Analysis of Fluoride Content in the Drinking Water from Rural Zones of Dahod District, Gujarat, India

Jay B. Pandya
Sir P. P. Institute of Science
Maharaja Krishnakumarsinhji Bhavnagar University
Bhavnagar

Bhavik R. Raval
Navjivan Science College
Affiliated to Gujarat University, Dahod

Gaurav H. Pawar
Navjivan Science College
Affiliated to Gujarat University, Dahod

Abstract

Present study was focused on the quality of ground water assessment which is used by the rural people for their drinking purpose. Drinking water was collected from bore wells or open wells and samples were brought to the laboratory and pH, conductivity, TDS, fluoride, calcium, magnesium, chloride, nitrate, sulphate, alkalinity, acidity were analyzed in triplicates. Values of results were compared with WHO standards and Indian standard values. The result is indicating that chemical and physical properties of these wells did not match with WHO and Indian standard values. Water samples of some villages of the Dahod district were suspected for having fluoride content and also unfavorable values in other quality parameters also, which creates major problems for human health. In the point of the human health it is very much essential to minimize the presence of fluoride content and also controlling the hazardous chemical and physical properties of drinking water. Elimination of fluoride content from the drinking water it is the major issue in the world. With the help of chemical process it can be possible, but the way it is also not good for the human health. The only solution is the removal of fluoride content from the water via biological and traditional methods which is in the practice from the ancient time. Biological and Traditional methods are safe and economically having low cost which is beneficial to the society.

Key words: Chemical and physical properties, drinking water, fluoride, health problems, quality analysis.

INTRODUCTION

Ground water has been an important natural resource for human beings. The population of the world depends entirely on the limited ground water resources to meet all of their requirement .A water supply system with good quality water is essential for these identified areas at least satisfy their requirement specially for domestic drinking purposes. (Nanthani T., *et al*, 2000)

Water is a chemical substance with the chemical formula H_2O. A water molecule contains one oxygen and two hydrogen atoms connected by covalent bonds. Water is a liquid at ambient conditions, but it often co-exists on Earth with its solid state, ice, and gaseous state (water vapors or steam). Water also exists in a crystal state near hydrophilic surfaces. Under nomenclature used to name chemical compounds, *dihydrogen monoxide* is the scientific name for water.

Water plays an important role as a chemical substance. Its many important functions include being a good solvent for dissolving many solids, serving as an excellent coolant both mechanically and biologically, and acting as a reactant in many chemical reactions.

In the present study, the quality of drinking water sources (bore and dug wells) of different villages of Dahod District was analyzed through testing of the physical and chemical standards which are designed to check the quality of water is up to the mark of the Drinking water or not. Then only anyone can have water is suitable and safe for drinking.

The importance of the study was to evaluate the sanctity of potable water in Dahod District and suggest safety measures to reduce the incidence of water – borne diseases.

The objective of this research is to identify appropriate water quality impact analysis methodologies that could be used for drinking water.

MATERIALS AND METHODS

The base data has been collected from the Gujarat State Water Supply Divison, Dahod. From previously available data, 20 villages of the Dahod Taluka which contains high concentration of salts were selected. The ground water samples of Bore well and dug well from selected villages were collected using pre-cleaned plastic bottles (sample from drinking purpose) for the further analysis purpose (Plate – 1, A and B). Following parameters were analyzed from water samples for checking drinking water quality.

POTENTIONAL OF HYDROGEN (pH)

Standard of pH in Drinking water as per WHO: 6.5 to 8.5

The Potential of Hydrogen was measured by using the pH meter (Equip Tronic EQ-615). For that the pH meter was calibrated with the help of buffer tablet of pH 7.0. After that all the samples pH was recorded measured at the room temperature. (Plate – 1, C) (Maiti, 2001)

CONDUCTIVITY or SPECIFIC CONDUCTANCE (E. C.)

