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Iron Excess in Drinking Water of Darrang District of Assam and Some Adjoining Areas

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Abstract. A study on the quality of drinking water in Darrang District (Assam) and some adjoining areas carried out during 1975-79 has been reported. A total of 1126 water samples (962 treated and 164 untreated) collected from different units/water distribution centres of army interest were analysed. It was observed that the underground waters of six deep tube wells were generally soft, acidic and highly ferruginous in character. All physicochemical constituents except the iron content were within the limits as prescribed for drinking purposes by ICMR. Raw waters drawn from deep tube wells and shallow wells were found to have iron content as high as 21.0 ppm and 24.36 ppm respectively. About half of the total treated water samples analysed (484 No out of 962) during the 5-year period contained iron beyond 1.0 ppm.

1. Introduction

Quality of drinking water plays an important role on human health. Bacteriological characteristics of waters used by defence services in north eastern region of the country have been reported earlier[1]. High iron content in shallow well waters of Assam has been reported by Verma *et al*[2], while deep tube well waters have also been reported to be highly ferruginous by Rai and Das[3]. Army/Air Force units stationed in this region generally make use of the underground waters as their chief source of water supply for drinking purposes. Ferruginous nature of these waters is generally due to soluble ferrous bicarbonate which gets oxidised with the atmospheric oxygen and imparts brownish or yellowish colour due to the formation of insoluble ferric hydroxide. ICMR[4] has laid down 1.0 ppm iron in drinking water as the maximum permissible limit. Higher iron content may produce undesirable effects such as astringent taste, discolouration, turbidity, deposits, growth of iron bacteria in pipes affecting the acceptability of water for domestic use. Other practical

problems are production of inky colour in tea infusions due to formation of iron tannin complexes, necessity for frequent cleaning of water treatment plants and those involved under certain conditions of ill health[5–9]. The present study was therefore undertaken to provide information on the suitability of waters used by various Army/Air Force units for drinking purposes particularly in relation to iron. In the present communication, data on physico-chemical characteristics of waters from six deep tube wells and iron content of raw and treated waters supplied to defence services from various sources during 1975-79 are reported.

2. Materials and Methods

Water samples from various sources were collected according to the procedures laid down by Indian Standard (IS 3025-1964). Raw waters from deep tube wells and shallow wells were drawn by motors used in the pump houses. Motor was run for about 15 min before collecting the water sample. Treated waters were collected from the consumers' end. Usual treatment procedures as practised in different water works before final chlorination step were either (i) aeration, sedimentation and filtration through a sand gravity filter or (ii) direct filtration through a pressure filter which had provision for application of compressed air and coagulants. Analysis of water was carried out immediately after collection and in a few cases within 24 hours. A pH meter was used for measurement of pH. Electrical conductivity, total solids, total hardness, calcium and magnesium (by difference of total hardness and calcium content) were determined as per Indian Standard cited above. Total iron content of the water sample was determined by thiocyanate method[10]. The red colour produced by ferricthiocyanate complexes was measured with the help of an EEL photoelectric colorimeter (using green filter No. 623).

3. Results

A total of 1126 water samples (962 treated and 164 raw water) have been analysed. Waters obtained from deep tube well, river, shallow well and spring are respectively 1026, 44, 28 and 2 in numbers, while 26 water samples have been obtained from miscellaneous sources. Physico-chemical characteristics of six representative deep tube well waters before and after chemical treatments for supply to consumers are shown in Table 1. Iron content of these raw waters varies from 2.4 to 13.6 ppm while that of treated waters from 0.3 to 6.6 ppm. Maximum iron content of raw waters, as observed in ten deep tube wells during 1976-79 ranged from 1.7 to 21.0 ppm (Table 2). Distribution of treated water samples conforming to ICMR standards for drinking purposes during the same period is also recorded in Table 2. Percentage of treated waters showing the iron content within 1.0 ppm is maximum (66.6 to 100%) in well No. 8, while it is minimum (13.0 to 37.5%) in well No. 3. Iron content and pH of raw and treated waters of a shallow well supplying water

