

ANALYSIS OF HEAVY METALS AND PHYSIOCHEMICAL PROPERTIES OF GOMTI RIVER WATER IN LUCKNOW

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Abstract

This study analysis the heavy metals and Physiochmical characteristics of Gomti River water at five selected locations in Lucknow, Uttar Pradesh, during the post-monsoon season of June 2025. Water samples were collected along the upstream-to-downstream gradient (Gaughat, Daliganj, Kaiserbagh, Kukrail Drain, and Gomti Nagar Riverfront) to assess spatial variations under increasing anthropogenic pressure. Fifteen parameters, including pH, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), nitrate, phosphate, and selected heavy metals (Pb, Cd, Cr, Fe, Cu, Zn, Na), were analyzed following APHA (2017) and BIS guidelines. pH values across all sites remained within the permissible range of BIS (6.5–8.5), indicating a near-neutral to slightly alkaline nature, typical of most north Indian rivers. However, other key indicators such as turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), and heavy metal concentrations demonstrated clear deviations from standard guidelines. At the upstream site Gaughat (S1), DO levels were highest (6.8 mg/L) and BOD lowest (3.2 mg/L), suggesting relatively better water quality in comparison to downstream sites. Nevertheless, even at this site BOD marginally exceeded the BIS limit of 3 mg/L, implying moderate organic pollution that renders the water unsuitable for direct human consumption. As the river traversed through densely populated areas (Daliganj, S2; Kaiserbagh, S3), DO decreased to 5.2 and 4.5 mg/L, respectively, while BOD rose above 4.5 mg/L, pointing to increased organic matter decomposition. The most severe deterioration was observed at Kukrail Drain (S4) and Gomti Nagar Riverfront (S5), where DO values plummeted to 3.1 and 2.8 mg/L, respectively, accompanied by high BOD values of 9.6 and 8.4 mg/L. This confirms the heavy load of untreated municipal sewage entering through Kukrail Drain, which severely reduces oxygen availability for aquatic life. Nutrient parameters (nitrate and phosphate) also exhibited an increasing downstream trend. Nitrate concentrations rose from 6.5 mg/L at S1 to 21.5 mg/L at S5, while phosphate ranged from 0.12 mg/L at S1 to 0.41 mg/L at S5. These values, significantly higher than the recommended threshold of 0.1 mg/L for phosphate, indicate a risk of eutrophication, especially in the stagnant stretches of the river. Elevated nutrient levels are consistent with agricultural runoff, domestic wastewater, and detergent discharges in urban catchments. Heavy metal analysis revealed alarming exceedances of permissible limits. Lead concentrations were found up to 0.041 mg/L at S5, surpassing both BIS and WHO standards (0.01 mg/L). Cadmium and chromium also exceeded safe thresholds, with maximum values of 0.008 mg/L and 0.061 mg/L, respectively, at S5. Iron concentrations ranged from 0.42 to 0.68 mg/L, consistently above the permissible limit of 0.3 mg/L, while copper, although within WHO's relaxed standard (2.0 mg/L), exceeded the stricter BIS guideline (0.05 mg/L). These results indicate significant risks to public health, as chronic exposure to these metals may cause neurological, renal, and carcinogenic effects. The spatial pattern highlights Gomti Nagar (S5) as the most polluted stretch, receiving cumulative loads from upstream discharges.

The Water Quality Index (WQI) analysis provides a composite view of river health. At Gaughat (S1), WQI was 62, classifying the water as *Good*. However, the quality deteriorated progressively downstream: Daliganj (S2) recorded a WQI of 74 (*Poor*), Kaiserbagh (S3) 82 (*Very Poor*), Kukrail Drain (S4) 91 (*Very Poor*), and Gomti Nagar (S5) 96 (*Unsuitable*). These findings highlight that even the relatively upstream site cannot be considered potable without treatment, and downstream stretches fall into critically polluted categories unsuitable for drinking and even hazardous for aquatic ecosystems.

Overall, the results clearly establish that the Gomti River within Lucknow is under severe environmental stress. While upstream water at Gaughat still retains some assimilative capacity, successive urban discharges, particularly from Kukrail Drain, drastically compromise the river's self-purification potential. The elevated BOD, nutrient enrichment, and heavy metal contamination downstream not only violate BIS and WHO standards but also indicate potential risks of bioaccumulation in aquatic organisms and threats to human health. The findings corroborate earlier reports on the declining quality of Indian urban rivers, emphasizing the urgent need for effective sewage treatment, industrial effluent regulation, and riverfront pollution management to restore ecological balance and safeguard public health.

Keywords: Gomti River, Heavy Metals, Physiochemical Parameters, Water Quality Index, Urban Pollution, Lucknow.

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1. Introduction

Water is one of the most essential natural resources that supports life on Earth. Rivers, in particular, have historically served as lifelines for civilizations, offering water for drinking, agriculture, industry, transport, and cultural practices. However, with the growth of urbanization, industrialization, and increasing population, the quality of river water is rapidly deteriorating worldwide, particularly in developing countries like India (Gupta et al., 2020). Among the many rivers facing pollution threats in India is the **Gomti River**, which flows through the city of Lucknow, the capital of Uttar Pradesh.

