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Water quality assessment of lower Ganga river near Haldia applying water quality index method

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This present study is aim to assess the water quality index for the lower Ganga river during dry season at Haldia through GIS modelling. This study also focused to develop a mapping to estimate values of water quality parameters graphically in locations where the parameters are not measured in the field using Arc-GIS and to classify the water quality of the lower Ganga river at various sampling points by applying Weighted arithmetic water quality index (WAWQI) method for better idea about water quality of the river. The analysis reveals that the surface water of the study area needs some remediation measurement to main water quality in river.

Keywords: Surface water, water quality index, Ganga river, salinity, WAWQI, water quality modeling.

Introduction

Water quality index (WQI) is very much helpful to reveals the quality of water into various classes such as very good, good, poor, very poor and not suitable for drinking, depending upon the severity of pollution and contamination[1]. This study mainly focused on the evaluation of water quality by adopting Weighted Arithmetic Water Quality Index (WAWQI) method[2], which is most commonly used to assess in drinking water quality indices[3]. The study on water quality parameters throughout the study area helps us to build up a clear conceptual model dependent on all the accessible data as well as to understand more completely the transport regime of the pollutan[4]. This study basically focused on the water quality parameters i.e. pH, TDS, chloride concentration, BOD and salinity.

Study area

The study area lies in Purba Medinipur district of West Bengal, within the co-ordinates of latitude 22°12′21.1″N to 22°56′57″N and longitude 88°02′49.7″E to 88°01′14.1″E, which is basically covers the city Haldia, Geonkhali and Nandigram. Haldia is a city and municipality in Purba Medinipur district in West Bengal. Haldia is a major river port based industrial city located approximately 125 km south-west of Kolkata near the mouth of the Hoogly river, which is one of the distributaries of the Ganges. The study area basically surrounded by the Hoogly river, and the Hoogly river is connected with the Rupnarayan river at Geonkhali and with the Haldi river at Haldia. In this region salinity is a major problem and due to industrial area, presence of heavy metal is a problem also. In the study area there has been a decrease in the quality of water, mainly in the Hoogly river. Salinity is the principal cause of this water quality degradation in this area.

Water samples were collected in the winter of 2020 from 15 sampling points.

The map of the study area including the Hoogly river, Rupnarayan river, Haldi river and the locality Haldia, Geonkhali, Nandigram are shown in Fig. 1. This Fig. 1 also indicates the main cities in the study area those are Haldia, Nandigram, Geonkhali etc.

Methodology

Sample collection:

Now time for the field visit and sample collection for the further study and analysis. Here the first sample collection was done on 11th January, 2020 from the river bank of the Hoogly river. The starting point was at Geonkhali, then heading towards Haldia throughout the river bank upto Township

Table 1. Location of sampling points

Sl. no.	Location	Latitude	Longitude	Sl. no.	Location	Latitude	Longitude
S1	Natshal	22°12′21″N	88°02′49″E	S9	Durga mandir	22°02′05″N	88°02′17″E
S2	Noorpur	22°12′57″N	88°04′13″E	S10	Balughata	22°04′38″N	88°01′03″E
S3	Geonkhali	22°11′31″N	88°03′44″E	S11	Kendamari	21°59′26″N	88°02′23″E
S4	Kukrahati	22°12′17″N	88°07′13″E	S12	Nandigram	21°58′54″N	88°02′08″E
S5	Finga	22°08′39″N	88°09′56″E	S13	Kantakhali	21°57′49″N	88°01′36″E
S6	CESC Haldia	22°05′59″N	88°11′24″E	S14	Nakchirachar	21°56′57″N	88°01′14″E
S7	Patikhali	22°03′59″N	88°09′25″E	S15	Nandigram bridge	21°55′11″N	88°00′28″E
S8	Township Haldia	22°01′19″N	88°03′11″E				

