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Qualitative Assessment of Surface Water of West Bokaro Coalfield, Jharkhand by Using Water Quality Index Method

Prasoon Kumar Singh[1], Ashwani Kumar Tiwari[1]* and Mukesh Kumar Mahato[1]

Department of Environmental Science & Engineering, Indian School of Mines, Dhanbad-826004, Jharkhand, INDIA.

***Corres.Author: ashwani.enviro@gmail.com**

Abstract: Water Quality Index (WQI), a technique of rating water quality, is an effective tool to assess spatial and temporal changes in water quality. Fourteen surface water samples were collected from rivers and ponds of the West Bokaro Coalfield area. The quality of water were evaluated by testing various physico-chemical parameters such as pH, Total Dissolved Solid, Total Hardness, Turbidity, Bicarbonate, Total Alkalinity, Calcium, Magnesium, Fluoride , Chloride, Nitrate and Sulphate . The WQI value 125.5 is maximum and the value 36.2 is minimum in the study area. The computed WQI shows that 28.6% of water sample falls in the good water category. On the other hand 42.9% of water samples falls in the poor category and 28.6 % falls in very poor category. Water Quality Index of 71.5% samples indicates that the water is not suitable for direct consumption. After treatment of that water samples can be used for drinking purpose. In the study area mining is one of the major activities causing water pollution and threatens the quality and quantity of surface water.
Keywords: Water Quality Index, Surface water, West Bokaro Coalfield.

