FLOURIDE IN GROUND WATER SOURCES OF SARDARSHAHAR CITY OF CHURU DISTRICT IN THE THAR DESERT OF RAJASTHAN

Gayatri Khatri*1 and C. K. Bahura2

1Post Graduate, Department of Zoology, Government Dungar College, Bikaner, Rajasthan, India.
2Lecturer, Department of Zoology, Government Dungar College, Bikaner, Rajasthan, India.

ABSTRACT

Groundwater is the major source of fresh water on the earth. Fluoride in groundwater has known to contaminate the water sources globally. Rajasthan, one of the states in the Northern part of India, has known to have excessive fluoride content in groundwater sources. Fluoride at optimal level decreases the incidence of dental caries and is also necessary for maintaining the integrity of oral tissues but at the same time when taken in excess during development stages can cause adverse effects like dental fluorosis, skeletal fluorosis, mottling of teeth, osteoporosis etc. Ground water contains fluoride ions dissolved from geological formations. Therefore, the concentration of fluoride should be within permissible limit as prescribed by various Organizations such as WHO, ICMR and BIS. Hence, it becomes very important to analyze the fluoride in the water of tube-wells used for drinking purpose. Hence, approximately 10 ground/drinking water sources (tube wells i.e. sampling stations) of Sardar Shahar tehsil of Churu (district of Rajasthan) is been examined for the evidence of fluoride in 2012. Out of these eight water sources (80%) showed the presence of excess fluoride beyond permissible limits with varying ranges. Fluoride content ranged from 0.72 ppm to 5.1 ppm at different sampling stations or tube wells (average of all the tube wells being 3.4 ppm). In fluoride containing water pH varied between 7.2 to 8.9, alkalinity between 250 to 540, total hardness between 130 to 320 ppm , Ca2+ between 30 to 110 ppm , Cl− between 230 to 850 ppm , NO3− between 5 to 70 mg/L, all of these were within limits except TDS as it varied between 1280 to 3350.

INTRODUCTION

Water is an integral part of our environment, all the living organisms depend upon water in one way or the other but there are instances that civilizations have disappeared due to shortage of water or due to water born diseases. Today water has become essential commodity for the development of industries and agriculture. The main source of potable water is ground water and many hazardous pollutants like colored dyes, nitrates, heavy metals, pesticides and fluoride, pollute it. Fluoride is one of the major concerns among these pollutants. Fluoride in drinking water can be either beneficial or detrimental to health, depending on its concentration.[33] The presence of fluoride in drinking water within permissible limits is beneficial in the calcification of dental enamel. According to the World Health Organization (WHO), the maximum acceptable concentration of fluoride is 1.5 mg/L.[49] South Africa’s acceptable limit is 0.75 mg/L (regulations on fluoride water supplies, 2000).[36] while India’s permissible limit of fluoride in drinking water is 1 mg/L.[32] Concentrations beyond these standards have shown dental and skeletal fluorosis, and lesions of the endocrine glands, thyroid and liver.[31,32,14] Specially, fluoride at optimal level decreases the incidence of dental caries and is also necessary for maintaining the integrity of oral tissues but at the same time when taken in excess during development stages can cause adverse effects like dental and skeletal fluorosis.[1,2] mottling of teeth, osteoporosis etc. Ground water contains fluoride ions dissolved from geological formations. Therefore, the concentration of fluoride should be within permissible limit as prescribed by various organizations such as WHO, ICMR and BIS.[14,22,48] Fluoride ingested with water is almost completely absorbed and distributed rapidly throughout the human body, with retention mainly in the bones and a small portion in the teeth. The proximal range of pH speculates large amount of hardness in capacity and bicarbonate rich alkaline water.[19]

The occurrence of high fluoride concentration in ground water has now become one of the most important health related geo-environmental issues in many countries of the world. Our country is also confronting the same problem where the high fluoride concentration in ground water resources and the resultant disease “Fluorosis” is been evenly distributed in nearly 150 districts of 15 states. It is been observed that about 25 million people in 8700 village in India are using ground water having fluoride content more than 1.5 mg/L. In Rajasthan, ground
waters of the western and some southern part of the state are enriched with high fluoride concentration. The arid areas of the state are prone to both dental and skeletal fluorosis.

