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Assessment of Physico-Chemical Property of the Gomti River Lucknow, Uttar Pradesh, India

Surendra Kr. Pali[1], Mohd. Aftab Alam[1]
[1]Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, UP, India

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Corresponding author: Mohd. Aftab Alam

Email: ***aftab.alam@shuats.edu.in***

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Abstract

Determining the current condition of the water in the Gomti River along the Lucknow section was the aim of this investigation. Sewage pollution, levels of organic compounds, different heavy metals, and physico-chemical properties have all been thoroughly examined across Lucknow. The Gomti barrage is below, while Gaughat is upstream.Samples are moved from regions upstream to those downstream.Total solids, total dissolved solids, total suspended solids, temperature, pH, As, Cd, nitrate, nitrite, chloride, iron, copper, hardness, and dissolved oxygen (DO) are all examined in water samples. According to the study's findings, the Gomti River is contaminated by numerous drains that dump untreated household and industrial garbage into the river. Other reasons to remove solid waste at pumping stations include the fact that most branch and trunk sewers don't work properly or that the pumping station occasionally malfunctions, causing sewage waste to be bypassed and dumped straight into the Gomti River. According to the report, the discharge of untreated garbage from roughly 26 major drains along the Gaughat to Gomti barrage has caused the water quality to deteriorate. The Gomti River near Lucknow, also known as Gaughat, is a river that has a minimum pH of 7.55 and a maximum dissolved oxygen content of 3.33 mg/lit. But due to presence of 26 drains the dissolved oxygen level decreases with its stretch and showed minimal DO at Laxmanamela Park.

Keywords: Gomti River: Water quality assessment: Sewage pollution: Heavy metals: Physico-chemical parameters.

Introduction

Water is fundamental to life on Earth, yet this vital resource is increasingly threatened by rising demand and degradation. Although water covers approximately 70% of the Earth's surface, only about 3% is fresh water, and of that, merely 0.15% is readily accessible for human use (Sangodoyin and Reoforiokuma, 2014; Shiklomanov, 1993). Surface-water bodies such as rivers, lakes, ponds, and canals play a key role in supporting ecosystems, supplying drinking water, and sustaining agricultural production. Traditionally, irrigation studies have focused primarily on the availability and allocation of water, but water quality is equally critical for sustainable agriculture (Ayers and Westcot, 1985). Unfortunately, in many regions, agricultural systems rely on low-quality water sources, leading to soil salinity, crop damage, and long-term land degradation.

Surface-water pollution has emerged as one of the most pressing environmental issues, particularly in developing countries. Numerous studies in India have examined surface-water quality to identify pollution hotspots, assess anthropogenic impacts, and support water management planning (Central Pollution Control Board, 2022; Sharma et al., 2021). Rivers flowing through densely populated and industrialized areas often experience severe contamination due to industrial discharge, municipal sewage, agricultural runoff, and unregulated dumping of solid waste. Pollutants from domestic sewage, detergents, animal washing, and industrial effluents degrade water quality and disrupt aquatic ecosystems. As water comes into contact with natural and anthropogenic materials, its chemical composition changes due to interactions with soil minerals, industrial contaminants, and organic waste.

The Gomti River, a major tributary of the Ganga, flows through one of the most densely populated regions of Uttar Pradesh, including major cities such as Lucknow, Lakhimpur Kheri, Sultanpur, and Jaunpur. The river basin supports approximately 18 million people, and flow in the river is highly dependent on monsoon rainfall. As Gomti passes through urban and industrial zones, it accumulates untreated municipal wastewater, industrial effluents, and agricultural runoff, leading to significant deterioration in water quality (UPPCB, 2013; Mishra and Malik, 2012). Industrial units such as sugar mills, distilleries, dairy plants, and vegetable-oil industries discharge wastewater directly or indirectly into the river system. In addition, domestic sewage, washing of clothes and animals, waste dumping, and inflow from local drains impose a high pollution load. The city of Lucknow alone contributes approximately 325 million litres per day of domestic and industrial wastewater to the river (UPPCB, 2013). As a result, the river's ecological health is severely threatened, impacting aquatic biodiversity and posing risks to human health and agricultural use.

