Assessment of Water Quality Index of Damodar River near Coal City Dhanbad

Md. Asif Ekbal[1] and Ashutosh Ramteke[2]

[1]Department of Environmental Science and Engineering Indian School of Mines, Dhanbad
[2]Department of Environmental Science and Engineering Indian School of Mines, Dhanbad
E-mail: [1]asif.ismu@gmail.com, [2]ramteke.ashutosh93@gmail.com

Abstract—*Assembling different water quality parameters into one single number leads an easy interpretation of an index, thus providing an important tool for management and decision making purposes. Water Quality Index exhibits the overall water quality at a specific location and specific time based on several water quality parameters. The purpose of an index is to transform the complex water quality data into information that is easily understandable and useable by the general public. Water Quality Index (WQI), a technique of rating water quality, is an effective tool to assess spatial and temporal changes in water quality. Water of Damodarriver is the main source of drinking water for Jharia people. For calculating the WQI, the different water quality parameters have been considered. The analysis reveals that the water of that area is not good because of the mining activities and it needs some degree of treatment before consumption.*

Keywords: *Water Quality, Water Quality Index (WQI), Quality rating scale (Qi), Grads of water Quality Index, Weighted Arithmetic Index, Relative (unit) weight (Wi), Damodar River.*

1. INTRODUCTION

Water is a dynamic renewable natural resource. Its availability with good quality and adequate quantity is very important for human life and other purposes. In general, the quality of water is equally important as the quantity. Therefore, water quality is considered as an important factor to judge environment changes which are strongly associated with social and economic development [1]. Water quality is used to describe the condition of the water, including its chemical, physical and biological characteristics, usually with respect to its suitability for a particular purpose (i.e., drinking, swimming or fishing), [2, 3, and 4]. Water quality is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose [5]. It is estimated that around seven billion people, out of the projected 9.3 billion in the entire world, will face water shortage problem and out of these 40% will suffer acute water crisis. In India's case, the future is a bit more-worse, since we have only 2.45% of the word's landmass supporting 16% of the world's population and our freshwater resource does not exceeding 4% of the global water resources. Apart from availability, continuous water pollution due to disposal of sewage, industrial and mining wastes also threatens to reduce the available quantity of usable water and more and more of our ground and surface water resources including lakes, ponds and rivers are being categorized as polluted[6,7,8,9,10,and11]. Nowadays, surface water quality became a critical issue in many countries; especially due to the concern that freshwater will be a scarce resource in the future, therefore, water quality monitoring program is necessary for the protection of freshwater resources [12]. Water Quality Index (WQI) is a very useful and efficient method for assessing the suitability of water quality. It is also a very useful tool for communicating the information on overall quality of water [13 and 14] to the concerned citizens and policy makers. WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves [15]. Factors to be included in WQI model could vary depending upon the designated water uses and local preferences. Water quality indices (WQIs) have been developed to integrate water quality variables [16, 17, and 18]. A WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to managers and the public in a consistent manner [19].

The objectives of the present study are: (1) To investigate water quality of River Damodar at near Jharia Coalfield, Dhanbad, India (2) To determine the present situations of water quality index using the standards of Central Public Health Environmental Engineering Organization (CPHEEO), 1991 & Indian Council of Medical Research (ICMR), 1975 and (3) To categorize the conditions of water quality as per the classification criteria standards based on National Sanitation Foundation Water Quality Index.

Looking over the Damodarriver near industrial area, coal mines are prominent in this area and the mining activities going there contribute much to the water pollution.Mining by its nature consumes, diverts and can seriously pollute water resources. The origin and impacts of mining on water resources arise at several stages of the mining cycle: the mining processes itself and/or at mineral processing operation sage. Water pollution in mining areas is mainly due to overburden (OB) dumps, surface impoundments, mine water, industrial effluents, acid mine drainage, tailing ponds etc. In various coalfields, it has been observed that over the years, water resource conditions had been affected due to unplanned mining history and urban sprawl resulting in severe damage to the quality and water table [20].

2. STUDY AREA

A stretch of Damodar River, of about 100 km, passing through major polluting zones like mining area, thermal power plants, dams, etc., situated in Jharkhand State in India was chosen for the present study. The geographical boundary of the study area is 23°37.945’ to 23°41.140’N latitude and 86°42.643’ to 86°49.363’ E longitude.. The river stretch starts from the Rajrappa Temple near Ramgarh to the river course near the ECL HRD guest house of West Bengal, which carries the effluents of coal washeries, mining areas, thermal power plants, etc. to the Damodar river stretch. The river stretch, which has been considered for the present study is just, located within Ramgarh, Bokaro and Dhanbad of Jharkhand and some outskirt part of West Bengal. The Jharia Coalfield is about 100 years old and subjected to intensive mining activities because of easy availability of coal at shallow depths in thick seams. The Coalfield is such exploited due to selective and unsystematic mining during pre-independence period. It is having a total area of 450 km^2 and produces about 27,000 tonnes of prime coking coal.

