e-ISSN No.: 2582-4228

Journal of Indian Association for Environmental Management

Journal homepage: www.http://op.niscair.res.in/index/php/JIAEM/index

Assessment of Water Quality in Amgaon's Lakes: Implications for Beautification and Recreation

Dipali Garghate[1], Samruddhi Bawankule[2] and Gajanan Khadse[3]
*Corresponding author: Gajanan Khadse
gk_khadse@neeri.res.in; gkkhadse2007@rediffmail.com (Gajanan Khadse)
CSIR-National Environmental Engineering Research Institute, Nehru Marg, Nagpur, India

Submitted: 28 May 2024 Revised: 10 July 2024 Accepted: 11 July 2024

***Abstract*: Evaluation of water quality was undertaken for three lakes viz. Matabodi, Padampur and Risama in Amgaon town, Gondia district, Maharashtra, India under the 'Amrut Sarovar' scheme, focusing on their suitability for beautification and recreational purposes. The lakes exhibit compromised water quality due to various contaminants. The presence of free ammonia found to be 3.9 to 4.5 mg/L which exceeds permissible limits as defined by CPCB standards. The lakes also show contamination with total coliforms and fecal coliforms. Phytoplankton analysis reveals the prevalence of cyanobacteria species, which can produce harmful toxins. The phytoplankton diversity index suggests moderately polluted waters. The Shannon Wiener Diversity Index (SWI) of 1.4 to 2.1 and Palmer Pollution Index (PPI) of 14, 7 and 6 indicating mildly to moderately polluted water. Zooplankton assessment shows the presence of rotifers and daphnia indicating certain ecological disturbances. Further efforts are required to restore and maintain the water quality of these lakes for beautification and recreation.**

***Keywords*: Cyanobacteria, Shannon Wiener Diversity Index (SWI), Palmer Pollution Index (PPI), Zooplankton, Phytoplankton**

I. Introduction

Surface water is highly prone to contamination because it is easily accessible for waste disposal. Human activities and natural occurrences like weathering, erosion, and industrial development considerably influence the overall quality of surface water worldwide. Over the past decade, there has been widespread degradation of inland aquatic systems due to industrial expansion, agricultural intensification, and urbanization. Concerns about freshwater scarcity underscore the urgent need to prioritize the protection of water resources. Achieving this necessitates comprehensive spatiotemporal evaluations of water quality, which reveal the complex interplay between pollution sources and natural factors (Bhat et al. 2014). Regular monitoring programs are essential for accurately assessing water quality variations over space and time. This monitoring serves not only to gauge pollution impacts but also to support effective water resource management and safeguard aquatic ecosystems. Lakes, as common recreational sites, offer various services like fishing, swimming, and boating, contributing to their aesthetic value. Assessing the economic worth of these services is crucial for informing policy decisions aimed at preserving or enhancing water quality (Corrigan et al. 2009). Traditionally, lake and reservoir management focuses on biophysical aspects, often overlooking their social significance. However, recognizing lakes' contributions to sustainable societies entails addressing their social value. Understanding how lakes meet social needs allows for a holistic approach to their management, ensuring their continued support for thriving communities (Klessig et al. 2001).

Lake ecosystems, as explored in limnology, encompass physical, chemical, and biological properties in diverse environments. These ecosystems offer unique insights into dynamics distinct from land or air, emphasizing tight coupling between water, land, and air components. Despite comprising 50.01% of Earth's water, lakes hold 49.8% of liquid surface freshwater, making them essential for diverse organisms and providing critical services like drinking water, waste removal, fisheries, irrigation, industry, and recreation (Bhateria et al. 2016). Wetland ecosystems, including lakes, are vital for ecological sustainability, with their integrity directly linked to watershed health. However, rapid urbanization and unplanned anthropogenic activities globally have severely impacted these ecosystems, necessitating lake restoration efforts to address issues such as water pollution, habitat destruction, and biodiversity loss, crucial for human health and environmental well-being (Ramachandra et al. 2020).

