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Short Communication

Appraisal of incrustation and corrosive properties of groundwater in industrial belt of Bonai Area, Odisha, India

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Abstract

The present paper aims at assessing the incrustation and corrosive properties of ground water for industrial uses in mining belts of Bonai area. The quality requirement for water used in the mining industry is highly variable, depending on the stage at which it is required i.e. whether during mining, flotation, leaching, smelting or refining operations or for water supply to industrial township. Many mining and mineral based industries are located in the study area. The study indicates that on the basis of criteria such as pH, EC, HCO_3^-, Cl^-, SO_4^{2-} and Fe^{2+} etc. 76.27% of water have corrosive properties and 21.43% of water have incrusting property. On the basis of Langelier Index 85.59% of ground water is generally corrosive. Only 10.17% of water have incrusting property and 4.24% of waters are neither corrosive nor incrusting. The water will have adverse effects on mine machinery, Iron pipes, casing pipes of tube well etc. Hence, the following remedial measures are to be taken to control or prevent the incrustation and corrosion. Treatment of incrusting materials with HCl, Chlorine and dispersing agents like Sodium hexa-metaphosphate $Na(PO_3)_6$. Use of corrosion resistant materials like brass, stainless steel, PVC material and epoxy-banded fiber glass and application of protective coating to metal parts.

Keywords: Langelier Index, Incrustation, Corrosion, Groundwater Quality.

Introduction

Groundwater has assumed a greater importance in meeting the growing needs due to ever increasing domestic, agricultural and industrial requirements. The amount and chemistry of the dissolved minerals in groundwater depend upon the type of rock or nature of soil with which it has been in contact or through which it has passed and the duration of contact of water with these geological materials. The percolating rainwater contains carbon dioxide derived from atmosphere, which increases the solvent action of the water. Quality of groundwater may vary from place to place and from stratum to stratum. It also varies from season to season. The requirement of quality of water for various purposes such as for drinking water, irrigation water and industrial water vary widely. The determination of suitability of groundwater, therefore, involves a description of the occurrence of the various constituents and their relation to the use to which water would be put. The water quality data also provides information about geological history of rocks, groundwater recharge, discharge, movement and storage. Evaluation of capability of groundwater for its use requires determination of its chemical, physical and biological characteristics. Chemical Analysis of groundwater requires determination of the concentration of inorganic constituents and measurement of PH and specific electrical conductance. Physical properties require determination of the temperature, color, turbidity, odor and taste. Chemical quality criteria for industrial use vary widely. The purest of waters are required for the manufacture of pharmaceuticals and paper, while for certain phases of the mining industry quality requirements are less exacting. The quality requirement for water used in the mining industry is highly variable, depending on the stage at which it is required i.e. whether during mining, flotation, leaching, smelting or refining operations or for water supply to Industrial Township. Many mining industries are located in the Bonai area of Sundargarh district. Small scale Sponge Iron Plants are located within the study area. Keeping the above facts in view, an extensive geochemical survey was carried out assess the suitability of ground water for industrial uses in mining belts of Bonai area.

The literature available on groundwater quality was reviewed in detail. Some authors have highlighted in their work the importance of groundwater quality for industrial use particularly in respect of corrosiveness and incrustations in other parts[1-6]. The methods of analysis, representation and quality assessment of ground water for drinking, irrigation and industrial uses in different areas have been studied by many researchers[7-18].

Bonai occupies the eastern part of Sundargarh district, bounded by North Latitudes $21^0$35' to $22^0$10' and East Longitudes $84^0$30' to $85^0$25' and falls in the SOI toposheets 73 B/12, 73 B/16, 73C/9, 73C/10, 73 C/10, 73 C/13, 73 C/14, 73 F/4, 73 G/1, 73 G/2 and 73G/5 with a total geographical area of 2200 sq.km. (Figure-1).

