Hydrogeochemical Investigation and Qualitative Assessment of Surface Water Resources in West Bokaro Coalfield, India

ASHWANI KUMAR TIWARI*, PRASOON KUMAR SINGH and MUKESH KUMAR MAHATO
Department of Environmental Science & Engineering, Indian School of Mines, Dhanbad – 826 004, Jharkhand, India.

Email: ashwani.enviro@gmail.com

Abstract: A hydrogeochemical study of surface water of the West Bokaro coalfield has been undertaken to assess its quality and suitability for drinking, domestic and irrigation purposes. For this purpose, fourteen samples collected from rivers and ponds of the coalfield were analysed for pH, conductivity, total dissolved solids (TDS), major cations (Ca$^{2+}$, Mg$^{2+}$, Na$^+$ and K$^+$), major anions (HCO$_3^-$, F$^-$, Cl$^-$, SO$_4^{2-}$ and NO$_3^-$) and trace metals. The pH of the analysed water samples varied from 7.3 to 8.2, indicating slightly alkaline in nature. The electrical conductivity (EC) value varied from 93 µs cm$^{-1}$ to 906 µs cm$^{-1}$ while the TDS varied from 76 mg L$^{-1}$ to 658 mg L$^{-1}$. HCO$_3^-$ and SO$_4^{2-}$ are the dominant anion and Ca$^{2+}$ and Na$^+$ the cation in the surface water. The concentration of alkaline earth metals (Ca$^{2+}$ + Mg$^{2+}$) exceed the alkali metals (Na$^+$ + K$^+$) and HCO$_3^-$ dominates over SO$_4^{2-}$ + Cl$^-$ concentrations in the majority of the surface water samples. Ca$^{2+}$-Mg$^{2+}$-HCO$_3^-$ and Ca$^{2+}$-Mg$^{2+}$-Cl$^-$ are the dominant hydrogeochemical facies in the surface water of the area. The water chemistry is mainly controlled by rock weathering with secondary contribution from anthropogenic sources.

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$^{2+}$, Mg$^{2+}$ and Fe are exceeding the desirable limits in some water samples and needs treatment before its utilization. The calculated parameters such as sodium absorption ration, percent sodium, residual sodium carbonate, permeability index and magnesium hazard revealed good to permissible quality and suitable for irrigation purposes, however, higher salinity, permeability index and Mg-ratio restrict its suitability for irrigation at few sites.

Keywords: West Bokaro coalfield, Surface water quality, Hydrogeochemical processes, Trace metals, Sodium percent, Sodium adsorption ratio, Residual sodium carbonate, GIS.

INTRODUCTION

Water is an essential natural resource for sustaining life and environment which we have always thought to be available in abundance and the free gift of nature. Water constitutes about 70% of the body weight of almost all living organisms. 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 of water resources available in a region, while planning for any developmental projects. 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 (Reddi et al. 1993). Nowadays, water quality issues have become a significant concern due to the growth of population, urban expansion and technological development. These factors influence the quality of water resources, especially surface waters, causing water contamination (Sánchez et al. 2007; Tezcanlı Guyer and Genc Ilhan, 2011; Mahapatra et al. 2012). World Health Organization (WHO 2004) reported that in developing countries over three million people (90% are children under 5) die every year because of waterborne diseases (WHO 2004; Akoteyon et al. 2011). Access to safe drinking water remains an urgent necessity, as 30% of urban and 90% of the rural Indian population still depend completely on untreated surface or groundwater resources (Kumar et al. 2005). While access to drinking water in India has increased over the past decades, the tremendous adverse impact of unsafe water on health continues. It is estimated that about 21% of the communicable diseases in India are water borne (Bradon and Homman 1995). Scarcity of clean and potable water has emerged in recent years as one of the most serious developmental issues in many parts of West Bengal, Jharkahnd, Orissa, Western Uttar Pradesh, Andhra Pradesh, Rajasthan and Punjab (Tiwari and Singh, 2014).

In the Jharkhand state the quality of water is a major...
issue due to the public ignorance to environmental considerations, lack of provisional basic social services, indiscriminate disposal of increasing anthropogenic and mining wastes, unplanned application of agrochemicals and discharges of improperly treated sewage/industrial effluents, resulting in excess accumulation of pollutants on the land surface and contamination of available water resources (Singh and Hasnain 1999; Tiwary 2001; Sarkar et al. 2007; Singh et al. 2007). Thus, proper assessment and reporting of water quality is an important issue. In the present work attempts have been made to detect surface water quality for drinking, domestic and irrigation uses and also to prepare the contour maps for the various water quality parameters by using ArcGIS 9.3 software. Geographical Information System (GIS) can be useful for taking quick decisions as graphical representation would be easy to take decision by the policy makers (Singh et al. 2013). This study will be useful in current water resource planning and provide some basic data for the rational exploitation and use of water resources in the future.

STUDY AREA
West Bokaro coalfield, located in the Ramgarh district of Jharkhand state, the coalfield covers an area of 207 sq km. The West Bokaro coalfield lies between 23°41’ to 23°52’ N latitude and 85°24’ to 85°41’ E longitude (Fig. 1). It is a major storehouse of medium coking coal and lies adjacent to the west of East Bokaro coalfield separated by the Lugu hill. The coalfield is drained by the Bokaro river passing through the central part of coalfield with easterly flows. The Chutua river is the main tributary of the Bokaro river which drains the northern hilly terrain of the coalfield. The Chotha river is also the tributary of the Bokaro river which drains the southern region of the coalfield. The West Bokaro coalfield is fourth, east of the Damodar valley coalfield.

The West Bokaro coalfield area experiences 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°C, while December and January are the coldest months. 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). The West Bokaro coalfield forms a broad syncline trending E-W and exhibits a complete sequence of lower Gondwana Formation which rest unconformably basement.