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Changes in water quality index of different Ghats of Ganges River in Patna

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Abstract
In this study, we have determined the Water Quality Index (WQI) of monsoon season water samples of River Ganges. The main aim is to assess changes in Ganges River at various Ghats in Patna city including Krishna Ghat, Gandhi Ghat, Rani Ghat, Kadam Ghat and Gai Ghat. For this, the physicochemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Dissolved Oxygen, Chloride content, Total Hardness, Alkalinity, Total Solid, Suspended Solid, Dissolved Solid and Biochemical Oxygen Demand (BOD) were analyzed by standard processes. The values obtained were then compared with the guideline values of drinking water by Bureau of Indian Standard (BIS) and World Health Organization (WHO). From the measured quantities, certain parameters were selected to derive WQI for the variations in water quality of each designated sampling site. WQI of Ganges river water at Patna city ranged from 50.32 to 59.62 which fall in the range of poor quality of water. It is shown that WQI may be a useful tool for assessing water quality and predicting trend of variation in water quality at different locations in the Ganges River.
Keywords: Water quality index; Ganga River; physicochemical parameters; monsoon season

1. Introduction

Ganges River is one of the largest river of India and a major source of drinking water for dwellers in cities, towns and villages in its basin area. The Ganges basin is one of the most heavily populated areas in the world with an average density of 520 persons/Km². The present study is being aimed to evaluate water quality of the river in Patna region at the various Ghats of Ganges River. People living on the bank of the river, apart from drinking, use its water for industrial, agricultural and other purposes like cattle bathing and cloth washing etc. After the usage, water is generally discharged into the river from industrial, agricultural and sewage systems. According to the report of Central Pollution Control Board (CPCB), the capacity of sewage treatment plants is only 70.9% of the total sewage generation (143 MLD) in Patna.

Frequent use of river water by the civilians increases the possibility of human health hazards. According to WHO, about 80% of all diseases in human populations are caused by drinking water (CPCB, 2006). The water quality determines the suitability of water usage for various purposes (Ahipathy and Puttaiah,2006). Both natural as well as effluent discharges with the toxic compounds due to anthropogenic activities cause problems to communities in the receiving aquatic system and has a potential effect on the human health (Duruibe et al., 2007). So in this regard, evaluations of quality of river water with respect to location along the stretch and in different weather conditions (mainly monsoon season) seems important to prevent the people from diseases and ill health.

The main objectives of the current study is to assess and evaluate Water Quality Index (WQI) based on physicochemical parameters, to envisage the local people towards proper management of water resources and to develop a baseline data which will help in future water management and conservation policies.

Many literatures have reported for Water Quality Index (WQI) for various river. Prerna Sharma et.al.,2013 have determined WQI of Ganges river water at Allahabad ranged which ranged from 86.20 to 157.69 which falls in the range of poor quality of water. Shekhar S et.al. 2015 studied that WQI of Hindon river water of western U.P. has been recorded 163.89- 487.89 for pre monsoon season and 33.0 -59.796 for post monsoon season which was very poor quality of water. Waribam Suraj Devi et.al.2014 studied that WQI of Nambol river water at Manipur ranged from 67.878 to 85.276 which falls in the range of poor quality of water. A.G. Murugesan et.al., 2011 studied that WQI of Tamirabarani river water (which feed two major districts Tirunevely and Thoothukudi of Tamilnadu, India**)** as recorded by K. Mophin–Kani and A.G. Murugesan and found that excellent quality of water was recorded at 21.53 %, very good quality at 28.47 %, good quality at 33.33 %, fair quality at 13.89 % and marginal quality at 2.78 % of sampling sites during the study tenure. Vineeta Kumara et.al.,2015 studied that WQI of Sai river water (which passes through Hardoi, Raibareli, Jaunpur, Pratapgarh, Unnao and finally meets Gomati river Lucknow) was recorded good (32.129) for Hardoi, excellent (17.168) for Unnao and Lucknow and moderate (62.376) for Raibareli, Pratapgarh and Jaunpur.

2. Material and Methods

2.1 Sample collection location

Samples were collected during monsoon period in the year 2016. The monsoon months are from July to September of each year. It was decided to select five designated sampling locations which include five Ghats of Ganges including Krishna Ghat, Gandhi Ghat, Rani Ghat, Kadam Ghat and Gai Ghat(as shown in figure 1,Table 1) . Water samples were collected from 0.5m from bank of the rivers and approx. 0.5 meter below the water surface in triplicates.

