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Study of Water Quality Index for Assessment of Characteristics of Water of Budhi Gandak River Near Muzaffarpur District of Bihar

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ABSTRACT

This paper presents the environmental quality is greatly focused on water because of its importance in maintaining human health and the health of the ecosystem. The Water Quality Index (WQI) is an arithmetic tool used to transform large water quality data into a single number that represents the water quality level for human consumption. In the present study surface water samples in summer, monsoon, and winter seasons were collected at three sampling sites in the Budhi Gandak River near Muzaffarpur for assessment of river water quality. The water quality variables analyzed for assessment of river water quality included temperature, pH, turbidity, total dissolved solids (TDS), conductivity, total hardness (TH), dissolved oxygen (DO), total alkalinity (TA), phosphate (PO^-), nitrate (NO^-) and chloride (Cl^-). The results indicated that most of the physico-chemical parameters were within the WHO limits (1998) and BIS: 10500(2004-2005) for drinking water except turbidity values which exceeded (18.55- 58.37 NTU) the maximum permissible limit of Indian standards at all the three sites in all the three seasons The seasonal water quality data showed the pH in the range of 6.9-7.3, DO in the range of 4.9-8.71 mg/L and total hardness in the range of 187.5-246.0 mg/L. A water quality index was calculated considering the relative weights of 9 water quality parameters following the calculation method prescribed by Ramakrishnaiah et al., 2009 and Gebrehiwot et al., 2011. WQI was in the range of good category (63.45-87.35) in the summer and winter seasons at each site and in the range of poor category in the monsoon season almost at all three sites.

Keywords : River Budhi Gandak, Water Quality, WQI

I. INTRODUCTION

India is blessed with water resources in its numerous rivers and streams. These freshwater resources are essential for sustainable development. Bihar has a striking feature- its network of rivers. North Bihar is a playground of various rivers like the

Gandak, Budhi Gandak, Bagmati, Kamla Balan, and the Kosi, to name a few. Budhi Gandak River is one of the major and significant tributaries of the Ganga in North Bihar. The origin of Budhi Gandak is at the West Champaran near Ramnagar and Bagaha. It is a rain-fed river and flows through West Champaran, East Champaran, Muzaffarpur, Samastipur, and Begusarai and flows into the Ganges near Muzaffarpur. The river shows very high sinuosity in its entire flow and has characteristically low silt content than other Himalayan rivers. The anthropogenic pressure on the river is very high impacting the ecological integrity of the river. The present study is an attempt to characterize the trends in the physicochemical properties of river water and to calculate the water quality index of the River water. The environmental status of any river anywhere indicates the environmental status of that region in the world. Therefore, the objective of the present study was to find out the ecological status of River Budhi Gandak and some clues for river water management in the future. In India, many researchers have worked on the physicochemical characteristics of rivers (Chaturvedi *et al*., 2006; Shrivastava *et al*., 2012) and on the water quality index (Parmer & Singh, 2011; Gupta *et al*., 2011; Saha *et a*l., 2012). Although some reports are available on the limnological study of the River Budhi Gandak (Kumar & Sinha, 2005; Mumtazuddin *et al*., 2009; Choudhary *et al*., 2009), Muzaffarpur stretch of the River Budhi Gandak has not been limnologically investigated till yet.

Bihar in general and North Bihar particularly is very rich in water resources. It has several water bodies like rivers, streams, ponds, lakes, and ditches. Water has always been an important and life-sustaining drink to humans and it is essential for the survival of all organisms. North Bihar has various rivers like the Budhi Gandak, Gandak, Bagmati, Lakhandei, Kamla Bagan, Koshi, etc. Budhi Gandak River is one of the major and significant tributaries of the Ganga in North Bihar. The origin of Budhi Gandak is at the West Champaran near Ramnagar and Bagha. This river flows through East Champaran, Samastipur, Begusarai, and finally flows into the Ganga near Muzaffarpur district. Budhi Gandak River shows very high sinuosity in its entire flow and has characteristically lower silt content than other Himalayan rivers. Many researchers have worked on the Physico–chemical characteristics of rivers in India [1, 2]. Some reports are available on the limnological study of the Budhi Gandak River [3, 4]. The present investigation was carried out to evaluate the physico–chemical characteristics of the water of river Budhi Gandak in the district of Bihar.

