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Water quality index of some ponds in western ghat region of Shimoga, Karnataka

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ABSTRACT

Water is most vital resource for all kinds of life on this planet, which is adversely affected both quantitatively and qualitatively by animal activities. This resource is put under tremendous pressure owing to the anthropogenic activities. Since water is a unique solvent with properties of dissolving and carrying in suspension, a huge variety of chemicals and gets contaminated usually. The water quality index was evaluated by observing the parameters such as water temperature, pH, DO, BOD, Chloride, Total hardness, Total alkalinity, Phosphate and Sulphate from June 2004 to February 2007. The data of physico- chemical characteristics of Kallambi, Vaddekere and Gudavi ponds, in the vicinity of Shimoga, Karnataka, were used for calculation of water quality index (WQI) and value of water quality index was 99.1, 94.2 and 99.1 and none of the pond had a value of 100. This indicates that the pond water was slightly below the ISI standards. But the water can be recommended for consumption and for domestic use after purification which is slightly towards permissible limit.

KEYWORDS

Water quality index (WQI);
Ponds;
Westernghat;
Rating scale;
Unit weight.

INTRODUCTION

Though, the defilement of which as a result of human activities. The industrialization, urbanization and developmental activities and consequent pollution of water has brought a veritable water crisis. Today most of the lotic and lentic water bodies receive millions of lives of sewage, domestic waste, industrial and agricultural

effluents containing substances varying in characteristics for simple nutrients and highly toxic substances. Pollution of water is responsible for a very large number of metabolites and incapacitates in the world. Polluted state of the water resources has led to a steady decline in fisheries and has also affected irrigated land. Availability of clean water is going to become the greatest constant for development tomorrow. Near by human habitat area of the water bodies are easily contaminated by wastes. Owing to accumulation of waste products, the water bodies are not able to recycle themselves and their self regulatory capacity is lost, which also increases its oxygen demand (BOD) and water becomes unfit for drinking and other domestic uses. A survey by NEERI showed that about 70% of India's fresh water resources are polluted[1]. Hence, the survey and documentation of water quality is essential. On the basis of observations, it is easy to formulate policies for implementations, hence, quality improvement programs. The water quality index (WQI) is most effective influencing factor on the quality of water. In the present study, the water quality Index (WQI) has been used for assessing the quality of Kallambi, Vaddekere and Gudavi ponds, in the vicinity of Shimoga in Western Ghat region in India.

MATERIALS AND METHODS

Kallambi, Vaddekere and Gudavi ponds are located in the vicinity of Shimoga at Sorab Taluk. The ponds are lies between latitude 14°25'59" to 14°26' 41" and langitude 75°6' 43" to 75°1' 28", in the Western Ghat region. The ponds are spread in an area of 33 hectare. The Kallambi pond had not enriched in nutrients, the Vaddekere pond slightly accumalated with fecal matter of birds and Gudavi pond affected by onthropogenic activities from neighbouring settlements. These ponds primarily rainfed, rain in this region in the months of May to November and average rain fall was 1000 mm in the study period. Temperature rises from February to April and April being hottest. South West mansoon starts from April and their after the temperature decreases. The average temperature during observation period was 29.9^0C.

The water samples were drawn separately in 2 lts capacity plastic cans from three ponds for the surface every month of three consecutive years. From June 2004 to February 2005, June 2005 to February 2006, June 2006 to February 2007. The methods for analysis were followed as prescribed for APHA[2], Trivedi and Goel[10]. The result taken as an average of 9 months for calculation of Water Quality Index (WQI) adopted the methods laid by Tiwari and Mishra[8], Tiwari et al.[9], Singh[7] and Nadoni et al.[6].

RESULTS AND DISCUSSION

Parameters such as Water temperature, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Hardness, Chloride, Sulphate and Phosphate have been considered out of nine parameters as the four important water quality parameters for classifications of surface water. The NSF WQI has been computed for Kallambi, Vaddekere and Gudavi ponds in western ghat region of Shimoga. The water temperature during the study period was around 27.70C in Kallambi, 27.8^0C in Vaddekere and 28.2^0C in Gudavi ponds respectively. It was always 1^0C below the ambient temperature.The pH values varied around 7.63 ± 0.52 in Kallambi, 6.77 ± 0.94 in Vaddekere and 7.35 ± 0.85 in Gudavi water samples respectively (TABLES 1 to 3). In Kallambi pond the water pH was always alkaline during study period. Where as it was acidic during September and October in every year but, in the other two ponds it was 6.5 to 6.0 in Vaddekere and 6.4 and 6.0 in Gudavi pond respectively.

