Seasonal Variations in Water Quality Of Main Channel And Side Channel Of River Ganga At Bhagalpur (Bihar)

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ABSTRACT

Water quality assessment is essential for providing information regarding water resource management. This study represents the seasonal variations of water quality of the River Ganga (Main and Side channel). The results in the present study in the pre-monsoon and post-monsoon seasons indicate that most of the water quality parameters were within the permissible limits of (WHO 1998 and BIS: 10500 2004-2005) for drinking water purposes except turbidity, DO, FCO_2, BOD values at some sites. DO was in the range of 2.6-9.8 mg/L, FCO_2 in the range of 21-120 mg/L. BOD in the range of 1.2-4 mg/L and turbidity in the range of 18.8-57.2 mg/L. Water quality index was calculated considering relative weights of 13 water quality parameters following the methods prescribed by Ramakrishnaiah *et al*., 2009 and Gebrehiwot *et al*., 2011.Water quality index values of selected sites in two seasons found under Good (71.44-91.83), poor (126.17-182.37) and very poor (208.58) category. Water of Side channel was not fit for human consumption in post monsoon season.

Keywords: River Ganga, Side Channel, Water Quality Index

INTRODUCTION

Rivers are complex and dynamic ecosystem. The nature of a river system is primarily controlled by the interaction between geology, climate and geomorphic features. Rivers and riverine habitats classified according to spatial and temporal scales or disciplinary focus i.e. geo morphological, hydrological/biological and their combination (Buffington and Montgomery, 2013). The aquatic habitats of the river are not limited to main channel only; they also include side channel habitats. Side channels are those bodies of water adjacent to the Main channel and clearly identifiable upstream and downstream connected to the main channel. River basin have been a major source of water supply for many purposes and provides fertile land which supports the development of highly populated residential area due to its favourable condition (Mouri *et al.*, 2011). Assessment of water resource quality of any region is an important aspect of developmental activities because rivers, lakes and manmade reservoirs are used for water supply for domestic, industrial, agricultural and fish culture purposes (Jackher and Rawat, 2003).

The Lower Ganga is one of the most hydro-geomorphological dynamic regions of the world. The river stretch near Bhagalpur lies in the Lower Ganga floodplain belt. Active braided channels, meanders, oxbow lakes and sandbars, which result from dynamic hydrological processes occurring within a low gradient alluvial plain, characterize the geomorphology of the river near Bhagalpur (Choudhary *et al.,* 2006).

The objective of the present study is to determine the water quality from pot ability point of view in two hydro-geomorphic units of the river i.e. side and main channels of the river and to ascertain if water quality differs between the two hydro-geomorphic units. For the purpose of computation of Water Quality Index (WQI) was done, as WQI is an effective tool to predict about the water quality. WQI gives a single value for the water quality of a source by translating the list of parameters and their concentrations present in a sample of single value, which in turns provides an extensive interpretation of the quality of water and its suitability for various purposes like drinking, irrigation, fishing etc (Abbasi, 2002).

MATERIALS AND METHODS

Study Area

The study was conducted in large hydro-geomorphic units of the River Ganga at Bhagalpur which are classified into Main Channel, Mixing zone and Side channel (Jamania Channel). Jamania channel is an offshoot of River Chanan. Chanan is the largest hill streams in the south of the Bhagalpur district. It is divided into fifteen smaller channels. Only two are able to touch the River Ganga. One of these channels, Jamania channel from Champanagar– Nathnagar onwards flows along the Bhagalpur city parallel to main Ganga and ultimately meets the main course of the river near Vikramshila Bridge at Barari.

