Uttar Pradesh Journal of Zoology

Volume 45, Issue 20, Page 472-478, 2024; Article no.UPJOZ.3997
ISSN: 0256-971X (P)

Evaluation of Physicochemical Parameters of Water in Three Lakes of Dindigul District, Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i204604

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/3997

Original Research Article

Received: 05/07/2024
Accepted: 07/09/2024
Published: 08/11/2024

ABSTRACT

The investigator's goal was to evaluate the effects of pesticide pollution brought on by the vegetable market's wastewater outflow from nearby ponds in and around Dindigul town, Tamilnadu, India. The surrounding research area's ponds have been greatly impacted by the ongoing use of pesticides in these vegetable wastes. Three sampling sites were chosen for this study such as Sadayan, Lakshmi Puram and Nagammal pondss and samples were taken in the summer to examine critical parameters like total hardness, pH, dissolved carbon dioxide (CO2), dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), chloride, total alkalinity, and total dissolved solids (TDS), as well as heavy metals. The results indicate that Sadayan Ponds is

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***Cite as:** Selvasubramani, Agalya, Priyadarshini Kasthuri Marthandam, and Senguttuvan Manickam. 2024. "Evaluation of Physicochemical Parameters of Water in Three Lakes of Dindigul District, Tamil Nadu, India". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (20):472-78. https://doi.org/10.56557/upjoz/2024/v45i204604.*

classified as severely polluted while compared other ponds. This investigation leads to the conclusion that the ponds's water is not appropriate for agriculture or for sustaining wildlife.

Keywords: Ponds; physic-chemical parameters; pesticide; vegetable waste; Dindigul.

1. INTRODUCTION

India is home to 1.2 billion people. Despite accounting for 16% of the world's population, India only has 4% of the world's water resources (GoI 2011). India has worked very hard to improve its water resources, but the country's demand for water exceeds its availability due to rapid industrialization, urbanization, population growth, and uneven water distribution (GoI 1999). In light of the increasing population and economic development, India is currently confronting a significant challenge of natural resource scarcity, particularly water. Most freshwater sources around the world are being polluted; reducing the availability of clean water (Gupta et al. 2005, Ndamitso et al. 2013). Water pollution is primarily caused by municipal water, industrial water, agricultural water, sewage water, and so on. Suspended solids, dissolved inorganic compounds, nitrogen and phosphorous compounds, animal wastes, toxic chemicals, insecticides, pesticides, medical waste, toxic heavy metals, and biological pollutants like pathogenic bacteria, fungi, protozoa, viruses, parasitic worms, and so on can all be found in polluted water. Sustainable development is impossible without sufficient and high-quality fresh water. Water contamination is a growing global issue, with fresh water resources deteriorating at an alarming rate (Mahananda 2010, Venkatesharaju et al. 2010, Andrew 2012).

Furthermore, ponds play a crucial role in Earth's ecosystems. These are extremely important ecosystems that provide humans with a wide range of products and services. In addition to providing a valuable source of water, they also serve as essential habitats for plants and animals. However, human demands on ponds have increased significantly in recent years. Many ponds have degraded due to issues such as habitat loss, toxic pollution, and eutrophication. Furthermore, encroachment on pond shores, coupled with activities like sewage disposal, water abstraction, reclamation of shallow pond borders, and diverse human activities, has contributed to the rapid degradation of these ecosystems (Markad et al. 2023). All of these activities are causing ponds to degrade rapidly. Water quality assessments often involve screening for physicochemical characteristics, heavy metal analysis, and assessing the abiotic and biotic state of the environment (Nautiyal 1985, Berkman 1987, Berkman et al. 1980, Baker et al. 1981). The current study aims to examine the water pollution conditions of three selected ponds in Dindigul to determine changes in water quality over the last decade.

2. MATERIALS AND METHODS

2.1 Location of the study

Dindigul district is an administrative region in southern Tamil Nadu, India. In 1985, the district was formed by dividing Madurai District. It covers 6266.64 square kilometers and is divided into three revenue divisions, eight taluks, and 14 panchayat unions. The investigator collected water samples from three pond in the study area: Sadayan Ponds, Lakshmi Puram Pond, and Nagammal Ponds to assess the influence of pesticide effluent on selected ponds. During the survey, the majority of the water samples were found to be unsafe for drinking due to their salty flavor.

