Physico-Chemical Studies on Surface Water Quality in the Jharia Coal Field Region, Dhanbad

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ABSTRACT

A segment of this investigation was carried out to study the surface water quality and its physic-chemical characteristics of Jharia coalfield region Dhanbad. The geographical area at study is situated between latitude 23º39′ N and 23º48′ N and longitudes 86º11′ E and 86º27′ E. The present work has been conducted by monitoring of surface water of Jharia Coal field. Attempts were made to study and analyze the physic-chemical characteristics of water, i.e. , temperature, pH, total dissolved solids, alkalinity, hardness, and chloride. The pH of the analysed water samples varied from 6.71 to 8.05, indicating slightly alkaline in nature. The Electrical Conductivity (EC) value varied from 175 µs cm^{-1} to 1280 µs cm^{-1} while the total dissolved solids (TDS) varied from 124.25 mg/l to 890 mg/l. The large variation in the EC, TDS and ionic concentration in the groundwater of the area may be attributed to variation in geo-chemical process and anthropogenic activities. . In majority of the samples, the analyzed parameters are well within the desirable limits and water is potable for drinking purposes. However, concentrations of TDS, TH, Ca^{2+}, and Mg^{2+} exceed the desirable limit at few sites.

Keywords: Surface water quality; major ion chemistry; Jharia Coalfield.

1. INTRODUCTION

Natural resources are the important wealth of our country, water is one of them. Water is a wander of the nature. " *No life without water* '' is a common saying depending upon the fact that water is the one of the naturally occurring essentional requirement of all life supporting activities [1]**.**The availability of water through surface and groundwater resources has become critical day to day. Only 1% part is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal [2].In India, most of the population is dependent on surface water (damp water) as the only source of drinking water supply. The groundwater is believed to be comparatively much clean and free from pollution than surface water [3]. Surface water typically transports three types of sediment namely: Dissolved load, suspended load and bed load. Chemical weathering in rocks produces ions in solution (e.g. Ca^{2+}, Mg^{2+} and HCO_3^-), hence a

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dissolved load. Suspended sediments make surface water look cloudy or opaque; the greater the suspended load, the muddier the water. Bed load (silt, sand and gravel) settle on the bottom of the channel [4]. The rapid growth of urban areas has further affected groundwater quality due to overexploitation of resources and improper waste disposal practices. Hence, there is always a need for and concern over the protection and management of surface water [5]**.** Surface water has played an important role in the development of human civilization. Good water quality resources depends on a large number of physicochemical parameters and the importance and source of any pollution load; and to assess that, monitoring of these parameters is essential [6]. Water is essential for life; however, its quality and availability vary in time and space. The stress on water resources is from multiple sources and the impact can take diverse forms [7]. The surface water quality within a region is governed by natural processes such as precipitation rate, weathering process, and soil erosion and anthropogenic effects such as urban, industrial and agricultural activities, and exploitation of water resources [8].

