Water quality analysis of Gandak River water at some pollution prone locations between Balmikinagar and Hajipur, Bihar

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Abstract: The Gandak River, a prominent tributary of the Ganga River, flows through various pollution-prone regions between Balmikinagar and Hajipur in Bihar. This study investigates the water quality of the Gandak River at selected pollution prone locations to evaluate the impact of anthropogenic activities on its physico-chemical parameters. The Water Quality Index (WQI) was calculated to provide an overall assessment of water quality at each location.

The WQI values indicate that the water quality at most locations is not so bad. The study underscores the need for effective water management practices and pollution control measures to maintain the ecological integrity of the Gandak River. The findings emphasize the importance of regular monitoring, public awareness, and stringent regulations to mitigate the adverse effects of pollution on water quality and public health.

Keywords: Gandak River, Water quality, Physicochemical parameters, Pollution, Water Quality Management,Water Quality Index (WQI), agricultural runoff, industrial effluents

INTRODUCTION

Importance of Studying water quality in rivers

It is well known that No water, No life. Water is medicine of our life [1]. Studying water quality in rivers is very crucial for various social, environmental, health, cultural and economic reasons. Rivers are vital sources of freshwater. However, the declining quality of the river water threatens their sustainability and is therefore a cause of concern [2]. Human health is directly affected by the quality of river water. Contaminated water can carry harmful pathogens, chemicals and heavy metals that cause several diseases .So , ensuring clean water is essential for preventing these health related problems and promoting overall well-being. Rivers support various water habitants. Polluted water can spoil these ecosystems, leading to loss of biodiversity and the collapse of food chains. Studying water quality helps to protect these important habitats.Economic activities such as agriculture and tourism depend on fresh water. Contaminated water can damage crops and cannot attract tourists, leading to significant economic loss. So, effective water quality monitoring will help to frame policy and regulatory frameworks and guide on pollution control measures and resource allocation to promote sustainable development [3].

About Gandak River and its stretch in Bihar

The Gandak River originates from the Nhubine Himal Glacier in the Mustang region of Nepal, near the Tibetan border.The river from Nepal enters India at Balmikinagar, Bagaha, West Champaran (Bihar), it flows southeast through West Champaran, Gopalganj, Muzaffarpur, and Saran and eventually merges with the river Ganga downstream of Hajipur at Sonepur (Harihar Kshetra). Gandak River banks are very fertile as it flows down to the plain from the Himalayas ranges and carries an ample amount of silt and soil which makes it very fertile for the agricultural sector and also for industrial set up. But we know, every coin has two sides. One side of it is really beneficial but on the other side it is very drastic because in past years due to rapid urbanization, industrial growth and agricultural intensification including sugar cane businesses set up along its banks have significantly affected the river water quality [3].Gandak River along its complete stretch in Bihar is facing several challenges due to various anthropogenic activities and natural factors. Industrial pollutants, agricultural run-off which contains fertilizers and pesticides, cremation of bodies and domestic sewage discharge, all of which contribute to the deterioration of water quality of river water [4]. This degradation of water quality in the Gandak River has several adverse effects on environment, human health as well as on aquatic ecosystem.

OBJECTIVES OF THE STUDY

This study aims to analyse key physicochemical parameters of the water quality of the Gandak River at selected pollution-prone locations between Balmikinagar and Hajipur, Bihar, using the Water Quality Index (WQI)) to evaluate the overall water quality.

METHODOLOGY AND STUDY DESIGN

Selection of Sites

Water samples were collected from 12 different sites from 4 places between Balmikinagar and Hajipur which are as give below

1. Konhara Ghat

S1 – No public gathering
S2 – Near temple
S3 – Cremation centre

2. Valmikinagar

S4 – Gandak river enters in bihar
S5 – Small water lane meeting Gandak river

3. Bagha

S6 – Gandak river and Harha nadi meeting point
S7 - Gandak river before meeting Harha nadi
S8 – Gandak river after meeting Harha nadi
S9 – Harha nadi before meeting Gandak river

4. Sonepur (Harihar kshestra)

S10 – Near temple
S11 – Mid of the river
S12 – Away from temple

Collection of water samples

Fresh sterile one-litre bottles were used for sampling. Initially, the bottles were cleaned with distilled water to ensure purity. Following this, they were rinsed with the sample water itself. The bottles were then immersed below the river's surface, opened to let in the water, and finally closed to secure the sample. For Iron and Arsenic testing few drops of HNO_3 were added to preserve the sample.