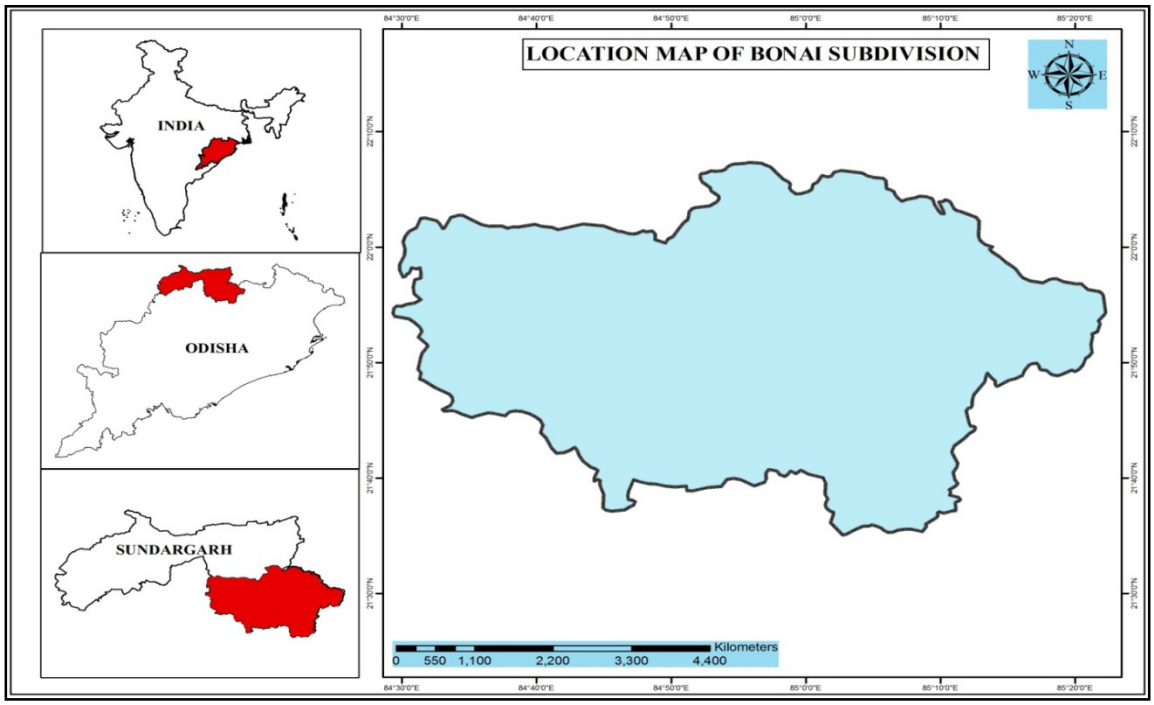

Figure-1: Location map of the study area.

The area enjoys sub-tropical climate with three distinct seasons, viz. (1) Winter (2) Summer (3) Monsoon and average rainfall is 1647 mm with 72 days of rain. Physiographically the area is characterized by hills with intervening narrow intermontane valleys, isolated hillocks and flat to gently undulating plain. The area is underlain by rocks of pre-cambrian age which are litho-logically, genetically and tectonically very complex[15]. The rocks of Iron Ore Group and Darjing Group are exposed in the eastern and western parts of the study area respectively. The middle part of the area is underlain by Bonai Granite. Deogarh Group of rocks are exposed along the southern margin of the area. Mining activities in Koira block is an ongoing process operated by Iron and Steel companies like SAIL, TICSO, Odisha Mining Corporation (OMC) etc. for exploitation of Iron and Manganese ores and bauxite. Some of the mines of SAIL and TISCO are completely mechanized. The important mining centers are Gonua, Potabeda, Malda, Kalamang, Adaghat, Sani Indupur, Ranisal, Patamunda, Panidihi, Koira, Kalta, Joda, Kusumdihi, Barsua, Tantra and Raikela. Total area presently utilized for mining is 956.39 Hect. There are twelve numbers of sponge iron plants in and around Bonai area.

Materials and methods

Secondary data like demography, rainfall, climate, soil, geology and mining were collected from various sources and analyzed. Toposheets were issued to prepare base map. Water samples numbering 118 which were collected during pre-monsoon (2016) covering the whole study area are analyzed chemically for major ions Ca^{2+}, Mg^{2+}, HCO_3^-, CO_3^{2-}, SO_4^{2-}, Fe^{2+}, Cl^- and the Total Dissolved Solid (TDS), Total Hardness (TH), Alkalinity, hydrogen ion concentration (pH) Specific Conductance, Temperature etc. are also determined adopting the procedure given by APHA(2005). The Corrosive and incrusting properties of ground water have been analyzed adopting the method as proposed by Langelier. Langelier Index determines the corrosive or incrusting ability of water. To understand the chemical action of water on the mine machinery, Iron pipes, Vessels, Casing pipes of tube wells, the above methods have been adopted. The Langelier Index is determined by the formula as given below.

Langelier Index = pH – pHs, where pH = actual pH of water , pHs = Saturation pH or the calculated pH at which, without change in total alkalinity and calcium content, a water would be in equilibrium with solid calcium carbonate. pHs = 9.3 + (A+B) – (C + D). The Langelier co-efficient A, B, C and D depend upon the following factors. i. Factor A- Total Dissolved Solids (TDS), ii. Factor B- Water Temperature, iii. Factor C- Calcium carbonate content in ppm or 2/3rd of the Total Hardness (ppm), iv. Factor D- Methyl Orange alkalinity as ppm of Calcium Carbonate.

