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Assessment of Groundwater Quality and its Suitability for Drinking Uses in Warora tehsil, District Chandrapur, India

S.M.Deshapnde*, K.R. Aher and G.D.Gaikwad

Post Graduate Department of Geology, Institute of Science, Nipatnirnjan Nagar, Caves road, Aurangabad (MS) INDIA

*Corresponding Address:

dr_smd@rediffmail.com

Research Article

Abstract: In order to evaluate the quality of groundwater in study area for its suitability for drinking purposes, sixty groundwater samples were collected during pre-monsoon period of the year 2011 and analyzed for various parameters. Physical and chemical parameters of groundwater such as electrical conductivity, pH, total dissolved solids, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, CO_3^{2-}, HCO_3^{-} and SO_4^{2-} , NO_3^{-}, PO_4^{-}, and F^{-} were determined. The value of TDS, Cl^{-} and SO_4^{-} ion concentration is within the limits in majority of the samples. The excess amount of Ca^{++}, Mg^{++}, TH and NO_3^{-} and F^{-} in the groundwater is due to anthropogenic factors and geological characteristics of the aquifer. Assessment of groundwater samples indicated that groundwater in study area is chemically not suitable for drinking uses. Total hardness (25%), Calcium (59%), Magnesium (13%), fluoride (50%) and nitrate (17 %) are crosses the maximum permissible limits for human consumption as per the drinking water standards.

Keywords: Groundwater Quality, drinking water, Warora, Fluoride

Introduction:

Groundwater is a vital source of clean drinking and irrigation water. This is increasingly the case due to the effects of population growth and climate change, which are causing severe stress to surface water supplies in these areas (Edmunds 2003; Shanmugam & Ambujam, 2011). Groundwater is the major source of water for domestic, agricultural and industrial purposes in many countries. India accounts for 2.2% of the global land and 4% of the world water resources and has 16% of the world's population. It is estimated that approximately one third of the world's population use groundwater for drinking (Nickson et al. 2005). Therefore, water quality issues and its management options need to be given greater attention in developing countries. Intensive agricultural activities have increased the demand on groundwater resources in India. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices (Ramesh & Elango, 2011). The chemical composition of groundwater is controlled by several factors that include composition of precipitation, anthropogenic activities, geological structure and mineralogy of the watershed and aquifers and geological processes within the aquifer medium (Andre et al. 2005). Chemistry of groundwater is an important factor determining its use for domestic and irrigation purposes. Interaction of groundwater with aquifer minerals through which it flows greatly controls the groundwater chemistry. Hydrogeochemical processes that are responsible for altering the chemical composition of groundwater vary with respect to space and time. The hydrogeochemical processes of the groundwater system help to obtain an insight into the contributions of rock and soil–water interaction and anthropogenic influences on groundwater. These geochemical processes are responsible for the spatiotemporal variations in groundwater chemistry (Matthess 1982; Kumar et al. 2006). Groundwater chemistry, in turn, depends on a number of factors, such as general geology, degree of chemical weathering of the various rock types, quality of recharge water and inputs from sources other than water–rock interaction (Domenico 1972; Schuh et al. 1997; Toth 1984; Nosrat and Mogaddam, 2010; Singh Kuldip et al.2011). The quality of ground water is the resultant of all the processes and reactions that have acted on the water from the moment it condensed in the atmosphere to the time it is discharged by a well. Therefore, the quality of ground water varies from place to place, with the depth of water table, and from season to season and is primarily governed by the extent and composition of dissolved solids present in it. Worldwide, aquifers are experiencing an increasing threat of pollution from urbanization, industrial development, agricultural activities and mining enterprises. In recent years, an increasing threat to ground water quality due to human activities has become of great importance (Ravikumar and Somashekar., 2010; Deshpande and Aher, 2011,2012; Aher K.R., 2012; Reddy et al, 2012). The objective of this study is to determine the groundwater quality is suitable or unsuitable for drinking purpose with special emphasis on fluoride concentrations.

Material and methods

To assess the groundwater chemistry, a total of 60 groundwater samples were collected from the study area. The samples were collected in sterilized polythene bottles and prior to sampling all the sampling containers were washed and rinsed with the groundwater. Then they were sealed and brought to the laboratory for analysis. The analyses were done, using standard procedures recommended by the American Public health Association (APHA,1992) and Trivedi and Goel (1984).

Results and Discussion

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being. Though many ions are very essential for the growth of human, but when present in excess, have an adverse effect on human body. Groundwater quality assessment was carried to determine its suitability in terms of drinking purposes, the hydro chemical analysis of groundwater samples is presented in (Table 1). The physical and chemical parameters of the analytical results of groundwater were compared with the standard guideline values recommended by the BIS (1991) and WHO (1993) for drinking and public health purposes. Table. 2 show the maximum desirable and most allowable limits for various parameters.

