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QUALITATIVE ASSESSMENT OF SURFACE WATER OF DHANBAD COALFIELD REGION IN THE STATE OF JHARKHAND, INDIA BY USING WATER QUALITY INDEX METHOD

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ABSTRACT

Water Quality Index (WQI), a technique of rating water quality, is an effective tool to assess spatial and temporal changes in water quality that offers a simple, stable, reproducible unit of measure and communicate information of water quality to the policy makers and concerned citizens. Twenty one surface water samples were collected from rivers, ponds and reservoirs of the Dhanbad Coalfield area. The quality of water were evaluated by testing various physico-chemical parameters such as pH, Total Dissolved Solid, Total Hardness, Turbidity, Total Alkalinity, Fluoride, Chloride, Iron, Nitrate, Sulphate, Dissolve Oxygen, BOD and other parameter Fecal Coliforms . The WQI value 60.96 is Maximum and the value 53.43 is Minimum in the study area. The computed WQI shows 100% of water samples fall in the poor category. Water Quality Index of 100% 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 (WQI), Physico-chemical parameters, Surface water, Dhanbad Coalfield Region, Jharkhand.

INTRODUCTION

Water is one of the most important of all natural resources. 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 estimate 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[1].

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[2]. 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 [2,3,4,5,6,7,8].

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[9]. WQI is a mathematical equation used to transform large number of water quality data into a single number[10] .It is simple and easy to understandable for decision makers about quality and possible uses of any water body[11].

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[12]

The main objective of the study is to assess the physical and chemical properties of surface water & water quality index of the study area.

STUDY AREA Dhanbad district lies in the mid eastern part of Jharkhand state. The Dhanbad Coalfield region consists of Block II and Barora II Area, Katras Area, Kusunda and Kustore area, Govindpur area, Bastacolla area, & Chanch Victoria area. Twenty one nos. of surface water samples were collected from rivers, ponds and reservoirs falling in these areas during October, 2015 to December'2015 (Post monsoon season) (**Table 1, Figure 1**). Surface Water samples were collected in polyethylene containers. The samples were analyzed as per the procedures specified in 'Standard Methods for the Examination of Water and Waste Water' published by American Public Health Association (APHA) 22nd Edition, 2012.

EXPERIMENTAL ANALYSIS

Materials and Methods For the assessment of surface water quality of the Dhanbad coalfield, systematic samplings were carried out during October, 2015 to December'2015 (Post monsoon season). Twenty one surface water samples were collected from rivers and ponds of the Dhanbad 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. The given parameters were analysed for WQI such as pH, Total Dissolved Solid (TDS), Total Hardness (TH), Turbidity, Total Alkalinity, Fluoride (F^-), Chloride (Cl^-), Nitrate (NO^-_3) and Sulphate (SO^{2-}_4).
The details of sampling location are given in Table 1.

Physico- Chemical Parameters It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physico-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we going to use that water and what extent we need its quality and purity. Water does content different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Some physical test should be performed for testing of its physical appearance such as temperature, color, odour, pH, turbidity, TDS etc, while chemical tests should be perform for its alkalinity, hardness and other characters. Following different physico-chemical parameters are tested regularly for monitoring quality of water. These parameters were determined by using standard procedures, APHA[20].***Gross appearance, odour and taste*:** The water samples were observed with naked eyes for gross appearance and examined for offensive odour through the subjective organoleptic assessment.

pH: pH is termed as negative logarithm of the H_2 ion concentration. The pH is determined by Eli co, digital pH meter which gives direct values of pH.

***Conductivity*:** The conductivity is determined by using digital conductivity meter.

***Temperature*:** A mercury filled centigrade thermometer calibrated from 0^0 to 100^0C is used for temperature measurements.

***Turbidity*:** It can be determined by using turbidity meter (Delux turbity meter, ESICO International, Model no. 335, Sr. No. 1401551, India).
Total Hardness: Fifty milliliters of water sample is titrated against 0.01M EDTA (Disodium salt) solution by using Solo chrome Black T as an indicator.

***Total Alkalinity*:** The alkalinity of water sample is determined by titrating it against standard acid solution using indicators like phenolphthalein and methyl orange.

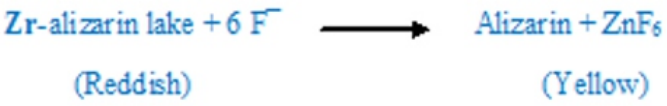
***Chloride*:** The chloride content in the water sample is determined by titrating the water sample against 0.02M silver nitrate solution using potassium chromate as an indicator.