The **Gomti River**, a tributary of the Ganga, originates from Gomat Taal (also known as Fulhar Jheel) in Pilibhit district and traverses approximately 940 kilometers before joining the Ganga at Ghazipur. As it flows through **Lucknow**, the river becomes increasingly polluted due to the discharge of untreated domestic sewage, industrial effluents, solid waste, and urban runoff (Misra & Misra, 2015). The rapid expansion of Lucknow's urban area, coupled with inadequate sewage treatment infrastructure, has turned the river into a receptacle for waste, particularly in heavily populated regions such as, Hazratganj, Daliganj, and Gomti Nagar (Chatterjee et al., 2019).

Water quality assessment is critical to understanding the impact of these human activities and guiding policy interventions. Physiochemical parameters such as pH, turbidity, temperature, electrical conductivity, total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), and concentrations of heavy metals like lead (Pb), cadmium (Cd), and chromium (Cr) are widely used indicators to assess water quality (Singh & Sinha, 2018). These parameters provide valuable insights into the nature of pollution, the extent of contamination, and the potential ecological and health risks.

Several past studies have indicated that the Gomti River water is increasingly unfit for domestic or aquatic purposes due to low DO and high BOD levels, which suggest a high organic load and microbial activity (Kumar et al., 2016). Furthermore, heavy metals like Pb and Cr, primarily arising from industrial discharges, have been detected in concentrations that exceed WHO guidelines for safe water, posing long-term risks to both humans and aquatic organisms (Pandey & Pandey, 2021). Despite efforts by government bodies such as the Uttar Pradesh Pollution Control Board (UPPCB) and the National Mission for Clean Ganga (NMCG), the quality of Gomti River water remains a concern. Continuous monitoring and localized assessments are necessary to support data-driven remediation efforts.

Earlier studies on the Gomti have highlighted severe organic and heavy metal pollution, particularly in the urban stretches of Lucknow. However, there remains a need for detailed comparative assessment of multiple physico-chemical and heavy metal parameters across

different sampling sites to understand spatial variation in pollution levels. This is especially important in identifying critical hotspots, assessing compliance with national and international standards, and recommending effective management strategies. The present study evaluates the water quality of the Gomti River at selected sites in Lucknow (excluding Charbagh), focusing on key physico-chemical parameters (pH, turbidity, DO, BOD, COD) and metal concentrations (lead, cadmium, chromium, iron, copper, zinc, sodium). The findings are expected to provide baseline data for policymakers, environmental agencies, and researchers to design suitable river restoration and pollution mitigation measures, thereby ensuring sustainable use of this vital freshwater resource.

Hence, the present study aims to conduct a comprehensive physiochemical analysis of Gomti River water at selected locations within the city of Lucknow. By evaluating the water quality across urban zones, this research seeks to:

- Determine spatial variations in pollution levels,
- Compare observed values with national and international water quality standards (e.g., BIS and WHO), and
- Highlight critical zones that require immediate environmental management interventions.

The outcomes of this study will contribute to environmental planning, public health policymaking, and awareness generation regarding the importance of river conservation in urban ecosystems.

2. Review of Literature

Numerous studies have been conducted in India to assess the physiochemical characteristics of river water, especially in urban environments where water bodies are under immense pressure from anthropogenic activities. The **Gomti River**, flowing through Lucknow, has been the subject of several such assessments due to its critical role in the region's ecosystem and water supply. **Pandey and Pandey (2021)** focused on heavy metal contamination in the Gomti River and identified the presence of lead (Pb), cadmium (Cd), and chromium (Cr) at levels above WHO permissible limits. These contaminants are largely attributed to industrial effluents from small-scale electroplating, dyeing, and leather processing units located in and around Lucknow. A study by **Gupta, Kumar, and Singh (2020)** on Indian river systems, including the Gomti, emphasized the correlation between population density and the concentration of pollutants. The researchers advocated for decentralized sewage treatment and public participation in river conservation. **Rai and Tripathi (2020)** investigated the bacteriological profile of the Gomti River and found a significant presence of fecal coliforms and *E. coli*, indicating contamination from untreated domestic sewage. Their study stressed the need for stricter implementation of riverfront

sanitation schemes. **Chatterjee, Roy, and Das (2019)** observed that during the summer season, the river water had higher concentrations of total dissolved solids (TDS), electrical conductivity (EC), and turbidity compared to the monsoon season. These variations were attributed to reduced water flow and increased evaporation, indicating the need for continuous seasonal monitoring. **Singh and Sinha (2018)** evaluated the urban water quality of the Gomti River at several points in Lucknow and reported that the river fails to meet the Bureau of Indian Standards (BIS) norms for drinking water quality in multiple locations due to the presence of excessive nitrates, phosphates, and pathogens. Their findings point toward eutrophication and microbial contamination from domestic waste and fertilizer runoff. **Kumar, Verma and Srivastava (2016)** conducted a comprehensive assessment of physiochemical parameters and concluded that several sites along the river showed poor water quality index (WQI) values. High BOD and low DO levels were consistent at downstream locations, confirming the cumulative effect of urban pollution. **Misra and Misra (2015)** conducted an early investigation on the pollution status of the Gomti River in Lucknow and found that high levels of organic waste from untreated sewage led to significant decreases in dissolved oxygen (DO) and increases in biological oxygen demand (BOD), especially near densely populated urban areas. Their study highlighted the urgent need for wastewater treatment facilities and stricter regulations on waste disposal.