II. MATERIALS AND METHODS

1) Study Area:

Budhi Gandak River flows by the side of Muzaffarpur town. Three sampling sites were selected for the physicochemical assessment of the water quality of Budhi Gandak River at Muzaffarpur: Site – I (Akharaghat, city), Site – II (Kanti), and Site III (Motipur) were selected for monthly sampling. The people reside in and around floodplains of Budhi Gandak River and use river water for various purposes like irrigation, fishing, ferries, cultural activities, bathing, washing clothes, cleaning of utensils, and cattle wallowing. Apart from this, agriculture, soil mining, brick making, construction work, and discharge of town sewage and inorganic wastes are the main activities in the river floodplain. Floodplain at both sides of the river shows more or less similar land use patterns.

2) Collection of water samples:

Three sampling sites – Site – I (Akharaghat, city), Site – II (Kanti), and Site III (Motipur) were selected for monthly sampling. Samples were collected for one year (March 2022 to February 2023). The sampling period was divided into three seasons – summer (March to June), Rainy (July to October), and winter (November to February). The sampling was done during the morning (9–10 am). The water samples for physico-chemical analysis were collected in five-litre

plastic jars from each site. The selected physico–chemical parameters analyzed during investigation were – temperature, turbidity, pH, total hardness, total dissolved solids, total alkalinity, B.O.D., C.O.D., free CO_2, dissolved oxygen, sulphate, and chloride. Selected physico–chemical parameters were analysed with the help of standard analytical methods [5]. Instruments and methods employed in analyzing physico–chemical factors of water are listed in Table–1.

3) **Water Quality Index (WQI):**

The water quality index is computed to reduce the large amount of water quality data to a single numerical value. The BIS: 2004-2005 standards for drinking purposes have been considered for the calculation of the WQI of Budhi Gandak River. The WQI of Budhi Gandak River has been calculated considering the relative weights of 9 water quality parameters listed in Table- 2.

Table – 1 : Instruments/methods used for the physicochemical analysis of water samples

Parameter	Instrument/method used
Temperature	Thermometer
Turbidity	Turbidity meter
pH	pH meter
Total hardness	EDTA Titration
Total dissolved solids	Conductivity / TDS meter
Total Alkalinity	Neutralising with standard HCl (Titration)
B.O.D.	B.O.D. Analyser
C.O.D.	C.O.D. Analyser
Free CO_2	Carbon dioxide meter
Dissolved oxygen	Dissolved oxygen meter
Chloride	Titration by $AgNO_3$

Table – 2 : Relative weights of physicochemical parameters used in the assessment of water quality of Budhi Gandak River.

Parameters	BIS Standards (Si)	Weight (wi)	Relative weight (Wi)
pH	6.5- 8.5	4	0.138
Turbidity	5- 10NTU	2	0.0689
TDS	500-2000	4	0.138
Conductivity	1000-2000*	2	0.0689
Total Hardness	300-600	2	0.0689
DO	5*	4	0.138
HCO^{--}	244-732	3	0.103
NO^{-}	45	5	0.172
Cl^{-}	250-1000	3	0.103
	Qwi=29	QWi=0.9987	

*CPCB Standards (BIS Standards are not available)/All standards in mg/L or ppm except pH, and Turbidity.

1. RESULTS AND DISCUSSION

Results of the monthly observations of the present investigation were averaged for different seasons viz. summer, rainy, and winter, and

summarized in Table 3. The parameter-wise results are discussed below: –

Table – 3 : Physicochemical characteristics of water of Budhi Gandak River in the district (March 2022 – February 2023)

