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Research Article

PHYSICO-CHEMICAL ANALYSIS OF LENTIC AND LOTIC WATER BODIES OF MATHURA BLOCK, MATHURA, UTTAR PRADESH

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ABSTRACT
The most essential or basic necessity for existence is water. Numerous physical, chemical, and biological parameters of a few chosen lentic and lotic system locations in Mathura, Uttar Pradesh, were examined. Because of the increased some physico-chemical parameters, the majority of the sites were extremely contaminated. The findings showed that these lotic and lentic system's water quality is quickly deteriorating. These systems may be preserved by regularly updating their data.

Keywords: *Water Analysis, Physico-Chemical Parameter, Lentic, Lotic*

INTRODUCTION
The most diversified ecosystem in the world is the aquatic ecosystem. The first life began in the water, and the first creatures were aquatic, with water serving as both the main external and internal medium for organisms. Water is therefore the most essential component for all living organisms to exist. Limnology is the study of fresh water ecosystems. The word lentic, which means "to make calm," is used to describe still lakes and ponds, which offer environmental circumstances that are very different from those of streams. Running water is referred to be lotic (from the Greek word lavo, which means "to wash"), in which the entire body of water travels in one direction.
Earth surface has limited sources of freshwater and it contributes only 2.5% to total water on Earth (Hu *et al.* 2018). Industrialization, urbanization, agricultural practices, and improper waste disposal have all contributed to the contamination of rivers and ponds (Mishra *et al.* 2014, Chen *et al.* 2019). The pollution can take various forms, including chemical pollutants, nutrient overload, plastic waste, and biological contaminants. The assessment of water quality may be a complex process with many variables, raising several concerns about the overall quality of the water (Bharti and Katyal 2011). Evaluating water quality for large samples with concentrations for several factors is challenging (Almeida *et al.* 2008). Conventional approaches to water quality assessment rely on comparing experimentally measured parameter values with established standards (Debels *et al.* 2005). Water quality indices are therefore methods that greatly reduce the amount of data and make it easier to communicate the state of water quality. The water quality index is calculated using a variety of physico-chemical and bacteriological factors. A few water quality parameters such as ambient temperature, water temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total dissolved solids, hardness, calcium and water conductivity are correlated with the abundance of planktons (ojha P. 2019). With drought, floods, and unpredictable rainfall all becoming more frequent due to climate change, water system protection is crucial. These lentic and lotic system conservation has perhaps been hampered by a lack of knowledge and comprehension. Various measures have been implemented by the Indian government at the national level. The Indian government worked together with the relevant state governments to operationalize the National Wetland Conservation Program (NWCP). Recently, the Indian government established a distinct ministry called "Jal Shakti" to oversee and protect the regional waterways.

The current study is based on water quality, specifically pollution, and analyses the nutrients of lentic (perennial ponds) and lotic (Yamuna River) water bodies of Mathura and its role in freshwater bodies with the impact of agricultural, domestic waste on water quality and nutrient analysis with physio-chemical parameters like Temperature pH, DO, BOD, PO4, SO4, NO2-N, NH3 etc.

MATERIALS AND METHODS

1. Selection of study area:

Mathura a city and the administrative headquarters of Mathura district in the Indian state of Uttar Pradesh. Mathura, which lies at the centre of the cultural region of Braj has an ancient history and is also believed to be the homeland and birthplace of Krishna, who belonged to the Yadu dynasty. The Coordinates of Mathura are 27.4949088N, 77.6779708E.

Sampling sites:

Lentic system - Perennial ponds only.
Lotic system – River Yamuna.

