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Studies on Physicochemical Parameters to Assess the Water Quality of the River Damodar

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ABSTRACT

The present study was carried out to determine the levels of water quality indicators and to analyze the statistical interrelationships among them. Water samples (n=12) were collected from the river Damodar and prepared for the analysis of various physicochemical parameters. The collection, preservation and analysis of river water samples were carried out according to the standard methods of APHA (1998). The present investigation deals with the study of some water quality parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), DO, BOD, alkalinity, total hardness, SO_4^{2-}, Cl^- and NO_3^-. The values of most of the parameters were least during the rainy season, when the flow volume increased greatly due to the surface runoff. Dissolved oxygen measures the waste assimilation and self-purification capacity of an aquatic ecosystem and the values ranged from 5.528 to 7.862 mg/l and 5.986 to 8.172 mg/l during rainy season and winter season respectively. Higher dissolved oxygen was found during winter season and relatively lower during rainy season. The results of BOD ranged from 1.278 to 4.878 mg/l and 1.432 to 4.179 mg/l during rainy season and winter season respectively. The result of correlation analysis showed that biochemical oxygen demand (BOD) was inversely correlated with dissolved oxygen (DO). Higher values of nitrate were observed during rainy season may be due to discharge of waste through agricultural runoff. This investigation revealed that the status of the river water quality in the studied region is optimum for fish health.
Keywords: Damodar River, Water Quality, Physico-Chemical Assessment, Correlation Analysis

I. INTRODUCTION

Chemistry of river waters is governed by both the natural processes [1] and anthropogenic activities [2] prevailing in the catchment area. Natural processes include precipitation, weathering of rocks and sediment transport, whereas anthropogenic activities include urban and industrial development influencing water quality. Regardless of origin, both the source loads typically find their way into the rivers and streams thus potentially leading to substantive pollution. Rapid industrialization and urbanization have resulted heavy and varied pollution in aquatic environment leading to deterioration of water quality and depletion of aquatic biota [3,4]. River water resources can be used in every sector of development like industrial purposes, agriculture, aquaculture, transportation and public water supply etc. [5]. The contamination of aquatic ecosystem is confirmed by determining the levels of contaminants in water, sediment and organisms [6,7]. The contaminated water can cause various environmental consequences like adverse effect on plant growth and human health etc. [8,9].

Water quality assessment on the ecological point of view is necessary for the protection and restoration of quality of the riverine ecosystem. Studies on ecology of the river mainly concentrated on some aspects such as physicochemical nature of water, zooplankton, phytoplankton, macrophyte study, productivity and heavy metal levels and their effects on organisms. The determination of physicochemical parameters is an important tool to assess the riverine ecosystem. The fluctuation of physical and chemical characteristics of water may exert an effect on the biological features of aquatic ecosystems of rivers [10]. The deterioration of water quality may lead to the destruction of ecosystem balance [11] and also may affects the surface water resources. Damodar is an important river of West

Bengal and being a peninsular Indian river, used to serve a variety of purposes including drinking, agriculture, and industry still now. This river flows through a vast track of eastern India with variable topography and geology and is subjected to intensive exploitation by various anthropogenic activities. Hence, it is very essential to monitor river water quality regularly to determine its suitability for various uses. The objective of the study was to examine the chemical composition of the river water and to assess the water quality on the basis of some ecological aspects.

II. METHODS AND MATERIAL

The study was carried out on the river Damodar which originates near Chandwa village, Palamau district, in the Jharkhand state, India. The water samples for physico-chemical analyses were collected (in triplicate) from twelve different sites near Andal, West Bengal, India in the rainy and winter season. The river water samples were collected and stored in acid cleaned, high-density polyethylene (HDPE) bottles (1,000 ml), which were carefully rinsed before use. Then the water samples were taken to the laboratory for further physico-chemical analysis. Analysis of physicochemical parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), alkalinity, total hardness, sulphate (SO_4^{2-}) chloride (Cl^-) and nitrate (NO_3^-) was carried out as per APHA (1998) guidelines [12]. Correlation study was performed for different water quality parameters to analyze the interrelations among them.

III. RESULTS AND DISCUSSION

In general, the status of river water quality at each sampling site could provide useful information on land use and land cover within the catchment area. A summary of the analytical and statistical data for the river water samples are presented in Table 1 and 2. pH is an important water quality parameter that determines the suitability of water for various purposes [13]. The fluctuation of pH in natural water may affect aquatic organisms because most of their metabolic activities are pH dependent. The results of pH varied from 7.00 to 8.269 in rainy season and 7.00 to 8.497 in winter season indicating that the river water samples are almost neutral to alkaline in nature. The increased level of pH in some sites of the study area may be related to growth and photosynthetic activities of algae [14].