TABLE 1: Water quality index of Kallambi pond

Parameters	Average values	q_i	W_j	q_iW_j
Water temperature	27.70	100	0.16	16.0
pH	7.70	100	0.16	16.0
DO	9.07	100	0.16	16.0
BOD	5.26	80	0.16	12.8
Chloride	44.48	100	0.08	8.0
Total hardness	150.50	80	0.08	6.4
Total alkalinity	90.83	50	0.12	6.0
Phosphate	0.19	100	0.04	4.0
Sulphate	0.04	100	0.04	4.0

TABLE 2: Water quality index of vaddekere

Parameters	Average values	q_i	W_j	q_iW_i
Water temperature	27.8	100	0.16	16.0
pH	7.0	100	0.16	16.0
DO	5.58	80	0.16	12.8
BOD	22.14	50	0.16	8.0
Chloride	46.08	100	0.08	8.0
Total hardness	136.4	80	0.08	6.4
Total alkalinity	60	80	0.12	9.6
Phosphate	0.21	100	0.04	4.0
Sulphate	0.05	100	0.04	4.0

TABLE 3: Water quality index of Gudavi pond

Parameters	Average values	qj	W_i	qjWj
Water temperature	28.20	100	0.16	16.0
pH	7.50	100	0.16	16.0
DO	8.74	100	0.16	16.0
BOD	13.56	80	0.16	12.8
Chloride	44.00	100	0.08	8.0
Total hardness	140.50	80	0.08	6.4
Total alkalinity	107.50	50	0.12	6.0
Phosphate	0.20	100	0.04	4.0
Sulphate	0.09	100	0.04	4.0

The DO is a vital factor used in qualifying water samples. Most of the desired fishes may not survive if the DO falls below 4 mg/lt. In the present study DO was always above 5 mg/1t in Kallambi and Gudavi ponds. It was recorded an average 8.81 mg/lt in Kallambi and 7.78 mg/lt in Gudavi ponds, but in contrast to the two ponds, Vaddekere pond always showed low levels of oxygen except during January. It was below 3 mg/ 1t in September to December and a maximum of 6.5 mg/ 1t in January, when there was no bird activity. Such a drastic low levels of DO in Vaddekere during breeding seasons are attributed to biodegradation of guano dropped by birds[3]. The minimum DO which supports most of the desired fish species is above 4 mg/lt. The reduced DO level in Vaddekere pond revealed that water is pollute by Oxygen demanding materials[4,5] added through fecal pollution. This might be attributed to the reason that in Vaddekere there were about 12,000 birds residing on emergent trees and discharged excreta. The uric acid and other organic matter which was present in excreta needed more Oxygen to stabilize the waste biologically.

Biological oxygen demand is an indirect measure of organic load present in any aquatic systems. In the present study the 5 day BOD values 5.82, 21.82 and 10.6 mg/ lt recorded for Kallambi, Vaddekere and Gudavi ponds respectively. Chlorides are gradually considered as nutrients. Presence of high levels of chlorides indicates that the water is polluted. The chlorine level was 54.2, 56.1 and 49.2 mg/l in the water samples from Kallambi, Vaddekere and Gudavi ponds respectively.

Hardness was 150.5, 136.4 and 140.5 mg/lt in respective ponds. The levels of hardness in all these three ponds are comparable. Phosphates are important macronutrients essential for plant growth. It was 0.37, 2.00 and 1.48 mg /lt recorded in Kallambi, Vaddekere and Gudavi ponds respectively. In the present study, the sulphate varied around 0.06, 0.07 and 0.08 mg/lt recorded in Kallambi, Vaddekere and Gudavi ponds respectively.

For water quality index (WQI) calculation, rating scale has been assigned to each physico-chemical parameters, which is weighed according to its relative importance in the over all water quality. The range of weight is from 1-4, the maximum weight of 4 has been assigned to the parameters like pH, DO and Chloride etc, due to their importance in water quality assessment and other parameters have been assigned the moderate weight of 3 and 2. The Sulphate has been assigned minimum weight of 1, as they do not play a very important role in the quality evaluation.

