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Impact of open cast coal mining on ground water quality

Abstract

Opencast mining methods affect the environment constituents, especially water resources, by discharging huge amounts of mine water. Physical impact of open cast mining mainly results from silting in the surface water bodies. Deterioration in drinking water quality is a serious human health issue due to release both major and trace elements into the environment. All the operations of mining, directly or indirectly require water for their functioning. The fluctuation of temperature, pH and turbidity was recorded from 22.3 to 31.2^0C, 6.5 to 7.5 and 0.1 to 0.6 NTU respectively. Total hardness, TDS, TSS and alkalinity was found comparatively higher in some samples, however the all sample values are under prescribed limits. Rich level Dissolved oxygen (DO) >4 mg/l was found in all samples. The range of calcium, Sulphate, magnesium and fluoride is comparatively higher in 50% samples but also indicates the safer values for uses. Chloride and Iron is also present under safe limit. Higher values of water parameter, trace elements and heavy metals are most dangerous pollutants due to their toxicity and persistence in the environment. These pollutants contaminated soils and water may reach human body at dangerous level through agricultural products and bio-magnification process and causes various diseases.

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Keywords

Open cast mining, water pollution, Trace metals, Heavy metals, pH, TDS, and alkalinity

Introduction

Water is an essential natural resource for requirement of human life and absolute necessity for sustaining life in the earth. It is the lifeblood and most delicate part of environment. Living beings are completely depending upon the availability of fresh water for livelihood (Gupta and Nikhil, 2016, Gupta *et al*., 2014 and Das and Acharya, 2003). Three-fourth part of earth is being surrounded by water but whole water cannot be used for drinking purpose. The estimated total volume of water on Earth is 1.386 billion km^3 (333 million cubic miles). 1869 billion cubic meters out of 4000 billion cubic meter annual rainfall reaches to the ocean by natural runoff and 432 billion cubic meter water reaches to ground water and recharge it. The 690 billion cubic meter water is available in the form of surface water (Allen *et al.,* 1996, Pal *et al.,* 2013).

Coal mining is one of the core industries that contribute to the economic development of country and share 67% of energy requirements of India. Coal mining provides coal as primary source of energy and contribute to the economic development of a country but deteriorate the environment. Coal mining is excavated by both opencast and underground mining methods and affects the environment constituents, especially water resources, by discharging huge amounts of mine water. Large scale open cut coal mining operations significantly impacts on groundwater in surrounding areas in both active and post-mining phases (Singh *et al.,* 2011, Swer *et al.,* 2004). The open cast coal mining may impact in term of lowering water table, lower soil and atmospheric moisture, rise in temperature due to Albedo effect, disturbance in hydrological cycle, rainfall and climate, increase in SPM and RSPM due to dust pollution, spontaneous heating and chances of fire.

Materials and Methods

The study area is situated in Udaipur tehsil, district Surguja Chhattisgarh. In this study ground water samples were analyzed to know the Impact of open cast coal mining on ground water quality. 20 km radius was covered in this study. 10 sampling stations were selected around operation open cost coal mining area, as this area is known as Hasdev Arand coal field in Udaipur Tehsil, Surguja District of Chhattisgarh.

Samples were collected by grab sampling method in polyethylene/plastic/glass bottle and analysed as per Standard method (APHA AWWA WPCF-2012) for physico-chemical. For physico-chemical analysis samples were collected in previously rinsed and dried polyethylene bottle and stored in ice box at 4°C. For bacteriological analysis samples were collected clean, sterilized and narrow mouthed glass bottle. The water sample for the

Fig. 1: Location Map of Study area

physicochemical study was collected from mine sump, seepage from Bench and hand pumps.

The physical parameters, like temperature (°C), pH, electrical conductivity (EC) (in µS/cm), Dissolved oxygen (DO) (in mg/L) and total dissolved solids (TDS) (in mg/L) were determined on the sampling location with the help of Hanna Multiparameter kit. Calcium, chloride, magnesium, nitrate, sulphate, turbidity, total hardness, and bio-chemical oxygen demand in (mg/L) were made in the departmental laboratories as per the usual procedures prescribed in APHA. Calculation of WQI was carried out by following the, weighted arithmetic index method (Brown *et al.*, 1972 and Cude, 2001.)