2. STUDY AREA

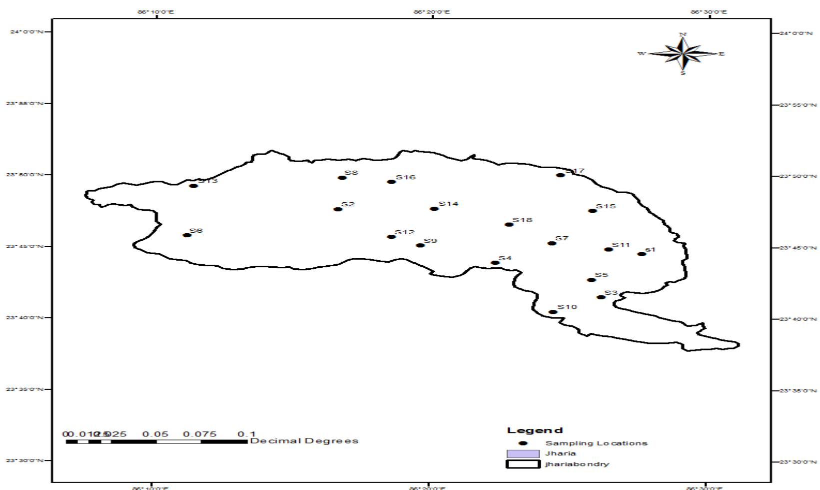

Fig 1. Location map of Jharia Coalfield showing the sampling site

Jharia Coal mining areas is one of the most important Coal mining areas in India. It is roughly elliptical or sickles shaped, located in Dhanbad district of Jharkhand lies between latitude $23^o39^/$ N and $23^o48^/$ N and longitudes $86^o11^/$ E and $86^o27^/$ E . It is bounded in the North by Eastern Railway and in the south by Damodar River. The main component of the natural drainage in JCF is the Damodar river, a fourth order stream that flows approximately west to east and captures all the surface drainage from the JCF, the drainage pattern of the drainage system in the area is dendritic.

There are eight major streams, a few perennials and the rest intermittent, which drains the JCF from north to south to join the Damodar River. They are Tisra, Chatkari, Katri, Khudia, Jamuniya, Kumari and Bansjora etc. Mining in this Coal mining area was initially in the hands of private entrepreneurs, who had limited resources and lack of desire for scientific mining. The mining method comprised of both opencast as well as underground. The opencast mining areas were not backfilled, so large void is present in the form of abandoned mining.

3. MATERIALS AND METHODS

For the assessment of surface water quality of the Jharia coalfields, systematic samplings were carried out during Post- monsoon, 2013. Eighteen surface water samples were collected from rivers and ponds of the Jharia Coalfield area (Fig 1). The surface water samples were collected in one litre narrow mouth pre-washed polyethylene bottles. 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. Acid titration and molybdosilicate methods were used to determine the concentration of bicarbonate in surface water (APHA 1998). Concentration of major anions (F^-, Cl^-, NO_3^- and SO_4^{2-}) was determined by ion chromatograph (Dionex DX-120). Concentration of major cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were determined by flame atomic absorption spectrophotometer (VARIAN-AA280 FS)

4. RESULTS AND DISCUSSION

4.1 pH, EC and TDS

pH is a measurement of the intensity of acidity or alkalinity and the concentration of H^+ ions in water. pH of the analyzed water samples varied from 6.71 to 8.05 and the average pH was found to be 7.29 indicating slightly alkaline nature of the surface water samples (fig.4). Electrical conductivity (EC) tells about the conducting capacity of water which in turn is determined by the presence of dissolved ions. Higher the ionisable solids, greater will be the EC. EC is a measure of total dissolved solids (TDS) i.e., it depends upon the ionic strength of the solution. Increase in the concentration of dissolved solids, increases the ionic strength of the solution.

The measured EC of the surface water in the study area varies from 175 to 1280μS cm^{-1} with an average value of 570.38 μS cm^{-1} (Fig.5). Concentration of total dissolved solids (TDS) in the surface water of the study area ranged from 124.2 to 890 mg l^{-1} with an average value of 403 mg l^{-1} (Fig. 6).Water can be classified in to fresh (TDS <1,000 mg L^{-1}), brackish (>1,000 mg L^{-1}), saline (>10,000 mg L^{-1}) and brine (1,00,000 mg L^{-1}) categories on the basis of TDS concentration (Freeze and Cherry 1979). Based on this classification, 100% of the surface water of the study area belongs to fresh water.

4.2 Major ion Chemistry

Among major cations, calcium was the dominant ions representing on average 39% of total cations. Sodium and magnesium ions were of secondary importance, representing on average 31% and 25% of total cations, respectively. Potassium was least dominant cation and representing 5% of the total cations (Fig.2). The order of cation abundance was Ca^{2+}> Na^{+}>Mg^{2+}>K^{+}. Among the major anions, bicarbonate was generally dominant and representing on average 83% of the total anions. Sulphate is the second dominant anion, representing on an average 13% of the total anions. Chlorides were less dominant ions and contributing 4% to the total anions respectively (Figure 3). Nitrate is the least dominant anion of the total anions. The order of anions abundance in the surface was found as HCO_3^-> SO_4^{2-}> Cl^->NO_3^-

