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Studies on Ground Water pollution due to Iron Content in Cuttack City, Odisha, India

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Abstract

A study has been carried out in Cuttack city of Odisha, India to ascertain the causes for the origin and distribution of iron content in the groundwater. Groundwater samples were collected quarterly for two consecutive years and analyzed for iron content. The content of iron ranges from 0.03 to 1.5 mg/l. A comparison of groundwater data with soil chemistry suggests that the concentration of iron in the ground water is derived from soils due to geogenic processes. Relatively higher concentration of iron was observed in some samples where the tube wells are located near municipal waste waters indicating the impact of anthropogenic activities on the ground water system. These activities mask the concentration of iron caused by geogenic origin. Hence both the geogenic and anthropogenic activities degrade the groundwater quality. Drinking water standards indicate that the iron content in most of the ground water samples exceeds the permissible limit (0.3 mg/l) recommended for drinking purposes, causing the health disorders. Necessity of close monitoring of ground water quality for assessing the impact of geogenic and anthropogenic sources with reference to land use / land cover activities is emphasized in the present study area to protect the ground water resources from the pollution.

Keywords: *Ground Water pollution, Iron Content etc.*

1. Introduction

Urban growth and rapid increase in population have induced tremendous pressure on natural resources . A common factor to most urbanization is that it results in impermeabilisation of a significant proportion of land surface and contamination of ground water. On the other hand concern about the degradation of water quality is now widespread among the public as the water is of utmost physiological importance in the human body. About 80% of the diseases of the world population and more than one-third of the deaths in the developing countries are due to contamination of water (WHO,1984; earth Summit,1990). Trace elements are essential for human health. How ever excess concentration of these elements cause health disorder. Man can control some undesirable chemical constituents in water before it enters the ground. But once the water enters the ground man's control over the chemical quality of percolating water is very limited (Johnson 1979)

Ground water composition in a region depends on the natural (such as wet and dry deposition of atmospheric salts, evaporation, soil-rock- water interactions) and anthropogenic processes, which can alter or modify the natural system of hydrological cycle (Subba Rao 2002, 2006, Subbba et al,2002 ,Singh et al 2006). Zuane (1990) has stated that the type and extent of chemical contamination of the ground water largely depend on the geochemistry of the soil, through which the water flows prior to reaching the aquifers. Romic and Romic (2003) have pointed out that the iron in the ground water is mainly derived from geogenic processes in the urban area. Ramesh et al (1995) have explained the unequal distribution of major and trace elements in the ground water because of anthropogenic activities (such as sewerage waste water, industrial effluents etc). Eswari and Ramanibai (2000) have estimated the seasonal variation of iron in the waters of Chennai, Tamilnadu, India and the study suggest that the more concentration of iron is observed during monsoon due to anthropogenic activities and land run off.

The huge population of this area use ground water for drinking and other purposes. A number of dug and tube wells have been constructed to met the short supply in Cuttack city. Some of these wells are located at immediate vicinity of the open top sewerage which carries very high potency of inorganic and microbial contaminants. Unfortunately the age old sewerage canal is not cleaned or maintained properly and there is every possibility of contamination of the ground water by the leakage of sewage through the badly damaged wall and bottom. Hence, the present paper deals with the causes for the origin and distribution of iron content in the ground water of the study area, as the iron plays a significant role on human health among the trace elements. A deficiency of iron causes anaemia, while an excess of iron develops undesirable taste and gastrointestinal irritation . It stains the cloths, teeth, gum and utensils, promoting the growth of bacteria and reduces the water flow. Abnormal content of iron leads to cancer (Micozzi 1994).

Study Area

Cuttack having latitude of 20°29′ to20°26′N and longitude 85°48′ to 85°56′E. River Mahanadi and its major distributaries Kathjodi surrounds the city in north and south boundaries and the city elongates in east-west direction. The surface has slope to the centro-axial zone both from south and north and a low regional gradient to the east. As the city is situated on the doab land, low lying areas are available centrally. The ground height of the study area varies from 19 to 20m on the north. The soil beneath the city is composed of unconsolidated alluvium in alternating sequence of sand, silt and clay, the depth of which continues upto 120m and is placed above Gondwanaland sedimentary rock of Archean crystallins (Mahallick,1992). The depth of water tables changes with monsoons going down to 4-6 m during premonsoon and rises to 0-3m during monsoon and post monsoon period (GWD. 1995). With in a depth of 90 meters besides the water tables two confined aquifers could be identified which are lined by impervious clay minerals. The first confined aquifer lies at a depth of 30 meters with thickness varying from 15 to 40 meters separated from the second confined aquifer by clay bed of 15 to 20 meter thickness. There is a possibility of third confined aquifer below the clay layer overlying the Gondwana basement (Mahallick, 1992).