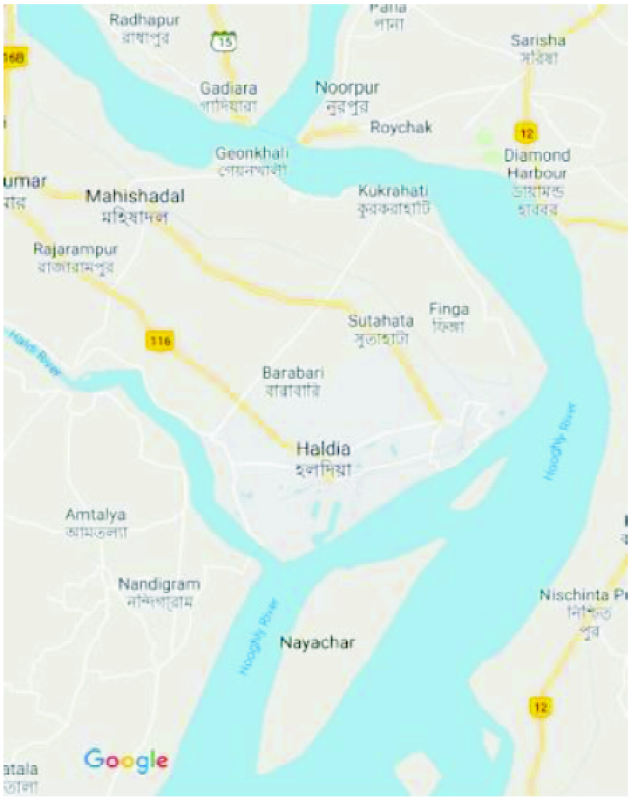

Fig. 1. Study area.

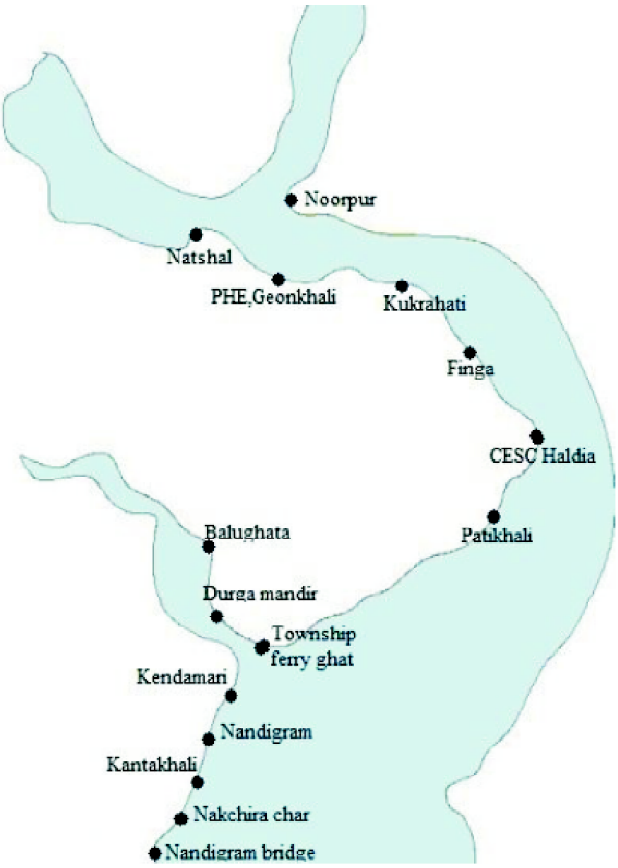

Fig. 2. Sampling points in study area.

ferry ghat, Haldia. Then from this point, heading towards Balughata throughout the river bank of Haldi river. Then the last five points are at Nandigram, river bank of Hoogly river which is heading to the Bay of Bengal. Then the second time site visit for collecting water sample was done on 22nd February, 2020. So, in this study total 15 nos of water sample from the sampling points are collected during the both field visit. Those sampling locations are shown in Fig. 2. The surface water quality studied thoroughly in those 15 sampling points and also from historical data.

Laboratory test:

(i) pH:

The determination of pH done electrometrically using pH meter provided with a pH electrode, vary with temperature,

note the temperature at which is determined and set the pH meter to the appropriate temperature. pH value (relative scale of 0–14) of the collected water samples were measured by using pH meter.

(ii) TDS:

TDS (Total dissolved solids) value of those collected water samples were measured by using TDS meter.

