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STUDIES ON WATER QUALITY INDEX OF BAY OF BENGAL AT DIGHA, WEST-BENGAL, INDIA

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ABSTRACT

The water quality Index basing on physico-chemical parameters of Bay of Bengal at Digha-on-Sea has been assessed for three study stations during January,2011 and December,2012. The observations revealed seasonal and topographical variations and the parameters were within permissible range(i.e. pH: 6.97 to 7.95, Total alkalinity: 38.00 mgl-1 to 70.95 mgl^{-1}, Total hardness : 9.83 mgl^{-1} to 28.28 mgl^{-1}, Chloride, 93.45 mgl-1 to 117.46 mgl^{-1}, BOD 5 days: 1.39 mgl^{-1} to 30.73 mgl^{-1}. However the WQI ranges between minimum of 52.46, 52.03, 48.05 and maximum of 54.39, 54.70, 54.31 at three study stations respectively. These were rated poor where water quality is adverse and the conditions deviate from desirable levels.

KEYWORDS : Quality, Bay of Bengal, Digha, Physico-Chemical, Parameters

Digha is West Bengal's popular Sea resort and tourist spot from Kolkata. The beach is girdled with casuarine plantations along the cost. This beach is 7 kms long and very wide. The Sea hear is calm and shallow for about a 1.6 kms from the beach making it quite safe for swimming. The main attraction of the Digha is that the river Hoogly merges into the Bay of Bengal over here. Physico-chemical parameters play a major role in ascertaining the distributional pattern and quantitative abundances of organisms inhabiting a particular ecosystem(Singh et al., 2009). Water Quality Index was first formulated by Horton, 1965 and then, by Ott (1978). Method given by Horton, 1965 was later on followed with slight modifications by Tiwari and Mishra, 1985), Trivedy and Goel, 1986.

MATERIALS AND METHODS

The water samples in triplicate were collected in plastic container during morning hours(0900h) at three Study sites of Bay of Bengal, Digha-on-sea (S_1,Talseri, S_2 Old Digha and S_3, Mohana). The different seasonal values(i.e., winter, Summer & Rainy) for each parameter were calculated from monthly sample data as per the methods suggested by (APHA, 2005; Pradhan et al., 2009; Sujitha et al., 2012). The water quality index formulae had been followed as per Mishra and Mishra, 1994.

Water Quality Rating And Weighage

The quality rating 'qi' is meant for the ith parameters.

Water quality parameters (i=1,2,3……9) was obtained from the relation:

Qi=100(Vi Vi0) / (Si- Vi0)…(I) (Mishra and Mishra (1994). Where, qi=Quality rating for the ith parameters (I=1,2,3……9)

Vi=The measured value of the ith parameter at a given sampling station, vio= The ideal value of this parameter in pure water & si= The standard permissible value for the ith Parameter.

Viewed from the ideal value, that is Vio=0 for natural water for the most parameters, assuming the following equation in its simple form for these parameters as:

Qi=100(vi/si), …….(II)

This equation ensures that qi=0, when a pollutant (the ith parameter) is totally absent in the water, and qi=100, if the value of this parameter is just equal to its permissible value si for the drinking water. Thus, larger the value of qi, the more polluted is the water with the ith pollutant. But there are following two exceptions to the equation(II).

For pH, the ideal value is 7.0(for neutral water) and permissible value is 8.5. Therefore, the quality rating for pH may be:

qph=100(vpH-7.0)/(8.5-7.0) ……..(III)

Where VpH is the observed value of pH. For DO, the situation is slightly complicated, since it contrasts to other pollutants, the quality of water is enhanced if it

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contains more dissolved oxygen. Therefore, the quality ratingDO has been calculated from the relation:

$$q^{DO} = \frac{14.5}{100(14.6-5.0)} \frac{V^{DO}}{14.6-5.0} \quad ....(IV)$$

Where, V^{DO} = observed value of dissolved oxygen. In equation (IV), 14.6 mg 1^{-1} is the ideal value (the solubility of oxygen, mg1^{-1}) in pure (distilled) water at 0^{0}C and 5.0 mg 1^{-1} is the standard for natural water. The equation (IV) gives q^{DO}=0 when V^{DO}= 14.6 mg 1^{-1} and q^{DO}=100 when=5.0 mg1^{-1}.

Unit weights (Wi) for various water quality parameters are assumed to be inversely proportional to the recommended standards for the corresponding parameters i.e. wi=K/si…………..(V)

Where, wi=unit weight for the ith parameter, si where(i=1,2,3………9) refers to water quality parameters and K=constant for proportionality which determined from the condition:

(For the sake of simplicity it is assumed K=1)

$$\sum_{i-1}^{q} \quad i=1 \quad ....(VI)$$

The unit weights wi calculated from equation (V) and (VI) are listed in Table,1.

