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Potability Studies of Drinking Water in Villages of Aundha, Hingoli District, Maharashtra, India

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ABSTRACT

Iron is an essential trace metal, required as a constituent of oxygen carrying and oxidative-reductive micro-molecules such as haemoglobin, myoglobin and cytochrome. Amongst various components, iron is an important trace metal required for all biological systems. Owing to the universal presence of fluoride in earth's crust, all waters contain fluoride in varying concentrations. Fluoride is an element of high biological activity and has a tendency to accumulate in organisms, making detrimental effects in very low and high levels of exposure. Inorganic nitrogen may exist in the free state as nitrogen gas, or as nitrate, nitrite or ammonia. Nitrate represents the highest oxidized form of nitrogen. Many groundwaters have significant quantities of nitrates due to leaching of nitrate with the percolating water. Iron, fluoride and nitrate concentration along with temperature and colour, in the drinking water from some villages of Aundha taluka of Hingoli District were studied monthly during January to June 2005. The samples were analysed with standard methods and observed results were compared with prescribed limits set by WHO and ICMR.

INTRODUCTION

A reliable and safe water supply is an essential base for development and stability. A report from World Health Organization (WHO) said that "all other things being equal, a safer and adequate water supply is directly associated with a more healthier and prosperous population" (WHO 1994). Groundwater, as a source of drinking and domestic use, is more important in rural and tribal areas than cities, because most times it is the only source available. Most of the rural people still live in absolute poverty and often lack access to clean drinking water and basic sanitation. Nearly half of the population is illiterate, not at all aware of the waterborne diseases affecting their health. Seventy percent of the infectious diseases in India are waterborne. Indian villages are posed with problem of overexploitation of groundwater due to increasing dependence on it as other freshwater resources are dwindling fast. The poor rural infrastructure having no systematic provision of sewage, unplanned growth, unorganized land-use and no drainage system further compound the groundwater quality concerns.

Iron is one of the most abundant elements of rocks and soil. Groundwaters have appreciable quantities of iron, have more solubility at acidic condition, therefore, large quantities of iron are leached out from the soils. In groundwaters, most of the iron remains in ferrous state due to general lack of oxygen. Although iron has got little concern as health hazard, but is still considered as nuisance in excessive quantities. Iron in excess of 0.3 mg/L causes staining of clothes and utensils. The higher concentration of iron is also not suitable for processing of food, beverage and bleaching. The limits on iron in water are based on aesthetic and test consideration rather than its physiological effect (Trivedy & Goel 1986). Iron is essential to nearly all known organisms. It is mostly stably incorporated inside of metalloproteins. In exposed or in free form it causes production of free radicals which are generally toxic to cells. Iron binds virtually to all biomolecules so it will adhere nonspecifically to cell membranes, nucleic acids, proteins, etc. Iron distribution is heavily regulated in mammals, both as a defence against bacterial infection and because of the potential biological toxicity of iron.

In small doses fluoride has remarkable influence on the dental system by inhibiting dental caries, but in higher doses it causes dental and skeletal fluorosis. A report of Central Pollution Control Board (1995) discloses similar facts. In India 62 million people including 6 million children are affected by fluoride related health diseases. Excess fluoride in groundwater is reported from 17 States. According to a latest estimate from UNICEF, fluorosis is endemic in at least 25 countries across the globe. This problem is most severe in the two largest countries of the world, India and China (UNICEF 2006).

Nitrate generally occurs in trace quantities in surface water but may attain high levels in some groundwaters. In excessive amounts, it contributes to an illness knows as methaemoglobinaemia in infants. A limit of 40 mg NO_3-N /litre has been imposed on drinking water to prevent this disorder. It is an essential nutrient for many photosynthetic autotrophic organisms, and in some cases has been identified as a growth limiting nutrient (Ramesh & Anbu 1996). The most important source of nitrate is biological oxidation of organic nitrogenous substances. Atmospheric nitrogen fixed into nitrates by the nitrogen fixing organisms is also a significant contributor to nitrates in waters. Many groundwaters have significant quantities of nitrates due to leaching of nitrate with the percolating water. Groundwater can also be contaminated by sewage and other wastes rich in nitrates (Trivedy & Goel 1986).