The unit weight(Wi) is calculated for the formula:

$$\mathrm{Wi} = \sum_{i=1}^{\mathrm{Wi}/10} \mathrm{Wi} \quad \text{as Wi} \quad \sum_{i=1} \overset{10}{\mathrm{Wi}} = 1$$

The rating scale for nine parameters evidence have been divided in four stages (permissible, higher, moderate and severe) and the quality index (qi) ranges from 0- 100. For calculating the water quality index (WQI), sample index (SI)i is first found out for each parameter, which is (SI)i= qi Wi and thus the formula is:

$$\mathrm{Wi} = \sum_{i=1}^{10} (\mathrm{SI})\mathrm{i} \qquad \sum_{i=1} \mathrm{Wi}^{10}$$

$$\text{Which is} \mathrm{WQI} = \sum_{i=1}^{10} \mathrm{qi\ Wi} \text{ as } \mathrm{wi} = 1$$

The water quality index (WQI) values are presented in TABELS 1-3 and it is clear that name of the ponds registered a water quality index of 100, but mainly there fore it is deciphered that pond Kallambi, Vaddekere and Gudavi ponds are recommended for domestic and consumption purpose. Kallambi pond flowed WQI of 99.1, Vaddekere 94.2 and Gudavi pond recorded 99.1. Such studies on the evaluation of WQI are most useful in quick assessment of water quality.

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Radiological, physio-chemical and biological analysis of water quality of river Ganga in relation to pollution

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ABSTRACT

The River Ganga and its tributaries are the main water resource in Northern India. The increasing pollution level of this river is of great concern in current days. To investigate how particulate materials and the toxicity of a polluted river can affect the human lives, In this present study, river water samples from Naihati and Batanagar-the two most highly polluted riverside regions of the River Ganga were collected upstream, downstream and discharge site and analysed for physical, chemical and radiological endpoints. The study reveals high chemical as well as radiological contamination level at discharge site that is of great concern for public health. The macrobenthic fauna structure has also been studied at both the stations.

KEYWORDS

River water;
Chemical contamination;
Radiological contamination;
Macrobenthic community.

INTRODUCTION

Modernization and progress has had its share of disadvantages and one of the main aspects of concern is the pollution it is causing to the earth-be it land, air, and water. With increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by household and number of industries. This waste is directly thrown or discharged to water bodies. Either due to resource crunch or inefficient infrastructure, not all of this waste gets collected and disposed. In this way most of the river systems gets contaminated and causes serious impacts on health and problems to the surrounding environment.

In India, the Ganga forms the most important river system in northern part. It is used as potential source of Inland captured fisheries and for drinking, domestic, agriculture, irrigation, industries, navigation, recreation etc. Being passing through a great industrialized and urbanized city of Calcutta and its adjoining areas, river Ganga has been continuously affected by anthropogenic environmental distortion and being the cheap source for the disposal of industrial effluents, domestic wasted and sewage, affected its delicately balanced ecosystem. Increasing pollution of Ganga River has become a matter of great concern over a period of last few decades. The co-disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards.

Uncollected solid waste can obstruct storm water runoff, resulting in the forming of stagnant water bodies that become the breeding ground of disease. Waste dumped near a water source also causes contamination of the water body or the ground water source. Direct dumping of untreated waste in river system results in the accumulation of toxic substances in the food chain through the plants and animals that feed on it. Rich variety of flora and fauna has now become threatened through the received polluted wastes. Effluents from the industries contain a wide variety of inorganic and organic pollutants such as oils, plastics, metallic wastes, toxins which cause very serious pollution and have disastrous effect on aquatic life.

The radioactive materials are also found in river originating from ^{238}U and ^{232}Th series that are present everywhere in earth crust. Because the earth's bedrock contains varying amounts of radioactive elements, the amount of alpha radiation in water also varies. As the radioactive elements decay, alpha radiation continues to be released into groundwater as well as surface water. The alpha radiation in water can be in the form of dissolved minerals, or in the case of radon, as a gas. Various other sources such as nuclear power plants, processing of ores or use of radioactive isotopes in medical and industrial research are also responsible for the alarming level of radioactivity in river water. There are no immediate health risks or symptoms from drinking water that contains alpha radiation. However, it may cause health problems over time. Over a long period of time, and at elevated levels, radon in air and water has been reported as one of the most significant sources of cancer[2]. Once ingested, these particles may be retained in the lungs damaging lung tissue and potentially resulting in lung cancer[17]. Regular actions like taking showers, doing laundry or running a dishwasher over a lifetime increases a person's risk of getting lung cancer.

