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Assessment and analysis of fluorides contamination in ground water of Agra district of U.P. (India)

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Abstract
An attempt has been made to study the Physico-chemical assessment of the ground waters of Agra district (U.P.). Eight water samples out of them 4 from hand pumps (HP) and 4 from the tube wells (TW) were collected from different villages around the main city of Agra District. The duration of the study was from January 2022 to June 2022. The physico-chemical parameters analyzed were pH, temperature, turbidity, DO, BOD, COD, chlorides, fluorides, sulphates, nitrates and total hardness. It was observed that all other parameters are within range when compared with WHO standards, only fluorides and chlorides were present in excess amount in tube well water of Rohta village. It has also been observed that tube well water samples have higher fluoride ions concentration as compared to hand pump water samples.

Keywords: fluoride, ground water, physico-chemical analysis, Agra district

Introduction

Water is essential for life and is an important component of the living system. It is being used by man for various purposes like drinking, cooking, bathing, washing, house hold activities, irrigation, electricity generation, industrial production and disposal of sewage and industrial waste. At present the menace of water born diseases and epidemics still looms layer on the horizon of the developing country. Ground water is the major source of water supply for domestic purposes in the urban as well as in rural parts of India. Various reasons for this include the non-availability of potable surface water and a general belief that ground water is pure and safer than surface water due to earth covering. The ground water contributes only 0.6% of the total water resources on earth. The ground water is the preferred and major source of drinking water in rural as well as in urban areas particularly in the developing countries like India as treatment of this water is often not required. The 90% of the total drinking water requirement and 50% of the agricultural requirement is fulfilled by the ground water in India but in the era of economical growth, groundwater is getting polluted due to urbanization and industrialization. The ground water is generally colourless but contains salts such as chlorides, sulphates, nitrates etc. of different metals. Water is one of the most important components for sustaining life but it is also the source of several sickness in human beings. The presence of hazardous contaminants like fluoride, nitrate, sulphate, toxic heavy metals etc. have been reported in many parts of India [1, 2, 3].

Fluoride is the major inorganic pollutant of natural origin found in ground water. In minute quantity of fluoride is an essential element needed for normal development and growth of animals and extremely useful for human beings. Fluoride is abundant in the environment and main source to drinking water. Fluoride gets accumulated in hard tissues of the body and plays an important role in mineralization of bones and formation of dental enamel [4]. It is known that growth of many plant species [5] is also stimulated but excessive intake of fluoride is toxic to plants and causes clinical disturbances in animal and human beings. There are many countries like Argentina, USA, Algeria, Libya, Egypt, Jordan, Turkey, Iran, Iraq, Kenya, China, Japan, New Zealand, Australia, Thailand, Canada, Sri Lanka, Syria etc. which are endemic for fluorosis. Fluoride is commonly found above the normal values in ground water of many states like U.P., M.P. Punjab, Haryana etc. Indian standards [7] for drinking water prescribes the desirable limit 1.0 mg/L. According to WHO [8] permissible limit for fluorides in drinking water is 1.5 mg/L whereas United States Public Health Sciences 1962 [9] has set a range of allowable concentration of fluoride in drinking water for a region depending on its climatic conditions. The amount of water consumed and consequently ingested being influenced primarily by the air temperature [10, 11] According to USPHS, the maximum allowable concentration of fluorides in drinking water in Indian conditions comes to 1.4 mg/L while as per Indian standards it is 1.5 mg/L [7].

Fluoride ions have dual significance in water supplies. High concentration of fluoride causes dental fluorosis (disfigurement of teeth), at the same time a concentration less than 0.8 mg/L results in dental carries. The major source of fluoride in ground water are fluoride bearing rocks such as fluoropar, cryolites, fluoropatite and hydroxyapatite [12]. In India, the fluorosis was first identified in Tamilnadu in 1937 [13] later, this disease was also identified in different states. At present more than 30 million people in 13 states have been affected by this disease [14, 15]. The disease is making its appearance in newer non-fluorotic areas due to geo-environmental conditions. According to WHO [16], one hospital bed out of four in the world is occupied by a patient who is sick because of polluted water.

Fluoride ion concentration in drinking water is playing a vital role in human health systematic fluorosis [17, 18] and is an endemic problem in several developing countries like India, Pakistan and Africa etc. Exposure to high level of fluoride can cause endemic fluorosis, arthritis, cancer stiff

joints, weight loss, brittle bones, anaemia and weakness and characterize endemic fluorosis. Discoloured, blackend, white teeth characterize dental fluorosis [19] Fluoride can damage a foetus and adversely affect the I.Q. of children [20] Right level of fluoride in drinking water can provide beneficial effects like developing tooth buds, makes the structure of the enamel and dentin harder and more resistant to acid attack produced by bacteria. Fluoride from saliva enters enamel of newly erupted teeth and enhances enamel classification.[21] Recently the Physico-chemical analysis of fluoride in ground water contamination has been carried out by various Scientist [22, 23, 24].