Standard of conductivity of drinking water by WHO: No Standard

The conductivity of the water samples was measured by the conductivity meter (EquipTronic,EQ-660).The conductivity cell is calibrated by using the chemical 0.01 N KCl and the specific conductance is 1.0 constant. The specific conductance is measured at room temperature in the laboratory. (Maiti, 2001)

TOTAL DISSOLVE SOLIDS (TDS)

Standard of TDS in Drinking water as per WHO: - 500mg/L

A well-mixed, 100 ml sample was analyzed by digital TDS meter (Equip Tronic, EQ-680), which counted in the unit of PPM (Part per million) or PPT (Part per thousand).

HARDNESS (CALCIUM AND MAGNESIUM)

Standard of Calcium in Drinking water as per WHO: 75mg/L

Standard of Magnesium in Drinking water as per WHO: 50mg/L to 150mg/L

The hardness of the Calcium and Magnesium were measured by the titration method. EDTA was added to water containing both Ca and Mg, it combines first with Ca. Calcium can be determined by EDTA, when the pH is made sufficiently high so that Mg is largely precipitated as the hydroxide and an indicator is used that combines with Ca only. Indicators give a color change when all of the Ca has been complexes by EDTA. (Plate – 1, E) (Maiti, 2001)

NITRATE

Standard of Nitrate (NO_3^-) in Drinking water as per WHO: 10mg/L

The nitrate was measured by the UV - Visible Spectrophotometer (Elico, SL-150) Screening method. An ultraviolet technique measured the absorbance of nitrate at 220nm. This is suitable uncontaminated water (low in organic matter). A second measurement made at 275nm may be used to correct the nitrate value (because 275nm is not absorbed by nitrate). (Maiti, 2001)

FLUORIDE

Standard of Fluoride (F^-) in Drinking water as per WHO: 1mg/L to 1.5mg/L

The fluoride was measured by the Ion meter (Chemi Line, CL-190). Ion meter is calibrated with the 1ppm and 10ppm sodium bicarbonate solution. The fluoride is measured at room temperature. (Plate – 1, D) (Maiti, 2001)

CHLORIDE

Standard of Chloride (Cl^-) in Drinking water as per WHO: 0.5mg/L

The Chloride was measured by the titration method. Water samples were titrated against the silver nitrate solution of 0.01N, using potassium chromate as an indicator. (Maiti, 2001)

SULPHATE

Standard of Sulphate (SO_4^{-2}) in Drinking water as per WHO: 400mg/L

The sulphate was measured by the Nephelo Turbidity Meter (Chemi Line, CL-810). It is calibrated by the buffer solution. (Maiti, 2001)

ALKALINITY

Standard of Alkalinity in Drinking water as per WHO: Maximum 200mg/L

The alkalinity was estimated by the titration method. Water samples were titrated against 0.02N sulphuric acid, using phenolphthalein as an indicator. (Plate – 1, F) (Saxena, 1998)

ACIDITY

The acidity was estimated by the titration method. Water samples were titrated against 0.02N NaOH solution, using methyl orange as an indicator. (Plate – 1, F) (Maiti, 2001)