In context of the above scenario, it is essential to monitor and evaluate the water quality and its suitability of river Ganga. It is impossible to assess the quality of water of whole Ganga for its vastness. So we have selected two stations, one is situated at Naihati, 24 Parganas (North), West Bengal, another is located on the east side of Ganga river under Batanagar, Kolkata. This portion of the Ganga River is further downstream than the Naihati area, We have chosen these two stations for having lots of industries situated here. Near Naihati, river bank is characterized by a no. of jute mills where as shoe industries are situated at Batanagar. Untreated effluents of these industries are directly discharged into the river. At each station, data and samples are collected from three different location based on accessibility; one is very near to the industries at the effluent discharge zone and another two are half kilometer away from the industrial zone (one upstream of industrial zone, another downstream of industrial zone). This paper aims at investigating the impact of pollution on the radiologic, hydrochemistry and macrobenthic community of river Ganga at Naihati and Batanagar area and made a comparative study among these locations. Macrobenthic animals are known to play an important role in indicating the quality of water[3] due to their longer life cycle stages, sedentary habit and comparatively stable mode of life. In India, several workers have also used benthos in the assessment of water quality[1,6]. Sikander[14] had studied ecology of river Ganga with special reference to pollution. Misra and Tripathi[8] have studied physio-chemical properties of city sewage discharged into river Ganga at Varanasi. Paul and Nandi[11] have done the work on health of Hooghly river by benthos. The present project was carried out to assess the aquatic ecosystem health of river Ganga and to determine the impact of pollution based on the physio-chemical properties of water and quantitative analysis of macrobenthic organism.

MATERIALS AND METHODS

Radiological contaminant

Estimation of alpha activity has been performed using CR-39- Solid State Nuclear Track Detector (SSNTD), obtained from Page Mouldings (pershore) Ltd, England. The SSNTD plates were attached with a glass rod stand which was dipped into the water sample taken in a beaker for both side exposures of the SSNTD plates. The exposure continued for 45 hours in undisturbed condition. The exposed plates were etched in 6N NaOH solution at 70^0C for 6 hours in a constant temperature bath. Temperature of the solution was never allowed to vary more than 0.1^0C. Etched plates were washed thoroughly in running water. The tracks were scanned under a Leitz Metalloplan Microscope and a Carl Zeiss Janaval Microscope provided with image analysis system. The number of etched pits formed by the alpha particles in the plates were counted using optics 10X objective in conjunction with 10X ocular lens. The number density of alpha track (track/sq cm) was converted to activity in Bq/l following the method suggested by Henahaw[4]. In each case background count was subtracted from the measured value. Radioactivity in all the samples was found to be above the detector's limit (1.99 Bq/l).

Chemical contaminants

Dissolved oxygen (DO)

One ml. of $MnSO_4$ and I ml. of alkaline potassium iodide solution are added to water sample collected in a BOD bottle. It is thoroughly mixed to dissolve the precipitate by adding 1 ml. of conc. H_2SO_4. 50 ml. of the above solution is titrated with 0.025 N $Na_2S_20_3$ using 2-3 drops of 1% starch indicator until the blue colour disappears.

DO in the sample (mg/litre) is obtained from the quantity of $Na_2S_2O_3$ used in titration.

$$DO = \frac{V_1 * N * E * 1000 mg/litre}{\frac{V_4(V_2 - V_3)}{V_2}}$$

Where, V_1 = Vol. of titrant; N= 0.025, E = 8; V_2 = Vol. of water sample in stopper bottle; V_3 = Vol. of Alk. Iodite and $MnSO_4$; V_4 = Vol. of Water Sample used for titration

Carbon-di-oxide

For estimation of carbondioxide, 25 ml. of water sample is taken in a conical flask and 1 drop of phenolphthalein indicator added to it. Colourless sample indicates presence of free carbondioxide. The solution is titrated against N/44 Sodium Hydroxide solution. Appearance of faint pink colour indicates the end point of titration.

$$\text{Carbondioxide} = \frac{\text{ml. of NaOH} * \text{N of NaOH} * 1000 * 44}{\text{ml. of sample for titration}}$$

Alkalinity

For estimation of alkalinity one drop of methyl orange is added to 25 ml. of water sample. The yellow coloured solution is titrated against 0.02 N sulphuric Acid solution. A pink to orangish pink colour indicates the end point of titration.

