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Research Article

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Hydro chemical investigation and qualitative assessment of surface water resources in Jharia Coal field region, Dhanbad

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ABSTRACT

Eighteen samples from surface water resources (rivers & ponds) were collected from different sampling sites of the Jharia Coalfield during Post- Monsoon season, 2013. The analytical data were evaluated in terms of the chemical characteristics its suitability for drinking purposes. For assessing the suitability of drinking water, the water quality data of the analyzed samples were compared with the prescribed drinking water standard of WHO and BIS (IS:10500).The pH of the analysed water samples varied from 7.3 to 8.3, indicating slightly alkaline in nature. The Electrical Conductivity (EC) value varied from 175 $\mu s\ cm^{-1}$ to 1280 $\mu s\ cm^{-1}$ while the total dissolved solids (TDS) varied from 136 mg/l to 1045 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. Among the major anions, bicarbonate was generally dominant and representing on average 49% of the total anions. Sulphate is the second dominant anion, representing an an average 43% of the total anions. Chloride and Nitrate were less dominant ions and contributing 8% and 1% to the total anions respectively. Fluoride is the least dominant. Among major cations, calcium was the dominant ions representing on average 52% of total cations. Sodium and magnesium ions were of secondary importance, representing on average 26% and 18% of total cations, respectively. Potassium was least dominant cation and representing 4% of the total cations. 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.

Key words: Surface water quality; major ion chemistry; Jharia Coalfield

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INTRODUCTION

The availability of fresh water is potentially one of the most pervasive crisis of the coming century. Water related decisions will determine the future of major ecosystems, the health of regional economies, and the political stability of the nations. The quality of water necessary for each human use varies, as do the criteria used to assess water quality. Water quality is much depending on the desired use of water. Therefore, different uses require different criteria of water quality as well as standard method for reporting and comparing result of water analysis [2]. 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 [13]. Today, water quality issues have become a significant concern due to the growth of population, urban expansion and technological development. Water can be easily contaminated in different ways through unregulated or regulated but not well designed and monitored disposal practices [3]. These factors influence the quality of water resources, especially for surface waters, causing water contamination [4][5][9]. World Health Organization (WHO) reported that in developing countries over three million people (90 % are children under 5) die every year because of waterborne diseases [6]. Access to safe drinking water remains an urgent necessity, as 30 % of urban and 90 % of the rural Indian population still depends completely on untreated surface or groundwater resources [7]. While access to drinking water in India has increased over the past decades, the tremendous adverse impact of unsafe water for health continues. It is estimated that about 21 % of the communicable diseases in India are water borne [2]. Thus, proper assessment and reporting of surface water quality is an important issue. In the present work attempts have been made to detect surface water quality by using conventional hydro chemical methods, water quality .

Study area

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.

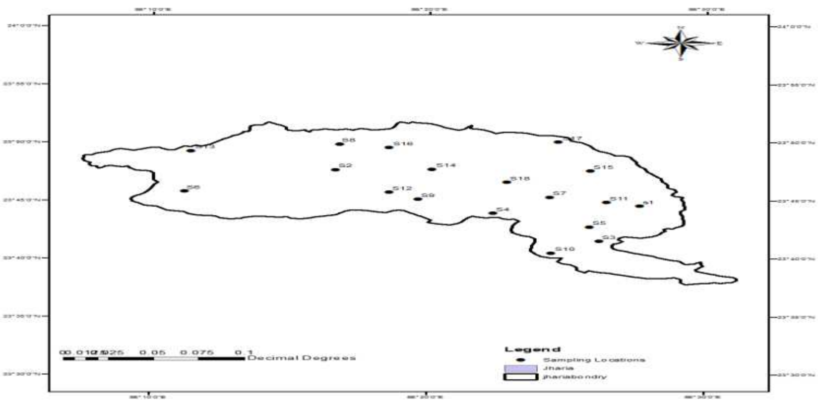

Fig1. Location map of Jharia Coalfield showing the sampling site

EXPERIMENTAL SECTION

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 0.45μm Millipore membrane filters to separate suspended particles.