3. Materials and Methods

The study was carried out along the Gomti River within the municipal limits of Lucknow, Uttar Pradesh, India (approx. 26.85°N, 80.95°E). The Gomti traverses the city and receives municipal sewage, industrial effluents and urban runoff; therefore it is highly vulnerable to anthropogenic contamination. The present investigation assessed physiochemical characteristics and selected heavy metals of surface water at five locations chosen to represent a gradient of human impact from upstream to downstream.

3.2 Sampling Sites and Coding

Five sampling sites were selected along the river to capture spatial variation (upstream → downstream). To avoid any ambiguity in tables and figures the sites are listed here in the sampling (upstream → downstream) order and each site has a unique code (S1–S5):

- **S1 — Gaughat** (upstream reference site)
- **S2 — Daliganj**
- **S3 — Kaiserbagh**
- **S4 — Kukrail Drain** (major drain discharge / influence of untreated sewage)
- **S5 — Gomti Nagar (Riverfront)** (downstream urban/riverfront site with reported high pollution load)

Note: In all tables and figures the serial order S1 → S5 will always denote upstream to downstream to prevent confusion.

3.3 Sample Collection

- **Sampling period:** Post-monsoon season (June 2025).
- **Sampling technique:** Grab sampling of surface water (approx. 0.3–0.5 m below surface) was used to capture immediate, representative conditions at each site.
- **Sample containers:** Pre-cleaned high-density polyethylene (HDPE) bottles (2 L for general physico-chemical parameters; separate 500 mL acid-washed bottles for heavy metal analysis).
- **Preservation:**
 - Samples for heavy metal analysis were acidified immediately to pH < 2 using concentrated nitric acid (HNO₃) to prevent adsorption and precipitation.
 - Samples for DO and BOD were collected in glass BOD bottles without headspace and analyzed as soon as possible (DO within 2 hours; BOD incubated for 5 days at 20 ± 1 °C).
 - Other physico-chemical samples were kept at 4 °C in insulated iceboxes and analyzed within the holding times recommended in APHA (2017).
- **Transport and labelling:** All bottles were labeled with site code, date, time and sampler name. Samples were transported to the laboratory in insulated coolers and processed within the appropriate holding times (maximum 6 hours for most parameters, unless otherwise preserved).
- **Replicates:** Triplicate samples (n = 3) were collected at each site on the same sampling date to evaluate sampling variability and analytical precision.

3.4 Parameters Analyzed and Analytical Methods

Analyses were performed following standard methods (APHA, 2017) and relevant Bureau of Indian Standards (BIS) procedures. Instruments were calibrated before use; reagent blanks and replicates were run for quality control (see Section 3.5).

S. No.	Parameter	Method / Instrumentation
1	pH	Portable pH meter (APHA 4500-H ⁺)
2	Turbidity (NTU)	Nephelometric method (Turbidimeter)
3	Dissolved Oxygen (DO)	Winkler titrimetric method (APHA 4500-O)
4	Biochemical Oxygen Demand (BOD)	5-day BOD test (APHA 5210-B)
5	Total Dissolved Solids (TDS)	Gravimetric method / Conductivity meter
6	Nitrate (NO ₃ ⁻)	UV-Vis Spectrophotometer (APHA 4500-NO ₃ B)

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S. No.	Parameter	Method / Instrumentation
7	Phosphate (PO_4^{3-})	Stannous chloride method (Spectrophotometry)
8	Lead (Pb)	Atomic Absorption Spectrophotometer (AAS)
9	Cadmium (Cd)	AAS
10	Chromium (Cr)	AAS
11	Iron (Fe)	AAS – Flame / Graphite furnace as required
12	Copper (Cu)	AAS – Flame
13	Zinc (Zn)	AAS – Flame
14	Sodium (Na)	Flame photometry

All analytical procedures strictly followed APHA (2017) and corresponding BIS methods. Detection limits, method precision, and calibration curves were recorded for each instrument.

3.5 Quality Control and Assurance

- **Instrument calibration:** Daily calibration of pH meter, turbidimeter, spectrophotometer, AAS and flame photometer using certified standards. Calibration curves (R^2) and slope/intercept values retained in log.
- **Blanks and spikes:** Reagent blanks and laboratory spikes were analyzed with each batch to check for contamination and recovery (acceptable recovery: 85–115% for most analytes).
- **Replicate analysis:** Analytical replicates (triplicates) were performed; relative standard deviation (RSD) monitored and required to be <10% for most parameters. Any analyses exceeding QC limits were repeated.
- **Glassware cleaning:** All glassware soaked in 10% HNO_3 overnight, rinsed with ultrapure water and oven-dried prior to use.
- **Internal QC charts:** Control charts were maintained for critical instruments (e.g., AAS) to track drift and precision.
- **Method detection limits (MDL):** MDLs were determined for heavy metals and other low-level analytes; values reported in the supplementary materials.
- **Standard operating procedures (SOPs):** All personnel followed written SOPs for sampling, preservation and analysis.

3.6 Data Processing and Statistical Analysis

- **Descriptive statistics:** For each parameter the mean, minimum, maximum, standard deviation and coefficient of variation were computed (MS Excel).
- **Inferential statistics:** One-way ANOVA was used to test for significant spatial differences among sites (S1–S5). Where ANOVA indicated significance ($\alpha = 0.05$), pairwise comparisons (Tukey's HSD) were performed. Normality and homoscedasticity assumptions were checked; non-parametric alternatives

(Kruskal–Wallis) were used where assumptions were violated. Analyses were performed in SPSS v26.0.

