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Assessment of Hydrochemical Characteristics of River Damodar

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ABSTRACT

Assessment of hydrochemical characteristics of the river system is very important for water resources protection and sustainable utilization. The objective of this study was to examine the water quality status through using several physicochemical parameters and to evaluate the hydro-chemical characteristics of river Damodar to access its implication on water quality. Water samples were collected from 14 sampling stations along the river Damodar in premonsoon and monsoon season and analyzed using standard methods. The concentrations of EC, TDS, DO and SO_4^{2-} ranged from 210–410, 123–254, 5.103–7.694 and 18.628–37.485 mg L^{-1} with an overall mean of 336, 204, 6.399 and 25.842 mg L^{-1} respectively in premonsoon season. Whereas the concentrations of EC, TDS, DO and SO_4^{2-} ranged from 200–370, 122–221, 5.579–7.862 and 14.451–27.275 mg L^{-1} with an overall mean of 289, 171.4, 6.766 and 20.053 mg L^{-1} respectively in monsoon season. Most of the analyzed parameters showed elevated concentrations during premonsoon season, while least concentrations were observed during monsoon season. However, the monsoon values of phosphate in the downstream of the study area were increased, which may be due to the surface runoff from the surrounding agricultural fields. The concentration of SO_4^{2-}, Cl^- along with TDS were higher in some sites of the study area may be due the disposal of solid waste along with wastewater from industrial sites. Continuous assessment of river water quality on routine basis is imperative and a sustainable management is required at the industrialized area.

Keywords: Damodar River, Hydrochemical Characteristics, Water Quality, Assessment

I. INTRODUCTION

From the very dawn of civilization the rivers have always been serving as the lifelines of development [1] and with the course of time have borne the impacts of development and industrialization. The advancement of industrial development and progressive growth of population in last few decades results in tremendous increase in the demand of fresh/surface water [2]. Water quality in such a reverine ecosystem may be determined by many physical, chemical and biological factors [3]. The physico-chemical characteristics of the water bodies play a crucial role for maintaining the healthy ecosystem of an aquatic environment on which biological diversity depends [4]. Aquatic ecosystems are affected by several health stressors that significantly deplete biodiversity.

A continuous monitoring of hydro-chemical properties of revirine water body is very much implicative for both short and long term evaluation of its quality, since the quality of water body i.e. the functioning of an aquatic ecosystem and its stability to support life forms, depend to a great extent on the hydro-chemical characteristics of water body [5]. Thus the assessment of hydrochemical properties of water remain as an important environmental issue of research finding worldwide [6,7,8]. The measurements of water quality are highly significant for lowering industrial and mining activities those results in short-term pollutant releases into or along riverine system. To warn the downstream users and to mitigate secondary damages the monitoring of water quality is highly beneficial [9]. It is also significant to evaluate the health of a watershed and to arrange necessary management decisions to regulate current and future pollution strategy of receiving water bodies [10]. The poor quality of water can also cause adverse effects on plant growth and human health [11,12,13,14,15] and causes various environmental consequences [16,17,18]. To improve the sustainable

water–use management strategies- surplus information on water quality status and pollution sources is highly desirable [19,20,21]. Thus, the stable sustainable maintenance of water quality is becoming a global problem [22] and is therefore essential to examine it at regular interval of period.

Being a significant peninsular Indian river, the Damodar tributaries are used to serve a variety of purposes including drinking, recreation, agriculture and industry. This river serves as a major source of domestic water supply also for various towns and it receives various untreated municipal sewage and effluents from different industries directly during its course. Wastewater from various industries like coke oven plants, sponge iron industries and several coal washeriesare discharged directly or indirectly into the river at different sites. The objective of this study was to examine the water quality status through using several physicochemical parameters and to evaluate the hydro-chemical characteristics of river Damodar to access its implication on water quality.