Calculation of Water Quality Index(WQI)

The water quality index(WQI) was calculated through the sub-index(si), corresponding to ith parameter calculation of the quality rating qi and the unit weight wi of the ith parameters i.e. (SI)i=qiwi ……..(VII), has to be acquired.

The overall water quality index(WQI) was then calculated by aggregating the quality ratings(or subindices) linearly. Thus, water quality index could be written as

$$WQI \sum_{i-1}^{q} (si) \Big/ \sum_{i-1}^{q} qiwi \quad ....(VIII)$$

But according to weighted geometric mean index, the WQI is calculated as

$$WQI \sum_{i-1}^{q} qiwi \Big/ \sum_{i-1}^{q} (si/i) \quad ....(IX)$$

In the present study, the calculations of WQI were made taking the data available from S_1, S_2 & S_3 and at Desha on sea.

RESULTS AND DISCUSSION

(pH)

The pH value showed a trend of increasing pattern from slightly acidic during monsoon slightly alkaline medium during summer Jerome and Pius (2010) found pH in ranging between of 6.97 to 7.95 mgl^{-1} in study as probably similar observations were made by in the present study.

Total Alkalinity

So far the total alkalinity is concerned the phenolphthalein alkalinity was absent throughout the observations at the three stations, whereas total alkalinity was the dominant anion and ranged between 38.03mg1-1(rainy season) and 62.75 mgl^{-1} (summer). High values of total alkalinity were reported during winter and summer. The value was comparatively low during rainy season. The increased alkalinity during summer was due to concentration of nitrates in water against the permissible limit of 600 mgl^{-1}.(Mishra & Mishra 1994)

Total Hardness

The total hardness of water varied from 9.83mg1^{-1} to 28.28 mg1^{-1} with the minimum value in rainy (2011) at station S1 and maximum value during summer, (2012) at S3. Higher values were reported during summer at all the stations. The similar trend of increasing in summer and decreasing in rainy season was established by Medudhula et al., 2012. Hardness in sea water is due to the natural accumulation of salts of mainly calcium and magnesium. The lower of values of total hardness could be due to high rate of precipitation during rainy season which diluted the salt content of the water. On the contrary, natural accumulation of salts and decrease in water volume during might be reasons for increase in the total hardness. Sea water was also observed by several researchers (Singh et al., 2009, Imnatoshi, and Ahmed, 2012, Medudhula et al., 2012).

Chloride

The variation in chloride content had a narrow range irrespective of all the seasons. Its content varied between 93.98mg1^{-1}(rainy,2012) and 117.46mg1^{-1} (Summer, 2012) against the permissible range of 250mg1^{-1} (Virendra et al., 2009).

Its highest value was noticed during Summer, 2012 at S_3, while the lowest was ascertained during Rainy, 2012 at S_1. The chloride content showed an increasing trend from post monsoon to summer. Its higher concentration was obtained along the S_1 which was an indication of sewage contamination of water.(Mini et al., 2003). The Low Chloride content in rainy season might be due to an increase in the amount of sea water level. Similar to our present observation, Mishra and Tripathy, 2003), Zafar and Sultana (2008), also reported low chloride in the rainy but high in winter. The high content of chloride may be due to storage of the accumulated sewage during rainy season coupled with decaying process that accomplished by the microbes (Kumar et al., 2005., 2012 and Imnatoshi and Ahmed, 2012).

Calcium

The variation in calcium concentration in water ranged from 4.53mg1^{-1} to 7.25mg1^{-1}. The maximum concentration was in July, 2011 at S_3 and minimum in February,2011 at S_3. The higher concentration was recorded during monsoon and lower during winter(APHA,2005).

Magnesium

Magnesium concentration varied between 1.52mg1^{-1} and 5.50mg1^{-1} around the year. The highest value was observed in May,2011 at S_3 while lowest in January 2012 at S_1. Its higher concentration was reported during summer and lower during winter (Sujitha et al., 2012) against the permissible limit of 1500 mgl^{-1} (WHO., 1991).