Table 1: water quality monitoring stations

Sample Code	Location	Distance from Boundary (km)
GW1	Deurpara village	Core Area
GW2	Phaterpur village	Core Area
GW3	Shivnagar village	2.3, N
GW4	Parsa village	3.0, E
GW5	Ghatbarra village	2.0, SE
GW6	Tara village	1.0, W
GW7	Jandardanpur village	5.3, NW
GW8	Udaipur town (tehsil)	10.5 EW
GW9	Gumga village	7.5
GW10	Ramgarh	9.7

Results and Discussion

Hasdev Arand coal field in Surguja District of Chhattisgarh is one of the major coalfields of the central India located in the upper reaches of Mahanadi Valley Master Gondwana Basin. The water samples collected from the different sites were analysed and results are given below:

The fluctuation of temperature was recorded from 22.3 to 31.2^0C. The pH of collected samples is varies from 6.5 to 7.5. This is the general and safe range for ecosystem and for different uses. The higher turbidity was found in sample GW10 while lower in GW2. The turbidity was comparatively higher in GW8, GW9 and GW10 but it is under limit of standards. Conductivity is also found higher in GW10 sample but under limit. Total hardness and TDS was found comparatively higher in GW8 and GW6 and lower in GW1and GW7 respectively but it's safe for different uses. TSS and alkalinity was found comparatively higher in GW3 and GW4 samples, however the all sample values are under prescribed limits which show the good management of water resources by the mining authorities. Rich level Dissolved oxygen (DO) was found at different sampling points, which indicates the proper management of waste water. It was fluctuated between 5.95 (GW4) to 10.48 mg/l (GW2). Calcium is also a very important parameter to access the water quality. The range of calcium was 6.5 to 23mg/l and found comparatively higher in GW9 sample. Sulphate, magnesium and fluoride is comparatively higher in 50% samples but also indicates the safer values for uses however the authorities should frequently monitor these parameters for better control and management. Chloride was found lower in GW1 (10 mg/l) and higher in GW6 (60 mg/l) and GW 5 (69 mg/l) sample. Iron is also present in appropriate amount and ranges between 0.1 to 0.57 mg/l. Nitrate ranges from 0.69mg/l (GW1) to 3.41mg/l.

Open cast mining has caused severe problems to the ecology and hydrology of the tiny state, mining activities can direct and indirect impacts on the quantity, Quality and usability of

