega* 2018;3:3819–29.
- [421] Jin L, Shi S, Zhao C, Yu X, Lu J, Wang Q, Wei Y. Y-shaped organic dyes with D2- π -A configuration as efficient co-sensitizers for ruthenium-based dye sensitized solar cells. *J Power Sources* 2021;481:228952.
- [422] Desta MB, Vinh NS, Pavan Kumar CH, Chaurasia S, Wu W-T, Lin JT, Wei T-C, Wei-GuangDiao E. Pyrazine-incorporating panchromatic sensitizers for dye sensitized solar cells under one sun and dim light. *J Mater Chem* 2018;6:13778–89.
- [423] Reddy KSK, Liu Y-C, Chou H-H, Kala K, Wei T-C, Yeh C-Y. Synthesis and characterization of novel β -bis(N,N-Diarylamino)-Substituted porphyrin for dye-sensitized solar cells under 1 sun and dim light conditions. *ACS Appl Mater Interfaces* 2018;10:39970–82.
- [424] Biswas S, Kim H. Solar cells for indoor applications: progress and development. *Polymers* 2020;12:1338.
- [425] Devidiga D, Selvakumar M, Shetty P, Santosh MS. Dye-sensitized solar cell for indoor applications: a mini-review. *J Electron Mater* 2021;50:3187–206.
- [426] Haridas R, Velore J, Pradhan SC, Vindhyasarumi A, Yoosaf K, Soman S, Unni KNN, Ajayaghosh A. Indoor light-harvesting dye-sensitized solar cells surpassing 30% efficiency without Co-sensitizers. *Materials Advances* 2021;2:7773–87.
- [427] Michaels H, Rinderle M, Freitag R, Benesperi I, Edvinsson T, Socher R, Gagliardi A, Freitag M. Dye-sensitized solar cells under ambient light powering machine learning: towards autonomous smart sensors for the internet of things. *Chem Sci* 2020;11:2895–906.
- [428] Saygili Y, Söderberg M, Pellet N, Giordano F, Cao Y, Muñoz-García AB, Zakeeruddin SM, Vlachopoulos N, Pavone M, Boschloo G, et al. Copper bipyridyl redox mediators for dye-sensitized solar cells with high photovoltage. *J Am Chem Soc* 2016;138:15087–96.
- [429] Freitag M, Giordano F, Yang W, Pazoki M, Hao Y, Zietz B, Grätzel M, Hagfeldt A, Boschloo G. Copper phenanthroline as a fast and high-performance redox mediator for dye-sensitized solar cells. *J Phys Chem C* 2016;120:9595–603.
- [430] Burnside S, Winkel S, Brooks K, Shklover V, Grätzel M, Hinsch A, Kinderman R, Bradbury C, Hagfeldt A, Petterson H. *J Mater Sci Mater Electron* 2000;11:355–62.
- [431] Lan J-L, Wei T-C, Feng S-P, Wan C-C, Cao G. Effects of iodine content in the electrolyte on the charge transfer and power conversion efficiency of dye-sensitized solar cells under low light intensities. *J Phys Chem C* 2012;116:25727–33.
- [432] Freitag M, Teuscher J, Saygili Y, Zhang X, Giordano F, Liska P, Hua J, Zakeeruddin SM, Moser J-E, Grätzel M, Hagfeldt A. Dye-sensitized solar cells for efficient power generation under ambient lighting. *Nat Photonics* 2017;11:372–8.
- [433] Cao Y, Liu Y, Zakeeruddin SM, Hagfeldt A, Grätzel M. Direct contact of selective charge extraction layers enables high-efficiency molecular photovoltaics. *Joule* 2018;2:1108–17.
- [434] Kapil G, Ogomi Y, Pandey SS, Ma T, Hayase S. Indoor light performance of coil type cylindrical dye sensitized solar cells. *J Nanosci Nanotechnol* 2016;16:3183–7.
- [435] Venkatesan S, Liu I-P, Hung W-N, Teng H, Lee Y-L. Highly efficient quasi-solid-state dye-sensitized solar cells prepared by printable electrolytes for room light applications. *Chem Eng J* 2019;367:17–24.
- [436] Reddy KSK, Chen Y-C, Wu C-C, Hsu C-W, Chang Y-C, Chen C-M, Yeh C-Y. Cosensitization of structurally simple porphyrin and anthracene-based dye for dye-sensitized solar cells. *ACS Appl Mater Interfaces* 2018;10:2391–9.
- [437] Chang T-K, Chi Y. Bis-tridentate Ru(II) sensitizers with a spatially encumbered 2,6-dipyrazolopyridine ancillary ligand for dye-sensitized solar cells. *RSC Adv* 2017;7:42013–23.
- [438] Liu Y, Cao Y, Zhang W, Stojanovic M, Dar MI, Péchy P, Saygili Y, Hagfeldt A, Zakeeruddin SM, Grätzel M. Electron-affinity-triggered variations on the optical and electrical properties of dye molecules enabling highly efficient dye-sensitized solar cells. *Angew Chem* 2018;130:14321–4.
- [439] Duan L, Hoex B, Uddin A. Progress in semitransparent organic solar cells. *Solar RRL* 2021;5:2100041.
- [440] Vesce L, Mariani P, Calamante M, Dessi A, Mordini A, Zani L, Carlo A. Process engineering of semitransparent DSSC modules and panel incorporating an organic sensitizer. *Solar RRL* 2022;6:2200403.
- [441] Chang C-Y, Zuo L, Yip H-L, Li Y, Li C-Z, Hsu C-S, Cheng Y-J, Chen H, Jen AK-Y. A versatile fluoro-containing low-bandgap polymer for efficient semitransparent and tandem polymer solar cells. *Adv Funct Mater* 2013;23:5084–90.



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IoBT: beamforming design in internet of things

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Abstract

Non-orthogonal multiple access (NOMA) is a key concept of the sixth generation (6G) mobile network. In the 6G paradigm, NOMA is a significant energy and spectral efficiency technique, especially in the indoor region, to maintain the quality of service. Multiple input multiple outputs (MIMO) base station serves as the main base station due to massive connectivity. In MIMO, spatial modulation (SM) gives a huge data rate and reduces inter-antenna interference. Beamforming permits a proficient intercell interference organization for short-distance data transmission. The prime concept in NOMA is to provide various end users with the same resource block based on a time frame, spreading code, or subcarrier successive interference cancellation. In this article, we propose a power-efficient 6G NOMA-beamforming-based spectrum allocation scheme for the Internet of Things (IoT) devices in the indoor region. MIMO with SM transmits the signal to indoor next-generation node B (gNB). It is a 3GPP-complaint implementation of 5G/beyond 5G base stations. Various IoT devices are connected with those gNBs and share the communication resources. In this paper, we propose an IoT device-interoperability scheme based on the requirements of the IoT devices aiming at improving the network performance. The simulation results show that the proposed model diminishes power consumption and improves signal-to-interferences-plus-noise ratio.

Keywords NOMA · Beamforming · 6G · Spectral efficiency · SINR · Power consumption

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7. Di Renzo M, Haas H, Ghayeb A, Sugiura S, Hanzo L (2013) Spatial modulation for generalized MIMO: challenges, opportunities, and implementation. *Proc IEEE* 102(1):56–103
8. Rajashekar R, Hari KVS, Giridhar K, Hanzo L (2013) Performance analysis of antenna selection algorithms in spatial modulation systems with imperfect CSIR. In: *European Wireless 2013; 19th European Wireless Conference*, pp 1–5
9. Huang X, Tang S, Zheng Q, Zhang D, Chen Q (2018) Dynamic femtocell gNB on/off strategies and seamless dual connectivity in 5G heterogeneous cellular networks. *IEEE Access* 6:21359–21368
10. Ahmed M, Peng M, Abana M, Yan S, Wang C (2018) Interference coordination in heterogeneous small-cell networks: a coalition formation game approach. *IEEE Syst J* 12(1):604–615
11. Damodaran SP, Srinivasan VK, Rajakani K (2019) Optimized and low-complexity power allocation and beamforming with full duplex in massive MIMO and small-cell networks. *J Supercomput* 75(12):7979–7993
12. Nguyen LD, Tuan HD, Duong TQ, Dobre OA, Poor HV (2018) Downlink beamforming for energy-efficient heterogeneous networks with massive MIMO and small cells. *IEEE Trans Wirel Commun* 17(5):3386–3400
13. Fama F, Faria JN, Portugal D (2022) An IoT-based interoperable architecture for wireless biomonitoring of patients with sensor patches. *Internet Things* 19:100547
14. Kumari A, Tanwar S, Tyagi S, Kumar N, Obaidat MS, Rodrigues JJ (2019) Fog computing for smart grid systems in the 5G environment: challenges and solutions. *IEEE Wirel Commun* 26(3):47–53
15. Xu D, Ren P, Du Q, Sun L, Wang Y (2018) Design in power-domain NOMA: eavesdropping suppression in the two-user relay network with compensation for the relay user. *Mob Netw Appl* 23(4):1068–1079
16. Yang Z, Ding Z, Fan P, Al-Dhahir N (2016) A general power allocation scheme to guarantee quality of service in downlink and uplink NOMA systems. *IEEE trans wirel commun* 15(11):7244–7257
17. Zhu J, Wang J, Huang Y, He S, You X, Yang L (2017) On optimal power allocation for downlink non-orthogonal multiple access systems. *IEEE J Sel Areas Commun* 35(12):2744–2757
18. Lv L, Chen J, Ni Q, Ding Z (2017) Design of cooperative non-orthogonal multicast cognitive multiple access for 5G systems: user scheduling and performance analysis. *IEEE Trans Commun* 65(6):2641–2656
19. Choi J (2016) On the power allocation for MIMO-NOMA systems with layered transmissions. *IEEE Trans Wirel Commun* 15(5):3226–3237
20. Sun X, Yu L, Yang Y (2021) Jointly optimizing user clustering, power management, and wireless channel allocation for NOMA-based internet of things. *Digit Commun Netw* 7(1):29–36
21. Miandoab FT, Tazehkand BM (2019) A user pairing method to improve the channel capacity for multiuser MIMO channels in downlink mode based on NOMA. *Comput Commun* 146:15–21
22. Lee E, Seo YD, Oh SR, Kim YG (2021) A survey on standards for interoperability and security in the internet of things. *IEEE Commun Surv Tutor* 23(2):1020–1047
23. Broring A, Ziller A, Charpenay V, Thuluva AS, Anicic D, Schmid S, Seidel C (2018) The big IoT API-semantically enabling IoT interoperability. *IEEE Pervasive Comput* 17(4):41–51
24. Noura M, Atiquzzaman M, Gaedke M (2019) Interoperability in internet of things: taxonomies and open challenges. *Mob Netw Appl* 24(3):796–809
25. Lee CH, Chang RY, Cheng SM, Lin CH, Hsiao CH (2021) Joint beamforming and power allocation for M2M/H2H co-existence in green dynamic TDD networks: low-complexity optimal designs. *IEEE Internet Things J* 9(6):4799–4815
26. Mahmood A, Zeeshan M (2019) Power allocation and performance analysis of multiuser NOMA under NYUSIM channel model. In: *2019 14th Conference on Industrial and Information Systems*, pp 296–301
27. Zhang Z, Junhui Z, Ni S, Gong Y (2019) A seamless handover scheme with assisted gNB for 5G C/U plane split heterogeneous network. *IEEE Access* 7:164256–164264
28. Khalid N, Yilmaz T, Akan OB (2018) Energy-efficient modulation and physical layer design for low terahertz band communication channel in 5G femtocell internet of things. *Ad Hoc Netw* 79:63–71
29. Bridgelall R (2003) Enabling mobile commerce through pervasive communications with ubiquitous RF tags. *IEEE Wirel Commun Netw* 3:2041–2046
30. Mukherjee A, De D, Deb P (2016) Interference management in macro-femtocell and micro-femtocell cluster-based long-term evaluation-advanced green mobile network. *IET Commun* 10(5):468–478

31. Li CF, Hwang JK, Ma C, Lin CJ (2017) Software defined radio implementation of LTE R13 NB-IoT downlink vector signal generator. In: 2017 IEEE International Conference on Consumer Electronics-Taiwan, pp 69–70

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Mobi-Sense: mobility-aware sensor-fog paradigm for mission-critical applications using network coding and steganography

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Abstract

Mission-critical applications refer to the real-time applications, which require fast and secure service provisioning, such as defense sector and disaster management. This paper proposes a delay-aware and secure service provisioning model for such types of applications. As a use-case, we have considered the defense sector, which is a vital sector for a country's all-round well-being including security, safety, society, and economy. In the conventional sensor-cloud model, the sensor data is stored and processed in the cloud. However, the sensor nodes have small coverage and the use of the long distant cloud servers increases the delay. Therefore, the conventional sensor-cloud model may not be efficient for defense application. Moreover, data hiding for security purposes is another important aspect of this field. To address these challenges, this paper proposes a mobility-aware sensor-fog paradigm for mission-critical applications based on network coding and steganography, referred to as *Mobi-Sense*. In *Mobi-Sense*, steganography is used for hiding the data during transmission. The theoretical results demonstrate that *Mobi-Sense* outperforms the existing frameworks with respect to delay and power consumption by $\sim (40 - 80)\%$. The simulation results present that *Mobi-Sense* reduces the delay by $\sim (18 - 40)\%$ than the conventional sensor-cloud framework for mission-critical applications. An optimal path finding algorithm based on deep learning has been deployed in the context of disaster scenario. The experimental analysis shows that the proposed optimal path finding method achieves precision and accuracy above 90%. This is observed that our proposed modules have outperformed existing baselines in terms of accuracy, delay, and power consumption.

Keywords Mission-critical · Sensor-fog · Delay-aware · Power-aware · Data hiding · Path extraction

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E-CropReco: a dew-edge-based multi-parametric crop recommendation framework for internet of agricultural things

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Abstract

Crop productivity prediction and recommendation is a significant research area of smart agriculture. This paper proposes an Internet of Things (IoT) framework based on dew computing, edge computing, and federated learning, where soil parameters, environmental parameters, and weather data are analysed to predict the crop productivity of a land, and then recommend suitable crop for the land. The dew layer pre-processes and accumulates the received sensor data, and forwards to the edge server. The edge server analyses the sensor data and the weather data, and then sends the result to the cloud along with the model characteristics and to the mobile device. The proposed framework is simulated in iFogSim. The theoretical analysis shows that the proposed framework has reduced the delay by 60–70% approximately and power consumption by 70–80% approximately than the conventional sensor-cloud framework. We also observe that the proposed framework has reduced the delay by 12–35% approximately and power consumption by 30–50% approximately than the edge-cloud framework. We compare four machine learning algorithms based on their performance in data analysis in terms of precision, recall, accuracy, and *F*-score. We observe that each classifier obtains more than 95% prediction accuracy. An Android application is also proposed for crop recommendation.

Keywords Crop recommendation · Dew computing · Edge computing · Internet of agricultural things

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22. Farooq Muhammad Shoaib, Riaz Shamyala, Abid Adnan, Abid Kamran, Naeem Muhammad Azhar (2019) A survey on the role of iot in agriculture for the implementation of smart farming. *IEEE Access* 7:156237–156271
23. Ananthi N, Divya J, Divya M, Janani V (2017) IoT based smart soil monitoring system for agricultural production. In 2017 IEEE technological innovations in ICT for agriculture and rural development (TIAR), pp 209–214. *IEEE*
24. Ahmed N, De D, Hussain I (2018) Internet of things (IoT) for smart precision agriculture and farming in rural areas. *IEEE Internet Things J* 5(6):4890–4899
25. Partha Pratim Ray (2017) An introduction to dew computing: definition, concept and implications. *IEEE Access* 6:723–737
26. Rana S, Obaidat MS, Mishra D, Mishra A, Rao SY (2022) Efficient design of an authenticated key agreement protocol for dew-assisted IoT systems. *J Supercomput* 78(3):3696–3714
27. Javadzadeh G, Rahmani AM, Kamarposhti MS (2022) Mathematical model for the scheduling of real-time applications in IoT using dew computing. *J Supercomput* 78(5):7464–7488
28. Hati S, De D, Mukherjee A (2022) Dewbcity: blockchain network-based dew-cloud modeling for distributed and decentralized smart cities. *J Supercomput* 78(6):8977–8997
29. Manocha A, Bhatia M, Kumar G (2021) Dew computing-inspired health-meteorological factor analysis for early prediction of bronchial asthma. *J Netw Comput Appl* 179:102995
30. Ghosh S, De D (2022) Dewcitygame: dew computing-based 5g iot for smart city using coalition formation game. *IETE J Res*, pp 1–10
31. Li T, Sahu AK, Talwalkar A, Smith V (2020) Federated learning: challenges, methods, and future directions. *IEEE Signal Process Magaz* 37(3):50–60
32. Kumar P, Gupta GP, Tripathi R (2021) Deep privacy-encoding based federated learning framework for smart agriculture. *IEEE Micro*, Pefl
33. Thilakarathne NN, Bakar MSA, Abas PE, Yassin H (2022) A cloud enabled crop recommendation platform for machine learning-driven precision farming. *Sensors* 22(16):6299
34. Cruz M, Mafra S, Teixeira E (2022) An iot crop recommendation system with k-nn and lora for precision farming
35. Gupta H, Vahid DA, Ghosh SK, Buyya R (2017) ifogsim: a toolkit for modeling and simulation of resource management techniques in the internet of things, edge and fog computing environments. *Softw Practice Exp* 47(9):1275–1296

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IoHMT: a probabilistic event-sensitive music analytics framework for low resource internet of humanitarian musical things

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Abstract

The proactive statistical framework of musical note structures produces a crucial role in multimedia music classification and reconstruction strategies. Another significant thing for harmonious music composition is the rhythmic structures that transform musical performances into harmonic forms. Intelligent music computing paradigms try to establish human–machine interaction phenomena for systematic music generations, compositions, and reconstructions. In the emergent internet era, musical composition and reconstruction schema are largely dependent on the IoT-based paradigm where human beings can arrange musical compositions through musical things, such as, remotely arranged singing and musical instruments, smart rhythmic behaviours, and intelligent auto-tuning systems. Although it can possess substantial success, computers yet struggle with comprehending several facets of computational musicology, that are challenging in formal characterization. Moreover, most of the success is achieved for chord-based standardized western music compositions, whereas melodic Indian music is composed through single-note structures. Low resource music computing is in dire need of tools and resources to overcome the resource barrier such that probabilistic and intelligent IoT-based music formations can deliver more widespread benefits. This paper illustrates (a) computational music speculation and associated characteristics to standardize what human beings can assimilate, recall, and reconstruct musical items for sustaining intangible cultural heritage; (b) a stochastic model along with probabilistic context-free music grammar to afford a syntactic outline of musical note arrangements; (c) state transition analysis; (d) Petri net-based complex music composition framework along with the simulation-based reachability and system efficiency for evaluating the effectiveness of event-driven music schema; (e) a systematized case study on low resource Internet of Music Things for humanistic care computing, that we have named as the Internet of Humanitarian Musical Things (IoHMT).

Keywords Computational musicology · Music automata · Music composition and reconstruction · Petri Nets · Markov model · Reachability · Low resource environment · Internet of music things

1 Introduction

Musical performances such as one of the intangible heritages in entertainment that, regardless of its pervasive existence in the human ethos, remain mostly unsusceptible to comprehensive understanding. The statistical and structural pattern recognition strategies are already active in the context of musical heritage conservancy and manipulation. Although, the specific issue is that the music information confined in the digital music representation is not laid back to extract musical background through the conventional paradigms [1]. With the advancements in computational paradigms, some novel music composition and reconstruction frameworks have been illustrated. Researchers have often visualized that music projects a handy affinity to mathematical analysis and

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- things. *Internet Technology Letters*. e331. <https://doi.org/10.1002/itl2.331>
29. Roy S, Biswas M, De D (2020) iMusic: a session-sensitive clustered classical music recommender system using contextual representation learning. *Multimedia Tools Appl* 79:24119–24155. <https://doi.org/10.1007/s11042-020-09126-8>
30. Mor B, Garhwal S, Kumar A (2020) A systematic literature review on computational musicology. *Archives Comput Methods Eng* 27(3):923–937. <https://doi.org/10.1007/s11831-019-09337-9>
31. Ruiz-Rube I, Person T, Dodero JM, Mota JM, Sánchez-Jara JM (2020) Applying static code analysis for domain-specific languages. *Softw Syst Model* 19(1):95–110. <https://doi.org/10.1007/s10270-019-00729-w>
32. Baratè A, Haus G, Ludovico LA, Mauro DA (2018) Formalizing Schoenberg's Fundamentals of Musical Composition through Petri Nets. In *Sound and Music Computing Conference, SMC network*, pp 254–258. <https://doi.org/10.5281/zenodo.1422578>
33. Roy S, De D (2020) Data for: MusicHeritage: a probabilistic event-sensitive computational framework for Indian music composition and reconstruction (2020). <https://doi.org/10.17632/8j7dgi9wbz.4>

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MCG: Mobility-Aware Computation Offloading in Edge Using Weighted Majority Game

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Abstract—Edge computing plays a pivotal role in computation offloading at low latency. However, selecting the appropriate node to offload a computation is a challenge, especially when the user node is mobile. The problem can be stated as follows: (i) a mobile device has to offload a computation, and the user is moving, (ii) a set of edge/fog devices is available nearby the mobile device, then to select the suitable device to offload the computation. To address the challenge, this paper proposes an end-to-end mobility-aware computation offloading framework, MCG, which consists of: (i) a novel mobility prediction module that finds the user mobility pattern, (ii) selection of a set of edge/fog devices based on the predicted mobility and user’s current location, (iii) selection of the high majority device from the set of edge/fog devices based on the resource availability and present load of the devices, and (iv) offloading the computation to the selected high majority device. The experimental results demonstrate that MCG outperforms existing mobility prediction modules in terms of accuracy, precision, and recall measures. The theoretical analysis and experimental results illustrate that MCG reduces the latency and power consumption of mobile device during offloading compared to existing offloading strategies.