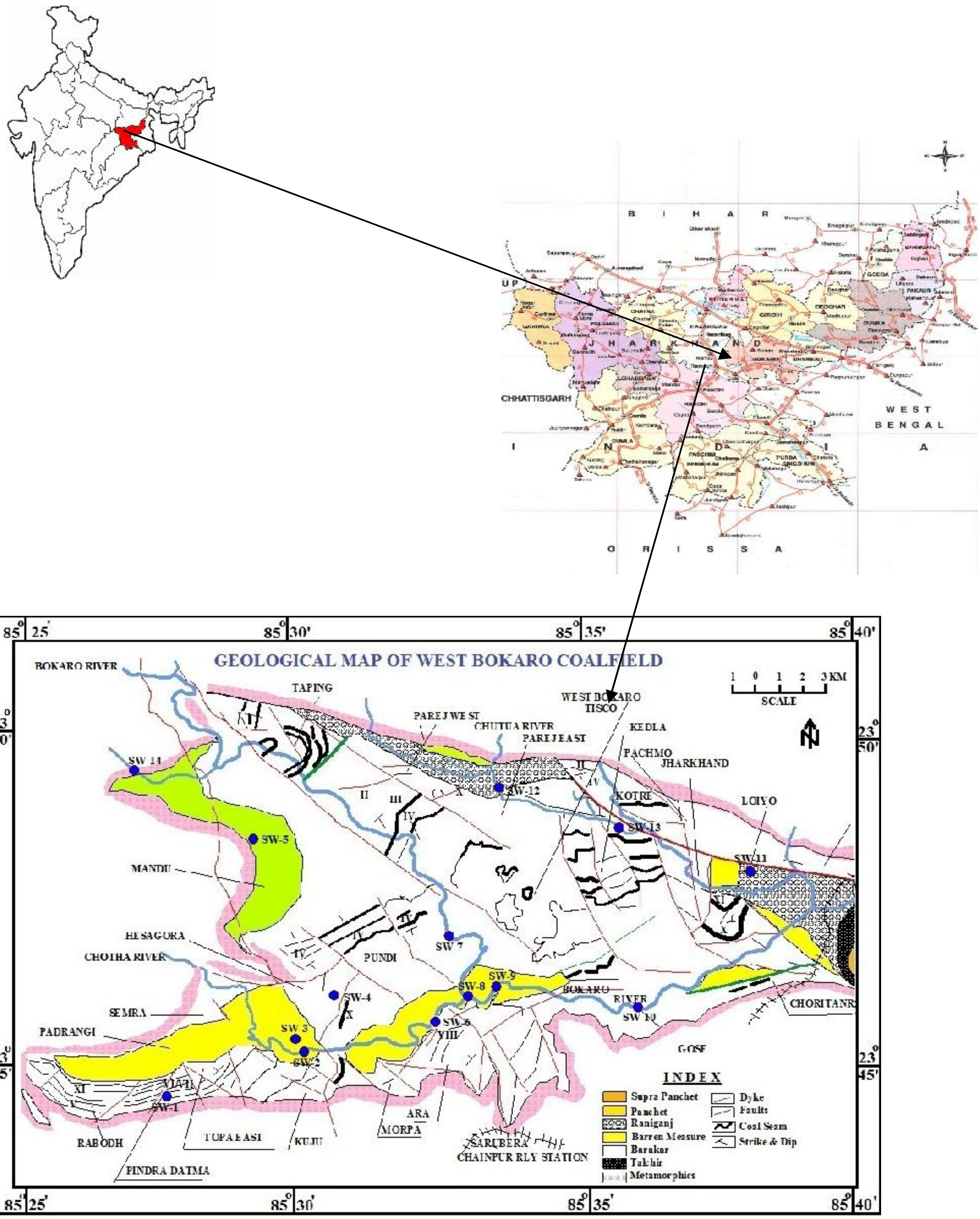
Introduction

Water is one of the most indispensable resources and is the elixir of life. Water constitutes about 70% of the body weight of almost all living organisms. Life is not possible on this planet without water. Water, a natural resource which has been used for different purposes, namely for drinking, domestic, irrigation and industrial, mainly depends on its intrinsic quality hence it is of prime importance to have prior information on quality and quality of water resources available in the region, while planning only developmental projects. 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[1]. 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[2,3,4,5,6,7].

Water quality index is one of the most effective tools to communicate information on the quality of any water body. Assessment of water quality is very important for knowing the suitability for various purposes[8]. WQI is a mathematical equation used to transform large number of water quality data into a single number[9]. It is simple and easy to understandable for decision makers about quality and possible uses of any water body[10].

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[11].

Figure1. Sampling location map and Geological map of the West Bokaro Coalfield India



Study Area

West Bokaro Coalfield, located in the Ramgarh district of Jharkhand, The coalfield covering an area of 207 sq km. The West Bokaro Coalfield lies between 23^0 45' to 23^0 50' N latitude and 85^0 25' to 85^0 40' E longitude (Fig.1). It is a major store house of medium coking coal and lies adjacent to the West of East Bokaro coalfield separated by the Lugu hill. The Barkakana - Gomoh railway line of Eastern railway passes through the eastern fringe of the coalfield and G.T. road passes along the western part of coalfield. Numerous all weather roads connect the various blocks of the coalfield with NH-33. The coalfield is drained by Bokaro River passing through the central part of coalfield with easterly flows. Jharna, Kajri and Chutua River are the main tributaries of the Bokaro River which drains the northern hilly terrain of the coalfield. Chotha River and Chutua River are also the tributaries of Bokaro River which drains the Southern region of the coalfield. The West Bokaro coalfield is fourth from east among the Damodar Valley coalfield. The North Karanpura coalfield in the West is separated by a narrow stretch of metamorphics.

The West Bokaro coalfield forms a broad syncline with its axis trending E-W and exhibits a complete sequence of the Lower Gondwana Formation which rest un-conformably on Archaean basement rock (Fig.1). The main coal bearing formations of this coalfield are the Barakar and Karharbari. Igneous intrusives in the form of micaperiodotite, lamrophyre and dolerite are reported from this coalfield.

The West Bokaro Coalfield area experience tropical climate and is characterized by very hot pre-monsoon and cold post- monsoon season. The month of May and mid June is the peak of pre-monsoon season with an average maximum temperature of 44^oc, while December and January are the coldest months. It is observed that the average annual rainfall has the range of 927 mm-1588 mm. The average annual rainfall of the district is 1418 mm and more than 85% of annual rainfall occurs during the four monsoon months (June to September).

