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FLUORIDE AND NITRATE TOXICITY IN GROUND WATER OF NOKHA TEHSIL IN BIKANER RAJASTHAN (INDIA)

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ABSTRACT

Groundwater is the major source of drinking water and over 91% of the drinking water demand is met by groundwater. Water quality is essential parameter to be studied when the overall focus is sustainable development keeping mankind at focal point. The objective of this study was to determine the nitrate and fluoride concentration in groundwater of Nokha tehsil in Bikaner district of Rajasthan state (India). Other water quality parameters such as, pH, total dissolved salts, chloride, carbonate, bicarbonate were also studied. The results indicated considerable variations among the analyzed samples with respect to their chemical composition. Total Alkalinity and Chloride ranges from 200 mg/L to 655 mg/L and 180 mg/l to 11200 mg/l respectively. Hardness fluctuates from 175 mg/L to1720 mg/L. Seven samples (S1,S2,S4,S5,S8,S9,S10,S15) out of 17 samples beyond the permissible limit and TDS value varied from 910 to 21000 mg/L, which is also not within the prescribed permissible limits by WHO and BIS. Nitrate concentration in sampling sites ranges from 10 to 400 mg/L in ground water samples. 70.58% water sample of studied shows higher level of nitrate in drinking water. Fluoride concentration varied from 0.30 mg/l to 2.86 mg/l in ground water samples. About 47.05% of samples showed fluoride concentration below 1.0 mg/ l and 29.41% samples showed fluoride concentration in between 1.0 to 1.5 mg/l. It is evident from the research analysis data; 4 samples out of 17samples about 23.52% of the groundwater samples analysed in the study area exceeds the maximum permissible limits of fluoride (> 1.5 mg/l, WHO) for drinking purpose. The majority of the samples do not follow with Indian as well as WHO standards for

most of the water quality parameters studied. It is found that some water samples are not suitable for drinking purpose due to high concentration of one parameter or other. The overall water quality was found unfit for drinking purposes without any prior treatment.

In the present study we found that nitrate, chloride and TDS reached to an alarming level in some areas which need proper removing before using water. Fluoride content is also higher than in some area comparison of normal value.

KEYWORDS: Ground water, Nitrate, Fluoride, Nokha Tehsil, Rajasthan.

INTRODUCTION

Water is an essential natural resource for sustaining life and environment that we have always thought to be available in abundance and free gift of nature however chemical composition of surface or subsurface water is one of the prime factors on which the suitability of water for domestic, industrial and agriculture purpose depends. Fresh water occurs as surface water and ground water in this groundwater contributes only 0.6% of the total water resources on earth. It is major and preferred source of drinking water in rural and urban areas particularly in India.

Ground water is the most appropriate and widely used source of drinking water. Ground water forms a major source of drinking water in urban as well as in rural areas. More than 90% of the rural population uses ground water for domestic purposes.

Water is an essential ingredient for animals and plant life. Environmental systems are often delicately balanced and perturbations imposed on them may produce either positive or negative effects. Any imbalance amongst these environmental components is associated with far reaching effects on life supporting systems. This aspect has therefore become recently an important matter for ecological investigations.

Water is nature's most wonderful, abundant and useful compound. It is a universal solvent and renewable resource. Of the many essential factors for the existence of human beings, animals and plants (viz. soil, air, water, food, shelter, etc.), water is rated to be of greatest importance next to air. Water is a prime natural resource, a basic biological necessity and an obligatory condition for sustenance of life. It constitutes about 65% of human body and about 95% by weight of some plants or fruits.

A part of the rainwater percolates into the ground due to the porosity of the soil and also through the cracks, cervices and fissures in the rock masses. It is obtained from natural springs, wells, tube wells, infiltration wells, radial collector wells and galleries etc. For small community water supply systems, groundwater has generally been the preferred source, because it is not likely to be contaminated like surface water and is relatively free from pollutants. However, as the rainwater journeys downward, it comes in contact with a number of mineral salts present in the soil and dissolves some of them. Some natural chemical contaminants such as nitrate, fluoride, arsenic, etc. may cause serious groundwater pollution and affect potability of the same. When the groundwater is present at a shallow depth, it may be polluted from sources of faecal contamination or from industrial activities.

Groundwater contaminants come from two categories of sources. Landfills, leaking gasoline storage tanks, leaking septic tanks, and accidental spills are examples of point sources. Infiltration from farmland treated with pesticides and fertilizers is an example of a non-point source.

The effect of groundwater contamination does not end with the loss of well-water supplies. Several studies have documented the migration of contaminants from disposal or spill sites to nearby lakes and rivers as this groundwater passes through the hydrologic cycle.