Index Terms—Computation offloading, Game theory, Latency-aware, Low power, Mobility analytics.

I. INTRODUCTION

THE explosive increase in the usage of smartphones for accessing resource exhaustive applications has raised different challenges, e.g. limited battery, increase in latency, high power consumption, etc. To deal with them, mobile cloud computing (MCC) comes [1], [2]. To overcome the problem of resource limitation of the mobile devices, the offloading of data and computation has been introduced, where mobile devices store their data and execute their computations inside the cloud, cloudlet, etc. [1],

[3]. In computation offloading, a node requests another node to execute its computation. After execution, the serving node sends the result to the requesting node. However, offloading computation from a mobile device to the remote cloud increases delay, and to overcome this problem edge and fog devices can be used [4], [5], [6]. Now, a situation may arise where multiple edge/fog devices are available in the vicinity of the mobile device. In such a scenario, the selection of the suitable edge/fog device for “green” offloading of the computation at low latency is a challenge because user mobility can affect network connectivity. Here, the term “green” refers to low power consumption.

Motivating scenario: Let a mobile device (say, D) has to offload a computation, and a set edge/fog devices is available nearby (say, $F_{pre} = \{F_1, F_2, F_3, F_4, F_5\}$) (refer to Fig. 1). Although, F_1 is the nearest one with respect to the present location of the mobile user (say, u), as he moves he goes out of the coverage of F_1 . In such a case, offloading the computation to F_1 may not be fruitful. As a solution to this problem, the prediction of the destination and the probable path to be followed by u is highly desirable. Consequently, the edge/fog devices in the predicted path can be detected. Let in the present scenario, u is currently at location A and his destination is location B . The probable path to be followed by u to reach B is marked in blue colour in Fig. 1. The set of edge/fog devices in the predicted path is $F_{nex} = \{F_3, F_4, F_5, F_6, F_7, F_8\}$ (refer to Fig. 1). In this scenario, offloading to a device, which is presently nearby as well as present in the predicted path may be better compared to selecting the presently nearest device to offload the computation. Now, if more than one device belong to the set $(F_{nex} \cap F_{pre})$, (here, $\{F_3, F_4, F_5\}$), then finding the suitable device among them to offload the computation is a challenge. The use of game theory can provide a solution to this problem. Now, another situation may also arise, where D gets disconnected from the serving edge/fog device due to mobility. In such a case, prediction of the next location and delivery of the result to D through the probable connecting edge/fog node, can be fruitful. For instance, D offloads computation to F_3 , and gets disconnected before getting the result. When the result is ready to deliver, D is not present in the coverage of F_3 . In such a case, F_3 sends the result to the cloud that forwards the result to the nearby connecting edge/fog device (say, F_5) of u after predicting his next location, and F_5 sends the result to D when it gets connected. Based on the discussed scenario, we can state that the objective of this work is to select the suitable edge/fog device for offloading a particular

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while using MCG. Consequently, the power consumption of the requesting mobile device during the entire period is calculated. We have observed in Section V-B that the proposed mobility analytics module has good prediction accuracy, precision, and recall. By using the mobility module, we are predicting the user's probable visiting path. Based on the predicted path and present location of the user, the edge/fog devices are chosen. From these edge/fog devices, the underloaded one as well as fulfilling maximum satisfying resource requirements, is selected as the high majority device. The requested code is offloaded to the high majority device. The MCG not only considers user mobility, but also the resource availability and current load of the participating edge/fog devices. Considering all these parameters the suitable edge/fog device for offloading a computation is selected and offloading takes place to that device, which results in the better performance of MCG than the existing offloading approaches.

VI. CONCLUSION

Computation offloading from a mobile device at low power consumption and low latency is a promising research area. In this paper, we propose a method for computation offloading at the edge/fog device based on mobility analytics and weighted majority game theory. Based on the user movement path and the current location of the user, a set of edge/fog devices are chosen. The current loads and resource availability of the chosen edge/fog devices are considered as parameters in the weighted majority game. The underloaded device fulfilling maximum satisfying resource requirements for the requested computation is selected as the high majority device for offloading the computation. The experimental results show that the proposed mobility analytics module has more than 90% accuracy, and it outperforms the existing mobility prediction methods in terms of accuracy, precision, and recall measures. The theoretical and experimental results demonstrate that the proposed offloading method decreases the latency and power consumption of mobile device during offloading than the existing offloading schemes. In future, we wish to apply the proposed method in various domains such as mobility-based healthcare, and other time-critical applications.

REFERENCES

- [1] J. Zheng, Y. Cai, Y. Wu, and X. Shen, "Dynamic computation offloading for mobile cloud computing: A stochastic game-theoretic approach," *IEEE Trans. Mobile Comput.*, vol. 18, no. 4, pp. 771–786, Apr. 2019.
- [2] Y. Hao, J. Cao, Q. Wang, and T. Ma, "Energy-aware offloading based on priority in mobile cloud computing," *Sustain. Comput.: Inform. Syst.*, vol. 31, 2021, Art. no. 100563.
- [3] L. Liu, X. Guo, Z. Chang, and T. Ristaniemi, "Joint optimization of energy and delay for computation offloading in cloudlet-assisted mobile cloud computing," *Wireless Netw.*, vol. 25, no. 4, pp. 2027–2040, 2019.
- [4] X. Xu et al., "An energy-aware computation offloading method for smart edge computing in wireless metropolitan area networks," *J. Netw. Comput. Appl.*, vol. 133, pp. 75–85, 2019.
- [5] P. A. Apostolopoulos, E. E. Tsiropoulou, and S. Papavassiliou, "Game-theoretic learning-based QoS satisfaction in autonomous mobile edge computing," in *Proc. Glob. Inf. Infrastructure Netw. Symp.*, 2018, pp. 1–5.
- [6] A. Mukherjee, D. De, and S. K. Ghosh, "Fogioht: A weighted majority game theory based energy-efficient delay-sensitive fog network for internet of health things," *Internet Things*, vol. 11, 2020, Art. no. 100181.
- [7] S. Ghosh, A. Mukherjee, S. K. Ghosh, and R. Buyya, "Mobi-IoST: Mobility-aware cloud-fog-edge-IoT collaborative framework for time-critical applications," *IEEE Trans. Netw. Sci. Eng.*, vol. 7, no. 4, pp. 2271–2285, Oct.–Dec. 2020.
- [8] S. Ranadheera, S. Maghsudi, and E. Hossain, "Computation offloading and activation of mobile edge computing servers: A minority game," *IEEE Wireless Commun. Letters*, vol. 7, no. 5, pp. 688–691, 2018.
- [9] G. Mitsis, P. A. Apostolopoulos, E. E. Tsiropoulou, and S. Papavassiliou, "Intelligent dynamic data offloading in a competitive mobile edge computing market," *Future Internet*, vol. 11, no. 5, 2019, Art. no. 118.
- [10] S. Josilo and G. Dán, "A game theoretic analysis of selfish mobile computation offloading," in *Proc. IEEE INFOCOM IEEE Conf. Comput. Commun.*, 2017, pp. 1–9.
- [11] Y. Wu, B. Shi, L. P. Qian, F. Hou, J. Cai, and X. S. Shen, "Energy-efficient multi-task multi-access computation offloading via NOMA transmission for IoTs," *IEEE Trans. Ind. Inform.*, vol. 16, no. 7, pp. 4811–4822, Jul. 2020.
- [12] H. Chen et al., "Mobility-aware offloading and resource allocation for distributed services collaboration," *IEEE Trans. Parallel Distrib. Syst.*, vol. 33, no. 10, pp. 2428–2443, Oct. 2022.
- [13] A. I. Jehangiri et al., "Limpo: Lightweight mobility prediction and offloading framework using machine learning for mobile edge computing," *Cluster Comput.*, pp. 1–19, 2022.
- [14] F. Yu, H. Chen, and J. Xu, "Dmpo: Dynamic mobility-aware partial offloading in mobile edge computing," *Future Gener. Comput. Syst.*, vol. 89, pp. 722–735, 2018.
- [15] E. F. Maleki, L. Mashayekhy, and S. M. Nabavinejad, "Mobility-aware computation offloading in edge computing using machine learning," *IEEE Trans. Mobile Comput.*, pp. 1–13, Jun. 2021, doi: 10.1109/TMC.2021.3085527.
- [16] Y. Shi, S. Chen, and X. Xu, "MAGA: A mobility-aware computation offloading decision for distributed mobile cloud computing," *IEEE Internet Things J.*, vol. 5, no. 1, pp. 164–174, Feb. 2018.
- [17] M. Zhao et al., "Energy-aware task offloading and resource allocation for time-sensitive services in mobile edge computing systems," *IEEE Trans. Veh. Technol.*, vol. 70, no. 10, pp. 10925–10940, Oct. 2021.
- [18] K. Peng, V. Leung, X. Xu, L. Zheng, J. Wang, and Q. Huang, "A survey on mobile edge computing: Focusing on service adoption and provision," *Wireless Commun. Mobile Comput.*, vol. 2018, pp. 1–17, 2018.
- [19] S. Ghosh, S. K. Ghosh, and R. Buyya, "Mario: A spatio-temporal data mining framework on google cloud to explore mobility dynamics from taxi trajectories," *J. Netw. Comput. Appl.*, vol. 164, 2020, Art. no. 102692.
- [20] S. Ghosh and S. K. Ghosh, "Mantra: Semantic mobility knowledge analytics framework for trajectory annotation," in *Proc. IEEE Conf. Comput. Commun.*, 2022, pp. 1–2.
- [21] M. Lv, L. Chen, and G. Chen, "Discovering personally semantic places from GPS trajectories," in *Proc. 21st ACM Int. Conf. Inf. Knowl. Manage.*, 2012, pp. 1552–1556.
- [22] M. Vlachos, G. Kollios, and D. Gunopulos, "Discovering similar multi-dimensional trajectories," in *Proc. 18th Int. Conf. Data Eng.*, 2002, pp. 673–684.
- [23] C. Cheng, H. Yang, M. R. Lyu, and I. King, "Where you like to go next: Successive point-of-interest recommendation," in *Proc. 23rd Int. Joint Conf. Artif. Intell.*, 2013, pp. 2605–2611.
- [24] A. Karatzoglou, N. Schnell, and M. Beigl, "A convolutional neural network approach for modeling semantic trajectories and predicting future locations," in *Proc. Int. Conf. Artif. Neural Netw.*, Cham, Switzerland: Springer, 2018, pp. 61–72.
- [25] H. Wang, Y. Li, D. Jin, and Z. Han, "Attentional Markov model for human mobility prediction," *IEEE J. Sel. Areas Commun.*, vol. 39, no. 7, pp. 2213–2225, Jul. 2021.
- [26] B. Mo, Z. Zhao, H. N. Koutsopoulos, and J. Zhao, "Individual mobility prediction in mass transit systems using smart card data: An interpretable activity-based hidden Markov approach," *IEEE Trans. Intell. Transp. Syst.*, vol. 23, no. 8, pp. 12014–12026, Aug. 2022, doi: 10.1109/TITS.2021.3109428.

RESEARCH ARTICLE

STOPPAGE: Spatio-temporal data driven cloud-fog-edge computing framework for pandemic monitoring and management

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Abstract

Several global health incidents and evidences show the increasing likelihood of pandemics (large-scale outbreaks of infectious disease), which has adversely affected all aspects of human lives. It is essential to develop an analytics framework by extracting and incorporating the knowledge of heterogeneous data-sources to deliver insights for enhancing preparedness to combat the pandemic. Specifically, *human mobility*, *travel history*, and other *transport statistics* have significantly impact on the spread of any infectious disease. This article proposes a spatio-temporal knowledge mining framework, named **STOPPAGE**, to model the impact of human mobility and other contextual information over the large geographic areas in different temporal scales. The framework has two key modules: (i) *spatio-temporal data and computing infrastructure* using fog/edge based architecture; and (ii) *spatio-temporal data analytics* module to efficiently extract knowledge from heterogeneous data sources. We created a *pandemic-knowledge graph* to discover correlations among mobility information and disease spread, a deep learning architecture to predict the next hotspot zones. Further, we provide necessary support in home-health monitoring utilizing Femtolet and fog/edge based solutions. The experimental evaluations on real-life datasets related to COVID-19 in India illustrate the efficacy of the proposed methods. STOPPAGE outperforms the existing works and baseline methods in terms of accuracy by $\approx(18-21)\%$ in predicting hotspots and reduces the power consumption of the smartphone significantly. The scalability study yields that the STOPPAGE framework is flexible enough to analyze a huge amount of spatio-temporal datasets and reduces the delay in predicting health status compared to the existing studies.

KEYWORDS

COVID-19, deep learning, healthcare, Internet of Spatial Things (IoST), knowledge graph, pandemic, spatio-temporal data

54. Trivedi R, Dai H, Wang Y, Song L. Know-evolve: deep temporal reasoning for dynamic knowledge graphs. Proceedings of the 34th International Conference on Machine Learning; Vol. 70, 2017:3462-3471.
55. Karatzoglou A, Schnell N, Beigl M. A convolutional neural network approach for modeling semantic trajectories and predicting future locations. Proceedings of the International Conference on Artificial Neural Networks; 2018:61-72; Springer, New York.
56. Liu Q, Wu S, Wang L, Tan T. Predicting the next location: a recurrent model with spatial and temporal contexts. Proceedings of the 30th AAAI Conference on Artificial Intelligence; 2016.

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REVIEW ARTICLE

Melatonin mediated activation of MAP kinase pathway may reduce DNA damage stress in plants: A review

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Abstract

Melatonin is an important biomolecule found in diverse groups of organisms. Under different abiotic stresses, the synthesis of melatonin is markedly increased suggesting pivotal roles of melatonin in plants enduring stresses. Being an endogenous signaling molecule with antioxidant activity, melatonin alters many physiological responses and is found to be involved in regulating DNA damage responses. However, the molecular mechanisms of melatonin in response to DNA damage have not yet been studied. The present review aims to provide insights into the molecular mechanisms of melatonin in response to DNA damage in plants. We propose that the MAP kinase pathway is involved in regulating melatonin dependent response of plants under DNA damage stress. Where melatonin might activate MAPK via H₂O₂ or Ca²⁺ dependent pathways. The activated MAPK in turn might phosphorylate and activate SOG1 and repressor type MYBs to mitigate DNA damage under abiotic stress.

KEYWORDS

abiotic stress, antioxidant, cyclin-CDK, DNA damage, MAP kinase, melatonin, MYBs, SOG1

1 | INTRODUCTION

A number of biomolecules are produced by plants in response to external stimuli, regulating different physiological responses. Melatonin (MET) or N-acetyl-5-methoxy tryptamine is such a biomolecule that is widely distributed in both plants and animals.¹ The presence of melatonin in diverse groups of organisms indicates the conserved nature of its biosynthetic pathway in different organisms. In both plants and animals, MET is biosynthesized from the amino acid tryptophan (trp) in a tryptophan-tryptamine-serotonin dependent pathway.¹⁻³

Serotonin, the precursor of MET, is acetylated to N-acetylserotonin which is then methylated to produce MET by serotonin N-acetyl transferase (SNAT) and acetyl serotonin methyl transferase (ASMT) or Caffeic acid O-methyl transferase (COMT), respectively. Serotonin may also form 5-methoxy tryptamine by ASMT/COMT. Finally, SNAT catalyzes the formation of MET from 5-methoxy tryptamine. These SNAT and ASMT are the key enzymes over-expression of which in plants are known to be associated with increased stress tolerance.⁴⁻⁷

Different plant species have been reported to produce melatonin (MET) with quantitative variations from

Abbreviations: Act-MYBs, activator MYBs; ASMT, acetyl serotonin methyl transferase; ATM, ataxia telangiectasia mutated; ATR, ataxia telangiectasia and Rad3 related; CHK1, checkpoint-1 kinase; CHK2, checkpoint-2 kinase; CKI, CDK inhibitor (CKI); COMT, caffeic acid O-methyl transferase; DSB, double stranded DNA breaks; HR, homologous recombination; MAPK, mitogen activated protein kinase; MDA, malondialdehyde; MET, melatonin; Rep-MYBs, repressor MYBs; SMR, SIAMESE-related; SNAT, serotonin N-Acetyl transferase; SOG1, suppressor of gamma response 1.



52. Santoro R, Marani M, Blandino G, Muti P, Strano S. Melatonin triggers p53Ser phosphorylation and prevents DNA damage accumulation. *Oncogene*. 2012;31(24):2931–42.
53. Xia XJ, Wang YJ, Zhou YH, Tao Y, Mao WH, Shi K, et al. Reactive oxygen species are involved in brassinosteroid-induced stress tolerance in cucumber. *Plant Physiol*. 2009;150(2):801–14.
54. Ge XM, Cai HL, Lei X, Zhou X, Yue M, He JM. Heterotrimeric G protein mediates ethylene-induced stomatal closure via hydrogen peroxide synthesis in *Arabidopsis*. *Plant J*. 2015;82(1):138–50.
55. Wang P, Song CP. Guard-cell signalling for hydrogen peroxide and abscisic acid. *New Phytol*. 2008;178(4):703–18.
56. Wang Y, Chen ZH, Zhang B, Hills A, Blatt MR. PYR/PYL/R-CAR abscisic acid receptors regulate K^+ and Cl^- channels through reactive oxygen species-mediated activation of Ca^{2+} channels at the plasma membrane of intact *Arabidopsis* guard cells. *Plant Physiol*. 2013;163(2):566–77.
57. Wei J, Li DX, Zhang JR, Shan C, Rengel Z, Song ZB, et al. Phytomelatonin receptor PMTR 1-mediated signaling regulates stomatal closure in *Arabidopsis thaliana*. *J Pineal Res*. 2018;65(2):e12500.
58. Chen Z, Gu Q, Yu X, Huang L, Xu S, Wang R, et al. Hydrogen peroxide acts downstream of melatonin to induce lateral root formation. *Ann Bot*. 2018;121(6):1127–36.
59. Xu L, Yue Q, Xiang G, Bian FE, Yao Y. Melatonin promotes ripening of grape berry via increasing the levels of ABA, H_2O_2 , and particularly ethylene. *Hortic Res*. 2018;5:41.
60. Ahmad S, Muhammad I, Wang GY, Zeeshan M, Yang L, Ali I, et al. Ameliorative effect of melatonin improves drought tolerance by regulating growth, photosynthetic traits and leaf ultrastructure of maize seedlings. *BMC Plant Biol*. 2021;21(1):1–14.

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High doses of nano-polystyrene aggravate the oxidative stress, DNA damage, and the cell death in onions

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ABSTRACT

Plastic pollution has been reported to negatively impact global biodiversity and ecosystem health. However, the molecular mechanisms of nano-plastics in plants are unidentified, especially their negative impacts on genomic stability. This study for the first time showed that nano-polystyrene leads to cell death in plants by subjugating the cellular antioxidant defence mechanisms through the aggravated production of ROS, which in turn could induce the DNA damage impairing the genetic regulation of the corresponding DNA repair pathway. To validate the proposed hypothesis, the DNA damage potential of nano-polystyrene and the expression levels of key genetic regulators of the DNA damage repair pathway (such as - *CYCA/B*, *CDKA*, *SOG1*, *MYB* transcription factors, and *RAD51*) have been assessed in onion roots after 72 h exposure with three ecologically relevant concentrations (25, 50, and 100 $\mu\text{g ml}^{-1}$) of 100 nm nano-polystyrene. In addition, imbalance in redox homeostasis (oxidative stress), cell viability, and nuclear aberrations such as – the frequency of micronucleus and bi-nucleate cells that are directly linked to the DNA damages have been checked to point out the cause and effect of nano-polystyrene-induced DNA damage. Results showed a significant increase in oxidative stress in each treatment concentrations of nano-polystyrene. However, ROS generated at 100 $\mu\text{g ml}^{-1}$ nano-polystyrene dose subdues the antioxidant defence system and induces cell death. These observations may be ascribed to the accumulation damaged DNA and the down-regulation of repair pathway-associated genes, as observed in this treatment group. Conversely, the observed DNA damage and the reduced expressions of genes would be a mere consequence of reduced cellular viability.

1. Introduction

Plastics are ubiquitously distributed in the environment due to their increasing global production with 367 Mt tons in the year - 2020, excluding recycled plastics (<https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf>). Among different plastic polymers, polystyrene (PS) is widely used in packaging, construction/building, fishing industries, electrical & electronic equipment, inner liner for fridges, eyeglasses frames, etc. (Boyle and Örmeci, 2020; <https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf>). Besides, PS is used in manufacturing coffee cups, and plates with a high rate of environmental disposal at the end of their uses. Polystyrene may represent one of the dominant plastic polymers in the environment and is synthesised from styrene monomers – an “anticipated human carcinogen”

and the un-polymerized residual styrene molecules can leach out of PS (Boyle and Örmeci, 2020).

In the terrestrial system, the abundance of microplastics (MPs) is 4–23 times higher than in the aquatic system (Horton et al., 2017). The annual emission of microplastics to European soils and North American soils through sludge application and other agricultural practices has been estimated to be 63 to 430 and 44 to 300 million tons, respectively (Nizzetto et al., 2016). Vollertsen and Hansen, 2017 quantified the mass concentration of microplastics in farmland soils with a maximum value of 224.3 mg kg^{-1} of soil. The concentration micro-plastics in highly contaminated soils may range from 0.03% to 6.7% (w/w) in industrial areas (Pflugmacher et al., 2021). Therefore, micro/nano-plastics – an emerging global threat, may severely impact the plants health. The negative impacts of nano-plastics on biota are more severe than microplastics due to their small size (Boyle and Örmeci, 2020).

