International Research Journal of Public and Environmental Health Vol.1 (8),pp. 170-174 ,October 2014
Available online at http://www.journalissues.org/IRJPEH/
http://dx.doi.org/10.15739/irjpeh.004

ISSN 2360-8803

Original Research Article

Iron in groundwater of Chandrapur city, central India

Accepted 24 October, 2014

R. K. Kamble

Centre for Higher Learning and Research in Environmental Science, Department of Environmental Science, Sardar Patel College, Chandrapur 442 402, India.

Author
E-mail: rahulkk41279@yahoo.com
Tel.:+919665499330

Iron concentration in groundwater was assessed in the Chandrapur city during summer season in 2014. Groundwater sampling was carried out from 22 sampling locations comprising of 11 sampling locations from bore well and 11 from hand pumps. Groundwater iron concentration was measured by Merck Aquaquant Iron Analysis Kit (Germany). The results revealed that groundwater iron concentration was in the range (SD) of 0-3.0 mg/L (± 0.75). Average iron concentration in groundwater in the study area from dug wells and bore wells was 0.34 mg/L. Total 22 groundwater samples analyzed, 15 (68.18%) samples had no iron. The groundwater iron concentration was detected in seven (31.81 %) samples. Out of these seven samples, five (22.72%) samples had iron concentration in groundwater above WHO Standards (1984) for drinking water (> 0.3 mg/L). Awareness amongst the individuals about the presence of iron in groundwater and development of low cost technology for removal of iron such as adsorption, absorption etc., is the need of the hour.

Key words: Central india, Chandrapur, groundwater, heavy metals, Iron

INTRODUCTION

Iron is the most abundant (by mass, 34.6%) element on the earth surface. The concentration of iron in various layers of the earth ranges from high at the inner core to about 5% in the outer crust. Most of this iron is found in various iron oxides, such as the minerals hematite, magnetite, and taconite. The earth's core is believed to consist largely of a metallic iron-nickel alloy. Iron is a non-volatile, lithohilic element. The iron cycle comprises weathering of rocks, which is necessary for water-mediated re-sedimentation (Burnner and Baccini, 1981).

Dissolved iron is mainly present as Fe $(OH)_2^+$ (aq.) under acidic and neutral, oxygen rich conditions. Under oxygen-poor conditions, it mainly occurs as binary iron. Iron concentration in river water was reported to be 40 µg/kg whereas in deep sea water it was 0.1 µg/kg (Wedepohil, 1991). In drinking water supplies, iron (II) salts are untraceable and are precipitated as insoluble iron (III) hydroxide, which settles out as a rust-coloured silt. Anaerobic groundwater may contain iron (II) at concentrations up to several milligrams per litre without discolouration or turbidity in water when pumped directly from a well, although turbidity and colour may develop in piped systems at iron levels above 0.05 - 0.1 mg/L (Department of National Health and Welfare, 1990).

Iron deficiencies lead to anaemia, causing tiredness, headache and loss of concentration. The immune system is also affected. In children this negatively affects mental development, leads to irritability and causes concentration disorders (FAO/WHO, 1988).

The average lethal dose of iron in human being is 200-250 mg/kg of body weight, but death has occurred following the ingestion of doses as low as 40 mg/kg of body weight (National Research Council, 1979). Autopsies have shown haemorrhagic necrosis and sloughing of areas of mucosa in the stomach with extension into the submucosa. Chronic iron overload results primarily from a genetic disorder (haemochromatosis) characterised by increased iron absorption and from diseases that required frequent transfusion. Adults have often taken iron supplements for extended periods without deleterious effects (Bothwell, 1979), and an intake of 0.4-1 mg/kg of body weight per day is unlikely to cause adverse effects in healthy persons (Finch and Monsen, 1972).

The Chandrapur district is bestowed with deposits of various minerals like coal, iron, limestone, clay, copper, chromium, etc. There are several mines in the Chandrapur district viz. coal, limestone, fluorite, chromium, fireclay, iron, copper, etc. The mineral based industrial development and rapid urbanization has resulted in environmental contamination and degradation and its effects are now being felt. The mining activities disturb the groundwater balance. The study strives to acquire knowledge of the quality of groundwater with respect to iron concentration.