Table 1. Name of the selected Lentic system (Ponds) for sample collection

S.N	Site Name	Type	Situated
1	Ganga Sagar tirth	Perennial Pond, Lentic	Kudarvan, Mathura
2	Shantanu Kund	Perennial Pond, Lentic	Girdharpur, Mathura
3	Madhu Kund	Perennial Pond, Lentic	Maholi, Mathura
4	Krishna Sarovar	Perennial Pond, Lentic	Baad, Mathura
5	Balbhadra Kund	Perennial Pond Lentic	Taarsi, Mathura

Table 2. Name of the selected Lotic system (Yamuna River) for sample collection

S. N	Site Name	Type	Situated
S_1	Abipur Khadar	Lotic, Yamuna	Mathura
S_2	Kans Quila	Lotic, Yamuna	Mathura
S_3	Gokul Barrage	Lotic, Yamuna	Mathura
S_4	Koile Ghat	Lotic, Yamuna	Koyla Gaon, Mathura

2. Sample Collection – Water sample collected from 5 lotic system (perennial ponds) and 4 lentic sites (S_1,S_2,$_3$,S_4, Yamuna River). Sample were collected from May to July 2024. Samples were taken at every sampling location in plastic bottles. During sample collection, the bottles were assigned sampling numbers (Table 1). The samples have been collected and preserved.

3. Sample Analysis – Physical parameters like - temperature, pH, turbidity, conductivity, were measured using mercury thermometer, Systronics water analyser, conductivity meter respectively. Colour measured by visual comparison of the sample with the distilled water (APHA 1999). Sodium and Potassium ion concentration was determined using SL270 Double Beam Photometer. DO and TDS were measured using Systronics water analyser. Total Alkalinity and total hardness were measured using titration methods (APHA 1999). Chloride was measured using mohr's method. Total Coliform also measured by using MPN test.
4. Statistical Analysis: The data collected was suitably tabulated and analysed.

RESULTS AND DISCUSSION

The most of community depend on lentic and lotic system for drinking water, agriculture irrigation, animal husbandry. However, water systems are no longer suitable for use as water sources due to the ongoing deterioration of the water quality. The majority of these system have physical and chemical characteristics that are outside of an acceptable range, according to the current study.

Table 3. Physical and Biological Parameters of Lentic water system (Ponds): -

S. N	Parameters ➡ / Sites ⬇	Colour	Odour	pH	Temperature (°C)	Turbidity (NTU)	Transparency (cm)	T. Coliform (MPN/100ml)
1	Ganga Sagar Tirth	Light green	Disagreeable	8.22	40.3	20.69	17-18	54
2	Shantanu Kund	Light Green	Disagreeable	8.12	37.6	31.21	18	50
3	Madhu Kund	Green	Agreeable	8.95	37.3	45.34	11-12	75
4	Krishna Sarovar	Light green	Disagreeable	8.13	36.2	17.34	14-15	61
5	Balbhadra Kund	Blackish	Disagreeable	9.27	38.5	19.64	18-19	37
	Acceptance Limit							
	Range	-	-	6.5-9.2	-	1	-	-
	Ref.	-	-	WHO	-	WHO	-	-

Physical Parameters –

Colour and Odour – Zooplankton and phytoplankton provides colour and odour to the water systems. Most of samples were green and blackish. S_1 was slight blue. Odour of most samples were non-agreeable. The colour and smell of fresh water bodies are markers of their water quality (Dhanalakshmi *et al*. 2013). Higher planktons are represented by the colour green, whereas lower planktons are represented by the colour light green (Das 1997).

Water Temperature – The range of temperature was 35.4 – 40.3.

The temperature seems to exhibit the greatest influence on the periodicity of zooplanktons (Battish and Kumari, 1996).

pH – pH ranged from 8.07 – 9.2 with permissible limit according to WHO. The Higher pH was for Balbhadra Kund and lower for S_2.
Transparency – It was determined by using Secchi disc apparatus. The range of transparency were 8-19.
Turbidity: The suspension of particles in water causes turbidity, which gives the solution a grainy appearance. The water sample's measured turbidity varied between 17.34 – 45.34 NTU. Soil runoff may contaminate freshwater bodies, increasing their turbidity. (EPA 2000, Schwartz et al 2000).
Biological Parameters –
Total Coliform (MPN) - Coliform bacteria are a group of gram-negative, rod-shaped bacteria that are commonly used as indicators of water quality. their presence suggests potential contamination and the possible presence of disease-causing organisms. The value total coliform ranged from 50-75 for lentic water bodies (Table 3) and 53-65 for lotic water bodies (Table 4).