In this paper, assessing and preserving surface water quality requires integrating scientific research with social considerations. This holistic approach informs policies that balance environmental protection with societal needs, promoting sustainable water resource management. It also highlights the mounting environmental challenges and the imperative to address water quality issues for the lakes' future viability.

II. Materials and Methods

Study Area

Amgaon is a town located in Gondia district of Nagpur Division in the state of Maharashtra, India. It is located 24 km east of its district headquarters at Gondia. It is situated at 21.3684° N latitude and 80.3798° E longitude. Amgoan has total 17,897 Urban population which rank 3rd in Gondia District after Gondia and Tirora. It is 150 kilometres (93mi) from Nagpur.

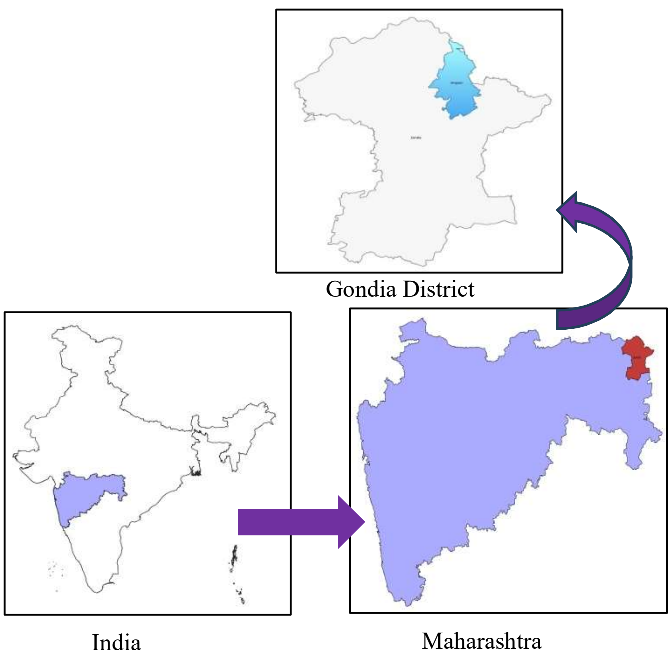

Fig.1 Study area map

Water Quality Testing

A methodical strategy was utilized to evaluate the water quality of lakes in Amgaon. Samples from Matabodi Lake, Padampur Lake, and Risama Lake (Table 1) were collected and subjected to analysis for a range of physical, chemical, organic, and bacterial parameters, as well as Soluble metals, using established procedures outlined in APHA 2017.

Temperature, pH, EC, TDS, and DO were measured in the field itself. Preservation of water samples was done with suitable preservatives for further analysis. Methods of preservation vary depending on the sort of analysis. The date, time, place, and kind of analysis to be carried were clearly labeled on each sample bottle. The collected, samples were immediately chilled at 4°C to slow down biological activity and chemical reactions. Preservatives are not required for physicochemical analysis. Nitric acid was added to acidify water samples to a pH of less than two and were refrigerated for heavy metal analysis. Before the heavy metal analysis, all samples were filtered using a 0.45 µm membrane filter to remove any particulate matter. Samples for Biochemical Oxygen Demand (BOD) analysis were kept cold, in the dark, at 4°C (in a refrigerator) to inhibit microbiological activity. To preserve a sample for Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN), and free ammonia sulfuric acid (H_2SO_4) was added to it until its pH falls below 2 and kept at 4°C.