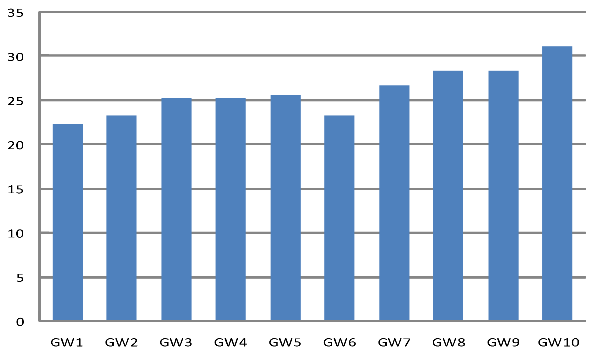

Fig. 2: Temperature of different sampling station

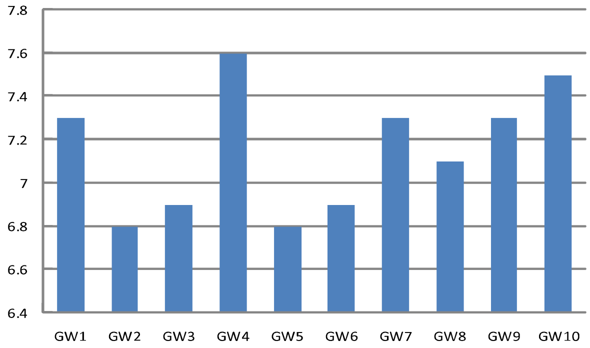

Fig. 3: pH of different sampling station

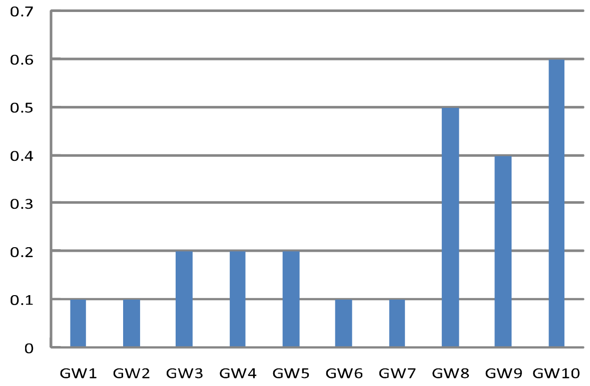

Fig. 4: Turbidity (NTU) at different sampling station

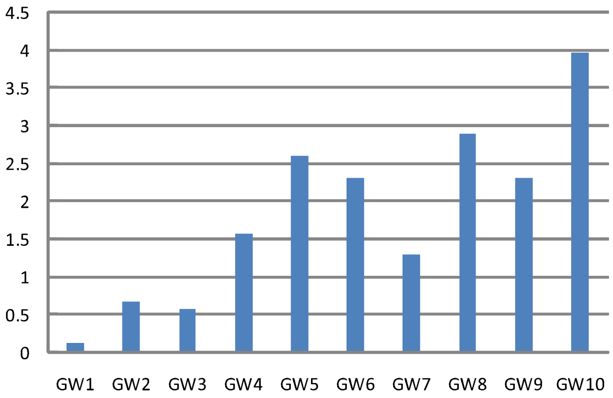

Fig. 5: Conductivity (μmhos/cm) at different sampling station

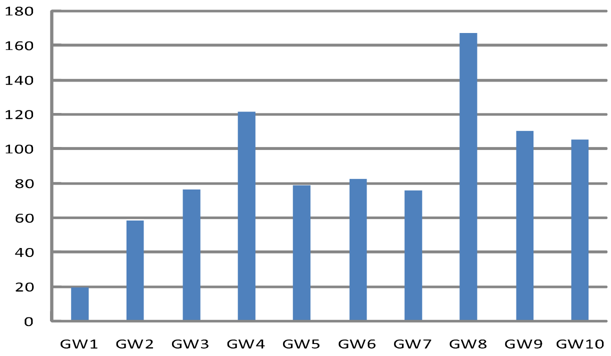

Fig. 6: Total hardness (mg/L) at different sampling station

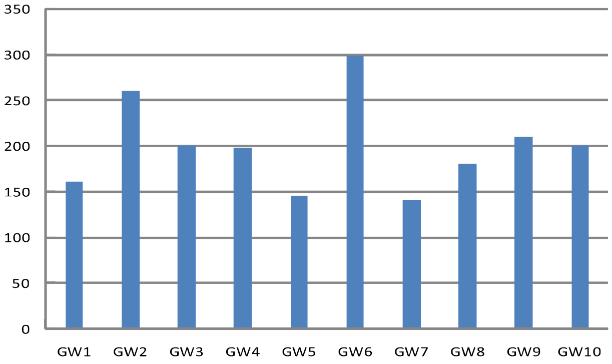

Fig. 7: TDS (mg/l) at different sampling station

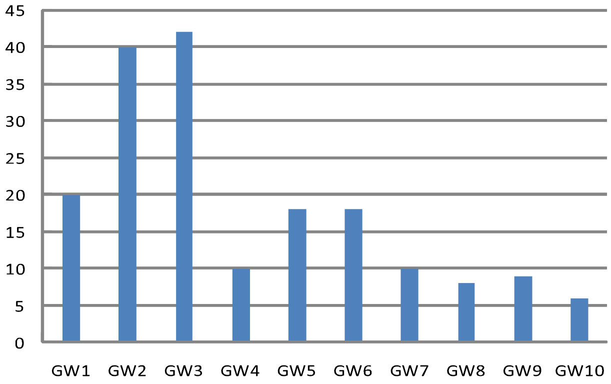