Groundwater pollution can occur where industrial wastewaters are discharged into pits, ponds or lagoons thereby enabling the wastes to migrate down to the water table.

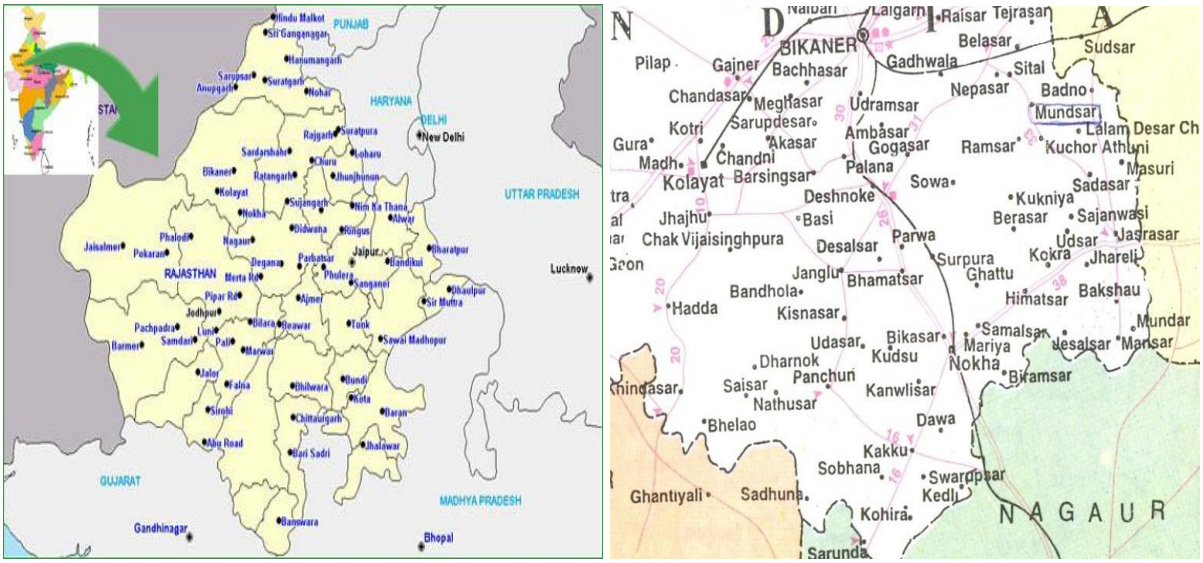
Fluoride rich minerals, which are present in rocks and soil, when come in contact with water of high alkalinity they release fluoride into groundwater through hydrolysis replacing hydroxyl (OH) ion. The degree of wreathing and leachable fluoride in a terrain is more important in deciding the fluoride bearing minerals in the bulk rocks or soil.

Fluoride is one of the important life elements. It is essential for normal mineralization of bones and formation of dental enamel. When fluoride is taken more than the permissible limit, it becomes toxic and would cause various metabolic disturbances in animals and human being including dental and skeletal fluorosis.

Generally, most groundwater sources have higher fluoride concentrations than surface water. As groundwater percolates through the weathered rock in the aquifers, it dissolves fluoride bearing minerals, hence releasing fluoride into solution.

STUDY AREA

Bikaner is located in the middle of the Thar Desert; it has an extremely hot and arid climate. In the summers, the temperature of the region goes beyond 45°C and in winters, it dips down below 0°C. Annual rainfall of the region is between 260 to 440 mm. The district is divided into five tehsils. They are Bikaner, Nokha, Loonkaransar, Kolayat and Sri Dungargarh. The selected project area is 17 villages lie in Nokha tehsil in Bikaner district. Bikaner is one of desert district situated in the North-West of Rajasthan. It extends from 27°11' to 29°3' North latitudes and 71°54 to 74°12'.



MATERIALS AND METHODS

Sampling methods

The water samples were collected from tube well near the residential and agricultural area of different villages of Nokha Tehsil. The water samples were extensively used for drinking and other domestic purpose. The water samples were collected in high grade plastic bottles of one litre capacity after rinsing with Distilled water.

Analysis Methods

The physicochemical characteristics of the ground water samples were determined by Standard methods, 2002.[2] The pH, TDS was measured by using portable meters and manual method. Total hardness of water was estimated by complex metric titration with EDTA. Chlorides content here determined volumetrically by AgNO3 titrimetric method. Other parameters like F- and NO3- were estimated by spectrophotometric method. The results are Comparable with WHO and BIS water standards.[3,30]

Location of sampling stations

The samples were collected from villages of different regions namely Bandhala (S1), Berasar (S2) Bhamatsar (S3), Bhadla (S4), Charakara (S5), Gajroopdesar (S6), Janglo (S7), Kakoo (S8) Kedli (S9), Maisar (S10). Mukam (S11), Moondar (S12), Panchoo (S13), Rora (S14), Sadhoona (S15), Sobhana (S16), Thawaria(S17).