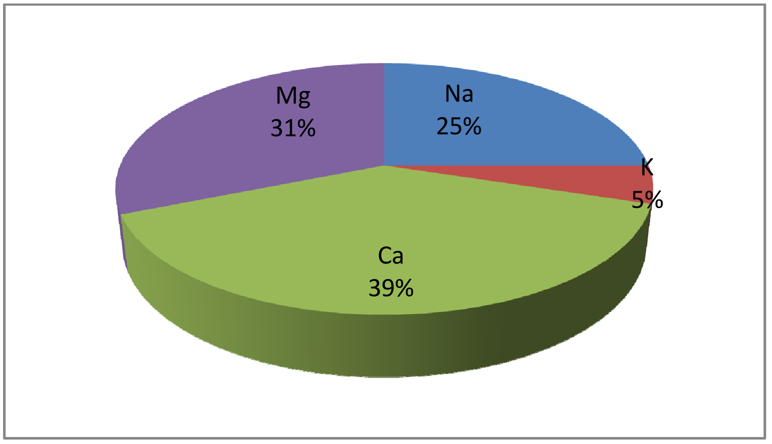

Fig: 2 Percentage contributions of cations to the total cationic balance (TZ^+)

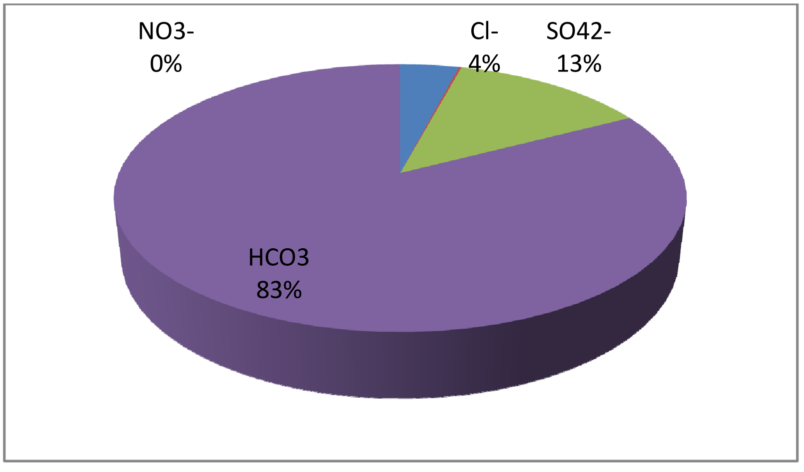

Fig: 3 Percentage contributions of anions to the total anionic balance (TZ^-)