Table 4. Physical and Biological Parameters of Lotic water system (Yamuna River): -

Parameters ➡ / Sites ⬇	Colour	Odour	pH	Temperature (°C)	Turbidity (NTU)	Transparency (cm)	T. Coliform (MPN/100ml)
S_1	Slight blue	Dis-agreeable	8.11	39.2	17.35	11-12	62
S_2	Blackish	Dis-agreeable	8.07	38.4	18.21	8-9	58
S_3	Blackish	Dis-agreeable	8.21	36.1	17.41	11-12	65
S_4	Blackish	Dis-agreeable	8.32	35.4	17.79	11-12	53
Acceptance Limit							
Range	-	-	6.5-9.2	-	1	-	-
Ref.	-	-	WHO	-	WHO	-	-

Chemical Parameters –
Conductivity: The recorded conductivity ranged from 1638- 3138 µs/cm. The maximum conductivity was recorded in Balbhadra Kund (3138 µs/cm) and minimum in Krishna Sarovar (1638 µs/cm). The acceptable limit for conductivity is 900 µs/cm (WHO). When compared to WHO standard all the samples were out of the acceptable limit.
DO: DO will be determined by Winkler's method. It was developed by the German chemist Lajos Winkler in 1888. The aquatic biota is negatively impacted by the drop in DO levels, which results in anaerobic conditions in the water. The value DO range from 4.2-5.2 for lentic water bodies (Table 3) and 4.4-5.1 for lotic water bodies (Table 4).
TDS: The range of TDS was 1.136 ppt to 2.194 ppt for lentic water bodies (Table 3) and 1.145-1.985 for lotic water bodies (Table 4). The allowable maximum of TDS for drinking water is 0.5 ppt, as per the WHO. Changes in total solids may be the cause of the salinity 3 shift. A high TDS level is a sign of higher nutrient content, which causes aquatic bodies to become eutrophic (Verma *et al*. 2012).
Free Carbon-dioxide – Free CO_2 will be determined by using Phenolphthalein indicator. Free CO_2 recorded in water samples ranged from 21.12-31.68 mg/l for lentic water bodies (Table 5) and 24.15-28.82 mg/l for lotic water bodies (Table 6). Sample of Balbhadra kund (31.68 mg/l) was reported to have a maximum value of sulphate and minimum was reported in case of Shantanu Kund (21.12 mg/l).

Total alkalinity: - Alkalinity is the capacity of water to resist acidification. Alkalinity will be measured by Titration method with phenolphthalein indicator. Total Alkalinity recorded in water samples ranged from 204-820 ppm (Table 5,6). The acceptable limit for alkalinity is 100 ppm (WHO).

Total Hardness – Hardness of the water is the capacity of the water to react with the soap. Calcium and magnesium are the principal cations that impart hardness. The total harness of water therefore reflects the sum total of alkaline metal cations present in it. Total Hardness recorded in water samples ranged from 435-584 ppm (Table 5,6). The acceptable limit for alkalinity is 150 ppm (WHO). Sample of Madhu Kund (584ppm) was reported to have a maximum value of total hardness and minimum was reported in case of S_3 (435 ppm).

Nitrates - Fertilizers, decomposing plant and animal debris, home and industrial effluents, and atmospheric washouts are significant sources of nitrates in aquatic ecosystems. Nitrates recorded in water samples ranged from 9-28 ppm (Table 5,6). The acceptable limit for alkalinity is 50 ppm (WHO). Sample S_3 (28 ppm) was reported to have a maximum value of nitrates and minimum was reported in case of Madhu Kund (9 ppm).

Chloride: Chloride range obtain from 345-1236 ppm in water samples (Table 5,6). Maximum in Balbhadra Kund (1236 ppm) and minimum in S_3 (345 ppm). The permissible limit of chloride content is 200 ppm according to WHO. The high chloride content in water samples may be due to the high rate of sedimentation and evaporation.