RESULTS AND DISCUSSION

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 7.3 to 8.3 and the average pH was found to be 7.0 indicating slightly alkaline nature of the surface water samples. 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 depend 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 527.05 µS cm-^{1} (Fig.5). Concentration of total dissolved solids (TDS) in the surface water of the study area ranged from 136 to 1045 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.

Major ion Chemistry:

Among major cations, calcium was the dominant ions representing on average 52% of total cations. Sodium and magnesium ions were of secondary importance, representing on average 26% and 18% of total cations, respectively. Potassium was least dominant cation and representing 4% of the total cations (Figure .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 49% of the total anions. Sulphate is the second dominant anion, representing on an average 43% of the total anions. Chloride was less dominant ions and contributing 8% to the total anions respectively

(Figure 4). Nitrate is the least dominant anion of the total anions. The order of anions abundance in the surface was found as $HCO_3^{-}> SO_4^{2-}> Cl^{-}>NO_3^{-}>F^{-}$

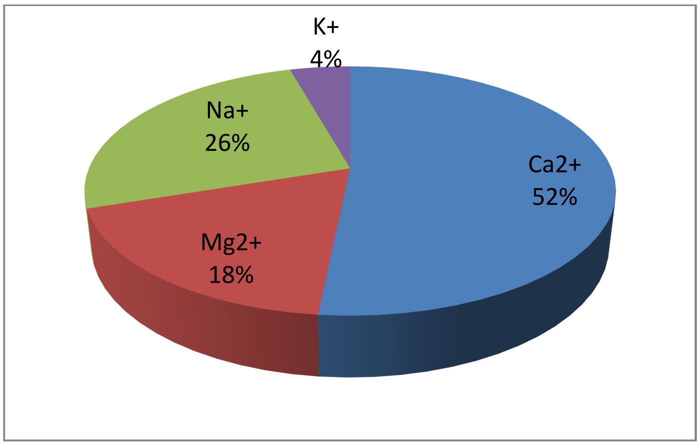

Fig : 2 Percentage contribution of cations to the total cationic balance (TZ^{+})

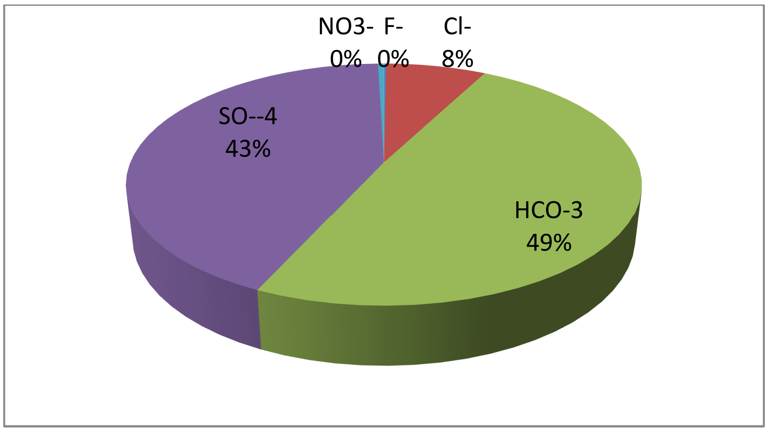

Fig : 3 Percentage contribution of anions to the total anionic balance (TZ^{-})