Physico-chemical parameters	**Summer**			**Rainy**			**Winter**		
	Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III
Water Temperature (^{0}C)	30.44	31.55	32.4	27.6	28.44	29.77	17.2	18.4	18.9
Turbidity (JTU)	22.46	23.88	28.85	32.6	34.88	36.22	21.50	19.6	27.77
pH	6.78	6.93	6.90	6.88	6.96	6.90	7.15	7.10	7.21
Total Hardness (mg/l)	191	195	210	235	200	215	242.2	248.6	239.6
Total dissolved solids (mg/l)	411.5	403.6	403.4	422.4	408.6	412.5	428.4	432.4	423.4
Total Alkalinity (mg/l)	52.25	52.66	50.1	38.4	35.2	35.5	33.6	32.4	32.3
B.O.D. (mg/l)	8.5	9.0	8.3	8.3	8.9	7.9	7.5	8.16	6.5
C.O.D. (ml/l)	18.6	20.8	18.2	16.4	18.4	15.8	13.4	14.80	12.4
Free CO2 (ml/l)	8.6	8.5	8.9	7.9	7.8	8.0	6.7	7.4	7.7
Dissolved oxygen (ml/l)	5.54	5.68	5.30	6.20	6.30	6.32	7.40	7.20	7.30
Sulphate (ml/l)	140.50	142.56	144.85	145.60	148.20	150.35	185.5	188.8	190.2

Water Temperature:

The water temperature ranged between 17.2 – 30.2 ^{0}C for Site–I, 18.4 – 31.4 ^{0}C for Site II, and 18.8 – 32.4 ^{0}C for Site III. The maximum temperature was recorded during summer followed by the rainy season while the minimum temperature was observed during winter months. It was observed that water temperature is influenced by air temperature. Water temperature influences the level of oxygen in the water body. In summer months water temperature is generally higher as compared to winter months [6].

Turbidity:

The maximum value of turbidity was during the rainy season and the minimum was during winter. It ranged between 21.51 to 32.61 for Site I, 19.61 to 34.82 for Site II, and 27.77 to 36.3 for Site III. The seasonal variation in turbidity value was very similar to the findings of Varunprasath and Danie [7]. Higher turbidity in river water might be due to the growth of phytoplankton, human activities, etc.

pH:

pH is one of the most important parameters in water chemistry. It also suggests that whether the water is suitable for drinking or not. The pH ranged between 6.88 – 7.15 for Site I, 6.92 – 7.10 for Site II, and 6.90 – 7.20 for Site III. The data of the present study reflected the highest pH value during winter when the water is slightly alkaline. These findings are also by Mishra et al [8]. The pH value of water during the summer and rainy seasons is very close but a little less than 7. The microbiological integrity of water also depends upon its pH value [9].

Total Hardness:

The total hardness of water is caused by carbonates, bicarbonates, sulfate, chlorides, and nitrates of calcium and magnesium ions. In the present investigation, maximum value of total hardness was observed during the winter season, followed by the rainy season. The

total hardness of water ranged between 190–242.2 for Site I, 194 – 248.6 for Site II, and 210 – 238.6 for Site III. The present investigation suggests that the water of every site in all seasons is hard. Water with a hardness up to 75 mg/l is treated as soft, from 75 – 150 mg/l moderately hard, 150–300 mg/l as hard, and above that very hard [10]. Total hardness values of river water at all three sites in different seasons were found to be well within the BIS permissible limit of 500 mg/l.

Total dissolved solids:

Dissolved solid substances influence the taste, hardness, and corrosive properties of water. Dissolved solids in water include organic salts and a small amount of organic matter. In the present investigation, the number of dissolved solids ranged between 412.5 – 428.4 for Site I, 402.6 – 432.4 for Site II and 403.4 – 424.4 for Site III. The high amount of suspended, dissolved and total solids adversely affects the quality of water and is unsuitable for any purpose including irrigation [11].

Total Alkalinity:

The total alkalinity of water is due to the presence of mineral salts. It is due to carbonate and bicarbonate ions. The total alkalinity of water ranged between 33.6 – 51.25 for Site I, 32.4 – 52.64 for Site II, and 32.2 –50.1 for Site III. The maximum alkalinity was observed during summer and the minimum during the winter season. The low alkalinity during winter is due to dilution [12]. Alkalinity is directly related to the productivity of water bodies because it regulates the pH and free CO_2 of the water bodies.