Four sampling sites were selected for the assessment of physico-chemical characteristics of water quality of River Ganga at Bhagalpur and those included i) Site I - Main Channel - north of Barari bridge Ghat (25°17'25.8"N 87°01'18.2"E), ii) Site II - Mixing zone in between Cremation Ghat and Vikramshila bridge (25°16'27.4"N 87°01'40.8"E), iii) Site III in Jamania channel (side-channel) near Inland Waterways Station about 9 km downstream of Barari Bridge Ghat (25°15'908"N 86°59 886"E), and iv) Site IV second side channel habitat in Jamania channel near Khirni Ghat 8.4 km downstream of Barari Bridge Ghat in Jamania channel (25°15'850"N 86°59'692"E). The study was conducted in pre-monsoon and post-monsoon periods of 2015 and 2016.

Fig. 1- Satellite image marking sampling sites in River Ganga at Bhagalpur

Collection and analysis of water samples

Water samples for physico-chemical analysis were collected from sampling sites at 7.00 -10.00 am in 1litre polythene bottles. The parameters like pH, Dissolved oxygen, Free-carbon dioxide, and Conductivity were determined on the spot and for analysis of remaining parameters, the water samples were transported to Bhagalpur University Environmental Biology Research Lab. The water parameters were analyzed in the lab following Standard Methods (APHA, 2005; Trivedy & Goel, 1986).

Water Quality Index (WQI)

Water Quality Index, a technique of rating water quality, is an effective tool to assess quality and ensure sustainable use of water for drinking (Tiwari *et al*., 2014). In this study for the calculation of water quality index, thirteen important parameters were chosen. The WQI has been calculated by using the standard of drinking water quality recommended by BIS (2004-2005). The WQI has been computed considering relative weights of water quality parameters (Table 1) following the calculation method prescribed by Ramakrishnaiah *et al*., 2009 and Gebrehiwot *et al*., 2011. Computed WQI values were classified into five categories (Table 2): Excellent, Good, Poor, Very poor and Unfit Water for drinking purposes (Ramakrishnaiah *et al*., 2009).

Table: 1 Relative weight for physico-chemical parameters of assessment of water quality of River Ganga

(Ramakrishnaiah *et al*., 2009 and Gebrehiwot *et al*., 2011)

Parameters	BIS(2004-05)Si	Weight(wi)	Relative weight(Wi)
pH	6.5-8.5	4	0.097560976
TDS	500-2000	4	0.097560976
Conductivity	1000-2000	2	0.048780488
DO	5	4	0.097560976
FCO_2	6*	3	0.073170732
HCO_3^-	150-300	3	0.073170732
Turbidity	05-10NTU	2	0.048780488
T.H.	300-600	2	0.048780488
NO_3-N	45	5	0.012195122
PO_4-P	0.1-1**	2	0.048780488
Cl^-	250-1000	3	0.073170732
BOD	3	4	0.097560976
COD	10-20**	3	0.073170732
		Σwi=41	

*ISI standard **WHO standard / All standards in mg/L or in ppm except pH, Turbidity and Conductivity

Table: 2 WQI based water quality categories (following Ramakrisnaiah *et al*., 2009)

WQI Value	Water quality category
<50	Excellent
50-100	Good
100-200	Poor
200-300	Very poor
>300	Unsuitable for drinking

RESULTS AND DISCUSSION

The physico-chemical analysis of water quality parameters along with water quality index of four sites are summarized in Table 3. In the present study pH values showed almost similar range of variation in pre-monsoon (7.9-8.3 mg/L) and post-monsoon seasons (8.4-8.6 mg/L). TDS values were higher at Site IV (311mg/L) in pre-monsoon season and lower at Site I (146mg/L)

in post-monsoon season. TDS values are depending upon the geology and climate of the region and weathering process that affect the dissolved materials. Maximum value (543µs) of conductivity was found in post-monsoon season at Site IV. Maximum value of DO (9.8 mg/L) was recorded at Site I and minimum (2.6 mg/L) at Site IV in pre-monsoon season. It might be due to dry periods (summer). Dry periods decrease flow rate and reduces the amount of oxygen dissolved into the water. DO is an important limnological parameter indicating level of water body (Kataria *et al*., 1996). The optimum value for good water quality is 4 to 6 mg/L of DO, which ensures healthy aquatic life in a water body (Sawyer *et al*., 1994; Leo and Dekkar 2000, Burden *et al*., 2002, and De 2003). Free carbon dioxide (FCO_2) was much higher (120 mg/L) in post-monsoon at Site IV compared to pre-monsoon value (21 mg/L).

