Comprehensive Assessment of Physicochemical Parameters Impacting Water Quality in the Gandak River at Bagaha, Bihar

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***Abstract*—The Gandak River is a lifeline, providing essential water for agriculture, industry and different trades, driving economic growth and prosperity. It is a vital waterway flowing through the northern regions of Bihar. The current study will comprehensively assess the Physicochemical parameters that influence water quality in the Gandak River at Bagaha, Bihar. By focusing on these parameters this study seeks to identify pollution sources, consider variations in water quality across different seasons and locations, and propose effective strategies for sustainable water management and pollution control in the Gandak River at Bagaha.**

***Index Terms*—Bagaha, Gandak River, Water quality, Physicochemical parameters, Pollution, Seasonal variation, Water Quality Management.**

I. INTRODUCTION

Importance of Studying water quality in rivers

Studying water quality in rivers is paramount across the environmental, public health and socioeconomic domains. Ecologically, rivers support diverse ecosystems that rely on clean water for survival, making it crucial to monitor and manage pollutants that can disrupt these habitats. From a public health perspective, ensuring that river water is safe for consumption and recreation is essential for preventing waterborne diseases and protecting community well-being. Work on the effect of cremation on the water quality of the Ganga River near Digha Ghat, Patna has been recorded in this laboratory [1]. Moreover, rivers are vital for agriculture, industry and energy production, necessitating rigorous monitoring to sustainably manage water resources amid increasing demands and potential contamination risks. [2,9 and 12] Effective water quality monitoring also helps to frame policy and regulatory frameworks and guides decisions on pollution control measures and resource allocation to promote sustainable development.

About Gandak River and about Bagaha

The Gandak River originates from the Tibetan border in Nepal's Mustang region (approximately 30.25°N latitude and 81.8°E longitude). The river has profound significance because of its pivotal role in shaping both natural and human landscapes across Nepal and India. The river, a major tributary of the Ganges, plays a vital role in supporting agricultural activities and serves as a primary water source in the region of Bagaha.

Bagaha is an inhabitant area of the West Champaran District of Bihar. It is a sub-division of West Champaran District, situated about 64 km North West of Bettiah, the District Headquarters of West Champaran. Over the years, rapid urbanization, industrial growth and agricultural intensification including sugar cane businesses set up along its banks have significantly impacted the river water quality. Bagaha, experiencing substantial economic development faces escalating challenges from industrial effluents, agricultural run-off encumbered with fertilizers and pesticides, and domestic sewage discharge, all of which contribute to the deterioration of water quality. [3] This degradation not only threatens aquatic biodiversity but also raises serious public health concerns for communities relying on the river for drinking water and other essential needs. [4] Moreover, it gives rise to economic risks by potentially reducing agricultural productivity, a

crucial economic activity in that region. Despite previous studies highlighting the presence of pollutants in the Gandak River, localized research specific to Bagaha remains limited. [5]

II. OBJECTIVES OF THE STUDY

This study aims to analyse key physicochemical parameters comprehensively revealing complicated interactions between natural processes, human activity and environmental care. It will help comprehend water resource management issues, promote sustainable development, and preserve the river's ecology for future generations.

III. METHODOLOGY AND STUDY DESIGN

A view of the Gandak River at Valmiki Nagar

Collection of water samples

Fresh sterile bottles (1 litre) were used to collect the samples. Distilled water was used to clean the bottles. The sample water was then used to rinse the bottles. The bottles were submerged in the water below the top of the river. They were then opened and closed again to capture the water sample and transfer it to the surface. The samples were collected during the pre-monsoon and post-monsoon periods of 2023.

Testing of the samples for physicochemical parameters

Water samples were collected from the Gandak River in clean plastic bottles to investigate their physico-chemical properties.

At the sampling site pH, TDS, conductivity and temperature were recorded. On-site findings were recorded separately. Samples were immediately taken for laboratory analysis. Physicochemical characteristics were analyzed with the help of methods recommended by APHA. [6] The pH and EC were measured on-site using a Systronics-371 Water Quality Analyzer for pH, TDS, and EC. Other characteristics such as Total Hardness (TH), Magnesium Hardness (Mg^{2+}), Calcium Hardness (Ca^{2+}), Fluoride(F^-), Sodium (Na^+), Potassium(K^+), Chloride (Cl^-), and Turbidity (NTU), were analyzed in the Centre for Fluorosis Research Laboratory, Department of Chemistry, A.N. College, Patna.

The Gandak River water physicochemical properties have been displayed in Table-I along with their seasonal changes (Pre-monsoon and post-monsoon).