Table 1. Physico- chemical characteristics of six representative deep tube well water samples before and after treatment

Wel No.	Raw Water*						Treated and Filtered Water					
	Electrical lconducti-vity (micromhos/ cm)	Total solids (ppm)	Total hardness (as $CaCO_3$) (ppm)	Iron (as Fe) (ppm)	Calcium (as Ca) (ppm)	Magne-sium (as Mg) (ppm)	Electrical conducti-vity micromhos/ cm	Total solids (ppm)	Total hardness (as $CaCO_3$) (ppm)	Iron (as Fe) (ppm)	Cal-cium (as Ca) (ppm)	Magnesium (as Mg) (ppm)
1	270	103	46	6.6	9.6	5.3	300	118	52	6.6	12.0	5.3
2	300	107	44	2.4	8.8	5.3	300	115	50	0.6	13.6	3.8
3	330	108	62	2.6	12.8	7.3	310	98	52	1.5	12.0	5.3
4	270	188	50	6.4	13.6	3.8	270	—	58	0.3	13.6	—
5	270	159	54	6.2	16.0	3.4	270	127	54	1.3	17.6	2.4
6	260	129	50	13.6	10.4	5.8	310	140	62	1.6	17.6	4.3

*pH of raw waters from all the wells : 6.4 to 6.8

Table 2 Percentage of treated waters from deep tube well sources showing iron content within permissible limit*

Well No.	Maximum iron content of raw water (ppm)	Percentage of treated water samples showing iron content upto 1.0 ppm			
		1976	1977	1978	1979
1	2.1	58.3 (24)**	55.0 (20)	72.7 (11)	77.7 (9)
2	1.7	87.5 (24)	94.7 (19)	80.0 (10)	87.5 (8)
3	3.5	13.0 (23)	14.2 (21)	24.0 (25)	37.5 (8)
4	2.4	20.8 (24)	84.2 (19)	80.2 (15)	100.0 (6)
5	2.7	Nil (24)	50.0 (18)	24.0 (25)	30.0 (10)
6	5.9	91.6 (24)	61.1 (18)	31.8 (22)	60.0 (10)
7	7.0	5.8 (17)	—	Nil (18)	66.6 (9)
8	15.3	66.6 (24)	90.0 (20)	90.9 (22)	100.0 (8)
9	15.3	27.2 (22)	11.1 (18)	28.5 (7)	71.4 (7)
10	21.0	66.6 (24)	57.1 (21)	16.6 (24)	77.7 (9)

*Maximum permissible limit of iron in drinking water—1.0 ppm

**Figures in parentheses indicate total No. of samples analysed

Table 3 pH and iron content of water from a shallow well before and after treatment

	pH		Iron (ppm)		
	Raw	Treated	Raw	Filtered*	Treated**
	(12)+	(12)	(12)	(12)	(12)
Max.	6.6	7.2	24.36	17.50	8.12
Min.	6.5	6.6	18.75	5.62	1.86

*Through 'Birds' pressure filter

**Water collected from consumers' end

+Figures in parentheses indicate total number of samples analysed

to nearby army units are shown in Table 3. Range of iron content of raw and treated waters supplied from all the sources during the 5-year period (1975-79) is recorded in Table 4. Out of a total of 164 raw water samples, 57 water samples show the iron content between 3 and 6 ppm, 35 water samples show the iron content more than 10 ppm while the iron content varies from 6 to 9 ppm and 9 to 10 ppm in 24 and 8 water samples respectively. Out of a total of 962 treated water samples, 484 water samples show the iron content within 1.0 ppm and 234 water samples show the iron content between 1.0 and 2.0 ppm and the rest above 2.0 ppm.