STUDY AREA

Hingoli is situated at the northern part of Marathwada in Maharashtra, at northe-western side of Nanded district. Latitude of Hingoli district is 19.43 N and Longitude is 77.11 E. Aundha is one of the five talukas in Hingoli district (Fig. 1). It is situated in the north side of the district. The climate of the region is generally dry except during southwest monsoon. The annual rainfall is around 750-900 mm and temperature in summer may go up to 42°C. The soil is black cotton in this region. The land region of this area (Marathwada region) comprises of a well-exposed assemblage of Deccan trap and granite intrusive formations. The deccan trap formations constitute compact, massive and vesicular basalt. The top of the rocks are weathered as murum and black cotton soil. The land is used primarily for agricultural and irrigation. The recharge from rainfall takes place about 12-14 percent for vesicular and jointed basalt, and 6-8 percent for weathered basalt from normal rainfall besides recharge from other sources (Jadhav 1998).

To check the potability of groundwater, samples were selected from highly populated major villages. The selected samples were collected from the tube wells and bore wells near the human settlements, domestic sewage, water logging and agricultural runoff areas to find the effect of these sources on the groundwater. The villages and their population are shown below.

Name of the village	Population	Name of the village	Population
1) Shirad Shahapur	6738	5) Dewala	1281
2) Pimpaldari	3313	6) Nishana	1217

3) Daudgaon	1682	7) Kanjara	1171
4) Nageshwadi	1673	8) Rameshwar	1146

MATERIALS AND METHODS

The samples from selected villages were analysed for iron, fluoride, nitrate, temperature and colour. The water samples were collected from tube wells and bore wells having an average depth of more than 150 ft. Samples were analysed monthly for six months during (January to June 2005) and the mean values were considered. Collection of samples was done as per the guidelines by APHA (1995) and Trivedy & Goel (1986). Clean pet bottles were used for sample collection. Temperature was recorded at the spot by ordinary thermometer and colour by visual appearance. The samples were brought to the laboratory and analysed on the same day by standard methods (APHA 1995, Trivedy & Goel 1986).

Iron content was estimated by 1,10-phenonthroline spectrophotometric method. All the iron is converted into ferrous state by boiling with hydrochloric acid and hydroxylamine. The reduced iron chelates 1,10-phenonthroline at pH 3.2 to 3.3 to from a complex of orange-red colour. The intensity of this colour is proportional to iron concentration and can be determined spectrophotometrically. The fluoride present in the samples was estimated by SPANDS spectrophotometric method. Fluoride ions change the colour of zirconium SPANDS (sodium2-(p-sulphophenylazo)-1,8-dihydroxy-3-6-naphthalene disulphonate) complex and the colour change is proportional to the fluoride ion concentration. The nitrate was measured by using the phenol disulfonic acid method. In this method nitrate reacts with phenol disulfonic acid to form a nitro derivative. The concentration of nitrates was determined spectrophotometrically.

RESULTS AND DISCUSSION

The iron, fluoride and nitrate concentration estimated from the samples collected from different sources are given in Table 1 and Fig. 2.