Climate

Cuttack city enjoys a subtropical monsoon climate with three distinct seasons viz (1) winter (2) summer (3) rainy. The winter season continues from November to February, the summer season extends form March to June and Rains form July to October. The city receives an average annual rain fall of 154 mm with average number of rainy days around 74. The area receives about 85% of the rain fall from south-west monsoon associated bay depressions and storms. The frequency of occurrence of bay depressions and storms affecting the city is high during the month of May to June and October to November. Cyclonic weather has been a common phenomenon in this area as it is situated hardly 90kms from the bay of Bangal. The variability of rain fall during the month of July, October and November is very high.

Water Supply and Population

Cuttack city is situated at the deltaic position of river mahanadi and kathajodi as a result of which sufficient water resources are available through the rivers and underground aquifers. But the ground water exploitation through the tube wells is found more economic. During 1949 the first organized water supply scheme was installed by Public Health Department and today the capacity of the scheme touches about 19.4 metric gallons per day which is not sufficient for the whole urban population. Rest of the drinking water requirement is met from the shallow dug and tube wells located inside the city. A large proportion of the dug wells and tube wells of the city are constructed in the close vicinity of sewerage drain. On a number of occasions the septic tanks are constructed adjacent to the wells. The city dwellers have no other choice but to use the water without any treatment for their daily consumption over the years.

Methodology

To have a through idea regarding iron content in the ground waters seven different locations were chosen keeping in mind that all the areas of Cuttack can be covered properly. The detailed locations of sampling points are described in table-01. from each location a particular tube well was chosen and grab sampling was done quarterly from that particular tube well for two consecutive years. Using these samples the iron content in ground water was studied. All chemicals/ reagents used were of analytical reagent grad. After sample collection and under preservation the samples are analyzed in laboratory according to APHA-2000.(19th Edition)

The analysis for iron content was done with the help of Atomic Absorbtion /Flame emission Spectrophotometer (ShimadzuAA/640 of Japan make) using air and acetylene flame(Brown et al.1974). In this procedure pure analytical reagent iron metal was dissolved in concentrated nitric acid. From this by multiplying dilution six known standards were prepared for drawing the calibration curve from which the unknown amounts were determined. All the samples were run thrice against the standard and average values were recorded. Minimum detected limit of iron is 0.01%. The concentration of iron is expressed in mg/l.

Results and Discussion

Table-02 shows the results of iron content determined from the groundwater of the study area for two consecutive years. Iron concentration in samples varies from 0.03 to 1.5 mg/l. Seasonal variation was observed in samples. Higher values were recorded in summer may be due to decrease of water levels. Except L-02,L-03, L-06 rest of the samples registered lower amounts of iron concentration. Iron in ground water supplies is a common problem, while WHO recommended level is <0.3 mg/l. The iron occurs naturally in the aquifers but levels in ground water can be increased by dissolution of ferrous boreholes and hand pumps components. Iron dissolved in ground water is in the reduced iron(II) form. This form is soluble and normally does not cause any problem by itself .Iron (II) is oxidized to iron (III) on contact with oxygen in the air or by the action of iron related bacteria. Iron(III) forms are insoluble hydroxides in water.