Table 1: Detail of sampling location of Damodar river

Sample code	Location	Latitude (N)	Longitude (E)	Elevation (feet)
SW1	Suramdih Mine Water, BirsaOverbridge	23°40.062’	86°24.842’	407
SW2	Suramdih, Damodar River	23°39.977’	86°24.817’	410
SW3	SahanaPahadi Mine water	23°45.063’	86°25.829’	626
SW4	Panchet Dam, Downstream	23°40.828’	86°44.933’	364
SW5	Panchet Dam, Upstream	23°40.856’	86°44.834’	529
SW6	Telmacho Bridge	23°43.102’	86°12.030’	484
SW7	Phusro	23°45.687	86°00.832’	723
SW8	Bokaro Thermal Power Plant & Dam, Upstream	23°45.689’	86°00.832	882
SW9	Effluent Stream from Bokaro Power Plant	23°47.093’	85°53.460’	787
SW10	Bokaro Thermal Power Plant, Downstream	23°47.070’	85°53.501’	716
SW11	Tenughat Dam, Downstream	23°43.761’	85°50.393’	818
SW12	Lalpaniya, Effluent Stream of Tenughat Power Plant	23°44.402’	85°45.417’	862
SW13	Rajrappa Temple	23°37.945’	86°42.643’	835
SW14	Maithon Dam, Upstream	23°37.945’	85°42.643’	375
SW15	Maithon Dam, Downstream	23°47.038’	86°48.766’	344
SW16	Chirkunda	23°44.154’	86°48.414’	354
SW17	ECL HRD Guest House	23°41.140’	86°49.363’	297

Fig. 1: Sampling location map of study area

3. MATERIALS AND METHODS

For the assessment of surface water quality of Damodar River, grab samples were taken from various selected points identified in the Damodar River .The grab samples were collected in sterilized polyethylene bottles for routine analysis and separate samples were collected in 1 L bottle & 250 mL (for heavy metal test). Sample for heavy metal test should be preserved with 2 drop of dilute acid. For the measurement of DO the bottles were tightly closed by paraffin films and the DO of the samples were fixed as soon as they were brought to the laboratory systematic samplings. The surface water samples were collected in one liter narrow mouth pre-washed polyethylene bottles. Six parameters were analysed for WQI such as pH, Total Dissolved Solid (TDS), Alkalinity, Dissolved Oxygen (DO), Zinc (Zn), Iron (Fe).

3.1 Calculating of Water Quality Index (WQI):

Calculating of water quality index is to turn complex water quality data into information that is understandable and useable by the public. Therefore, water Quality Index (WQI) is a very useful and efficient method which can provide a simple indicator of water quality and it is based on some very important parameters. In current study, Water Quality Index (WQI) was calculated by using the Weighted Arithmetic Index method as described by [12]. In this model, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean. For assessing the quality of water in this study, firstly, the quality rating scale (Qi) for each parameter was calculated by using the following equation;

• Qi = {[(Vactual – Videal) / (Vstandard – Videal)] * 100}

Where, Qi = Quality rating of ith parameter for a total of n water quality parameters,Vactual = Actual value of the water quality parameter obtained from laboratory analysis,Videal = Ideal value of that water quality parameter can be obtained from the standard Tables.

Videal for pH = 7 and for other parameters it is equaling to zero, but for DO Videal = 14.6 mg/L

Vstandard = Recommended WHO standard of the water quality parameter.

Then, after calculating the quality rating scale (Qi), the Relative (unit) weight (Wi) was calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression;

• Wi = K/ Si

Where, • Wi = Relative (unit) weight for nth parameter

• Si= Standard permissible value for nth parameter

• K = Proportionality constant.

Where, K=1/$\sum_1^n 1/Si$ and n is total no. of parameter.

That means, the Relative (unit) weight (WI) to various water Quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

Finally, the overall WQI was calculated by aggregating the quality rating with the unit weight linearly by using the following equation:

• WQi = ∑QiWi/ ∑ Wi

• Where, • Qi = Quality rating • Wi = Relative weight In general, WQI is defined for a specific and intended use of water. In this study the WQI was considered for human consumption or uses and the maximum permissible WQI for the drinking water was taken as 50 score.