The electrical conductivity indicates the amount of material dissolved in water and the values ranged from 180 to 410 μS/cm and 200 to 430 μS/cm during rainy season and winter season respectively. The electrical conductivity is also a good measure of the total dissolved solids like carbonate, bicarbonate, phosphate, sulphate, chloride, etc. The highest conductivity in some sites, mainly in the upstream of the studied region may be due to the inundation of effluent water from various industries. Electrical conductance values for the dry season (winter season) were higher than that for the monsoon (rainy season). Total dissolved solids (TDS) may be organic or inorganic in nature, indicating the general nature of the water quality or salinity. Measurement of TDS expresses the dissolved matter present in water and the values were ranged from 118.73 to 252.38 mg/l and 127.64 to 258.47 mg/l during rainy season and winter season respectively. The values of total dissolved solids (TDS) indicated that, there was a considerable amount of various dissolved ions in the prevailing sampling sites. Seasonal variations showed higher value in winter and lower value in rainy due to dilution with rain water. Electrical conductivity was positively correlated with total dissolved solids in both the seasons [rainy season: r=. 0.981; winter season: r= 0.968].

Dissolved oxygen (DO) is an important parameter in river water quality assessment and also measures the waste assimilation and self-purification capacity of an aquatic ecosystem. It is considered as an essential environmental factor for the sustenance of riverine aquatic ecosystem. Dissolved oxygen reflects the physical and biological processes prevailing in the water and the values were ranged from 5.528 to 7.862 mg/l and 5.986 to 8.172 mg/l during rainy and winter respectively. Kaur and Toor, (1978) [15] observed that the level of dissolved oxygen (DO) below 6.0 mg/l appeared inadequate for the survival of early stage of fishes. The increase of industrial and domestic waste in S4 and S6 sites decreases the DO level in the studied river. Though the overall DO level in the winter season was at a very satisfactory range, this could be due to the fact that the microbial activities get reduced due to low

temperature. Biochemical Oxygen Demand (BOD) is a measure of the oxygen in the water that is required by the aerobic organisms. It is an indication of the organic load and also a pollution assessment index for the water bodies which mainly receives organic wastes [16]. High value of BOD indicates a decrease in DO level because oxygen is consumed by aerobic bacteria. BOD tests of water and wastewater, measures the biodegradable fraction of the total DO consumption of a water sample. BOD values were ranged from 1.278 to 4.878 mg/l and 1.432 to 4.179 mg/l during rainy and winter respectively. The higher BOD values at the site S6 showed that this site was more affected by organic substances. The result of correlation analysis showed that biochemical oxygen demand (BOD) was inversely correlated with dissolved oxygen (DO) [rainy season: r=. −0.648; winter season: r=−0.635].

Table 1. Physico-chemical characteristics of the Damodar river water in rainy season

	pH	EC	TDS	DO	BOD	Alkalinity	TH	SO_4^{2-}	Cl^-	NO_3^-
S1	7.326	210	142.64	6.352	3.452	108	104	21.515	10.354	1.584
S2	7.000	190	119.74	7.862	2.124	88	92	19.285	12.625	0.724
S3	8.165	200	144.62	6.541	3.149	92	100	12.418	14.322	1.915
S4	7.652	250	158.48	5.895	2.432	124	140	18.543	16.242	2.174
S5	8.024	300	182.95	6.247	3.956	116	152	17.542	9.859	2.145
S6	7.658	410	252.38	5.528	4.878	112	160	20.518	12.468	3.225
S7	7.429	260	165.18	6.962	2.719	124	84	17.549	8.295	0.934
S8	7.000	270	186.56	6.745	2.838	152	72	23.659	14.426	0.273
S9	8.269	220	141.51	6.239	4.054	108	124	18.846	9.554	2.492
S10	8.037	230	157.25	7.694	1.278	144	108	15.842	11.378	0.786
S11	7.245	180	121.16	6.825	2.782	88	96	19.472	10.452	1.425
S12	7.483	190	118.73	7.627	3.703	120	80	25.667	8.879	1.395
Min	7.000	180	118.73	5.528	1.278	88	72	12.418	8.295	0.273
Max	8.269	410	252.38	7.862	4.878	152	160	25.667	16.242	3.225
Ave	7.607	242.5	157.60	6.710	3.114	114.7	109.3	19.238	11.571	1.589

