engineering proceedings

MDPI

Proceeding Paper

Water Quality Status of Different Ghats of River Ganga in Patna Urban Area †

Aftab Alam *, Md. Barkatullah and Amit Kumar

Department of Civil Engineering, National Institute of Technology Patna, Patna 800005, India; mdb.phd22.ce@nitp.ac.in (M.B.); amitkr.ph21.ce@nitp.ac.in (A.K.)

* Correspondence: aftaba.phd19.ce@nitp.ac.in; Tel.: +91-8797527215

† Presented at the 4th International Electronic Conference on Applied Sciences, 27 October–10 November 2023; Available online: https://asec2023.sciforum.net/.

Abstract: The Ganga is a river and a representation of morality and purity for the people of India. From a geographical perspective, it is also India's main river. A significant part of Patna's population used ganga water for a variety of uses, including domestic, agricultural, and industrial. This study aims to evaluate the Ganga River's water quality for different Ghats of Patna urban area from Digha to Gai Ghat. Samples of water were taken from 15 distinct Ghats. The biological, chemical, and physical characteristics of water have significantly changed as a result of heavy municipal waste discharge and anthropogenic activities in the river. All the Ghats were classified as unfit for drinking purposes, and it was suggested that water be made available only after thorough treatment. People's habitual usage of Ganga water for various purposes raises the potential of human health hazards.

Keywords: water quality; water pollution; physicochemical parameters; Ganga; Patna

Citation: Alam, A.; Barkatullah, M.; Kumar, A. Water Quality Status of Different Ghats of River Ganga in Patna Urban Area. *Eng. Proc.* **2023**, *52*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s): Name

Published: date

1. Introduction

The Ganga basin, encompassing multiple states in India, constitutes over a quarter (26.3%) of the country's total geographical area. It is the largest river basin in India with a catchment area of 8, 61, 404 sq. km. and a total length of 2525 km, bordered by the Himalayas to the north and the Vindhyas to the south. Originating as the Bhagirathi in the Garhwal Himalaya, near Gaumukh, the river travels approximately 205 kilometres through Uttarakhand before merging with the Alaknanda at Devprayag to form the Ganga. The Alaknanda begins at the confluence of the Satopanth and Bhagirath Kharak glaciers. From there, the Ganga flows through Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal, ultimately emptying into the Bay of Bengal. Along its course, the Ganga is joined by various tributaries, including the Kali, Ramganga, Yamuna, Gomti, Ghaghara, Gandak, and Kosi rivers [1]. The worsening condition of the Ganga River is attributed to various factors, including population pressures, inadequate investment in water quality infrastructure, limited government initiatives, and the lack of empowerment among the population.

Water, a crucial natural resource that sustains life, has historically been the cornerstone of major civilizations worldwide [2]. However, due to the increasing global population, unregulated urbanization, and rapid industrialization along riverbanks, both the quality and quantity of water resources have been in decline. The assessment of water quality is based on its physical, chemical, and biological characteristics [3]. In the case of the Ganga River at Patna, the primary sources of pollution include untreated domestic sewage, industrial effluents, and human remains. Presently, the Ganga riverbanks are home to more than 29 cities, 70 towns, and numerous villages, collectively discharging over 1.3 billion Liters of sewage daily into the river. The utilization of river water for daily needs exposes many people to health hazards caused by water pollutants. It is noteworthy that approximately 80% of all human diseases are attributed to the quality of drinking water [4]. To assess the suitability and usability of water, experts employ the water quality index (WQI) [5]. However, the water quality and quantity along riverbanks are declining [6]. Municipal waste is responsible for approximately 80% of the total waste that is disposed of in the Ganga River, while industries contribute to around 15% of this waste. The primary sources of pollution in the Ganga include organic waste, plastics, household waste, and animal remains [7]. Various research studies have highlighted that the pollution levels in the water of the Ganga River exceed the permissible limits, rendering it unsuitable for domestic usage. This study specifically concentrated on evaluating the physicochemical characteristics of the water at 15 different riverbank sites (Ghats) along the Ganga River within the Patna district. The parameters analysed included pH, dissolved oxygen, biochemical oxygen demand, and total hardness, with standardized procedures being followed for the assessments. The research findings are expected to assist in devising strategies to control water pollution and mitigate health risks for humans.