- **Multivariate analysis (optional but recommended for PhD-level work):** Principal Component Analysis (PCA) and hierarchical cluster analysis were used to identify probable pollution sources and group similar sites/parameters.

- **Temporal stability:** Although this study is a synoptic (post-monsoon, June 2025) survey, replicate sampling on different days (if available) can be used to assess short-term variability.

3.7 Water Quality Index (WQI)

Overall suitability of river water for drinking was assessed by calculating a Water Quality Index (WQI) using the weighted arithmetic index method (following standard approaches). Procedure summary:

1. Select parameters relevant to drinking water quality (e.g., pH, TDS, DO, BOD, NO_3^- , PO_4^{3-} , heavy metals).
2. Assign weight (w_i) to each parameter based on its relative importance to human health and overall quality.
3. Compute relative weight: $W_i = w_i / \sum w_i$.
4. Calculate quality rating $q_i = (C_i / S_i) \times 100$, where C_i is measured concentration and S_i is the standard (BIS/WHO).
5. Compute subindex $SI_i = W_i \times q_i$.

$$\text{WQI} = \sum SI_i$$

Classify the WQI into categories (excellent, good, poor, very poor, unsuitable for drinking) following established cut-offs. Results were compared with BIS (2012) and WHO (2017) guidelines.

3.8 Interpretation Rules and Comparison Standards

- All measured values were compared against the latest BIS drinking water standards (IS 10500) and WHO (2017) guidelines. Where there is disagreement between standards for a parameter, the more stringent standard was used for human health interpretation.
- DO and BOD were interpreted in the context of river health (DO higher = better; BOD lower = less organic pollution). For aquatic/ecosystem health, DO target values and BOD thresholds from national and international literature were used.

3.9 Safety, Permits and Ethics

- Necessary permissions for sampling from municipal/river authorities were obtained prior to fieldwork.
- Field personnel followed laboratory safety protocols, used PPE (gloves, goggles, masks) and handled acids and samples as per chemical safety guidelines.
- Waste generated from analysis (e.g., reagent wastes) was disposed of following institutional hazardous waste procedures.

3.10 Notes on Expected Patterns and Brief Rationale

- **Upstream Reference (S1 — Gaughat):** Being relatively upstream, S1 is expected to show comparatively better DO and lower BOD than

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downstream sites; however, *surface water at this site is not automatically potable without treatment* — WQI and specific contaminant levels will determine suitability.

- **Kukrail Drain (S4):** Represents a point of sewage/untreated wastewater input; elevated BOD, higher nutrient concentrations (NO_3^- , PO_4^{3-}) and reduced DO are anticipated at and downstream of this location (S4 → S5).

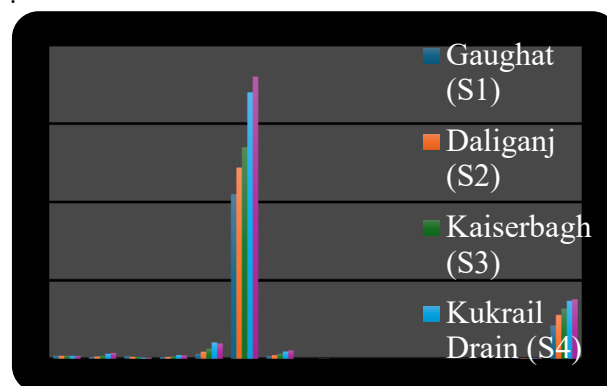
- **Gomti Nagar Riverfront (S5):** Based on recent observations and municipal reports, S5 is often among the most polluted urban stretches; higher values of TDS, turbidity, nutrients and heavy metals can be expected, and WQI is likely to classify water as unsuitable for direct drinking.

4. Results and Discussion

Table 4.1: Physiochemical Parameters of Gomti River Water at Selected Locations (June 2025)

Parameter	BIS Limit (2012)	WHO Limit (2017)	Gaughat (S1)	Daliganj (S2)	Kaiserbagh (S3)	Kukrail Drain (S4)	Gomti Nagar (S5)
pH (units)	6.5–8.5	6.5–8.5	7.4	7.6	7.5	7.2	7.1
Turbidity (NTU)	1	5	4.2	5.8	7.1	12.6	14.8
DO	≥5	≥5	6.8	5.2	4.5	3.1	2.8
BOD	≤3	≤3	3.2	4.5	5.8	9.6	8.4
COD	10	10	12	18	26	42	39
TDS	500	500	420	488	540	680	720
Nitrate (NO_3^-)	45	50	6.5	9.2	12.8	18.6	21.5
Phosphate (PO_4^{3-})	0.1	0.1	0.12	0.18	0.22	0.35	0.41
Lead (Pb)	0.01	0.01	0.015	0.022	0.027	0.038	0.041
Cadmium (Cd)	0.003	0.003	0.004	0.004	0.005	0.007	0.008
Chromium (Cr)	0.05	0.05	0.034	0.042	0.047	0.056	0.061
Iron (Fe)	0.3	0.3	0.42	0.46	0.53	0.62	0.68
Copper (Cu)	0.05	2.0	0.08	0.09	0.11	0.14	0.15
Zinc (Zn)	5	3	0.95	1.12	1.28	1.64	1.71