Therefore, the quality of water is of vital concern for mankind since it is been directly linked with human welfare. It is been matter of history, that pollution of drinking water caused water borne diseases that wiped out entire population of cities. The aim of this study was to determine the amount of fluoride in drinking water of ten blocks of Sardar Shahar city of Churu district. Polluted water is the culprit in all such cases. It is therefore, essential to monitor the water supply as well as quality of water.

Study Area
Sardar Shahar city of Churu District was selected for present pilot study. Rajasthan is the largest state of India, lying between 23°3’ and 30°12’ N latitude and 69°30’ and 78°17’ E longitude with its 342,239 km² being 10.4% of the area of the country. Churu is located in the North East part of the Indian Thar Desert at 28° 14’ North latitude and 74° 58’ East longitude as shown in Figure 1. It is divided in six tehsils- Churu, Sardar Shahar, Sujangarh, Ratangarh, Taranagar, Rajgarh. Sardar Shahar is a Tehsil in Churu district in the Indian state of Rajasthan. It is geographically located at latitude (28.45 degrees) 28° 26’ 59” North of the Equator and longitude (74.48 degrees) 74° 28’ 48” East of the Prime Meridian on the Map of the world. Sardar Shahar has dry climate with large variation in temperature. The minimum and maximum temperature varies from 0.5 to 48.2 degree Celsius. The normal rainfall is only 32.8 cm.

Figure 1: Map of India showing Rajasthan State and location of study area Sardar Shahar City in Churu District.
MATERIAL AND METHODS

It has been found that most of the people use bore wells as the drinking water sources. In the present study, the water samples from ten ground/drinking water sources (tube wells i.e. sampling stations) of Sardar Shahar Tehsil of Churu District of Rajasthan were collected in polythene bags. The fresh drinking water was monitored for various Physio-chemical factors viz. water temperature, air temperature, pH, TDS, EC, alkalinity, total hardness, calcium ions, chloride ions, nitrate, and fluoride. Few of these parameters like water temperature, air temperature, pH, TDS and EC were recorded on the spot by a battery operated digital portable water analyzer kit (Model: Century CK 710) while water samples were brought to the laboratory for the analysis of alkalinity, total hardness, calcium$^{2+}$, Cl$^{-}$, NO$_3^{-}$ and F$^{-}$. Alkalinity of the water sample has measured using phenolphthalein and methyl orange indicators while titrating with sulphuric acid. Total hardness of sample is been estimated by titrating the sample against Ethylene Diamine Tetra Acetic acid (EDTA) using Erichrome black T indicator. Calcium and magnesium is been estimated by using sodium hydroxide and Murexide indicator titrating against EDTA. Chloride is been measured by Oranometric method in which sample was titrated against silver-nitrate using Potassium chromate indicator. Estimation of nitrate has done by Brucine method using Spectrophotometer. Estimation of fluoride has done by Spectrophotometry using reagents like alizarin red solution, zirconyl acid solution, sodium fluoride etc.

Standard method as prescribed by APHA-AWWA-WPCF (1975),$^{[8]}$ were followed for the monitoring of chemical parameters.$^{[20,38,41]}$ The water samples Nitrate, phosphate and sulphate concentrations as described by American Public Health Association (1985).$^{[7]}$