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- Schwinn, K.E., Ngo, H., Kenel, F., Brummell, D.A., Albert, N.W., McCallum, J.A., Pither-Joyce, M., Crowhurst, R.N., Eady, C., Davies, K.M., 2016. The onion (*Allium cepa* L.) R2R3-MYB gene MYB1 regulates anthocyanin biosynthesis. *Front. Plant Sci.* 7, 1865.
- Sjogren, C.A., Bolaris, S.C., Larsen, P.B., 2015. Aluminum-dependent terminal differentiation of the *Arabidopsis* root tip is mediated through an ATR-, ALT2-, and SOG1-regulated transcriptional response. *Plant Cell* 27 (9), 2501.
- Tank, J.G., Thaker, V.S., 2011. Cyclin dependent kinases and their role in regulation of plant cell cycle. *Biol. Plantarum* 55 (2), 201–212.
- Tank, J.G., Thaker, V.S., 2014. Systemic control of cell division and endoreduplication by NAA and BAP by modulating CDKs in root tip cells of *Allium cepa*. *BioMed Res. Int.* 2014, 1–14.
- Vijayaraghavareddy, P., Adhinarayanreddy, V., Vemanna, R.S., Sreeman, S., Makarla, U., 2017. Quantification of membrane damage/cell death using evan's blue staining technique. *Bio-protocol* 7 (16).
- Vollertsen, J., Hansen, A.A., 2017. Microplastic in Danish Wastewater: Sources, Occurrences and Fate. The Danish Environmental Protection Agency, Environmental Project No. 1906.
- Wang, Z., Li, S., Jian, S., Ye, F., Wang, T., Gong, L., Li, X., 2022. Low temperature tolerance is impaired by polystyrene nanoplastics accumulated in cells of barley (*Hordeum vulgare* L.) plants. *J. Hazard Mater.* 426, 127826.
- Weimer, A.K., Biedermann, S., Harashima, H., Roodbarkelari, F., Takahashi, N., Foreman, J., Guan, Y., Pochon, G., Heese, M., Van Damme, D., Sugimoto, K., 2016. The plant-specific CDKB 1-CYCB 1 complex mediates homologous recombination repair in *Arabidopsis*. *EMBO J.* 35 (19), 2068–2086.
- Wu, X., Liu, Y., Yin, S., Xiao, K., Xiong, Q., Bian, S., Liang, S., Hou, H., Hu, J., Yang, J., 2020. Metabolomics revealing the response of rice (*Oryza sativa* L.) exposed to polystyrene microplastics. *Environ. Pollut.* 266, 115159.
- Yoshiyama, K., Conklin, P.A., Huefner, N.D., Britt, A.B., 2009. Suppressor of gamma response 1 (SOG1) encodes a putative transcription factor governing multiple responses to DNA damage. *Proc. Natl. Acad. Sci. USA* 106 (31), 12843–12848.
- Yoshiyama, K.O., Kobayashi, J., Ogita, N., Ueda, M., Kimura, S., Maki, H., Umeda, M., 2013. ATM-mediated phosphorylation of SOG1 is essential for the DNA damage response in *Arabidopsis*. *EMBO Rep.* 14 (9), 817–822.
- Zong, X., Zhang, J., Zhu, J., Zhang, L., Jiang, L., Yin, Y., Guo, H., 2021. Effects of polystyrene microplastic on uptake and toxicity of copper and cadmium in hydroponic wheat seedlings (*Triticum aestivum* L.). *Ecotoxicol. Environ. Saf.* 217, 112217.

Physico-chemical analysis of newly prepared prebiotic chocolates by using Galacto Oligosaccharides (GOS)

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Abstract

In India, chocolate is very famous mood freshening sweet food product specially for children. But high consumption of chocolate may be harmful for human health, because most of the chocolates contain high fat. This research has been done to increase the health benefits of chocolate by using cocoa and Galacto Oligosaccharides (GOS). Many researchers have shown their research that GOS is very beneficial for human health such as it helps to lower down the cholesterol levels in the blood, to prevent colon cancer, and helps to improve mineral absorption in human body. Basically, GOS is a type of prebiotic e.g., food for probiotic bacteria. Prebiotics are non-digestible ingredients that benefit the host by boosting the growth and activity of one or a few bacterial species that are already present in the colon. It was also studied by many researchers that cocoa powder contains a lot of caffeine, flavanols, which are polyphenolic compounds. Flavanols, particularly epicatechin monomer and oligomer cocoa flavanols have been linked to a number of health advantages, including boosting nitric oxide synthase, enhancing blood flow and arterial flexibility, lowering blood pressure and platelet aggregation, and reducing inflammation. The main objectives of this research are to develop the formulation of prebiotic chocolate and to evaluate the physicochemical parameters of the newly prepared chocolate. After physico-chemical analysis of carbohydrate, fat, crude fibre and p^H , it was found that both the newly prepared prebiotic enriched chocolates (T_1 and T_2) were significantly different ($p \leq 0.01$) from control (T_0) and after analysis of protein content, it was also found that both the newly prepared prebiotic enriched chocolates (T_1 and T_2) were insignificantly different ($p \leq 0.01$) from control (T_0).

Keywords: Cocoa, flavanols, Galacto Oligosaccharides, prebiotics, probiotic bacteria, polyphenolic compounds.

1. INTRODUCTION:

1.1. Background and History of the chocolates

The Mayans were most likely the first people in South America to cultivate the cocoa plant, according to the history of chocolate. Chocolate, according to the Mayans, was a cocoa drink made with hot water and often flavored with cinnamon and pepper. "Drink of the Gods" was the

name of the drink. Chocolate, derived from the seeds of the cocoa tree, was once thought to be the 'Food of Gods' (Verna, 2013). The scientific name *Theobroma cacao* for the cocoa tree was derived from the Greek terms "theo" which means God and "broma" which means food, as a result of this link. T.L. (Dillinger *et al.*, 2000). The term cocoa refers to the least processed and most natural form of the bean. The solid chocolate industry originated in the 19th

Hanks T Heslen MK Johnson J Kleyn DH Mercer F Monahan D Peat B Petit M, 2001. Determination of fat in raw and processed milks by the Gerber method: collaborative study. *Journal of AOAC international*, 84(5), pp.1499-1508.

Lim, L.S., Fink, H.A., Kuskowski, M.A., Cauley, J.A. and Ensrud, K.E., 2005. Diuretic use and bone mineral density in older USA men: the osteoporotic fractures in men (MrOS) study. *Age and ageing*, 34(5), p.504.

Liu, Y., Cai, J. and Zhang, F., 2021. Functional comparison of breast milk, cow milk and goat milk based on changes in the intestinal flora of mice. *LWT*, 150, p.111976.

Louis, P., Scott, K.P., Duncan, S.H. and Flint, H.J., 2007. Understanding the effects of diet on bacterial metabolism in the large intestine. *Journal of applied microbiology*, 102(5), pp.1197-1208.

McCrickerd, K. and Forde, C.G., 2016. Sensory influences on food intake control: moving beyond palatability. *Obesity Reviews*, 17(1), pp.18-29.

Messerli, F.H., 2012. Chocolate consumption, cognitive function, and Nobel laureates. *N Engl J Med*, 367(16), pp.1562-1564.

Montagna, M.T., Diella, G., Triggiano, F., Caponio, G.R., Giglio, O.D., Caggiano, G., Ciaula, A.D. and Portincasa, P., 2019. Chocolate, "food of the gods": History, science, and human health. *International journal of environmental research and public health*, 16(24), p.4960.

Muller, J.A., Ross, R.P., Fitzgerald, G.F., Stanton, C., Charalampopoulos, D. and Rastall, R., 2009. Prebiotics and probiotics science and technology.

Manufacture of probiotic bacteria. Springer SBM, Heidelberg, pp.725-59.

Ooi, L.G. and Liong, M.T., 2010. Cholesterol-lowering effects of probiotics and prebiotics: a review of in vivo and in vitro findings. *International journal of molecular sciences*, 11(6), pp.2499-2522.

Özer, D., Akin, S. and Özer, B., 2005. Effect of inulin and lactulose on survival of *Lactobacillus acidophilus* 5 and *Bifidobacterium bifidum* bb-02 in *Acidophilus-bifidus* yoghurt. *Food Science and Technology International*, 11(1), pp.19-24.

Petroff, A.J., 2017. *Developing a pollinator education program for the MetroParks of Butler County* (Doctoral dissertation, Miami University).

PFA, 2006. Prevention of food adulteration act, Food Safety and Standards Act.

Ranganna, S., 1977. Manual of analysis of fruit and vegetable products.

Rozin, P., Levine, E. and Stoess, C., 1991. Chocolate craving and liking. *Appetite*, 17(3), pp.199-212.

Sauer, J., Richter, K.K. and Pool-Zobel, B.L., 2007. Physiological concentrations of butyrate favorably modulate genes of oxidative and metabolic stress in primary human colon cells. *The Journal of nutritional biochemistry*, 18(11), pp.736-745.

van den Heuvel, O.A., van Wingen, G., Soriano-Mas, C., Alonso, P., Chamberlain, S.R., Nakamae, T., Denys, D., Goudriaan, A.E. and Veltman, D.J., 2016. Brain circuitry of compulsivity. *European Neuropsychopharmacology*, 26(5), pp.810-827.

Verna, R., 2013. The history and science of chocolate. *The Malaysian journal of pathology*, 35(2), p.111.

Wang, M., Veeraperumal, S., Zhong, S. and Cheong, K.L., 2023. Fucoidan-derived functional oligosaccharides: Recent developments, preparation, and potential applications. *Foods*, 12(4), p.878.

Weingarten, H.P. and Elston, D., 1990. The phenomenology of food cravings. *Appetite*, 15(3), pp.231-246.

Wijnands, M.V.W., Appel, M.J., Hollanders, V.M.H. and Woutersen, R.A., 1999. A comparison of the effects of dietary cellulose and fermentable galacto-oligosaccharide, in a rat model of colorectal carcinogenesis: fermentable fibre confers greater protection than non-fermentable fibre in both high and low fat backgrounds. *Carcinogenesis*, 20(4), pp.651-656.

Wijnands, M.V.W., Schoterman, H.C., Bruijntjes, J.P., Hollanders, V.M.H. and Woutersen, R.A., 2001. Effect of dietary galacto-oligosaccharides on azoxymethane-induced aberrant crypt foci and colorectal cancer in Fischer 344 rats. *Carcinogenesis*, 22(1), pp.127-132.

Winardi-Liem, M., 2011. *Rheology of Prebiotic Chocolate* (Doctoral dissertation, The Ohio State University).

Modal data-based simple statistical analysis as an effective petrogenetic indicator: a study from Kadavur gabbro-anorthosite complex, Tamil Nadu, southern India

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Field and petrographic studies on the Neoproterozoic Kadavur intrusive complex (10°35'N, 78°11'E) (located in the Southern Granulite Terrane of the Indian shield) reveal three distinct types: (i) earliest phase of deformed schistose gabbro-anorthosite; (ii) most dominant layered gabbro-anorthosite, and (iii) locally developed pegmatoidal gabbro-anorthosite. A simple modal data-based statistical analysis of layered gabbro-anorthosite type yields highly significant or significant correlation coefficients for different mineralogical parameters and strongly supports differentiation from a common magma. Typical dispositions of the mineralogical parameters (as depicted by isopleths patterns) suggest maintenance of a magmatic lineage in varying hydration ambience that developed several petrographic variants within the layered type.

Keywords: Gabbro-anorthosite, isopleths map, mineralogical parameters, modal data, statistical analysis.

MODAL analysis studies on gabbro-anorthosites have been useful to classify and characterize such rocks. For example, Ashwal¹ worked out the genesis of the Mount Marcy anorthosite massif (Adirondacks, New York, USA) with a particular focus on anorthositic rocks associated with the high-grade terrain^{2,3}. Even for the Apollo-11 samples, modal analyses helped ascertain the heterogeneity in the lunar highland series⁴. However, in recent times, such modal analysis-based approaches for gabbro-anorthosites are lacking. In reality, modal data of igneous rocks represent the actual mineralogical composition and help in accurate nomenclature. Nowadays, however, the emphasis has shifted to other domains, presumably because of the availability of major, trace and isotopic data^{5,6}. Even in this scenario, in the recent past, modal data-based studies have helped resolve the long-standing controversy related to the accretion of gabbroic lower crust at the ridge axis⁷. In this context of the intrusive gabbro-anorthosite complex near Kadavur (10°35'N, 78°11'E), southern India (Figure 1), the present study performs statistical analyses of several mineralogical parameters to present a cogent petrogenetic history. The Kadavur complex was initially reported

from the Southern Granulite Terrane (SGT) of the Indian shield (Figure 1 a)^{8,9}. However, during 1980s, the region (hosting the Kadavur complex) was known as the Eastern Ghats Belt¹⁰. Early studies on the Kadavur complex suggest that: (i) the intrusion represents a funnel-shaped concordant body and (ii) the complex bears geological similarities with the Adirondack mountains¹¹. However, later studies have argued against the similarities between the Kadavur complex and intrusive rocks in the Adirondack region¹²; on the contrary, it was compared with early Archean, layered gabbro-anorthosite complex. It has been suggested that the Kadavur complex manifests multiple phases of magmatism with corresponding mappable attributes^{13,14}. Recent workers suggest a tholeiitic parentage and an inferred age of ~810 Ma for the anorthositic intrusions^{15,16}. However, it is unclear whether the complex is a product of differentiation from common parent magma or corresponds to discrete and separate magmatic pulses. Hence, this study attempts to resolve this issue with the help of statistical analyses of modal data and relevant correlation characteristics amongst mineralogical parameters.

The present work involves field studies, petrographic analyses and detailed statistical studies on modal variables that help throw light on the petrogenesis of the Kadavur

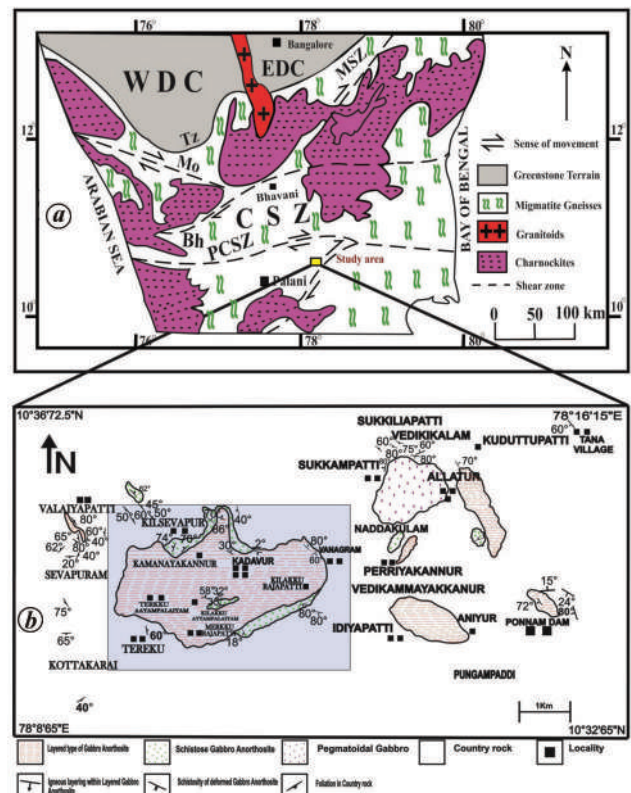


Figure 1. a, Location of the study area (Kadavur complex) within the regional tectonic frame of the Southern Granulite Terrane⁹. The complex falls within the branch-out portions of the Palghat–Cauvery shear zone⁵. b, Geological map of the Kadavur complex (by the present authors). Shaded portion represents the area where isopleths maps for different mineralogical parameters were constructed.

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- magmatism in southern India: Geochemistry, zircon U–Pb geochronology and Hf isotopes of the Sittampundi Anorthosite Complex. *Gondwana Res.*, 2013, **23**, 539–557.
7. Van Tongeren, J. A., Hirth, G. and Kelemen, P. B., Constraints on the accretion of the gabbroic lower oceanic crust from plagioclase lattice preferred orientation in the Samail ophiolites. *Earth Planet. Sci. Lett.*, 2015, **427**, 249–261.
 8. Chetty, T. R. K. and Rao, Y. J. B., The Cauvery Shear Zone, Southern Granulite Terrain, India: a crustal-scale flower structure. *Gondwana Res.*, 2006, **10**, 77–85.
 9. Santosh, M., The Southern Granulite Terrane: a synopsis. *Episodes*, 2020, **43**, 109–123.
 10. Subhramanyam, C. and Verma, R. K., Gravity field, structure and tectonics of Eastern Ghats. *Tectonophysics*, 1986, **126**, 195–212.
 11. Subramanian, A. P., Petrology of the anorthosite–gabbro mass at Kadavur, Madras, India. *Geol. Mag.*, 1956, **93**, 287–300.
 12. Windley, B. F. and Selvan, T. A., Anorthosites and associated rocks of Tamil Nadu, Southern India. *J. Geol. Soc. India*, 1975, **16**, 209–215.
 13. Sarkar, A. and Bose, M. K., Observations on the Kadavur igneous complex, Tiruchirappalli, Tamil Nadu. *India J. Earth Sci.*, 1978, **15**, 194–199.
 14. Sarkar, A. and Bose, M. K., Geology of the Kadavur complex, Tamil Nadu. *Rec. Res. Geol.*, 1987, **13**, 97–107.
 15. Kumar, V. M., Kumar, R. S., Rajaprian, K. and Singh, K., Petrography and major geochemical studies of anorthosite, Kadavur and adjoining area, Tamil Nadu, India. *Int. Res. J. Earth Sci.*, 2013, **1**, 15–22.
 16. Kooijman, E., Upadhyay, D., Mezger, K., Raith, M. M., Berndt, J. and Srikantappa, C., Response of the U–Pb chronometer and trace elements in zircon to ultrahigh-temperature metamorphism: the Kadavur anorthosite complex, southern India. *Chem. Geol.*, 2011, **290**, 177–188.
 17. Skjerna, L., Tubular folds and sheath folds: definitions and conceptual models for their development, with examples from Grapesvare area, northern Sweden. *J. Struct. Geol.*, 1989, **11**, 689–703.
 18. Streckeisen, A., To each plutonic rock its proper name. *Earth Sci. Rev.*, 1976, **12**, 1–33.
 19. Chayes, F., Numerological correlation and petrographic variation. *J. Geol.*, 1962, **70**, 440–452.
 20. Chayes, F., Effect of a single non zero open covariance on the simple closure test. In *Geostatistics* (ed. Merriam, D.), Plenum Press, New York, USA, 1970, pp. 11–22.
 21. Saha, A. K., Bhattacharya, C. and Lakshminpathy, S., Some problems of interpreting the correlation between the modal variables in granitic rocks. *J. Int. Assoc. Math. Geol.*, 1974, **6**, 245–258.
 22. Dasgupta, S., Ray, J., Mazumder, A., Sarkar, N. K., Das, S. and Dasgupta C., Correlation characteristics among mineralogical parameters in Porphyritic granite bodies around Raghunathpur, Purulia district, West Bengal. *J. Geol. Soc. India*, 2000, **54**, 263–270.
 23. Hazra, S., Saha, P., Ray J. and Podder, A., Simple statistical and mineralogical studies as petrogenetic indicator for Neoproterozoic Myllem porphyritic granites of East Khasi hills, Meghalaya, North eastern India. *J. Geol. Soc. India*, 2010, **75**, 760–768.
 24. Chakraborti, T. M., Ray, A. and Deb, G. K., Crystal size distribution analysis of plagioclase from gabbro-anorthosite suite of Kuli-ana, Orissa, eastern India: implication for textural coarsening in a static magma chamber. *Geol. J.*, 2015, **52**, 234–248.
 25. Chayes, F., A simple point counter for thin section. *Am. Mineral.*, 1949, **34**, 1–11.
 26. Snedecor, G. W. and Cochran, W. G., *Statistical Methods*, Oxford and IBH Publication, 1967, p. 593.
 27. Ashwal, L. D., *Anorthosites*, Springer-Verlag, Berlin, Germany, 1993, p. 422.
 28. Weaver, B. L., Tarney, J. and Windley, B., Geochemistry and petrogenesis of the Fiskenaeset anorthosite complex, southern West Greenland: nature of the parent magma. *Geochim. Cosmochim. Acta*, 1981, **45**(5), 711–725.
 29. Girardi, V. A. G., Rivalenti, G. and Sinigoi, S., The petrogenesis of the Niquelandia layered, basic–ultrabasic complex, Central Goias, Brazil. *J. Petrol.*, 1986, **27**, 715–744.
 30. Polat, A., Brian, J. F., Peter, W. U. A., Kalvig, P., Kerrich, R., Dilek, Y. and Yang, Z., Geochemistry of anorthositic differentiated sills in the Archean (~2970 Ma) Fiskenaeset Complex, SW Greenland: implications for parental magma compositions, geodynamic setting, and secular heat flow in arcs. *Lithos*, 2011, **123**, 50–72.
 31. Berger, J. *et al.*, Petrogenesis of Archean PGM bearing chromitites and associated ultramafic–mafic–anorthositic rocks from the Guelb el Azib layered complex (West African craton, Mauritania). *Precambrian Res.*, 2013, **224**, 612–628.
 32. Pinto, V. M. *et al.*, Petrogenesis of the mafic–ultramafic Canindé layered intrusion, Sergipano Belt, Brazil: constraints on the metallogenesis of the associated Fe–Ti oxide ores. *Ore Geol. Rev.*, 2020; <https://doi.org/10.1016/j.oregeorev.2020.103535>.
 33. Longhi, J. and Ashwal, L. D., Two-stage models for lunar and terrestrial anorthosites: petrogenesis without a magma ocean. *J. Geophys. Res.*, 1985, **90**(2), C571–C584.
 34. Scoates, J. S. and Frost, C. D., A strontium and neodymium isotopic investigation of the Laramie anorthosites, Wyoming, USA: implications for magma chamber processes and the evolution of magma conduits in Proterozoic anorthosites. *Geochim. Cosmochim. Acta*, 1996, **60**(1), 95–107.
 35. Huang, H., Polat, A., Fryer, B. J., Peter, W. U. A. and Windley, B. F., Geochemistry of the Mesoarchean Fiskenaeset Complex at Majorqap qáva, SW Greenland: evidence for two different magma compositions. *Chem. Geol.*, 2012, **314–317**, 66–82.
 36. Bybee, G. M. *et al.*, Proterozoic massif-type anorthosites as the archetypes of long-lived (≥ 100 Myr) magmatic systems – new evidence from the Kunene Anorthosite Complex (Angola). *Precambrian Res.*, 2019; <https://doi.org/10.1016/j.precamres.2019.105393>.