II. METHODS AND MATERIAL

The river water samples were collected in the field (Damodarriver) for hydro-chemical analysis. Water samples were collected from fourteen different sites and preserved following the standard procedure described by America Public Health Association (1998). The physico-chemical parameters of the river water were measured during the two investigation periods; 1st sampling (in premonsoon period) and 2nd sampling (in monsoon period). The collected samples were filtered (Whatman no. 42) and preserved with HNO_3 for further analysis [23]. Water samples were analyzed for pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), alkalinity, total hardness (TH), SO_4^{2-}, Cl^- and PO_4^{3-}. pH, Electrical conductivity (EC) and dissolved oxygen of water samples were measured in the field immediately after collection of the samples. Analytical grade chemicals were used throughout the experiment. The glassware was washed with nitric acid followed by distilled water. All the experiments were carried out in triplicate.

III. RESULTS AND DISCUSSION

The analytical results of different hydro-chemical parameters along the river Damodarare presented in Table 1. pH is quite an important measurement of water quality that determines the solubility and biological availability of water for various purposes. Since both very high and low pH may be deleterious in nature, it is essential to maintain the overall range of pH from 6.5 to 9 for an aquatic ecosystem which is appropriate for it [24]. In the present study the pH value of river water samples ranged from 7.14 to 8.52 in 1st sampling and 7.0 to 8.32 in 2nd sampling indicating that the nature of water was neutral to alkaline. The average value of pH in 1st sampling and 2nd sampling were found to be 7.81 and 7.59 respectively (with the standard deviation 0.46 and 0.41 respectively). Distribution of pH, EC and TDS is presented in Fig. 1. Electrical conductivity, which is an important parameter for measuring the ionic strength of solution, varied between 210–410 μS/cm in pre-monsoon and 200–370 μS/cm during monsoon seasons with an overall mean 336 and 289 μS/cm respectively. The lowest conductivity in monsoon may be due to dilution effect of rain water. In case of total dissolved solids (TDS) -being a measure of the combined content of all inorganic and organic substances in suspended form, there was a considerable amount of various dissolved ions in the prevailing sampling locations. In the study area the amount of total dissolved solid ranged between 123 and 254 mg L^{-1} in 1st sampling and 122–221 mg L^{-1} in 2nd sampling. The average value of total dissolved solid in 1st and 2nd sampling were found 204 mg L^{-1} and 171.4 mg L^{-1} respectively (with the standard deviation 37 and 30.14 respectively).

Generally degradation of organic matter in water bodies needs dissolved oxygen, occasionally low levels of which indicate high pollution. Usually decomposition of organic matter, high levels of biotic respiration, oxygen demanding wastes and inorganic reductants such as ammonia, hydrogen sulphide, nitrites etc remain responsible for the decrease of DO. Dissolved oxygen (DO) is considered as an essential environmental factor for the sustenance of riverine aquatic ecosystem. It is also an important parameter in river water quality assessment and measures the waste assimilation and self-purification capacity of an aquatic ecosystem. The values of Dissolved oxygen in the studied water were ranged from 5.10 to 7.69 mg L^{-1} and 5.57 to 7.86 mg L^{-1} in 1st and 2nd sampling respectively with an overall mean 6.39 and 6.76 mg L^{-1} respectively. The DO level found in the study area was adequate for the planktons

to survive and to do various physiological activities. Distribution of DO and BOD of river wateris presented in Fig. 2. BOD is the amount of dissolved oxygen needed by the aerobic biological organisms to breakdown organic material residing in given water bodies, which is serving as an indicator of organic load and also a pollution assessment index for those water bodies. The values of BOD were ranged from 1.76 to 4.24 mg L^{-1} and 1.10 to 4.17 mg L^{-1} in 1st and 2nd sampling respectively. The average value of BOD was 3.26 mg L^{-1} in pre-monsoon and 2.66 mg L^{-1} in monsoon with the standard deviation 0.76 and 0.97 respectively. The concentrations of BOD found by Gasim*et al.,* (2005) [25] during the study of Semenyih river water quality in Malaysia was ranged from 2.4 to 19.8 mg/L which is considered to be high in comparison to the present study. Usually BOD concentration is directly associated with DO concentrations. Low value of DO indicates increased value of BOD and these phenomena are common as similar observation has been characterized by earlier researchers like Rosli, *et al.,* (2010) [24].