(iii) Chloride concentration:

The chloride concentrations have been determined by titration with standard silver nitrate solution (0.014 1 *N*) using potassium chromate (K_2CrO_4) as indicator.

(iv) Salinity:

Here the following equation was followed to calculate salinity, Salinity = 0.00180665 x Cl^- (mg/L)

where Cl^- indicates the chloride concentration (mg/L).

(v) BOD:

Basically BOD determination involves determination of D.O. at a particular interval and at a specific temperature (200°C). BOD measurement is done usually by any one of the following two methods depending upon dissolved oxygen depletion. Direct method is suitable for those BOD_5 that does not exceed 7 mg/L , provided that they are aerated to bring the dissolved oxygen level nearly to the saturation at the start of the test. This method does not involve any modification of the sample.

WAWQI method:

WQI basically indicates the quality of water with respect to an index number which shows generally the quality of water for any expected use. There are many WQI method i.e. the National Sanitation Foundation Water Quality Index (NSFWQI), Groundwater Quality Index (GWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), Weighted Arithmetic Water Quality Index Method (WAWQI) etc . Here WAWQI[5] method is used for the assessment of the quality of water. In this study pH, TDS, chloride concentration, salinity, BOD etc. parameters are considered for the assessment of the quality of water. In this method, less number of parameters are required in comparison to all the water quality parameters to assessment the quality of water for a particular use. Among all the WQI methods, WAWQI method gives us a better idea about the quality of water.

The WAWQI calculated by the following governing equation[6]:

$$\text{WAWQI} = \frac{\sum_{i=1}^{i=n} Q_i W_i}{\sum W_i} \quad (1)$$

where, W_i = unit weight for each quality parameters, Q_i = the quality rating scale for each parameters.

Step 1 : Calculation of W_i (unit weight) of various parameters.

So, basically the first step is to calculate the unit weight (W_i) of each parameters which is inversely proportional to the standard (S_i) of those following parameters. This W_i value of the various parameters were calculated by using this following equation,

$$W_i = k \sum \frac{1}{S_i} \quad (2)$$

where, K = the proportionality constant, S_i = recommended standard (S_i) value of each parameters.

Step 2 : Calculation of the proportionality constant (K). The proportionality constant (K) is calculated by using the following equation,

$$K = \frac{1}{\sum_{i=1}^{i=n} \frac{1}{S_i}} \quad (3)$$

Step 3 : Calculation of quality rating scale (Q_i). The quality rating scale (Q_i) for various parameters is calculated by using the following equation,

$$Q_i = 100 \frac{(Q_a - Q_o)}{(S_i - Q_o)} \quad (4)$$

where, Q_a = the estimated concentration value of i-th parameter, Q_o = ideal value of the corresponding i-th parameter in pure water, Q_o = 0 (but for pH = 7.0), S_i = recommended standard value of ith parameter.

WAWQI is used for the assessment of the quality of water, in this method the status of quality of water in terms of quality index number is classified based on the WAWQI standard grading system which is shown in Table 6.

Table 2 shows the standard value of those considered water quality parameters recommended by WHO, CPCB and BIS.

Table 2. Standard value recommended by CPCB and BIS[7]

Parameters	WHO/CPCB/BIS Std.
pH	6.5–8.5
TDS	500
Chloride	250
Salinity	0.5
BOD	2

After the calculation of overall WAWQI, it provides an index number. Then as per Table 2 the quality of water of those sampling sites are classified whether it is suitable or not for the human consumption for drinking purpose.

Results and discussion

In this WAWQI method, less number of parameters are required. Then after the calculation it generates an index number which indicates the status of quality of water as per WAWQI rating scale. In this present study the water samples are collected on January and February of 2020. Table 4 shows the calculated value of water quality index of each samples by using WAWQI, which samples were collected in January, 2020. The value of unit weight (W_i) of various parameter which are considered for this assessment are calculated. The W_i value of pH, TDS, chloride concentration, salinity and BOD are 0.04484, 0.00076, 0.00152, 0.7623 and 0.19057 respectively. This Table 3 basically shows the values of unit weight (W_i) of each parameters, and Table 4 shows the quality rating scale (Q_i) of each parameters and the overall WAWQI values also.