Recent studies on the Gomti River highlight increasing concern over declining water quality due to rapid urbanization, industrial discharge, and inadequate wastewater treatment. Researchers have frequently applied physicochemical analysis along with Water Quality Index (WQI) and multivariate statistical techniques to assess pollution hotspots and temporal variations in water quality. Mishra and Malik (2012) reported significant contamination in the Lucknow stretch, mainly due to untreated sewage and industrial effluents. Krishan et al. (2019) found high pollution loads using WQI and Synthetic Pollution Index, identifying urban stretches as critically polluted. More recent investigations such as Kushwah et al. (2023) confirmed degradation driven by domestic sewage, industrial discharge, and agricultural runoff, emphasizing seasonal fluctuation in pollution intensity. Reports by CPCB (2022) also classified the Gomti as a polluted river stretch, urging improved sewage treatment and river rejuvenation measures. Overall, literature underscores that continuous monitoring and effective wastewater management are essential for protecting the Gomti River's ecological health and ensuring safe water availability. The present study aims to analyze the physicochemical characteristics of water from the Gomti River at selected locations and investigate spatial trends in water quality parameters to understand pollution dynamics and its implications for water resource management.

Material and Methods

Study Area

The central Gangetic plain is home to Lucknow, the capital of Uttar Pradesh, India (Fig. 1). The city experiences intense summers from April to June and chilly, dry winters from December to February due to its humid, dry subtropical climate. Summertime highs are 48.9°C, while wintertime lows are 1.67°C. Between July and September, the southwest monsoon brings roughly 900 mm of rain to the city each year. The city typically slopes eastward and ranges in elevation from 100 to 130 meters above sea level. One of the cities with the fastest growth in 2011 was Lucknow. Along with groundwater, the Gomti River is one of the city's main supplies of public water. The city's main issue is the production of sewage and the appropriate handling and disposal of this waste. River water quality has drastically declined as a result of inadequate sewage systems and insufficient sewage treatment unit capacity.

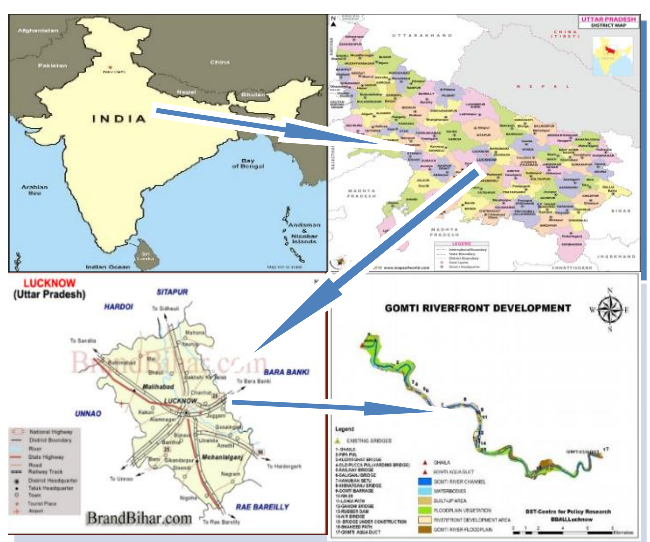

Fig.1 Location map of the study area

Water Sampling

For the purpose of analysis, a representative sample of water from the industrial site and natural surroundings was collected using the conventional procedure. A water sample's main objective is to track and quantify changes in water quality over time. Before collecting a sample of water from a tap, the tap was operated for one minute. Before being filled and sealed, the bag was rinsed twice with sample water. There is more space for oxygen when the bottle is just halfway full, which will encourage sample erosion. Table 1 lists the samples that were taken from the Gomti River sampling locations.

Table 1 Sampling points

1	Gaughat	9	Boat Club
2	Hussainabad	10	Hanuman Setu
3	Gulalghat	11	LaxmanMela
4	Gudiyaghat	12	Monkey Bridge
5	Pakkapul	13	Parag
6	Mohenemkin	14	Baikunth Dham
7	Mankameshwar	15	Gomti barrage
8	Daliganj		

Results and Discussion

Table 2 displays the Gomti River's water quality in the Lucknow region. Gaughat to Hussainabad, Hussainabad to Gulalghat, Gulalghat to Kudiyaghat Nala, Kudiyaghat Nala to Pakkapul, and Pakkapul to Mohan Meekin comprise the complete stretch. River Gomti pollution from Mohan Makakin to Daliganj, Daliganj to Hanuman Setu, Hanuman Setu to Boat Club, Laxman Fair to Boat Club, Monkey Bridge to Parag Factory, Parag Factory to BaikunthaDham, and BaikunthaDham to Gomti Barrage. Because of the sewers' sewage disposal, the water's quality has declined. A variety of physico-chemical parameters, including temperature, pH, DO, TDS, TSS, water hardness, cadmium (Cd), copper (Cu), arsenic (As), chloride (Cl), nitrite, nitrate, and iron, were examined in water samples from the Gomti River at all fifteen study sites.