Total hardness

For estimation of total hardness 2 drops of ammonia buffer solution and few drops of Erichrome black T indicator are added to 10 ml. of water sample and is titrated against standard 0.01 M EDTA solution till the colour changes from wine red to blue.

$$\text{Total Hardness (mg/litre or ppm of } CaCO_3) = \frac{\text{ml. of EDTA soln. used} * 1000}{\text{ml. of water sample taken}}$$

Calcium hardness

For estimation of Calcium hardness, few amount of muroxide and 0.2 ml of 1N NaOH solution is added to 10 ml of water sample taken in a conical flask. The solution is titrated against EDTA solution till a pink colour develops. This pink colour changes to purple which indicates the end point of titration.

$$\text{Total Hardness} = \frac{\text{Vol. of titrant} * 400.08 \text{ mg/lit}}{\text{sample taken for titration}}$$

Magnessium hardness

$$\text{Magnessium hardness} = \frac{(y - x) * 400.08}{\text{Vol. of sample} * 1.645}$$

Where, y= Vol of EDTA solution required for estimation of total hardness; x= Vol of EDTA solution required for estimation of Calcium hardness; Vol of sample taken= 10 ml

3. Macrobenthic fauna

Exmann Dredge method was used for the collection of Macro-zoo-benthos. The collected specimens were preserved in 70% alcohol. Total 16 quadrates sampling were taken from each stations. Macrobenthic fauna were collected only from the site 2 of each station.

Analysis of benthic fauna

a. Percentage frequency of benthos

Density represents the number of individual / unit area. In this study the fauna obtained in the sample (16cm

* 16 cm) were expressed as a no. of organism / m^2 using the following formulae :

(i) n = (o / a * s) * 100

where n = no. of organism / m^2;o = no. of organism counted; a = area of the sample; s = no. of replicates taken.

(ii) $$\text{Percentage Frequency} = \frac{\text{No. of Quadrate in which species occurred}}{\text{Total No. of Quadrate}} * 100$$

b. Calculation of biological indices

1. Shannon weiver index

The most widely used index for estimating the species diversity is the Shannon Weiver Index given by the formulae:

$$H = -(n_i / N) \log (n_i / N)$$

Where H = Shannon Weiver Index; n_i = Importance value of each species; N = Total of importance Value

2. Evenness Index (J)

Evenness Index was calculated by Pielou[12] is given below:

$$J = H / \log S$$

Where S = No. of species

3. Index of dominance

Index of dominance (C) was reached by Simpson (1949) as below:

$$C = (n_i / N)^2$$

RESULTS AND DISCUSSION

The details of radiological and chemical contamination level at both Naihati and Batanagar site has been given in TABLES 1 and 2 respectively.

(i). Alpha radioactivity: An interesting result is observed in case of values of alpha activity in all the samples (TABLE 1). The value is nearly twice at discharge site than that at upstream and downstream. The range is 360-720 Bq/l for upstream and 630-700 Bq/l for downstream water samples at Naihati, where the value is as high as 1000-1100 Bq/l in discharge site. The same observation has been made at Batanagar, where up-

TABLE 1: Details of radiological contamination level at station I and II

Radiological contamination	[Alpha Radioactivity (Bq/l)]														
	Site 1					Site 2					Site 3				
	Up stream					Effluent discharge site					Down stream				
	Mar	Apr	May	Jun	Jul	Mar	Apr	May	Jun	Jul	Mar	Apr	May	Jun	Jul
Naihati	708	367	684	716	696	1086	1035	1106	1094	1047	657	677	700	669	637
Batanagar	577	617	597	621	565	1035	1015	1043	1027	1011	605	649	593	617	601