2. Materials and Method

2.1. Locations

The study area Patna falls in lower ganga basin. As per census the estimated population of Patna is 1.68 million in 2011. It is the 19th most populous city in India. The locations for the sampling and analysis were selected Ghats along the river Ganges, namely: Digha (S1), Kurzi (S2), Lct (S3), Bans (S4), Collectorate (S5), Anta (S6), Adalat (S7), Kali (S8), Krishna (S9) Gandhi (S10), Gulbi (S11), Choudhary Tola (S12), Alamganj (S13), Raja (S14), Gaighat (S15) (Figure 1). The details of the sampling sites are given in the Error! Reference source not found.. Water samples were collected in a single day of 20th May 2022 for the analysis. It was a clear sunny day with temperature ranging from 78.8 °F to 95 °F, having no precipitation and wind speed of 9.21 mph East. The water is mainly drawn from the Ghats that are used the most daily or the most crowded Ghats on puja days (public gathering for worship) such as Chhath puja, Dasherra, Sarsawati puja and Ganga Aarti etc. During puja days' various activities taking places by people such as bathing and immersion of worshiping materials in river led to further additional contamination of the Ganga.

Table 1. Descriptive statistics of water samples.

Statistic	Minimum	Maximum	1st Quartile	3rd Quartile	Mean	Std. Deviation
pH	7.250	8.300	7.655	8.105	7.853	0.331
EC	480.000	776.000	500.500	741.000	606.267	121.227
TDS	310.000	425.000	330.500	398.500	371.400	38.026
Turbidity	35.000	145.000	57.500	108.500	86.880	33.952
DO	6.100	8.400	6.800	7.850	7.367	0.703
BOD	2.600	6.300	3.760	5.500	4.501	1.146
Alkalinity	80.000	178.000	118.000	160.500	139.980	29.102
TH	195.000	405.000	247.000	340.000	288.667	63.555
Cl	61.200	89.200	67.730	81.930	74.575	9.451
Sulphate	24.300	72.620	35.175	53.250	44.643	13.487

pH is in numerical value, Turbidity in NTU, EC is in μS/cm, all others parameter are in mg/L.

2.2. Sampling Procedure and Method of Analysis

In the Bihar district of Patna, samples of surface water were collected from the Ganga River, amounting to a total of 15 samples. Surface water samples is collected near Ghats which is situated along the river Ganga that are most crowded, and areas with high population density and significant anthropogenic activities. Water samples were carefully preserved in polypropylene bottles at a temperature of 4 °C until they were ready for analysis [8]. Prior to sampling, all containers used were meticulously cleaned using a 10% nitric acid solution followed by double-distilled water. The water samples, with a volume of 125 mL, were subjected to vacuum filtration using 0.45-Millipore membrane filter paper, while an additional 250 mL remained unfiltered and served as the raw samples. Field measurements, including pH, electrical conductivity (EC), and temperature, were taken directly from the unfiltered water using a field water analyser kit. The major tests were conducted in the laboratory according to the methods described in [9] and were subsequently compared to the standards specified by the Bureau of Indian Standards (BIS) [10].