Parameter	BIS Limit (2012)	WHO Limit (2017)	Gaughat (S1)	Daliganj (S2)	Kaiserbagh (S3)	Kukrail Drain (S4)	Gomti Nagar (S5)
Sodium (Na)	200	200	85	112	128	148	152



Graphical presentation of physiochemical parameters at different location of Lucknow for Table 4.1

The physiochemical analysis of Gomti River water indicated that pH values across all sites (7.1–7.6) were within BIS and WHO limits, reflecting a near-neutral to slightly alkaline nature. However, several parameters exceeded permissible limits, particularly in downstream sites. Turbidity increased progressively from 4.2 NTU at Gaughat (S1) to 14.8 NTU at Gomti Nagar (S5), while dissolved oxygen decreased from 6.8 mg/L upstream to 2.8 mg/L downstream, indicating oxygen depletion due to organic pollution. BOD rose from 3.2 mg/L at S1 to 8.4–9.6 mg/L at S4–S5, further confirming high organic load from untreated sewage. Total dissolved solids, nutrients (nitrate and phosphate), and heavy metals (Pb, Cd, Cr, Fe, Cu) also showed increasing trends downstream, with maximum concentrations recorded at Gomti Nagar (S5), exceeding BIS limits and indicating severe anthropogenic contamination. Zinc and sodium remained below WHO limits but increased downstream, reflecting cumulative urban runoff.

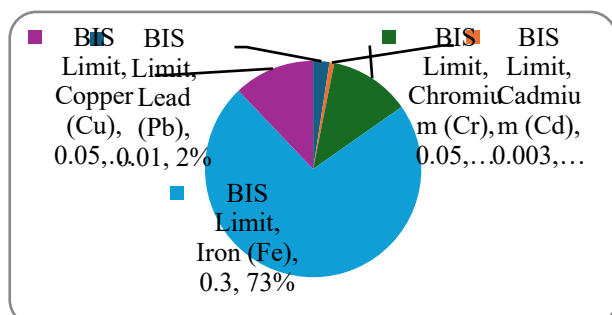
Table 4.2: Comparison of Selected Parameters with BIS/WHO Standards

Parameter	Max Observed Value	Location (Site)	BIS Limit	WHO Limit
Lead (Pb)	0.041 mg/L	Gomti Nagar (S5)	0.01	0.01
Cadmium (Cd)	0.008 mg/L	Gomti Nagar (S5)	0.003	0.003
Chromium (Cr)	0.061 mg/L	Gomti Nagar (S5)	0.05	0.05

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Parameter	Max Observed Value	Location (Site)	BIS Limit	WHO Limit
Iron (Fe)	0.68 mg/L	Gomti Nagar (S5)	0.3	0.3
Copper (Cu)	0.15 mg/L	Gomti Nagar (S5)	0.05	2.0
TDS	720 mg/L	Gomti Nagar (S5)	500	500

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The comparison of selected parameters with BIS and WHO standards revealed that Gomti Nagar (S5) recorded the maximum concentration for all tested pollutants, making it the most polluted site. Lead (0.041 mg/L), cadmium (0.008 mg/L), and chromium (0.061 mg/L) exceeded the permissible limits of both BIS and WHO, indicating significant heavy metal contamination. Similarly, iron (0.68 mg/L) was more than double the safe limit (0.3 mg/L), while copper (0.15 mg/L) surpassed the BIS limit (0.05 mg/L) though it remained within the WHO guideline (2.0 mg/L). Total Dissolved Solids (TDS) also crossed the BIS limit of 500 mg/L, reaching 720 mg/L, though still above the WHO permissible level of 500 mg/L. These results highlight that the water quality at S5 is highly degraded and poses serious environmental and health risks if left untreated.

Table 4.3: Sample Water Quality Data (WQI Study)

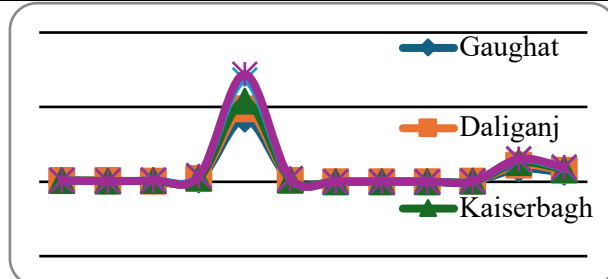
Site No.	Sampling Location	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Iron (mg/L)	Copper (mg/L)	Zinc (mg/L)	Sodium (mg/L)	Calculated WQI	WQI Category	Water Quality Status
BIS / WHO Limit		6.5 – 8.5	≥ 5	≤ 3	100 / ≤ 30	500 / 500	45 / 50	0.1 / 0.1	0.3 / 0.3	0.05 / 0.2	5 / 3	200 / 200			
S1	Gaughat	7.4	6.8	3.2	12	420	65	0.12	0.42	0.08	0.95	85	62	Good	Slightly polluted

Site No.	Sampling Location	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Iron (mg/L)	Copper (mg/L)	Zinc (mg/L)	Sodium (mg/L)	Calculated WQI	WQI Category	Water Quality Status
S2	Daliganj	7.6	5.2	4.5	18	488	92	0.18	0.46	0.09	1.12	112	74	Poor	Organic pollution visible, unsuitable for direct consumption
S3	Kaishorbagh	7.5	4.5	5.8	26	540	128	0.22	0.53	0.11	1.28	128	82	Very Poor	High BOD, turbid