TABLE 2A : Details of chemical contamination level at station I and II

Chemical contamination	Site 1					Site 2				
	Up stream					Effluent discharge site				
	Mar	Apr	May	Jun	Jul	Mar	Apr	May	Jun	Jul
Naihati										
DO_2 (mg/l)	5.3	5.4	5.3	5.5	5.6	3.6	3.8	3.5	3.7	3.6
Free CO_2 (mg/l)	4.3	4.3	4.5	3.7	3.8	3.1	3.0	3.2	2.9	2.8
Total alkalinity (ppm)	190	204	210	225	232	255	250	260	275	280
Ca^{2+} (ppm)	127.1	125.2	125	115.2	114.3	105.4	105.8	106.7	104.3	105.7
Mg^{2+} (ppm)	14.7	14.7	14.1	12.3	12.3	10.9	10.9	11.1	10.7	10.8
Total hardness (ppm)	378	370	367	342	338	313	318	320	305	312
pH	8.2-8.7	8.5-9.0	8.4-8.9	8.2-8.7	8.3-8.8	8.5-9.0	8.7-9.2	8.8-9.3	8.7-9.2	8.7-9.2
Water temp.(°C)	30	29	31	29	30	30	30	30	28	29
Batanagar										
DO_2 (mg/l)	5.2	5.6	6.0	5.1	5.3	4.1	3.9	3.9	4.0	3.8
Free CO_2 (mg/l)	3.6	3.6	3.5	3.9	3.8	3.1	2.9	3.2	3.5	3.6
Total alkalinity (ppm)	205	212	204	220	210	240	250	245	255	260
Ca^{2+} (ppm)	140.3	138.4	142.3	135.2	136.1	120	125.1	128.2	123.5	122.7
Mg^{2+} (ppm)	16.9	15.8	17.2	16.4	16.8	13.2	13.8	14.1	13.9	13.3
pH	8.2-9.0	9.0-9.6	8.5-9.0	8.7-9.2	-	7.9-8.5	7.9-8.7	8.0-8.5	8.3-8.6	-
Total hardness (ppm)	410	400	418	397	402	350	378	370	355	352
Water temp.(°C)	30	31	31	29	28	30	31	31	29	29

TABLE 2B: Details of chemical contamination level at station I and II

Chemical contamination	Site 3				
	Down stream				
	Mar	Apr	May	Jun	Jul
Naihati					
DO_2 (mg/l)	5.5	5.2	5.3	5.6	5.5
Free CO_2 (mg/l)	4.5	4.7	4.8	3.9	3.8
Total alkalinity (ppm)	202	210	207	232	230
Ca^{2+} (ppm)	128.2	128.2	127.9	120.3	120.3
Mg^{2+} (ppm)	14.8	15.3	15.1	13.7	13.6
Total hardness (ppm)	385	390	385	365	362
pH	8.3-8.8	8.5-9.0	8.5-9.0	8.2-8.7	8.3-8.8
Water temp.(°C)	30	30	31	29	30
Batanagar					
DO_2 (mg/l)	5.0	5.0	5.2	5.3	5.4
Free CO_2 (mg/l)	3.9	3.7	3.7	4.1	3.09
Total alkalinity (ppm)	180	182	190	192	194
Ca^{2+} (ppm)	142.3	140.1	143.2	135.7	136.1
Mg^{2+} (ppm)	17.6	18.2	18.1	16.6	16.7
pH	8.3-9.0	8.7-9.2	8.6-9.1	8.8-9.3	
Total hardness (ppm)	430	430	422	403	403
Water temp.(°C)	29	31	31	30	29

stream and downstream samples have alpha activity of the range of 560-630 Bq/l and 590-650 Bq/l respectively; the value is more than 1000 Bq/l for all the samples at discharge site. While there is no EPA Standard for Radon in water, now a maximum contaminant level (MCL) of 11 Bq/l is being considered for public water supplies. All the measured values of alpha activity in our samples are much higher than this MCL value and also much higher than world average value of 10 Bq/l[18,20].

(ii). Dissolved oxygen: The DO content of water could be used as an indicator to assess the water quality. Patil et al.[10] have attempted and correlated the oxygen depletion with sewage and industrial effluents in fresh water bodies. But it becomes high in other site. Singh et al.[16] have also made similar observations in the industrial combined effluent polluted Damodar River. At Naihati, dissolved oxygen (DO_2) at upstream and downstream sites is in the range of 5.2-5.6 mg/l whereas it is only 3.5-3.7 mg/l in discharge site. At Batanagar also the same nature is observed-at upstream and downstream site DO_2 ranges from 5-6 mg/l, the same value lies in the range of 3.8-4.1 mg/l at discharge site. The more oxygen is dissolved in water the more it is drinkable.

(iii). pH and alkalinity: The changes in pH concentration of water will bring about changes in the functional and structural variations in any of the aquatic organism. The measurement of pH further gains importance, especially in the areas where the river receives industrial effluents. It has been observed from the present study, the pH value ranges from 8.2-9.3 at Naihati, whereas, at Batanagar it is slightly high (8.2- 9.6). These high pH values of water of both station indicates some kind of pollution stress. Such an alternation could be caused by effluents from industry or extensive use of domestic sewage (effluents from industry are highly alkaline in nature). Changes in pH of river water might be attributed due to the climatological and industrial activities reported by Iyyappan et al.[5]. Alkalinity is also important for aquatic life because it acts as buffer to control pH fluctuation. At discharge site, total alkalinity is also higher which also has threatening effect on health if taken regularly. At Naihati, total alkalinity in water samples is 250-280 ppm and at Batanagar, it is within 240-260 ppm. At up and down stream it is less than that at discharge site: 190-232 ppm (upstream), 200-230 ppm (downstream) at Naihati and 200-220 ppm (upstream), 180-190 ppm (downstream) at Batanagar.