RESULTS and DISSCUTION

Sample code	pH	Conductivity (mMho)	TDS (ppm)	Fluoride (mg/L)	Calcium (mg/L)	Magnesiu m(mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Alkalinity (mg/L)	Acidity	Opinion
1	6.15	0.042	943	1.04	35.2	34.8	157.62	33.66	24	170	Nil	Unfit
2	6.39	0.063	1721	5.06	145.6	140	309.56	61.63	76	304	Nil	Unfit
3	6.93	0.036	890	1.97	44.8	42.8	110.76	31.01	33	270	Nil	Unfit
4	6.67	0.082	2220	1.63	166.8	6.0	384.82	40.41	80	382	Nil	Unfit
5	6.32	0.078	2210	3.13	86.4	64.8	604.92	44.30	93	344	Nil	Unfit
6	6.42	0.027	650	0.71	72.0	18.4	63.90	32.78	37	192	Nil	Unfit
7	6.62	0.045	1115	1.92	86.4	30.8	232.88	05.31	20	176	Nil	Unfit
8	6.92	0.025	590	0.14	44.8	45.6	97.98	25.59	26	202	Nil	Fit
9	6.78	0.024	561	4.10	51.2	25.6	105.08	28.25	24	236	Nil	Fit
10	6.58	0.055	1456	1.62	41.6	53.2	289.68	31.85	67	432	Nil	Unfit
11	6.44	0.048	1308	4.01	49.6	46.8	239.98	36.62	17	286	Nil	Unfit
12	6.59	0.039	835	1.62	78.4	38.8	110.76	01.77	22	184	Nil	Unfit
13	6.28	0.039	618	1.15	49.6	20.4	137.74	19.49	22	196	Nil	Fit
14	6.94	0.038	581	1.02	65.6	12.4	107.92	26.31	10	206	Nil	Fit
15	6.52	0.054	1410	1.97	142.4	21.6	318.08	22.15	05	204	Nil	Unfit
16	6.25	0.206	5770	7.92	274.0	102.4	2398.38	23.03	353	210	Nil	Unfit
17	6.57	0.041	1057	1.98	99.2	37.4	238.56	10.67	35	224	Nil	Unfit
18	6.68	0.044	1095	1.81	92.8	64.2	157.62	15.66	41	242	Nil	Unfit
19	6.48	0.039	851	0.42	105.6	18.4	107.92	19.16	17	162	Nil	Unfit
20	6.29	0.048	1251	0.77	155.2	4.8	276.90	26.15	61	226	Nil	Unfit

Table: Physio-chemical analysis of Water Samples

1) Jhalod: The quality of drinking water of village Jhalod showing the fluoride, calcium, magnesium, sulphate and alkalinity in the range while pH, TDS, chloride and nitrates are out of the range. In the view if above results the water of Jhalod Village is unfit for drinking purpose.

2) Limadi: The quality of drinking water of village Limadi mention that the magnesium and sulphate only in the range. But the other parameter like TDS, fluoride, calcium, chloride, nitrate, and alkalinity has very high range. So for that the water of the village Limdi is unfit for drinking purpose.

3) Lilva thakore: The quality of drinking water of village Lilvathakore showing that the pH, Calcium, Magnesium, and sulphate are in the range while TDS, fluoride, chloride, nitrate and alkalinity are out of range. It is Showing that the above results of the water of Lilvathakore are unfit for drinking purpose.

4) Prathmapura: The drinking water quality of the village Prathmapura viewing that pH, magnesium and sulphate are in the range of good quality water, while TDS, fluoride, calcium, chloride, nitrate and alkalinity are out of range for the good quality of water. Thus performance of this water of Prathmapura is unfit for drinking purpose.

5) Varod: The quality of the drinking water of the village Varod showing that magnesium and sulphate are in the range for the drinking water purpose, while pH, TDS, fluoride, calcium, chloride, nitrate and alkalinity are out of range. Thus the drinking water of Varod is unfit for drinking purpose.

6) Mirakhadi: The drinking water quality of the village Mirakhadi viewing that fluoride, calcium, magnesium, sulphate and alkalinity are in the range of good quality water, while pH, TDS, chloride and nitrate are out of range for the good quality of water. Thus performance of this water of Mirakhadi is unfit for drinking purpose.

7) Lilvadeva: In the village Lilvadeva, the quality of the drinking water viewing that pH, magnesium, nitrate, sulphate and alkalinity are in the range. But the other parameters like, TDS, fluoride, calcium and chloride are out range. So for that the drinking water of Lilvadeva is unfit for drinking purpose.

8) Nan Salai: The drinking water quality of village Nan Salai is showing that pH, fluoride, calcium, magnesium and sulphate are in the range. But the range of TDS, chloride and nitrate are nearly in the range of drinking water purpose. So it consider as fit for drinking purpose.

9) Kadwal: The drinking water quality of the village Kadwal is viewing that the parameters like, pH, calcium, magnesium and sulphate are in the range, while the other parameters like, TDS, fluoride, chloride, nitrate and alkalinity are nearly in the range. So from the above results the drinking water of Kadwal is considered as fit.

10) Mundaheda: In the village Mundaheda, the result of drinking water quality showing that pH, calcium, magnesium and sulphate are in the range, while TDS, fluoride, chloride, nitrate and alkalinity are out of range. So from the above result the drinking water quality of Mundaheda is unfit for the drinking purpose.