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Petrogenetic implications of mineral chemistry and mode-based statistical studies of Sholayar alkaline syenite complex, Southern Granulite Terrane, India

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A recent petrological study on the lesser-known Sholayar alkaline syenite complex (10°17'59.9"N: 076°47'26.3"E) accommodated in the high-grade rocks of the Southern Granulite Terrane reveals the presence of three distinct petrographic types namely leuco syenite, melanofelsic syenite and mela syenite. The syenites, in general, have the following constituent minerals, namely alkali feldspar (Or_{76.8}Ab_{23.2}–Or_{93.4}Ab_{6.6}), plagioclase (An_{4.1}–An_{17.3}), calcic amphibole (edenitic hornblende/ferropargasitic hornblende), quad pyroxene (diopside–hedenbergite), biotite and opaque minerals (magnetite and ilmenite). Mode-based statistical studies indicate that a highly significant correlation exists among certain mineralogical parameters including quartz%, total feldspar%, colour index, alteration index and hydration index. Isoopleth plots of these parameters strongly suggest maintenance of a magmatic regime throughout, with increasing water content towards the end stage of crystallization. Several geothermobarometric methods point to shallow to moderate level emplacement (~9–23 km) of the alkaline/sub-alkaline syenite magma which was facilitated by a 'hydration event'. The steep change in water gradients (in localized pockets) of the syenite intrusives has been corroborated by textural evidences.

Keywords. Mineral chemistry; geothermobarometry; equilibration depth; mode-based statistics; Sholayar Complex; mineralogical parameters.

1. Introduction

The mineral chemistry of syenites and associated rocks has received attention (though limited in number) by petrologists for long. For the Klokken syenite(-gabbro) complex, south Greenland based on mineral-chemical evaluation, it has been documented (Parsons 1981) that the less fractionated

members of syenite probably crystallized with PH₂O less than P_{total} at temperature greater than 870°C where as more fractionated syenite had PH₂O similar to P_{total} with a different range of crystallization-temperature. For this complex, the fO_2 condition of ambient melt could also be successfully evaluated by Parsons (1981). Mineral chemistry-based similar approach for the Maboutou

- Molina J, Scarrow J, Montero P G and Bea F 2009 High-Ti amphibole as a petrogenetic indicator of magma chemistry: Evidence for mildly alkalic-hybrid melts during evolution of Variscan basic-ultrabasic magmatism of Central Iberia; *Contrib. Mineral. Petrol.* **158** 69–98.
- Morimoto N 1989 Nomenclature of pyroxenes; *Canadian Mineral.* **27** 143–156.
- Mukhopadhyay S, Ray J, Chattopadhyay B, Sengupta S, Ghosh B and Mukhopadhyay S 2011 Significance of mineral chemistry of syenites and associated rocks of Elagiri Complex, Southern Granulite Terrane of the Indian shield; *J. Geol. Soc. India* **77** 113–129.
- Nabelek C R and Lindsley D H 1985 Tetrahedral Al in amphibole: A potential thermometer for some mafic rocks; *Geol. Soc. Am.*, Abst. with programs, 673p.
- Nair N G K, Santosh M and Thampi P K 1984 The syenite of Sholayar, Trichur district, Kerala, India; *J. Earth Sci.* **11(2)** 148–157.
- Parsons I 1980 Alkali-feldspar and Fe–Ti oxide exsolution textures as indicators of the distribution and subsolidus effects of magmatic ‘water’ in the Klokken layered syenite intrusion, South Greenland; *Trans. Roy. Soc. Edinb. Earth Sci.* **71(1)** 1–12.
- Parsons I 1981 The Klokken Gabbro-Syenite Complex, South Greenland: Quantitative interpretation of mineral chemistry; *J. Petrol.* **22(2)** 233–260.
- Parsons I, Brown W L and Jacquemin H 1986 Mineral chemistry and crystallization conditions of the Mbutou layered Gabbro–Syenite–Granite Complex, North Cameroon; *J. Petrol.* **27(6)** 1305–1329.
- Powell R and Powell M 1977 Geothermometry and oxygen barometry using coexisting iron–titanium oxides: A reappraisal; *Mineral. Mag.* **41** 257–263.
- Putirka K 2008 Excess temperatures at ocean islands: Implications for mantle layering and convection; *Geology* **36(4)** 283–286.
- Radhakrishna B P 1989 Records of the Geological Survey of India; Extended Abstracts of Progress Reports 1987–88, Govt. of India 122 pt. 7.
- Ratnakar J and Leelanandam C 1989 Petrology of the alkaline plutons from the eastern Peninsular India; *Mem. Geol. Soc. India* **15** 145–176.
- Ridolfi F, Renzulli A and Puerini M 2010 Stability and chemical equilibrium of amphibole in calc-alkaline magmas: An overview, new thermobarometric formulations and application to subduction-related volcanoes; *Contrib. Mineral. Petrol.* **160** 45–66.
- Saha A K, Bhattacharya C and Lakshminpathi S 1974 On some problems of interpreting the correlation between the modal variables in granitic rocks; *J. Int. Assoc. Math. Geol.* **6** 245–258.
- Santosh M, Tagawa M, Taguchi S and Yoshikura S 2003a The Nagercoil Granulite Block, southern India: Petrology, fluid inclusions and exhumation history; *J. Asian Earth Sci.* **22** 131–155.
- Santosh M, Yokoyama K, Sekhar S B and Rogers J J W 2003b Multiple tectonothermal events in the granulite block of southern India revealed from EPMA dating: Implications on the history of supercontinents; *Gondwana Res.* **6** 29–63.
- Santosh M and Sajeew K 2006 Anticlockwise evolution of ultrahigh-temperature granulites within continental collision zone in southern India; *Lithos* **92** 447–464.
- Santosh M, Maruyama S and Sato K 2009 Anatomy of a Cambrian suture in Gondwana: Pacific-type orogeny in southern India; *Gondwana Res.* **16** 321–341.
- Santosh M, Yang Q Y, Mekala R, Tsunogae T, Shaji E and Satyanarayanan M 2014 Cryogenian alkaline magmatism in the Southern Granulite Terrane, India: Petrology, geochemistry, zircon U–Pb ages and Lu–Hf isotopes; *Lithos* **208** 430–445, <https://doi.org/10.1016/j.lithos.2014.09.016>.
- Santosh M, Hu C N, He X F, Li S S, Tsunogae T, Shaji E and Indu G 2017 Neoproterozoic arc magmatism in the southern Madurai Block, India: Subduction, relamination, continental outbuilding, and the growth of Gondwana; *Gondwana Res.* **45** 1–42.
- Santosh M 2020 The Southern Granulite Terrane: A synopsis; *Epi. J. Int. Geosci.* **43(1)** 109–123.
- Snedecor G W and Cochran W G 1967 Statistical methods 6th edn. Oxford and I.B.H. Publishing Co., Calcutta, 593p.
- Streckeisen A 1976 To each plutonic rock its proper name; *Earth Sci. Rev.* **12** 1–33.
- Widom E, Gill J B and Schmincke H U 1993 Syenite nodules as a long-term record of magmatic activity in Agua de Pao volcano, Sao Miguel, Azores; *J. Petrol.* **34(5)** 929–953.

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Genetic variation in natural population of *Mystus gulio*

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Abstract: Long-whiskered catfish, *Mystus gulio* is one of the important estuarine as well as freshwater fish. It was distributed large geographical area. Due to its delicious taste, it is very popular in eastern India and Bangladesh. Genetic variation was estimated among 29 sequences of three populations of *Mystus gulio* i.e., Tamilnadu (n = 15), Bangladesh (n = 13), and West Bengal (n = 2) using COI gene sequencing. In population 1, the total alignment length was 696 base pairs (including sites with gaps /missing data) containing 577 monomorphic and 45 polymorphic sites with eight haplotypes. In population 2, COI sequence total alignment length was 846 base pairs (including sites with gaps /missing data) containing 487 monomorphic and 21 polymorphic sites with nine haplotypes. Haplotype diversity (Hd) and nucleotide diversity (π) of population 1 were 0.8901 ± 0.063 and 0.02043 ± 0.0062 respectively. Haplotype diversity (Hd) and nucleotide diversity (π) of population 2 were 0.8718 ± 0.052 and 0.01023 ± 0.0025 respectively. Genetic distances among the three populations were varying from 0.00 to 7.3%. The results of haplotype networks can help in conservation decisions and management of the fishery of this species.

Keywords: *Mystus gulio*, COI, population structure, genetic diversity

1. Introduction:

Mystus gulio is also known as the long-whiskered catfish. It was reported that this fish dwells predominantly in brackish water but can also be found in freshwater (Talwar and Jhingran, 1991). It was documented that they were also found in beels, haors, canals, oxbow lakes, rivers and estuaries of Bangladesh (Shafi and Quddus, 2001). It has been reported that this fish is distributed in India, Sri Lanka, Indonesia, Bangladesh, Java, Pakistan, Nepal, Myanmar and Malaysia (Day, 1878; Talwar and Jhingran, 1991; Roberts, 1993; Jhingran, 1997; Kottelat, 2001; Senarathne and Pathiratne, 2007; Weber and de Beaufort, 1913). Due to its delicious taste, it is very popular in eastern India and Bangladesh (Tripathi, 1996; Sarker et al., 2002). This fish is also reported as an ornamental fish (Ng, 2010; Gupta and Banerjee, 2014).

Analysis of genetic variability has been helpful for the proper conservation and management of any natural population (Mukhopadhyay and Bhattacharjee, 2014). Measurement of

18. Shen, Y., Guan, L., Wang, D., & Gan, X., 2016. DNA barcoding and evaluation of genetic diversity in Cyprinidae fish in the midstream of the Yangtze River. *Ecology and Evolution*, 6(9), 2702–2713. <https://doi.org/10.1002/ece3.2060>
19. Talwar P.K., & Jhingran A.G., 1991. Inland fishes of India and adjacent countries. Vol-1 and Vol-2. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Bombay and Calcutta. 1063 p.
20. Thompson, J. D., Gibson, T. J., Plewniak, F., Jeanmougin, F., & Higgins, D. G. (1997). The CLUSTAL_X windows interface: Flexible strategies for multiple sequence alignment aided by quality analysis tools. *Nucleic Acids Research*, 25(24), 4876–4882. <https://doi.org/10.1093/nar/25.24.4876>
21. Tripathi S.D., 1996. Present status of breeding and culture of catfishes in south Asia. In: M. Legendre, J.P. Proteau (ed.). *The biology and culture of catfishes*. Aquatic Living Resources. 9, Hors Serie. pp: 219-228
22. Weber M.C.W. & de Beaufort L.F., 1913. The fishes of the Indo-Australian archipelago. II. Malacopterygii, Myctophoidea, Ostariophysi: I Siluroidea. E.J. Brill Ltd. Leiden. 404 p.
23. Wilson, A.G., Chan, Y., Taylor, S.S. & Arcese, P., 2015. Genetic divergence of an avian endemic on the Californian Channel Islands. *PLoS One*, 10(8), p.e01344

The mechanism of rearrangement process in styrene based iodohydrin via deiodination pathway

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Abstract: Deiodination of styrene based vicinal iodohydrins with the hypobromous acid derived from acid activated bromate/bromide couple and simultaneous 1,2 migration of a phenyl group or hydrogen atom has been reported. The semipinacol rearrangements observed with styrene based vicinal iodohydrins are however dependent on the substrates examined. DFT study has been performed to investigate the semipinacol rearrangement processes of styrene based vicinal iodohydrins. The preference for the phenyl migration in 2-iodo-1-phenylethanol (1a) and in other substrates 2a was predicted with B3LYP/6-31G* level of theory in both ground state and transition state calculations. The dramatic difference in the preference of migration of hydrogen atom of 3a was predicted with DFT calculations in agreement with the observed results. It is to note that the (RS) configuration of 3a showed the hydrogen migration is preferred over the phenyl migration. The preference of hydrogen migration over phenyl migration in this case is due to the intramolecular hydrogen bonding interaction between the hydroxyl group and the carbonyl oxygen of the ester moiety. However, the (RR) configuration of 3a showed the phenyl migration as observed with substrates 1a-2a. The DFT calculations shed the light on the importance of the configuration of substrates to achieve the desired products in such cases.

Keywords: semipinacol rearrangement; iodohydrin; DFT calculations; migratory aptitude

1. Introduction:

The pinacol-pinacolone rearrangement is an important acid catalyzed process in organic synthesis.^[1] It is used for the preparation of aldehydes or ketones from the rearrangement of vicinal-diols. This rearrangement process involves the formation of carbocations.^[1] The structure, stability of such carbocations is important for the formation of rearranged products.^[2] The formation of carbocation in the rearrangement process can compete with the migratory aptitudes of the groups. In general, it is found that the migratory aptitude is in the order $\text{Ph} > \text{Me}_3\text{C} > \text{MeCH}_2 > \text{Me} > \text{H}$. However, in the rearrangement of the compound 2-methyl-1,1-diphenylpropanediol [$\text{Ph}_2\text{C}(\text{OH})\text{C}(\text{OH})\text{Me}_2$], the less prior migratory aptitude methyl group migrates compared to the phenyl group, because the reaction is governed by the formation of more stable initial carbocation.^[3] The disadvantages of this rearrangement process are the excess of Lewis acids required for the completion of the reaction,^[4] poor regio- and dia-stereoselectivity and unpredictable side reactions.^[5] To

configuration of **3a** showed that the hydrogen migration is preferred over the phenyl migration in both the ground state and transition state calculations.

References:

1. March, J., 1992, *Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 4th ed.; Wiley-Interscience: New York, 1072.
2. Creary, X., 1991, Electronegatively substituted carbocations, *Chem. Rev.* 91 (8), 1625-1678.
3. Sykes, P., 2005, *A Guidebook To Mechanism In Organic Chemistry*, 6th ed.; Pearson Education, 114.
4. Kita, Y., Yoshida, Y., Mihara, S., A. Furukawa., Higuchi, K., Fang, D., Fujioka, H., 1998, Non-dehydrative pinacol rearrangement using a Lewis acid-trialkyl orthoester combined system, *Tetrahedron*, 54 (49), 14689-14704.
5. Kürti, L., Czakó, B., 2005, In *Strategic Applications of Named Reactions in Organic Synthesis*; Elsevier Academic Press: Burlington, MA, 350-351.
6. Hu, X. D., Fan, C. A., Zhang, F. M., Tu, Y. Q., 2004, A Tandem Semipinacol Rearrangement/Alkylation of α -Epoxy Alcohols: An Efficient and Stereoselective Approach to Multifunctional 1,3-Diols, *Angew. Chem. Int. Ed.* 43 (13), 1702-1705.
7. Tiffeneau, M., J. Levy, 1923, Pinacolic and semi-pinacolic transpositions. comparative migratory tendencies of different radicals, *Comptes. Rendus.* 176 (1), 312.
8. March, J., 1992, *Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 4th ed.; Wiley-Interscience: New York, 1073.
9. Song, Z. L., Fan, C. A., Tu, Y. Q., 2011, Semipinacol Rearrangement in Natural Product Synthesis, *Chem. Rev.* 111 (11), 7523-7556.
10. Agrawal, M. K., Ghosh, P. K., 2009, Halonium Ion-Assisted Deiodination of Styrene-Based Vicinal Iodohydrins Followed by Rearrangement through Phenyl Migration, *J. Org. Chem.* 74 (20) 7947-7950.
11. Becke, A. D., 1993, Density-functional thermochemistry. III. The role of exact exchange, *J. Chem. Phys.* 98 (7), 5648.
12. Lee, C., Yang, W., Parr, R. G., 1988, Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density, *Phys. Rev. B.* 37 (2), 785.
13. Hehre, W. J., Radom, L., Schleyer, P. v. R., Pople, J. A., 1988, *Ab initio Molecular Orbital Theory*, Wiley, New York, 224.
14. Gilow, H. M.; Ridd, J. H., 1973, Mechanism of aromatic bromination by hypobromous acid in aqueous perchloric acid. Kinetic evidence against the prior formation of 'positive bromine'. *J. Chem. Soc., Perkin Trans. 2* 10, 1321.
15. Anslyn, E. V., Dougherty, D. A., 2006, *Modern Physical Organic Chemistry*, University Science Books, 675-676.

Edge computing-based Internet of Things for Crop Productivity Prediction

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Abstract: *Internet of Things (IoT) has become the key component of designing smart systems. In conventional IoT systems, the use of remote cloud servers for data storage and processing increases the service latency. As a solution, this paper focuses on the use of edge computing in IoT. The edge computing-based IoT architecture is illustrated in this paper. The edge device is used for pre-processing the collected sensor data. The pre-processed data is sent to the cloud for further analysis and storage. For data analysis, we use logistic regression in this paper. The simulation results present that the edge computing-based IoT system reduces the latency by approximately 55% than the cloud-only IoT system. As a case study, we have considered crop productivity prediction based on the soil, weather, and crop related dataset. The experimental results demonstrate that the logistic regression achieves the average accuracy of approximately 90%. Using edge computing, the response time is also reduced by approximately 67% than the cloud-only IoT system.*

Keywords: *Edge computing, low latency, logistic regression, data analysis, Internet of Things.*

1. Introduction:

In the world of contemporary wireless telecommunications, Internet of Things (IoT) is gaining ground quickly. IoT combines a number of technologies, including embedded systems, pervasive computing, actuators, ambient intelligence, sensors, communication technologies, etc. [1, 2]. It is an integration of various devices which communicate, sense, and interact with their internal and external states via the embedded system. It has emerged as a trend for next-generation technologies and the entire business spectrum with extended benefits such as increased connection of end devices, systems, and services. IoT provides appropriate solutions for a wide range of real-time applications, including smart health care, smart cities, smart retail, smart transport, and smart agriculture [3]. Along with the facilities of IoT, cloud computing is introduced in the field of modern research. In cloud computing, dynamically scalable and frequently virtualized resources are supplied through the Internet as a service. The enormous storage, processing, and service capabilities of cloud computing, combined with the information collection capability in IoT, create a network between people

26. A. Boukerche, R.W. Coutinho, 2019. Crowd management: The overlooked component of smart transportation systems, Publisher, City.
27. E.M. Abou-Nassar, A.M. Iliyasu, P.M. El-Kafrawy, O.-Y. Song, A.K. Bashir, A.A. Abd El-Latif, 2020. DITrust chain: towards blockchain-based trust models for sustainable healthcare IoT systems, Publisher, City.
28. S.B. Kelley, B.W. Lane, B.W. Stanley, K. Kane, E. Nielsen, S. Strachan, 2020. Smart transportation for all? A typology of recent US smart transportation projects in mid-sized cities, Publisher, City.
29. N. Guhr, O. Werth, P.P.H. Blacha, M.H. Breitner, 2020. Privacy concerns in the smart home context, Publisher, City.
30. D. Ferraris, D. Bastos, C. Fernandez-Gago, F. El-Moussa, 2021. A trust model for popular smart home devices, Publisher, City.

Field Relation and Petrographic Implication of Kadavur Complex, Southern Granulite Terrane, Tamil Nadu, India

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Abstract: The Precambrian (~810Ma) gabbro-anorthosite Kadavur complex (10°35'N:78°11'E), Karur district, Tamil Nadu occurs as intrusive within the country rocks comprising quartzite, granitic gneiss and migmatites belonging to the Southern Granulite Terrain (SGT). The detailed field investigations reveal that Kadavur complex consists of three well defined types: i) earlier deformation-controlled schistose (remnant) gabbro-anorthosite, ii) well defined layered gabbro-anorthosite and iii) lensoid pegmatoidal gabbro-anorthosite. Petrography of the layered gabbro-anorthosite type (as per IUGS classification) indicates several petrographic variants namely gabbro-norite, noritic-gabbro, gabbro, anorthositic norite, anorthosite, norite and anorthoitic gabbro, leucogabbro and rarely melagabbro and pyroxene hornblende gabbro norite.