It is clear from the comparison TABLE Station I is more affected than Station II. The water and ecological environment of Ganga of Station I are extensively used by human and aquatic biota. It has shown also that Site 2 of Station I was polluted more than other sites because it was very near to industrial zone. These industrial effluents and contamination had great impact on aquatic environment of River Ganga.

(iv). On the contrary, some parameters have lower value at discharge site than that at upstream or downstream site. The level of total hardness, $Ca^{2+}$and Mg^{2+} are among those. At Naihati, total hardness in water sample is within 330-380 ppm in upstream and 360-390 ppm in downstream samples. The value lies between 300-320 ppm at discharge site. Similarly at Batanagar, upstream and downstream samples contain 390-430 ppm of total hardness, but samples collected from discharge site contain total hardness of 350-380 ppm.

Ca^{2+} content is within 110-130 ppm in up-down stream site 3, but it is within 104-106 ppm in other site at Naihati. At Batanagar, it lies between 130-150 ppm at up-down stream site 3, whereas it is within 120-130

TABLE 3: Macrobenthic community structure, species diversity index in station I

Se. no.	Name of the species	Ni	Ni / N	Partial H	H	J
1	Chironomid larvae	7	0.01866	0		
2	Tubifex	53	0.1413	-0.0663		
3	Nereis	00	0	0		
4	T.lineata	129	0.344	-0.3931		
5	T.scrabra	77	0.2053	-0.1396	0.6644	0.2452
6	Marisa	9	0.024	-.0002		
7	Belamia	21	0.056	-0.0104		
8	Pleurocera	22	0.0586	-0.0111		
9	Pouch Snail	23	0.0613	-0.012		
10	Mysis	00	00	0		
11	Crab	34	0.0906	-0.0269		

TABLE 4: Macrobenthic community structure, species diversity index in station II

Se. no.	Name of the species	Ni	Ni / N	Partial H	H	J
1	Chironomid larvae	28	0.0773	-0.197		
2	Tubifex	31	0.0853	-0.024		
3	Nereis	6	0.0165	-0.0009		
4	T.lineata	190	0.2754	-0.912		
5	T.scrabra	30	0.0068	-0.022	1.2614	0.419
6	Marisa	0	0	00		
7	Belamia	7	0.0193	-0.0012		
8	Pleurocera	4	0.0110	-0.0004		
9	Pouch Snail	8	0.0220	-0.0016		
10	Mysis	7	0.0193	-0.0193		
11	Crab	43	0.118e	-0.0141		

TABLE 5: Index of dominance (C) and another measure of diversity (D) in Naihati Ganga

Se. no.	Name of the species	Partial C (ni / N) 2	C	D = 1-C
1	Chironomid larvae	0.0003		
2	Tubifex	0.0199		
3	Nereis	0		
4	T.lineata	0.1183		
5	T.scrabra	0.0421	0.1995	0.8005
6	Marisa	0.0005		
7	Belamia	0.0031		
8	Pleurocera	0.0034		
9	Pouch Snail	0.0037		
10	Mysis	0		
11	Crab	0.0082		

ppm at remaining site.

Mg^{2+} content lies within 12-16 ppm at Naihati and 15-20 ppm at Batanagar for site upstream and downstream. The value ranges from 10-12 ppm and 13-15 ppm at discharge site at Naihati and Batanagar respectively.

(v). Macrobenthic organism: In TABLES 3 and 4

TABLE 6: Index of dominance (C) and another measure of diversty (D) in Batanagar Ganga

Se. no.	Name of the species	Partial C $(ni / N)^2$	C	D = 1-C
1	Chironomid larvae	0.0059		
2	Tubifex	0.0073		
3	Nereis	0.0002		
4	T. lineata	0.2754		
5	T.scrabra	0.0068	0.3108	0.6892
6	Marisa	0		
7	Belamia	0.0003		
8	Pleurocera	0.0001		
9	Pouch Snail	0.0004		
10	Mysis	0.0003		
11	Crab	0.0141		