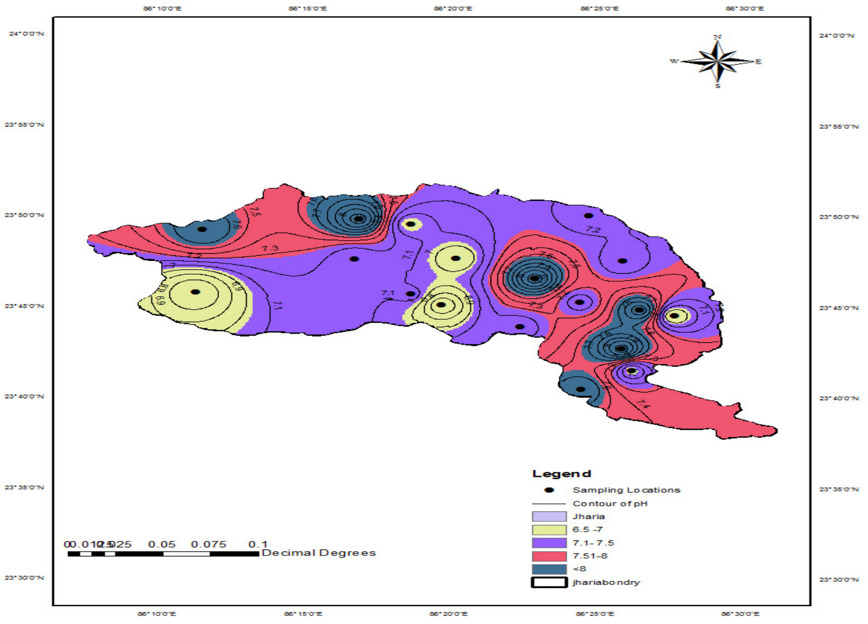

Fig: 4 Distribution of pH in Jharia Coalfield area

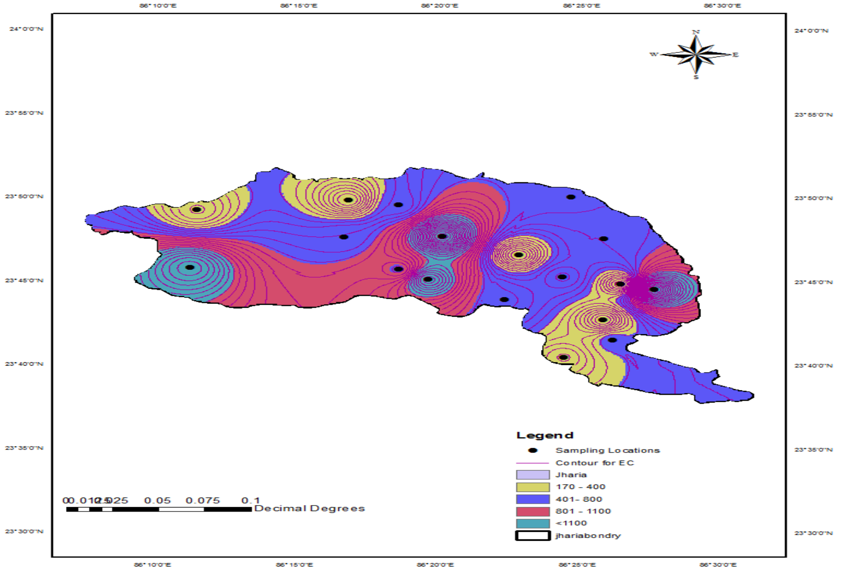

Fig: 5 Distribution of EC in Jharia Coalfield area

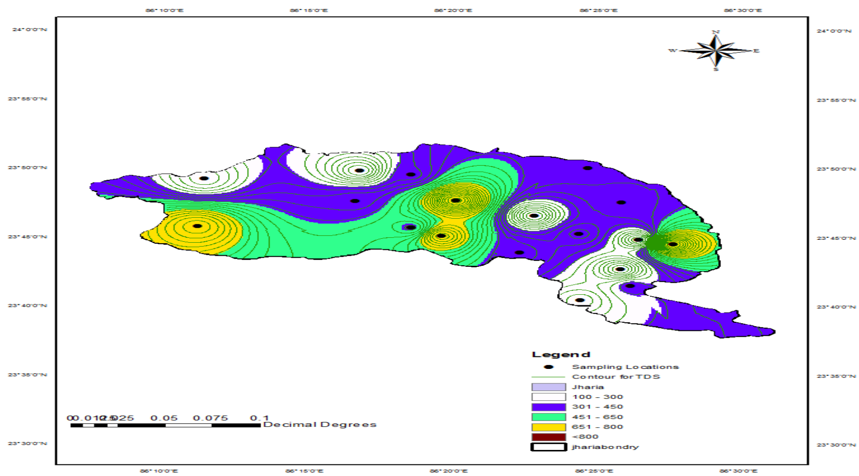

Fig: 6 Distribution of TDS in Jharia Coalfield area

5. SUITABILITY OF SURFACE WATER FOR DRINKING AND DOMESTIC USES

The physical and chemical parameters of the analytical results of surface water were compared with the standard guideline values recommended by the World Health Organisation (WHO, 1997) and Bureau of Indian Standards (BIS, 2003) for drinking and public health standards (Table 1). The pH of the surface water samples (6.71–8.05) are within the safe limit of 6.5–8.5, prescribed for drinking water. The turbidity is one of the important physical parameters for water quality defining the presence of suspended solids in water and causes the muddy or turbid appearance of water body. The consumption of high turbid water may cause a health risk as excessive turbidity can protect pathogenic microorganisms from effects of disinfectants and stimulate the growth of bacteria during storage (Singh et al. 2012). In the study area, the turbidity ranges from 0.3 to 7.6 NTU and exceeds the recommended value of 5 NTU in 36 % of surface water samples. The values of total dissolved solids (TDS) exceed the desirable limit of 500 mg L^{-1} in two samples of surface water. The total hardness (TH) is an important parameter of water quality whether it is to be used for domestic, industrial or agricultural purposes. Hardness is the properties of water by which it prevents the lather formation with soap and increasing the boiling point of water. Hardness of the water is the property attributed to the presence of alkaline earths. Water can be classified into soft (75 mg L^{-1}), moderately hard (75–150 mg L^{-1}), hard (150–300 mg L^{-1}) and very hard (>300 mg L^{-1}) based on hardness (Sawyer and McCarty1967). The total hardness of the analysed surface water of the study area varies between 120 and 644 mg L^{-1} (avg. 138 mg L^{-1}) indicating soft to very hard types of surface water. The analytical data indicate that 36% surface water samples soft, 14% moderate hard and 50 % hard samples (Fig.5). The high hardness may cause encrustation on water supply distribution systems. There is some suggestive evidence that long term consumption of extremely hard water might lead to an increased incidence of urolithiasis, anecephaly, parental mortality, some types of cancer and cardio-vascular disorders (Agrawal and Jagetia 1997; Durvey et al. 1991). Beyond 3.0 mg L^{-1} if water consumed for a prolong period i.e. 6 months to several years (Nawlakhe and Bulusu 1989). Concentration of