Sampling location- Bagaha							Average Value			
Seasons	Pre	Post	Pre	Post	Pre	Post	Pre		Post	
Parameters	Upstream the river		At the BagahaGhat of the river		Downstream the river		AM	ST.DV.	AM	ST.DV.
pH	9.0	8.45	8.6	6.26	8.7	8.16	8.76	0.21	7.62	1.19
Temperature (^{0}C)	26	19.8	25	20	26	20	25.67	0.58	19.93	0.12
Turbidity (NTU)	4.0	9.2	3.0	11.9	4.0	12.7	3.67	0.58	11.27	1.83
Total dissolved solid (mg/l)	145	173	140	296	146	278	143.67	3.21	249	66.43
Conductivity	206	258	204	442	206	416	205.33	1.15	372	99.58
Total Hardness (mg/l	70	284	56	358	54	344	60	8.72	328.67	39.31

Calcium) (mg/l	24	72	18	96	16	109	19.33	4.16	92.33	18.77
Magnesium (mg/l	22	94	16	116	16	101	18	3.46	103.67	11.24
Alkalinity (mg/l)	276	300	290	350	270	348	278.67	10.26	332.67	28.31
Chlorides (mg/l)	107	25	110	30	101	25	106	4.58	26.67	2.89
Sodium (Na+)	4.0	6.6	3.0	10.4	4.0	10.6	3.67	0.58	9.2	2.25
Potassium (K+)	3.0	2.8	4.0	2.6	4.0	2.4	3.67	0.58	2.6	0.2
Iron (mg/l)	4.22	0.02	4.16	0.08	5.66	0.02	4.68	0.85	0.04	0.03
Arsenic (mg/l)	0.0	0.0	0.06	0.002	0.0	0.0	0.02	0.036	0.0007	0.001

Table-I

AM-Arithmetic Mean; ST.DV.-Standard Deviation

IV. RESULTS AND DISCUSSION

1. pH

pH is a hydrobiological parameter that is very important in many chemical processes that keep life going on. It shows the intensity of alkalinity and acidity in water. The water in India's rural areas is usually alkaline. The average pH recorded during pre-monsoon was 8.76±0.21 and during post-monsoon was 7.62±1.19 at Bagha.

2. Temperature

The temperature of the Gandak River fluctuated between seasons, with an average of 25.67 ± 0.58°C recorded during pre-monsoon (July 2023), which was found to be higher, and an average of 19.93 ± 0.12°C during post-monsoon (December 2023), which was found to be lower.

3. Turbidity

The study found higher turbidity values during the post-monsoon season, with an average of 11.27 ± 1.83 NTU, while lower turbidity was recorded during pre-monsoon, with an average of 3.67 ± 0.58 NTU.

4. Electrical Conductivity

Electrical conductivity indicates the purity of water and the presence of dissolved ions. It depends on the concentration of ions, nutrients, and other solutes in the water. In this study, EC readings ranged from an average of 205.33 ± 1.15 µS/cm during pre-monsoon to 372.0 ± 99.58 µS/cm, recorded higher during post-monsoon. A high EC value suggests that the aquatic ecosystem may be polluted and eutrophic. [7]

Analysis of Chemical Parameters

Chemical parameters pertain to the chemical composition and properties of water. These parameters include measurements of Total hardness, Total Dissolved Solids, Total Alkalinity, Sodium, Potassium, Iron, Arsenic, Phosphate concentration, Ammonia levels and chloride concentration. The Table-I outlines the chemical parameters analyzed in the present study.

1. Total Hardness

In the present study, the total hardness of the river water was recorded at 60 ± 8.72 mg/l during pre-monsoon and increased significantly to an average of 333.33 ± 39.31 mg/l during post-monsoon. According to IS 10500:2012 standards, the acceptable limit for total hardness in drinking water is 200 mg/l. Some samples from Bagaha exceeded this limit during the study period. As per Kiran (2010), water can be classified by hardness levels: soft (0–75 mg/l), moderately hard (75–150 mg/l), and hard (150–300 mg/l). Therefore, the water in the Gandak River can be considered hard.[9]

2. Total Dissolved Solids

The higher levels of total dissolved solids (TDS) were recorded post-monsoon, with an average of 249 ± 66.43 mg/l, whereas the lower TDS levels during pre-monsoon were 143.67 ± 3.21 mg/l.

3. Total Alkalinity

In this study, the total alkalinity levels in the Gandak River at Bagaha averaged 278.67 ± 10.26 mg/l as $CaCO_3$ during pre-monsoon, increasing to 332.67 ± 28.31 mg/l during post-monsoon. The rise in alkalinity during post-monsoon is likely due to increased runoff and mineral dissolution.