2.2 Sample Analysis

For the purpose of evaluating the pond's general condition, sampling locations were chosen based on the identified pollution issues. Three distinct ponds locations were used to gather water samples for analysis: Nagammal Ponds served as the first sampling location (L1), Sadayan Ponds served as the second sampling location (L2), and the Lakshmi Puram served as the third sampling location (L3). pH, dissolved oxygen (DO), chemical oxygen demand (COD), biological oxygen demand (BOD), chloride, total alkalinity, total hardness, carbon dioxide, total dissolved solid, copper and manganese were among the water parameters that were analyzed. The samples were stored and sent to a research facility. The standard procedures were adhered to for the preservation and analysis of the pond water samples (Trivedy and Goel, 1986 and APHA Standard techniques, 2012).

Water samples were collected at 10:30 a.m. Monsoon month, 2023. The samples for analysis were gathered in sterilized bottles. All necessary precautions were taken to ensure that no bubbling occurred during sampling. The pH of pond water samples was measured using a pH Meter equipped with a glass electrode. The COD of the sample was evaluated using the Open Reflux Method. The dissolved oxygen and BOD were determined using Wrinkle's Azide Modification Titrimetric Method. The total hardness was determined using the EDTA Titrimetric Method. Chloride was measured using the Argentometric Method. The alkalinity and carbon dioxide levels of the water sample were determined using the Titration Method. TDS in the sample was determined by drying it at 1800 °C. The metals in water samples were evaluated by Flame Atomic Absorption Spectroscopy.

3. RESULTS AND DISCUSSION

The chemical, biological, and physical properties of the ponds varied depending on the degree of pollution in the surrounding areas. Ponds in and around Dindigul town were sampled for analysis.; these ponds were precisely those where pesticide waste mixing had occurred. Table 1 presents the results together with a full discussion of the findings and a comparison of the data versus WHO recommended limits.

pH: The pH scale is used to determine the acidity or alkalinity of a solution. In this study, the pH concentration of water samples ranged between 8.4 and 6.7, all within the acceptable limit of 6.5 to 8.5 as per IS:10500 (BIS, 1991). At water location 1, the maximum pH value was 8.4 in September 2023, and the minimum was 7.6 in July 2023. At water location 2, the highest pH value was 8.0 in September 2023, and the lowest was 6.9 in both March and July 2023. At water location 3, the maximum pH value was 7.8 in September 2023, and the minimum was 6.7 in March 2023. Overall, the pond samples showed no unusual variations in pH. According to Koul Nishtha (Koul et al. 2012), deviations in pH range within tolerance levels may impact cell mucous membranes. Previous research has indicated that various human activities may cause high pH levels (Skoulikidis et al. 1998, Dineshkumar et al. 2020). An increase in pH is often associated with the prominent use of alkaline detergents in domestic areas and industrial areas containing alkaline substances as waste products (Chang et al. 2008).

Dissolved oxygen: The concentration of dissolved oxygen (DO) in water can provide direct and indirect information on bacterial activity, photosynthesis, nutrient availability, and stratification (Boyd 2020). The range of DO concentrations in the pond samples that were analyzed was 0.4 to 0.9 mg/L. Station L1 reported the highest DO value of 0.9 mg/L, while L2 and L3 recorded the lowest values of 0.4 mg/L in May and September. The usual range of DO values in clean water is 8–10 mg/L. All pond samples, however, had extremely low DO levels, suggesting that biological breakdown of organic matter is most likely the cause of the de-oxygenation seen in these samples. This result is consistent with Muhammad Barzani Gasim's findings (Gasim et al. 2012). Dissolved oxygen is essential for controlling an organism's metabolic processes. Oxygen depletion in water can occur due to biota respiration, organic matter decomposition, elevated temperatures, oxygen-demanding wastes, and inorganic sources (Mushtaq et al. 2020). DO levels between 5-8 mg/l are satisfactory for the survival and growth of aquatic organisms.