Keywords: SGT, Gabbro-anorthosite, Kadavur complex, Intrusive rock

1. Introduction:

The terrestrial anorthosite bodies do not have voluminous and widespread distribution over the world. Their restricted occurrences include Lac-Saint Jean complex, Quebec (Buddinton 1939), Fiskenaesset, Greenland and Grenville of eastern Canadian Shield (Ashwal, 2000, 2010; Ashwal and Myers, 1994), layered Bushveld Complex or Stillwater Complex (Cawthorn, 1996) and Superior Province of Canada (Polat et al. 2018). Terrestrial anorthosite occurrences may be divided into the following five types [Ashwal (1993)] which are: a) Archean anorthosite plutons b) Proterozoic “massif-type” anorthosite plutons c) centimeter to 100m thick layers in layered mafic intrusions d) thin cumulate layers in ophiolites / oceanic crust and e) anorthosite xenoliths occurring in other rock types. So far as the Indian context is concerned, Southern Granulite Terrain (SGT) and Eastern Ghats Granulite Belts (EGB) are classical terrains of anorthosite occurrences of Precambrian time (Naqvi and Rogers, 1987; Radhakrishna, 1990, 1993). The common country rocks in the SGT accommodating the anorthosite represent high grade rocks (Ramakrishnan et al. 1978; Santosh et al.1992). In a recent review paper of the Southern Granulite Terrane, Santosh (2020) emphasized the important role of gabbro-anorthosite bodies in the sense that these bodies probably represent

29. Sarkar, D, Ray, J; Banerjee, P; Kayal, S. (2022) Modal-data based simple statistical analysis as effective petrogenetic indicator: a case study from Kadavur Gabbro-Anorthosite Complex, Tamil Nadu, Southern India,. *Current Sc.*, v.123(4), pp 601-605.
30. Streckeisen, A. (1976) To each plutonic rock its proper name. *Earth Sci. Reviews*, v. 12(1), pp.1-33.
31. Subramanian, A. P. (1956) Petrology of the anorthosite- gabbro mass at Kadavur, Madras, India. *Geol. Magazine*, v.93904, pp.287-300.
32. Subhramanyam, C. and Verma, R.K. (1986) Gravity field, structure and tectonics of Eastern Ghats. *Tectonophysics*, v.126, pp.195-212
33. Windley, B.F. and Selvan, T.A. (1975) Anorthosites and associated Rocks of Tamil Nadu, Southern India. *Jour. Geol. Soc. India*, v.16, pp.209-215.

Social impact of climate change: The source of climate injustice

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Abstract: *Climate change is one of the biggest threats to the world today. The climate change has not only caused danger to ecosystem or bio-diversity but has great impact on social, economic and political life of the people. The climate change has affected the economy, livelihood, health, migration pattern, socio-cultural life of the people and the community. Here arises the question of injustice. The poor, marginalised, vulnerable and the weaker section of the people are the most sufferer of climate change impact through they are least responsible or not responsible for the climate change. Not only the weaker section of the population, the under developed and poor states and even developing states of the south are the main victims of the climate change and they demanded climate justice. The paper is deal with the social impact of climate change and its relation with climate justice.*

Introduction:

Climate change is one of the most significant threats facing the world today and it is the cause behind the biggest socio political and economic injustice of the contemporary world. From the late 60s of the last century, the human environment is one of the emerging issues in global politics. The problem of environmental pollution and global temperature rise have led to changes in the nature of global climate which lead to melting mountain glaciers, global sea levels rise, coastal erosion, increase in the intensity and frequency of extreme weather events. Such climate events result in impacts on socio-economic structure, human health, and political system and also affect vital systems, such as growing food and energy supplies. They may occur immediately following the event or have longer-term implications. Significantly, these calamities affect all the people irrespective of north south but those people who live in developing southern countries are the worst affected as they do not have the capacities to grapple or cope with the changes. The most vulnerable are often disproportionately impacted by the costs of addressing climate change. Thus, in the discussion on climate impact the question of justice is becoming the central notion. Injustice is in part due to the differential socio-political impacts of climate change and uneven patterns of social vulnerability. The impact of climate injustice is becoming hardest for vulnerable

26. United Nations Framework Convention on Climate Change., 2016. Synthesis report on the Aggregate effect of indcs. <https://unfccc.int/process/the-paris-agreement/nationally>
27. United Nations Framework Convention on Climate Change., 2019. United Nations Climate Change Annual Report 2019. <https://unfccc.int/documents/234048>
28. World Health Organization [WHO]. (2018). Global status report on road safety 2018. <https://www.who.int/publications/i/item/9789241565684>
29. World Health Organization [WHO]., 2019. Global status report on road safety 2019. WHO Results Report 2018-2019

Super Foods for Liver Health: A Critical Review

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ABSTRACT: A special food category known as "Super foods" has emerged as a result of the advancement of food within nutrition. Superfoods are particular food items that are able to express numerous advantageous effects like mitigate multiple complications, this type of foods convey strong immunity, have chief compounds such as polysaccharides, polyphenols, essential fatty acids. Apart from that, it carries macro & microminerals in enough quantity. In modern community, super foods are substantial regard which is caused of enhanced health awareness of people. It is a functional food that protects against liver illness by helping the liver to detoxify. This critical review's goal is to analyse the effects of superfoods on liver detoxification from a scientific perspective.

Keywords: Superfoods, Brazil nuts, Hemp seeds, Garden cress seeds, Maca, Amla, Oats, Black rice, orange-coloured fruits & vegetables, tomato & pink grape fruits.

INTRODUCTION

For millions of years ago, with advanced study, foods & its constituent have positive influence on human health. People discrimination regarding foods has altered substantially. Aside from gratifying considerable requirement by adequate nutrition, consumer think that, foods have incredible power to maintain good health status by inhibiting ailments & increasing mental & physical health. This idea has remarkable point authorised by Hippocrates- 'Let food be thy medicine and medicine be thy food'. Foods that upgrade health status & decreases completely manifestation & also applicable for improving symptoms of disorders which is defined as 'Functional foods'. The expenditure of this term was proposed for first time before 30 years in Japan. Now it has been conceded all over the world. In modern community, super foods are the habitual term applied for functional foods. super foods are composed of antioxidant, polysaccharides, essential fatty acids. Moreover, super foods are considered as nutritious particularly as well as it is very much friendly to keep good wellbeing (Meyerding *et al.*, 2018).

Super foods are considered as nutrient dense foods that promote good effects for establishing better health being, it also contains antioxidant which is functioned actively along with promote good bioavailability as it contains bioactive products. Moreover, superfoods establish good immunity. Noteworthy, Superfoods can be described as it constitutes all kind of natural sources of vitamin, minerals & other nutrients that helps for living healthy life with enormous health benefits (Jagdale *et al.*, 2021). The phrase 'Super foods' was utilised for functional foods. it is contemplated to be an umbrella term for understanding the nature of foods. Furthermore, it's nutritional constituents provide advantageous effects for improving health condition (Lunn, 2006).

Additionally, superfoods are traditional food stuffs which escalates good functional properties through many processing applications than gene alteration (Hefferon, 2012). Super foods or functional foods promote healthy effects in body & stable macro or micro nutrients composition these are referred as functional foods which is processed negligibly & available in nature, also highlight that, distinct property

- Yang, Q., Zhao, D. & Liu, Q. (2020). Connections between amino acid metabolisms in plants: Lysine as an example. *Front. Plant Sci.*, 11, 928.
- Yau, Y. F., El-Nezami, H., Galano, J. M., Kundi, Z. M., Durand, T. & Lee, J.C. (2020). *Lactobacillus rhamnosus* GG and oat beta-glucan regulated fatty acid profiles along the gut-liver-brain axis of mice fed with high fat diet and demonstrated antioxidant and anti-inflammatory potentials. *Mol. Nutr. Food Res.*, 64, e2000566.
- Zhang, L., Li, G., Wang, S., Yao, W. & Zhu, F. (2017). Physicochemical Properties of Maca Starch. *Food Chem.*, 218, 56–63.
- Zhang, L., Zhao, Q., Wang, L., Zhao, M. & Zhao, B. (2017). Protective Effect of Polysaccharide from Maca (*Lepidium meyenii*) on Hep-G2 Cells and Alcoholic Liver Oxidative Injury in Mice. *Int. J. Biol. Macromol.*, 99, 63–70.
- Zhou, Y., Li, P., Brantner, A., Wang, H., Shu, X., Yang, J., Si, N., Han, L., Zhao, H. & Bian, B. (2017). Chemical Profiling Analysis of Maca Using UHPLC-ESI-Orbitrap MS Coupled with UHPLC-ESI-QqQ MS and the Neuroprotective Study on Its Active Ingredients. *Sci. Rep.*, 7, 1–14.
- Zhou, Y., Wang, S., Lou, H. & Fan, P. (2018). Chemical Constituents of Hemp (*Cannabis sativa* L.) Seed with Potential Anti Neuroinflammatory Activity. *Phytochem. Lett.*, 23, 57–61.

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Effect of diet and physiotherapy for reducing gout associated symptoms

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Abstract

Increased levels of uric acid in the blood cause gout, a chronic and progressive disease. This causes urate crystals to develop in our joints, which causes inflammation and encourages gout attacks. Gout, a form of arthritis, results in painful, joint stiffness and decrement of joint space. Strengthening of muscles along with the biomechanical correction as much as possible, also maintenance and improving the joint range of motion reducing joint pain, increasing the mobility which are the benefits of physiotherapy. The act of walking may be painful or challenging in some cases of acute or, chronic joint discomfort. There are four stages that gout can go through. Asymptomatic hyperuricemia is the first stage, followed by acute gout, inter-critical gout, and chronic tophaceous gout as the fourth stage. Complex carbohydrate, low protein, low fat (mainly from MUFA and PUFA), high fibre, suitable vitamins, minerals, and adequate hydration intake are recommended for patients who are having gout-related symptoms. On the other hand, physiotherapy is essential in the treatment of gout in addition to diet. In this review article, the effectiveness of diet and physiotherapy in reducing gout-related symptoms is reviewed.

Keywords: Arthritis, cryotherapy, diet, PUFA, MUFA, hydrotherapy

Introduction

An inflammatory arthritis known as gout develops when monosodium urate crystals accumulate in synovial joints (Beyl *et al.*, 2016) ^[5]. It is a typical inflammatory arthritis whose prevalence has grown in recent years. Gout typically develops as a result of the interplay of risk factors from the environment, constitution, and genes. Men and older persons are more likely to experience it. The extent to which uric acid levels are raised over the saturation point as a result of urate crystal formation, which is mostly brought on by ineffective renal urate excretion, is a key determinant (Doherty, 2009) ^[9].

As stated in the definition of gout, it is "a disease characterized by recurrent episodes of violent arthritis associated with the presence of monosodium urate monohydrate crystals in the synovial fluid, and in many cases, the eventual appearance of gross uratic deposits (tophi) in and around the joints, in the kidneys, and in certain subcutaneous sites" (Kwan *et al.*, 2013) ^[16].

Gout is a type of chronic and progressive disease occurred due to increased level of uric acid in the blood. This results formation of urate crystals in our joint, leading to inflammation and promotes gout attack. Gout may progress through four stages. First stage is asymptomatic hyperuricemia, second stage acute gout, third stage inter-critical gout, and fourth stage is chronic tophaceous gout (Nuki and Simkin, 2006) ^[17].

Bardin and Richette (2014) ^[2] reported that there are several factors that contribute gout attack. These are high protein rich diet, fructose rich drinking beverages, over weight/obesity, diabetes, heart disease, hypertension, alcohol consumption, family history, certain drugs and medications, surgery, trauma, dehydration. The sign and symptoms of gout include intense joint pain, tenderness, swelling, redness, stiffness, burning sensation. Generally, gout attacks our big toe, but gradually the inflammation spreads heels, knees, ankles, fingers and elbows

The first gouty arthritis attack typically affects just one joint. The metatarsophalangeal (MTP) joint at the base of the big toe is where gout most frequently manifests itself. 90% of gout sufferers will eventually have discomfort in the MTP joint. Knee joints, ankle joints, heels, and mid-foot joints are additional joints that are frequently impacted. Gout can also occur in the elbows, wrists, and fingers less frequently (Roddy, 2011) ^[22].

10. Goldberg EL, Asher JL, Molony RD, Shaw AC, Zeiss CJ, Wang C, *et al.* β -Hydroxybutyrate Deactivates Neutrophil NLRP3 Inflammasome to Relieve Gout Flares. *Cell Rep.* 2017;18(9):2077-2087.
11. Guillot X, Tordi N, Mourot L, Demougeot C, Dugue B, Prati C, *et al.* Cryotherapy in inflammatory rheumatic diseases: a systematic review. *Expert Review of Clinical Immunology.* 2014;10(2):281-294.
12. Juraschek SP, McAdams-Demarco M, Gelber AC, Sacks FM, Appel LJ, White KJ, *et al.* Effects of lowering glycemic index of dietary carbohydrate on plasma uric acid levels: the Omni Carb randomized clinical trial. *Arthritis & Rheumatology.* 2016;68(5):1281-1289.
13. Juraschek SP, Yokose C, McCormick N, Miller IIIER, Appel LJ, Choi HK. Effects of dietary patterns on serum urate: results from a randomized trial of the effects of diet on hypertension. *Arthritis & Rheumatology.* 2021;73(6):1014-1020.
14. Juraschek S, Gelber AC, Choi HK, Appel LJ, Miller ER. Effects of the Dietary Approaches to Stop Hypertension (DASH) Diet and Sodium Intake on Serum Uric Acid. *Arthritis Rheumatol.* 2016;68:3002-3009.
15. Khanna PP, Gladue HS, Singh MK, FitzGerald JD, Bae S, Prakash S, *et al.* Treatment of acute gout: a systematic review. In *Seminars in arthritis and rheumatism.* WB Saunders. 2014 Aug;44(1):31-38.
16. Kwan BYM, Osman S, Barra L. Spinal gout in a young patient with involvement of thoracic, lumbar and sacroiliac regions. *Joint Bone Spine.* 2013;6(80):667-668.
17. Nuki G, Simkin PA. A concise history of gout and hyperuricemia and their treatment. *Arthritis research & therapy.* 2006;8(1):1-5.
18. Perez-Ruiz F, Marimon E, Chinchilla SP. Hyperuricaemia with deposition: latest evidence and therapeutic approach. *Therapeutic Advances in Musculoskeletal Disease.* 2015;7(6):225-233.
19. Rai SK, Choi HK, Choi SH, Townsend AF, Shojanian K, De Vera MA. Key barriers to gout care: a systematic review and thematic synthesis of qualitative studies. *Rheumatology.* 2018;57(7):1282-1292.
20. Rai SK, Fung TT, Lu N, Keller SF, Curhan GC, Choi HK. The Dietary Approaches to Stop Hypertension (DASH) diet, Western diet, and risk of gout in men: Prospective cohort study. *BMJ.* 2017;357:1794.
21. Retterstøl K, Svendsen M, Narverud I, Holven KB. Effect of low carbohydrate high fat diet on LDL cholesterol and gene expression in normal-weight, young adults: A randomized controlled study. *Atherosclerosis.* 2018;279:52-61.
22. Roddy E. Revisiting the pathogenesis of podagra: why does gout target the foot?. *Journal of foot and ankle research.* 2011;4(1):1-7.
23. Saltiel AR, Olefsky JM. Inflammatory mechanisms linking obesity and metabolic disease. *J Clin. Investig.* 2017;127(1):1-4.
24. Stamp LK, Jordan S. The challenges of gout management in the elderly. *Drugs & aging.* 2011;28:591-603.
25. Tewari S. *Therapeutic diet to control diseases*, AkiNik Publications, 2019, 79. ISBN:978-93-5335-482-484.
26. Tewari S, Vaishnav S, BISwas S, Khalua RK, Chakraborty R, Chakraborty A. Fish liver oil: omega-3 fatty acid and human health. *Uttar Pradesh journal of Zoology.* 2022;43(24):307-310.
27. Vieira A, Galvão I, Macia L, Sernaglia M, Vinolo MA, Garcia C, *et al.* Dietary fiber and the short-chain fatty acid acetate promote resolution of neutrophilic inflammation in a model of gout in mice. *J Leukoc. Biol.* 2017;101(1):275-284.
28. Wang Y, Chu C, Wang K.-K, Hu J.-W, Yan Y, Lv Y.-B, *et al.* Effect of Salt Intake on Plasma and Urinary Uric Acid Levels in Chinese Adults: An Interventional Trial. *Sci. Rep.* 2018, 8(1434).
29. Yang Y, Piao W, Huang K, Fang H, Ju L, Zhao L, *et al.* Dietary pattern associated with the risk of hyperuricemia in Chinese elderly: result from china nutrition and health surveillance 2015–2017. *Nutrients.* 2022;14(4):844.
30. Yokose C, McCormick N, Choi HK. The role of diet in hyperuricemia and gout. *Current opinion in rheumatology.* 2021;33(2):135.
31. Yokose C, McCormick N, Lu N, Joshi AD, Curhan G, Choi HK. Adherence to 2020 to 2025 Dietary Guidelines for Americans and the Risk of New-Onset Female Gout. *JAMA Intern. Med.* 2022;182(3):254-264.
32. Zhang M, Gao Y, Wang X, Liu W, Zhang Y, Huang G. Comparison of the effect of high fruit and soybean products diet and standard diet interventions on serum uric acid in asymptomatic hyperuricemia adults: An open randomized controlled trial. *Int. J Food Sci. Nutr.* 2016;67(3):335-343.
33. Danve A, Sehra ST, Neogi T. Role of diet in hyperuricemia and gout. *Best practice & research Clinical rheumatology.* 2021;35(4):101723.



A short review on medicinal value of Indian blackberry (*Syzygium cumini* L.)

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Abstract

Indian blackberry, also known as Java plum, black plum, jambolan, or jamun, is a tropical evergreen tree in the *Myrtaceae* genus of flowering plants. It is mostly used for conventional treatment of diarrhoea, ulcers, inflammation, and diabetes mellitus. It is a good source of anthocyanin, which is useful against analgesic characteristics, and it has medicinal benefits. Additionally, it possesses antineoplastic, radioprotective, and chemopreventive qualities. The information about the therapeutic benefits of Indian blackberries for human health is briefly described in the current article.

Keywords: Indian blackberry, medicinal value, human health, chemo preventive qualities, ulcers, inflammation

Introduction

Syzygium cumini, a member of the *Myrtaceae* family, is also known as *Eugenia cumini* and *Syzygium jamunum*. Other names for Indian blackberry include Jambul, Black Plum, Java Plum, Jamblang, and Jamun (Tewari *et al.*, 2021) [16, 17]. The tree only bears fruit once a year, and the taste of the berries is sweetish-sour. The ripe fruits are used to produce wine, squash, jellies, and health beverages. All components of the tree, but most significantly the seeds, are used to manage diabetes mellitus in connection with its nutritional usage. Jamun has antioxidant, anti-inflammatory, anti-HIV, anti-leishmanial and antifungal, nitric oxide scavenging, free radical scavenging, anorexigenic, gastroprotective, anti-ulcerogenic, and radio-protective effects (Baliga *et al.*, 2011) [3].

Nutritional composition of Indian blackberries

Table 1: Nutritional composition of Indian Blackberry

Java Plum, raw - Nutritional value per 100 g	
Energy	60 kcal
Carbohydrates	15.56 g
Fat	0.23 g
Protein	0.72 g
Water	83.13 g
Vitamin A	3 IU
Thiamine (vit. B1)	0.006 mg (1%)
Riboflavin (vit. B2)	0.012 mg (1%)
Niacin (vit. B3)	0.260 mg (2%)
Pantothenic acid (B5)	0.160 mg (3%)
Vitamin B6	0.038 mg (3%)
Vitamin C	14.3 mg (17%)
Calcium	19 mg (2%)
Iron	0.19 mg (1%)
Magnesium	15 mg (4%)
Phosphorus	17 mg (2%)
Potassium	79 mg (2%)
Sodium	14 mg (1%)

Source: USDA Nutrient Database

13. Sagrawat H. Pharmacological potential of *Eugenia jambolana*: A review. *Pharmacogn Mag*,2006;2(6):96-105.
14. Sontakke SD, Patil MS, Umopathy G, Rao KR, Shivaji S. Ejaculate characteristics, short-term semen storage and successful artificial insemination following synchronisation of oestrus in the Indian blackbuck antelope (*Antelope cervicapra*). *Reproduction, Fertility and Development*,2009;21(6):749-756.
15. Srivastava Y, Bhatt H, Gupta OP, Gupta PS. Hypoglycemia induced by *Syzygium cumini* Linn. seeds in diabetes mellitus. *Asian Medical Journal*,1983;26(7):489-492.
16. Tewari S, David J, Gautam A. Physicochemical analysis of probiotic functional Kulfi by using Indian blackberry (*Syzygium cumini* L.). *Journal of Pharmacognosy and Phytochemistry*,2021;10(5):236-246.
17. Tewari S, David J, Gautam A. Sensory analysis of probiotic functional kulfi by using Indian blackberry (*Syzygium cumini* L.). *The Pharma Innovation Journal*,2021;10(9):1421-1426.

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From *Bastuhara* to *Immigrati*: Resistance and Refugee Solidarity in Amitav Ghosh's *The Hungry Tide* and *Gun Island*

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Abstract

Refugees exist throughout human history, though it is after the British imperial collapse that the term ‘refugee’ finds currency in South Asia. This paper shows how refugee solidarity finds different expressions in the face of resistance and securitization in two of Amitav Ghosh’s novels - from the state-sponsored genocide of refugees in the regime of a left-wing government in *The Hungry Tide*, to the right-wing resistance denying the entry of immigrants stranded on the Italian coastline of the Mediterranean in *Gun Island*. This paper also unfolds how politicization of issues like sheltering and socializing the refugees affects the idea of solidarity: the indifference of civic society to state-sponsored atrocities against the refugees in *The Hungry Tide* stands in contrast with the support extended to illegal immigrants by the human rights activists despite the opposition of “right-wing, anti-immigrant groups” in *Gun Island*. Finally, the paper reflects how, in this age of economic globalization, digital media appears more powerful than any doctrinaire ideology of the ‘dispossessed’ in managing refugees’ solidarity.