F^- and NO^-_3 are within recommended limit of 1.5 mg L^{-1} in surface water samples. Concentrations of Cl^- and SO_4^{2-} are well within the desirable limit mg L^{-1}. Sodium and potassium are the most important elements occurring naturally. The major source of both the cations may be weathering of rocks (Singh et al., 1999) besides the sewage and industrial effluents. A higher sodium intake may cause hypertension, congenial heart diseases and kidney problems (Singh et al. 2008) and the excess amount of potassium present in the water sample may lead nervous and digestive disorder (Tiwari 2001). The recommended permissible limit for sodium and potassium concentration in drinking water is 200 mg L^{-1} (WHO 1997). Concentrations of Na^+ and K^+ are within the recommended limit of 200 mg L^{-1} in surface water samples. Calcium and magnesium are the essential nutrient for the plant growth, animals and play an important role in the development of bone, nervous system and cell. One possible adverse effect from ingesting high concentration of Ca^{2+} for long periods may be an increased risk of kidney stones (Maragella et al. 1996).

Table 1: Summary statistics of the analytical data and compare with WHO and Indian Standard (IS: 10500) for domestic purposes

				WHO (1997)	BIS 2003 (IS 10500)	WHO (1997)	BIS 2003 (IS 10500)
Water quality parameters	**Units**	**Range**	**Average**	**Highest allowable limits**	**Max. desirable**	**Highest allowable limits**	**Max. desirable**
pH	-	6.7 - 8.05	7.29	6.5-9.2	7.0-8.5	8.5-9.2	6.5-8.5
EC	µS cm-^{1}	175 - 1280	570.38	1,500	750	-	-
HCO_3^-	mg L^{-1}	111.1 - 387	199.37	600	200	600	200
Cl-	mg L^{-1}	0.598 - 34	9.59	600	250	1,000	250
NO_3^-	mg L^{-1}	0.1 – 2.2	0.4	50	-	100	45
SO_4^{2-}	mg L^{-1}	18.9 – 49.2	31.8	600	200	400	200
Na^+	mg L^{-1}	14.1 – 110.2	31.4	200	50	-	-
Ca^{2+}	mg L^{-1}	25.2 – 75.7	49	200	75	200	75
Mg^{2+}	mg L^{-1}	3.1 – 131.0	39.1	150	30	100	30
K^+	mg L^{-1}	2.0 – 40.2	6.1	200	100	-	-
TDS	mg L^{-1}	124.25-890	403.62	1,500	500	2,000	500
TH	mg L^{-1}	120-644	285.33	500	100	600	300

6. CONCLUSION

The surface water of Jharia coalfield is slightly alkaline in nature. The chemistry of surface water is dominated by Ca^{2+} and Na^{+} and HCO_3^- and $SO^{2-}{}_4$. In majority of the samples, the analyzed parameters are well within the desirable limits and water is potable for drinking purposes. However, concentrations of TDS, TH, $Ca^{2+,}$ and Mg^{2+} exceed the desirable limit at few sites. The surface water of this area is very much affected by various natural source such as rock weathering and anthropogenic sources, like Mining activity, agricultural wastes and domestic sewage disposals.

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