Iron is generally present in organic waste and as plant debris in soil. Activities in the biosphere may have strong influence on the occurrence of the element in ground water. Higher iron concentration in the groundwater could result from interaction between oxidized iron minerals and organic matter or dissolution of $FeCO_3$. This type of water is clear when drawn but soon becomes cloudy and then brown by precipitation of $Fe(OH)_3$ (Hem 1991). Which is a common problem in some parts of the study area. The other reasons of higher concentration of the element may be removal of dissolved oxygen by organic matter within the sediments leading to reduced conditions. Under this condition the solubility of iron bearing minerals (Siderite/Marcacite) increases leading to enrichment of the dissolved iron in the ground water (White et al 1991, Applin and Zhao 1989) .Presence of clay layers above the aquifers of the study area promotes the development of reducing environment and therefore higher levels of the element in the ground water. Enrichment of Fe in all the seasons indicates the biological cycle and consequent leaching from top soil to the ground water.

Health Disorders

The use of contaminated ground water is highly objectionable as they cause health disorders. The reported health disorders in the study area are skin, digestive respiratory and nervous system, kidney, spinal code, heart, mental imbalance, miscarriage and cancer.

Management of Ground Water Quality

Management of groundwater quality is important aspect before one can speak about aim of water quality control and improvement. Monitoring of water quality is of crucial importance which is a part of water resources management especially in an area when the people depend upon the ground water for drinking. There is no groundwater quality monitoring network properly and systematic on regular basis for assessing the impact of pollutants on ground water system in the study area. Hence the present study emphasized the necessity of close monitoring of ground water quality with reference to land use/land cover activities to protect the ground water resources from the pollution for sustaining life. In this context environment awareness and education among the public are very essential for proper understanding about the water quality at different levels of management.

Conclusion

The present study carried out in Cuttack city of Odisha to assess the causes for the origin and distribution of iron content in the ground water. Spatial distribution of iron content indicates that the higher concentration of iron is observed at locations nearby municipal waste water due to inadequate sanitary facilities. This clearly suggests that the anthropogenic activities such as municipal waste water influence the eugenic processes. These factors degrade the ground water quality which is a persistence of environmental problem in the study area. Hence the pollution is the least checked perennial problem in the area.

Table-01 Locations of ground water sampling stations

Stations	Locations	Code No
1	Bus stand area	L-01
2	C.D.A area	L-02
3	Pattapolo area	L-03
4	Barabati area	L-04
5	Near S.C.B. medical college	L-05
6	Khapuria industrial area	L-06
7	Kalyani nagar area	L-07

Table-02 Seasonal variation of iron content in different locations

	Winter-11	Summer-11	Rainy-11	Winter-12	Summer-12	Rainy-12
Location-01	0.04	0.09	0.03	0.05	0.09	0.04
Location-02	1.1	1.5	1	1.2	1.5	1.1
Location-03	0.57	0.62	0.49	0.59	0.63	0.55
Location-04	0.38	0.51	0.36	0.4	0.52	0.38
Location-05	0.35	0.39	0.34	0.36	0.4	0.34
Location-06	0.67	0.69	0.66	0.69	0.7	0.67
Location-07	0.05	0.06	0.05	0.06	0.07	0.06

As a result the concentration of iron in some areas is crossing safe limit prescribed for drinking purposes causing the health disorders. The present study emphasized the necessity of close monitoring of ground water quality with reference to land use/land cover activities to protect the ground water resources from the pollution . we should take steps to remove iron from the ground water by aeration or by chemical dosing to comedown the iron level within standards i.e 0.3 mg/l.

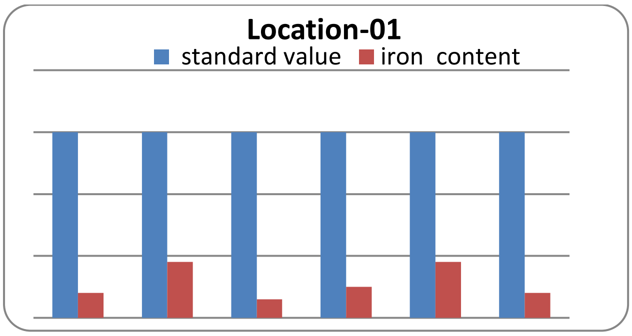
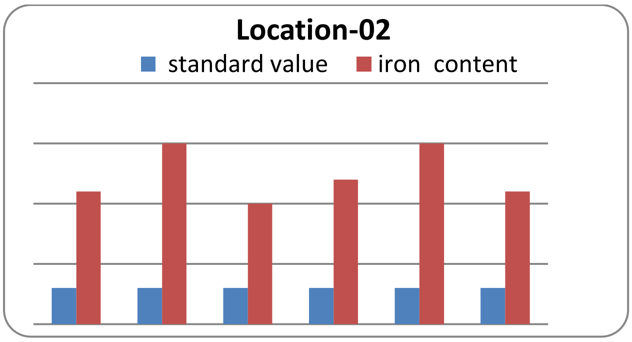