Units: EC in µS/cm; other physicochemical parameters are in mg/l

Table 2. Physico-chemical characteristics of the Damodar river water in winter season

	pH	EC	TDS	DO	BOD	Alkalinity	TH	SO_4^{2-}	Cl^-	NO_3^-
S1	7.450	210	127.64	7.452	2.854	132	136	16.984	12.669	1.442
S2	8.164	300	186.66	6.373	3.145	112	116	18.634	15.427	0.489
S3	7.000	250	158.95	8.172	1.432	108	172	24.657	9.325	0.658
S4	7.359	330	202.43	6.251	3.229	156	120	20.227	10.641	0.376
S5	8.245	350	236.26	7.963	2.297	168	140	26.964	15.441	1.453
S6	8.341	430	258.47	5.986	4.179	212	216	32.722	20.475	1.159
S7	7.446	320	221.74	7.976	2.205	184	124	19.554	18.225	2.839
S8	7.000	280	176.95	7.364	3.129	108	128	28.653	16.289	0.719
S9	8.497	300	189.54	6.375	3.228	112	92	15.384	17.347	0.557
S10	7.938	260	178.47	8.169	2.986	180	104	34.815	10.626	1.463
S11	8.497	200	142.36	6.875	1.623	128	88	24.638	9.869	0.723
S12	7.491	220	147.63	6.558	2.897	108	92	18.762	12.359	0.975
Min	7.000	200	127.64	5.986	1.432	108	88	15.384	9.325	0.376
Max	8.497	430	258.47	8.172	4.179	212	216	34.815	20.475	2.839
Ave	7.786	287.5	185.59	7.126	2.767	142.3	127.3	23.500	14.058	1.071

Units: EC in µS/cm; other physicochemical parameters are in mg/l

The Total Hardness (TH) is also an important water quality parameter whether to be used for industrial, domestic or agricultural purposes. Hardness refers to the concentration of divalent metal ions in water and the values were ranged from 72 to 160 mg/l and 88 to 216 mg/l during rainy and winter respectively. According to Boyd, (1982) [17] the hardness in water should be > 20 mg/l to protect the inhabiting fishes against harmful effects and also for the satisfactory production, though < 20 mg/l hardness may create stress in fishes. This study also revealed that the total hardness of the river water was satisfactory for fish health. Alkalinity measures the amount of alkaline compounds present in river water such as bicarbonates, carbonates, borates, silicates along with hydroxides. Alkalinity is a total measure of the substances in water that have acid neutralizing capacity and the values were ranged from 88 to 152 mg/l and 108 to 212 mg/l during rainy and winter season respectively.

The major sources of sulphate in water bodies derived from rock weathering, volcanic explosions [18] and anthropogenic activities such as mining, waste discharge and fossil fuel combustion processes [19]. The values of sulphate in the studied river were ranged from 12.415 to 25.667 mg/l in rainy and 15.384 to 34.815 in winter season. Seasonal variations showed higher value in winter and lower value in rainy season due to dilution effect. The chloride concentration in fresh water serves as an indicator of pollution. The discharge of sewage and industrial wastewater containing high level of Cl^-, may elevate the level of chloride in fresh water [20]. During winter its value ranged from 9.325 to 20.475 mg/l and in rainy season it varied between 8.295 to 16.242 mg/l. According to Olapade, (2011) [21] the nitrate-nitrogen (NO_3^-) is generally the product of bacterial decomposition of organic substances. The results of nitrate in the studied river were ranged from 0.273 to 3.225 mg/l and 0.376 to 2.839 mg/l during rainy and winter season respectively. There was a negative correlation between DO and NO_3^- in both the seasons [rainy season: r=. −0.786; winter season: r=−0.727]. Higher values of nitrate were observed during rainy season may be due to discharge of waste through agricultural runoff.

IV. CONCLUSION

pH of the river water was neutral to alkaline in nature. The values of most of the parameters were least during the rainy season, when the flow volume increased greatly due to the surface runoff. The overall DO level in the winter season was at very satisfactory range, which could be due to the fact that the microbial activities get reduced due to low temperature. The high BOD in the rainy season can be attributed to the increase of discharges into the rivers such as contaminated top soils and other organic wastes brought about by heavy rains. The result of correlation analysis showed that biochemical oxygen demand was inversely correlated with dissolved oxygen (DO). Nitrate content was recorded higher in rainy season in comparison to the winter. The present piece of work also revealed that the status of the river water quality in the studied region was optimum for fish health.

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