Major cations and anions were analyseed in the water samples. Sodium and potassium were measured using a flame photometer, while chloride, total hardness, and total alkalinity were determined through titrimetry. Sulphate, nitrate, and phosphate concentrations were determined using a spectrophotometer. Bacteriological examination was conducted using the standard membrane filtration technique (APHA 2012) to quantify *total coliforms* and *fecal coliforms.*

Water samples designated for phytoplankton were collected in sterile bottles and promptly preserved with Lugol's iodine. For zooplankton, 40 liters of surface water were filtered through a plankton net (mesh size: 64 µm) and preserved using a 5% formaldehyde solution. Both plankton samples were concentrated using batch centrifugation. Microscopic examination was conducted on various transects of the ultimate 1 mL of concentrated sample to identify plankton. Phytoplankton enumeration was performed using the Lackeydrop method (Kankal et al. 2012), while zooplankton were assessed utilizing the Sedgewick–Rafter cell. Composition and diversity of the plankton were assessed using the Shannon-Weiner Diversity Index (Shannon et al. 1949). The Palmer Pollution Index was worked out based on pollution-tolerant algae and their respective index factors (Person 1989; Palmer 1969).

Sources of pollution of the lakes can be identified as follows:

1. Plastic waste dumped in and around the lake.
2. Household Waste: Discarded sacs, clothes, and Nirmalya (floral offerings) around the lake.
3. Detergents: Detergents used for washing clothes by women at the corner of the lake.
4. Organic Waste: Degraded plant parts floating in the lake and around the water body.
5. Aquatic plant growth, including Nymphoides indica, indicating nutrient-rich conditions.
6. Public Facilities: Presence of public washrooms near the lake, potentially contributing to pollution if waste management is inadequate.

TABLE 1
Locations of Water Samples

S.N.	Locations	Latitude (N)	Longitude (E)	Observations
1	Matabodi Lake	21˚22′18″	80˚23′13″	Greenish water, garbage and waste of plastic, sacs, clothes and *Nirmalya* were dumped in and around lake. Aquatic plant growth was seen around water body.
2	Padampur Lake	21˚21′11″	80˚23′47″	Brownish green colour water. Growth of *Nymphoides indica* (Water Snowflake flower) seen inside the lake, degraded plant parts were floating. The women were washing clothes at the corner of the lake. Plastic waste and detergents were seen near lake shore.
3	Risama Lake	21˚21′53″	80˚22′41″	Greenish water, degraded plant parts, and *Nirmalya* were found around the lake. Public washroom were located beside the lake.

III. RESULTS AND DISCUSSIONS

Physico-Chemical parameters

The physico-chemical parameters of the water Samples is provided in Table 2. pH of the water samples vary from 7.3 to 7.5. Surface water conductivity ranged from 205 to 1562 µS/cm. TDS were observed within 123 to 938 mg/L. Alkalinity and Total hardness fell within 80 to 328 mg/L and 76 to 124 mg/L, respectively. Sodium and potassium levels span from 20-240 mg/L and 5-160 mg/L, respectively. Chloride, sulphate, phosphate, and nitrate were found within 16 to 284 mg/L, 2 to 41 mg/L, 0.2 to 0.6 mg/L, and 1 to 2 mg/L, respectively. Turbidity measurements vary from 8 to 45 NTU.

The water samples underwent on-site testing for DO and found as 5.8 and 8.8 mg/L (Table 3). BOD levels are 2.3-5.8 mg/L, while COD ranged from 46 to 108 mg/L. TKN was observed within the range of 15 to 22 mg/L, and Free Ammonia was found to be between 3.9 to 4.5 mg/L, exceeding the permissible limit CPCB for Class D, as shown in Table 3.

The quantity of total coliforms and thermotolerant coliforms was assessed in each sample and reported as Colony-Forming Units (CFU/100ml). Total Coliforms were found to range from 6.1×10^2 to 1.4×10^3 CFU/100mL, while thermotolerant coliforms ranged from 1.1×10^2 to 8.9×10^2 CFU/100 ml across all water samples.

