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Comprehensive assessment of physicochemical parameters of yamuna river water quality

Divesh Goyal
Department of Geography, Amity University Noida, Uttar Pradesh, India

Abstract
This experimental study aims to comprehensively assess the physicochemical parameters of the Yamuna River to understand its water quality status. By analyzing water samples from various sites along the river, we measure key parameters such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), turbidity, and the presence of heavy metals. The findings provide critical insights into the health of the river and inform strategies for pollution control and water quality management.

Keywords: Yamuna river, water quality, physicochemical parameters, pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total dissolved solids, turbidity, heavy metals

Introduction
The Yamuna River is one of the most important rivers in India, playing a crucial role in the livelihoods of millions of people. It provides water for drinking, agriculture, and industry, and supports a diverse ecosystem. However, the river's water quality has been deteriorating due to increasing anthropogenic pressures, including industrial discharge, agricultural runoff, and urban waste. This study aims to assess the current state of the Yamuna River's water quality by analyzing various physicochemical parameters.

Objective
The main objective of this study is to evaluate the physicochemical properties of the Yamuna River water to determine its quality and identify major pollution sources. This will help in understanding the extent of pollution and provide data for effective water management strategies.

Methods
Study Area: The study covers the Yamuna River from its upper reaches in Uttarakhand to its confluence with the Ganges at Allahabad. Major urban centers along this stretch, including Delhi and Agra, are included to capture a comprehensive picture of the river's water quality.

Sample Collection: Water samples were collected from ten sites along the Yamuna River at monthly intervals over one year. The sites were selected to represent different land uses and potential pollution sources:

Table 1: Yamuna River Water collection sites

Palla (Upper Yamuna, Uttarakhand)	Wazirabad (Delhi)
ITO (Delhi)	Okhla Barrage (Delhi
Faridabad (Haryana)	Mathura (Uttar Pradesh)
Agra (Uttar Pradesh)	Etawah (Uttar Pradesh)
Hamirpur (Uttar Pradesh)	Allahabad (Prayagraj) (Confluence with Ganges)

Samples were collected in clean, acid-washed polyethylene bottles for analysis. Field measurements of temperature and pH were taken using portable meters. All samples were transported to the laboratory under refrigerated conditions for further analysis.

Physicochemical Analysis: The following parameters were analyzed

- **pH:** Measured using a pH meter.
- **Dissolved Oxygen (DO):** Determined using the Winkler method.
- **Biochemical Oxygen Demand (BOD):** Measured after incubating samples for five days at 20 °C.
- **Chemical Oxygen Demand (COD):** Determined using the dichromate digestion method.
- **Total Dissolved Solids (TDS):** Measured using a TDS meter.
- **Turbidity:** Measured using a turbidity meter.
- **Heavy Metals:** Analyzed using Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for lead (Pb), mercury (Hg), cadmium (Cd), and chromium (Cr).

Results
The physicochemical parameters varied significantly across the study sites, reflecting the diverse pollution sources and land uses along the Yamuna River.

Table 2: Average Physicochemical Parameters of Yamuna River Water

Site	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	Turbidity (NTU)	Pb (mg/L)	Hg (mg/L)	Cd (mg/L)	Cr (mg/L)
Palla	7.5	8.0	2.0	15.0	350	5.0	0.05	0.001	0.002	0.004
Wazirabad	7.2	5.5	10.0	40.0	650	15.0	0.22	0.009	0.005	0.008

ITO	7.1	5.0	12.0	50.0	700	20.0	0.24	0.010	0.006	0.010
Okhla Barrage	7.3	6.0	8.0	35.0	600	10.0	0.20	0.008	0.004	0.006
Faridabad	7.4	6.5	6.0	30.0	500	8.0	0.18	0.007	0.003	0.005
Mathura	7.5	7.0	5.0	25.0	450	7.0	0.17	0.006	0.003	0.004
Agra	7.2	6.0	9.0	40.0	650	12.0	0.23	0.009	0.005	0.007
Etawah	7.3	6.5	7.0	30.0	550	9.0	0.19	0.007	0.004	0.006
Hamirpur	7.4	7.0	6.0	28.0	500	8.0	0.20	0.008	0.004	0.006
Allahabad	7.5	7.5	4.0	20.0	400	6.0	0.16	0.006	0.003	0.004