Table. 1 Physicochemical analysis summary of groundwater samples in the study area

Sr. No	Parameter	Unit	Maximum (N=60)	Minimum	Average
1	pH		8.55	7.14	7.83
2	EC	µs/cm	1580	250	768.33
3	TDS	mg/L	1027	162.5	499.42
4	Ca++	mg/L	740	32	264.53
5	Mg++	mg/L	220	10	58.82
6	Na+	mg/L	760	35	134.10
7	K^+	mg/L	25	1	3.02
8	HCO_3^-	mg/L	800	60	443.83
9	SO_4^-	mg/L	546	32	168.87
10	Cl^-	mg/L	1221.2	49.7	284.26
11	F^-	mg/L	4.7	0.56	1.75
12	NO_3^-	mg/L	84	7	37.87
13	PO_4^-	mg/L	5.95	0.1	0.56
14	TH	mg/L	952	30	428.20

Table 2 Quality of groundwater in part of Warora district Chandrapur

Sr. No	Parameter	<DL %	>DL<MPL %	>MPL %
1	TH	32	43	25
2	Ca++	3	38	59
3	Mg++	25	62	13
4	TDS	60	40	-
5	Cl^-	58	40	2
6	SO_4^-	63	29	8
7	NO_3^-	-	83	17
8	F^-	7	43	50

DL = Desirable limit MPL = Maximum permissible limit

pH is one of the important factor of ground water. The pH of groundwater water sample varies from 7.14 to 8.55 (Table 1). The pH values of all samples are well within the limits prescribed by BIS (1991) and WHO (1993). Conductivity is the measure of capacity of a substance to conduct the electric current. Most of the salts in water are present in their ionic forms and capable of conducting current and conductivity is a good indicator to assess groundwater quality. The conductivity of groundwater sample ranged from 250 to 1580 µ/mhos/cm (Table 1). TDS is the concentrations of all dissolved minerals in water indicate the general nature of salinity of water. Concentration of dissolved solids is important parameter in drinking water. To ascertain the suitability of the groundwater for any purpose, it is essential to classify the groundwater depending upon its hydrochemical properties based on the total dissolved solids (TDS) values (Freeze and Cherry 1979). The Total Dissolved Solids ranged from 163 to 1027 mg/L (Table 1). In natural waters, dissolved solids consists mainly of inorganic salts such as carbonates, bicarbonates, Chlorides, sulphates, phosphates, and nitrates of calcium, magnesium, sodium, potassium, iron, etc., and a small amount of organic matter and dissolved gases. In the present study, about 60% of the samples were found within the desirable limit of 500 mg/L while about 40% of the samples were found above the desirable limit but well within the maximum permissible limit of 2,000 mg/L (Table, 2), TDS in ground water originate from natural sources, sewage, urban run-off and industrial wastes. Calcium is naturally present in water. It may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is a determinant of water hardness; Calcium is present in various construction materials, such as cement, brick lime and concrete. The presence of calcium in drinking water is natural geological source, industrial waste, mining by products and agricultural wastes. The calcium content of ground water showed variation from 32 to 740 mg/L (Table 1). The desirable limits for calcium for drinking water are 75 mg/L (BIS 1991). In ground water of the study area, about 3% of the samples of the study area fall within the desirable limit of 75 mg/L for calcium and 38 % of the samples exceed the desirable limit but are well within the permissible limits 200 mg/L and 59% of the samples exceed permissible limits prescribed for drinking water (Table 2). A large number of minerals contain magnesium; Magnesium is washed from rocks and subsequently ends up in water. Magnesium has many different purposes and consequently may end up in water in many different ways. Chemical industries add magnesium to plastics and other materials as a fire protection measure or as filler. It also ends up in the environment from fertilizer application and from cattle feed. The values of magnesium from groundwater ranged between 10 to 220 mg/L (Table 1). The desirable limits limit for this parameter in drinking 30 mg/L and 100 mg/L is maximum permissible limit, 13% of the sample in the study area exceeds the maximum permissible limit prescribed BIS (1991). Total Hardness is considered as a major character of drinking water. Hardness is defined as the concentrations of calcium and magnesium ions. Calcium and magnesium are dissolved from most soils and rocks. The hardness of natural waters depends mainly on the presence of dissolved calcium and magnesium salts. The values of total hardness of ground water varied from 30 to 952 mg/L (Table 1). The high degree of hardness in the study area can definitely be attributed to the disposal of untreated, improperly treated sewage and industrial wastes. A limit of 300 mg/L has been recommended for potable water. As evident from the results, about 32% of the samples fall within the desirable limit of 300 mg/L, 43 % is above desirable limit but below permissible limit and remaining 25 % of the samples exceeds the maximum permissible limit of 600 mg/L (BIS 1991) (Table 2). Chloride ions are generally present in natural waters and its presence can be attributed to dissolution of salts. Chloride originates from sodium chloride which gets dissolved in water from rocks and soil. It is good indicator of groundwater quality and its concentration in groundwater will increase if it mixed with sewage or sea water. The chloride content of ground water varied from 50 to 1221 mg/L (Table 1), As evident from the results, about 58% of the samples fall within the desirable limit, 40 % is above desirable limit but below permissible limit and only 2 % of the samples exceeds the maximum permissible limit of 1000 mg/L (BIS 1991) (Table 2). Alkalinity is the measure of the capacity of the water to neutralize a strong acid. The Alkalinity in the water is generally imparted by the salts of carbonates, silicates, etc. together with the hydroxyl ions in free State. Most of the natural waters contain substantial amounts of dissolved carbon dioxide, which is the principal source of alkalinity. The bicarbonate alkalinity (HCO_3^-) content of the ground water ranged from 60 to 800 mg/L (Table 1). Sodium is the sixth most abundant element in the Earth's crust and sodium stems from rocks and soils. Not only seas, but also rivers and lakes contain significant amounts of sodium. Concentrations however are much lower, depending on geological conditions and waste water contamination sodium compounds serve many different industrial purposes, and may also end up in water from industries. The sodium (Na^+) content of the groundwater ranged from 35 to 760 mg/L (Table 1). Potassium is an essential element for humans, plants and animals, and derived in food chain mainly from vegetation and soil. The main sources of potassium in ground water include rain water, weathering of potash silicate minerals, use of potash fertilizers and use of surface water for irrigation. The European Economic Community (EEC) has prescribed the guideline level of potassium at 10 mg/L in drinking water. The potassium (K^+) content of the groundwater ranged from 1 to 25 mg/L (Table 1). As per EEC criteria, only 3% the samples of the study area exceeds the guideline level of 10 mg/L. The sulphate content in groundwater generally occurs as soluble salts of calcium, magnesium and sodium. The sulphate (SO_4^-) content of the groundwater ranged from 32 to 546 mg/L (Table 1). About 63% of the samples of the study area fall within the desirable limit of 200 mg/L, 29% the samples exceed the desirable limit but are well within the permissible limits and remaining 8% of the samples exceed the permissible limits 400 mg/L prescribed for drinking water prescribed by BIS (1991) and WHO (1993) (Table,2). Phosphorous is an essential plant nutrient and is extensively used as fertilizers. Phosphate gets adsorbed or fixed as aluminum or iron phosphate in acidic soils or as calcium phosphate in alkaline or neutral soils; as a result, the concentration of phosphate in ground water is usually low, but various chemical processes in soil strata may induce the mobility of phosphate in sub-soil and ground water.