The geographic fluctuation of water temperature at various sampling points along the Gomti River is displayed in Fig. 2. The temperature generally varies between 12°C and 20°C, suggesting a considerable degree of thermal variance between locations. The majority of places had temperatures between 16 and 19°C, indicating that the river stretch has generally consistent temperatures. Sites like Gulaab Ghat, Pakka Pul, and Hanuman Setu have the greatest temperatures (19–20°C), whereas Daliganj has the lowest temperature (12°C). While lower measurements upstream or at less affected locations indicate better flow conditions and less anthropogenic influence, slightly greater temperatures along urban and highly populated parts may be attributable to domestic discharge, reduced flow velocity, and urban heat influence. The river's temperature profile is mild to moderately warm, which is ideal for aquatic life but exhibits localized warming in metropolitan areas. The pH of the majority of water samples is higher than 7.0.

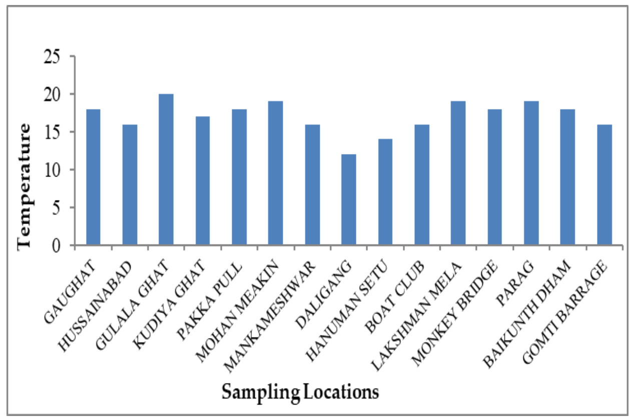

Fig. 2 Spatial variation of water temperature at different sampling locations along the Gomti river

TDS levels along the Gomti River are moderately high, with peak concentrations in densely populated urban stretches, reflecting human activity and wastewater inflow, and indicating the need for better wastewater management and pollution control measures (Fig. 3). TSS values range approximately from 450 to 700 mg/L, indicating high suspended particulate load in the river. Most sites fall within 500–600 mg/L, reflecting considerable turbidity and sedimentation, commonly associated with urban runoff, sewage discharge, storm water inflow, and riverbank erosion.

The highest TSS concentration is observed near Bakunthi Dham (~700 mg/L) and Parag Factory (~650 mg/L), locations associated with industrial discharge and dense urban activity. This suggests direct or indirect input of suspended waste, untreated effluents, or solid waste dumping. Elevated TSS levels are also seen at Hanuman Setu and Monkey Bridge, which may receive wastewater from densely populated catchment areas. Lower TSS values (~450–500 mg/L) appear at Gomti Barrage, Daliganj, and Kudia Ghat, likely due to better mixing, flow dispersion, or reduced pollutant input at those points. DO levels across the Gomti River are critically low, with most sites below acceptable limits, indicating serious organic pollution and limited self-purification capacity in urban stretches.

Cadmium levels in the Gomti River are above safe limits at nearly all sites, indicating industrial and sewage-driven heavy metal pollution and highlighting the need for strict monitoring and control measures (Fig.4). The bar chart depicts Iron (Fe) concentrations across sampling points along the Gomti River. The values range approximately from 0.1 mg/L to 1.6 mg/L, indicating notable spatial variability in iron levels. Lower iron concentrations (0.1–0.4 mg/L) are observed at sites such as Gulaab Ghat,
Pakka Pul, and Manak Nagar, suggesting relatively less influence from corrosive pipelines, industrial effluents, or sediment resuspension (Fig. 5). Moderate levels (0.6–1.0 mg/L) appear at Gaugghat, Hussainabad, Daliganj, Boat Club, and Hanuman Setu, representing typical fluvial iron content with some anthropogenic input. The highest iron concentrations (1.4–1.6 mg/L) are seen at Monkey Bridge, Parag, Bakunthi Dham, and Gomti Barrage, areas influenced by industrial discharges, sewage inflow, and stagnation, especially near urban outlets. Elevated iron levels may result from rusting pipelines, industrial wastewater, soil erosion, and mixing with iron-rich sediments. According to WHO/BIS standards, permissible iron concentration for drinking water is 0.3 mg/L, meaning most sites exceed this limit. Prolonged exposure to high iron levels can cause taste and staining issues, biofouling, and in extreme cases may affect sensitive aquatic species.