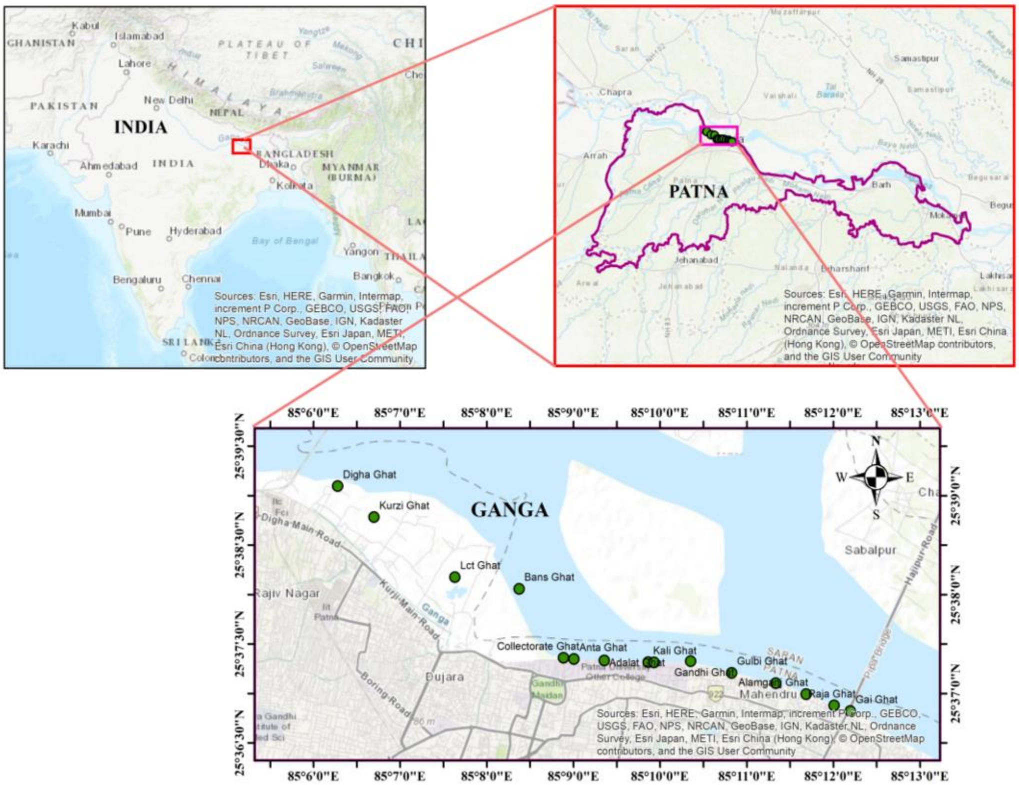

Figure 1. Sampling locations of study area.

3. Results and Discussion

Scattering plots were used to visualize and compare the concentration variations of numerous variables at different sampling sites and plot of pH, DO and BOD is shown in Figure 2; EC, TDS and TH in Figure 3 and Turbidity, Alkalinity, chloride, and sulphate in Figure 4. The pH value is a measure of whether water is acidic or alkaline. In the context of the Ganga River water, changes in pH are affected by the existence of dissolved gases like carbon dioxide, hydrogen sulphide, and ammonia, which can lead to fluctuations in the pH level. In present study all the samples were found above the pH value of 7, indicating the nature of water of ganga in current stretch is Alkaline. The occurrence of algal blooms contributes to the production of carbon dioxide. Moreover, the discharge of sewage and industrial waste significantly affects the pH variation. Microorganisms involved in organic matter decomposition release hydrogen sulphide, ammonia, and other compounds. The measurement of pH is a critical parameter, as it impacts various stages of water supply. Fortunately, the pH values of all investigated samples were found to be within the acceptable limits. Dissolved oxygen (DO) is an essential requirement for supporting aquatic life in water bodies. The minimum DO level necessary for the survival of aquatic organisms is 4 mg/l. In the present study, the investigation focused on determining the locations along the Ghats where the highest minimum DO values were observed to ensure the sustenance of aquatic life. The current study reveals that DO levels along the current stretch of Ganga was found above the minimum required limit (4 ppm). It indicates that the river is capable of self-purification but DO levels in all the samples were found below the DO_{sat} indicates the anthropogenic pollution influenced the river. Biochemical Oxygen Demand (BOD) is a parameter that measures the amount of oxygen consumed by microorganisms during the decomposition of organic waste. Unfortunately, all the samples analysed in this study exhibited BOD levels that exceeded the permissible limits. It is particularly crucial for BOD levels in drinking water to be negligible to ensure its quality and safety. The BOD in Ganga River may be attributed to the open sewage drains merging to river prior to any degree of treatment. Total dissolved solids (TDS) can contribute to water hardness, scale deposits, a bitter taste, and pipe and fitting corrosion. If the total dissolved solids (TDS) in water go beyond 2000 (mg/L), the water might not taste good and could even cause stomach problems. However, in the samples taken, the TDS levels were within the safe limits set by the Bureau of Indian Standards (BIS). Total hardness (TH) in water shows how much dissolved calcium and magnesium are present. For water meant for drinking, it's okay if the TH is up to 200 mg/L. But if it goes higher than 600 mg/L, that water is not considered suitable for drinking. Most of samples were found outside the desirable BIS limits of 200 mg/L. Turbidity in water depends on the presence of suspended particles. The study revealed that the turbidity values in the Ganga water samples exceeded the acceptable limit for drinking purposes. Electrical conductivity is an indicator of high ionic concentrations in water. For drinking water, the maximum allowable limit for electrical conductivity is set at 1400 μS/cm. However, all the samples analysed in this study exceeded the permissible limits for electrical conductivity. Temperature influences the concentration of dissolved oxygen, diffusion rate, and photosynthetic activity in water. The rate of temperature change plays a crucial role in determining the availability of oxygen and the types of organisms that can thrive in rivers and lakes. Unfortunately, the specific temperature values measured in the investigated samples are not provided. Alkalinity quantifies the presence of bicarbonates, carbonates, and hydroxides in water. Insufficient alkalinity can lead to plumbing deterioration and increase the likelihood of heavy metal leaching from pipes and fixtures. According to the Bureau of Indian Standards (BIS) guidelines, all the samples investigated met the permissible limits for alkalinity in drinking water, which range from 200 mg/L to 600 mg/L. Alkalinity in all the samples were found within the limits. Excessive chloride ions in water can impart a salty taste. The permissible limit for chloride concentration in drinking water is 250 mg/l. Among the investigated Ghats, Kali Ghat exhibited the highest chloride value, while Collectorate Ghat had the lowest chloride value.