4. RESULTS AND DISCUSSION

The data were also used to calculate the Water Quality Index (WQI) to get a better understanding of the overall water quality. The Indian Standards as per ISI for the drinking water together with its corresponding status categories of WQI are given in Tables 2, Table 3 and Table 4, respectively. The WQI ranged from 4.655 to 118.776 which indicate Very Good to Very Poor status of water quality.

Table 2: Chemical Parameters Corresponding the IS: 10500

Parameter	Standard	Wi
PH	6.5-8.5	0.0347222
TDS	500	0.0005208
Alkalinity	200	0.0013208
DO	6	0.0434028
Zinc	5	0.0520833
Iron	0.3	0.8680556

Units: Concentration in mg L-1, except pH

Table 3: Status categories of WQI

WQI	Status
0-25	Very Good
25-50	Good
50-70	Poor
>70	Very poor

Table 4: Water Quality Index for Surface water of Damodar River

Sample code	Location	WQI	Status
SW1	Suramdih Mine Water, BirsaOverbridge	12.00	Very Good
SW2	Suramdih, Damodar River	21.07	Very Good
SW3	SahanaPahadi Mine water	23.46	Very Good

SW4	Panchet Dam, Downstream	11.16	Very Good
SW5	Panchet Dam, Upstream	4.655	Very Good
SW6	Telmacho Bridge	36.41	Good
SW7	Phusro	31.52	Good
SW8	Bokaro Thermal Power Plant & Dam, Upstream	35.77	Good
SW9	Effluent Stream from Bokaro Power Plant	118.776	Very Poor
SW10	Bokaro Thermal Power Plant, Downstream	58.30	Poor
SW11	Tenughat Dam, Downstream	26.03	Good
SW12	Lalpaniya, Effluent Stream of Tenughat Power Plant	19.51	Very Good
SW13	Rajrappa Temple	45.05	Good
SW14	Maithon Dam, Upstream	62.40	Poor
SW15	Maithon Dam, Downstream	42.91	Good
SW16	Chirkunda	33.94	Good
SW17	ECL HRD Guest House	46.098	Good

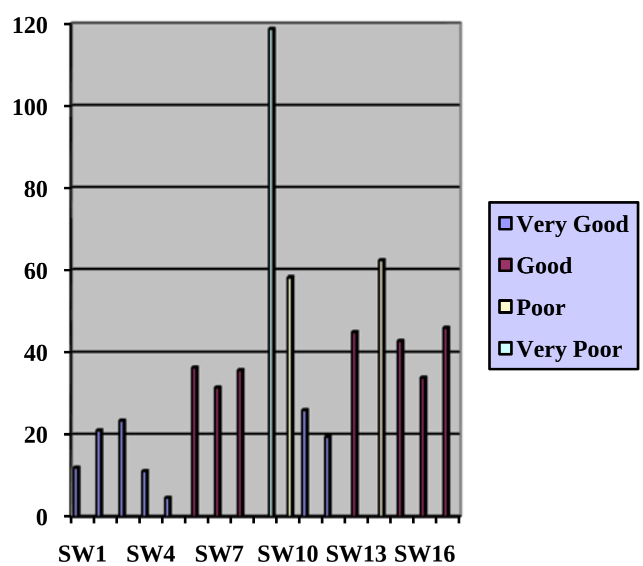

Fig2. Water Quality Index (WQI) at the studied sampling sites of Damodar River

As indicated from the results of the present study, Damodar river is contaminated at the different sampling site, But still this river is used as an important source for many purposes demand. Therefore, one of the important recommendation outputs of the present study is that the local authority and industrialization in Dhanbad city and Bokaro city should take this serious issue of water quality degradation in Damodarriver into account by reducing the effluence sources of the pollutant into the stream. Moreover, there should be a regular or constantly monitoring for the quality of the stream, because this could increase the risk of direct threats to human health and environment, because more pollution could increase the concentrations of unhealthy water pollutants for all organisms.

5. CONCLUSION

The water quality rating at more of the sampling sites clearly showed that the status of the water body in Damodarriver was degraded and unsuitable for the human uses during the period of study because it was not within the WHO standards and guidelines for drinking. It has been concluded that discharging of domestic and industrial wastewater and also other anthropogenic activities were the main factors for contaminating Damodarriver. However, there is need for regular monitoring of water quality in order to detect changes in physiochemical parameters concentration and convey it to the public through WQI.-

6. ACKNOWLEDGEMENT

The authors are grateful to Dr. AlokSinha Dr. P.K.Singh and Dr. S.R. Samaddar Department of Environmental Science and Engineering, Indian School of Mines, Dhanbadfor providing knowledge and assistantship in writing the paper.

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