Chemical oxygen demand: Chemical oxygen demand (COD) measures the amount of oxygen needed for the chemical oxidation of organic matter. In water locations 1, 2, and 3, COD levels ranged between 30 to 125 mg/L. Location 1 recorded the highest value of 125 mg/L in March, while location 3 recorded the lowest value of 30 mg/L in July 2023. All COD measurements at the sample locations exceeded the WHO-established permissible level of 10 mg/L. Elevated COD levels can pose a hazard to aquatic life by causing oxygen depletion through microbial degradation (Sivakumar et al. 2002, Mohamed Hanipha 2013, Dineshkumar 2020).

Chloride: In the present study, chloride levels in water locations 1, 2, and 3 ranged from 120 to 273 mg/L. Water location 1 had the highest chloride value of 273 mg/L in March 2023 and the lowest value of 120 mg/L in July and September 2023. Water locations 2 and 3 recorded their highest chloride values of 266 mg/L and 250 mg/L, respectively, in September 2023, with their lowest values of 125 mg/L and 130 mg/L in May 2023. While excessive chloride in potable water isn't particularly harmful, criteria for chloride levels are based on their potential for high corrosiveness. Soil porosity and permeability also influence chloride accumulation (Jain et al. 2010). Elevated chloride concentrations in pond water may result from pollution by sewage waste and the addition of common salt. Increased chlorine levels in water can be detrimental to individuals with heart and kidney diseases.

Table 1. Chemical analysis of water samples from Nagammal pond (Location L1) for the year 2023

Chemical Examination Nagammal pond (L1)	January	March	May	July	September	November
pH	8.1	8.2	7.8	7.6	8.4	8.3
Total Hardness (mg/L)	311	455	420	299	370	475
Cl (mg/L)	260	273	170	120	120	160
Total Alkalinity (mg/L)	27.30	27.30	20.00	110.00	140.5	132.2
BOD (mg/L)	37.00	35.00	29.00	16.00	18.00	22.00
DO (mg/L)	0.9	0.7	0.4	0.5	0.4	0.7
CO_2 (mg/L)	2.80	2.20	2.98	3.80	3.85	2.90
TDS (mg/L)	699	750	890	989	1120	1000
Copper (mg/L)	0.850	0.775	0.990	0.888	0.970	0.950
Manganese (mg/L)	0.270	0.285	0.300	0.290	0.990	0.775

Table 2. chemical analysis of water samples from Sadayan pond (Location L2) for the year 2023

Chemical Examination Sadayan Ponds(L2)	January	March	May	July	September	November
pH	7.9	7.3	6.8	6.7	8.0	7.9
Total Hardness (mg/L)	160	215	175	200	215	199
Cl (mg/L)	130	165	125	250	266	257
Total Alkalinity (mg/L)	75.22	87.33	22.33	119.00	139.5	129.00
BOD (mg/L)	30	23	27	34	14	34
DO (mg/L)	0.7	0.8	0.4	0.5	0.4	0.9
CO_2 (mg/L)	2.50	2.86	2.99	3.90	3.70	3.70
TDS (mg/L)	680	477	477	970	1000	950
Copper (mg/L)	0.780	0.650	0.987	0.800	0.987	0.755
Manganese (mg/L)	0.270	0.285	*0.300*	0.290	0.340	0.300

Table 3. chemical analysis of water samples from Lakshmipuram pond (Location L3) for the year 2023

Chemical Examination Lakshmipuram (L3)	January	March	May	July	September	November
pH	6.9	6.7	7.2	7.0	7.8	7.5
Total Hardness (mg/L)	130	215	145	170	215	187
Cl (mg/L)	150	170	130	190	250	240
Total Alkalinity (mg/L)	35.20	89.00	21.55	97.80	129.3	120.2
BOD (mg/L)	30	18	25	32	14	32
DO (mg/L)	0.8	0.7	0.4	0.5	0.4	0.9
CO_2 (mg/L)	2.45	2.60	2.80	3.40	3.67	3.70
TDS (mg/L)	740	650	465	465	960	899
Copper (mg/L)	0.590	0.460	0.987	0.890	0.987	0.770
Manganese (mg/L)	0.470	0.530	0.665	0.770	0.850	0.270