Sample	Village Name	pH	Chloride mg/l	Alkalinity mg/l	TDS mg/l	Nitrate mg/l	Hardness mg/l	Fluoride mg/l
S1	BANDHALA	7.9	960	410	2310	10	660	2.12
S2	BERASAR	7.5	240	280	1190	113	300	0.39
S3	BHAMATSAR	7.7	330	270	1330	30	350	0.57
S4	BHADLA	7.15	11200	220	21000	51.22	880	0.42
S5	CHARAKARA	7.5	1410	270	3500	13	960	0.30
S6	GAJROOPDESAR	7.5	310	210	910	24	300	0.4
S7	JANGLOO	7.8	300	260	910	220	330	0.63
S8	KAKOO	7.15	700	300	2870	347	740	0.36
S9	KEDLI	7.8	2760	220	8680	63.2	1720	1.86
S10	MAISAR	8.5	1090	655	2735	25	715	2.86
S11	MUKAM	7.9	310	230	1120	60	380	1.0
S12	MOONDAR	7.4	180	428	1420	211.5	270	1.05
S13	PANCHOO	8.0	400	380	1260	62	350	1.32
S14	RORA	8.0	390	370	1120	58	390	1.08
S15	SADHOONA	6.97	1860	240	6090	95.21	2500	2.0
S16	SOBHANA	8.0	330	200	1470	400	410	1.02
S17	THAWARIA	7.5	241	354	970	105	175	0.86

Standards for Drinking Water Quality.

S. No.	Parameters	BIS: 1999	ICMR: 1975	WHO: 2003	USPH Standards
1.	pH	6.5–8.5	7.0–8.5	6.5–9.5	6.5–8.0
2.	EC (μ seimens/cm)	–	–	1400	1400
3.	TDS	2000	500	600	600
4.	Na^{+}	–	–	–	200
5.	K^{+}	–	–	–	–
6.	Ca^{2+}	200	200	100	100
7.	Mg^{2+}	100	200	150	150
8.	Cl^{-}	1000	200	250	250
9.	F^{-}	1.5	1.0	1.5	1.5
10.	CO_3^{2-}	–	–	–	–
11.	HCO_3^{-}	–	–	–	500
12.	SO_4^{2-}	400	200	250	250
13.	NO_3^{-}	100	50	50	50
14.	TH	600	600	500*	500*
15.	DO	–	–	–	4.0 – 6.0
16.	COD	–	–	–	4.0
17.	BOD	–	–	–	5.0
18.	%Na	–	–	75^{+}	–
19.	SAR	–	–	10^{+}	–

Note: All values except pH, EC, %Na and SAR are expressed in mg/L.

[*] TDS = Total Dissolved Solid [*] EC = Electrical Conductance [*] TH = Total Hardness

[*] DO = Dissolved Oxygen [*] BOD = Biological Oxygen Demand[*] COD = Chemical Oxygen Demand

[*] WHO, 1993 [#] USPH = United States Public Health [+] CPCB = Central Pollution Control Board

RESULTS AND DISCUSSION

pH

The pH of water is an important indication of its quality and it depends on the CO2, CO3-2 and HCO3- equilibrium. Acid-Base reaction is important in ground and surface water and their influence on pH and on the ion chemistry.

pH is measure of intensity of acidity or alkalinity of water. All chemical and biological reactions are directly dependent upon the pH of water system.[18] In our findings pH varied between7.15-8.5. Maximum pH was recorded at in village *Maisar* (S10) and minimum pH was recorded at in village *Bhadla(S4) and Kakoo(S8)*, which shows that all samples are alkaline in nature. The pH of all samples was within limit. The pH of water is very important indication of its quality and provides information in many types of geochemical equilibrium or solubility calculations.[15]

Total alkalinity

Total Alkalinity ranges from 200 mg/L to 655 mg/L; the maximum value was recorded in village *Mainsar (S10)* and minimum in village So*bhana.*[16] All the samples in study area showed that they are in permissible limit but one village in study area *Mainsar(S10)* having high alkalinity value which is not in permissible limit according to BIS, ICMR and WHO. In ground water, most of the alkalinity is caused due to carbonates and bicarbonates.