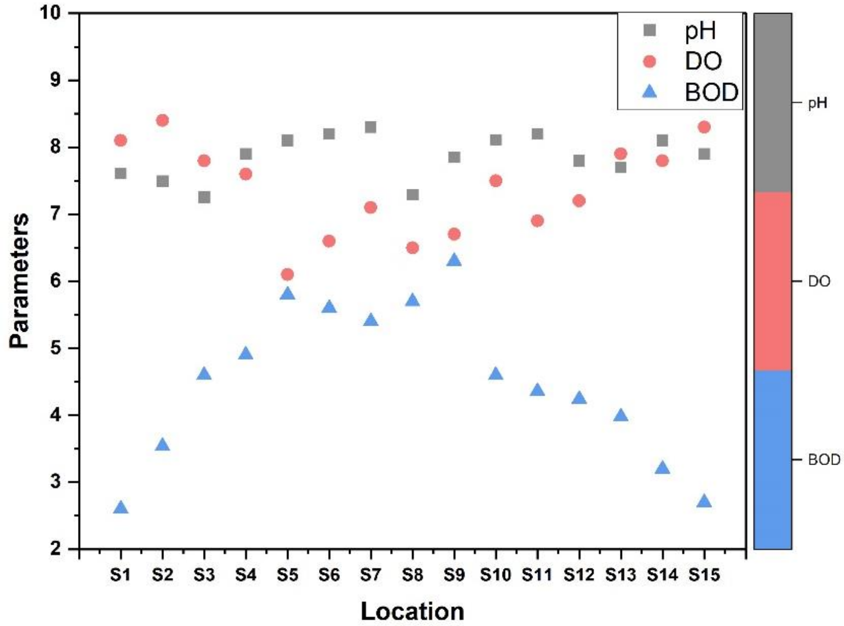

Figure 2. Scatter plot of samples for pH, DO and BOD.

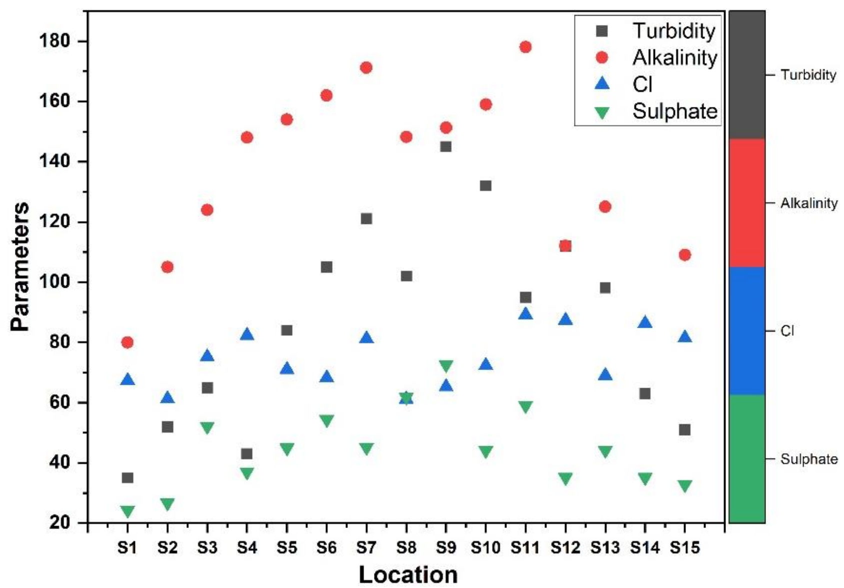

Figure 3. Scatter plot of samples for Turbidity, Alkalnity, Cl and Sulphate.