High FCO_2 concentrations are almost accompanied by low dissolved oxygen concentrations. From the results, it was obvious that the FCO_2 value increased with decreasing DO. Bicarbonate (HCO_3^-) was observed in the range of 24-61mg/L in pre-monsoon while 27-60mg/L in post-monsoon season. All values of HCO_3^- recorded were within permissible limit of BIS (2004-2005) throughout the study period. High Turbidity (57.2 NTU) was recorded in the side channel at Site IV (Khirni Ghat) in post-monsoon period whereas low Turbidity (18.8 NTU) in the main-channel at Site I near Vikramshila bridge in pre-monsoon period. Turbidity inhibits photosynthesis by blocking sunlight. The higher the turbidity levels, the less light that can reach the lower levels of water resulting into decrease in DO level. The result was very similar to the results observed by Yashoda *et al*., 2014.

Total hardness values varied from 150-442 mg/L well within permissible limit of BIS (2004-2005). Khopkar (1993) classified hardness of water into five categories on the basis of total ion content viz. soft (0-40 mg/L), moderately hard (40-100 mg/L), hard (100-300 mg/L), very hard (300-500 mg/L), and extremely hard (500-1000 mg/L). Based on these, the investigation can be placed in the hard to very hard category.

Both NO_3-N and PO_4-P were present very low concentrations in the waters of side and main channels of the rivers, so do not pose a threat to the human health. The pre- and post-post monsoon chloride content in the river water was found in the range of 8.49-65.48 mg/L the values within permissible limit. BOD is one of the most common measure of pollutant of organic material in water sources. Maximum BOD (4 mg/L) was observed in pre-monsoon at Site IV and minimum (1.2 mg/L) in pre-monsoon season at Site I, similar to results reported by Badaii *et al*., 2013. COD values were low in all the water samples analyzed for all the sites and it varied from 0.74 -17.56 mg/L (within BIS permissible limit). In the present study computed Water Quality Index values ranged from 71.44 - 91.83 in pre-monsoon and 94.29-208.58 in post-monsoon season.

Pre-monsoon WQI values computed for all the sampling sites, following Ramakrishnaiah *et al*. (2009) suggest that river water may be treated as of Good category, whereas post-monsoon WQI values suggest category of river water varying from Good to Very Poor.

Correlation coefficient of WQI with water variables in both seasons are depicted in Table 4. WQI was positively correlated with all the water variables except those of pH, DO, COD in both pre-monsoon and post-monsoon seasons, values being significant at 0.05, 0.01, 0.001% level at all the studied sites.

Water quality is important not only to protect public health but for ecosystem habitats also which are used for farming, fishing, mining, recreation and tourism. If water quality is not maintained, it is not just the environment that will suffer but the commercial and recreational values of our water resources will also diminish. The results of the present study clearly establish the status of water quality of side-channel in River Ganga near Bhagalpur and may be classified under Poor to Very Poor categories in post-monsoon season.

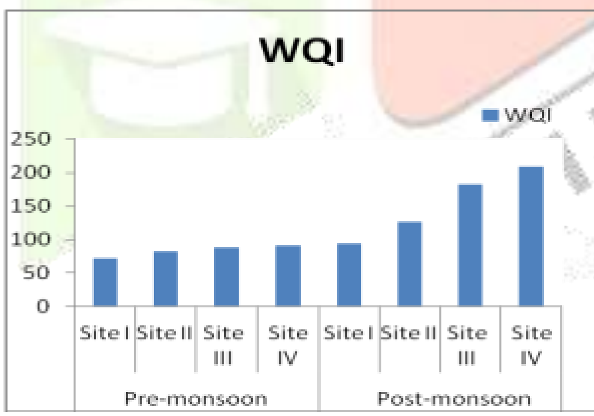

Fig. 2 Showing level of water quality category

Table: 3 Physico-chemical characteristics and WQI of Main Channel and Side Channel of River Ganga in pre-monsoon & post-monsoon season (2015-2016).