Keywords: Refugees, immigrants, sociality, resistance, refugee solidarity

Introduction

“The refugee question is, of course, the most visible form of the current planetary crisis. Ten years ago if somebody had suggested that the movement of a relatively small number of people would fundamentally destabilize the political systems of Europe and North America nobody would have believed them—but that is exactly what has happened. But I think it is vital to point out that the current migrations cannot be reduced simply to “climate change”; they are the product of many interesting factors.” - Amitav Ghosh²

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² In reply to a question put by Asis De (one of the authors of this article) in an interview, Amitav Ghosh’s statement quoted above appears quite significant. For details, please see: *Amitav Ghosh’s Culture Chromosome*, eds. Asis De and Alessandro Vescovi (Leiden and Boston: Brill, 2022), 336.

- . *Gun Island: A Novel*. Hamish Hamilton, Penguin, 2019.
- . "A Few Words from Amitav Ghosh on *Gun Island*." Interview by Asis De and Alessandro Vescovi, *Amitav Ghosh's Culture Chromosome*, edited by Asis De and Alessandro Vescovi Brill, 2022, p. 336.
- Hoydis, Julia. "*Tackling the Morality of History*": *Ethics and Storytelling in the Works of Amitav Ghosh*. Winter Universitätsverlag, 2011.
- Mehta, Rini Bhattacharya and Debali Mookerjea-Leonard. "Introduction." *The Indian Partition in Literature and Films: History, Politics, and Aesthetics*, edited by Rini Bhattacharya Mehta and Debali Mookerjea-Leonard. Routledge, 2015.
- Mondal, Anshuman A. *Amitav Ghosh*. Manchester UP, 2007.
- Murshid, Navine. *The Politics of Refugees in South Asia: Identity, Resistance, Manipulation*. Routledge, 2014.
- Porta, Donatella della. "Contentious Moves: Mobilising for Refugees' Rights." *Solidarity Mobilizations in the 'Refugee Crisis': Contentious Moves*, edited by Donatella della Porta. Palgrave Macmillan, 2018, pp. 1-38.
- UN General Assembly. "Convention Relating to the Status of Refugees." United Nations, Treaty Series 189, 1951, pp. 153.
<https://www.refworld.org/docid/3be01b964.html>
- Zamponi, Lorenzo. "From Border to Border: Refugee Solidarity Activism in Italy across Space, Time, and Practices." *Solidarity Mobilizations in the 'Refugee Crisis': Contentious Moves*, edited by Donatella della Porta. Palgrave Macmillan, 2018, pp. 99-123.

রবীন্দ্র-দর্শন

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রবীন্দ্রনাথ এক বিশ্ব-বীক্ষা। তাঁর জীবনের সত্তার সঙ্গে মিশে আছে বিশ্ব-মনস্কতার ছাপ। তাঁর চিন্তন ও মনন কখনোই কেবল বাঙালিদের সীমার মধ্যে সীমাবদ্ধ ছিল না; এমনকী তাঁর চিন্তার আলোকজ্যোতি ভারতবর্ষের মাটি ছাড়িয়ে সমগ্র বিশ্বের মানব-কল্যাণে ছড়িয়ে পড়েছিল। তিনি ছিলেন এক বিশ্ব-মানবতাবাদী কবি। সারাজীবন তিনি বিশ্বের মানুষকে ভালোবেসেছেন, তাঁদের দুঃখে তাঁর অন্তরাত্মা কেঁদে উঠেছে। তাঁর লেখনীতে বিশ্বলোকের মঙ্গলবার্তা ধ্বনিত হয়েছে বলেই তিনি হয়ে উঠেছেন সকলের 'বিশ্বকবি'। তিনি কেবল একজন বিশ্বের শ্রেষ্ঠ কবি তা নয়, বিশ্ববাসীর আশা-আকাঙ্ক্ষা ও প্রাণের সুরও তাঁর কাব্য-গীতির মধ্য দিয়ে বারে বারে বেজে উঠেছে। তাঁর এই বিশ্ব-মনস্কতা, বিশ্ব-মানব প্রেম, পরিপূর্ণ মনুষ্যত্ববোধ ও ঋষিকল্প চিন্তা-ভাবনার উৎস-মুখ নিহিত রয়েছে তাঁর জীবন-দর্শনের মধ্যে। তাঁর এই জীবন-দর্শনের ভিত একদিনে গড়ে ওঠেনি, তা গড়ে উঠেছে সমগ্র জীবন-চর্যার সাধনায়। রবীন্দ্র-জীবন-দর্শন বিশ্বাসের গভীর শিকড় থেকে উথিত। তাই সত্য-দর্শনই রবীন্দ্র-দর্শন।

রবীন্দ্রনাথের যে বিশ্ব-মানবিক জীবন-দর্শন, তা তাঁর অধ্যাত্ম-চেতনা থেকে উৎসারিত। আর তিনি এই অধ্যাত্ম-প্রেরণা পেয়েছেন তাঁর পিতা মহর্ষি দেবেন্দ্রনাথের কাছ থেকে এবং পরবর্তী কালে তা আরও বেশি গভীর ও ব্যাপ্তিলাভ করে উপনিষদ ও বৈষ্ণব-ভাবাদর্শের প্রভাবে। ঠাকুরবাড়ির পরিবেশ ও কালচার রবীন্দ্র-জীবন-দর্শন গঠনে বিশেষ ভূমিকা নিয়েছিল। দেবেন্দ্রনাথ জমিদার হয়েও তাঁর সন্তানদের বিলাসিতার মধ্য দিয়ে মানুষ করেননি। তাই সাধারণ মানুষদের মত কষ্ট-সহিষ্ণুতা আয়ত্ত করেছিলেন রবীন্দ্রনাথ। স্কুলের ধরা-বাধা নিয়মের পড়াশুনা না করলেও তার জন্য দেবেন্দ্রনাথ চিন্তিত হননি; কেননা বাড়িতে বিভিন্ন বিষয়ে নিয়মিত গৃহ-শিক্ষকের কাছে পড়াশোনা করতেন রবীন্দ্রনাথ। শুধু তাই নয়, শরীরকে ঠিক রাখার জন্য ভোরে উঠে ধুলো-কাদার মধ্যে খালি গায়ে কুস্তি শিখতে হত। এভাবেই রবীন্দ্রনাথের ছেলেবেলা কেটেছে হৃন্দে-বাধা রুটিন ধরে।

দিয়ে তাঁর বিশ্ব-মনস্কতার মনোভাব দ্যোতিত হয়েছিল। আবার মানুষকে ভালোবাসার মধ্য দিয়েই তিনি ঈশ্বরকে পেতে চেয়েছিলেন,—‘জীবে প্রেম করে যেইজন/সেইজন সেবিছে ঈশ্বর’ – বিবেকানন্দের এই মর্মবাণী রবীন্দ্রনাথ নিজের জীবনে পালন করতেন। এভাবেই রবীন্দ্রনাথের পরিপূর্ণ মনুষ্যত্ববোধ, বিশ্ব-মানবতাবোধ ও অধ্যাত্ম-চিন্তা ‘বড়ো আমি’র জগৎ থেকেই আলোর দ্যুতির মতো উৎসারিত হয়েছে। সারাজীবন ‘বড়ো আমি’র সাধনা করেছিলেন বলেই তাঁর জীবনখানিও হয়ে উঠেছিল সুন্দর ও ছন্দোময়। এরূপ ছন্দোময় জীবন আয়ত্ত করেছিলেন বলেই তিনি একটাই জীবনে পাহাড় প্রমাণ সাহিত্য-নিদর্শন রাখতে পেরেছেন। তাঁর সাহিত্যসামগ্রী যেমন উৎকৃষ্ট, তেমনি তাঁর জীবন ও জীবন-দর্শনও মহিমময়।

রবীন্দ্রনাথ ছিলেন পুণ্য জ্যোতির্ময়স্বরূপ এক বিশ্বমনস্ক আন্তর্জাতিক ব্যক্তিত্ব। তাঁর নশ্বরদেহ আর নেই; কিন্তু আছে তাঁর কীর্তি, আছে জীবন-দর্শন। তাঁর সাহিত্য আমাদের অবসাদ-ক্লিষ্ট মনের শান্তির উৎস, তাঁর জীবন-দর্শন আমাদের লক্ষ্যহীন অন্ধকার জীবনের আলোর দিশারী। দুঃখ-জর্জর হতাশাগ্রস্ত বাঙালিকে যথার্থ মনুষ্যত্ববোধে উত্তীর্ণ হতে প্রেরণা জাগাতে পারে রবীন্দ্র-দর্শন। কেননা রবীন্দ্রনাথ আমাদের দেখিয়েছেন— ‘কীভাবে আমরা বাঁচবো।’ তিনি শিখিয়েছেন কীভাবে জীবনকে ছন্দোময় করে তুলতে হয়। তিনি আমাদের শিখিয়েছেন, কীভাবে মৃত্যু-শোককে ভুলে থাকতে হয়, কীভাবে নিরাসক্ত ও নির্লোভ হতে হয়, কীভাবে সঙ্কীর্ণ স্বার্থের উর্ধ্ব উঠে মানুষকে ভালোবাসতে হয়, কীভাবে ঈশ্বরের সাধনা করতে হয় এবং সর্বোপরি তিনি শিখিয়েছেন কীভাবে শান্তিতে ভালো থাকা যায়। তাই রবীন্দ্র-জীবন-দর্শনই হয়ে উঠুক আমাদের সকলের পাথর।

তথ্যসূত্র:

- ১। ১ নং গ্লোক। ২০১২। ঈশোপনিষদ। তুলসী প্রকাশনী। পৃষ্ঠা ২১।
- ২। রবীন্দ্রনাথ ঠাকুর। ১৩৯৫ বঙ্গাব্দ। ‘মুক্তি’ কবিতা। নৈবেদ্য। বিশ্বভারতী। পৃষ্ঠা ৩৮।
- ৩। রবীন্দ্রনাথ ঠাকুর। ১৩৯৫ বঙ্গাব্দ। ‘প্রাণ’ কবিতা। কড়ি ও কোমল। বিশ্বভারতী। পৃষ্ঠা ৩৬।

संस्कृत चन्द्रिका

त्रयोदश वर्ष

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সংস্কৃত : অ-মৃত এক নদীর ধারা

নবনীতা রাগ মাইতি

মানব সভ্যতা ও সংস্কৃতির ধারক ও বাহক হল ভাষা। যার মাধ্যমে যুগ থেকে যুগান্তরের সচ্ছাত্তা ও সংস্কৃতির এক অচ্ছেদ্য প্রবহমানতা বজায় থাকে। ভাষা হল এক নদীর মতো। যা দীর্ঘ পথ অতিক্রম করে চলে। কখনো তার চঞ্চল উন্মাদ গতি, কখনো বা সে ভরা যৌবনবতী। আবার কখনো সে ফল্গুধারারূপী।

পৃথিবীর ভাষা পরিবারের অন্তর্গত যে ভাষাগুলি পাওয়া যায় তার মধ্যে বহু ভাষা আছে যা আজ তার মানুষের কথা ভাষারূপে প্রচলিত নেই। কিন্তু সেসব ভাষার সাহিত্যপরম্পরা আজও বিশ্ববিস্তৃত। ভাষা যদি কথাভাষা হিসেবে না প্রচলিত থাকে তবে সাধারণভাবে আমরা তাকে অমৃত ভাষা বলি। কিন্তু যদি আমরা একটি অন্যভাবে ভেবে দেখি তাহলে দেখব যে—ভাষার মৃত্যু কখনো হতে পারে না। নদীধারার রূপবিবর্তনের মতোই ভাষাও বিবর্তনের মধ্য দিয়ে প্রবাহিত হয়। প্রতিনিয়ত ভাষা ও ভাষান্তরের মধ্যে পারস্পরিক আদান-প্রদানে ভাষার মূল রূপ পরিবর্তন বা বিবর্তিত হতেই পারে। যেমন আমরা প্রত্যেক রাজ্যের সীমান্তবর্তী এলাকায় প্রচলিত যে ভাষা দেখি সেই ভাষাগুলোর মধ্যে পার্শ্ববর্তী রাজ্যের ভাষার প্রভাব লক্ষ্য করা যায়। বিশেষ চর্চা করলে ওই সীমান্তবর্তী এলাকায় প্রচলিত ভাষা থেকে দুটি রাজ্যের মূল ভাষার উদ্ভাব সম্ভব। কারণ সীমান্তবর্তী আঞ্চলিক ভাষার যে রূপ আমরা পাই সেই রূপের মধ্যেই দুটি রাজ্যের মূল ভাষাতে প্রচলিত যে ভাষা তার রূপ অনুসৃত হয়ে থাকে। যদি আমরা বাংলা এবং ওড়িশার বা যে-কোনো সীমান্তবর্তী এলাকার ভাষাগুলি নিয়ে চর্চা করি এ ধরনের উদাহরণ আমরা বিশেষভাবে অনুভব করব। সুতরাং পরিবর্তিত রূপের মধ্যেই মূল ভাষাটি কোনো না কোনোভাবে অনুসৃত হয়ে অনশকট অবস্থায় ভাষান্তরে প্রবাহিত হয়ে চলে। আর এও তো হতে পারে যে কোনো ফল্গুধারারূপী ভাষা কোনো না কোনো কালে বিশেষ প্রচেষ্টায় প্রকটরূপে প্রকাশিত হবে।

আমাদের আলোচ্য ভাষা হলো সংস্কৃত। যে ভাষার সজীবতা নিয়ে শিক্ষিত সমাজে এক বিষয়তার প্রবাদ প্রচলিত—‘সংস্কৃত মৃতভাষা’। বিষয়তা এ কারণে

সংঘটি ভারতের ঘোষিত জনসংখ্যার দ্বারা এক শতাংশেরও কম। তবুও এই সংঘটি সংস্কৃতভাষার সক্রিয়তার প্রমাণ বহন করে। সুতরাং আধুনিক ভারতে সংস্কৃতভাষাকে আর মুড়ভাষা বলা যায় না।

ভারত ছাড়াই পৃথিবীর বিভিন্ন প্রান্তে সংস্কৃতভাষা চর্চাকেন্দ্রে সুপ্রতিষ্ঠিত। প্রথমেই জার্মানির কথা বলতে হয়। জার্মানিতে প্রায় ১৪টি বিশ্ববিদ্যালয়ে সংস্কৃত ভাষা ও ইন্ডোলজি বিষয়ের পঠন পাঠন হয়। আমেরিকায় প্রায় তিনটি বিশ্ববিদ্যালয়ে সংস্কৃত সাহিত্যের পঠন পাঠন প্রচলিত। ইউনাইটেড কিংডম, অস্ট্রেলিয়া, রাশিয়া, পোল্যান্ড এবং অবশ্যই বাংলাদেশ, নেপাল—এ সমস্ত দেশে সংস্কৃতভাষা ও সাহিত্যের পঠন পাঠন প্রচলিত। সাতীর্থ অফ্রিকাতে সংস্কৃতকে মাইনেট্রিটি ল্যান্ডুয়েজ্‌জ্‌ ক্রমে স্বীকৃতি দেওয়া হয়েছে। বিশ্বব্যাপী অক্সফোর্ড ও হার্ভার্ড ইউনিভার্সিটিতেও সংস্কৃতের পঠন পাঠন বহুদিন ধরেই প্রচলিত।

এভাবেই সারা পৃথিবী জুড়ে সংস্কৃতভাষা ও সাহিত্যচর্চার প্রকৃষ্টি নিদর্শন পত্রিকা বা ভারতের প্রাচীন ইতিহাস, রাজনীতি, বিজ্ঞান, ধর্ম, দর্শন ইত্যাদি জানতে গেলে সংস্কৃতভাষা চর্চা অত্যাৱশ্যক। বর্তমান ভারতে সংস্কৃতভাষায় নতুন সাহিত্যস্রাব গড়ে উঠছে আর এটাই আমাদের সংস্কৃতপ্রেমী মানুষের কাছে আনন্দের বিষয়।

প্রত্নসূত্র

1. Wikipedia, List of Sanskrit Universities in India.
2. "Indian Constitution Art.344(1) & Art.395" (PDF) / সংস্কৃতের ভারিণ ৪ অক্টোবর ২০০৭।

Rejuvenating the Voiceless Women Entities: Re-writing Mahasweta Devi's *Draupadi* and Toni Morrison's *Beloved*

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Abstract: *The issues of culture, identity and representation are significant to reflect analytically on tribal and black women's identity, culture, and their condition of being voiceless in Indian and American English texts with the reference to Stuart Hall's canonical essay 'Cultural Identity and Diaspora' which states identity and identification can be seen as a process never completed, thus always changing. In the definition of cultural identity, he popularizes a term called an essentialist identity which emphasizes the similarities among a group of people. Interestingly the said definition can and does inspire feminist, anti-colonial and anti-racist art and activism. Some prominent Indian and American fiction writers like Mahasweta Devi and Toni Morrison highlight the activism on behalf of indigenous tribal and black women and lead us to think about the voice for the voiceless tribal and black women's identity, existence and resistance.*

Keywords: *Cultural Identity, Representation, Activism and Resistance.*

"I see a voice" (Shakespeare, 1998/5.1). In 'A Midsummer Night's Dream' Bottom playing the role of Pyramus rightly pronounces this meaningful and significant maxim. Actually it might express the experience of the reader who can see voices on the page. The French writer Pascal Quignard argues that in a literary text the writer tries to present silence and then perceive some lost voice in the socio-economic structure of the society and reflect the lost voice efficiently in their narratives to be a eloquent voice for the community. As Homi K. Bhabha justifiably says in his *The Locations of Culture*, 'there is a conspiracy of silence around the colonial truth.' (Bhabha, 2004). My objective in this article is to illustrate how Draupadi Mehjen in Mahasweta's *Draupadi* and Sethe in Toni Morrison's *Beloved* break this shackle of silence of colonial truth and emerges as voice for socially, economically politically exploited and oppressed people in the postcolonial world. These prominent Indian and American fiction writers like Mahasweta Devi and Toni Morrison highlight the activism on behalf of indigenous tribal and black women and lead us to think about the voice for the voiceless tribal and black women's identity, existence and resistance.

4. Bjork, P. B., 1996, *The Novels of Toni Morrison, The Search for Self and Place Within the Community*. New York: Peter Lang.
5. Christian, Barbara, 1985, *Black Feminist Criticism: Perspectives on Black Women Writers*. New York: Pergamon Press.
6. Conrad, Joseph., 2007, *Heart of Darkness* (R.Hampson and O. Knowles Eds), Penguin Classics. P-50
7. Devi, M., 1995, *Draupadi*. (G. C. Spivak Trans.). London: Routledge.P-34
8. Devi, M. (1997) *Breast Stories* (G. C. Spivak Trans.). Calcutta: Seagull.P-36
9. Hall, S.(1990) *Cultural Identity and Diaspora: Identity: Community, Culture, Difference*.London P-37
10. Morrison, T. (1987) *Beloved: A Novel*. New York: Alfred A.s Knopf Inc. P-16
11. Spivak.C. G. (1998) '*Draupadi*' in *the Other Worlds: Essays in Cultural Politics*. New York: Routledge.P-11
12. Spivak, G. C. (2001) *Can the Subaltern Speak? The Norton Anthology of Theory and Criticism*.New York: W.W. Norton.
13. Shakespeare, W. (1998). *A Midsummer Night's Dream*. New York: Signet Classic.P-189.
14. Waghmare, J.M. (2000) "*Literature of Marginality*." *Literature of Marginality, Dalit Literature and African-American Literature*" ed N M Aston New Delhi: OUP. P-20

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Socio-religious Complexities of Nyishi Tribes: A critical Study of Yumlum Tana's *the Wind Also Sings* and *The Place Where Rivers Meet*

Shyamal Mondal* Dr. Shantanu Siuli**

[Arunachal Pradesh, the land of rising sun, is the abode of different tribes like Nyishi, Sherdukpen, Adi and Monpa etc. The Nyishi Community, the largest ethnic group in Arunachal Pradesh is passing through severe socio-cultural change. In this changing scenario of religious, political and cultural dynamics, theology of Christianity, Buddhism and Hinduism is tremendously striving with the indigenous tribal theology. Nyishi tribe specifically the youth with the arrival of the Hariangs (non-tribal) tries to hug the modern life, education and western culture raising the issue of tribal identity crisis. Indigenous tribal traditions, Donyi-Polo, Abutani of Nyishi tribes have to face challenges due to alien theological perspectives of Christian Church, Hinduism and Buddhist Spirituality. The purpose of my article is to explore and explain the socio-religious complexities and the revival of indigenous tribal religion of Nyishi tribe against the progressive chariot of Christianity through critical study of Nyishi Writer Yumlum Tana's *The Wind also Sings* and *The Place Where Rivers Meet*.]

The most significant and influential prose writer of 20th century literature Franz Kafka vividly represents his feelings of imprisonment in foreign country as an immigrants and his participation in their alien bizarre rituals. Yumlum Tana as an embodiment of Nyishi Tribes has almost the same feelings when he was forcefully compelled to participate in the bizarre rituals of Christian missionaries leaving behind his indigenous identity, culture and theology. The analysis of Yumlum Tana's *The Wind Also Sings* (2015) and *The Place Where Rivers Meet* (2020) demonstrates to a great extent that the majoritarian discourse and religion encompass all the other minoritarian discourses. It is not

wrong to say that the Nyishi community, the largest ethnic group in Arunachal Pradesh, is made to mourn the cultural loss in main land India. This loss of culture and religion within Indian nation state is definitely due to the socio-cultural and socio-religious complexities of different dominant territorial groups. An ethnically different and socio-economically disempowered group Nyishi Tribe is subjected to alienation and discrimination due to their status of marginalized minorities and cultural differences. However, with the British Colonization and growing urbanization the tribal theology of Nyishi people has been identified as peripheral with a stigma of superstitious beliefs.