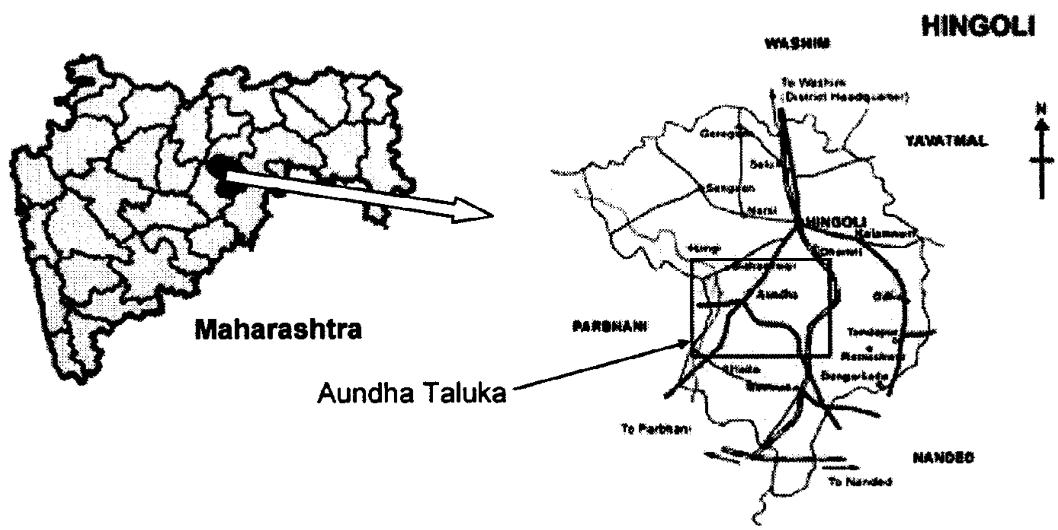

Fig. 1: Map showing Hingoli district and the study area.

Minimum temperature (34°C) was recorded from Nageshwadi village, and maximum temperature (37°C) from Pimpaldari, Daudgaon, Dewala and Rameshwar villages. Temperature is regarded as one of the relevant parameters. It is obvious from the results that seasonal changes in groundwater are temperature dependent. Isaiah et al. (2003) studied groundwater quality of Salem district, Tamil Nadu and reported the temperature values varying from 25 to 39°C. Gupta & Deshpande (2003) studied groundwater quality in Bhavnagar in Gujarat. They examined a total of 18 samples, which showed temperature range of 30-40°C in September 2000, 28-31°C in January 2001 and 28-40°C in March 2001. Temperature variation in groundwater of Nagpur City (Maharashtra) was observed by Shelke et al. (2002). The above temperature values were found in accordance with the present study.

The level of iron was found to be lesser than WHO standards (0.3 mg/L) but slightly higher than ICMR standard (0.1 mg/L). If iron exceeds 0.3 mg/L, it causes staining of cloths and utensils. The water is also not suitable for processing food, beverage, ice, dyeing, bleaching etc. The limits on iron

Table 1: Values of various physico-chemical parameters in the studied waters.

Village	Temperature	Colour	Iron (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
1. Shirad Shahpur	35.0	Colourless	0.14	0.64	115.00
2. Pimpaldari	37.0	Colourless	0.17	1.70	15.60
3. Daudgaon	37.0	Colourless	0.17	1.64	12.20
4. Nageshwadi	34.0	Colourless	0.17	1.70	6.30
5. Dewala	37.0	Colourless	0.21	1.64	2.70
6. Nishana	36.0	Colourless	0.09	1.57	4.50
7. Kanjar	35.0	Colourless	0.04	1.70	23.00
8. Rameshwar	37.0	Colourless	0.26	1.89	2.70

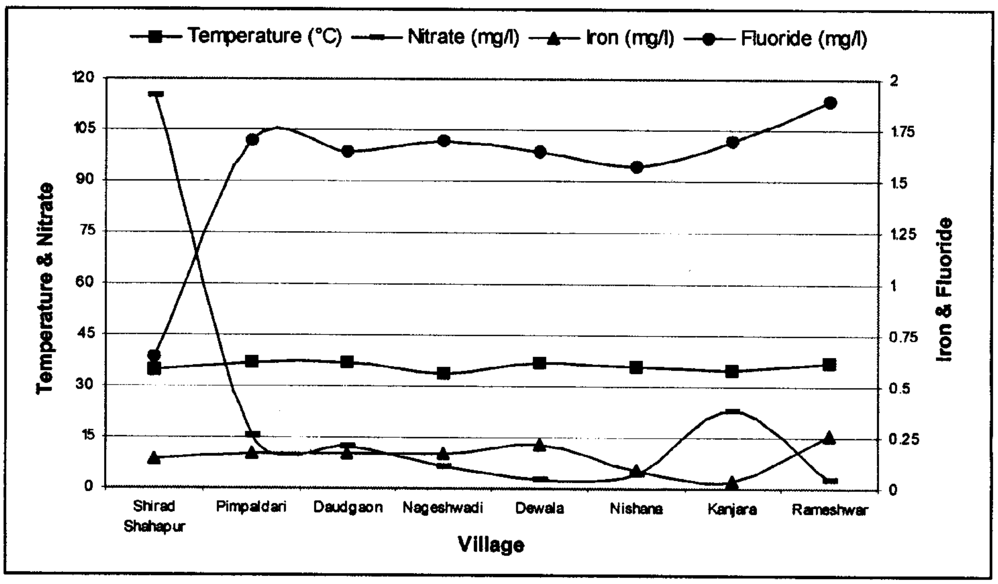

Fig. 2: Various physico-chemical parameters in the studied waters.