11) Sanpoi: The quality of drinking water of village Sanpoi showing the calcium, magnesium and sulphate are in the range, but other parameters like, pH, TDS, fluoride, chloride, nitrate and alkalinity are out of range. In the view of above result the drinking water quality of village Sanpoi is consider as unfit.

12) Kalimahudi: The drinking water quality of village Kalimahudi mention that the parameters like, pH, magnesium, nitrate, sulphate and alkalinity are in the range. But other parameters, TDS, fluoride, calcium and chloride are out of range. From the above results, village Kalimahudi is unfit for the drinking water.

13) Ambakach: The drinking water quality of village Ambakach is showing that fluoride, calcium, magnesium, sulphate and alkalinity are in the range, while pH, TDS, chloride and nitrate are nearly in the range. So for that the drinking water of the village Ambakach is considered as fit for drinking purpose.

14) Kaligam: From the parameters pH, fluoride, calcium, magnesium and sulphte are in the range of drinking water quality for the village Ambakach. But the other parameters TDS, chloride, nitrate and alkalinity are in the range. So for that the drinking water of the village Kaligam is considered as unfit for drinking purpose.

15) Navagam: The drinking water quality of village Navagam is showing that pH, magnesium and sulphate are in the range, while the other parameters like, TDS, fluoride, calcium, chloride, nitrate are out of range. In the above results, the drinking water quality of village Navagam is consider as unfit for drinking purpose.

16) Karath: In the village Karath, only magnesium and sulphate are in the range. But the other parameters like, pH, TDS, fluoride, chloride, calcium, nitrate and alkalinity has very high from the range. Karath has very high range from above all of the villages. In the viewing from above result, village Karath's drinking water is unfit for drinking purpose.

17) Pavdi: The quality of drinking water of village Pavdi showing the pH, magnesium and sulphate are in the range. But the TDS, fluoride, calcium, chloride, nitrate and alkalinity are out of range. So from the above results, the drinking water quality is unfit.

18) Nalvai: From the parameters like, pH, magnesium and sulphate are in the range. But the TDS, fluoride, calcium, chloride, nitrate and alkalinity are out of range. So from the above results, the drinking water quality of village Nalvai is unfit.

19) Chayan: The drinking water quality of village Chayan showing the parameters pH, fluoride, magnesium and sulphate are in the range, while TDS, calcium, chloride, nitrate and alkalinity are out of range. In the above results, the driking water quality of village Chayan is unfit for drinking purpose.

20) Godhra: The quality of drinking water of village Godhra showing the fluoride, magnesium and sulphate are in the range. But the pH, TDS, calcium, chloride, nitrate and alkalinity are out of range. So from the above results, the drinking water quality of Godhra is unfit.

Potential of Hydrogen

Fisher, 2002 has described that; pH is one of the most important parameter, which describe the groundwater quality, because pH largely controls the amount and chemical form of many organic and inorganic solutes in groundwater. Both temperature and dissolved gases affect the pH of groundwater.

pH of the collected sample was found between 6.15 to 6.94 which shows the pH of some of the villages are not preferable; that is accordance with the Pandya *et al*, 2012.

Conductivity

Conductivity in aqueous solutions is by means of ionic motion and invariably increases with increasing temperature, opposite to metals but similar to graphite. It is affected by the nature of ions, and by the viscosity of the water. In low ionic concentrations (very pure water), the ionization of water provides appreciable part of the conducting ions. All these processes are quite temperature dependent and thus conductivity has a substantial dependence on temperature. (Aquarius Technical Bulletin-No. 08, 2000)

Total Dissolve Solids

"Dissolved solids" refer to any minerals, salts, metals, cations or anions dissolved in water. This includes anything present in water other than the pure water molecule and suspended solids. (Ref………..WHO)

Some dissolved solids come from organic sources such as leaves, silt, plankton, and industrial waste and sewage. Other sources come from runoff from urban areas, road salts used on street during the winter, and fertilizers and pesticides used on lawns and farms. (Ref………..WHO)