***Sulphate*:** Sulphate content in the water sample is determined by turbid metric method.

***Nitrate*:** UV light having 220 nm wave length is passed through the sample. The

absorbance obtained is directly proportional to the concentration of NO_3^- ions.

***Fluoride*:** Determination of Fluoride By Scott- Sanchis Method. Fluoride decolourizes the zirconium alizarin complex & the de-colourization is proportional to fluoride concentration.



***Total dissolved solids*:** Fifty milliliters of water sample is filtered through ordinary filter paper and water is collected in the evaporating dish of known weight. Further it is heated and water is totally evaporated. Whatever dissolved solid matter is present gets accumulated at the bottom of evaporating dish. The evaporating dish is cooled and weighed. By weight difference method the total dissolved solids is determined.

WATER QUALITY INDEX (WQI):

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, W_i is the unit weight for the i^{th} parameter; **Si** the recommended standard for ith 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 ith parameter, **Vi** is the measured value of the ith parameter in water sample under consideration and Si the standard or permissible limit for the ith parameter.

The **WQI** is then calculated as follows:

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

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 concentration of Dissolve Oxygen, BOD and Turbidity in all water samples exceeds the limit of IS-2296 **(Table 3).** The remaining other physico-chemical parameters like gross appearance, pH, Na, K, Cl^-, SO_4^{--} NO_3^-, F^-, TDS were within acceptable limit as per IS-10500 **(Table 2, Fig. 2).** The Indian Standards as per ISI for the drinking water together with its corresponding status categories of WQI [18] are given in **Tables 4, Table 5** and **Table 6** respectively. The WQI ranged from 50-70 which indicate Poor status of water quality. The highest WQI were calculated from the sample collected from Kusunda and Kustore area (Damodar River), Chanch Victoria area (Barakar River), Chanch Victoria area (Damodar River) etc. sampling location. This may be attributed to the proximity of the location to the mining activities. Among all the of the water samples, All locations fall in the Poor category.

On the basis of the above discussions, it may be concluded that all of the surface water has polluted as indicated by WQI. The water quality analysis shows all of water samples are the Poor. Water Quality Index of 100% 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.

Table 1: Details of sampling locations of around Dhanbad Coalfield Region

S.No.	Sample Code	Location	Type of Water
1	SW1	Block II and Barora II Area	Jamunia River
2	SW2	Block II and Barora II Area	Khudia Nala
3	SW3	Block II and Barora II Area	Damodar River
4	SW4	Govindpur area	Khudia Nala
5	SW5	Near Harna Village of Govindpur area	Pond Water
6	SW6	Govindpur area	BagdigiJore
7	SW7	Katras area(after confluence with kumara jore)	Katri Nadi
8	SW8	Ramkanali of Katras area	Pond Water
9	SW9	Katras area (Before confluence with Katri nadi)	Kumari jore Nala
10	SW10	Kusunda and Kustore area	Kari jore River
11	SW11	Alkusa villageof Kusunda and Kustore area	Pond Water
12	SW12	Kusunda and Kustore area	Damodar River
13	SW13	Bastacolla area	Kashi jore
14	SW14	Chandkuya Village of Bastacolla area	Pond Water
15	SW15	Bastacolla area	Damodar river
16	SW16	Chanch Victoria area	Khudia River
17	SW17	Chanch Victoria area	Barakar River
18	SW18	Chanch Victoria area	Panchet Reservior
19	SW19	Chanch Victoria area	Barakar River
20	SW20	Chanch Victoria area	Damodar River
21	SW21	Chanch Victoria area	Maithon Reservior

Table 2: Comparative variation in physico- chemical properties estimation of surface water samples collected from rivers, ponds and reservoirs of the Coalfield area of Dhanbad District, Jharkhand, India
(Results are expressed in mg/l except pH)