Fig. 8: TSS (mg/l) at different sampling station

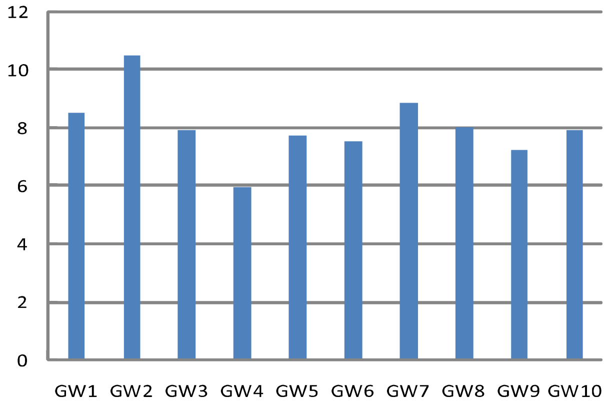

Fig. 9: DO (mg/l) at different sampling station

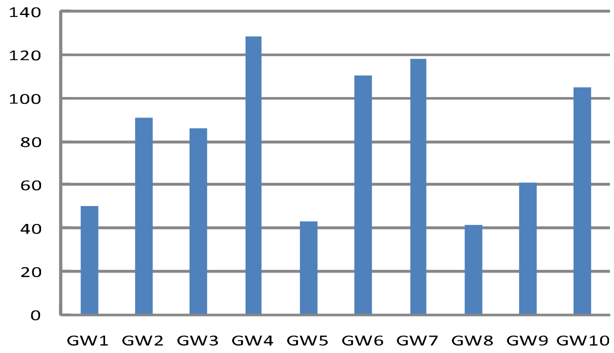

Fig. 10: Alkalinity (mg/l) at different sampling station

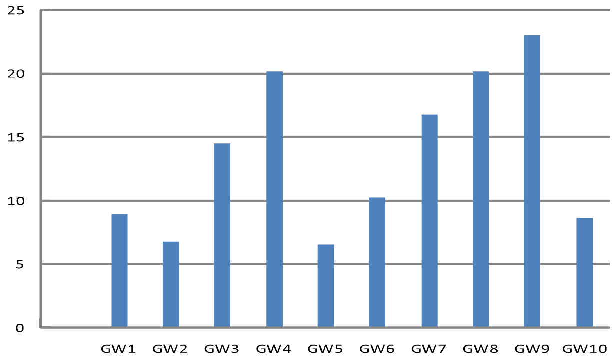

Fig. 11: Calcium (mg/l) at different sampling station

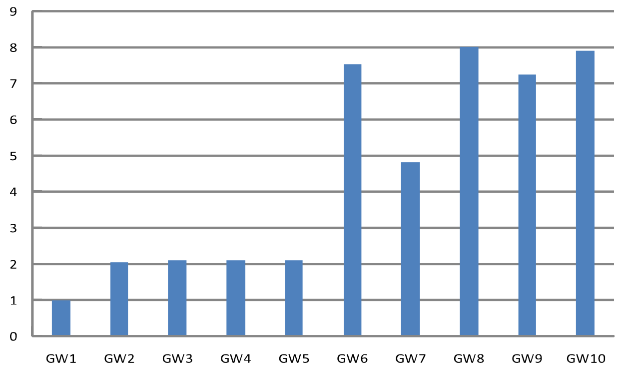

Fig. 12: Sulphate (mg/l) at different sampling station

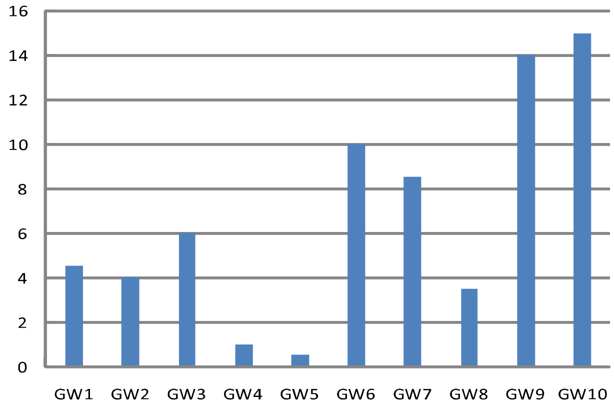

Fig. 13: Magnesium (mg/l) at different sampling station

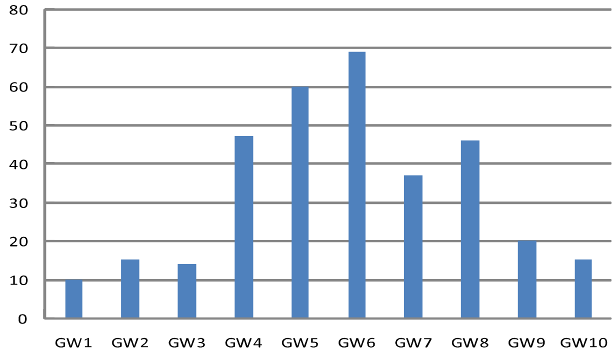

Fig. 14: Chloride (mg/l) at different sampling station