Total alkalinity as a measure of alkaline compounds in surface water mostly comes from calcium carbonate ($CaCO_3$) being leached from rocks and soil, mining and also from urban development. In the present study area the alkalinity were ranged from 112 to 204 mg L^{-1} and 84 to 148 mg L^{-1} during pre-monsoon and monsoon seasons respectively. Distribution of alkalinity and total hardness of river wateris showed in Fig. 3. Usually total hardness is considered as an important geological function for a site with which the surface water is associated. Generally it has no stressful effect on health, although a little bit impact on heart diseases is reported [26]. The Total Hardness (TH) values were ranged from 96 to 216 mg L^{-1} and 88 to 164 mg L^{-1} during pre-monsoon and monsoon seasons respectively.

The principal sources of sulphate in river water are volcanoes, rock weathering and human practices like waste discharge, combustion of fossil fuel and mining etc.[27]. In the present study area the amount of sulphate ranged between 18.62–37.48 mg L^{-1} in pre-monsoon and 14.45–27.27 mg L^{-1} during monsoon season. The average value of sulphate was 25.84 mg L^{-1} in pre-monsoon and 20.05 mg L^{-1} in monsoon with the standard deviation 6.04 and 3.87 respectively. The distribution of SO_4^{2-}, PO_4^{3-} and$Cl^-$is represented in Fig. 4. Surface water may be contaminated with chloride through industrial wastewater, agricultural runoff, road salting etc.

Chloride concentration was varied between 9.84–23.51 mg L^{-1} in pre-monsoon and 8.74–19.16 mg L^{-1} during monsoon seasons with an overall mean of 16.10 mg L^{-1} and 12.94 mg L^{-1} in pre-monsoon and monsoon respectively (with the standard deviation 4.41 and 3.07 respectively). Domestic sewage, detergents, agricultural effluents and fertilizer runoff may serves as different sources for phosphate contamination in surface water. Surplus phosphates become detrimental causing stepped up eutrophication by lowering the DO levels and further excess of which degrades the water quality and harmfully affect distribution of aquatic life in the river.

Table 1: Hydrochemical characteristics of the river Damodar

	1st Sampling				2nd Sampling			
Parameters	**Min**	**Max**	**Ave**	**SD**	**Min**	**Max**	**Ave**	**SD**
pH	7.142	8.521	7.815	0.468	7.00	8.329	7.599	0.411
EC	210	410	336	55.0	200	370	289.0	46.296
TDS	123	254	204	37.0	122	221	171.4	30.145
DO	5.103	7.694	6.399	0.871	5.579	7.862	6.766	0.738
BOD	1.765	4.243	3.261	0.768	1.104	4.179	2.662	0.976
Alkalinity	112	204	152	32.0	84.0	148	115.4	19.092
TH	96.0	216	133	33.0	88.0	164	115.6	27.224
SO_4^{2-}	18.628	37.485	25.842	6.048	14.451	27.275	20.053	3.871
Cl^-	9.845	23.514	16.108	4.416	8.741	19.162	12.946	3.072
PO_4^{3-}	0.035	0.451	0.167	0.127	0.073	0.659	0.284	0.222

Units: EC in μS/cm; other hydro-chemical parameters are in mg L^{-1}

The concentration of phosphate was ranged between 0.03–0.45 mg L^{-1} in pre-monsoon and 0.07–0.65 mg L^{-1} during monsoon seasons. The average value of phosphate was 0.16 mg L^{-1} in pre-monsoon and 0.28 mg L^{-1} in monsoon with the standard deviation 0.12 and 0.22 respectively.