Materials and methods

Analysis of ground water for Physico-Chemical contamination in the eight water samples out of them four from hand pumps (S_1 - S_4) and four from tube wells (S_1 - S_4) were collected in polythene bottles. The samples were analysed for pH, temperature, turbidity, DO, BOD, COD, chlorides, fluorides, sulphates, nitrates and total hardness in the months of January 2022 to June 2022.

Temperature was measured by Celsius thermometer, pH and turbidity were measured by digital pH meter (Type - 335), digital Nephlo turbidity meter (Type - 132) respectively. DO, BOD and COD were determined in laboratory using the method suggested by APHA (1985) and NEERI manual (1986). Chloride and nitrates were estimated by volumetric titration with $AgNO_3$. Total hardness was determined by volumetric titration (EDTA method). 'Sulphate was estimated by UV-VS spectro-photometer (type -118). Fluoride concentration was determined by spectrophotometrically using Alizarin red - S and SPAND reagents. The Alizarin red-S method was found useful in higher fluoride range while SPANDS reagents was employed in low fluoride range [25]. The results for ground water are presented in Table-1 and Table-2.

Table 1: Physico-chemical analysis of water samples collected from hand pumps of various villages of Agra district (U.P.)

Parameters	Site	Jan	Feb	Mar	Apr	May	Jun
pH	S_1	7.5	7.6	7.6	7.2	7.5	7.8
	S_2	7.6	7.4	7.7	7.8	7.5	7.4
	S_3	7.4	7.4	7.5	7.9	7.5	7.9
	S_4	7.5	7.5	7.3	8.0	7.2	7.9
Temperature (^{0}C)	S_1	17.81	22.15	22.95	26.15	26.86	28.10
	S_2	17.77	21.97	23.15	26.55	26.98	27.95
	S_3	18.25	19.45	21.23	25.14	27.82	28.47
	S_4	17.15	20.45	21.22	24.95	26.88	27.47
Turbidity (NTU)	S_1	1.8	1.9	1.6	2.0	1.9	1.9
	S_2	1.4	1.3	1.3	1.2	1.5	1.5
	S_3	0.7	0.8	0.8	0.8	0.7	0.6
	S_4	5.0	4.9	4.9	4.7	4.9	4.8
DO (mg/L)	S_1	6.37	6.15	6.57	5.92	6.32	6.40
	S_2	6.50	6.19	6.07	5.77	5.78	5.61
	S_3	6.33	5.47	5.53	6.13	6.15	6.11
	S_4	6.27	6.11	6.05	5.87	6.38	5.55
BOD (mg/L)	S_1	11.2	11.0	10.8	11.5	11.3	10.8
	S_2	8.6	10.6	10.8	9.51	9.3	10.5
	S_3	9.1	9.8	10.8	1.5	1.3	10.8
	S_4	11.2	9.5	10.8	1.5	1.3	10.8
COD (mg/L)	S_1	84	76	74	78	74	80
	S_2	76	76	84	78	85	79
	S_3	63	66	71	68	70	69
	S_4	69	66	72	68	72	69
Chlorides (mg/L)	S_1	1220	1200	1240	1250	1215	1195
	S_2	465	465	500	490	485	480
	S_3	990	970	975	975	970	980
	S_4	1210	1170	1170	1175	1160	1200
Fluorides (mg/L)	S_1	1.10	1.10	1.00	0.95	0.90	1.00
	S_2	0.80	0.90	0.70	0.80	0.70	0.70
	S_3	0.90	0.90	0.70	0.80	0.70	0.70
	S_4	1.60	1.50	1.60	1.70	1.50	1.60
Sulphates (mg/L)	S_1	235	238	255	250	251	245
	S_2	190	170	170	165	175	185
	S_3	185	195	195	175	170	170
	S_4	220	210	170	170	180	195
Nitrates (mg/L)	S_1	23	22	25	27	26	26
	S_2	31	31	35	34	31	33
	S_3	42	41	41	38	38	38
	S_4	29	29	26	30	27	27
Total hardness (mg/L)	S_1	741	750	740	740	730	750
	S_2	320	300	310	310	345	305
	S_3	300	285	295	300	285	300
	S_4	290	310	280	300	309	320

S_1: Bichpuri, S_2: Rohta, S_3: Sikandra, S_4: Chhalesar

Table 2: Physico-chemical analysis of water samples collected from tube wells of various villages of Agra district (U.P.)