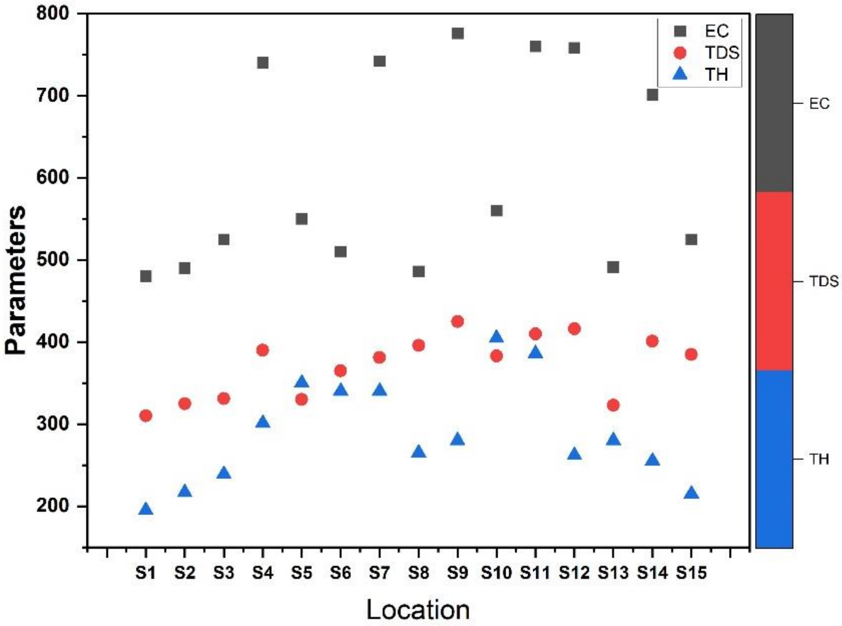

Figure 4. Scatter plot of samples for EC, TDS and TH.

4. Conclusions

The research findings provide clear evidence of the contamination and deterioration of water quality in the Ganga River. The major contributors to this decline are the discharge of untreated sewage water, domestic waste water from the Patna urban area, and the establishment of numerous apartments, industries, and hospitals along the riverbank. Ugent measures are required to prevent further degradation of the Ganga River water quality. It is crucial to raise awareness among the local population and implement a collective approach involving the government, media, students, and all sections of society. The study also indicates that while aquatic plants and fishes are able to sustain in the Ganga water with a dissolved oxygen (DO) level above 4 mg/L, the water is not suitable for drinking purposes without proper treatment. The BOD levels and the presence of pollutants at maximum Ghats highlight the need for wastewater treatment plants and continuous monitoring of water quality. The regular use of Ganga water by people for different activities increases the risk of potential health hazards. Overall, concerted efforts are necessary to address the pollution issues and safeguard the Ganga River's ecosystem and the well-being of the communities relying on it.

Author Contributions: Conceptualization, methodology, software, formal analysis, writing—original draft preparation, review and editing was carried out by A.A., M.B. and A.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: Authors are thankful to National Institute of Technology for financial support.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. CGWB. *National Aquifer Mapping and Management Plan*; CGWB: 2022.
2. Alam, A.; Singh, A. Groundwater quality assessment using SPSS based on multivariate statistics and water quality index of Gaya, Bihar (India). *Environ. Monit. Assess.* **2023**, *195*, 687. https://doi.org/10.1007/s10661-023-11294-7.

3. Kumar, A.; Alam, A.; Singh, A. Simulation of One-Dimensional Solute Transport with Equilibrium-Controlled Non-Linear Sorption Using Modular Three-Dimensional Multispecies Transport Model. *Eng. Proc.* **2023**, *37*, 28. https://doi.org/10.3390/ECP2023-14741.
4. WHO. *Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum*; World Health Organization: Geneva, Switzerland, 2017; Volume 55.
5. Masood, A.; Aslam, M.; Pham, Q.B.; Khan, W.; Masood, S. Integrating water quality index, GIS and multivariate statistical techniques towards a better understanding of drinking water quality. *Environ. Sci. Pollut. Res.* **2022**, *29*, 26860–26876. https://doi.org/10.1007/s11356-021-17594-0.
6. Aenab, A.M. *Evaluating Water Quality of Ganga River Within Uttar Pradesh State by Water Quality Index Analysis Using C ++ Program*; 2013; Volume 3.
7. Effendi, H. River Water Quality Preliminary Rapid Assessment Using Pollution Index. *Procedia Environ. Sci.* **2016**, *33*, 562–567. https://doi.org/10.1016/j.proenv.2016.03.108.
8. Kumar, D.; Singh, A.; Jha, R.K.; Sahoo, S.K.; Jha, V. A Variance Decomposition Approach for Risk Assessment of Groundwater Quality. *EXPO Health* **2019**, *11*, 139–151. https://doi.org/10.1007/s12403-018-00293-6.
9. APHA. *Standard Methods for the Examination of Water and Waste-Water*; American Public Health Association (APHA): Washington, DC, USA, 2005.
10. BIS. *Indian Standard Drinking Water Specification (Second Revision)*; Bureau of Indian Standards: 2012; Volume IS 10500, pp. 1–11.