Sl. No.	Sample Code	Type of Water	Parameter								
			pH	TDS	TH	TA	Cl-	SO4- -	F-	Fe	NO_3-
1.	SW1	Jamunia River	7.1	407	280	166	66	84	<0.4	0.2	2.24
2.	SW2	Khudia Nala	7.4	468	342	176	84	104	<0.4	0.3	3.52
3.	SW3	Damodar River	7.3	346	270	148	56	66	<0.4	0.16	4.3
4.	SW4	Khudia Nala	7.5	297	214	64	38	104	<0.4	0.09	2.6
5.	SW5	Pond Water	7.8	470	394	142	90	120	<0.4	0.06	4.6
6.	SW6	BagdigiJore	7.3	510	390	164	72	146	<0.4	0.16	4.8
7.	SW7	Katri Nadi	8.2	610	452	152	76	226	<0.4	0.16	3.8
8.	SW8	Pond Water	7.8	570	432	142	82	196	<0.4	0.08	4.3
9.	SW9	Kumari jore Nala	7.4	512	388	134	74	166	<0.4	0.1	3.32
10.	SW10	Kari jore River	7.6	446	366	160	144	32	<0.4	0.06	2.6
11.	SW11	Pond Water	7.8	450	336	280	38	80	<0.4	0.08	4.2
12.	SW12	Damodar River	7.2	386	314	212	34	78	<0.4	0.08	2.5
13.	SW13	Kashi jore	7.7	536	386	270	64	96	<0.4	0.08	2.4
14.	SW14	Pond Water	8.1	594	260	226	86	66	<0.4	0.05	3.6
15.	SW15	Damodar river	7.2	372	298	206	36	40	<0.4	0.06	3.2
16.	SW16	Khudia River	7.4	414	314	284	44	38	<0.4	0.06	2.66
17.	SW17	Barakar River	7.3	134	68	84	16	6	<0.4	0.06	1.64
18.	SW18	Panchet Reservior	7.2	150	120	84	24	10	<0.4	0.04	1.8
19.	SW19	Barakar River	7.7	145	104	94	16	10	<0.4	0.04	2.7
20.	SW20	Damodar River	7.2	132	74	88	12	6	<0.4	0.06	1.6
21.	SW21	Maithon Reservior	7.5	166	102	112	12	10	<0.4	0.04	3.8
IS:10500 Acceptable/ Permissible Limits			6.5-8.5	500/ 2000	200/ 600	200/ 600	250/ 1000	200/ 400	1.0/1.5	0.3	45

Abbreviations:
1. TDS- Total Dissolved Solid. 2. TH- Total Hardness 3. TA- Total Alkalinity. 4. Cl- --Chloride. 5. SO4- -- Sulphate. 6. F- Fluoride. 7. NO3-- -Nitrate

Table 3: Comparative variation in physico- chemical properties estimation of surface water samples collected from rivers, ponds and reservoirs of the Coalfield area of Dhanbad District, Jharkhand, India

Sl. No.	Sample Code	Type of Water	Parameter							
			DO (in mg/l)	DO in % Sat.	BOD(in mg/l)	Turbidity (NTU)	Nitrate (in mg/l)	Nitrogen in Nitrate (in mg/l)	Fecal Coliforms*	Total Phosphorus (in mg/l)
1.	SW1	Jamunia River	6.6	45.14	2.8	16	2.24	0.51	2.0 x 10^3	0.022
2.	SW2	Khudia Nala	5.8	39.67	3.2	22	3.52	0.79	2.2 x 10^3	0.019
3.	SW3	Damodar River	6.8	46.51	3.2	16	4.3	0.97	2.2 x 10^3	0.018
4.	SW4	Khudia Nala	6.4	43.78	2.4	10	2.6	0.59	2.0 x 10^3	0.017
5.	SW5	Pond Water	5.8	39.67	2.2	14	4.6	1.04	2.3 x 10^3	0.023
6.	SW6	BagdigiJore	5.8	39.67	1.8	8	4.8	1.08	2.0 x 10^3	0.025
7.	SW7	Katri Nadi	5.4	36.94	5.4	16	3.8	0.86	2.2 x 10^3	0.018
8.	SW8	Pond Water	6	41.04	3.2	10	4.3	0.97	2.1 x 10^3	0.019
9.	SW9	Kumari jore Nala	6.8	46.51	2.8	18	3.32	0.75	2.4 x 10^3	0.02
10.	SW10	Kari jore River	7	47.88	3.8	12	2.6	0.59	2.1 x 10^3	0.017
11.	SW11	Pond Water	6.8	46.51	2.7	16	4.2	0.95	2.2 x 10^3	0.019
12.	SW12	Damodar River	7.2	49.25	3	6	2.5	0.56	2.2 x 10^3	0.017
13.	SW13	Kashi jore	5.8	39.67	2.8	12	2.4	0.54	2.0 x 10^3	0.018
14.	SW14	Pond Water	6.6	45.14	2.4	16	3.6	0.81	2.3 x 10^3	0.019
15.	SW15	Damodar river	6.8	46.51	2.4	16	3.2	0.72	2.0 x 10^3	0.02
16.	SW16	Khudia River	6.4	43.78	2.4	7	2.66	0.60	2.2 x 10^3	0.017
17.	SW17	Barakar River	6.6	45.14	2.8	6	1.64	0.37	2.0 x 10^3	0.02
18.	SW18	Panchet Reservior	6.8	46.51	2	8	1.8	0.41	1.9 x 10^3	0.019
19.	SW19	Barakar River	6.6	45.14	2.6	8	2.7	0.61	1.8 x 10^3	0.017
20.	SW20	Damodar River	6.4	43.78	2.6	8	1.6	0.36	2.0 x 10^3	0.017
21.	SW21	Maithon Reservior	7	47.88	3	8	3.8	0.86	2.2 x 10^3	0.02
Acceptable Limits			4 (As per IS:2296-1982)	-	3 (As per IS:2296-1982)	5 (As per IS:10500-2012)	50(As per IS:2296-1982)	-	5000(As per IS:2296-1982)	-