Dissolved solids also come from inorganic materials such as rocks and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur, and other minerals. Many of these materials form salts, which are compounds that contain both a metal and a nonmetal. Salts usually dissolve in water forming ions. Ions are particles that have a positive or negative charge. (Ref………..WHO)

Water may also pick up metals such as lead or copper as they travel through pipes used to distribute water to consumers. (Ref………..WHO)

Note that the efficacy of water purifications systems in removing total dissolved solids will be reduced over time, so it is highly recommended to monitor the quality of a filter or membrane and replace them when required. (Ref………..WHO)

If TDS levels are high, especially due to dissolved salts, many forms of aquatic life are affected. The salts act to dehydrate the skin of animals. High concentrations of dissolved solids can add a laxative effect to water or cause the water to have an unpleasant mineral taste. It is also possible for dissolved ions to affect the pH of a body of water, which in turn may influence the health of aquatic life. If high TDS readings are due to hard-water ions, then soaps may be less effective, or significant boiler plating may occur in heating pipes. (Ref………..WHO)

TDS of the samples collected from Dahod District are not consumable as per the range mention by the WHO (World Health organization) (Ref………..WHO)

Fluoride

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many type of rock. It exists in the form of fluorides in a number of minerals of which fluorspar; cryolite, fluorite and fluorapatite are the most common. Fluorite (CaF_2) is a common fluoride mineral. (Ref………..WHO)

Fluoride levels in surface waters vary according to location and proximity to emission sources. Surface water concentrations generally range from 0.01 to 0.3 mg/liter. Seawater contains more fluoride than fresh water, with concentrations ranging from1.2 to 1.5 mg/litre. Higher levels of fluoride have been measured in areas where the natural rock is rich in fluoride, and elevated inorganic fluoride levels are often seen in regions where there is geothermal or volcanic activity (e.g., 25–50 mg fluoride/liter in hot springs and geysers and as much as 2800 mg/liter in certain East African Rift Valley lakes). Anthropogenic discharges can also lead to increased levels of fluoride in the environment. (Dr R. Liteplo 2002)

Calcium

Most calcium in surface water comes from streams flowing over limestone, $CaCO_3$, gypsum, $CaSO_4 \cdot 2H_2O$, and other calcium-containing rocks and minerals. Groundwater and underground aquifers leach even higher concentrations of calcium ions from rocks and soil. Calcium carbonate is relatively insoluble in water, but dissolves more readily in water containing significant levels of dissolved carbon dioxide.

The concentration of calcium ions (Ca2+) in freshwater is found in a range of 0 to 100 mg/L, and usually has the highest concentration of any freshwater cation. A level of 50 mg/L is recommended as the upper limit for drinking water. High levels are not considered a health concern; however, levels above 50 mg/L can be problematic due to formation of excess calcium carbonate deposits in plumbing or in decreased cleansing action of soaps. If the calcium-ion concentration in freshwater drops below 5 mg/L, it can support only sparse plant and animal life, a condition known as *oligotrophic*. (http: //www. vernier. Com /cmat /wqv. html)

Magnesium

The drinking-water resources in Asia are diverse and include piped and non-piped supplies. Most drinking-water is piped, but ditches, ponds, springs and rivers are important in some regions, accompanied by rainwater collection and wells. The mineral contents of water from most Asian drinking-water supplies are generally 20 mg/l for magnesium (Mg2+).

Studies by Yang and his colleagues showed that there was an inverse relationship between water hardness and various diseases, including coronary mortality, cerebrovascular disease and gastrointestinal tract cancers in Taiwan, China; however, the specific concentrations of calcium, magnesium and other minerals that made up the total water hardness were not given in these reports (Yang and Hung 1999).

A survey of trace elements, including magnesium, but not calcium, was conducted by al-Saleh and al-Doush (1998) in Riyadh, Saudi Arabia. This city is supplied mainly with desalinated seawater and water from deep wells. The study found that the household drinking-water contained magnesium at concentrations ranging from 0.78 to 0.88 mg/l, suggesting that the concentration of this trace element in drinking-water is minimal. (Olajire and Imeokparia, 2001)

Magnesium intake can be appreciably influenced by water consumption (Marier 1990; IOM 1997). Because the magnesium concentration of tap water is related to the degree of hardness (e.g. calcium and magnesium contents), it has been estimated that drinking-water can contribute 40–100 mg/day (Marier, 1990).