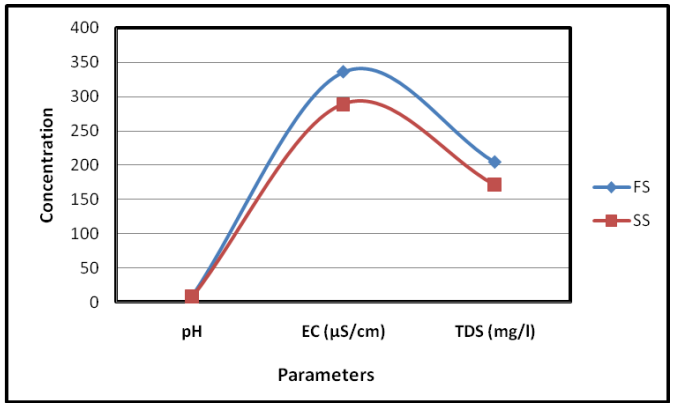

Figure 1: Distribution of pH, EC and TDS in the river water

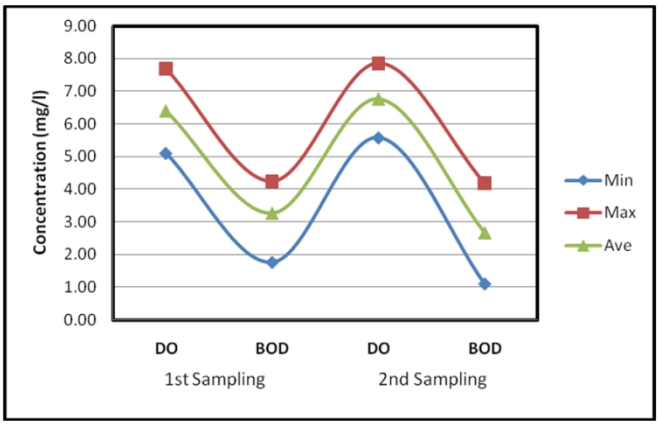

Figure 2: Distribution of DO and BOD in the river water

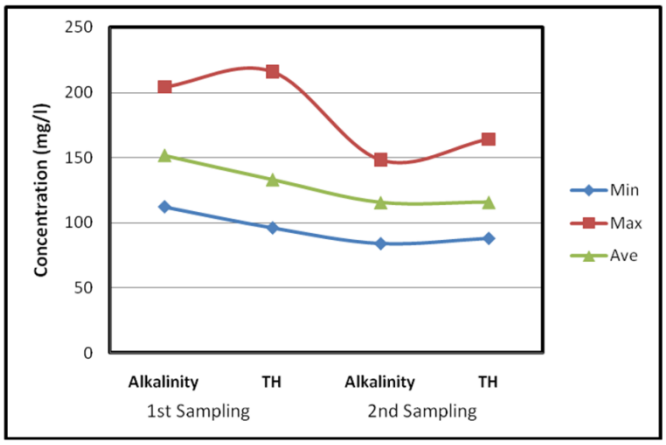

Figure 3: Distribution of alkalinity and total hardness in the river water

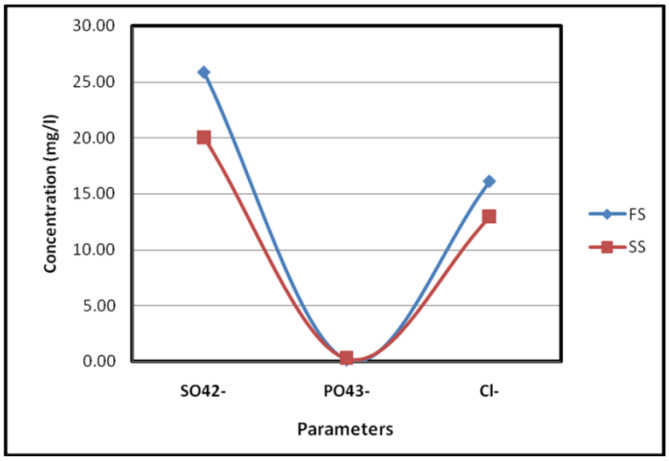

Figure 4: Distribution of SO42–, PO43– and Cl– in the river water

IV. CONCLUSION

The study revealed that there was a considerable variation in the concentration of hydrochemical parameters in analyzed water samples. The lowest conductivity along with other hydrochemical parameters in monsoon may be due to dilution effect of rain water. The optimum DO level found in the study area which was adequate for the survival and growth of planktons and to do various physiological activities. The results of water quality trends clearly showed that the majority of the water quality parameters were quite high in the premonsoon season compared to monsoon season. However, phosphate content was recorded higher in monsoon season due to the impact of agricultural activities in the studied region. The concentration of SO_4^{2-}, Cl^- along with TDS were higher in some sites of the study area may be due the disposal of solid waste along with wastewater from industrial sites. Further extensive research works are needed to be carried out to assess the water quality of river Damodar in the industrial area.

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