Biochemical Oxygen Demand: The amount of organic material that degrades bio degradable in water samples is measured by the BOD test. The levels of BOD in water location 1, 2 and 3 were ranged between 21.43±0.50 and 38.00±1.00 mg/l. During the study period, water location 1 had the highest value (37.00 mg/l) in January, 2023 and the lowest value (18 mg/l) in

September, 2023.Water location 2, 3 showed the highest value (34 mg/l) and (32 mg/l) in July and November, 2023 and lowest value (14 mg/l) in September, 2023. Maximum value of Bio-chemical Oxygen Demand (BOD) was recorded in summer and lowest value in winter during the present investigation. Nonetheless, they show that the ongoing release of household, commercial, and municipal sewage has deteriorated the ponds at all stations. Zahir Hussain and Mohamed Hanipha 2012 reported similar results. These findings are corroborated by earlier research conducted by Sharma and Walia 2015 and Dineshkumar and Natarajan 2020. According to Bhatt et al. 1999, Devaraju et al. 2005 and Garg et al. 2010 higher BOD values result from increased organic decomposition. In contrast, lower BOD values occur due to decreased microbial activity caused by lower temperatures.

Total Alkalinity: According to Sverdrup et al. 1942, the alkalinity of water signifies the existence of weak acids and the equilibrium of cations against them. The total alkalinity of the pond water samples used in this investigation varied from 22.33 mg/L at L3 to 140.5 mg/L at L1. During the study period, water locations 1, 2, and 3 had their highest values of 140.5 mg/l, 139.5 mg/l, and 129.3 mg/l, respectively, in September 2023. Their lowest values were 22.33 mg/l, 21.55 mg/l, and 20.00 mg/l, respectively, recorded in November and January. These numbers are less than the uppermost allowable limit. Higher alkalinity values than those found by Mohanraj 2000 may be related to open defecation and residential dumping (Chandra et al. 2010). Alkalinity is typically higher in the monsoon season and lower in winter. Total alkalinity is a measurement of the buffering capacity of pond water (Dey et al. 2021, Verma et al. 1978).

Total hardness: The total hardness values in all the pond exceed the permissible limit of 200 mg/L. PondsL2 and L3 are marginally above this limit, each with a hardness of 215 mg/L in March and september, while L1 has a significantly higher value of 475 mg/L in November, 2023. These hardness values are consistent with those discussed by Dinesh Kumar and Natarajan 2020.

Carbon dioxide: In almost all aquatic habitats, carbon dioxide is the final by product of the breakdown of organic carbon, and variations in it are frequently indicators of net ecosystem metabolism. At location L3, the dissolved CO_2 levels in the ponds are 3.62 mg/L in September, while at position L1, they are 3.90 mg/L in July, 2023. These values do not exceed the maximum allowable limit.

Total dissolved solids: All pond samples have total dissolved solids (TDS) ranging from 477 to 1120 mg/L. The World Health Organization (WHO) has established 1500 mg/L as the highest permissible TDS level for home use. Location L1 recorded the highest TDS value of 1120 mg/L in September, while location L2 and L3 recorded the lowest value of 477 mg/L and 465 mg/L in March and May. All pond samples in this investigation are categorized as non-saline based on TDS levels. As a result, all sample TDS levels are far within the 1500 mg/L allowable limit. High values of total suspended solids noticed in rainy season might be due to the presence of rain water runoff, heavy precipitation, siltation and deterioration, etc Sverdrup et al. 1942. Intrusions of industrial, agricultural, and animal wastes, along with reduced rainfall and increased evaporation, might also be significant contributing factors. As reported by Verma et al. 2000 high levels of dissolved solids result in increased osmotic pressure in organisms.