Here in the Dahod district, all of the villages, water samples contains magnesium is not dangerous to health.

Chloride

Chloride is present in all natural waters, mostly at low concentrations. It is highly soluble in water and moves freely with water through soil and rock. In ground water the chloride content is mostly below 250 mg/l except in cases where inland salinity is prevalent and in coastal areas. (Jha B.M., 2010)

At a local scale, the groundwater quality is influenced by infiltration of waste water and/or water that has percolated through solid municipal waste in the villages, which increases the mineralization of groundwater, in particular its chloride content down gradient of chloride sources (villages and poultry farms). Even small villages in rural area are shown to have an impact on the groundwater quality due to the absence of sewage collection and treatment facilities. At the present time, the level of chloride content is still acceptable but its accumulation in soil and groundwater must be monitored and controlled in order to avoid health problems for the local population for whom groundwater is the only source of drinking water. (WHO)

Nitrate

The main cause for increase in nitrates in groundwater is open sewage disposal and use of nitrogen fertilizers. Since rural sanitation in Karnataka is in a dismal condition, some districts like Gulbarga, Bijapur, Raichur and Tumkur have sanitation coverage below 20%. The presence of nitrates in water is evidence of such contamination. Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants by a process called nitrogen fixation. Dissolved Nitrogen in the form of Nitrate is the most common contaminant of ground water. Nitrate in ground water generally originates from non-point sources such as leaching of chemical fertilizers & animal manure, ground water pollution from septic and sewage discharges etc. It is difficult to identify the natural and manmade sources of nitrogen contamination of ground water. Some chemical and micro-biological processes such as nitrification and denitrification also influence the nitrate concentration in ground water. (B. M. Jha, 2010)

Sulphate

Ojo and Bakare have tested microbial and chemical analysis of potable water in public – water supply within Lagos University. They mention that the range of the sulphte of the all the faculty of Lagos university are as per WHO. In the Dahod district, the range of the sulphte of all the villages are comes into the range of WHO.

Alkalinity

Simpi and his colleagues has mention from the physical and chemical analysis of Hosahali tank in Shimoga, that the total alkalinity ranges from 110 mg/l to 165 mg/l the maximum value (165mg/l) was recorded in the month of May (summer) and minimum value (110 mg/l) in the month of January (winter). The alkalinity was maximum value in April (summer) due to increase in bicarbonates in the water.(Hujare, M. S. 2008) also reported similar results that it was maximum in summer and minimum in winter due to high photosynthetic rate.

Here from the tested water samples of Dahod district are very fluctuate and not good for the drinking purpose.

CONCLUSION

The Present data reveals that, in many villages of Dahod District, Gujarat shows a very high amount of fluoride in the drinking water, which highly affects the health of the Human. If the people do not get the healthy drinking water it also affects the growth of the state and nation. Build up the strong nation it is very essential that government and public will take care for the supply of Healthy Primary requirements such as "DRINKING WATER".

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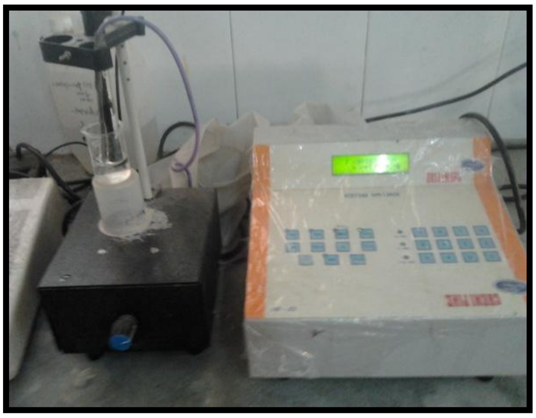
(A) Sample Collection from open well **(B) Sample collection from hand pump**



(C) pH Meter **(D) Fluoride Ion Meter**

(E) Calcium Estimation

(F) Acidity and Alkalinity

PLATE – 1