Parameters	Pre-monsoon Site I	Site II	Site III	Site IV	Post-monsoon Site I	Site II	Site III	Site IV
pH	8.1	8.3	7.9	8.1	8.4	8.6	8.5	8.4
TDS	158	159	275	311	142	146	224	263
Conductivity	298.5	307	421	435	266	277	498	543
DO	9.8	8.2	3.6	2.6	7.4	8	4.5	3
FCO_2	21	25	31	35	40	59	113	120
HCO_3^-	35	24	65	61	27	27	55	60
Turbidity	18.8	20.9	25	27.5	21.1	32.2	26.8	57.2
T.H.	196	195	328	442	150	189	190	188
NO_3-N	0.045	0.046	0.046	0.053	0.036	0.038	0.043	0.045
PO_4-P	0.045	0.056	0.081	0.074	0.044	0.044	0.039	0.048
Cl^-	14.99	17.49	55.48	65.48	8.49	12.49	32.98	27.99
BOD	1.2	3.6	2.6	2.2	2.2	2.7	2.4	4
COD	1.26	4.32	17.56	17.1	2.52	2.82	0.74	2.24
WQI	71.44	83.09	87.87	91.83	94.29	126.17	182.37	208.58
WQI Class	Good	Good	Good	Good	Good	Poor	Poor	Very poor

* All parameters are in mg/L except pH and Turbidity. TD-Total Dissolved Solids, TH- Total Hardness, HCO_3^- - Bicarbonate, PO_4-P- Phosphate, NO_3-N- Nitrate, Cl^--Chloride, BOD-Biological Oxygen Demand, COD- Chemical Oxygen Demand, WQI:- Water Quality Index. Site I:- Main-Channel, Site II:- Mixing zone, Site III Station Inland waterways Station (Side-channel), Site IV:- Khirni Ghat (Side-channel).

Good health of large rivers depends on quality of ephemeral streams. Major drains of the town carrying urban wastes, both of organic and inorganic nature, are channelized to the Jamania channel (side-channel) which ultimately flows into the main-channel of River Ganga near Barari. Based on WQI values the present study indicates the water quality of the side-channel in the post-monsoon season unsuitable for human consumption. Side-channel is supposed to play a major role in the secondary productivity of the main channel of the River Ganga at Bhagalpur and that is important for sustaining the aquatic wildlife in the river. Thus, there is a need to properly manage sewage and other wastes generated in enormous quantity in Bhagalpur city and for continuous monitoring of anthropogenic activities in the river and regular assessment of river water quality.

Table: 4 Correlation between Water Quality Index (WQI) and physico-chemical parameters of River Ganga

Significant at **0.1% level, ǂ0.01% level,*0.05 % level

	pH	TDS	Conductivity	DO	FCO_2	HCO_3^-	Turbidity	TH	NO_3-N	PO_4-P	Cl^-	BOD	COD
Pre-Monsoon WQI	-0.221	0.845ǂ	0.859ǂ	-0.924	0.953ǂ	0.662*	0.938ǂ	0.826ǂ	0.714**	0.893ǂ	0.861ǂ	0.500	0.888ǂ
Post-Monsoon WQI	-0.159	0.973ǂ	0.971ǂ	-0.936	0.989ǂ	0.963ǂ	0.758**	0.741**	0.998ǂ	0.131	0.921ǂ	0.734**	-0.527

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