Table 1

GPS location of each sampling site. (Description of site)

Locations	Latitude	Longitude
Krishna Ghat	25°37´19.8´´N	85°10´05.8´´E
Gandhi Ghat	25°37´20.3´´N	85°10´21.1´´E
Rani Ghat	25°37´15.9´´N	85°10´38.7´´E
Kadam Ghat	25°37´05.2´´N	85°11´26.2´´E
Gai Ghat	25°36´50.4´´N	85°12´11.2´´E

2.2 Sample collection and analysis

Water samples were collected in polyethylene bottles rinsed with 15% HNO_3 (v/v). Collected samples were stored in refrigerator at 4 C for subsequent analysis. A total of 15 water quality parameters were analyzed. Temperature , pH, TDS and EC were analyzed in situ with the help of portable water analysis kit (pH meter, conductivity meter) and calibration was done for each sample before measurement with the help of Rapid Calibration Solution. For the measurement of other parameters, such as alkalinity, chloride, BOD, total hardness, total solid etc., we used the methods as discussed in Standard Method for determination of respective water quality parameters.

2.3 WQI determination

The method adopted for the calculation of WQI was as described by Hameed et al. (2010). To calculate WQI, a total of 12 parameters were considered and each parameter was assigned with a definite weightage (W_a) according to its relative importance on the overall quality of water which ranges from 1 to 5 (Table 2). Parameters which influence more significantly, the water quality were assigned weight 5 and 1 to that of the least influencing. Relative weights (W_r) were calculated by using the following formula

$$W_r = W_{ai} \div \sum_{i=1}^{n} Wai$$

Where,

W_r = Relative weight, W_{ai} = assigned weight of each parameter, n = Number of parameters considered for the WQI. The calculated value of Wr for each parameter is given in the Table 2.

Following the next step, Quality rating scale (Q) has been measured for each parameter by dividing its respective standard values as suggested in the BIS and WHO guidelines.

$Q_i = [C_i \div S_i] \times 100$

To calculate the Q for the DO and pH, the different methods were employed. The ideal values (V_i) of pH (7.0) and DO (14.6) were deducted from the measured values in the samples (Hameed et al., 2010).

$Q_{ipH;\ DO} = [(C_i - V_i) \div (S_i - V_i)] \times 100$

Where, Q_i = quality rating scale, C_i = measured concentration of each parameter, S_i = drinking water standard values for each parameter according to BIS and WHO.

Next sub-indices (SI) have been calculated to compute the WQI.

$SI_i = W_r \times Q_i$

$WQI = \Sigma SI_i$

The computed WQI values were classified according to proposed categorization of water quality (Ramakrishnaiah et al.,2009; Yadav et al., 2010).

Table 2

Relative weight of water quality parameters. (Prerna et.al., 2014)

Parameters	Weight(W_a)	Relative weight(W_r)
pH	4	0.098
Electrical conductivity	5	0.122
TDS	4	0.098
Dissolved oxygen	5	0.122
Alkalinity	2	0.049
Total hardness	4	0.098
Chloride	3	0.073
Total solid	4	0.098
Suspended solid	3	0.073
Dissolved solid	2	0.049
BOD	5	0.122

3. Results and Discussion

Water quality parameters, namely, pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), alkalinity, total hardness, chloride, total solid, suspended solid, dissolved solid and BOD at a total of five sites of Ganges rivers within a stretch of about 7 km at Patna city was measured. The values obtained in our studies were compared with the guideline values suggested by BIS (Indian Standard Specification for Drinking Water, 2004) and WHO (World Health Organization, 2011). We have calculated WQI from the measured parameters and then prepared respective tables which are given below: -

Krishna Ghat

Parameters	Data(C_i)	Standard(S_i)	Q_i	SI_i
pH	8.2	8.5	80	7.84
Electrical Conductivity	250	500	50	6.10
TDS	125	500	25	2.45
Dissolved Oxygen	10.17	7.5	62.39	7.61
Alkalinity	45.4	200	22.7	1.11
Total hardness	49.3	300	16.43	1.61
Chloride	39.98	250	15.99	1.17
Total solid	390	500	78	7.64
Suspended solid	130	350	37.14	2.71
Dissolved solid	260	500	52	2.55
BOD	3.97	3	132.33	16.14
			WQI=	***56.93***