4. Chloride

Chlorine, used for controlling waterborne illnesses, has specific standards to minimize its side effects. Chloride is naturally present in surface waters, though typically at low concentrations in freshwater. During pre-monsoon, the chloride concentration in the samples averaged 106.0 ± 4.58 mg/l, while post-monsoon it dropped to an average of 26.67 ± 2.89 mg/l. [10]

5. Sodium and Potassium

Guidelines not have been provided according to BIS for sodium and potassium. During the pre-monsoon recorded Na and K were the same i.e. an average of 3.67±0.58, while during the post-monsoon sodium was recorded at an average of 9.2±2.25 and potassium at an average of 2.6±0.2.

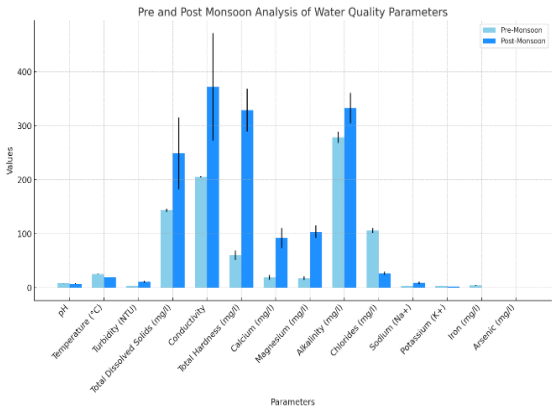
6. Iron

Iron was higher than the permissible limit during pre-monsoon recorded at 4.68±0.85 mg/l, while during post-monsoon it was recorded below the permissible limit i.e. 0.04±0.03mg/l. Iron also promotes the growth of “iron bacteria” which derive their energy from the oxidation of ferrous ion to ferric ion and in the process deposit a slimy coating on the piping.[11]

7. Arsenic

Arsenic may be introduced into drinking water via natural sources primarily by the dissolution of naturally occurring minerals, ores, and industrial effluents. [12] The present study revealed that the value of Arsenic in water samples lies within BIS guidelines during both the seasons pre-monsoon and post-monsoon i.e. 0.02±0.006 mg/l and 0.007±0.0001 mg/l respectively.

Graphical Representation of Water Quality Parameters:



Graph: River Water Quality Parameters at Bagaha

V. CONCLUSION

Based on the comprehensive analysis of the physicochemical parameters of the Gandak River at Bagaha Ghat, it can be concluded that the river's water quality needs assessment and regular monitoring as some of the parameters like Turbidity, Alkalinity and Total Hardness exceeded in our study beyond the permissible limits set by the IS 10500:2012. The pH levels, ranging from 7.62 to 8.8, indicate a neutral to slightly alkaline condition, suitable for aquatic life and various uses. Electrical conductivity values, between 205.33 µS/cm and 372 µS/cm, showed minimal pollution from dissolved ions. Turbidity levels, fluctuating between 3.67 NTU to 11.27 NTU, reflect moderate water clarity, influenced by seasonal sediment load. Temperature variations from 19.3°C to 26.7°C align with typical seasonal patterns, impacting biochemical processes in the river.

The total hardness (TH) of the river ranged from, ranging from 60 mg/l to 333.33 mg/l, which classifies it as hard water, while total dissolved solids (TDS) levels of 143.67 mg/l to 249 mg/l remained well below the IS 10500:2012 guideline of 500 mg/l, indicating low concentrations of dissolved solids. Chloride concentrations, consistently below 1.2 mg/l, are minimal, showing no significant salinity. Alkalinity levels were between 216.67 mg/l to 390 mg/l as $CaCO_3$ which are well within the permissible limit.

However, the study reveals the impact of anthropogenic activities, including industrial effluents, agricultural runoff, and domestic sewage, on the river’s pollution load. Elevated turbidity levels

at certain times suggest sedimentation from farming practices and erosion.

Continuous monitoring and effective pollution control measures are essential to sustain the river's ecological integrity and water quality. This includes enforcing pollution control regulations, promoting sustainable agricultural practices, enhancing wastewater treatment facilities and educating local communities on water conservation and pollution prevention.

In conclusion, while the Gandak River at Bagaha faces challenges from human activities impacting its water quality, proactive management and monitoring are crucial. Implementing full-bodied water management strategies and pollution control measures will ensure the river's sustainability, supporting its ecological health and meeting the needs of future generations.

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