Table1. Details of Sampling Locations of West Bokaro Coalfield

S. No.	Sample Code	Location	Type of Water	Latitude(N)	Longitude(E)	Elevation(ft)
1	SW1	Datma, Pindra	Pond Water	23^o44'16.5"	85^o27'53.4"	1420
2	SW2	Hesagara	Chotha River	23^o45'17.4"	85^o30'07.1"	1170
3	SW3	Hesagara	Pond Water	23^o45'54.0"	85^o30'27.2"	1279
4	SW4	Pundi	Pond Water	23^o46'48.2"	85^o31'18.1"	1331
5	SW5	Mandu	Pond Water	23^o47'47.2"	85^o28'04.5"	1443
6	SW6	Hesagara, Ara	Chotha River	23^o45'49.7"	85^o32'36.0	1056
7	SW7	Before Ghato Washery	Bokaro River	23^o45'51.5"	85^o32'34.9"	1057
8	SW8	Confluence of Bokaro & Chotha River	River	23^o45'52.2"	85^o32'36.6"	1082
9	SW9	After Ghato Washery	Bokaro River	23^o46'06.5"	85^o33'59.5"	1047
10	SW10	Gose	Bokaro River	23^o46'52.4"	85^o36'54.5"	1213
11	SW11	Laiyo	Pond Water	23^o47'12.7"	85^o37'33.2"	1072
12	SW12	Before Kedla Washery	Chutua River	23^o49'27.8"	85^o33'05.7"	1165
13	SW13	After Kedla Washery	Chutua River	23^o43'57.8"	85^o34'35.6"	1062
14	SW14	Jokkdhr	Dudhi River	23^o49'07.6"	85^o27'18.6"	1418

Materials and Methods

For the assessment of surface water quality of the West Bokaro coalfields, systematic samplings were carried out during post- monsoon, 2012. Fourteen surface water samples were collected from rivers and ponds of the West Bokaro Coalfield area. The surface water samples were collected in one liter narrow mouth pre-washed polyethylene bottles. Temperature, electrical conductivity (EC) and pH values were measured in the field using a portable conductivity and pH meter. In the laboratory, the water samples were filtered through 0.45 µm Millipore membrane filters to separate suspended particles. Twelve parameters were analysed for WQI such as pH, Total Dissolved Solid (TDS), Total Hardness (TH), Turbidity, Bicarbonate (HCO^-_3), Total Alkalinity, Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Fluoride (F^-), Chloride (Cl^-), Nitrate (NO^-_3) and Sulphate (SO^{2-}_4). The details of sampling location along with their latitude and longitude are given in Table 1.

Water Quality Index

Water Quality Index method (WQI) provide the mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality. One of the major advantages of WQI is that, it incorporates data from multiple water quality parameters into a mathematical equation that rates the health of water quality with number[12]. Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human consumption. The standards for drinking water (IS: 10500) have been considered for calculation of WQI[13]. The weights for various water quality parameters are assumed to be inversely proportional to the recommended standards for the corresponding parameters[14,15,16,17.]

The formulation for weight calculation is given by the expression:

$$Wi = k/Si,$$

Where, Wi is the unit weight for the ith parameter; Si the recommended standard for i^{th} parameter and i = 1, 2, 3, ..., 16; and k the constant of proportionality.

The calculation involves the following steps:

(1) First, the calculation of the quality rating for each of the water quality parameters

(2) Second, a summation of these sub-indices in the overall index.

Individual quality rating is given by the expression:

$$Qi = 100Vi/Si,$$

Where, Qi is the sub index of i^{th} parameter, Vi is the measured value of the i^{th} parameter in water sample under consideration and Si the standard or permissible limit for the i^{th} parameter.