Table 3. Calculation of unit weight (W_i) of each parameters

	W_i value of used elements in WAWQI				
Parameters	pH	TDS	Chloride	Salinity	BOD
W_i	0.04484	0.00076	0.00152	0.7623	0.19057

Table 5 shows the calculated value of water quality index of each samples by using WAWQI, which samples are collected from the 15 nos of sampling points in February, 2020.

Now Table 6 discloses the quality status of water in those ampling points whether the quality is good or poor, whether they are suitable or not for the human consumption for drinking purpose in the study area and this table also shows that the quality of water are not suitable for drinking purpose in maximum nos of sampling points.

Table 4. Calculation of quality rating scale (Q_i) and unit weight (W_i) of each parameters and total WAWQI value

	Q_i value					
Stations	pH	TDS	Chloride	Salinity	BOD	WAWQI
S-01	52.67	45.2	16	14	87.5	29.77
S-02	61.33	80.4	68.8	62	90	67.34
S-03	52.67	45.4	19.04	18	75	30.44
S-04	59.33	88.4	77	70	82.5	71.93
S-05	72	127.2	138	124	65	110.45
S-06	72.67	450	628	568	70	450.89
S-07	68	600	784	708	77.5	559.18
S-08	80.67	1028	1288	1164	72.5	907.5
S-09	72	1026	1320	1192	59	925.93
S-10	71.33	794	1048	946	57.5	737.5
S-11	64.67	944	1269.6	1146.86	61.5	891.53
S-12	62	958	1229.6	1110.73	57.5	863.05
S-13	67.33	962	1349.6	1219.13	55	945.63
S-14	59.33	1106	1569.6	1417.86	45	1095.31
S-15	65.33	1048	1389.6	1256	40	970.92

Table 5. Calculation of quality rating scale (Q_i) and unit weight (W_i) of each parameters and total WAWQI value

	Q_i value					
Stations	pH	TDS	Chloride	Salinity	BOD	WAWQI
S-01	30	67.2	56.98	51.47	90	57.88
S-02	11.33	81.8	76.98	70	92.5	71.68
S-03	38	68.8	59.98	18	76	30.06
S-04	38.67	138	131.96	119.2	80	108.16
S-05	38	316	469.84	424.42	67.5	339.06
S-06	39.33	326	519.84	469.58	65	373.16
S-07	41.33	652	919.72	830.8	87.5	653.75
S-08	47.33	1300.4	1704.92	1540.1	74	1193.83
S-09	46.67	1299.6	1716.24	1550.33	55	1198
S-10	48	1293.6	1712.64	1547.07	64	1197.28
S-11	48	1296	1691.28	1527.78	60	1181.78
S-12	46.67	1294.2	1689.48	1526.15	68.5	1182.09
S-13	55.33	1304	1719.47	1553.24	61.5	1201.85
S-14	56	1306	1749.46	1580.33	57.5	1221.82
S-15	43.33	1322	1759.46	1589.36	61	1228.83

Table 6. WAWQI based water quality status in the study area[8]

Sl. No.	WAWQI standard	Quality status of water	Grading	No. of water samples	
				January	February
1.	0 to 25	Very good	A	0	0
2.	26 to 50	Good	B	2	1
3.	51 to 75	Poor	C	2	2
4.	76 to 100	Very poor	D	0	0
5.	> 100	Not suitable for drinking	E	11	12

Conclusions

Different parameters such as pH, TDS, salinity, chloride concentration and BOD are considered to assess the quality of water in lower Ganga river at total fifteen nos. of sampling points (S-01 to S-15). This study discloses that the quality of surface water of Ganga in the study area that is not suitable for drinking or human consumption during the study period as the values of those considered quality parameters doesn't satisfy the standard value recommended by different regulatory bodies i.e. WHO, CPCB, BIS etc. According to the water quality index values calculated in this study, it can be stated that the surface water of the river Ganga are not suitable for human consumption specially in drinking purpose (except 3 or 4 stations i.e. S-01 to S-04). In this present study, WAWQI method is used which is a very useful method in the assessment of quality of water.

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