The most widely used unit of measurement for hardness is milligrams of calcium carbonate equivalent per liter. According to Mc Gawn (2000), water with calcium carbonate concentrations below 60 mg/l is typically regarded as soft, 60–120 mg/l as moderately hard, 120–180 mg/l as quite hard, and more than 180 mg/l as very hard. Despite the fact that total hardness levels are typically reported at the lowest level of 140 mg/l at Monkey Bridge and the highest level of 249.5 mg/l at Pakkapul. At very low concentrations, chloride is necessary for plants, but at excessive concentrations, it can be hazardous to sensitive crops. an anion element that, in large concentrations, can be extremely harmful to plants. Copper concentrations in Gomti River water are
frequently reported to be as low as 0.014 mg/l near Gaughat.The maximum concentration, however, is 0.052 mg/l. At Kudiyaghat, the lowest arsenic value is 0.02. In contrast, the Gomti Barrage has the greatest concentration of 0.07. The Gomti River The lowest nitrate concentration recorded at Mohan Meakin is 31.27 mg/l. The maximum quantity of nitrates, an anion element that can be problematic in high concentrations in drinking water but not in irrigation water, is 89.80 mg/l at Laxman Mela. The crop receives nutrients from irrigation water with high nitrates. Drinking water typically has nitrite levels less than 0.1 mg/l. The highest permissible nitrite concentration is 3 mg/l, which is equal to 1 mg/l nitrite to nitrogen. More over 0.75 parts per millions of nitrite in water can stress fish, and more than 5 parts per million can be harmful to humans and animals. Laxman mela has the greatest value of 0.6800 mg/l, while Gulalaghat has the lowest value of 0.0926 mg/l.