BOD:

Biochemical oxygen demand (BOD) is one of the most important parameters as it reflects status of aquatic pollution. BOD is the oxidisable organic matter found in water and its value may be used as a measure of waste strength. BOD ranged between 7.4 – 8.4 for Site I, 8.26 – 9.0 for Site II and 6.4 – 8.2 for Site III. BOD was recorded maximum during summer while minimum during winter. The data of BOD suggests that all selected sites of river were moderately polluted since water having BOD less than 1.0 mg/l is unpolluted between 2.0 – 9.0 mg/l is moderately polluted and above 9.0 mg / l is heavily polluted.

COD:

COD or Chemical Oxygen Demand is the total measurement of all chemicals (organic & inorganic) in the water. COD is a measure of the total quantity of oxygen required to oxidize all organic material into CO_2 and water. COD values are always greater than BOD values. COD ranged between 13.4 – 18.6 for Site I, 14.8 – 20.8 for Site II, and 12.4 – 18.2 for Site III. It is evident from the findings that the COD value is maximum during summer and minimum during winter season. The BOD and COD were recorded maximum at Site II in all seasons because the water of the river at Kanti was receiving many pollutants from the Kanti factory and sewage of the municipal area.

Free CO_2:

Free CO_2 in a water body is generally derived from the atmospheric sources, biotic respiration, decomposition of organic matter etc. According to the present findings free CO_2 ranged between 6.6 – 8.6 for Site I, 7.4 – 8.4 for Site II, and 7.6 – 8.8 for Site III. Free CO_2 was maximum during summer and minimum during winter. The higher value of CO_2 in summer months might be due to the decomposition of organic matter by microbes in the bottom. The present findings are very close to that of other workers [13].

Dissolved Oxygen:

Dissolved oxygen is an important parameter for water quality. It also serves as an indicator of the physical, chemical, and biological activities of the water body. During the investigation, the minimum value of DO_2 of water was recorded during summer months while the maximum during winter. DO_2 ranged between 5.54 – 7.40 for Site I, 5.68 – 7.20 for Site II, and 5.30 – 7.30 for Site III. The highest dissolved oxygen during

winter months might be due to high photosynthetic activity during these months [14].

Sulphate:

The maximum concentration of sulphate was recorded during winter while the minimum was during summer months. It ranged between 140.50 – 185.50 for Site I, 142.56 – 188.80 for Site II, and 144.85 – 190.2 for Site III.

Chloride:

The level of chloride ranged between 6.24 – 19.52 for Site I, 6.28 – 17.63 for Site II, and 5.86 –18.45 for Site III. It is evident here that chloride was minimal during winter and maximum during the summer season. The major anthropogenic sources of chloride in surface waters include deicing salt, urban and agricultural runoff, municipal discharges, etc. Chloride is an index of pollution of human origin [15].

III. CONCLUSION

The water quality of the River Budhi Gandak at Muzaffarpur in Bihar has been assessed based on the results of the analysis of river water samples for important physicochemical parameters at three sites (upstream, downstream & one in between two). An attempt has been also made to investigate the impact of anthropogenic activities, both in the river and in the catchment area of the river, on the river water quality. The water quality analysis results in the present study indicated that most of the physico-chemical parameters investigated were within the WHO limits (1998) and BIS:10500(2004-2005) for drinking water except that of turbidity which exceeded the permissible limit during all three seasons at all the three sites. WQI results suggested that the river water was in the poor category (105.55- 122.03) at sites I and III during monsoon, and might be classified under the good category in winter (63.45- 87.35) and summer (73.86- 82.45) seasons. The study suggests river water is unsuitable for human consumption during monsoon months [16-22]. However, the river water is suitable for diverse uses like irrigation, recreation, and other domestic uses except drinking. Budhi Gandak River and other such rivers (tributaries) are very important as they feed into and create our big rivers. Therefore, the good health of our big rivers depends on the adequate quantity and quality of their tributaries and other small streams. These rivers play a critical role in the quality and supply of drinking water by ensuring a continuous flow of surface water and helping recharge underground aquifers. Thus, there is a need to properly manage wastes in the town and control and monitor human activities in river Budhi Gandak or in its floodplain to ensure that such activities have minimal negative effects on the river in the Muzaffarpur stretch. Though the nutrient concentrations were low in the river stretch near Muzaffarpur, care must be taken by inhabitants to avoid abusing the river.

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