High bicarbonate ions concentration (350-450 mg/l) is favorable to fluoride dissolution parent resources.[20]

Alkaline water dissolve fluoride bearing minerals under simultaneous precipitation of calcium carbonate which shows the increase in fluoride content with increase in alkalinity.[17]

Chloride

Chloride is also one of the important parameters to know the quality of water. Sources of chloride include fertilizers, salt, and human and animal wastes. Concentration of chlorides is considered to be indicator of organic pollution of animal origin. Chloride contents in ground water are largely influenced by precipitation.

Chloride found high during the study ranged from 180 mg/l to 11200 mg/l. Minimum value was observed at village Moondar (S12) and maximum value was observed at in village B*hadla(S4).* Except S2, S12, S17 the entire study sample are not suitable for drinking according to WHO and BIS.[3,30]

These unusual concentrations may indicate pollution by organic waste. Chloride salts in excess of 100 mg/l give salty taste to water and when combined with calcium and magnesium, may increase the corrosive activity of water.[27] Chloride ions are generally more toxic than sulphate to most of the plants and are best indicator of pollution.[18]

Total dissolved solid (TDS)

In the present finding TDS value varied from 910 to 21000 mg/L, which is also not within the prescribed permissible limits by WHO and BIS. Maximum TDS recorded in village *Bhadla(S4)* and minimum in village G*ajroopdesar (S6)and Jangloo(S7).*

Total dissolved solid is an important parameter for drinking water and water to be used for other purposes beyond the prescribed limit, it imparts a peculiar taste to water and reduce its potability.[15]

Higher TDS value also reported in ground water of SriGanganagar in Rajasthan.[25]

The major part of the TDS is consistent with composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of Calcium, Magnesium, Sodium, Potassium, Manganese, organic matter salt and other particles. These ions usually comprise about 90% of TDS. The intake of higher TDS in human body may cause gastrointestinal problem.[10]

Total hardness

Hardness is the property of water which prevents lather formation with soap and increases the boiling point of water. In our findings the value of hardness fluctuates from 175 mg/L to1720 mg/L. Seven samples(S1,S2,S4,S5,S8,S9,S10,S15) out of 17 samples beyond the permissible

limit as prescribed by BIS, ICMR and WHO. The minimum value was found in Village *Thawaria (S17)* and maximum value was found in samples of village *Kedli(S9)*.

Hardness of water mainly depends upon the amount of calcium or magnesium salt or both (Singh et al., 2012), It is an important criterion for determining the usability of water for domestic, drinking and many industrial supplies.[15]

Nitrate

Nitrate concentration in sampling sites ranges from 10 to 400 mg/L in ground water samples, with lowest value 10 mg/L in villages *Bandhala(S1)* and highest value 400 mg/l in village *Sobhana(S16).* All the sample except sample S1,S3,S5,S6,S10 Shows higher level of nitrate in drinking water which is beyond permissible limit according to BIS and WHO. So, this water is not good for health.

Nitrate (NO3-) contamination of the groundwater is mainly due to the intensive use of fertilizers. Leaching of nitrate to groundwater is due to excessive application of N- fertilizer, the absence of proper soil and water management practices, septic tanks, improper disposal of domestic wastes.

Nitrate content in groundwater serves as a basis for detecting pollution. High nitrate levels found in drinking water have been proven to be the cause for numerous health conditions across the world such as gastrointestinal cancers, methaemoglobinaemia, alzheimer's disease, vascular dementia, multiple sclerosis in human beings. Nitrate contamination leads to Eutrophication of water bodies.[24]

Ingestion of nitrites and nitrates also has a potential role in developing cancers of the digestive tract through their contribution to the formation of nitrosamines. In addition, some scientific evidences suggest that ingested nitrites and nitrates might result in mutagenicity, teratogenicity and birth defects, contribute to the risks of non-Hodgkin's lymphoma and bladder and ovarian concerts, and play a role in the etiology of insulin dependent diabetes mellitus and in the development of thyroid hypertrophy, or cause spontaneous abortions and respiratory tract infections. Indirect health hazards can occur as a consequence of algal toxins causing nausea, vomiting, diarrhea, pneumonia, gastroenteritis, hepatoenteritis, muscular cramps and several poisoning syndromes. Other indirect health hazards can also come from

the potential relationship between inorganic nitrogen pollution and human infectious diseases (malaria, cholera Camargo and Alonso, 2006).

Nitrate in high level in ground water with Ca and Mg content indicated decay and leaching of biomass as it Probable sources. Prevalence of high nitrate in ground water may be due to excessive use of fertilizer.[16]

The poor sanitation level is also another important source contributing high amount of nitrate in ground water.[4,11]

Nitrate content in present investigation was higher mainly due to the agricultural fields where the nitrogenous fertilizers make their entry into ground waters due to leaching.