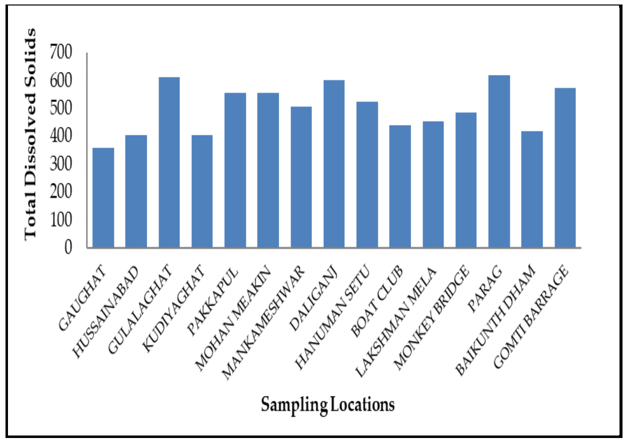

Fig. 3 Spatial variation of total dissolved solids (TDS) in Gomti river water

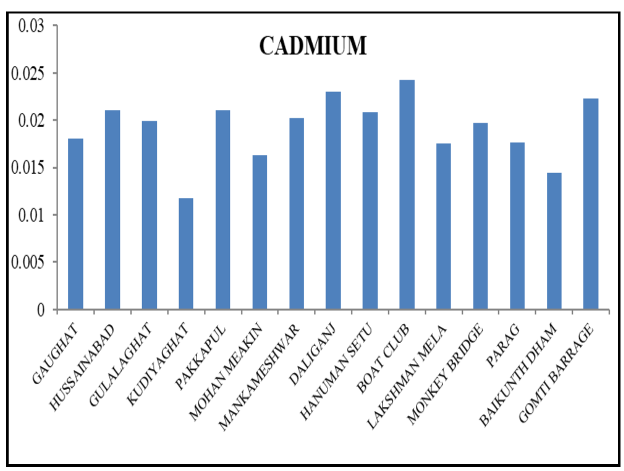

Fig. 4 Spatial Variation of Cadmium (Cd) Concentration in Gomti River Water

Table 2 Water quality parameters of Gomti river from Gaughat to Gomti barrage

Location	P^H	TDS	TSS	As	Cd	Nitrates	Chloride	Iron	Cu	Hardness	Nitrite	DO	Temp
		Mg/l	Mg/lit	Mg/lit	Mg/lit	Mg/lit	Mg/lit	Mg/lit	Mg/lit	Mg/lit	Mg/lit	Mg/lit	℃
Gaughat	7.55	357.5	417.5	0.03	0.018	44.79	3.05	0.665	0.014	175.5	0.5556	3.33	18
Hussain bad	7.84	404	525.5	0.06	0.021	55.06	7.85	1.021	0.061	166.5	0.1305	2.30	16
Gulalagat	7.76	611	465	0.04	0.019	41.68	8.42	0.077	0.032	175.5	0.0926	2.65	20
Kuriyagat	7.88	405	485.5	0.02	0.011	45.87	25.88	0.725	0.018	149.0	0.4593	4.00	17
Pakkapul	8.26	556.5	460	0.07	0.021	53.92	88.15	0.092	0.031	249.5	0.1239	2.55	18
Mohan Meakin	8.58	555.5	565	0.04	0.016	31.27	32.37	0.850	0.017	214.5	0.2666	1.95	19
Mankameshwar	7.54	504	494.5	0.04	0.020	66.47	62.65	0.715	0.052	231.0	0.3772	2.15	16
Daliganj	6.88	600	55.7	0.07	0.023	77.39	41.50	1.075	0.019	206.0	0.1827	2.60	12
Hanuman setu	7.85	525	453.5	0.03	0.020	73.54	20.66	0.801	0.024	183.5	0.1706	2.85	14
Boat Club	8.47	440	537	0.03	0.024	51.33	14.61	0.405	0.018	169	0.0441	2.55	16
Lakshaman mela	7.51	455	538	0.04	0.017	89.80	18.65	0.720	0.026	175	0.6800	1.70	19
Monkey bridge	7.79	486.5	485	0.06	0.019	45.75	16.86	1.685	0.023	140	0.1279	2.10	18
Parag	7.88	620	678.5	0.03	0.017	57.55	2.61	1.485	0.025	198	0.3645	1.70	19
Baikunth Dham	7.65	417.5	469	0.03	0.014	57.20	16.29	1.545	0.025	179	0.4002	2.05	18
Gomti Barrage	8.28	573.5	595	0.07	0.022	64.58	19.26	1.525	0.026	161	0.3140	2.65	16

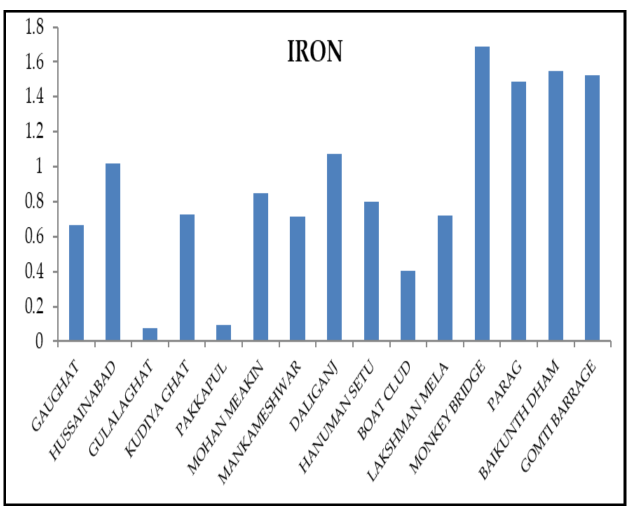

Fig. 5 Spatial Variation in Iron (Fe) Concentration Along the Gomti River

Conclusions

The study clearly indicates that the water quality of the Gomti River deteriorates significantly in the downstream stretches, reflecting increasing pollution loads as the river flows through densely populated and industrial zones. Physico-chemical and microbiological analyses revealed that most parameters exceeded permissible limits, rendering the water unfit for domestic, agricultural, or recreational use. Elevated concentrations of suspended solids, dissolved solids, organic matter, and heavy metals highlight intense anthropogenic pressure, primarily due to untreated discharges from multiple drains, industrial effluents, agricultural runoff, and domestic sewage. The continuous input of organic and inorganic waste has impaired the river's natural self-purification capacity, resulting in enhanced microbial growth and poor ecological health. These findings underscore the urgent need for effective wastewater treatment, strict regulatory enforcement, pollution source control, and restoration initiatives. Implementing decentralized wastewater treatment, improving sewage interception and diversion systems, regulating industrial effluents, and raising community awareness are essential to protect the ecological integrity of the Gomti River and safeguard human and aquatic life.

Data Availability Statement

The datasets generated during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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