Testing of the samples for physicochemical parameters

Water samples were collected from below the surface of the Gandak River using clean plastic bottles to study their physical and chemical properties. At the sampling site, we recorded pH, Total Dissolved Solids (TDS), conductivity, and temperature. These on-site measurements were noted separately. The samples were then taken to C.F.R laboratory Dept. of Chemistry, A.N College, Patna for further analysis. The physical and chemical properties were analyzed using methods recommended by the American Public Health Association (APHA) [5]. For on-sitemeasurements, a Systronics-371 Water Quality Analyzer was used to measure pH, TDS, and electrical conductivity (EC). Other characteristics, such as Total Hardness (TH), Magnesium Hardness (Mg^{2+}), Calcium Hardness (Ca^{2+}), Fluorides (F^-), Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), and Turbidity (NTU), were analyzed at the Centre for Fluorosis Research Laboratory, Department of Chemistry, A.N. College, Patna. After measuring the physicochemical parameters WQI was calculated for each sample.

Water quality index

Introduction

The WQI was developed by Brown et al [6]. using the Delphi method, which involves selecting parameters rigorously, developing a common scale, and assigning weights to these parameters. This method ensures that the index is comprehensive and reliable [7].

Importance of WQI

a) Simplification: It reduces complex data into a single value, making it easier for policymakers, scientists and the public to understand water quality.
b) Decision Making: Helps in making informed decisions regarding water resource management and pollution control.
c) Public Awareness: Raises awareness about water quality issues among the general public.
d) Environmental Health: Assists in monitoring and maintaining the health of aquatic ecosystems. [7]

METHODOLOGY

The WQI is calculated using the Weighted Arithmetic Index Method. WQI was calculated by the given formula

$$\text{WQI} = \sum_{i=1}^{n}(Q_r \times W_r)$$

Where:

- Q_r = Quality rating for the i-th parameter
- W_r = Related weight for the i-th parameter
- The quality rating (Q_r) is calculated by the given formula

$$Q_r = 100 \text{ x } \frac{v_i - v_o}{v_s - v_o}$$

Where:

- v_i = Observed value of the parameter
- v_0 = Ideal value of the parameter (often 0)
- v_s = Standard permissible value of the parameter.
- Water Quality Standard:

Water Quality Index	Rating of water quality
0-25	Excellent water quality
26-50	Good water quality
51 - 75	Poor water quality
76-100	Very poor water quality
100 above	Unsuitable for drinking purpose

Table 1

- Water quality parameters of 12 samples are given below:

Parameter	IS 10500 : 2012 Acceptable limit	IS 10500 : 2012 Permissible limit	Samples											
			S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
pH	6.5 - 8.5	NR*	7.60	8.04	7.75	8.20	8.14	8.04	8.45	6.26	8.16	8	7.8	7.8
Temperature (^{0}C)	NR*	NR*	20.8	21.3	20.4	20	20	20.3	20	19.8	20	21	20.8	20.2
Total dissolved solid (ppm)	500	2000	184.4	165.1	179.8	161.4	295.2	179.8	173.2	295.2	278.5	180.5	179.3	178.7

Conductivity (µmhos/cm)	NR*	NR*	271.8	246.5	268.4	240.9	440.7	268.4	258.5	441.7	415.7	267.8	266.4	164.9
Total Hardness (mg/l)	200	600	284	286	314	270	460	270	284	358	344	296	298	266
Calcium (mg/l)	75	200	181.1	133.0	184.3	141.0	86.5	73.7	72.1	96.1	109.0	72.1	54.5	48.0
Magnesium (mg/l)	30	100	28.1	58.3	40.8	45.6	171.0	86.5	94.3	115.7	101.1	100.1	11.7	100.1
Alkalinity (mg/l)	200	600	200	224	226	350	470	350	300	350	348	290	324	376
Chlorides (mg/l)	250	1000	24.99	24.99	25.99	23.99	22.99	21.99	24.99	29.99	24.99	24.99	24.99	24.99
Fluorides (mg/l)	1	1.5	0.218	0.208	0.196	0.156	0.277	0.189	0.184	0.408	0.381	0.175	0.120	0.204
Sodium (Na+)	NR*	NR*	6.98	6.74	6.99	6.81	11.62	6.86	6.60	10.44	10.57	7.32	7.16	7.18
Potassium (K+)	NR*	NR*	3.49	2.67	8.13	1.37	3.11	3.01	2.86	2.63	2.47	2.86	2.66	2.65
Iron (mg/l)	1	NR*	0.05	0.09	0.03	0.06	0.02	0.03	0.02	0.08	0.02	0.04	0.04	0.06
Sulphates (mg/l)	200	400	0.65	8.21	1.24	3.30	6.64	3.86	.24	5.68	2.31	7.91	4.26	2.15
Nitrate	NR*	NR*	0.3	3.15	0.68	0.08	3.86	2.0	3.98	2.24	1.0	3.68	1.99	0.69