Fluoride

Fluoride concentration varied from 0.30 mg/l to 2.86 mg/l in ground water samples as shown in table. Lowest value was found 0.30 mg/l in *Charakara(S5)* village and highest value 2.86 mg/l in *Mainsar(S10)* villages. Sample S1, S9, S10, S15 showed more than 1.5 mg/l fluoride content in water which is beyond permissible limit. The rest of the village's sample are not affected by fluoride disorders, because fluoride content in the groundwater is within the permissible limit (<1.5 mg/l).

About 47.05% of samples showed fluoride concentration below 1.0 mg/ l and 29.41% samples showed fluoride concentration in between 1.0 to 1.5 mg/l. It is evident from the research analysis data; 4 samples out of 17samples about 23.52% of the groundwater samples analysed in the study area exceeds the maximum permissible limits of fluoride (> 1.5 mg/l, WHO) for drinking purpose (Table).

Fluoride contamination is mainly a natural process, i.e. leaching of fluorine-bearing minerals, since no man-made pollution has been noticed. Since fluorite, apatite, mica and various other minerals take part during rock–water interaction and liberate fluoride into the groundwater.

High concentration of fluoride content in ground water bodies were also reported by various workers.[1,6,9,19,21,23]

In southern Rajasthan, where tribal populations are predominant, 0.3 to 10.8 ppm F concentration is reported.[5]

Fluoride mainly occurs in ground water as natural constituents,[20] and continuously dissolves in ground water. Some physico chemical processes also contribute to natural contamination of fluoride in ground water bodies.

Generally the ground water interact with fluoride parent rock at fluoride rich minerals which are present in earth crust, due to this interaction the leaching of fluoride from parent rock take place and ultimately it rises fluoride concentration in ground water. The nature of water is also depending on type and composition of existing rocks.[20,13]

The high irrigation or over exploitation of ground water is also responsible for the high concentration of fluoride in ground water.[23,28,29]

The high concentration of fluoride in ground water may be associated with the agricultural activities.[19]

High fluoride concentration due to high irrigation was also reported.[23]

Higher values of fluoride also reported in water sources of Sardarshahar city of Churu district in the thar desert of Rajasthan.[12]

High fluoride content was also reported in the ground of less rain areas as compared to in the ground water of high rain fall areas due to dilution of water.[7,8]

Less fluoride content in low rainfall area also reported.[14]

The primary manifestation of fluorosis are mottling of teeth and osteosclerosis of the skelton.in india, fluorosis is endemic in many states.[26]

Recent investigation on study area indicates that severe health disorders have been indentified in some villages of Nokha tehsil Bikaner due to excess intake of fluoride through drinking water. Domestic animals and people are studied in this area and found that some of them are suffer from dental & skeletal flurosis such as mottling of teeth, deformation of ligaments, bending of spinal column and ageing problem.

CONCLUSION

It has been concluded from the analysis of groundwater of Nokha tehsil that the ground water quality in all villages is either below or higher than the permissible limit, which makes it

unsuitable for drinking or other household purposes. Data clearly indicate that ground water is severely affected by various natural and human activities. TDS, chloride and nitrate was greater in all the villages' samples of studied area and other samples were also higher in than maximum permissible limit by WHO and BIS. Nitrate concentration in sampling sites ranges from 10 to 400 mg/L in ground water samples. 70.58 % water sample of studied shows higher level of nitrate in drinking water. Fluoride concentration varied from 0.30 mg/l to 2.86 mg/l in ground water samples. About 47.05% of samples showed fluoride concentration below 1.0 mg/ l and 29.41% samples showed fluoride concentration in between 1.0 to 1.5 mg/l. It is evident from the research analysis data; 4 samples out of 17samples about 23.52% of the groundwater samples analyzed in the study area exceeds the maximum permissible limits of fluoride (> 1.5 mg/l, WHO) for drinking purpose.

Study clearly indicate that water of studied villages have high level of nitrate, chloride, TDS, hardness which is not in permissible limit according to WHO and BIS and some samples showed fluoride level in alarming level which is very worried situation for us in future.

The water in some village is not suitable for domestic consumption without prior treatment. Use of N- fertilizer should be less in this area. So, that nitrate level can be control in ground water. Defluoridation and reverse osmosis method should be used in this area for treatment of groundwater.

Environmental factors and human activities also have impact on water parameters. So, Environmental awareness of health implication of fluoride should be emphasized through sustainable education and community participation.

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