Total Solids

The total solids in Sea water were varied from 99.00 mg1^{-1} to 309.75mg1^{-1}. The total residue of water was more during monsoon and ranged up to 309.75 mg1^{-1} with the higher concentration (75%) of suspended solids consisting of silt, clay, silica and humus etc. During winter and summer, concentration of dissolved solids was reported to be more (54.01, 74.0%) in comparison to the suspended residues (Singh et al.,, 2010). The total dissolved solids depend on various factors such as geological character of the water shed, rainfall and amount of surface runoff. The variation in the values of TDS at different study stations is also shown in table-2, -3. High values of TDS recorded during rainy season could be related to increase in the load of soluble salts, mud, increase in the surface runoff and erosion of sea-shore. Low value of TDS recorded in winter might be due to sedimentation of suspended solids and slow decomposition rate during rainy season. Similar results were also reported by Chauhan (2002), Ganai et al., 2010. Singh, 2010, Thirumala et al., 2011 and Imnatoshi and Ahmed., 2012.

DISSOLVED OXYGEN(DO)

The DO is another vital parameter regulating the survival of aquatic life. The permissible standard and of DO is above 5 mgl^{-1}1 (WHO,1991). Dissolved oxygen content varied from 6.00mgl^{-1} to 8.02mgl^{-1}. Higher DO values were noted 5.6mgl^{-1} during to winter. It increased appreciably in winter at all the sampling stations. It becomes low during monsoon and summer. Higher values of DO during winter could be one to greater solubility of O_2 in water at lower temperature and Lower oxygen content during summer may be due to high temperature and decay of macro vegetation(Bhalla, (2010) and Bhalla et al., 2006b.

Biological Oxygen Demand(BOD 5-days)

The 5-days biological oxygen demand values assess the organic load in a water body Bhalla, (2010) indicated low values (15.0mg1^{-1} to 3.73mg1^{-1}) at three

Parameters	Unit Weights(wi)
pH	0.2069
Total alkalinity	0.0146
Total hardness	0.0058
Chloride	0.0070
Calcium	0.0234
Magnesium	0.0352
Total solids	0.0035
Dissolved oxygen	0.3518
BOD 5-days	0.3518
$\sum wi$	1.0000

different stations. The highest value was reported in summer, 2012 at S_3 and lowest value during winter, 2012 at S_2. BOD 5-days value increased along the study sites of the marine ecosystem(Jhingran,1991; Kumar et al., 2005).

The BOD values were higher in summer could be the result of reduced volume of water degradation of organic

Table 2 : Seasonal Mean Value of Physical Chemical Parameters, water Quality Rating & Water Quality Index of Bay of Bengal(2011)

Parameters		Water quality parameters			Water quality rating (QI)			Water quality index(QWI)		
		Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
pH		7.95x9.12	7.55x5.66	6.97x0.09	72.54	42.76	0.66	15.0085 (0.0269x72.54)	8.8470 (0.0269x42.76)	0.1366 (0.0269x0.66)
Total alkalinity	(mgl^{-1})	59.50x0.83	62.75x0.83	38.00x0.83	49.58	52.29	31.66	0.7239 (0.0146x49.58)	0.7634 (0.0146x52.29)	0.4624 (0.0146x31.67)
Total Hardness	(mgl^{-1})	20.66x0.33	26.08x0.33	9.83x0.33	6.88	8.69	3.29	0.0399 (0.0058x06.88)	0.0504 (0.0058x08.69)	0.0191 (0.0058x03.29)
Chloride	(mgl^{-1})	98.80x0.40	107.15x0.40	93.45x0.40	1.92	2.85	1.39	0.0134 (0.0070x1.92)	0.0200 (0.0070x2.85)	0.0097 (0.0070x1.39)
Calcium	(mgl^{-1})	4.53x1.51	5.825x1.38	6.91x1.38	6.84	8.04	9.55	0.1601 (0.0234x6.84)	0.1881 (0.0234x8.04)	0.2235 (0.0234x9.55)
Magnesium	(mgl^{-1})	1.525x2.00	5.25x2.00	4.18x2.00	3.05	10.50	8.36	0.1074 (0.0352x3.05)	0.3696 (0.0352x10.50)	0.2943 (0.0352x8.36)
Total solids	(mgl^{-1})	99.75x0.20	151.88x0.20	309.75x0.20	19.95	30.37	61.95	0.0698 (0.0035x19.95)	0.1036 (0.0035x30.37)	0.2168 (0.0035x61.95)
Dissolved oxygen	(mgl^{-1})	7.3x8.96	6.00x11.82	6.45x13.02	65.38	70.90	83.96	23.0007 (0.3518x65.38)	24.9426 (0.3518x70.90)	29.5358 (0.3518x70.90)
BOD 5-days	(mgl^{-1})	2.17x20.00	3.73x20.00	2.76x20.00	43.4	74.60	55.20	15.2681 (0.3518x43.40)	19.4193 (0.3518x74.60)	19.4194 (0.3518x74.60)
$\sum qiwi =$								54.3918	54.7067	50.3186
WQI $\sum qiwi/wi =$								54.3918	54.7067	50.3186