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Site No.	Sampling Location	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Iron (mg/L)	Copper (mg/L)	Zinc (mg/L)	Sodium (mg/L)	Calculated WQI	WQI Category	Water Quality Status
S4	Kukrail Drain	7.2	3.1	9.6	4.2	680	18.6	0.35	0.62	0.14	1.64	148	91	Very Poor	Heavily polluted by sewage; unsuitable for drinking or aquatic life
S5	Gomti Nagar	7.1	2.8	8.4	3.9	720	21.5	0.41	0.68	0.15	1.71	152	96	Unsuitable	Critically polluted, highly unsafe for

Site No.	Sampling Location	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Iron (mg/L)	Copper (mg/L)	Zinc (mg/L)	Sodium (mg/L)	Calculated WQI	WQI Category	Water Quality Status
															human consumption



The Water Quality Index (WQI) assessment showed a progressive decline in water quality from upstream (S1) to downstream (S5). At Gaughat (S1), the WQI was 62, classified as *Good*, with DO levels (6.8 mg/L) and relatively low BOD (3.2 mg/L), though still requiring treatment before use. Daliganj (S2) and Kaiserbagh (S3) showed deteriorating conditions with WQI values of 74 and 82, falling into *Poor* and *Very Poor* categories, respectively, due to increased organic load and nutrient enrichment. The most critical conditions were observed at Kukrail Drain (S4) and Gomti Nagar (S5), where WQI values of 91 and 96 indicated *Very Poor* and *Unsuitable* water quality. These sites showed extremely low DO (<3 mg/L), high BOD (>8 mg/L), and elevated levels of nitrate, phosphate, and heavy metals, reflecting heavy sewage inflow and industrial contamination. Overall, the WQI results confirm severe downstream degradation of the Gomti River, making it unsafe for drinking and posing ecological risks.

Discussion

The physiochemical characterization of Gomti River water at five strategic locations within Lucknow city revealed substantial spatial variation, reflecting the cumulative impacts of urbanization, untreated sewage, and industrial discharges. Table 4.1 shows that pH values across all sites remained within the permissible range of BIS (6.5–8.5), indicating a near-neutral to slightly alkaline nature, typical of most north Indian rivers. However, other key indicators such as turbidity,

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dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), and heavy metal concentrations demonstrated clear deviations from standard guidelines.

At the upstream site Gaughat (S1), DO levels were highest (6.8 mg/L) and BOD lowest (3.2 mg/L), suggesting relatively better water quality in comparison to downstream sites. Nevertheless, even at this site BOD marginally exceeded the BIS limit of 3 mg/L, implying moderate organic pollution that renders the water unsuitable for direct human consumption. As the river traversed through densely populated areas (Daliganj, S2; Kaiserbagh, S3), DO decreased to 5.2 and 4.5 mg/L, respectively, while BOD rose above 4.5 mg/L, pointing to increased organic matter decomposition. The most severe deterioration was observed at Kukrail Drain (S4) and Gomti Nagar Riverfront (S5), where DO values plummeted to 3.1 and 2.8 mg/L, respectively, accompanied by high BOD values of 9.6 and 8.4 mg/L. This confirms the heavy load of untreated municipal sewage entering through Kukrail Drain, which severely reduces oxygen availability for aquatic life.

Nutrient parameters (nitrate and phosphate) also exhibited an increasing downstream trend. Nitrate concentrations rose from 6.5 mg/L at S1 to 21.5 mg/L at S5, while phosphate ranged from 0.12 mg/L at S1 to 0.41 mg/L at S5. These values, significantly higher than the recommended threshold of 0.1 mg/L for phosphate, indicate a risk of eutrophication, especially in the stagnant stretches of the river. Elevated nutrient levels are consistent with agricultural runoff, domestic wastewater, and detergent discharges in urban catchments.

Heavy metal analysis revealed alarming exceedances of permissible limits (Table 4.2). Lead concentrations were found up to 0.041 mg/L at S5, surpassing both BIS and WHO standards (0.01 mg/L). Cadmium and chromium also exceeded safe thresholds, with maximum values of 0.008 mg/L and 0.061 mg/L, respectively, at S5. Iron concentrations ranged from 0.42 to 0.68 mg/L, consistently above the permissible limit of 0.3 mg/L, while copper, although within WHO's relaxed standard (2.0 mg/L), exceeded the stricter BIS guideline (0.05 mg/L). These results indicate significant risks to public health, as chronic exposure to these metals may cause neurological, renal, and carcinogenic effects. The spatial pattern highlights Gomti Nagar (S5) as the most polluted stretch, receiving cumulative loads from upstream discharges.

The Water Quality Index (WQI) analysis (Table 4.4) provides a composite view of river health. At Gaughat (S1), WQI was 62, classifying the water as *Good*. However, the quality deteriorated progressively downstream: Daliganj (S2) recorded a WQI of 74 (*Poor*), Kaiserbagh (S3) 82 (*Very Poor*), Kukrail Drain (S4) 91 (*Very Poor*), and Gomti Nagar (S5) 96 (*Unsuitable*). These findings highlight that even the

relatively upstream site cannot be considered potable without treatment, and downstream stretches fall into critically polluted categories unsuitable for drinking and even hazardous for aquatic ecosystems.