Metals content in water samples from the lakes for various elements are provided in Table 3. Results indicated that aluminium was found to be in the range of 2-3 ppm in Matabodi and Padampur lakes, while manganese concentrations were approximately 2 ppm, 1 ppm, and 1 ppm in samples from Matabodi, Padampur and Risama lakes respectively (Table 4). In a basic pH environment, aluminium tends to precipitate out as hydroxides and is less soluble, making the presence of dissolved aluminium in lake waters unexpected, however aluminium may associate with colloidal particles or organic matter, which can keep it in suspension and prevent precipitation even in basic conditions. Natural sources such as weathering of rocks and leaching from soils also contribute, while human activities like agricultural runoff and urban runoff can further introduce aluminium. Environmental factors, including complexation with organic matter and colloidal formation, help maintain aluminium in solution at higher pH levels. Sediment resuspension and atmospheric deposition also play roles in its presence. Therefore, despite the basic pH typically reducing aluminium solubility, specific local factors and contamination can still result in its presence in lake waters.

Phytoplankton

The results of several phytoplankton and species identified are presented in (Table 5). The Shannon Weiner Diversity Index (SWI) serves as a tool for evaluating phytoplankton composition and diversity, as well as their influence on water quality. The water samples contain 19 different genera, with Cyanobacteria, Dinoflagellates, Diatoms, and Chlorophyta being the predominant phytoplankton groups. Matabodi Lake water is associated with the Cyanobacteria phylum. Notably, Cylindrospermopsin toxin, produced by Cylindrospermopsis (a cytotoxin), was detected in Matabodi and Padampur lakes. Oscillatoria cyanobacteria, present in both Matabodi and Padampur lake samples, have the potential to produce toxins such as anatoxin-a and microcystin (EPA 2014). Cylindrospermum cells may produce anatoxins (nerve toxin), lipopolysaccharides (skin irritants), and BMAA (beta-Methylamino-L-alanine; a nerve toxin). Organic contamination was inferred from SWI values ranging from 1.4 to 2.1. The SWI for phytoplanktons in Matabodi and Padampur lakes is 2.1, indicating medium pollution, while in Risama Lake, the SWI is 1.4, suggesting moderate pollution.

The study aimed to evaluate the composition and diversity of phytoplankton, focusing on their biotic and abiotic interactions and impact on water quality, utilizing the Shannon Weiner Diversity Index (SWI). A total of 19 genera were identified. The predominant phytoplankton groups were Bacillariophyta, Chlorophyta, Ochrophyta, Heterokonta, and Cyanobacteria. Water samples from Matabodi and Padampur lakes exhibited a high proportion of species from the Cyanobacteria group, while Risama lake displayed a significant presence of species from the Ochrophyta group, as outlined in Table 6.

TABLE 2
Water Quality Parameters

S. N.	Parameters	Results			Desirable/ Permissible limit CPCB (Class-D)
		Matabodi Lake	Padampur Lake	Risama Lake	
1.	pH	7.5	7.3	7.4	**6.5-8.5**
2.	EC (µS/cm)	1562	205	668	-
3.	Turbidity (NTU)	45	8	17	-
4.	TDS	938	123	401	-
5.	Total Alkalinity as $CaCO_3$	328	80	140	-
6.	Total Hardness as $CaCO_3$	124	76	116	-
7.	Calcium as Ca^{2+}	16	11	10	-
8.	Magnesium as Mg^{2+}	20	12	22	-
9.	Chloride as Cl^-	284	16	116	-
10.	Sulphate as SO_4^{2-}	41	2	9	-
11.	Sodium as Na^+	240	20	102	-
12.	Potassium as K^+	160	5	22	-
13.	Fluoride as F^-	0.4	0.1	0.3	-
14.	Phosphate as PO_4^{3-}	0.2	0.6	0.4	-
15.	Nitrate as NO^-_3	2	1	2	-
16.	Total Coliform (TC)	$1.4x10^3$	$1.3x10^3$	$6.1x10^2$	-
17.	Thermotolerant Coliforms (FC)	$1.1x10^2$	$8.9x10^2$	$2.3x10^2$	-
Unit from S.N. 4-15 is in mg/L , whereas for S.N. 16-17 it is in CFU/100 mL					