In addition to the above, the following criteria are used to study the incrustation and corrosion. Water carrying > 400 ppm of HCO_3^- cause soft incrustation. Water carrying > 100 ppm SO_4^{2-} or 40 ppm Silicon causes hard incrustation. Water with pH < 7 are corrosive. Water with EC > 1500 micro mhos/cm cause corrosion of Iron and Steel. Presence of chloride > 500 ppm are corrosive. Presence of 2 ppm of Fe^{2+} or 2 ppm of Mn^{2+} cause incrustation.

Results and discussion

The mineral contents of the water are primarily responsible for corrosion and incrustation of metals. Corrosion is a chemical action on metals which results in the metal being eaten away, whereas incrustation involves deposition of undesired materials on the metal. Incrustation is generally hard, brittle and cement like deposition. Hard incrustations are formed due to SO_4^{2-} and silicates of calcium and magnesium. In most of the cases, incrustation is due to deposition of calcium carbonate which is usually the basic binder and causes the chief trouble. Soft incrustations occur due to precipitation of bicarbonate of calcium and magnesium. Corrosion occur in the form of general rusting or uniform loss of metal with occasional perforations in some area, selective corrosion; localized pitting and perforations. Table-1 shows the Equivalent Factors-Langelier Saturation Index.

A zero value of Langelier Index indicates that water is in chemical balance. A positive value indicates tendency to deposit calcium carbonate and a negative value indicates a tendency to dissolve calcium carbonate. From the above study, it is clear that 85.59% of ground water is generally corrosive. Only 10.17% of water have incrusting property and 4.24% of waters are neither corrosive nor incrusting (Table-2).

The incrusting and corrosive properties of ground water of the area have been classified using other criteria such as pH, EC, HCO_3^-, Cl^-, SO_4^{2-} and Fe^{2+} etc. Table-3 and 4 show the per cent of samples with corrosive and incrusting properties in the study area.

Table-1: Equivalent factors-langelier saturation Index.

Temp (F)	Temp. Factor	Ca Hardness (ppm)	Ca Hardness factor	Alkalinity (ppm)	Alkalinity factor	pH	pH Factor	TDS (ppm)	TDS Factor
32	0.0	5	0.3	5	0.7	7.0	0.23	<1000	12.10
37	0.1	25	1.0	25	1.4	7.2	0.27	1000	12.19
46	0.2	50	1.3	50	1.7	7.4	0.31	2000	12.29
53	0.3	75	1.5	75	1.9	7.6	0.33	3000	12.35
60	0.4	100	1.6	100	2.0	7.8	0.35	4000	12.41
66	0.5	150	1.8	150	2.2	8.0	0.36	-	-
76	0.6	200	1.9	200	2.3	-	-	-	-
84	0.7	300	2.1	300	2.5	-	-	-	-
94	0.8	400	2.2	500	2.6	-	-	-	-
105	0.9	800	2.5	800	2.9	-	-	-	-

Table-2: Samples with Langelier Index in Percentage.

Langelier Index	Water Property	No. of samples Analyzed	Percentage of Sample
Positive Value	Incrusting	118	10.17
Negative Value	Corrosive	118	85.59
Zero Value	Neither incrustation nor corrosive	118	4.24

Table-3: Percentage of samples with Corrosive Property.

Criteria for corrosion	No. of sample Analyzed	No. of water samples with corrosive property	% age of sample with corrosive property
pH < 7	118	90	76.27
EC > 1500	118	Nil	Nil
Cl^- > 500 ppm	118	Nil	Nil

Table-4: Percentage of samples with Incrusting Property.

Criteria for Incrustation	No. of Sample Analyzed	No. of samples with incrusting property	% of samples with incrustation property
HCO_3^- > 400	118	Nil	Nil
SO_4^{2-} > 100	118	Nil	Nil
Fe^{2+} > 2 mg/h	Dug well – 39 Tubewell-42	Nil 9	Nil 21.43

Conclusion

From the above study it is clear that on the basis of criteria such as pH, EC, HCO_3^-, Cl^-, SO_4^{2-} and Fe^{2+} etc. 76.27% of water have corrosive properties and 21.43% of water have incrusting property. On the basis of Langelier Index 85.59% of ground water is generally corrosive. Only 10.17% of water have incrusting property and 4.24% of waters are neither corrosive nor incrusting. The water will have adverse effects on mine machinery, Iron pipes, casing pipes of tube well etc. Hence, the following remedial measures are to be taken to control or prevent the incrustation and corrosion. Treatment of incrusting materials with HCl, Chlorine and dispersing agents like Sodium hexametaphosphate $Na(PO_3)_6$. Use of corrosion resistant materials like brass, stainless steel, PVC material and epoxy-banded fiber glass and application of protective coating to metal parts.

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