Gandhi Ghat

Parameters	Data(C_i)	Standard(S_i)	Q_i	SI_i
pH	8.1	8.5	73.33	7.19
Electrical Conductivity	259	500	51.80	6.32
TDS	131	500	26.20	2.57
Dissolved Oxygen	7.72	7.5	71.67	8.74
Alkalinity	60	200	30	1.47
Total hardness	58	300	19.33	1.89
Chloride	23	250	9.20	0.67
Total solid	457.5	500	91.50	8.97
Suspended solid	300	350	85.72	6.26
Dissolved solid	157.5	500	31.5	1.54
BOD	1.5	3	50	6.1
			WQI=	***51.72***

Rani Ghat

Parameters	Data(C_i)	Standard(S_i)	Q_i	SI_i
pH	8.2	8.5	80	7.84
Electrical Conductivity	274	500	54.8	6.69
TDS	137	500	27.4	2.69
Dissolved Oxygen	8	7.5	92.95	11.34
Alkalinity	49	200	24.5	1.2
Total hardness	58.3	300	19.4	1.9
Chloride	32.29	250	12.9	0.94
Total solid	470	500	94	9.21
Suspended solid	310	350	88.57	6.47
Dissolved solid	160	500	32	1.57
BOD	1.0	3	33.33	4.06
			WQI=	***53.91***

Kadam Ghat

Parameters	Data(C_i)	Standard(S_i)	Q_i	SI_i
pH	8.2	8.5	80	7.84
Electrical Conductivity	230	500	46	5.61
TDS	115	500	23	2.25
Dissolved Oxygen	8.13	7.5	85.13	10.39
Alkalinity	49.4	200	24.7	1.21
Total hardness	45	300	15	1.47
Chloride	34.68	250	13.87	1.01
Total solid	420	500	84	8.23
Suspended solid	110	350	31.43	2.29
Dissolved solid	310	500	62	3.04
BOD	3.2	3	106.67	13.01
			WQI=	***56.35***

Gai Ghat

Parameters	Data(C_i)	Standard(S_i)	Q_i	SI_i
pH	8.3	8.5	86.67	8.49
Electrical Conductivity	233	500	46.6	5.69
TDS	117	500	27.4	2.69
Dissolved Oxygen	8.47	7.5	86.34	10.53
Alkalinity	48	200	24	1.18
Total hardness	46	300	15.33	1.50
Chloride	30.59	250	12.24	0.89
Total solid	440	500	88	8.62
Suspended solid	70	350	20	1.46
Dissolved solid	370	500	74	3.63
BOD	3.67	3	122.33	14.92
			WQI=	***59.60***

A comparison of water quality index based on scale by Yadav et al.2010 and Ramakrishnaiah et al.2009 is shown in Table 3.

Table 3

Water quality indices and water quality at different location.

Location	WQI	Water quality Based on scale suggested by Yadav et al. (2010)	Water quality Based on scale suggested by Ramakrishnaiah et al. (2009)
Krishna Ghat	**56.35**	Poor	Good
Gandhi Ghat	**51.72**	Poor	Good
Rani Ghat	**53.91**	Poor	Good
Kadam Ghat	**56.35**	Poor	Good
Gay Ghat	**59.60**	Poor	Good

Table 4

Water quality scale.

Water quality	WQI Yadav et al. (2010)	WQI Ramakrishnaiah et al. (2009)
Excellent	0-25	<50
Good	26-50	50-100
Poor	51-75	100-200
Very poor	76-100	200-300
Unsuitable	Above 100	>300

4. Conclusions

From the results of our study we infer that increased concentration of Na^+ and Cl^- ions may be attributed to domestic waste water and sewage discharge as the main cause of increased pollution in Ganges river at Patna. Ganges river was found with almost saturated level of oxygen and increased alkalinity in the monsoon period which represents the river system as good habitat for the aquatic organisms. By analyzing the quality of water using WQI, we have found a significant decline in water quality of Ganges river including various Ghats at each location in Patna. Results suggest that purification of water may be necessary for consumption of the monsoon water for drinking and irrigation purposes. This study recommends the pressing need for continuous monitoring of river water for determining the factors affecting pollution and its impact on water quality are instructive. The reasons behind poor water quality of Ganges river at Patna city are sewage disposal, animal bathing, cloth washing and high silt discharge.

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