in water are based on aesthetic and taste considerations rather than its physiological effects (Trivedy & Goel 1986). Concentration of iron in Assam and U. P. ranges from 1.16 to 8 mg/L and 0.31 to 0.34 mg/L respectively (Siby & Sarmah 1997). The present results are much higher than those in the Assam region and lesser than those in the U. P. region. Seasonal changes in groundwater quality in Gwalior were assessed by Sharma & Mathur (1995), they reported the iron content from 0.128 to 0.398 mg/L, which is quite similar to the present results. The mean concentration of iron varies from 0.12 to 3.339, 0.008 to 1.882 and 0.14 to 1.97 mg/L at industrial, commercial and residential sites respectively. Iron content in the present results is found similar to that of residential sites.

The fluoride level of water samples was found to be varied between 0.64 and 1.89 mg/L, which is higher than the prescribed permissible limit (1 mg/L) set by WHO (2004) and ICMR (1975). Minimum concentration of fluoride was observed in the village Shirad Shahapur (0.64 mg/L), while rest of the villages have more than 1 mg/L. However, the absence of any symptoms of fluorosis among children and adults in this area is an indication that this is not a serious problem of water pollution.

Fluoride content of groundwater of Malaprabha sub-basin, Belgaum (Karnataka) was studied and it was observed that fluoride level fluctuates between 0.55 and 2.80 mg/L for pre-monsoon, and 0.20 to 2.75 mg/L for post-monsoon seasons (Varadarajan & Purandara 2003). Groundwater of Parbhani city (Maharashtra) was analysed for fluoride content and results range from 0.20 to 2.42 mg/L among 48 bore well water samples tested (Gaikwad et al. 2002). The present results are comparatively lesser than these results. Presence of fluoride in groundwaters poses a great problem in most of the States of India (Muralidharan et al. 2002, Susheela 2001).

The nitrate concentration was found to be quite high (115 mg/L) in Shirad Shahapur village, while the minimum concentration (2.70 mg/L) was found in Dewala and Rameshwar villages. A survey of the literature reveals that excess nitrate intake and gastric cancer risk was observed by Armigo & Coulson (1975) and Breimer (1982) during their study at Colombia (USA), Chile (South America), Japan and Iran. Scragg et al. (1982) reported on the basis of their study in Australia that elevated nitrate level in groundwater (drinking water) may lead to prenatal death. Arbuckle et al. (1988) observed that there is a small risk of delivering an infant with central nervous system disorders for mothers consuming water containing high nitrate. The nitrate content in the groundwater of Agra city was reported to be ranging from 9.36 mg/L (summer) to 47.24 mg/L (monsoon) as reported by Singh et al. (2000). Robertson et al. (1991) observed that nitrate contamination in India was due to human and animal waste, industrial effluents, use of fertilizers and chemicals, and especially due to seepage of sewage and sullage through drainage system. The standard limit for nitrate is 45 mg/L (WHO) and 20 mg/L (ICMR) in drinking water. All samples were found to be within the limit except one.

Temperature and colour were observed within the standards prescribed by WHO, whereas iron was observed slightly higher than the WHO standard. Fluoride was observed higher than the permissible limit. Nitrate was observed much lesser than the limits set by WHO except one sample (i.e. Shirad Shahapur). The overall results indicate that the water can be used for drinking and domestic purposes. The people living in this area have to be advised to use water from this source after mixing with water from nearby sources with less content of fluoride so that fluoride intake through drinking water will be minimized. It is further advised to the residents of Shirad Shahapur that not to use the water for drinking until the contamination of water from sewage and domestic waste stops.

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