TABLE 3
Organic Parameters of Water

S. N.	Parameters	Results			Desirable/ Permissible limit CPCB (Class-D) Propogation of Wild life & Fisheries
		Matabodi Lake	Padampur Lake	Risama Lake	
1.	DO	8.8	5.8	7.0	4 mg/L or more
2.	BOD (27 °C for 3 days)	5.8	4.6	2.3	-
3.	COD	108	46	62	-
4.	TKN	16	15	22	-
5.	Free Ammonia	3.9	4.5	3.9	1.2 mg/L or less
Unit from S.N.1-5 is in mg/L					

TABLE 4
Metal Content in Water

S. N.	Locations	As	Al	Ba	Co	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
1	Matabodi Lake	0.01	3	0.5	ND	ND	ND	0.02	1	2	ND	0.01	0.1
2	Padampur Lake	0.01	2	0.4	ND	ND	0.01	ND	1	1	ND	0.01	0.1
3	Risama Lake	0.01	ND	0.2	ND	ND	ND	ND	0.8	1	ND	ND	0.01
ND- Not Detected ; Unit for parameters is in mg/L													

TABLE 5
Phytoplankton Content in Water Samples

S. N.	Locations	Name of Phylum	Name of Genera	PPI	SWI	Pielou's Evenness Index
1	Matabodi Lake	Bacillariophyta	Conscinodiscus	14	2.1	0.8938
		Cyanobacteria	Chroococcus			
			Aphanizomenon			
			Anabaenopsis			
			Oscillatoria			
		Chlorophyta	Scenedesmus acuminatus			
		Heterokonta	Thalasiossria			
		Ochrophyta	Synedra Formosa			
			Vaucheria			
			Nitzschia			
2	Padampur Lake	Bacillariophyta	Conscinodiscus	7	2.1	0.8999
		Cyanobacteria	Chroococcus			
			Anabaenopsis			
			Cylindrospermum			
			Synechococcus			
			Rivularia			
			Oscillatoria			
		Chlorophyta	Pleurococcus			
		Ochrophyta	Dinobryon			
			Synedra formosa			
3	Risama Lake	Cyanobacteria	Gloeocapsopsis	6	1.4	0.6060
			Gomphosphaeria			
		Ochrophyta	Nitzschia			
			Navicula			
			Planothidium			

SWI: < 1: maximum pollution; 1-2:medium pollution; > 2: minimum pollution

Zooplankton

Enumeration of zooplankton was done using Sedwick-Rafter (S-R) counting cells. The planktons were identified and the total number of zooplamktons was reported as a number per litre.The results of a number of several zooplankton and species identified are presented in (Table 7).

Implications and Recommendations

Implications for Beautification and Recreation

The results of the evaluation of water quality present notable obstacles for initiatives aimed at enhancing the appearance of lakes in Amgaon. Elevated levels of water pollution can diminish the visual attractiveness of the lakes, diminish the efficacy of green infrastructure, and adversely affect the plants and animals that enhance the area's natural allure. Moreover, the compromised water quality raises concerns for recreational pursuits. Increased pollutant levels and algal blooms can jeopardize the health of individuals participating in water-based recreation. Furthermore, the decline in water quality may discourage tourists and local residents from utilizing the recreational amenities surrounding the lakes.

This Paper deals into the implications of the water quality assessment for the ongoing beautification projects around Amgaon's lakes and the local recreational activities. It provides a series of recommendations for sustainable management, such as water quality improvement measures, ongoing monitoring, public awareness campaigns, and potential regulatory changes.

TABLE 6

Percentage Composition of the Algal Group in Water Samples

S.N.	Locations	Percentage composition of the algal group				Cyano-bacteria	SWI	Palmer Pollution Index (PPI)
		Bacillariophyta	Chlorophyta	Heterokonta	Ochrophyta			
1	Matabodi Lake	10%	10%	10%	30%	40%	2.1	14
2	Padampur Lake	10%	10%	-	20%	60%	2.1	7
3	Risama Lake	-	-	-	60%	40%	1.4	6

TABLE 7
Zooplankton Content in Water Samples

S. N.	Locations	Genera	Numbers in 2ml of sample	SWDI	Pielou's Evenness Index
1	Matabodi Lake	*Rotifer*	21	0.30871	0.445374
		Moina	11		
2	Padampur Lake	*Asplancha*	25	0.47053	0.678831
		Daphnia	38		
3	Risama Lake	*Asplancha*	39	0.26613	0.383944

Recommendations

Based on the research findings, several recommendations are proposed:

Water Quality Improvement: Implement water quality improvement measures, such as nutrient reduction strategies, and promote sustainable agricultural and waste management practices to reduce pollution inputs into the lakes.