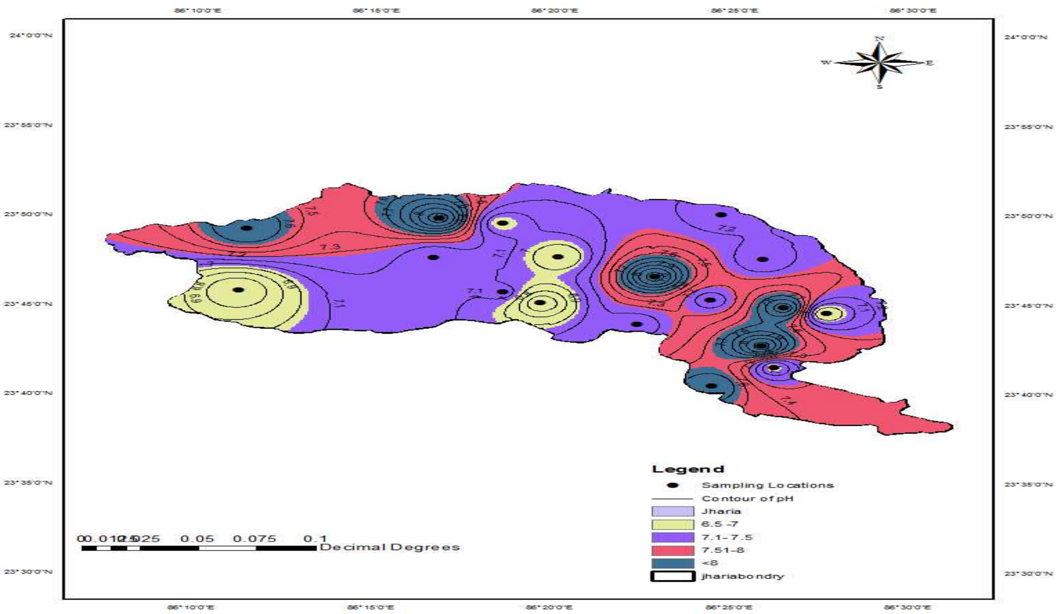

Fig : 4 Distribution of pH in Jharia Coalfield area

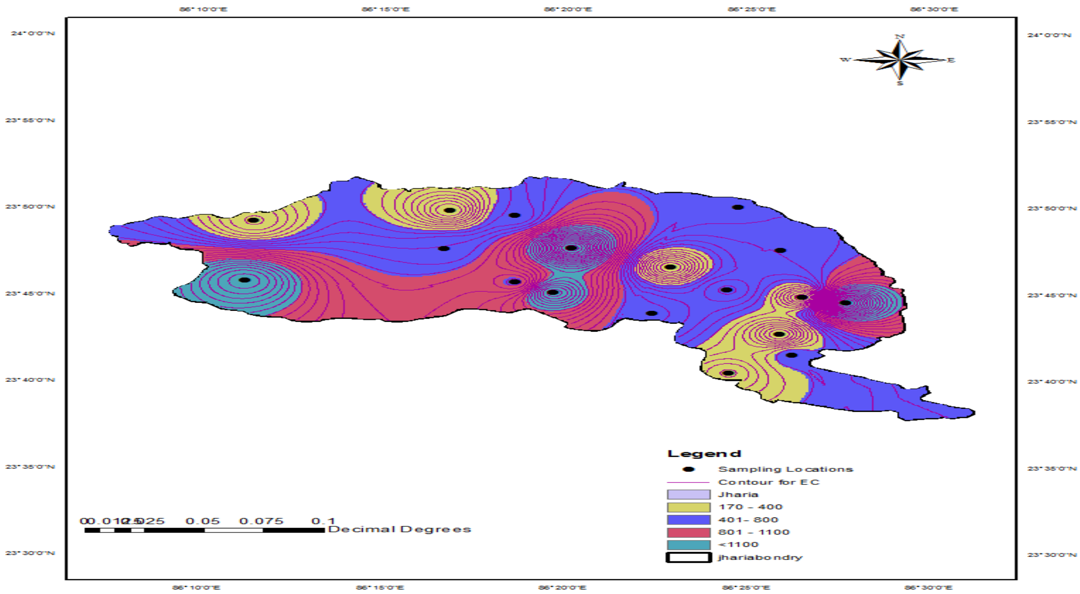

Fig: 5 Distribution of EC in Jharia Coalfield area

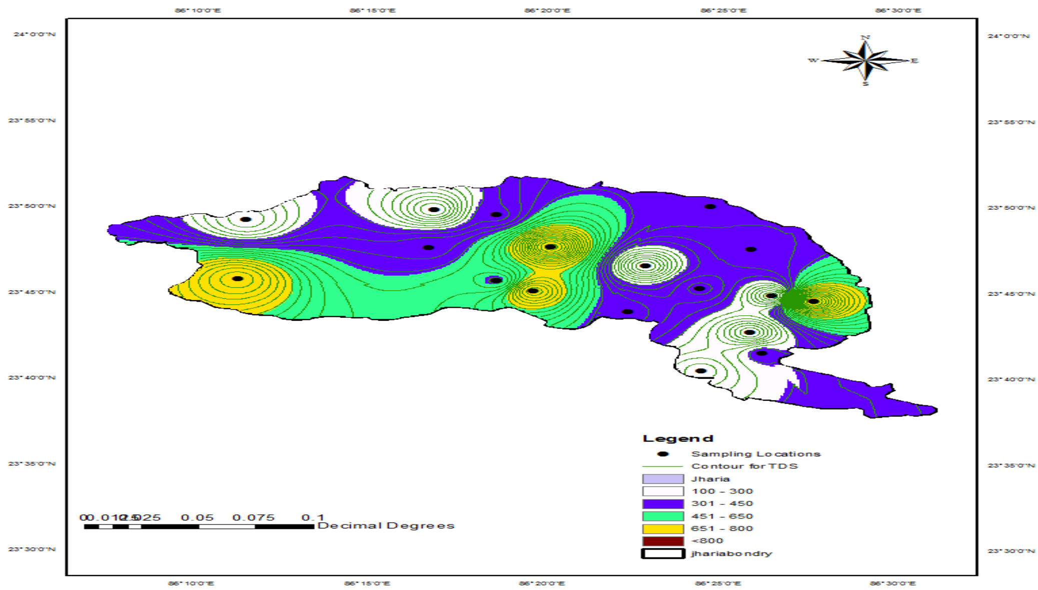

Fig:6 Distribution of TDS in Jharia Coalfield area

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 [18] and Bureau of Indian Standards [9] for drinking and public health standards (Table 1). The pH of the surface water samples (7.3–8.3) 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 **[10]**. 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 76.78 and 547.37 mg L^{-1} (avg. 233.78 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 . 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, anencephaly, parental mortality, some types of cancer and cardio-vascular disorders [11][12]. Beyond 3.0 mg L^{-1} if water consumed for a prolong period i.e. 6 months to several years [13]. 