RESULTS AND DISCUSSION

The results of the analysis of drinking water samples is been depicted in Table 1. A comparison of results of these parameters with different Standards i.e. prescribed permissible limits of water quality is been presented in Table 2.
Table 1: Physico-chemical parameters of ground water of Sardarshahar city of Churu District in Rajasthan.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of Station</th>
<th>Water Temp.</th>
<th>Air Temp.</th>
<th>TDS</th>
<th>Cl</th>
<th>NO₃⁻</th>
<th>F</th>
<th>SO₄</th>
<th>Total alkalinity</th>
<th>pH</th>
<th>Total Hardness</th>
<th>Ca⁺⁺</th>
<th>Mg⁺⁺</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I</td>
<td>24</td>
<td>37</td>
<td>1280</td>
<td>230</td>
<td>5</td>
<td>0.72</td>
<td>102.8</td>
<td>250</td>
<td>8.9</td>
<td>160</td>
<td>24.05</td>
<td>24.4</td>
<td></td>
</tr>
<tr>
<td>2. II</td>
<td>24.5</td>
<td>37.6</td>
<td>2205</td>
<td>420</td>
<td>5</td>
<td>1.3</td>
<td>101.9</td>
<td>470</td>
<td>8.5</td>
<td>230</td>
<td>24.05</td>
<td>41.8</td>
<td></td>
</tr>
<tr>
<td>3. III</td>
<td>23.9</td>
<td>37.5</td>
<td>2160</td>
<td>480</td>
<td>5</td>
<td>1.8</td>
<td>102.8</td>
<td>400</td>
<td>8.8</td>
<td>130</td>
<td>19.76</td>
<td>19.52</td>
<td></td>
</tr>
<tr>
<td>4. IV</td>
<td>23.9</td>
<td>36.8</td>
<td>2030</td>
<td>400</td>
<td>30</td>
<td>4.8</td>
<td>102.4</td>
<td>290</td>
<td>7.2</td>
<td>210</td>
<td>12.02</td>
<td>43.92</td>
<td></td>
</tr>
<tr>
<td>5. V</td>
<td>24</td>
<td>37.5</td>
<td>1985</td>
<td>410</td>
<td>30</td>
<td>5.1</td>
<td>102.2</td>
<td>270</td>
<td>7.0</td>
<td>340</td>
<td>15.98</td>
<td>73.2</td>
<td></td>
</tr>
<tr>
<td>6. VI</td>
<td>23.9</td>
<td>36.8</td>
<td>2160</td>
<td>490</td>
<td>45</td>
<td>4.0</td>
<td>102.9</td>
<td>250</td>
<td>7.2</td>
<td>280</td>
<td>24.05</td>
<td>53.68</td>
<td></td>
</tr>
<tr>
<td>7. VII</td>
<td>23.8</td>
<td>36.8</td>
<td>3350</td>
<td>740</td>
<td>70</td>
<td>2.9</td>
<td>102.7</td>
<td>450</td>
<td>7.4</td>
<td>320</td>
<td>24.05</td>
<td>63.44</td>
<td></td>
</tr>
<tr>
<td>8. VII</td>
<td>23.8</td>
<td>36.8</td>
<td>2240</td>
<td>390</td>
<td>30</td>
<td>5.1</td>
<td>102.7</td>
<td>490</td>
<td>8.3</td>
<td>160</td>
<td>7.99</td>
<td>34.16</td>
<td></td>
</tr>
<tr>
<td>9. IX</td>
<td>23.7</td>
<td>36.7</td>
<td>2300</td>
<td>510</td>
<td>55</td>
<td>5.1</td>
<td>101.9</td>
<td>540</td>
<td>8.5</td>
<td>130</td>
<td>12.02</td>
<td>24.4</td>
<td></td>
</tr>
<tr>
<td>10. X</td>
<td>24.5</td>
<td>37.5</td>
<td>3260</td>
<td>850</td>
<td>5</td>
<td>3.6</td>
<td>102.7</td>
<td>520</td>
<td>7.9</td>
<td>290</td>
<td>44.07</td>
<td>43.42</td>
<td></td>
</tr>
</tbody>
</table>

All values are in mg/L except pH and temperature.

Table 2: Comparison of average value of various measured parameters of ground water for Sardar Shahar city, Churu District, Rajasthan with World’s standard Parameters of drinking water.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parameters</th>
<th>BIS : 1999 (mg/L)</th>
<th>ICMR :1975 (mg/L)</th>
<th>WHO (1984) (mg/L)</th>
<th>Average values (average of all the stations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>pH</td>
<td>6.5 – 8.5</td>
<td>7.0 – 8.5</td>
<td>6.9 – 9.2</td>
<td>7.9</td>
</tr>
<tr>
<td>2.</td>
<td>TDS</td>
<td>500 – 2000</td>
<td>500</td>
<td>1000 – 2000</td>
<td>2239</td>
</tr>
<tr>
<td>3.</td>
<td>Alkalinity (as CaCO₃)</td>
<td>200 – 600</td>
<td>---</td>
<td>100 – 200</td>
<td>387</td>
</tr>
<tr>
<td>4.</td>
<td>Total Hardness (as CaCO₃)</td>
<td>200 – 600</td>
<td>200 – 600</td>
<td>100 – 500</td>
<td>221</td>
</tr>
<tr>
<td>5.</td>
<td>Ca⁺²</td>
<td>200 – 1000</td>
<td>up to 200</td>
<td>75 – 200</td>
<td>23</td>
</tr>
<tr>
<td>6.</td>
<td>Mg⁺²</td>
<td>200 – 400</td>
<td>100 – 200</td>
<td>75 – 100</td>
<td>39.4</td>
</tr>
<tr>
<td>7.</td>
<td>Cl⁻</td>
<td>200 – 1000</td>
<td>up to 200</td>
<td>200 – 600</td>
<td>498</td>
</tr>
<tr>
<td>8.</td>
<td>NO₃⁻</td>
<td>up to 100</td>
<td>up to 50</td>
<td>45 – 100</td>
<td>34</td>
</tr>
<tr>
<td>9.</td>
<td>SO₄²⁻</td>
<td>200 – 400</td>
<td>up to 200</td>
<td>up to 250</td>
<td>102.5</td>
</tr>
<tr>
<td>10.</td>
<td>F</td>
<td>1.0 – 1.50</td>
<td>1.0</td>
<td>1.0 – 1.5</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Water Temperature