Monitoring and Maintenance: Establish a regular monitoring program to track water quality changes and identify potential pollution sources. Implement maintenance programs to ensure that recreational facilities remain clean and functional.

Public Awareness: Raise public awareness about the importance of preserving the lakes and adopting eco-friendly practices. Encourage community participation in beautification and conservation efforts.

Regulatory Measures: Enforce existing regulations and develop new ones, if necessary, to protect the lakes and their surroundings. Implement strict zoning and land-use policies to control potential pollution sources.

IV. Conclusions

The key findings, implications, and recommendations derived from the study underscores the importance of addressing water quality issues for Amgaon's lakes and highlights the need for integrated efforts to safeguard the lakes' natural beauty and enhance their role as recreational assets. The assessment of water quality in Amgaon's lakes underscores the need for immediate action to address the deteriorating conditions. The implications for beautification and recreation are significant, as poor water quality can undermine the visual appeal of the lakes and affect the health and safety of those using recreational facilities. By implementing the recommended measures, Amgaon can ensure the long-term sustainability and vitality of its lakes, preserving them as valuable assets for both residents and visitors.

ABBREVIATIONS

SWI: Shannon Wiener Diversity Index, PPI: Palmer Pollution Index, CPCB: Central Pollution Control Board, APHA: American Public Health Association, DO: Dissolved Oxygen, BOD: Biochemical Oxygen Demand, COD: Chemical Oxygen Demand, NTU: Nephelometric Turbidity Unit, EC: Electrical Conductivity, TDS: Total Dissolved Salts, FC: Fecal Coliforms; TC: Total coliforms

V. References

Bhat, S. A., & Pandit, A. K. Surface water quality assessment of Wular Lake, a Ramsar site in Kashmir Himalaya, using discriminant analysis and WQI. *Journal of Ecosystems*, *2014*.

Corrigan, J. R., Egan, K. J., Downing, J. A., & Likens, G. Aesthetic values of lakes and rivers. *Encyclopedia of inland waters*, 2009, 14-24.

Klessig, L. L. Lakes and society: The contribution of lakes to sustainable societies. *Lakes & Reservoirs: Research & Management*, *6*(2), 2001, 95-101.

Bhateria, R., & Jain, D. Water quality assessment of lake water: a review. *Sustainable Water Resources Management*, *2*, 2016, 161-173.

Ramachandra, T.V., & Asulabha, K.S. Efficacy of rejuvenation of lakes in Bengaluru, India. *Green Chemistry & Technology Letters*, *6*(1), 2020, 14-26.

APHA, AWWA, WPCF. Standard methods for examination of water and wastewater, method 9221 B, 22nd edn. *American Public Health Association*, Washington, 2012.

Kankal, N.C., Warudka,r S. Biodiversity of Phytoplankton, Zoo plankton and Zoobenthos in East Coast, Bay of Bengal Near Nellore, Andhra Pradesh (India). *Int J Pharm Med Bio Sci* 1(2):2012, 272–285

Shannon, C.E., Weaver, W. The mathematical theory of communication. University of Illinois Press, Urbana, 1949.

Person J.L. Use of algae to determine water quality. *Environ Sci Investig*, 1989, 131.

Palmer C.A.Composite rating of algae tolerating organic pollution. *J. Phycol* 5:1969, 78–82.

EPA. Cyanobacteria and Cyanotoxins: Information for Drinking Water Systems. U.S. Environmental Protection Agency, Office of Water, EPA-810F11001,2014.