Table 3 : Seasonal Mean Value of Physical Chemical Parameters, water Quality Rating & Water Quality Index of Bay of Bengal(2012)

Parameters		**Water quality parameters**			**Water quality rating (QI)**			**Water quality index(QWI)**		
		Winter	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**
pH		7.91x10.51	7.612x6.45	7.16x1.12	83.13	49.11	8.04	17.1996 (0.0269x83.13)	10.1609 (0.0269x49.11)	1.6635 (0.0269x8.04)
Total alkalinity	(mgl^{-1})	70.95x0.83	69.00x0.83	39.25x0.83	58.54	57.20	32.70	0.8547 (0.0146x58.54)	0.8351 (0.0146x57.20)	0.4774 (0.0146x32.70)
Total Hardness	(mgl^{-1})	17.68x0.33	28.28x0.33	12.55x0.33	5.89	9.42	4.18	0.0342 (0.0058x05.89)	0.0546 (0.0058x09.42)	0.0242 (0.0058x04.18)
Chloride	(mgl^{-1})	94.50x0.40	117.425x0.40	93.98x0.40	1.80	2.97	1.42	0.0126(0.0070x 1.80)	0.0208 (0.0070x2.97)	0.0099 (0.0070x1.42)
Calcium	(mgl^{-1})	4.80x1.33	5.81x1.33	7.25x1.33	6.39	7.74	9.67	0.1495 (0.0234x6.39)	0.1811(0.0234x 7.74)	0.2263 (0.0234x9.67)
Magnesium	(mgl^{-1})	1.825x2.00	5.50x2.00	4.525x2.00	3.65	11.00	9.05	0.1285 (0.0352x3.65)	0.3872 (0.0352x11.00)	0.3186 (0.0352x9.05)
Total solids	(mgl^{-1})	90.00x0.20	193.25x0.20	90.00x0.20	18.00	38.65	18.00	0.0630 (0.0035x18.00)	0.1353 (0.0035x38.65)	0.063(0.0035x 18.00)
Dissolved oxygen	(mgl^{-1})	8.02x8.59	6.36x10.79	6.93x12.45	68.92	68.65	86.30	24.2460 (0.3518x68.92)	24.1511 (0.3518x68.65)	30.3603 (0.3518x86.30)
BOD 5-days	(mgl^{-1})	1.39x20.00	2.29x20.00	2.12x20.00	27.80	45.80	42.40	9.7800 (0.3518x27.80)	16.1124 (0.3518x45.80)	14.9163 (0.3518x42.40)
$\sum qiwi =$								52.4681	52.0385	48.0595
WQI $\sum qiwi/wi =$								52.4681	52.0385	48.0595

matter and accumulation of wastes due to anthropogenic activities while low BOD during rainy season could be attributed to the dilution of sea water (Upadhaya and Rana, 1991, Kumar et al., 2005).

Calcium level within $10.02mgl^{-1}1$ is an index of medium productivity. In the present study, the higher rainfall in the first year, 2011), has not only caused a higher rate of inflow, but also an increase in the level of nutrients like Calcium, Nitrogen and Phosphate. However, the sedimentary rock strata form almost the entire source of calcium in the medium.

Magnesium hardness increases in summer whereas calcium hardness decreases(Virendra et al., 2003). It might be due to in the insoluble magnesium carbonate which was converted to soluble bicarbonate. The same possibly does not occur with calcium carbonate because of its lower solubility. Magnesium compounds are in general more soluble than the calcium salts. In the investigation it has been found that the magnesium concentration is within the permissible range or $15.0 mgl^{-1}$.

In the present study the results of analysis of variance for biological oxygen demand between sampling stations are highly significant. BOD 5-days value of Indian standard limit for sea is $20.0 mgl^{-1}$. But when its value exceeds $30.0 mgl^{-1}$, the water becomes polluted and it shows the nature of eutrophication. However, BOD 5-days value of Digha on sea at study stations remains within the range $15.0 mgl^{-1}$ to $3.73 mgl^{-1}$ unaffected by the seasonal trend. However the present study provides first hand information on the geomorphology and seasonal variations of the water quality of the sea. The disposal of polythenes, dry and decomposed fishes and other animals, thrown out foods by the visitors, deforestation, direct drainage system to the sea, animal excreta and repeated fishing as well as garbage's in the beach are some of the important factors for sea pollution. Therefore, a continuous monitoring of the water quality variables covering all the seasons over a period of time is necessary for management practices of the wonderful sea water resources of the state (W.B) that supports a lucrative abode of huge icthyofaunal diversity. an as such the sea water might be suitable for bathing, washing etc.

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