Sodium: Sodium range obtain from 170 - 568 ppm in the sample. the higher level of sodium in sample of Balbhadra Kund and lower level was in S_1. The acceptance limit of sodium a 200 ppm according to WHO. Samples of Ganga Sagar tirth, Shantanu Kund, Madhu Kund & Balbhadra Kund were out of the permissible limit.

Potassium: Potassium concentration recorded from water samples ranged from 2.6 - 9 ppm. The maximum value of potassium was recorded in Balbhadra Kund (9 ppm) and minimum in Ganga Sagar Tirth (2.6 ppm). The acceptable limit Potassium for drinking water is specified at 10 ppm according to WHO. All water samples were out of acceptable limit.

Table 5: Various Analysed Chemical Parameters of Lentic water system (Ponds): -

Para-meters → / Sites ↓	Conductivity (µs/cm)	DO	TDS (ppt)	Free CO2 (ppm)	T. Alkalinity (ppm)	T. Hardness (ppm)	Nitrates (ppm)	Cl^- (ppm)	Na^{2+} (ppm)	K^+ (ppm)
Ganga Sagar tirth	2596	5.2	1.815	26.64	820	480	19	446	211	2.6
Shantanu Kund	2830	5.1	1.977	21.12	536	520	28	672	330	3.3
Madhu Kund	2458	4.7	1.706	26.40	204	584	09	732	354	3.9
Krishna Sarovar	1638	4.5	1.136	28.16	524	464	25	370	172	3.9
Balbhadra Kund	3138	4.2	2.194	31.68	496	484	22	1236	568	9
Permissi-ble Limit										
Range	900	5.0	0.5	-	100	150	50	200	200	10
Ref.	WHO	WHO	WHO		WHO	WHO	WHO	WHO	WHO	WHO

Table 6: Various Analysed Chemical Parameters of Lotic water system (Yamuna River)

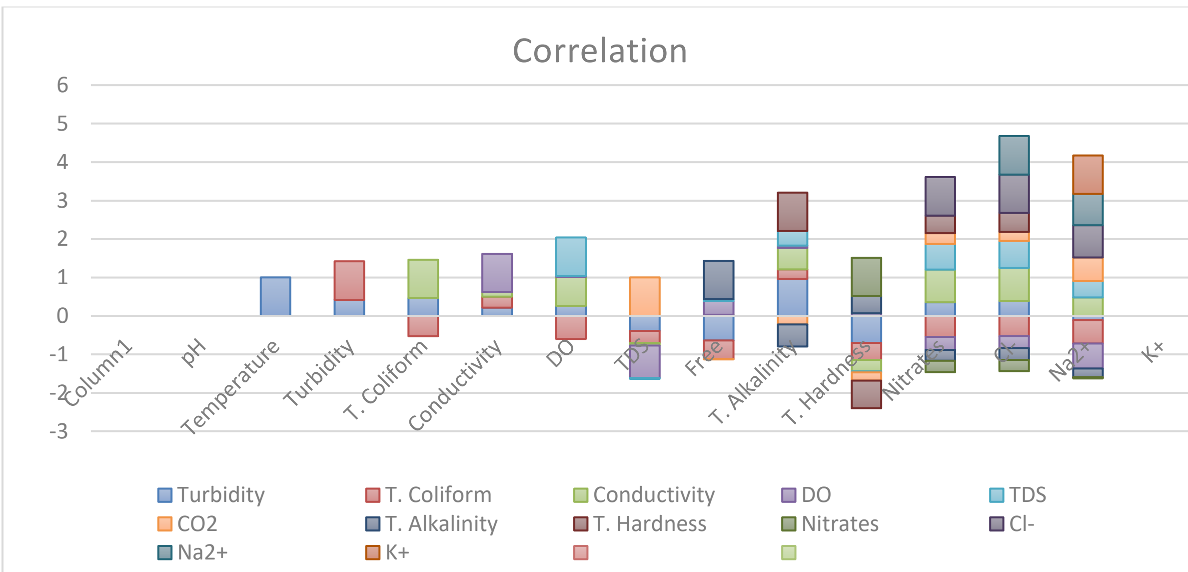
Parameters → / Sites ↓	Conductivity (µs/cm)	DO	TDS (ppt)	Free CO2 (ppm)	T. Alkalinity (ppm)	T. Hardness (ppm)	Nitrates (ppm)	Cl^- (ppm)	Na^{2+} (ppm)	K^+ (ppm)
S1	1639	4.6	1.145	28.12	527	450	22	375	170	3.7
S2	1650	4.5	1.356	28.35	522	460	24	369	172	3.9
S3	1658	5.1	1.587	24.15	499	435	28	345	176	3.8
S4	1690	4.4	1.985	28.82	530	475	26	370	190	3.7
Permissible Limit										
Range	900	5.0	0.5	-	100	150	50	200	200	10
Ref.	WHO	WHO	WHO		WHO	WHO	WHO	WHO	WHO	WHO