TABLE 7: Abundance of benthic fauna at station I

Benthic Fauna	% Of presence
Chironomid in all individual	1.86
Tubifex in all individual	14.13
Nereis in all individual	00
T.lineata in all individual	34.4
T.scabra in all individual	20.5
Marisa in all individual	2.4
Belamia in all individual	5.6
Pleurocera in all individual	5.8
Pouch snail in all individual	6.1
Mysis in all individual	00
Crab in all individual	9.1

Macrobenthic Community Structure, Species Diversity Index has been given at Station I and II respectively. Notations are as: (n_i-importance value of each species, N- Total of importance value, H- Shannon Weiver Index, J-evenness index, J = H / log S, S-no. of species. In both the stations, the macro benthic community was dominated by Mollusca. Tubifex sp. Is the sole number of annelida in Station I, but both Tubifex and Nereis are present in Station II. Chironomid larvae are more in Station II than in station I. Bellamya sp. is higher in Station I than in station II. Shannon Weiver Index (H) value[13] is higher in Station II than in Station I. Index of dominance (C) suggested by Simpson[15] and Evennesss Index (J) calculated for both stations, revealed that both were high for Station II than in Station I. These are given in detail in TABLES 5 and 6.

(vi) The abundance of Benthic Fauna at Station I and percentage of abundance of different species of animals in Station II are shown in TABLES 7 and 8 respectively.

The Shannon Weiver Index Value (H) is more than 1 i.e. it is substantially polluted. In Station II, the Shan-

TABLE 8: Percentage of abundance of different species of animals in station II (Batanagar Ganga)

Species of animals	% Of presence
Chironomid in all individual	7.7
Tubifex in all individual	8.5
Nereis in all individual	1.6
T.lineata in all individual	52.5
T.scabra in all individual	8.3
Marisa in all individual	00
Belamia in all individual	1.93
Pleurocera in all individual	1.10
Pouch snail in all individual	2.20
Mysis in all individual	1.93
Crab in all individual	11.9

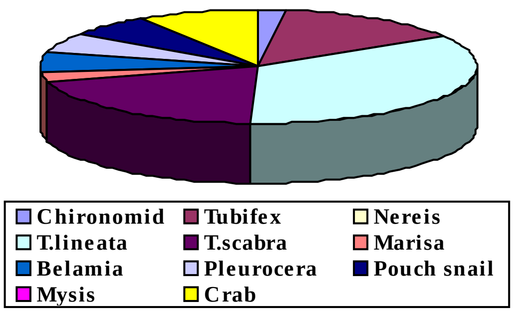

Figure 1: Percentage of distribution of different species of animals in Station I (Naihati Ganga)

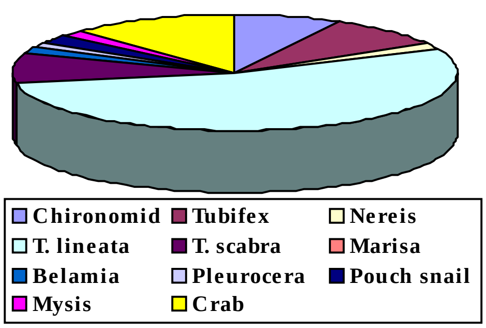

Figure 2: Percentage of distribution of different species of animals in Station II (Batanagar Ganga)

non Weiver Index Value is less than 1 revealed it is moderately clean water. When H value lies between 3-5, it shows that water is clean. The presence of higher densities of Tubifex and lower density of Chironomid larvae may indicate the pollution level is higher at Station I than at Station II. It was reported by Wiederholm [19] that presence of Tubifex sp. In higher numbers in the stations enriched with organic matter and with minimum amount of oxygen. The data from Station I also supported this view. The occurrence of minimum number of Chironomid larvae at the station I may be attributed to heavy organic pollution. The density of Chironomid larvae in station II is more because of presence of algal population and sandy sediment and relatively less amount of organic matter[7]. The percentage of distribution of different species of animals in Station I (Naihati Ganga) and Station II (Batanagar Ganga) has been given in figure 1 and 2 respectively.

There is no such significant difference in case of values of free CO_2, pH and water temperature at all the sites at both the places Naihati and Batanagar.

CONCLUSION

From the above mentioned facts, it is true that the river is polluted. Station I (Naihati) is more polluted than Station II (Batanagar). In view of urbanization and industrialization monitoring of river for various pollutional parameters has to be done to increase awareness among the people, so as not to form the river an open sewer. Moreover, the present investigation has given an advance warning of the increased pollution by various sources discharged in the river Ganga, for necessary preventive measures in the near future.

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