Abbreviations:
1. DO-Dissolve Oxygen. 2. BOD- Biochemical oxygen Demand 3. * - only use microorganism, not fecal coliforms and *E. coli*

Table 4. Chemical Parameters Corresponding the IS: 10500

Parameters	Standard
pH	7.5
TDS	500
Turbidity	5
Alkalinity	200
Hardness	200
F-	1
Cl-	250
NO_3-	45
SO_4^{2}-	200

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

Table 5. Status categories of WQI

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

Table 6. Water Quality Index for Surface water of Dhanbad Coalfield Region

S. No.	Sample Code	Location	Type of water	WQI	Status
1.	SW1	Block II and Barora II Area	Jamunia River	59.08	Poor
2.	SW2	Block II and Barora II Area	Khudia Nala	56.41	Poor
3.	SW3	Block II and Barora II Area	Damodar River	57.84	Poor
4.	SW4	Govindpur area	Khudia Nala	59.85	Poor
5.	SW5	Near Harna Village of Govindpur area	Pond Water	56.97	Poor
6.	SW6	Govindpur area	BagdigiJore	58.49	Poor
7.	SW7	Katras area(after confluence with kumara jore)	Katri Nadi	53.61	Poor
8.	SW8	Ramkanali of Katras area	Pond Water	57.23	Poor
9.	SW9	Katras area (Before confluence with Katri nadi)	Kumari jore Nala	58.48	Poor
10.	SW10	Kusunda and Kustore area	Kari jore River	59.14	Poor
11.	SW11	Alkusa villageof Kusunda and Kustore area	Pond Water	57.98	Poor
12.	SW12	Kusunda and Kustore area	Damodar River	60.91	Poor
13.	SW13	Bastacolla area	Kashi jore	58.42	Poor
14.	SW14	Chandkuya Village of Bastacolla area	Pond Water	57.67	Poor
15.	SW15	Bastacolla area	Damodar river	59.29	Poor
16.	SW16	Chanch Victoria area	Khudia River	60.18	Poor
17.	SW17	Chanch Victoria area	Barakar River	60.96	Poor
18.	SW18	Chanch Victoria area	Panchet Reservior	53.43	Poor
19.	SW19	Chanch Victoria area	Barakar River	60.18	Poor
20.	SW20	Chanch Victoria area	Damodar River	60.51	Poor
21.	SW21	Chanch Victoria area	Maithon Reservior	59.50	Poor

S.No	No of Samples	Type of Water	Location
1.	03	River and Nala	Block II and Barora II Area
2.	03	River, pond and Nala	Katras Area
3.	03	River and pond	Kusunda and Kustore area
4.	02	Nala	Govindpur area
5.	03	River and pond	Bastacolla area
6.	06	River and Reservoir	Chanch Victoria area

Fig.1 : . Sampling location map of the West Bokaro Coalfield India

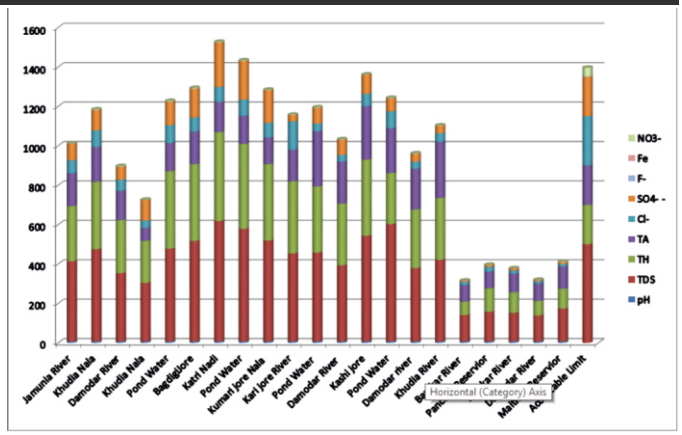


Fig.2 : Comparative variation in physico- chemical properties estimation of surface water samples collected from rivers, ponds and reservoirs of the Coalfield area of Dhanbad District, Jharkhand, India

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