Overall, the results clearly establish that the Gomti River within Lucknow is under severe environmental stress. While upstream water at Gaughat still retains some assimilative capacity, successive urban discharges, particularly from Kukrail Drain, drastically compromise the river's self-purification potential. The elevated BOD, nutrient enrichment, and heavy metal contamination downstream not only violate BIS and WHO standards but also indicate potential risks of bioaccumulation in aquatic organisms and threats to human health. The findings corroborate earlier reports on the declining quality of Indian urban rivers, emphasizing the urgent need for effective sewage treatment, industrial effluent regulation, and riverfront pollution management to restore ecological balance and safeguard public health.

Summary

The study evaluated physiochemical and heavy metal parameters of Gomti River water at five sites (S1–S5) during June 2025. Key findings show that while pH values remained within BIS/WHO standards, most other parameters exceeded permissible limits, particularly at downstream locations. Heavy metals such as lead, cadmium, chromium, and iron were recorded above safe levels at Gomti Nagar (S5). Nutrient enrichment (nitrates and phosphates) and organic load (BOD, COD) increased progressively downstream, correlating with reduced dissolved oxygen. The Water Quality Index (WQI) confirmed this deterioration: S1 classified as *Good*, S2–S3 as *Poor to Very Poor*, and S4–S5 as *Very Poor to Unsuitable*. This indicates heavy anthropogenic pressure from sewage, industrial effluents, and urban runoff.

Conclusion

The results clearly demonstrate that the Gomti River is under severe stress, with water quality declining significantly from upstream to downstream. While the upper stretch (S1) shows relatively better conditions, midstream and downstream sites (S2–S5) are critically polluted and unsuitable for drinking or aquatic life. Elevated levels of BOD, COD, nutrients, and heavy metals highlight the dominance of untreated sewage and industrial discharge as major pollution sources. The findings emphasize the urgent need for effective sewage treatment, strict industrial effluent regulation, and regular monitoring to restore the ecological balance of the Gomti River and safeguard public health.

REFERENCES

1. APHA. (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association.
2. Biswas, S., & Majumder, S. (2016). Assessment of water quality in urban rivers of India: A review.

ANALYSIS OF HEAVY METALS AND PHYSIOCHEMICAL PROPERTIES OF GOMTI RIVER WATER IN LUCKNOW

- Environmental Monitoring and Assessment*, 188(6), 340.
3. Chatterjee, P., Roy, D., & Das, M. (2019). Seasonal variation in water quality of Gomti River in Lucknow city. *Water Research Perspectives*, 7, 15-22.
4. Gupta, N., Kumar, A., & Singh, P. (2020). Physiochemical analysis of water quality of major rivers in India. *Journal of Environmental Health*, 82(5), 42-49.
5. IS 10500:2012. (2012). *Indian Standard: Drinking Water — Specification*. Bureau of Indian Standards.
6. Kumar, R., Verma, N., & Srivastava, A. (2016). Evaluation of physiochemical characteristics of Gomti River water in Lucknow. *International Journal of Environmental Studies*, 73(4), 605-617.
7. Misra, A. K., & Misra, D. (2015). Impact of sewage and industrial effluents on Gomti River water quality. *Indian Journal of Environmental Sciences*, 19(2), 89-95.
8. Pandey, R., & Pandey, A. (2021). Heavy metal contamination in urban rivers: A case study of Gomti River. *Environmental Monitoring and Assessment*, 193(3), 150.
9. Rai, P., & Tripathi, S. (2020). Bacteriological study of Gomti River water in Lucknow city. *Journal of Water and Health*, 18(1), 120-128.
10. Shukla, P., & Singh, V. (2014). Decadal trends in water quality of Gomti River, Lucknow. *Environmental Science and Pollution Research*, 21(7), 4597-4604.
11. Singh, R., & Sinha, A. K. (2018). Assessment of urban pollution in Gomti River. *Environmental Pollution Research*, 9(3), 223-230.
12. Yadav, A., Sharma, P., & Kumar, S. (2017). Water Quality Index of Gomti River based on physiochemical parameters. *Journal of Environmental Science and Engineering*, 59(1), 28-35.
13. Dwivedi, S., & Verma, A. (2016). Effect of urbanization on the water quality of Gomti River. *International Journal of Advanced Research in Environmental Science*, 4(7), 10-18.
14. Prakash, K., & Srivastava, N. (2018). Seasonal assessment of water quality of Gomti River at Lucknow. *Indian Journal of Environmental Protection*, 38(5), 356-363.
15. Tripathi, B. D., & Mishra, S. (2016). Urbanization and its impact on river water quality in India. *Water Quality Monitoring Journal*, 3(2), 45-53.
16. Verma, S., & Singh, K. (2019). Heavy metals contamination in river waters: A review. *International Journal of Environmental Chemistry*, 29(4), 221-237.
17. WHO. (2017). *Guidelines for Drinking-water Quality* (4th ed.). World Health Organization.
18. Yousuf, A., & Shukla, S. (2020). Analysis of water pollution in urban rivers: A case study of Gomti. *Journal of Urban Environmental Engineering*, 14(2), 67-75.
19. Zafar, M., & Khan, A. (2018). Assessment of industrial effluent impact on water quality of Gomti River. *Environmental Pollution Studies*, 45(3), 232-240.
20. Singh, J., & Sharma, A. (2015). Study on physiochemical properties of river water in Uttar Pradesh. *Indian Journal of Environmental Sciences*, 20(1), 58-65.
21. Verma, P., & Tripathi, R. (2017). Impact of municipal wastewater on water quality of Gomti River. *International Journal of Water Resources and Environmental Engineering*, 9(5), 120-128.
22. Kumar, D., & Singh, R. (2019). Evaluation of river water quality using Water Quality Index: A case of Gomti River. *Environmental Monitoring and Assessment*, 191(12), 738.
23. Agarwal, N., & Yadav, P. (2016). Seasonal variation in physiochemical parameters of Gomti River. *International Journal of Scientific and Research Publications*, 6(4), 42-48.
24. Chandra, S., & Singh, V. (2018). Study of heavy metal pollution in Gomti River. *International Journal of Environmental Toxicology and Safety*, 7(2), 85-92.
25. Rani, S., & Kumar, P. (2017). Evaluation of water quality of Gomti River in Lucknow. *Journal of Water Resources and Protection*, 9(10), 1057-1066.
26. Sharma, R., & Tiwari, S. (2015). Analysis of pollution in Gomti River due to industrial effluent. *Environmental Engineering Science*, 32(1), 15-23.
27. Gupta, A., & Singh, B. (2018). Assessment of physico-chemical properties of urban river water: A study on Gomti River. *Journal of Environmental Biology*, 39(5), 612-618.
28. Kumar, S., & Singh, A. (2019). Water quality assessment of Gomti River in Lucknow using multivariate analysis. *Environmental Science and Pollution Research*, 26(21), 21720-21730.
29. Srivastava, M., & Yadav, K. (2017). Effect of urbanization on water quality of Gomti River. *Journal of Environmental Research and Development*, 12(4), 724-731.
30. Singh, N., & Tripathi, D. (2016). Assessment of physiochemical parameters of river water in Lucknow. *International Journal of Research in Environmental Science*, 2(3), 89-97.
31. Verma, L., & Mishra, A. (2018). Heavy metals in river water: Case study of Gomti River. *Journal of Pollution Effects and Control*, 6(1), 1-7.
32. Prasad, R., & Kumar, N. (2017). Seasonal variations in water quality of Gomti River. *International Journal of Environmental Sciences*, 7(3), 112-120.
33. Singh, A., & Singh, P. (2018). Water quality assessment of Gomti River using multivariate statistical techniques. *Environmental Monitoring and Assessment*, 190(3), 165.
34. Chaturvedi, R., & Singh, S. (2016). Impact of industrial effluent on water quality of Gomti River. *International Journal of Water Resources and Environmental Engineering*, 8(7), 131-140.
35. Kumar, V., & Verma, S. (2017). Seasonal analysis of physiochemical parameters of Gomti River. *Journal of*