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 [14] besides the sewage and industrial effluents. A higher sodium intake may cause hypertension, congenial heart diseases and kidney problems [15] and the excess amount of potassium present in the water sample may lead nervous and digestive disorder [16]. The recommended permissible limit for sodium and potassium concentration in drinking water is 200 mg L^{-1} [17]. 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 [18].

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	-	7.3 - 8.3	7	6.5-9.2	7.0-8.5	8.5-9.2	6.5-8.5
EC	µS cm-^{1}	175 - 1208	527.05	1,500	750	-	-
HCO_3^-	mg L^{-1}	67 - 246	145.89	600	200	600	200
F^-	mg L^{-1}	0.3 – 1.0	0.53	1.5	0.6-0.9	1.5	1.0
Cl-	mg L^{-1}	3.9-62.3	22	600	250	1,000	250
NO_3^-	mg L^{-1}	0.16-4.6	1.31	50	-	100	45
SO_4^{2-}	mg L^{-1}	9.78-496	126.92	600	200	400	200
Na^+	mg L^{-1}	5.4 - 61	29.45	200	50	-	-
Ca^{2+}	mg L^{-1}	17 - 155	59.07	200	75	200	75
Mg^{2+}	mg L^{-1}	6.7-45	20.95	150	30	100	30
K^+	mg L^{-1}	1.2-14.6	5.055	200	100	-	-
TDS	mg L^{-1}	136-1045	417.8	1,500	500	2,000	500
TH	mg L^{-1}	76.4-547	233.78	500	100	600	300

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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