References

1. Das, Nigamananda. (2004) *Mosaic of Redemption*. Cuttack: M.G. Publication.
2. Horace, Kallen. (1956). *Cultural Pluralism and the American Idea: An Essay in Social Philosophy*. Pennsylvania Press.
3. Horace, Kallen. (1996). 'Democracy versus the Melting Pot', in Sollars W. (ed.) *Theory of Ethnicity*. New York: New York University Press.
4. Nongsiej, Tloyen. (2002). *Khasi Cultural Theology: (Tribal Theology)*. Kolkata. ISPK
5. Nongkynrih, K. S. (2005). *Hard-edged modernism: contemporary poetry in north east India*. *India International Centre Quarterly*, Vol. 32, No. 2/3.
6. Pereira, M., Dutta, B., & Kakati, Binita. (2017). *Legal Pluralism and Indian Democracy: Tribal Conflict resolution systems in Northeast India*. Taylor & Francis.
7. Prabhakara, M.S. (2020). *Looking back into the future: identity and insurgency in North East India*. Taylor & Francis press.
8. Tana, Yumlum. (2015). *The Wind Also Sings*. Haryana: Partridge Publishing House.
9. Tana, Yumlum. (2020). *The Place Where Rivers Meet*. Mumbai: Leadstart Publishing Pvt Ltd.



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ভারতীয় নারী এবং সামাজিক পরিবর্তন : একটি বিশ্লেষণ

বরুণ কুমার ঘোষ
সহকারী অধ্যাপক, দর্শন বিভাগ,
মহিষাদল রাজ কলেজ

সারসংক্ষেপ :- পরিবর্তনশীলতা হল মানব সমাজের ধর্ম। আর সামাজিক পরিবর্তন হল এই বৃহত্তর সমাজের পরিবর্তন। ম্যাকাইডার ও পেজ তাই সমাজের সংজ্ঞায় বলেছেন – ‘সমাজ হল সামাজিক সম্বন্ধের জটাজাল, যা নিয়ত পরিবর্তনশীল’। আদিম সমাজ ব্যবস্থা এ প্রকার নানা পরিবর্তিত অবস্থার মধ্য দিয়ে বর্তমান সমাজে পরিণত হয়েছে। বর্তমান সমাজ-ব্যবস্থাও পরিবর্তনশীল এবং গতিশীল। কারণ সমাজ স্থির থাকতে পারে না। আমরা বলতে পারি যে, পরিবর্তন হল সমাজের আইন, অপরিবর্তনীয় সমাজ একটি কল্পকাহিনী। আমাদের জীবনের দৈনন্দিন শুরু হয় শব্দ পরিবর্তন দিয়ে, দিনের শুরু থেকেই আমরা আলোচনা শুরু করি গত এক বছর, এক দশক বা বিগত পঁচিশ বছরে পরিস্থিতি কী ছিল। মূল্যবোধ, রীতিনীতি, আচার-আচরণ, ধর্ম, সংস্কৃতি, ঐতিহ্য, বিশ্বাস ইত্যাদি কতটা পরিবর্তন হয়েছে। নিঃসন্দেহে পরিবর্তন সমাজ ও মানবজীবনের কোনো কোনো কোণে রেখে যায়নি। নারীরাও পরিবর্তনের ব্যতিক্রম নয়। আমরা দেখি নারীর জীবন নিয়ে লিখতে শুরু করলে কালি ও কাগজের অভাব হবে। একটি মজার বিষয় হল পৃথিবীর প্রতিটি কোণে যেখানে আমরা মানুষের আবাস খুঁজে পাই সেখানে নারীর মর্যাদা পুরুষদের পাশে, প্রায় সব সংস্কৃতি ও সম্প্রদায়ে আছে। এই সত্য নিজেই গ্রন্থটির নিয়ম হয়ে উঠেছে। স্বাধীনতা অর্জনের পর, ভারত সরকারও উন্নয়নমূলক কর্মসূচির মাধ্যমে নারীদের পুরুষের সমান মর্যাদা দেওয়ার পরিকল্পনা করেছে। আমি আমার এই প্রকল্পে সামাজিক পরিবর্তনে ভারতীয় মহিলাদের মুখ্য ভূমিকা নিয়ে আলোচনা করেছি।

সূচকশব্দ :- মহিলাদের অবস্থান, সমতা, শিক্ষা, ক্ষমতায়ন, কর্মসংস্থান, রাজনীতি।

ভূমিকা :- পরিবর্তনশীলতা হল মানব সমাজের ধর্ম। আর সামাজিক পরিবর্তন হল এই বৃহত্তর সমাজের পরিবর্তন। ম্যাকাইডার ও পেজ তাই সমাজের সংজ্ঞায় বলেছেন – ‘সমাজ হল সামাজিক সম্বন্ধের জটাজাল, যা নিয়ত পরিবর্তনশীল’। আদিম সমাজ ব্যবস্থা এ প্রকার নানা পরিবর্তিত অবস্থার মধ্য দিয়ে বর্তমান সমাজে পরিণত হয়েছে। বর্তমান সমাজ-ব্যবস্থাও পরিবর্তনশীল এবং গতিশীল। কারণ সমাজ স্থির থাকতে পারে না। আমরা বলতে পারি যে, পরিবর্তন হল সমাজের আইন, অপরিবর্তনীয় সমাজ একটি কল্পকাহিনী। আর এই পরিবর্তনশীল সমাজে নারীরা হল মৌলিক একক। নারীরা একটি পরিবার তৈরী করে, পরিবার একটি বাড়ি তৈরী করে, বাড়ি একটি

রয়ে গেছে। যদিও ভারতে আজকের আধুনিক নারীদের মর্যাদা উচ্চতর হয়েছে। মহিলারা সমস্ত প্রতিকূলতার বিরুদ্ধে একটি পার্থক্য তৈরী করেছে। বর্তমানে মহিলারা বিভিন্ন ক্ষেত্রে পঞ্চায়েত রাজ করেছে বলা যায়। সমসাময়িক ভারতীয় সমাজে নারীর দৃষ্টিভঙ্গির পরিবর্তন হয়েছে বিভিন্ন কারণে। যেমন - আধুনিক শিক্ষা, উচ্চ জৌগলিক এবং পেশাগত গতিশীলতা এবং নতুন অর্থনৈতিক নিদর্শনগুলির উত্থান মহিলাদের একটি নতুন মর্যাদা অর্জনে সাহায্য করেছে। সুতরাং মহিলাদের জন্য সামাজিক পরিবর্তনের ইতিবাচক পদ্ধতিগুলি সময়ে নেওয়া প্রয়োজন। নারী এবং দেশের অগ্রগতিতে নারীদের সমান অংশগ্রহণকারী হিসাবে গ্রহণ করা প্রয়োজন।

গ্রন্থ নির্দেশিকা :-

- ১) Sharma, K.L., Indian Social Structure and Change, Rawat Publication, Jaipur, 2008.
- 2) Chandra, Suresh, Social Change in Modern India, Jnanda Prakashan, New Delhi, 2011.
- 3) Desai, Neera, & Krishna Raj, Maithreyi, Women and Society in India, Ajanta Books, New Delhi, 1987.
- ৪) ভট্টাচার্য, সুকুমার, প্রাচীন ভারতে নারী ও সমাজ, গার্ভটিল, ২০০২।
- ৫) সেন, শ্রীক্ষিতিমোহন, প্রাচীন ভারতে নারী, বিশ্বভারতী গ্রন্থালয়, কোলকাতা, ২০১৭।
- ৬) ভট্টাচার্য,সমরেন্দ্র, সাম্মানিক নীতিবিদ্যা, বুক সিডিকিট প্রাইভেট লিমিটেড, কোলকাতা, ২০০৮।

কবি বিনয় মজুমদার : জীবন ও সৃষ্টি

(নির্বাচিত কবিতার আলোকে)

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‘আমি তার উপেক্ষার ভাষা আমি তার ঘৃণার আক্রোশ’—প্রেমে এমনি বিপর্যাসের ছবি এঁকেছিলেন কবি জীবনানন্দ দাশ। ‘যে নক্ষত্র নক্ষত্রের দোষ’ কবির প্রেমের পথে বাধা হয়ে উঠেছিল, তিনি নিজেও তাকে ভুলে গিয়েছিলেন—এমনটাই স্বীকারোক্তি শুনি। কিন্তু এই উপেক্ষা, ঘৃণা যখন প্রেমকে ছাড়িয়ে একজন কবির জীবনের সকল উপাস্তকে গ্রাস করে ফেলে—আর ব্যক্তি যদি তাকে কখনোই ভুলতে না পারেন— যদি ভুলতে দেওয়া না হয়—তাহলে জীবনের গান কীভাবে জীবনের গদ্য হয়ে ওঠে? আজীবন আঙনের সেকঁ চেয়ে চেয়ে হাঙরের ঢেউয়ে লুটোপুটি খাওয়া এমনি একটি জীবনকে যদি ‘পাগল’ বিশেষণে চিহ্নিত করে অনিবার বিদ্ধ করা হয়, পাগলাগারদে আটকে রেখে এক শ্রেণীর মানুষ যদি আখের গোছাতে চায়— তবে সেই সেই অবমূল্যায়নের নাম দেওয়া যেতে পারে কবি বিনয় মজুমদার।

আজীবন ছিন্নমূল, আজীবন ছন্নছাড়া, আজীবন উপেক্ষিত, আজীবন চক্রান্তের শিকার হওয়া এক নির্জিত মানুষ যদিও বা কখনো প্রতিরোধে হিংস্র হয়ে ওঠেন, আর হাসপাতালে নিয়ে গিয়ে আঠারোবার ইলেকট্রিকের শক দেওয়া হয়—তাহলেই বুঝি তাঁর মধ্যকার কবিত্বের যত বাষ্প উবে যায়? হাসপাতালে থেকে কিংবা সেখান থেকে ফিরে এসেও যে মানুষটি লেখনীর অনায়াস শক্তিতে জিতে নেন ‘রবীন্দ্রপুরস্কার’ কিংবা ‘সাহিত্য অ্যাকাডেমি’র মতো মহার্ঘ পুরস্কার—তাঁকে যাঁরা ‘পাগল কবি’র লেবেল সেন্টে দিয়ে নিজেদের দিগ্গজ প্রমাণ করার চেষ্টা করেন—তাঁদের জন্য উপহার হিসেবে রইল কবি প্রেমেন্দ্র মিত্রের কবিতার নিম্নোক্ত চরণক’টি—

“ ছোট ভীরা হাত দিয়ে

জীবনের মাপ নিয়ে যারা

৩৯. ভদেব।

৪০. বিনয় মজুমদার। ২০১৪। মানুষের আলো। আমাদের বাগানে। কাব্যসমগ্র, ২য় খণ্ড। প্রতিভাস। পৃ: ৮২।

৪১. রবীন্দ্রনাথ ঠাকুর। ১৪২১। বর্ষশেষ। কল্পনা। বিশ্বভারতী। পৃ: ৪৭।

৪২. রবীন্দ্রনাথ ঠাকুর। ১৪২১। গীতবিতান ১ম খণ্ড। পূজা পর্যায়। বিশ্বভারতী। পৃ: ৫০।

৪৩. বিনয় মজুমদার। ২০১৪। মানুষের আলো। আমাদের বাগানে। কাব্যসমগ্র, ২য়খণ্ড। প্রতিভাস। পৃ:৮২।

৪৪. দীপেন্দ্রনাথ বন্দ্যোপাধ্যায়। ২০১২। অশ্বমেধের ঘোড়া। দীপেন্দ্রনাথ বন্দ্যোপাধ্যায় গল্পসমগ্র। একুশ শতক। পৃ: ২৫১।

৪৫. সনাতন পাঠক। জানুয়ারী ২০০৬। একটি অসাধারণ কবিতার বই। বিনয় মজুমদারের ডায়েরি (সম্পা. অজয় নাগ, কমল মুখোপাধ্যায়)। শিলীক প্রকাশন। পৃ: ১৪৫।

পাণিনীয় বর্ণোচ্চারণ-শিক্ষা বনাম বিদ্যাসাগরীয়-বর্ণপরিচয়

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সারসংক্ষেপ:- মনুষ্য ভাষার মাধ্যমে পরস্পরের মধ্যে ভাব ব্যক্ত করে থাকে। পৃথিবীতে যদি ভাষার মতো কোন বস্তুর অস্তিত্বই না থাকতো, বোধ হয় কোন শব্দই হত না। কবি দণ্ডীর কথায় - “বাণী বিনা সংসারের কার্য অচল হত। আর যদি শব্দ নামক জ্যোতি জগৎ কে প্রকাশিত না করতো তাহলে সম্পূর্ণ জগৎ অবিদ্যারূপী অন্ধকারে ব্যাপ্ত হতো।” তাই ভাষা হল ব্যক্ত বাণী অর্থাৎ ৭ যার দ্বারা বর্ণের সুস্পষ্ট উচ্চারণ সম্ভব হয়। আমরা কথা বলার সময় উচ্চারণের প্রতি ধ্যান দিই না। কিন্তু অধ্যয়ন-অধ্যাপনের সময় উচ্চারণের প্রতি ধ্যান দেওয়া উচিত। বিশেষ করে পূজো-অর্চনা বা যজ্ঞীয় আচার-অনুষ্ঠানের সুস্পষ্ট রূপে বর্ণের উচ্চারণ করা বাঞ্ছনীয় হয়ে যায়। কারণ উচ্চারণের ত্রুটির ফলে অর্থ অনর্থ পরিণত হয়ে যায় এবং অযাচিত ফলপ্রাপ্তির সম্ভাবনা থেকে যায়। এরূপ ঘটনা যাতে না ঘটিত হয়, তারজন্য আচার্য পাণিনি “বর্ণোচ্চারণ-শিক্ষা” শাস্ত্রে বর্ণের যথাস্থান উচ্চারণ প্রদর্শিত করেছেন। যাতে শিশুরা প্রথম থেকেই সেই শিক্ষা গ্রহণ করতে সমর্থ হয় এবং পরবর্তীকালে উচ্চারণের দোষে অর্থ অনর্থ পরিণত না হয়ে বিতরীত ফললাভও না হয়।

অনুরূপভাবে পণ্ডিত ঈশ্বরচন্দ্র বিদ্যাসাগর মহাশয়ও “বর্ণপরিচয়” এর মাধ্যমে বাংলায় শিশু-শিক্ষার উপর জোর দিয়েছিলেন। যাতে বাংলার শিশুরা বর্ণ শিক্ষা গ্রহণ করে উচ্চশিক্ষায় শিক্ষিত হতে পারে। তাই প. মহাশয় দ্বারা বাংলা “বর্ণমালাকে” নতুন রূপ প্রদান করে বর্ণপরিচয় রচনা করা ছিল যুগান্তকারী ঘটনা। যার ফল সমাজে পরিলক্ষিত হয়েছিল।

শব্দসংকেত -

ভাষা, সুস্পষ্ট-উচ্চারণ, যজ্ঞীয়-অনুষ্ঠান, ফললাভ, শিশু-শিক্ষা, দোষমুক্ত।

ভূমিকা: -

সংস্কৃত-ব্যাকরণ শাস্ত্রের অমর জ্যোতি-স্বরূপ দেদীপ্যমান আচার্য পাণিনির সময় বিষয়ে পর্যাপ্ত মত পার্থক্য দেখা গিয়েছে। তবুও প্রামাণিক বিদ্বানদের দ্বারা উনার সময় আনুমানিক 450-400 খ্রী:পূ: মধ্য ভাগ নির্ধারিত করা হয়েছে। আচার্য পাণিনির পূর্বজ শালাতুর(বর্তমান-লাহৌর, পাকিস্তান) গ্রামের নিবাসী ছিলেন, তাই তিনি শালাতুরীয় নামে পরিচিত ছিলেন।

প. ঈশ্বরচন্দ্র বিদ্যাসাগর মহাশয় ছিলেন ঊনবিংশ শতকের এমনই এক ব্যক্তিত্ব; যিনি ছিলেন বিশিষ্ট শিক্ষাবিদ, সংস্কৃতজ্ঞ, সাহিত্যজ্ঞ ও সমাজ-সংস্কারক। কারণ সেসময় দেশে প্রচলিত ছিল নানা কুরীতি ও কুপ্রথা। সেই কুরীতি ও কুপ্রথার বিরুদ্ধে জোনাকির মতো আলো জ্বালিয়ে সংঘর্ষরত ছিলেন সামান্য কিছু

- 8 . অষ্টা. 1/3/2
- 9 . উচ্চারণম্ । কুত এতত্ ? দিশিরুচ্চারণমক্রিয়ঃ । বৃত্তিসমবায়ার্থো বর্ণানামুপদেশঃ । (উচ্চারণ্য হি বর্ণানাহ-''উপদিষ্টা ইমে বর্ণা'' ইতি) মহা.ভা.-বা.16
- 10 . বর্ণপরিচয় -ঈশ্বরচন্দ্র বিদ্যাসাগর ।
- 11 . মহা. ভা. - 1/1/5
- 12 . ঐ - 1/2/1
- 13 . ঐ
- 14 . ঐ
- 15 . ঋগ্বেদ প্রাতিশাখ্য - উবটভাষ্যম্
- 16 . সমগ্র ব্যা. কৌ. - ঈশ্বরচন্দ্র বিদ্যাসাগর, পৃ. 2
- 17 . ম. ভা - 1/1/2
- 18 . বর্ণোচ্চারণ-শিক্ষা, পৃ. 5
- 19 . বর্ণপরিচয় রচনা ও প্রকাশনার ইতিহাস ।
- 20 . বর্ণ. র. প্র. ইতিহাস ।
- 21 . স. ব্যা. কৌ, পৃ.- 5
- 22 . স. ব্যা. কৌ, পৃ.- 7
- 23 . স. ব্যা. কৌ, পৃ.- 5
- 24 . বর্ণপরিচয় (প্রথম-ভাগ) ।
- 25 . অ ই উ ঞ্ - সূত্র ব্যাখ্যা প্রসঙ্গ ।

সন্দর্ভ-গ্রন্থসূচী:-

1. শ্রীমদ্রয়ানন্দ সরস্বতী কৃত ব্যাখ্যা সহিত, 2009, বর্ণোচ্চারণ-শিক্ষা(পাণিনি-মুনি-প্রণিতা), রামলাল কপূর ট্রাস্ট, সোনীপত ।
2. শ্রী ঈশ্বরচন্দ্র বিদ্যাসাগর, সং-1931, বর্ণপরিচয়(প্রথম-ভাগ), কলিকাতা ।
3. ড. দ্বিবেদী কপিলদেব, 1983, লঘুসিদ্ধান্ত কৌমুদী, বিশ্ববিদ্যালয় প্রকাশন, বারাণসী ।
4. ড. কর গঙ্গাধর ন্যায়াচার্য, 2002 মহাভাষ্যম্ সংস্কৃত বুক ডিপো, 28/1 বিধান সরণী, কোলকাতা ।
5. দুর্গাচরণ সাংখ্য-বেদান্ত তীর্থ , jun-2009, , সমগ্র ব্যাকরণ কৌমুদী (ঈশ্বরচন্দ্র বিদ্যাসাগর), শ্রীঅরুণ কুমার মজুমদার,দেব সাহিত্য কুটীর প্রা.লি.21, কলিকাতা ।
6. প্রো. পাণ্ডেয় গোপালদত্ত , 1992, অষ্টাধ্যায়ী, চৌখম্বা সুরভারতী প্রকাশন, বারাণসী ।
7. ড. ত্রিপাঠী রমাকান্ত, 2008, রঘুবংশম্ , চৌখম্বা প্রকাশন, বারাণসী ।
8. ড. বন্দ্যোপাধ্যায় অসিত, 2005, বাংলা সাহিত্যে বিদ্যাসাগর, দেজ পাবলিশিং, কোলকাতা ।

মনুসংহিতা ও অর্থশাস্ত্রের দিশায় স্বাস্থ্য সচেতনতা

অঞ্জনা সেনাপতি*

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সারসংক্ষেপ : ডারউইনের 'বিবর্তনবাদ অনুযায়ী অভিযোজনই প্রাকৃতিক নির্বাচনের চাবিকাঠি। অর্থাৎ প্রকৃতির দরবারে সবল জীবেরই লড়াই করে টিকে থাকার সম্ভাবনা বেশি। এই সম্ভাবনাময় জীবন যুদ্ধে শ্রেষ্ঠ জীব হিসাবে মানবজাতি তাই সৃষ্টির উন্মত্ত থেকে নানা উদ্ভাবনী উপায়ে জীবনযাত্রার মানোন্নয়নের প্রচেষ্টা চালিয়ে যাচ্ছে। সেই উচ্চাকাঙ্খা থেকেই মানুষ অত্যাধুনিক প্রযুক্তি ও উদ্ভাবনীবিদ্যার মাধ্যমে তার দৈনন্দিন জীবনশৈলীতে নানা পরিবর্তন আনতে সক্ষম হয়েছে। তবে এই উন্নতি করতে গিয়ে প্রকৃতিতে অত্যাধিক মানব হস্তক্ষেপ, মানুষের অতি স্বার্থপ্রিয়তা দুরারোগ্য ব্যাপির প্রকোপ, প্রকৃতির হঠাৎ হঠাৎ ধ্বংসলীলায় মেতে ওঠা প্রভৃতি পরিস্থিতির কারণ হয়ে উঠছে। বিভিন্ন শতাব্দীতে এবং সম্প্রতিও আমরা সেইরকম পরিস্থিতির (করোনা ভাইরাসের প্রাদুর্ভাব, আমফান, ফণ প্রভৃতি ঘূর্ণঝড়) সম্মুখীন হয়েছি। সেখান থেকে আজও আমরা সম্পূর্ণভাবে নিষ্কৃতি পাইনি। সমগ্র বিশ্বের বিজ্ঞানি থেকে শুরু করে প্রকৃতিবিদ, স্বাস্থ্যবিশেষজ্ঞরা এর মুক্তির পথ অনুসন্ধানের নিরলস চেষ্টা চালিয়ে যাচ্ছেন। এই ধরনের পরিস্থিতিতে স্বাস্থ্যসচেতনতা কথাটি বারবার উঠে আসে আমাদের সামনে। আমরা খুঁজতে থাকি সম্পূর্ণভাবে সুস্বাস্থ্য বজায় রাখার বিভিন্ন পথ। ফিরে দেখি ভারতীয় প্রাচীন সভ্যতা, সংস্কৃতি, প্রাচীন শাস্ত্রগুলি, যদি কোন মুক্তির সন্ধান পাওয়া যায়। আর সুস্বাস্থ্যের এই উপায় সন্ধান করতে গিয়ে ভারতীয় সংস্কৃত সাহিত্যের প্রাচীন দুই গ্রন্থ অর্থশাস্ত্র ও মনুসংহিতার স্বাস্থ্য সম্পর্কিত সচেতনামূলক ভাবনা ও বিধানগুলির যুক্তিগ্রাহ্যতা আমাদের বিস্মিত করে বারে বারে। আলোচ্য প্রবন্ধে এই দুই গ্রন্থের স্বাস্থ্য সম্পর্কিত সচেতনামূলক বিষয়গুলির কিছু অংশ বিশ্লেষিত হয়েছে। বিশেষত স্বাস্থ্য সচেতনতার ক্ষেত্রে নিত্যকর্ম, খাদ্যাভ্যাস, আচার আচরণ প্রভৃতি বিষয়ে কি ধরনের সচেতনতা অবলম্বন করলে সুস্থ থাকা যায় প্রভৃতি বিষয় নিয়ে সূক্ষ্ম তিসুক্ষ্মভাবে আলোচনা করা হয়েছে।