Study Area

The Chandrapur city is located on 19^{o}57' N latitude and 79^{o}18' E longitude in the Vidarbha region of Maharashtra state in Central India. It is situated at an altitude of 189.90 m above mean sea level (amsl). The city is located at southeast direction from Nagpur city, on the Delhi-Chennai railway route. The area of the city is about 70.02 sq km. The city is located on the bank of Erai River, another river flowing through the city is Zarpath. The northern part of the city is high and southern is low as per topographical map. The Gaontidev nullah is originating from the upland of Chandrapur Super Thermal Power Station (CSTPS). The Mucchi nullah is originating from the upland of Ranger College. This nullah is merging with the Ramala Lake which is located in the heart of the city. The average annual rainfall is about 1420 mm.

MATERIALS AND METHODS

Groundwater sampling from Chandrapur city was carried out by grab sampling method in the month of May 2014 (summer season). Total 22 representative groundwater samples from hand pumps and bore wells from various parts of the city were collected in a pre-cleaned, dry, one litre capacity polythene bottles. Out of these 22 groundwater samples; 11 samples were from hand pumps and equal number from bore wells. Before taking water sample, hand pumps and bore wells were pumped for five minutes to avoid stagnation of sampling water in the hand pump or bore well pipe. At the time of flow of water from hand pump or bore well, internal pipe structure of the outlet was cleaned with the help of figures so as to remove any solids or foreign material adhered to its inner surface. Groundwater samples were collected in pre-cleaned, 1000 mL polythene bottles. The polythene bottles were rinsed with hand pump or bore well water first and then water sample was filled in it. The water sample was collected up to the rim of the sampling bottle so as to avoid entry of any atmospheric gases into it and thus altering its physico-chemical properties. The sampling bottles were marked with sampling location details and its cap was sealed with the help of an adhesive tape so as to avoid entry of any contaminant in it. Water quality parameters such as pH and conductivity were measured in the field itself by using water analysis kit (Deluxe Water And Soil Analysis Kit, Model 172) and temperature by mercury thermometer (Gera, GIT, India). Latitude, longitude and altitude of sampling site were collected with the help of a hand held GPS (Map My India Navigator). These details were also recorded in the field book. Relevant data with respect to hand pump/bore well depth, year of installation, usability, availability of water were also collected from individuals of respective house/locality.

The groundwater samples were brought to the laboratory for further physico-chemical analysis. Iron in groundwater was estimated by using Merck Iron Analysis Kit (Merck, Aquaquant Iron Analysis Kit, range 0.25-15 mg/L, Germany).

RESULTS

Groundwater sampling in the study area was carried out for summer season in 2014 (May). The groundwater sampling locations and their geographical details viz. latitude, longitude and altitude are depicted in Table 1. Out of 22 sampling locations; 11 samples were from bore wells and equal number from hand pumps. The groundwater sampling locations altitude was in the range of 121 to 230 m amsl. The average altitude was 193.27 m amsl.

The temperature of groundwater samples in study area ranges between 29.5-32.5 ^{o}C and average temperature was 30.61 ^{o}C. Iron concentration in groundwater in study area is presented in Table 2. Out of these 22 groundwater sampling locations, in 15 (68.18 %) samples iron was absent; whereas in seven (31.81 %) water samples iron in groundwater was present. Out of these seven groundwater samples, four (18.18 %) water samples were from hand pumps and three (13.63 %) water samples were from bore wells. Maximum iron concentration in groundwater was observed in Babupeath (3.0 mg/L, BW). Out of these 22 groundwater samples, 17 (77.27 %) water samples had groundwater iron concentration within permissible limit as per WHO Standards (WHO, 1984) (< 0.3 mg/L); whereas in five (22.72 %) water samples it was above WHO permissible limit (> 0.3 mg/L). Two (9.09 %) water samples had iron concentration in the range of 0.1 to 0.3 mg/L; three (13.63 %) water samples in the range of 0.4 to 1.0 mg/L, one (4.54 %) water sample between 1.1 to 2.0 mg/L and 2.1 to 3.0 mg/L. The average iron concentration in groundwater was 0.34 mg/L. The standard deviation of iron concentration in groundwater was 0.75 and variance 0.57 (Table 3).