Fig-02



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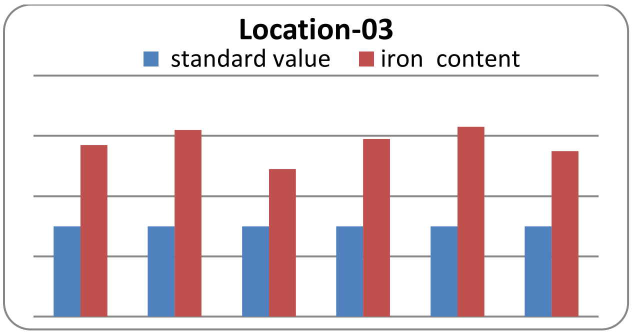
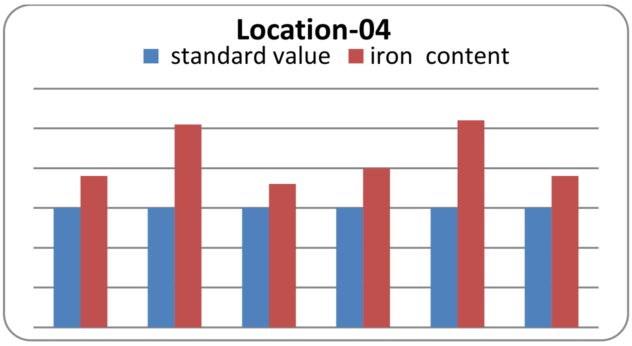


Fig-04



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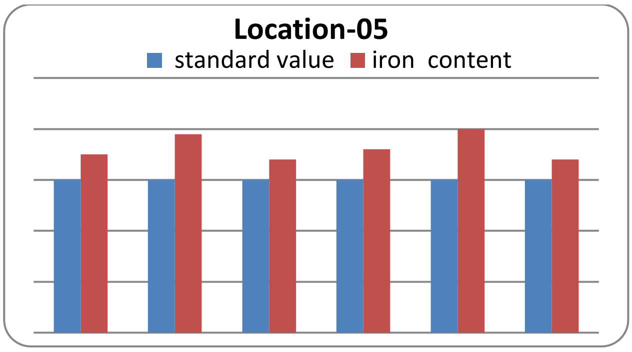

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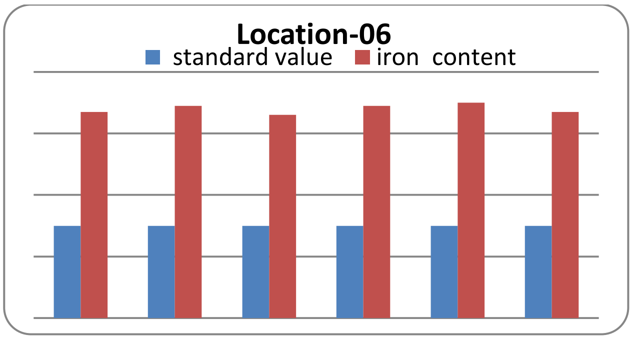

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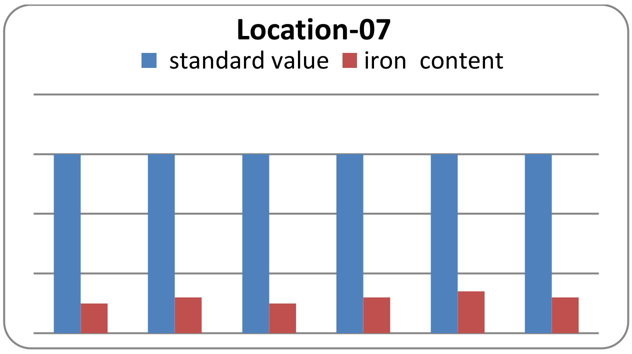

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