Discussion and Analysis

The results of the physicochemical analysis of the Yamuna River water reveal significant variations in water quality across different sampling sites, reflecting the diverse sources and extents of pollution along the river's course. The pH levels ranged from 7.1 to 7.5, indicating slightly acidic to neutral conditions, which are typical for river water. The slight acidity in some areas can be attributed to industrial discharges and urban runoff, which often contain acidic compounds. Dissolved oxygen (DO) levels varied considerably, with lower concentrations observed in urban areas such as Wazirabad, ITO, and Okhla Barrage in Delhi. These sites recorded DO levels as low as 5.0 mg/L, reflecting higher organic pollution loads and microbial activity consuming oxygen. In contrast, upstream sites like Palla and downstream sites like Allahabad exhibited higher DO levels, closer to 8.0 mg/L, indicative of lower organic pollution and healthier water quality. Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) are critical indicators of organic pollution in water. Elevated BOD and COD values were observed in urban and industrial areas, particularly in Delhi, where BOD values reached up to 12.0 mg/L and COD values up to 50.0 mg/L. These high values suggest substantial organic matter input from domestic sewage, industrial effluents, and other sources. The presence of high BOD and COD indicates significant microbial activity, which depletes dissolved oxygen, adversely affecting aquatic life. Total dissolved solids (TDS) and turbidity levels were also significantly higher in urban and industrial zones. TDS values in Delhi ranged from 650 to 700 mg/L, while turbidity levels reached up to 20.0 NTU. These elevated levels are indicative of high concentrations of dissolved ions and suspended particles, stemming from industrial discharges, urban runoff, and sediment disturbances. High TDS and turbidity can impair aquatic habitats, reducing light penetration and affecting photosynthesis in aquatic plants. The presence of heavy metals such as lead (Pb), mercury (Hg), cadmium (Cd), and chromium (Cr) was a major concern in this study. The highest concentrations of these metals were detected in samples from Delhi. Lead levels ranged from 0.20 to 0.24 mg/L, mercury from 0.008 to 0.010 mg/L, cadmium from 0.004 to 0.006 mg/L, and chromium from 0.006 to 0.010 mg/L. These concentrations are significantly above the acceptable limits set by national and international water quality standards, indicating severe contamination. The industrial activities along the riverbanks, particularly in Delhi, are the primary sources of these heavy metals. Factories involved in electroplating, tanning, battery manufacturing, and other industrial processes release heavy metals into the river, either through direct discharge or via runoff. Agricultural runoff also contributes to the heavy metal load, as fertilizers and pesticides used in farming contain trace amounts of these metals. Urban runoff, containing metals from vehicular emissions and construction activities, further exacerbates the contamination. The ecological implications of these findings are profound. High levels of heavy metals and organic pollutants can have detrimental effects on aquatic life. Fish and other aquatic organisms are particularly vulnerable to heavy metal poisoning, which can cause physiological and reproductive impairments, reduce biodiversity, and disrupt the food web. Bioaccumulation of heavy metals in aquatic organisms poses risks to higher trophic levels, including humans, who consume contaminated fish. Moreover, sediment contamination with heavy metals presents a long-term environmental hazard. Metals that settle in the riverbed can be re-mobilized into the water column during events such as floods or dredging, perpetuating the cycle of pollution. This continuous release of heavy metals from sediments can maintain toxic conditions in the river, even after efforts to reduce surface water contamination. Human health risks associated with heavy metal contamination are significant. Communities using the river water for drinking, cooking, and irrigation are exposed to toxic metals, which can lead to severe health issues, including neurological disorders, kidney damage, and various cancers. The consumption of contaminated fish further increases the risk, particularly for vulnerable groups such as children and pregnant women. In conclusion, the physicochemical analysis of the Yamuna River water highlights the urgent need for effective pollution control measures. Regulatory authorities must enforce stricter effluent standards and ensure compliance by industries to reduce the discharge of heavy metals and organic pollutants. Improved wastewater treatment facilities and sustainable agricultural practices are essential to mitigate pollution sources. Public awareness campaigns can educate communities about the health risks associated with river pollution and promote better waste management practices. Regular monitoring of water quality is crucial to track the effectiveness of implemented measures and to ensure the long-term health and sustainability of the Yamuna River.

Conclusion

This comprehensive assessment of the physicochemical parameters of the Yamuna River highlights the varying water quality along its course, with significant pollution detected in urban and industrial areas. The findings underscore the need for stringent pollution control measures, improved wastewater treatment facilities, and regular monitoring to protect the river's health and ensure the safety of its water for ecological and human use. Future research should focus on identifying specific pollution sources and developing targeted strategies for remediation and sustainable management of the Yamuna River.

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