The average iron concentration in groundwater in study area was above the permissible limit of WHO Standard (WHO, 1984) for drinking water (< 0.3 mg/L). It was observed that groundwater iron concentration was found only at a particular area i.e. at the outskirt of Chandrapur-Mul road and Chandrapur-Ballarsha road. This may be due to the presence of Maharashtra Electrosmelt Limited (MEL)

Table 1: Details of groundwater sampling locations in study area

Samples Locations	Geographical Details			Groundwater Source
	Latitude (E)	Longitude (N)	Altitude (m)	
Sawari Bangla	79°17’29”	19°57’29”	196	HP
Ram Nagar	79°17’26”	19°57’41”	186	HP
Jagannath Baba Nagar	79°16’57”	19°57’50”	189	BW
Omkar Nagar	79°16’50”	19°57’27”	220	BW
Sister Colony	79°17’12”	19°57’21”	187	BW
Ghutkala	79°17’25”	19°57”00”	197	HP
Buradkar Moholla	79°17’31”	19°56’37”	180	HP
Ekori Ward	79°17’39”	19°56’52”	206	HP
Bombay Plot	79°19’16”	19°57’58”	202	HP
Chavhan Colony	79°18’33”	19°58’33”	230	BW
Sugat Nagar	79°18’22”	19°59’13”	195	BW
Shiv Nagar	79°17’53”	19°58’36”	222	BW
Vivek Nagar	79°18’20”	19°58’11”	201	HP
Wadgaon Ward	79°16’28”	19°58’29”	190	BW
Near BBC House	79°16’19”	19°59’06”	195	BW
Datta Nagar	79°17’03”	19°58’34”	189	HP
Aashtabhuja	79°19’10”	19°57’07”	121	HP
Ambedkar Nagar	79°19’17”	19°56’12”	220	HP
Babupeath	79°18’54”	19°56’18”	191	BW
Babupeath	79°18’59”	19°55’50”	206	BW
Indira Nagar	79°19’25”	19°58’00”	128	BW
Ganj Ward	70°18’00”	19°57’00”	201	HP

HP = Hand Pump, BW = Bore Well, Altitude (m) = above mean sea level

Table 2: Iron in groundwater in study area

Samples Locations	Groundwater Source	Temperature (°C)	Iron (mg/L)
Sawari Bangla	HP	30	Absent
Ram Nagar	HP	32.5	Absent
Jagannath Baba Nagar	BW	29.5	Absent
Omkar Nagar	BW	30.5	Absent
Sister Colony	BW	30.5	Absent
Ghutkala	HP	30.5	Absent
Buradkar Moholla	HP	30.5	Absent
Ekori Ward	HP	29.5	Absent
Bombay Plot	HP	31.5	Absent
Chavhan Colony	BW	31.5	Absent
Sugat Nagar	BW	32	Absent
Shiv Nagar	BW	30.5	Absent
Vivek Nagar	HP	30.5	Absent
Wadgaon Ward	BW	32	Absent
Near BBC House	BW	31	Absent
Datta Nagar	HP	30	0.25
Aashtabhuja	HP	30.5	0.5
Ambedkar Nagar	HP	30	1.0
Babupeath	BW	30.5	0.25
Babupeath	BW	30	3.0
Indira Nagar	BW	30	2.0
Ganj ward	HP	30	0.5

HP = Hand Pump, BW = Bore Well

in that particular area and the effluents of this industry may be percolating into groundwater and thus polluting groundwater with iron. However, to ascertain this more in-depth study is required.

On comparison of groundwater samples in which iron concentration was observed (seven samples) maximum