The phosphate (PO_4^-) content of the groundwater ranged from 0.10 to 5.95 mg/L (Table 1). The Nitrate (NO_3^-) content of the ground water ranged from 7 to 84 mg/L (Table 1), from the study its indicate that about 83 % is below desirable limit and remaining 17% of the samples exceeds the maximum permissible limit given by (BIS 1991) (Table 2). High concentration of nitrate has undesirable effects when present in drinking water. High concentrations of nitrates can cause methemoglobinemia, gastric cancer, goiter, birth malformations, and hypertension (Majumdar and Gupta 2000, Bhardwaj and Singh, 2010). Fluorine is one of the most abundant trace elements in the earth's crust and occurs in natural waters in concentrations depending on the geological setting (Brunt et al. 2004; Jha et al. 2008). High dissolved fluoride concentrations can be found in various geological settings, among them typically crystalline i.e. igneous and metamorphic rocks (Ozsvath, 2006). When drinking water exceeds the guideline value of 1.5 mg/L, there is an increasing risk of dental and skeletal fluorosis, which makes this element of great health concern in many regions (Harrison 2005; Mohapatra et al. 2009; Berger et al.2012). Fluoride (F^-) is an essential element for maintaining normal development of teeth and bones, but higher concentration causes fluorosis problems. The Fluoride (F^-) content of the ground water ranged from 0.56 to 4.7 mg/L (Table 1), As evident from the results, about 7% of the samples fall within the desirable limit of 1 mg/L, 43% of the samples exceeds the desirable limit of 1 mg/L but is well within the maximum permissible limit of 1.5 mg/L and 50% of the samples exceeds the maximum permissible limit prescribed by (BIS 1991), (WHO1993) (Table 2).

Conclusion

When data was compared with water quality standards, it was revealed that in majority of samples parameter like Ca^{++}, Mg^{++}, TH, NO_3^- and F^- exceeded the highest desirable limits prescribed by WHO (1993) and BIS (1991) for drinking water is due to anthropogenic factors and geological characteristics of the aquifer. Assessment of water samples from various methods indicated that groundwater in study area is chemically not suitable for drinking uses. Total hardness (25%), Calcium (59%), Magnesium (13%), fluoride (50%) and nitrate (17 %) are crosses the maximum permissible limits for human consumption as per the drinking water standards.

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