Table 4. Distribution of raw and treated water samples supplied from various sources during 1975-79 in relation to their iron content

Year	Raw						Treated			
	Total No. of samples analysed	No. showing iron content in ppm					Total No. of samples analysed	No. showing iron content in ppm			Percentage of treated water samples showing iron content up to 1.0 ppm*
		⩽3.0	⩽ 6.0	⩽ 9.0	⩽ 10.0	> 10.0		⩽ 1.0	⩽ 2.0	> 2.0	
1975	48	17	10	10	2	9	76	32	15	29	42.10
1976	5	1	1	1	1	1	268	129	64	75	48.13
1977	28	10	5	7	1	5	199	114	55	30	57.28
1978	61	4	35	5	4	13	266	101	82	83	37.96
1979	22	8	6	1	—	7	153	108	18	27	70.58
Total	164	40	57	24	8	35	962	484	234	244	50.31

*Maximum permissible limit of iron in drinking water—1.0 ppm

4. Discussion

It is observed that deep tube well is used by army extensively for supply of drinking water since out of a total of 1126 water samples analysed, 1026 water samples are contributed by deep tube well sources. Armed Forces deployed in this region generally do not prefer surface and shallow ground waters as these are likely to be polluted by surface washings, seepage from privies, septic tanks, cess pools, etc. It is observed from Table 1 that the deep tube well waters are generally acidic, soft and ferruginous. All the chemical constituents studied, except the iron content, are found within the maximum permissible limit as fixed by ICMR. After treatment the waters show marginal change in their hardness and electrical conductivity. Iron content of the treated waters supplied from all the water works, except two, is found to exceed 1.0 ppm. With a view to confirming the efficacy of treatment procedures adopted for iron removal, ten water works exclusively supplying waters from deep tube well sources to various army units were selected to record the iron content of both raw and treated waters for a period of 4 years (Table 2). It is observed that the maximum iron content in deep tube well waters is 21 ppm and all the wells contain iron far above 1.0 ppm.

Treated water samples as analysed from these waterworks show that the iron content in most of the cases conformed to ICMR standard.

Verma *et al*[2] have reported that shallow ground waters of Assam contain iron as high as 50 ppm while in the present investigation 24.36 ppm has been recorded as maximum in the shallow well waters. The shallow well showing the maximum iron content (24.36 ppm) was also selected for a typical observation on the efficacy of the treatment procedures adopted for iron removal. It is observed from Table 3 that the iron content of filtered water prior to chlorination varies from 5.62 to 17.50 ppm indicating inefficiency of the pressure filter as well as the treatment procedures adopted for removal of excess iron from water. Consequently, treated waters supplied for drinking purposes show high iron content in the range of 1.86 to 8.12 ppm. Raw water is acidic (pH 6.5-6.6) almost similar to deep tube well water (pH 6.4-6.8). It is observed from Table 4 that most of the waters (50.31%) supplied from all the sources put together during the period 1975-79 could be brought to contain iron below 1.0 ppm, from the very high amounts contained in the raw waters from these sources. Iron content was marginally higher up to 2 ppm in 24.32% of the samples (data not included in Table) while only about 25% of the samples had iron content above 2 ppm. While this shows that the treatment has been successful in bringing down iron from very high levels, there is still scope for improvement in iron removal procedures. Earlier work from this laboratory showed that highly ferruginous water containing about 25 ppm iron could be treated efficiently in a continuous water flow system installation[3] (having an open channel embedded with stones, sedimentation tank and sand gravity filter) using copperas and bleaching powder to bring down the iron content within the maximum permissible limit of 1.0 ppm. On the basis of experience in the Netherlands with regard to water containing a high amount of iron, Putto[11] came to the same conclusion as those of

Twort[12] namely, "this metal is not harmful but there are two objections to its presence above a certain amount; i) it can make water unpalatable imparting a bitter taste to water when present in large amounts; ii) when the water is exposed to air and takes up oxygen, the iron is likely to precipitate and the deposits cause brownish stains upon sinks, baths, washbasins and laundry". It is thought[11], however, that some persons will have intestinal troubles if the amount of iron is high, eg, 10 ppm. In the present study only 2 samples (0.2%) out of a total of 962 have been found to contain iron beyond 10 ppm. Thus, iron as one of the substances present in water, although not constituting and a health hazard[13], may affect its acceptability as a domestic supply.

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