শব্দ সংকেত:

ধর্মশাস্ত্র, অর্থশাস্ত্র, স্বাস্থ্যসচেতনতা, নিত্যকর্মে, খাদ্যাভ্যাসে, আচার আচরণে স্বাস্থ্য সচেতনতা।

ভূমিকা - সুপ্রাচীনকাল থেকে ভারতীয় সমাজব্যবস্থা, শিক্ষা, সংস্কৃতি মূলত ধর্মের উপর ভিত্তি করে দাঁড়িয়ে আছে। প্রিয়তে লোকোহনেন ধরতি লোকং বা ইতি ধর্মঃ (ধৃ + মন) অর্থাৎ যার দ্বারা বা যা লোক সমূহের ধারক তাই ধর্ম। জীবনের প্রতি পদক্ষেপে নিয়মানুবর্তিতা, কর্তব্যতা, সতর্কতার বার্তা দিয়ে মানবচরিত্রে কে মহিমান্বিত করে তোলাই হল ধর্ম। এই ধর্মের নির্দেশক গ্রন্থকে বলা হয় ধর্মশাস্ত্র। ভগবান মনু রচিত মনুসংহিতা গ্রন্থটি মানবহিতকর কল্যাণের বিধানে সমুজ্জ্বল ধর্মগ্রন্থ। সেখানে মনু কেবল বেদবিহিত ধর্মবিধানের নির্দেশ দেননি, পরিবেশ ও স্বাস্থ্যসম্পর্কেও মানবকুলকে সচেতন করছেন যা বর্তমান পরিস্থিতির প্রেক্ষিতেও যুক্তিযুক্ত। ধর্মশাস্ত্রের একটি অঙ্গ রাষ্ট্রনীতি বা রাজধর্ম। সকল ধর্ম আবার রাজধর্মের উপর নির্ভরশীল। তাই মহাভারতে

- 1 . ম. ভা - 1/1/2
- 1 . বর্ণোচ্চারণ-শিক্ষা, পৃ. 5
- 1 . বর্ণপরিচয় রচনা ও প্রকাশনার ইতিহাস ।
- 1 . বর্ণ. র. প্র. ইতিহাস ।
- 1 . স. ব্যা. কৌ, পৃ.- 5
- 1 . স. ব্যা. কৌ, পৃ.- 7
- 1 . স. ব্যা. কৌ, পৃ.- 5
- 1 . বর্ণপরিচয় (প্রথম-ভাগ) ।
- 1 . অ ই উ ঞ্ - সূত্র ব্যাখ্যা প্রসঙ্গ ।

সন্দর্ভ-গ্রন্থসূচী -

1. শ্রীমদ্রায়ানন্দ সরস্বতী কৃত ব্যাখ্যা সহিত, 2009, বর্ণোচ্চারণ-শিক্ষা(পাণিনি-মুনি-প্রণিতা), রামলাল কপূর ট্রাস্ট, সোনীপত ।
2. শ্রী ঈশ্বরচন্দ্র বিদ্যাসাগর, সং-1931, বর্ণপরিচয়(প্রথম-ভাগ), কলিকাতা ।
3. ড. দ্বিবেদী কপিলদেব, 1983, লঘুসিদ্ধান্ত কৌমুদী, বিশ্ববিদ্যালয় প্রকাশন, বারাণসী ।
4. ড. কর গঙ্গাধর ন্যায়াচার্য, 2002 মহাভাষ্যম্ সংস্কৃত বুক ডিপো, 28/1 বিধান সরণী, কোলকাতা ।
5. দুর্গাচরণ সাংখ্য-বেদান্ত তীর্থ , jun-2009, , সমগ্র ব্যাকরণ কৌমুদী (ঈশ্বরচন্দ্র বিদ্যাসাগর), শ্রীঅরুণ কুমার মজুমদার, দেব সাহিত্য কুটীর প্রা.লি.21, কলিকাতা ।
6. প্রো. পাণ্ডেয় গোপালদত্ত , 1992, অষ্টাধ্যায়ী, চৌখম্বা সুরভারতী প্রকাশন, বারাণসী ।
7. ড. ত্রিপাঠী রমাকান্ত, 2008, রঘুবংশম্ , চৌখম্বা প্রকাশন, বারাণসী ।
8. ড. বন্দ্যোপাধ্যায় অসিত, 2005, বাংলা সাহিত্যে বিদ্যাসাগর, দেজ পাবলিশিং, কোলকাতা ।

To Study the Relationship between Emotional Intelligence and Learning Style among Adolescent School Students of Paschim Medinipur District

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Abstract: *This research studies the relationship between learning styles and emotional intelligence school going adolescent student's in govt aided/govt sponsored schools in paschim medinipur district of West Bengal. students with higher levels of emotional intelligence are managing better than themselves and others around them. It helps them in many ways like sub scales of emotional intelligence: self-awareness, self-motivations, empathy, internal motivation etc, emotional intelligence not only influences one's emotionas but also their learning styles. If a student lacks emotional intelligence, then their environment, psychological, physiological characteristics and process are affected which in term affects their learning styles and education. Learning styles differ from one student to another. This examines the relationship between learning styles and emotional intelligence among adolescents students and find out the significant difference in learning styles between Girl's and Boy's students and their significant differ in emotional intelligence too.*

Keywords: *Emotional Intelligence, Learning style, Adolescents.*

1. Introductions:

Education is the continuous process to all round development of the student and enrichment of high and better quality of life. Education is now become a successful passport for the development of a nation in general and of a person in particular. Success in life can be achieved through education. Today our educational systems mainly focus on student academic achievement. But not interested to know causes of unsatisfactory academic performance of their children and how to find out the causes of the psycho-social and emotional problem of school-going adolescents.

The present study research has been an attempt to study the relationship to emotional intelligence and learning style of school going adolescents of paschim medinipur district.

3. Alavinia,P., 2012, On the correlation between emotional intelligence and learning style : the case of Iranian academic EFL learners. *Theory and Practice in Language Studies*,2(6),p.1291-1299.
4. Altun, F.,&Yazici,H., 2010, Learning styles of the gifted students in turkey. *Procedia-social and Behavioural SCIENCES*,9,P.198-202.
5. Andreo,E., and Valchos,F., 2013, Learning styles of typical readers and dynamic adolescents. *Journal of Visual Literacy*,32(2),p.1-14.
6. Caulfield,R., 1996, Social and emotional development in the first two years. *Early childhood education Journal*,24,p.55-58. Allinson, C.W and Hayes, j (1990) *Validity of Learning Styles Questionnaire*, *Psychological Report*,67,pp.859-866.
7. Amir, R and JELAS ,Z.M., 2010, Teaching and learning styles in higher education institutions:do they match? *Procedia social and behavioural sciences*,7(C),pp-680-684.
8. Babaei, D., Ahmad, A., Idris, K., Omar, Z andrahimian, H., 2012, ‘The impact of human resource practices and organizational citizenship behaviours on firm performance’, *American Journal of Applied Sciences*,9(1),pp.47-53.
9. Davis, S.K., & Humphrey, N., 2012, Emotional predicts adolescent mental health beyond personality and cognitive ability .*Personality &Individual Differences*, 52. P.144-149.
10. Mathibe, G.E., 2015, The relationship between perceived parenting styles, resilience and emotional intelligence among adolescents (Unpublished master’s thesis).North west university.
11. Naghavi, F.,& Redzuan,M.R., 2012, Father’s education and construct of the early adolescents emotional intelligence .*Journal of American Science*,8,p.682-686.
12. Singh,D., &Sahu,K., 2013, Psychological wellbeing and emotional intelligence among adolescent boy’s and girl’s. *Indian Journal of Health and Wellbeing*,4,p.38-40.
13. Stephens, M.A., 2009, Gender differences in parenting styles and effects on the parent-child relationship. *University Honors Program, Texas State University-San Marcos*.
14. Tatyana, M.,Nguyen, D.D.,& Shin,J.Y., 2014, Parenting in Vietnam, In H. Selin (Ed), *parenting across cultures: childbearing, motherhood and fatherhood in Non-Western Cultures*.(p.47-57)
15. Tran, N.T., 2013, Vietnamese parents attitudes towards western parenting behaviours and interventions (Doctor of philosophy in Psychology). *Vanderbilt University*.

A Study on Financial Performance of Cement Industry with Special Reference to Ambuja Cement Limited

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Abstract: *India's cement industry plays a vital role in economy. This industry provides employment to more than a million of people directly and indirectly. Cement Industry mainly engaged in housing, infrastructure, commercial and industrial. Indian cement industry is the largest producer of cement in the world just behind china.*

The study mainly deals with financial performance of Ambuja Cement Limited. The primary objective is to study the financial performance and the secondary objectives are to evaluate the profitability and liquidity position as well as operational position of the industry. The researcher has used only secondary data. Ratio analysis, paired correlation and regression analysis have been used for analysing the data. The results indicate that the liquidity position of the company is satisfactory. The researcher does not find out any significant relationship between liquidity and profitability.

Keywords: Liquidity, Profitability, Paired Correlation and Regression Analysis

1. Introduction:

Cement is a very essential commodity which is manufactured by local plants. There are twenty companies in cement industry. India is a developing country so there is a large scope to expand the cement industry. Development is synonymous with industrialization and industry mainly concentrating to the basic goods of steel and machinery.

Liquidity has an important relationship with profitability. If we have enough liquid resources then we may be able to get benefit of cash discount on purchases and as well as increasing profits. If we cannot pay the creditors in the given period then we have to pay interest. Thus, shortage of liquid resources will show the low cash discount and payment of interest. Both the losses will certainly decrease profits. Stock is also an important factor because if we are not able to keep sufficient stock due to shortage of liquid resources, then the production cycle may not be continued and that will result in heavy losses. Financial analysis is a depth study of a firm's financial position (i.e., capital, assets and liabilities of a firm at a point of time) and its financial performance (i.e., income, profitability, solvency, earnings per share, dividend payout etc.,) over a period.

2. Objectives of the study:

The study was conducted to achieve the following objectives-

In India the cement sector is one of the most important manufacturing industries. Cement companies make a significant contribution to India's economy. These businesses have created employment opportunities. Liquidity position of the company was satisfactory during the study period. The result of profitability shows the satisfactory results of the concern. The correlation between liquidity and profitability was highest in the company which shows a high degree of positive correlation but liquidity has no impact on profitability.

References:

1. Burange, L.G, Yamini, S., 2009, Performance of the Indian Cement Industry: The Competitive Landscape, *ArthaVijanana*, LI(3), p. 209-242.
2. Dhivya, J., Shobanpriya, P., Karthika, P., Bakiyaraj, K., 2017, A study on financial performance of cement industry with special reference to ACC Limited, *International Journal of Creative Research Thoughts*, 5(4), p. 1627-1635.
3. Ershad, S., Uddin, M., Faruk O., 2021, Analysis of the financial performance of selected cement industries of Bangladesh, *Internal Journal of Finance Research*,2(1). P.46-57.
4. Prajapati, J.K., 2019, Financial performance analysis of selected cement companies in India, *IJESE*, 9(11), P. 24109-24111.
5. Soni, S., 2018, A study on the financial performance of JK cement, *International Journal of Research and Review*, 1(5), p. 115-119.



Amino Acid And Fatty Acid Analysis Of Avocado (*Persea Americana*) Powder

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Abstract:

Avocado (*Persea americana*) is a well-known food ingredient with a variety of health benefits. Avocado powder is derived from dried and ground avocados. This article focuses on the amino acid and fatty acid composition of avocado powder, highlighting its potential health benefits and applications in food science. The lipid extract of the sample was analyzed using gas chromatography-mass spectrometry (GC-MS) and characterized by the presence of saturated, monounsaturated, and polyunsaturated fatty acids, with the following percentages: lysine, leucine, valine, linoleic acid, glutamic acid, and aspartic acid. The presence of 1.2 and 1.5 grams of valine per 100 grams of the avocado powder contributes to muscle health and metabolic regulation. The high concentration of oleic acid in avocado powder adds to its overall nutritional profile, supporting various bodily functions ranging from muscle repair and immune response to energy metabolism and cognitive health. This makes avocado powder an attractive ingredient for dietary supplements, protein-rich foods, and functional food products aimed at promoting overall health and well-being.

Keywords: Avocado, amino acids, fatty acids, human health, functional foods

Introduction:

Avocado (*Persea americana*) has a long history of cultivation, dating back to ancient Mesoamerican civilizations such as the Aztecs and Mayans (Galindo-Tovar, 2007), who valued it for its nutritional benefits and believed it possessed aphrodisiac properties. The fruit was introduced to Europe and other parts of the world by Spanish explorers in the 16th century and has since spread to many tropical and subtropical regions (Galán Saúco and Cubero, 2010). Avocado, a nutrient-dense fruit, is widely recognized for its rich content of healthy fats and amino acids. The growing popularity of avocado powder, derived from dried and ground avocados, has spurred interest in its nutritional profile. This article delves into the amino acid and fatty acid composition of avocado powder, highlighting its potential health benefits and applications in food science.

Methodology:

Sample Preparation

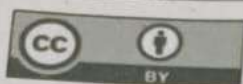
Fresh avocados were sourced from local markets, peeled, and the seeds removed. The pulp was sliced, dried at 60°C until completely dehydrated, and then ground into a fine powder.

Amino Acid Analysis

Amino acid composition was determined using high-performance liquid chromatography (HPLC) following acid hydrolysis of the sample. The amino acids were quantified and expressed in grams per 100 grams (g/100g) of the sample (Qabaha, 2010).

Fatty Acid Analysis

Fatty acid methyl esters (FAMES) were prepared from the lipid extract of the sample and analyzed using gas chromatography-mass spectrometry (GC-MS). The fatty acid content was expressed as a percentage of total fatty acids (Prato and Biandolino, 2012)



Chemical Analysis Of Avocado (*Persea Americana*) Powder

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Abstract

Avocado (*Persea americana*) is a nutrient-dense fruit that offers a wide array of health benefits. Its rich content of vitamins, minerals, healthy fats, and antioxidants makes it a valuable addition to any diet. The present study investigates the chemical composition of avocado powder, focusing on its proximate composition. Avocado is widely recognized for its health benefits, attributed to its rich nutrient profile. This study aims to provide a detailed chemical analysis of avocado powder to explore its potential as a nutritional supplement.

Keywords: Avocado, carbohydrate, protein, health benefits, human health, nutritional supplement.

Introduction

Avocado (*Persea americana*) is a nutrient-dense fruit known for its high content of healthy fats, vitamins, and minerals (Chaudhary et al., 2015). With the increasing interest in functional foods and dietary supplements, avocado powder has gained popularity for its potential health benefits (Siol and Sadowska, 2023). This study aims to analyze the chemical composition of avocado powder, including its proximate composition, amino acid profile, and fatty acid content, to evaluate its nutritional value and potential health benefits.

Health benefits of Avocado:

Heart Health

Avocados are heart-healthy due to their high content of monounsaturated fats, particularly oleic acid, which has been shown to reduce bad cholesterol (LDL) levels while maintaining or increasing good cholesterol (HDL) levels. Additionally, avocados contain potassium, which helps regulate blood pressure, and dietary fibre, which is associated with lower cholesterol levels and a reduced risk of heart disease (Wang et al., 2015).

- **Reduces LDL cholesterol:** Oleic acid helps lower bad cholesterol levels.
- **Increases HDL cholesterol:** Monounsaturated fats promote good cholesterol.
- **Regulates blood pressure:** Potassium content helps manage blood pressure.
- **Supports overall heart health:** Fibre and antioxidants like vitamin E contribute to cardiovascular wellness.

Weight Management

Despite being high in calories, avocados can aid in weight management. The fibre and healthy fats in avocados promote a feeling of fullness, which can help reduce overall calorie intake. The fruit's low carbohydrate content also makes it suitable for low-carb and ketogenic diets (Heskey et al., 2019).

- **Promotes satiety:** Fibre and healthy fats keep you full longer.
- **Supports metabolism:** Nutrient-rich profile aids in balanced nutrition.
- **Suitable for low-carb diets:** Low in carbohydrates, making it ideal for ketogenic and other low-carb diets.

Digestive Health

Avocados are high in fibre, which is essential for maintaining a healthy digestive system. Fibre helps regulate bowel movements, prevent constipation, and promote a healthy gut microbiome (Dreher, 2018).

- **Regulates bowel movements:** High fibre content ensures regularity.
- **Prevents constipation:** Fibre helps soften stool and ease passage.
- **Supports gut health:** Promotes a healthy gut microbiome.

Physicochemical Analysis of Dietary Fibre Enriched Prebiotic Biscuit

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ABSTRACT: This research study's primary goal was to assess the physicochemical analysis of freshly made biscuits. In this study, control biscuits were made without prebiotics, while experimental biscuits were made with varying prebiotic dosages. A prebiotic was used, oat powder. Customers' interest was piqued by the nutritional content of bakery goods and their potential for use in feeding programmes and crises. Physical and chemical tests revealed that the experimental treatment combination had a higher concentration of dietary fibre.

Keywords: Bakery products, carbohydrate, dietary fibre, fat, physicochemical analysis, prebiotics, protein, oats.

INTRODUCTION

It is customary to prepare biscuits primarily with wheat flour, oil, and sugar. Biscuits are ready-to-eat foods. Technology for biscuits has recently advanced quickly in order to enhance their nutritious qualities (Goubgou *et al.*, 2021). In this research, dietary fibre rich biscuit has been developed. The component of a plant that resists intestinal digestion in the human large intestine is known as total dietary fibre. Total dietary fibre has been shown to have positive impacts on human health and bodily function, therefore in modern societies, consuming a lot of dietary fibre is linked to a lower occurrence of common disorders and diseases (Parveen *et al.*, 2017).

This research study was carried out to develop dietary fibre enriched prebiotic biscuit. As a source of dietary fibre and prebiotics, oats are used in this experimental biscuit.

Aims And Objectives. The research study was carried out to evaluate the physicochemical analysis of newly prepared biscuit.

MATERIALS AND METHODS

Procurement of raw material. For preparation of biscuit, the raw ingredients like Oat powder, Wheat Flour, sugar, oil, Baking Powder were purchased from local market of Mahishadal.

Treatment combinations (Mondal *et al.*, 2022).

T₀= Oats powder (0%): Wheat Flour (80 g) + Sugar (5 g) + Salt (0.90 gm) + Butter (5 g) + Water (10) Baking at 175°C for 15 Mins.

T₁= Oats powder (10 g): Wheat Flour (70 g) + Sugar (5 g) + Salt (0.90 gm) + Butter (5 g) + Water (10) Baking at 175°C for 15 Mins.

T₂= Oats powder (15g): Wheat Flour (65 g) + Sugar (5 g) + Salt (0.90 gm) + Butter (5 g) +Water (10) Baking at 175°C for 15 Mins.

T₃= Oats powder (20 g): Wheat Flour (60 g) + Sugar (5 g) + Salt (0.90 gm) + Butter (5 g) +Water (10) Baking at 175°C for 15 Mins.

No. of Treatment: 4 +1 =5

No of replication: 03

Total no of trials: 15

Physicochemical analysis of final products

• **Determination of carbohydrate:** The carbohydrate percent in the sample was measured by method as per Ranganna (1977).

• **Determination of protein:** The protein content of prebiotic chocolate samples was determined by method as per Ranganna (1977).

• **Determination of fat:** Fat content of prebiotic chocolate samples was determined by modified Gerber method (Kleyn *et al.*, 2001).

• **Determination of ash:** Ash content of prebiotic chocolate samples was determined according to AOAC, 2000 (AOAC, 2000).

• **Determination of moisture:** Moisture content of prebiotic chocolate samples was determined according to AOAC, 2000 (AOAC, 2000).

• **Determination of dietary fibre:** The dietary fibre percent in the sample was measured by AOAC, 2000 standard method (AOAC, 2000).

Flow chart for the preparation of biscuit (control biscuit) (Uchenna & Omolayo 2017)

Ingredient weighing (Wheat Flour, sugar, salt, butter and water)