Table 3: Statistical summary of iron in groundwater in study area

Particulars	Details
Total groundwater samples analyzed	22
Groundwater samples from bore well	11 (50 %)
Groundwater samples from hand pump	11 (50 %)
Altitude (m amsl) Average (Range)	193.27 m amsl (121-230 m amsl)
Groundwater temperature (^{o}C) Average (Range)	30.61 ^{o}C (29.5-32.5 ^{o}C)
Groundwater samples in which iron present	7 (31.81 %)
Groundwater samples in which iron absent	15 (68.18 %)
Maximum iron concentration in groundwater	3.0 mg/L
Minimum iron concentration in groundwater	0.0 mg/L
Groundwater samples having iron concentration within permissible limits as per WHO Standards (1984) (< 0.3 mg/L)	17 (77.27 %)
Groundwater samples having iron concentration above permissible limits as per WHO Standard (1984) (> 0.3 mg/L)	5 (22.72 %)
Iron detected in groundwater in hand pump water samples	4 (18.18 %)
Iron detected in groundwater in bore well water samples	3 (13.63 %)
Iron concentration in groundwater between 0.1-0.3 mg/L	2 (9.09 %)
Iron concentration in groundwater between 0.4-1.0 mg/L	3 (13.63 %)
Iron concentration in groundwater between 1.1-2.0 mg/L	1 (4.54 %)
Iron concentration in groundwater between 2.1-3.0 mg/L	1 (4.54 %)
Average iron concentration in groundwater in the study area	0.34 mg/L
Range	0.0-3.0 mg/L
Standard deviation	0.75
Variance	0.57

iron concentration of 3.0 mg/L followed by 2.0 mg/L were observed from bore well samples (Babupeath and Indira Nagar) whereas from hand pump samples groundwater iron concentration ranged from 0.25 mg/L to 1.0 mg/L. Thus, from these observations it can be concluded that in deeper aquifers iron concentration was more (bore wells, in the range of 2.0-3.0 mg/L) as compared with shallower aquifer (hand pumps, in the range of 0.25 to 1.0 mg/L).

DISCUSSION

Spatial distribution of average iron concentration in groundwater in study area was 0.34 mg/L (summer 2014). Out of 22 groundwater samples analysed in study area, 15 samples had no iron in groundwater whereas seven had in the range of 0.25-3.0 mg/L.

The plausible reason behind the presence of iron in groundwater in study area may be due to the presence of Maharashtra Electrosmelt Limited (MEL) industry in the outskirt of study area (Chandrapur-Mul road) whose effluent discharge may be polluting groundwater aquifers in that particular area (Indira Nagar, Ashtabhuja and Babupeath). As other locations in study area viz. near BBC House, Wadgaon ward, Jagannath Baba Nagar and Omkar Nagar Erai River is present. The water of this river may dilute groundwater and thus there was no iron in groundwater. The presence of groundwater iron in study area can also be due to geogenic in origin which needs to be ascertained with further studies.

Creating awareness in society about presence of iron in groundwater and its adverse effects should be carried out by municipal corporation authorities and alternative safe drinking water should be made available to individuals from study area. The presence of iron in groundwater in study area which has prominently socially and economically weaker individuals and thus they may be not in a position to afford expensive water filtration devices, hence, an alternative low cost technology based on adsorption or absorption needs to be developed for removal of iron in groundwater which can be easily adopted by these local inhabitants.

REFERENCES

Bothwell TH, Charlton RW, Cook ID, Finch CA (1979). Iron metabolism in man. Oxford, Blackwell.

Brunner PH, Baccini P (1981). Forschung und Technik; Neue Zürcher Zeitung, No. 70, p 65 (25 March), Zürich, Switzerland.

Department of National Health and Welfare (1990). Nutritional recommendations. The report of the Scientific Review Committee. Ottawa, Canada.

FAO/WHO Report (1988). Requirement of vitamin A, iron, folate and vitamin B_{12}. Report of a joint FAO/WHO Expert

Consultation. Food and Agricultural Organisation of the United Nations, Rome (FAO Food and Nutrition Series, No. 23).

Finch CA, Monsen, ER (1972). Iron nutrition and the fortification of food with iron. J. Am. Med. Assoc., 219: 1462-1465.

National Research Council (1979). Iron. Baltimore, MD, University Park Press, U.S.A.

Wedepohil KH (1991). The composition of the upper Earth's crust and the Natural cycle of selected metals. Metals in natural raw materials. Natural resources. **In** Merian E (Ed.). Metals and their compounds in the environment: occurrence, analysis, and biological relevance (pp. 945-958). VCH Verlagsgesllschaft mbH, D-6940 Weinheim, Germany.

WHO (1984). Guidelines for Drinking Water Quality, Vol. 1, Recommendations.