Copper: The trace element copper is widely dispersed and usually found in low quantities in natural waterways. This is because most copper minerals are somewhat insoluble and tend to interact with solid phases. Copper concentrations in the ponds vary, with L2 exhibiting minor presence and L3 in September and May, displaying a maximum of 0.987 mg/L. These findings suggest that the maximum allowable limit for copper concentration in pond water is not being exceeded.

Manganese: Water frequently contains manganese, a metal that is necessary for all living things in trace amounts. Manganese values in the ponds vary from 0.320 mg/L at position L3 to 9.990 mg/L at site L1. These findings suggest that the maximum allowable limit for manganese concentration in pond water is exceeded.

4. CONCLUSION

Three ponds Sadayan, Lakshmi Puram, and Nagammal were examined, and their physico-chemical and biological properties were compared with accepted limitations. In the majority of the pond samples, it was discovered that total hardness, fluoride, dissolved oxygen, biochemical oxygen demand, and chemical oxygen demand were higher than allowed levels. These findings suggest that in order to stop more contamination, frequent monitoring and recurrent evaluation of the pond's quality in this research area are necessary.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENT

Authors of the research paper are thankful to the authority of the Bharathiar University for providing necessary facilities to carry out this research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Andrew, O. A. (2012). Physicochemical analysis of Ogun River (water samples) within two locations (Akin-Olugbade and Lafenwa) in Abeokuta, Ogun State, Nigeria. *IOSR Journal of Applied Chemistry, 1*(4), 24-27.

Baker, J. A., & Ross, S. T. (1981). Spatial and temporal resource utilization by southeastern cyprinids. *Copeia, 81*, 178-179.

Berkman, H. E., & Rabeni, C. F. (1987). Effect of siltation in stream fish communities. *Environmental Biology of Fishes, 18*(28), 285-294.

Bhatt, L. R., Lacoul, P., Lekhak, H. D., & Jha, P. K. (1999). Physico-chemical characteristics and phytoplanktons of Taudaha Lake, Kathmandu. *Pollution Research, 18*, 353-358.

Boyd, C. E. (2020). Microorganisms and water quality. In Water quality: An introduction (pp. 233-267). https://doi.org/10.1007/978-3-030-23335-8-12

Bureau of Indian Standards (BIS). (1991). *Indian standard drinking water specification* (IS 10500).

Chandra, R., Nishadh, K. A., & Azeez, P. A. (2010). Monitoring water quality of Coimbatore wetlands, Tamil Nadu, India. *Environmental Monitoring and Assessment, 169*, 671-676.

Chang, C. Y., Chang, J. S., Vigneswaran, S., & Kandasamy, J. (2008). Pharmaceutical wastewater treatment by membrane bioreactor process: A case study in southern Taiwan. Desalination, 1-9.

Devaraju, T. M., Venkatesha, M. G., & Singh, S. (2005). Studies on physico-chemical parameters of Maddur Lake with reference to suitability for aquaculture. *Nature Environment and Pollution Technology, 4*(2), 287-290.

Dey, S., Botta, S., Kallam, R., Angadala, R., & Andugala, J. (2021). Seasonal variation in water quality parameters of Gudlavalleru Engineering College pond. *Current Research in Green and Sustainable Chemistry, 4*, 100058.

Dineshkumar, S., & Natarajan, N. (2020). Assessment of water quality status in the inland ponds of Coimbatore, Tamil Nadu, India.

Garg, R. K., Rao, R. J., Uchchariya, D., Shukla, G., & Saxena. (2010). Seasonal variation in water quality and major threats to Ramsagar Reservoir, India. *African Journal of Environmental Science and Technology, 4*(2), 061-076.

Gasim, M. B., Toriman, M. I., Lihan, T., & Rahman, Z. A. (2012). Flux of nutrients and heavy metals from the Melai River sub-catchment into Ponds Chini, Pekan, Pahang, Malaysia. *Environmental Earth Sciences*. https://doi.org/10.1007/s12665-012-1919-1

Government of India (GoI). (1999). *Integrated water resource development: A plan for action*. Report of the National Commission on Integrated Water Resources Development (NCIWRD). Ministry of Water Resources, Government of India.