Water bodies get untreated or insufficiently treated effluent from factories that contains oils, heavy metals, and hazardous compounds. Nutrient contamination results from agricultural fertilizers, insecticides, and herbicides washing into rivers and ponds. dumping detergents, domestic trash, and untreated sewage straight into bodies of water. Hazardous chemicals are released and water bodies become clogged by non-biodegradable garbage. Along that in Mathura these water systems have great religious impact. Some religious ponds are also used for dumping of religious and ceremonial waste in the ponds.
The pH, chloride and sodium, turbidity and total hardness, chloride and sodium were positively correlated because correlation coefficient (r) nearly to 1. Turbidity and temperature, free co_2 and total alkalinity were negatively correlated and zero or no correction between total hardness and potassium because r value was 0 for that.

Table 7: Correction of various parameters

Column	pH	Temp.	Turbidity	T. Coliform	EC	DO	TDS	CO2	T. Alkalinity	T. Hardness	NO_2+	Cl-	Na^{2+}	K+
pH	1.00													
Temp.	0.05	1.00												
Turbidity	0.42	-0.01	1.00											
T. Coliform	-0.25	-0.23	0.42	1.00										
EC	0.64	0.42	0.46	-0.53	1.00									
DO	-0.44	0.20	0.21	0.29	0.11	1.00								
TDS	0.58	-0.01	0.26	-0.60	0.76	0.03	1.00							
Free	0.46	0.13	-0.39	-0.31	-0.07	-0.84	-0.03	1.00						

T. Alkalinity	-0.48	0.46	-0.64	-0.48	0.03	0.35	0.05	-0.01	1.00					
T. Hardness	0.51	0.01	0.96	0.25	0.56	0.06	0.38	-0.22	-0.57	1.00				
NO^{2+}	-0.55	-0.33	-0.70	-0.44	-0.30	0.07	-0.03	-0.21	0.45	-0.72	1.00			
Cl-	0.88	0.22	0.35	-0.54	0.85	-0.34	0.66	0.28	-0.28	0.46	-0.30	1.00		
Na2+	0.88	0.18	0.39	-0.53	0.86	-0.31	0.70	0.24	-0.30	0.49	-0.30	1.00	1.00	
K+	0.79	0.05	-0.11	-0.61	0.48	-0.65	0.43	0.61	-0.23	0.00	-0.03	0.84	0.82	1.00



CONCLUSION

All of the samples foul smells pointed to contaminants in the pond water. Turbidity physical parameter was above allowable limits in every sample. The potassium and nitrates concentrations were below the permissible limits based on WHO. Conductivity, Total Alkalinity, Total hardness and Chlorides or Sodium were higher from acceptance value provided by WHO. Additionally, these water sources are constantly deteriorating and degrading as a result of overexploitation. Both the water system is unfit for ingestion by humans and animals. Regular monitoring and assessment of the lentic and lotic water is necessary. These water bodies can be conserved and protected with the cooperation of the local population and the government. Conservation of these system may be aided by enhanced pond-river regulation, awareness-raising efforts, and routine monitoring.

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