

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

Abstract

Evaluation of water quality of 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 of 1.4 to 2.1 and Palmer Pollution Index 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

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

Research Article

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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 [1]. 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 [2]. Traditionally, lake and reservoir management focus 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 [3].

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 [4]. 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 [5].

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.

Materials and Methods

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. Amgaon has total 17,897 Urban population which rank 3rd in Gondia District after Gondia and Tirora. It is 150 kilometres (93 mi) from Nagpur.

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 gathered and subjected to analysis for a range of physical, chemical, organic, and bacterial parameters, as well as metals, using established procedures outlined in APHA 2017.

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 <i>Nirmalya</i> 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 <i>Nymphoides indica</i> (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 <i>Nirmalya</i> were found around the lake. Public washroom was located beside the lake.

Table 1. Locations of water samples

Temperature, pH, EC, TDS, and DO were measured in the field itself. Preservation of water samples was done with suitable preservatives for further analysis. Major cations and anions were assessed 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 [6] 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 [7], while zooplankton were assessed utilizing the Sedgewick–Rafter cell. Composition and diversity of the plankton were assessed using the Shannon-Weiner Diversity Index [8]. The Palmer Pollution Index was worked out based on pollution-tolerant algae and their respective index factors [9,10].

Result and Discussion

Physico-chemical parameters

The physico-chemical parameters of the water is provided in (Table 2). pH of the water samples varies from 7.3 to 7.5. Surface water conductivity ranged from 205 to 1562 $\mu\text{S}/\text{cm}$. 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 as 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 3).

Phytoplankton

The results of several phytoplankton and species identified are presented in (Table 4). 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 [11]. 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 1.3 to 2.0. 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

SL. NO.	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 ($\mu\text{S}/\text{cm}$)	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)	1.4×10^3	1.3×10^3	6.1×10^2	-
17.	Thermotolerant Coliforms (FC)	1.1×10^2	8.9×10^2	2.3×10^2	-

Unit from S.N. 4-15 is in mg/L, whereas for S.N. 16-17 it is in CFU/100 mL

Table 2. Water quality parameters

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 5).

Zooplankton

Enumeration of zooplankton was done using Sedwick-Rafter (S-R) counting cells. The planktons were identified and the total number of zooplanktons was reported as a number per litre. The results of a number of several zooplankton and species identified are presented in (Table 6).

S. N.	Parameters	Results			Desirable/ Permissible limit
		Matabodi Lake	Padampur Lake	Risama Lake	CPCB (Class-D) Propagation of Wild life & Fisheries
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 3. Organic parameters of 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 3. Metal content in water

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.

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.

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	Thalassiosira			
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

Table 4. Phytoplankton content in water samples

S.N.	Locations	Percentage composition of the algal group					SWI	Palmer Pollution Index
		Bacillariophyta	Chlorophyta	Heterokonta	Ochrophyta	Cyano bacteria		
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 5. Percentage composition of the algal group 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

Table 6. Zooplankton content in water samples

Conclusion

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.

Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

The authors have no competing interests to declare that are relevant to the content of this article.

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