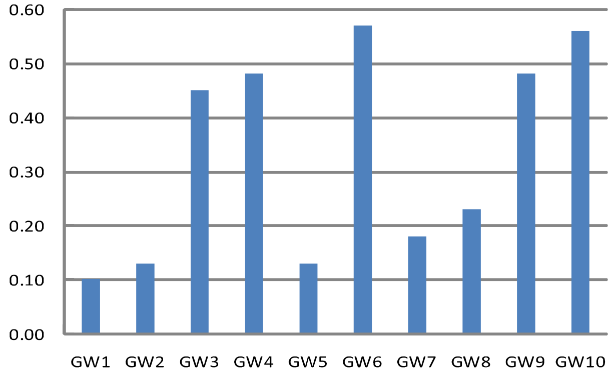

Fig. 15: Iron (mg/l) at different sampling station

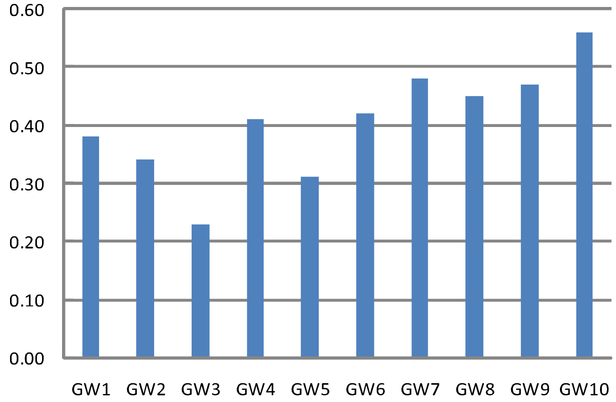

Fig. 16: Fluoride (mg/l) at different sampling station

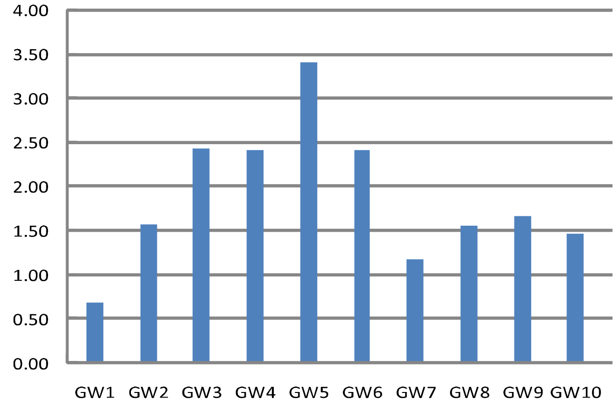

Fig. 17: Nitrate (mg/l) at different sampling station

groundwater supplies. Operations such as coal cutting in mines, dust suppression, coal preparation, coal washing and domestic use usually retrieve the ground water to meet their demands and in the absence of ground water, they acquire water from the nearby water resources (Dwivedi *et al.* 2014, Tiwari *et al.* 2004, Xu and Gao 2009).