Water temperature ranges from 23.7°C (St. IX) to 24.5°C (St. II & St. X). The average water temperature of all the stations was 24.0°C.
Air Temperature

Air Temperature is been reported to be $37^0\text{C}$.

pH

In present study, pH of the water always remained on the alkaline side from 7.0 (St. V) to 8.9 (St. I) Table 1. The average pH has found to be 7.9. This value is acceptable according to guidelines suggested by WHO.

T.D.S (Total Dissolved Solids)

T.D.S consists of inorganic substances. In the groundwater samples of the study area T.D.S has been recorded minimum 1280 mg/L at St. I and maximum 3350 mg/L at St. VII. TDS is within limits as per WHO (Table 2) at St.’s I and V while TDS is found higher than standard limits of drinking water according to all the organizations(Table 2) at other St.’s. The average TDS was found to be 2239 mg/L, is beyond the permissible limits (Table 2).

Total Alkalinity

The groundwater containing 2000 ppm of Bicarbonate is been considered fairly safe and 6000 ppm good for irrigation and domestic purpose. The Total alkalinity, in the present study, is been reported to be minimum 250 mg/L (St. I) and maximum 540 mg/L (St. IX). The average has been 387mg/L. WHO acceptable limit is 2000 ppm.

Total Hardness

Total hardness is one of the most important properties of drinking water. Calcium hardness and magnesium hardness combined to form total hardness. In present study, total hardness of ranged from 130 mg/L (St. III) to 340 mg/L (St. V). The average has been 221 mg/L and it is within permissible limits of Standards of drinking water.

Calcium

Calcium is a cation. In the present analysis, it is been recorded to be minimum 20mg/L as CaCO$_3$ at St. VIII and maximum 110 mg/L as CaCO$_3$ at St. X. The average value of calcium was 23 mg/L as CaCO$_3$, it is ranging according to permissible limit. If calcium is present in higher concentration, it is most effective in reducing fluoride concentration. In Rajasthan, low community fluorosis index is been reported from fluorotic belt where calcium intake of people was found to be high.$^9$
Magnesium
The average magnesium is been reported to be 39.4 mg/L as CaCO₃ that is well within the permissible limits as prescribed by various organizations (Table 2).

Chloride
Chloride concentration measured in the water sample of Station I was 230 mg/L while that of Station X was 850 mg/L. This is above desirable limits of ICMR recommendation of 200 mg/L of chloride in groundwater. The average value of chloride is been measured to be 498 mg/L.

Nitrate
Nitrate is the highest oxidized form of nitrogen. Nitrate concentration in the water samples of St. I, II and III was reported to be 5mg/L and at St. VII it was reported as 70 mg/L. Average value of chloride of all the St.’s was 34 mg/L. BIS recommended 45 mg/L as desirable limit while 100 mg/L as permissible limit. Thus, all the samples in the study were within this limit. Human and animal wastes, industrial effluents, application of fertilizers and chemicals, seepage and silage through drainage system are the main sources of nitrate contamination of the groundwater. Nitrates are naturally occurring ions that is a part of the nitrogen cycle. Naturally occurring nitrate level in surface and groundwater is generally a few milligrams per liter. Nitrate-nitrogen and phosphate in water are due to the result of disposal systems such as landfills, septic tanks etc. Pesticides, fertilizers, domestic waste and industrial waste contaminate groundwater. High content of nitrate-nitrogen in water may be toxic to babies when used for making up feeds from milk powders. High concentration of nitrate-nitrogen in drinking water (>40 mg/L) may cause blue baby disease. If nitrate-nitrogen is greater than 100 mg/L, influence bitter taste to water and may cause methemoglobinemia in infants. Epidemiological studies have predicted the cause of gastric cancer because of the high intake of nitrate-nitrogen. This is because of the reaction of nitrate with amines in diet forming carcinogenic nitroso amines.

