Geochemical studies of fluoride and other water quality parameters of ground water in Dhule region Maharashtra, India

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Abstract

This study has been carried out to find out the water pollutants and to test the suitability of water for drinking and irrigation purposes in Dhule and surrounding areas in Maharashtra State in India. The analysis was carried out for the parameters pH, DO (dissolved oxygen), BOD (biological oxygen demand), Cl−, NO3−, F−, S^{2}−, total alkalinity, total solid, total dissolved solids (TDS), total suspended solids (TSS), total hardness, calcium, magnesium, carbonate and noncarbonate hardness, and concentrations of calcium and magnesium. These parameters were compared against the standards laid down by World Health Organization (WHO) and Indian Council of Medical Research (ICMR) for drinking water quality. High levels of NO_3−, Cl−, F−, S^{2}−, total solid, TDS, TSS, total hardness, magnesium and calcium have been found in the collected samples. From these observations, it has been found that fluoride is present as per the permissible limit (WHO 2003) in some of the villages studied, but both fluoride and nitrate levels are unacceptable in drinking water samples taken from several villages in Dhule. This is a serious problem and, therefore, requires immediate attention. Excess of theses impurities in water causes many diseases in plants and animals. This study has been carried out to find out the water pollutants and to test the suitability of water for drinking and irrigation purposes in Dhule and surrounding areas in Maharashtra.

Key words: Dhule, fluoride, ground water, nitrate, surface water

INTRODUCTION

Ground water comes into contact with various minerals which are soluble in water to varying degrees. The dissolved solutes determine the usefulness of water for various purposes. Ground and surface water attain their chemical characteristics by chemical reactions with solids, i.e., soil sediments and sedimentary rocks.[1] Water being a very good solvent dissolves all kind of impurities (solids, liquids, and gases). Impurities may be organic or inorganic, which is dissolved further. Suspended or colloidal organic impurities are obtained from decomposition of plants and animals, particles suspended in water such as clay, silt, sand, and other solid particles, which absorb or reflect light turbidity.[2] Excess of these impurities causes pollution of water or make it unsafe for drinking purposes including heavy metals like Fe, Mn, Cu, and Zn as well as fluoride, nitrates, and chloride. Their excess in water causes many diseases in plants and animals. This study has been carried out to find out the water pollutants and to test the suitability of water for drinking and irrigation purposes in Dhule and surrounding areas in Maharashtra.

MATERIALS AND METHODS

Experimental

Water samples were collected in polythene bottles as per the standard procedure from few villages in Dhule. Sample bottles were well-washed with distilled water, dried and were stored in refrigerator at 4°C till the analyses were completed. The physicochemical parameters like temperature, pH, dissolved oxygen, total dissolved solid, and alkalinity were analyzed using portable kits at the sampling sites, and rest of the parameters were done following the standard methods APHA (American Public Health Association).[2-4] Distilled

water and analytical reagent grade chemicals were used wherever required.

RESULTS AND DISCUSSION

The results of physicochemical characteristics are depicted in Tables 1 and 2. The decrease and increases in the temperature of the samples analyzed might be due to the low water level, low velocity, atmospheric conditions, and greater solar radiation. The pH values of the samples analyzed were recorded in the range from 7.5 to 8.3, which shows that the samples are alkaline in nature. The dissolved oxygen concentration of samples varied from a minimum of 1.6 mg/l to maximum of 7.3 mg/l. BOD value in the samples ranges from valid 0 to 5.9 mg/l. this difference might be due to the difference in the biological activity at different temperature and strength of the waste.[5]

The values of alkalinity in water samples varied from a minimum of 100 mg/l to maximum of 510 mg/l. Calcium concentration in the samples ranged from 12 to 72 mg/l and magnesium concentration in the samples ranged from 8.9 to 53 mg/l. Calcium is naturally present in water. It may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite, and apatite. The significant increase in the calcium and magnesium concentration might be due to the fact of high evaporating rate or due to the increased rate of decomposition.[6] Calcium is a dietary mineral present in the human body of an amount of about 1.2 kg. No other element is more abundant in the body. Calcium phosphate is a supporting substance, and it causes bone and tooth growth, together with vitamin D. Calcium is also present in muscle tissue and in the blood. It is required for cell membrane development and cell division, and it is partially responsible for muscle contractions and blood clotting. Calcium regulates membrane activity, it assists nerve impulse transfer and hormone release, stabilizes the pH of the body, and is an essential part of conception. In order to stimulate these body functions, a daily intake of about 1000 mg of calcium is recommended for adults. Total hardness of water varied from 70 to 490 mg/l. Hardness is caused due to the presence of calcium and magnesium carbonates and non-carbonates. Calcium hardness was noticed in the range from 30 to 180 mg/l, and the values of magnesium hardness ranges from 10 to 140 mg/l, while the carbonate and noncarbonate hardness ranges from 50 to 180 mg/l and from 0 to 230 mg/l, respectively. There is no adverse effect on the health due to this hardness.

The value of total solids in the water samples varied from a minimum of 365 mg/l to a maximum of 745 mg/l. Total dissolved solids (TDS) from 145 to 385 mg/l, total suspended solids (TSS) from 74 to 490 mg/l, which shows that the value of solids in water is very high. It may be due to the particles suspended in water such as silt, sand, natural/human caused soil erosion and waste discharge.