Parameters	Site	Jan	Feb	Mar	Apr	May	Jun
pH	S_1	7.3	7.5	7.4	7.4	7.6	73
	S_2	7.8	7.45	7.6	7.6	7.6	7.9
	S_3	74	7.5	75	7.3	7.6	8.0
	S_4	7.6	7.5	7.6	7.4	7.7	7.8
Temperature (^{0}C)	S_1	17.17	21.96	22.18	25.14	26.74	285
	S_2	18.12	22.10	24.23	25.78	27.00	27.79
	S_3	17.82	20.21	22.23	24.15	26.12	28.14
	S_4	17.85	21.22	22.13	25.18	27.11	27.97
Turbidity (NTU)	S_1	1.8	1.6	11.7	1.6	1.5	28.21
	S_2	1.1	11	1.2	1.4	1.4	1.9
	S_3	0.8	0.7	0.7	0.7	0.8	1.1
	S_4	4.8	4.7	4.8	4.6	4.9	0.8
DO (mg/L)	S_1	5.90	5.57	5.67	6.12	6.13	5.0
	S_2	6.31	6.42	5.91	5.87	5.60	6.41
	S_3	5.98	6.17	6.11	6.27	6.23	5.98
	S_4	6.48	6.17	6.15	5.97	5.44	5.87
BOD (mg/L)	S_1	10.50	12.10	10.40	10.40	11.50	6.15
	S_2	10.30	10.20	8.60	8.90	8.80	11.20
	S_3	9.50	11.00	10.50	10.60	9.60	10.50
	S_4	11.40	11.00	9.60	9.60	9.40	9.20
COD (mg/L)	S_1	76	74	81	84	80	9.10
	S_2	77	79	81	80	84	76
	S_3	65	61	66	66	69	85
	S_4	68	71	72	66	67	70
Chlorides (mg/L)	S_1	1150	1190	1200	1175	1175	67
	S_2	420	415	420	470	470	1170
	S_3	985	985	980	970	990	460
	S_4	1170	1180	1190	1190	1175	945
Fluorides (mg/L)	S_1	1.00	0.80	0.70	0.70	0.80	1185
	S_2	0.90	0.70	0.70	0.80	1.00	0.60
	S_3	0.80	0.80	0.60	0.60	0.90	1.00
	S_4	1.60	1.60	1.70	1.80	1.70	0.90
Sulphates (mg/L)	S_1	210	215	215	210	165	1.60
	S_2	180	180	165	160	165	165
	S_3	190	190	185	185	190	170
	S_4	200	170	170	190	195	195
Nitrates (mg/L)	S_1	21	19	19	23	22	22
	S_2	29	30	31	31	33	34
	S_3	37	42	42	41	38	38
	S_4	26	26	29	29	30	28
Total hardness (mg/L)	S_1	209	198	188	165	175	188
	S_2	155	178	110	115	185	107
	S_3	851	751	851	55	75	67
	S_4	35	40	75	145	285	145

S_1: Bichpuri, S_2: Rohta, S_3: Sikandra, S_4: Chhalesar

Results and discussion

Results obtained during the physic-chemical analysis of ground water sample have been given in Table-1 and Table-2. The pH of samples collected from various villages of Agra district of U.P. (India) were in the range of 7.2 to 8.1 (hand pump) and 7.3 to 8.0 (tube well), Temperature ranged 17.15 to 28.47 °C (HP) 17.17 to 28.21 °C (TW), turbidity ranged 0.6 to 5.0 NTU (HP) and 0.7 to 5.0 NTU (TW), DO ranged 5.47 to 6.57 mg/L (HP) and 5.44 to 6.48 mg/L (TW), BOD ranged 8.6 to 11.5 mg/L (HP) and 8.60 to 12.10 mg/ L (TW), COD ranged 63.0 to 85.0 mg/L (HP) and 61.0 to 85.0 mg/L (TW), chloride ranged 465 to 1250 mg/L (HP) and 415 to 1200 mg/L (TW), fluorides ranged from 0.50 to 1.60 mg/L (HP) and 0.60 to 1.80 mg/L (TW), sulphate ranged 165 to 255 mg/L (HP) and 160 to 215 mg/L (TW), nitrate ranged 22 to 42 mg/L (HP) and 19 to 42 mg/L (TW), total hardness 280 to 750 mg/L (HP) and 55 to 285 mg/L (TW).

Prevention and control

The people of study areas are advised not to use water for drinking and cooking purposes. Instead the villagers are advised to use the other bore well water which may be supplied through taps to the villagers which contains comparatively less fluoride content. Another alternative is to defluoridate the drinking water supplied to the villagers by standard techniques, such as Nalgonda technique (Technical digest, 1978). Bore well water with low concentration (<0.5 ppm) of fluoride can be mixed with water having higher concentration of fluorides (>1.5 ppm) and sulphates. The short-term solution to minimize the fluoride level in drinking water could, be the use of domestic defluoridation filters. Along with the fluoride concentration consumed through water, hot climate conditions, unhygienic surroundings, illiteracy, lack of awareness about the water quality which they are using are some of" important reasons for this disease. It is recommended that alternative

arrangements for 2 supply of potable water from other safe sources to the affected village or supply of treated potable water to this village may be taken up on top priority. The villagers have to be educated through, awareness camps on health, sanitation, and nutrition and water quality.

Conclusion

It is shown that all other parameters are within range when compared with WHO standards, only fluorides and chlorides is present in excess amount of grove water in tube well water of Chhalesar village of Agra district that is sample No.4. It has been observed that tube well water samples have higher fluoride concentration as compared to hand pump water. Regular intake of fluoride rich water seems to be main course for high incidence of fluorosis. Chemical weathering under arid to semiarid conditions with relatively high. alkalinity seems to have favoured high concentration of fluorides in ground water of Agra district of U.P. (India).

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