NR* No Relaxation

Table -2

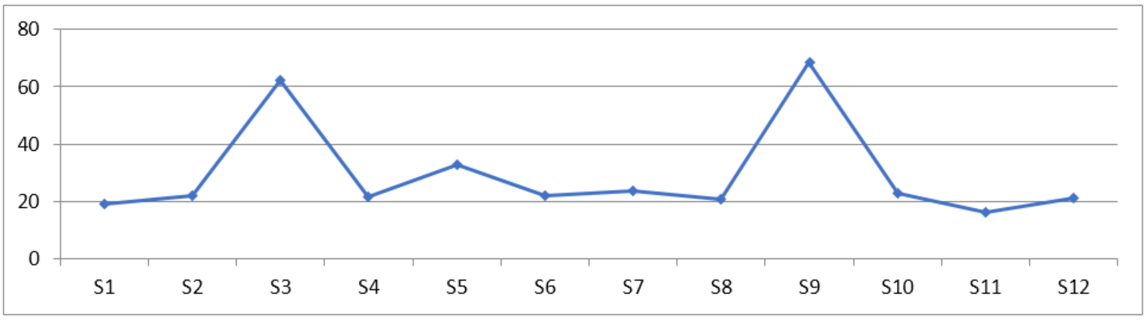
RESULTS AND DISCUSSION

Samples	Locations	Latitude	Longitude	Date	WQI	WQS
S1	Konhara ghat (No public gathering)	25.6804666	85.196266	13 -11-23	19.2368	Excellent
S2	Konhara ghat (Public gathering- near temple)	25.680571	85.196131	13 – 11- 23	21.8918	Excellent
S3	Konhara ghat (Cremationcentre)	25.678793	85.196282	13 – 11- 23	62.2347	Poor
S4	Balmikinagar (Gandak river enters in Bihar) site – 1	27.436172	83.908076	14 – 11- 23	21.4217	Excellent
S5	Balmikinagar (site -2)	27.436172	83.908076	14 – 11- 23	32.6625	Good
S6	Bagha site -1 Gandak river meets Harha nadi	27.078676	84.139721	14 – 11- 23	22.1869	Excellent
S7	Bagha site -2 Gandak river Before meeting Harha nadi	27.078364	84.129211	14 – 11- 23	23.7742	Excellent
S8	Bagha site -3 Gandak river After meeting Harha nadi	27.078378	84.129264	14 – 11- 23	20.9329	Excellent

S9	Bagha site -4 Harha nadi before meeting gandak river	27.083893	84.124218	14 – 11- 23	68.5347	Poor
S10	Sonepur (Harihar kshetra) Site – 1 Near temple	25.684379	85.195072	11 – 12- 23	22.7270	Excellent
S11	Sonepur (Harihar kshetra) Site – 2 Mid point of the river	25.684489	85.195348	11 – 12- 23	15.9980	Excellent
S12	Sonepur (Harihar kshetra) Site – 3 Away from temple	25.684569	85.195848	11 – 12- 23	21.1795	Excellent

Table-3

Based on results of each sample as shown in table 1, the WQI falls under a range of 15.99 to 68.53 (Graph 1). The majority of the samples exhibit excellent water quality, except sample 3 and sample 9 have significantly higher WQI values of 62.23 and 68.53, respectively, indicating poor water quality. At site Konhara ghat - Cremation centre the WQI level was found to be high because of cremation of human bodies done there, however at site Harha nadi (Rivulet) before meeting gandak river the WQI level was high due to the discharge of waste in Harha nadi (Rivulet) from sugar mill located at Bagaha in Harha nadi.



Graph 1

Aquatic Ecosystems: Poor water quality can harm the animals and plants living in the water. It is important to keep the water clean to protect different species and the overall health of the ecosystem. High levels of pollution, as seen in the WQI values at Site 3 and Site 9, can damage habitats and cause the loss of aquatic species [8].

Public Health: Water quality has a direct impact on human health, particularly in communities that use river water for drinking, bathing, and farming. Contaminated water can cause waterborne diseases like cholera, dysentery, and typhoid. The poor water quality at some locations shows the urgent need for better water treatment and sanitation facilities to keep people healthy [7].

Water Resource Management: Effective water resource management needs constant checking of water quality to find out where pollution is coming from and take the right actions to fix it. The WQI values give important information to help decision-makers prioritize actions and allocate resources to improve water quality [6].

CONCLUSION

The water quality analysis of the Gandak River reveals significant variations in WQI values across different locations. Most sites demonstrate excellent water quality, with WQI values ranging from 15.99 to 23.77. However, two locations, Site 3 (Konhara ghat - Cremation centre) and Site 9 (Harha nadi before meeting Gandak River), stand out due to their significantly higher WQI values of 62.23 and 68.53, respectively. The elevated WQI at Site 3 is attributed to the cremation activities, while the high WQI at Site 9 is linked to the discharge of waste from a sugar mill located at Bagaha in Harha nadi[9]. These findings underscore the need for targeted interventions to mitigate pollution sources and improve the overall water quality of the Gandak River [10].

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