Spontaneous abortions in animals due to ingestion of high nitrate contaminated water have been also been observed. It is also been observed that in many herbivorous animals excess of nitrate ingestion through fodder and drinking water causes severe ailments. Therefore, it is been suggested that woman who are pregnant on trying to become pregnant should not consume water containing high levels of nitrate.
Sulphate
Sulphate ion is one of the important anions present in natural waters and reduces cathartic effect upon human beings when it is present in excess amount. The average sulphate ions content is been recorded to be 102.5 mg/L and it is ranging between permissible limit.

Fluoride
Fluoride is naturally present in water. Fluorides are more common in groundwater than in surface waters. According to the BIS 1.0mg/L is the potable limit of ground water. Fluoride concentration is been reported as minimum 0.72 mg/L at St. I and at St.’s V, VIII, and IX it measured a maximum s 5.1 mg/L which is higher than all standards of drinking water. Fluoride at lower concentration (0.6-1.5ppm) according to WHO[47] and Bureau of Indian Standard (10500-1991) is essential element for the development of teeth and bones and in growth, fertility, prevention of anemia in pregnancy and infancy (rodents). Higher content of fluoride in drinking water can cause severe health problems, particularly in arid and semi-arid regions. This could be due to the prevalent climatic conditions that necessitate people to drink water in quantities higher than what people drink in temperate regions.

The main sources of fluoride in groundwater are different fluoride bearing rocks such as fluorospar, cryolite, fluorapatite and hydroxylapatite.[6] Fluoride abundance levels in groundwater is been generally controlled by local geological regime. The fluoride content in the groundwater is a function of many factors, such as availability and solubility of fluoride minerals, velocity of flowing water, temperature, pH, concentration of calcium and bicarbonate ions in water etc.[11,26]

Various workers previously report fluorosis effect in form of dental fluorosis and skeletal fluorosis. In India.[46] first reported a disease similar to mottled enamel, that is prevalent in human beings in Madras presidency. Enamel mottling at 0.5 ppm and 0.9-1.0 ppm fluoride levels is been reported.[35,45] At 6.0 ppm, 100% prevalence of dental fluorosis is been reported.[12,27] and have observed a prevalence of 25.6% and 84.4% of grade II dental fluorosis in children at fluoride levels of 1.4 ppm and 6.04 ppm, respectively.[29] Reports 2.0 ppm fluoride level in village Chani, Kolayat Tehsil of the Bikaner district in the Indian Thar Desert of Rajasthan where Overall 36.66 percent populations are affected with dental fluorosis and 24.44 percent people are affected with skeletal fluorosis problem.[13] Dental and skeletal fluorosis in cattle is been reported in village Chani and Kolayat Tehsil of the Bikaner district in Indian Thar Desert of Rajasthan. Toxic effects of chronic fluoride reported in the
form of osteo-dental and non-skeletal fluorosis are been observed in 85 domestic animals including cow, goat and sheep.\textsuperscript{[30]}

CONCLUSIONS

The analysis of ground water under study shows higher values of fluoride, TDS (Total Dissolved Solids), and alkalinity than the permissible limits. The results envisaged that the quality of groundwater at most of the stations is very poor and is not suitable for drinking purpose and can only be used after proper treatment. These findings would also illustrate as contributing significantly to our existing knowledge of fluorosis. The provision of de-fluoridated drinking water and health education aimed at abating fluorosis in human is highly desirable in this desert area of Rajasthan.

ACKNOWLEDGEMENTS

We are thankful to the Principal, and Head of Post Graduate Department of Zoology, Government Dungar College, Bikaner for providing all necessary facilities.

REFERENCES


18. Ghosh, S. Environmental Chemistry, Dominant Publishers and Distributors, New Delhi (India), 2003; 47.