Water-pollution problems caused by mining include acid mine drainage, metal contamination, and increased sediment levels in streams. Sources can include active or abandoned surface and underground mines, processing plants, waste-disposal areas, haulage roads, or tailings ponds. Sediments, typically from increased soil erosion, cause siltation or the smothering of streambeds. This siltation affects fisheries, swimming, domestic water supply, irrigation, and other uses of streams (Milivojeviæ *et al.*, 2016). Acid mine drainage (AMD) is a potentially severe pollution hazard that can contaminate surrounding soil, groundwater, and surface water. The formation of acid mine drainage is a function of the geology, hydrology, and mining technology employed at a mine site. The primary sources for acid generation are sulfide minerals, such as pyrite (iron sulfide), which decompose in air and water. Many of these sulfide minerals originate from waste rock removed from the mine or from tailings. If water infiltrates pyrite-laden rock in the presence of air, it can become acidified, often at a pH level of two or three (Awalla, 2016). This increased acidity in the water can destroy living organisms, and corrode culverts, piers, boat hulls, pumps, and other metal equipment in contact with the acid waters and render the water unacceptable for drinking or recreational use. A summary chemical reaction that represents the chemistry of pyrite weathering to form AMD is as follows:

Pyrite + Oxygen + water   Yellowboy + Sulfuric acid

Yellowboy" is the name for iron and aluminum compounds that stain streambeds. AMD can enter the environment in a number of ways, such as free-draining piles of waste rock that are exposed to intense rainstorms, transporting large amounts of acid into nearby rivers; ground waters that enter underground workings which become acidic and exit via surface openings or are pumped to the surface; and acidic tailings containment ponds that may leach into surrounding land (Johnson and Hallberg, 2005).

The pyrite content in the coal as inorganic impurities may change the pH of water due to presence of sulphur in pyrite (FeS_2). It's also increases the level of total suspended solids, total dissolved solids and some heavy metals (Tiwary 2000, Tiwary and Dhar 1994). Zakir *et al* (2013) assessed the water quality around Barakpuria opencast coal mine for suitability in domestic, industrial, livestock and irrigation use. The analysis showed the water samples to vary from neutral to little alkaline, high values of EC, TDS, TH, HCO3-, Cl, SO42- and K. Among the trace metals Fe, Zn, Cu and Mn analyzed, Mn content was found to be dominant. Verma *et al.* (2012) analyzed the water sample of pond located near Nandani Mines in Durg district, Chhattisgarh. It was found that the pond water was slightly alkaline and hardness and TDS was high. The values were found to be quite higher in comparison to tap water.

Carlos et al. (2011) studied the impact of coal mining on water quality of three artificial lakes in Morizini River Basin. The results showed that pH increased with depth ranging from 5-7; the pH being slightly higher during winter. The electrical conductivity, Total solids, So42-, Ca, Mg and K concentrations values were higher in Lakes. The data observed showed that coal mining has made a strong environmental impact. Singh (1998) investigated water samples from Jharia, Raniganj and Northeastern Coalfields to study the impact of coal mining on water quality from underground mines of Indian coalfields. The results showed that the underground mine waters were neutral to slightly alkaline and pH values lied within permissible limits. Sulphate concentrations exceeded the permissible Public Health Standards. Trace metals were found to be either completely absent or present in quantities less than 0.1 mg/l.

Pollutants such as TSS, TDS, heavy metal, oil and grease are found in the coal mining waste and successfully treated by the modern water treatment technologies. The open cast mining directly or indirectly affects flora and fauna in the surrounding areas of mining and resulting in a grave ecological imbalance (Khandelwal and Singh 2005). It clearly shows that coal mining has certain impact on the water quality. The low pH values, high mineral concentrations and certain anomalies in some samples are testimony to it (Singh *et al.* 2010, 1998, Pathak *et al.* 1992). As per study of Sandipan *et al* (2013), the surface water quality in the abandoned mines were alkaline, soft to moderately hard and fresh in nature. The rest of the parameters were within permissible limit hence the pit could be used as a reservoir and its water for various purposes.

The management of the mine has done well to keep the concentrations of most of the parameters within the permissible limits. However they still have to be vigilant, since some of the parameters are falling higher in some samples. The acidic nature of the water is mainly due to the pyrite content contained in the coal. The high mineral concentrations may be due the presence of selenium, calcium, iron, sulphates and magnisium etc. (Jaynes *et al.* 1984, Muthangya and Samoei 2012). Since awareness and restriction with regard to water quality has already been put in place by the regulatory authorities, the impact here is not as profoundly seen as the coal mining process can have.

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