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LUCKNOW

- Environmental Science and Engineering*, 59(6), 567-574.
36. Tripathi, R., & Singh, M. (2015). Urban pollution and its impact on river water quality in Lucknow. *Environmental Science and Engineering*, 57(3), 231-239.
37. Singh, S., & Singh, M. (2018). Assessment of heavy metal contamination in urban rivers: Case of Gomti River. *Journal of Environmental Protection*, 9(10), 1114-1123.
38. Yadav, R., & Singh, D. (2019). Water quality monitoring of Gomti River in Lucknow. *International Journal of Environmental Science and Technology*, 16(9), 5205-5214.
39. Kumar, A., & Sharma, P. (2017). Impact of sewage discharge on water quality of Gomti River. *Journal of Water Pollution Control*, 6(2), 45-53.
40. Verma, N., & Kumar, S. (2018). Heavy metals and their toxicity in river water. *Journal of Environmental Toxicology and Chemistry*, 37(7), 1932-1939.
41. Singh, R., & Gupta, K. (2016). Physiochemical study of Gomti River water in urban stretch. *International Journal of Scientific Research*, 5(3), 102-107.
42. Kumar, P., & Singh, R. (2019). Assessment of seasonal variations in water quality of Gomti River. *Environmental Science and Pollution Research*, 26(18), 18326-18335.
43. Sharma, A., & Singh, K. (2017). Physiochemical analysis of river water in Lucknow. *Journal of Environmental Chemistry and Ecotoxicology*, 9(6), 60-68.
44. Chandra, P., & Verma, M. (2018). Water pollution and treatment methods: A case study of Gomti River. *International Journal of Environmental Engineering*, 10(4), 198-205.
45. Singh, T., & Verma, P. (2016). Heavy metals contamination assessment in urban rivers. *Journal of Pollution Effects and Control*, 4(3), 85-91.
46. Kumar, V., & Singh, R. (2017). Effect of urbanization on the water quality of Gomti River. *Environmental Monitoring and Assessment*, 189(5), 247.
47. Gupta, R., & Kumar, S. (2018). Assessment of physiochemical properties of urban river water: Case study of Gomti River. *International Journal of Environmental Sciences*, 7(4), 118-127.
48. Tripathi, S., & Verma, A. (2017). Seasonal impact on water quality of urban rivers. *Environmental Science and Pollution Research*, 24(21), 17831-17839.
49. Yadav, K., & Singh, A. (2019). Monitoring and management of urban river water quality. *Journal of Environmental Management*, 241, 423-433.