The WQI is then calculated as follows:

$$\mathbf{WQI} = \sum_{i=1}^{n} (Qi\, Wi) \Big/ \sum_{i=1}^{n} Wi$$

Where, Qi is the sub index of i parameter. Wi is the unit weightage for i^{th} parameter, n is the number of parameters considered.

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 [18] are given in Tables 2, Table 3 and Table 4, respectively. The WQI ranged from 36.2 to 125.2 which indicate Good to Very Poor status of water quality. The highest WQI were calculated from the sample collected from the Mandu (pond water), Hesagora (pond water), Hesagora (river water), Laiyo (pond water) etc. sampling location. This may be attributed to the proximity of the location to the mining activities. Among all the of the water samples, the percentage (%) of WQI categories Good (28.6%), Poor (42.9%) and Very Poor (28.6 %) were observed (Fig. 2). More than half of the locations fall in the Poor to Very Poor category.

Table 2. Chemical Parameters Corresponding the IS: 10500

Parameters	Standard	Wi/kSi
pH	7.5	0.093465
TDS	500	0.001402
Turbidity	5	0.140198
Alkalinity	200	0.003505
Hardness	300	0.002337
F^-	1	0.700989
Cl^-	250	0.002804
NO_3^-	45	0.015578
SO_4^{2-}	200	0.003505
HCO^-_3	200	0.003505
Ca^{2+}	75	0.009347
Mg^{2+}	30	0.02366

Units: Concentration in mg L-^{1}, except pH, Turbidity (NTU).

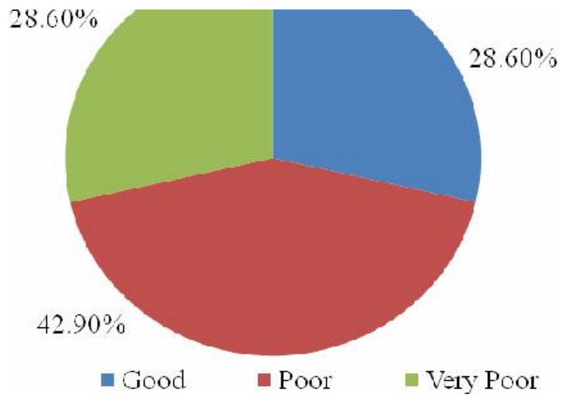
Table 3. Status categories of WQI

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

Table 4. Water Quality Index for Surface water of West Bokaro Coalfields

S.No.	Sample Code	Location	Type of water	WQI	Status
1	SW1	Datma, Pindra	Pond Water	42.99	Good
2	SW2	Hesagara	Chotha River	93.89	Very poor
3	SW3	Hesagara	Pond Water	103.11	Very poor
4	SW4	Pundi	Pond Water	72.10	Poor
5	SW5	Mandu	Pond Water	125.16	Very poor
6	SW6	Ara	Chotha River	51.43	Poor
7	SW7	Before Ghato Washery	Bokaro River	48.17	Good
8	SW8	Confluence of Bokaro & Chotha River	River	51.9	Poor
9	SW9	After Ghato Washery	Bokaro River	70.00	Poor
10	SW10	Gomia	Bokaro River	57.51	poor
11	SW11	Laiyo	Pond Water	85.64	Very poor
12	SW12	Before Kedla Washery	Chutua River	41.3	Good
13	SW13	After Kedla Washery	Chutua River	52.28	Poor
14	SW14	Jokkdhr	Dudhi River	46.86	Good

Figure 2: WQI Categories of Samples (%)



Conclusion

On the basis of the above discussions, it may be concluded that the more than half of the surface water has polluted as indicated by WQI. The water quality analysis shows that 28.6% of water samples were found as Good category and can be use for direct consumption while 42.9% of water samples are the Poor category and 28.6 % in Very Poor category. Water Quality Index of 71.5% samples shows that the water is not suitable for direct consumption. After treatment of that water samples can be used for drinking purposes in the study area.

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