During the period of the study, the values of chloride ranged from 24 to 277 mg/l, while the permissible limit of chloride prescribed by WHO for drinking water is 200 mg/l. The minimum concentration of chloride may

Table 1: The physicochemical characteristics of various sample stations (site 1-8)

Parameters	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Temperature	30.3	30.2	30.2	30.4	30.2	30.3	30.2	30.2
Dissolved oxygen	6.6	6.3	7.2	5.6	4.7	6.5	7.3	5.6
Biological oxygen demand	3.5	2.3	4.8	Nil	Nil	4.1	3.0	5.1
pH	7.8	8.0	8.1	7.5	7.8	7.9	8.2	8.3
Chloride	120	198	175	235	277	156	170	209
Total alkalinity	280	240	490	520	450	510	420	390
Total hardness	90	150	70	220	230	190	180	240
Calcium hardness	70	30	70	180	110	50	90	110
Magnesium hardness	40	90	20	50	110	80	60	40
Carbonate hardness	90	110	90	120	150	130	140	80
Non carbonate hardness	230	60	40	50	220	80	70	Nil
Nitrates	97	91	92	85	93	109	99	145
Calcium	38	42	37	43	54	36	29	22
Magnesium	23.5	10.5	21.3	14	16	21	34	53
Total solids (TS)	450	470	570	690	380	520	745	670
Total dissolved solids	320	190	230	385	154	239	255	310
Total suspended solids	130	280	340	305	226	281	490	360
Total acidity	25	15	5	10	6	23	15	5
Sulfides	1.4	1.6	1.8	1.5	1.4	1.2	1.0	1.0
Fluoride	1.003	0.324	0.912	0.621	1.402	1.022	1.46	1.922

Table 2: The physicochemical characteristics of various sample stations (site 9-16)

Parameters	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16
Temperature	30.3	30.3	30.2	30.2	30.2	30.3	30.2	30.3
Dissolved oxygen	5.9	6.4	3.6	3.9	7.3	7.1	4.2	1.6
Biological oxygen demand	Nil	3.4	4.6	3.7	Nil	5.9	2.9	3.4
pH	7.9	7.6	8.3	8.2	7.9	7.9	7.6	8.0
Chloride	24	30	205	269	99	126	245	201
Total alkalinity	330	410	460	340	100	190	220	320
Total hardness	230	280	220	140	230	490	390	290
Calcium hardness	80	120	90	80	70	30	110	120
Magnesium hardness	120	140	30	60	10	30	80	70
Carbonate hardness	140	80	180	130	120	50	90	130
Non carbonate hardness	60	60	120	90	20	Nil	Nil	40
Nitrates	87	82	96	89	83	89	73	76
Calcium	39	25	37	46	72	56	75	12
Magnesium	39.6	25.2	34.9	45	9.6	8.9	10.6	15
Total solids (TS)	560	670	450	680	365	390	653	460
Total dissolved solids	320	265	376	277	145	250	265	295
Total suspended solids	240	405	74	403	220	140	398	165
Total acidity	10	13	25	30	20	15	5	6
Sulfides	1.5	1.3	1.5	1.6	1.4	1.0	1.2	1.0
Fluoride	0.911	0.879	0.786	1.209	1.345	1.486	1.366	1.320

be due to dilution in large amount while high content in the samples may be due to the input of highly soluble chloride salts and high evaporation rate. The values of sulfide varied between a minimum of 1.0 mg/l to a maximum of 1.8 mg/l. Usually, it is not a health-risk at concentrations present in household water, except in very high concentrations. While such concentrations are rare, hydrogen sulfide's presence in drinking water when released in confined areas has been known to cause nausea, illness and, in extreme cases, death. Generally, hydrogen sulfide occurs in concentrations of less than 10 mg/l. Occasionally, the amount goes as high as 50-75mg/l. Hydrogen sulfide is more common to well waters than to surface water supplies. Nitrate in the samples varied from 73 to 145 mg/l. The permissible value of NO3- is 100 mg/l; above this concentration water becomes harmful and causes a disease namely methamoglobinemia in infants a condition known as "blue baby." The infant is being asphyxiated because oxygen cannot be transported by the blood. Prompt medical attention normally results in quick recovery of the infant. The concentration of NO_3^- ion increases with the increase of the depth of the ground water because the upper level of NO_3^- is consumed by the plants. Fluoride concentration varied in all the water samples from 0.0324 to 1.922 mg/l and was found maximum at site (8) while the permissible limit of fluoride prescribed by WHO for drinking water is 1.45 mg/l. The fluoride levels around 0.5-1.0 mg/l reduce the risk of dental caries, while significantly higher levels may cause skeletal fluorosis, depending on water intake and the fluoride content of the diet.

CONCLUSIONS

The problem of fluorosis in Maharashtra has only increased with time despite substantial efforts. The health-related water quality parameters need specific attention. One such health-related constituent of water is fluoride. The health effect of consumption of fluoride through water is serious. The strategic and technological options are available for control of fluoride in drinking water. The objective of community awareness has to be the preparation of community for participation in best utilization of the available water resources. Dilution of fluoride rich water with fluoride free water should be encouraged.

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