Government of India (GoI). (2011). *Census of India*. Office of the Registrar General and Census Commissioner, Government of India, New Delhi.

Gupta, S. K., Dixit, S., & Tiwari, M. S. S. (2005). Assessment of heavy metals in surface water of Lower Ponds, Bhopal, India. *Pollution Research, 24*(4), 805.

Jain, C. K., Bandyopadhyay, A., & Bhadra, A. (2010). Assessment of ground water quality for drinking purpose, District Nainital, Uttarakhand, India. *Environmental Monitoring and Assessment, 166*, 663-676.

Koul, N., Lokhande, R. S., & Dhar, J. K. (2012). Physico-chemical, bacteriological and pesticide analysis of tap water in Millennium City Gurgoan, Haryana, India.

International Research Journal of Environment Science, 1(2), 1-7.

Mahananda, M. R. (2010). Physico-chemical analysis of surface water and ground water of Bargarh District, Orissa, India. *International Journal of Research and Review in Applied Sciences, 2*(3), 284-295.

Markad, A. T., Landge, A. T., Kulkarni, A. S., Sutar, V. B., & Meshre, S. D. (2023). Correlation analysis of various water quality parameters of the Tiru reservoir, Maharashtra, India. *International Journal of Bio-resource and Stress Management, 14*(10), 1411-29.

Mohamed Hanipha, M., & Zahir Hussain, A. (2013). Study of groundwater quality at Dindigul town, Tamilnadu, India. *International Research Journal of Environmental Science, 2*(1), 68-73.

Mohanraj, R., Sathishkumar, M., Azeez, P. A., & Sivakumar, R. (2000). Pollution status of wetlands in urban Coimbatore, Tamil Nadu, India. *Bulletin of Environmental Contamination and Toxicology, 64*, 638-643.

Mushtaq, N., Singh, D. V., Bhat, R. A., Dervash, M. A., & Hameed, O. B. (2020). Freshwater contamination: Sources and hazards to aquatic biota. In *Fresh Water Pollution Dynamics and Remediation* (pp. 27-50).

Nautiyal, P. (1985). Studies on the riverine ecology of the torrential waters in Indian uplands of Garhwal region: Seasonal variations in the percentage occurrence of planktonic algae. *Journal of Zoology, (1)*, 14-19.

Ndamitso, M. M., Idris, S., Likita, M. B., Tijani, J. O., Ajai, A. I., & Bala, A. A. (2013). Physico-chemical and *Escherichia coli* assessment of selected sachet water produced in some areas of Minna, Niger State, Nigeria.

Sharma, V., & Walia, Y. K. (2015). Water quality assessment using physico-chemical parameters and heavy metals of Gobind Sagar ponds, Himachal Pradesh, India. *Current World Environment, 10*(3), 161-166.

Sivakumar, A. A., & Jaganathan, R. (2002). Hydrology of River Bhavani, Tamilnadu, India. In *Ecology and conservation of ponds, reservoirs and rivers* (p. 1246).

Skoulikidis, N. T., Bertahas, I., & Koussouris, T. (1998). The environmental state of freshwater resources in Greece (rivers and ponds). *Environmental Geology, 36*, 1-17. https://doi.org/10.1007/s002540050315

Sverdrup, H. H., Johnson, M. W., & Fleming, R. H. (1942). *The oceans: Their physics, chemistry and general biology*. Prentice Hall.

Vannote, R. L., Minshall, G. W., Cummins, K. W., Sedel, J. R., & Cushing, C. E. (1980). The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences, 37*, 130-137.

Venkatesharaju, K., Ravikumar, P., Somashekar, R. K., & Prakash, K. L. (2010). Physico-chemical and bacteriological investigation on the river Cauvery of Kollegal stretch in Karnataka. *Journal of Science, Engineering and Technology, 6*(1), 50- 59.

Verma, S. R., Tyagi, A. K., & Dalella, R. C. (1978). Pollution studies of a few rivers of Western Uttar Pradesh with reference to biological indices. *Proceedings of the Indian Academy of Sciences, B, 87*(6), 123-131.

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