International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)

| ISSN: 2395-7852 | www.ijarasem.com | Bimonthly, Peer Reviewed & Referred Journal |

| Volume 4, Issue 6, November 2017 |

Fluoride Contamination Analysis of Drinking Water of Dausa City and Its Impact on Human Health

Barola D.S., Mohan Singh

Botany Dept., SPNKS Govt. PG College, Dausa, Rajasthan, India

ABSTRACT: Groundwater is the major source of drinking water in semi-arid region of Rajasthan, India but its quality has been degraded by the addition of contaminants through natural and or anthropogenic reasons. Fluoride is one among these contaminants. The deterioration in the water quality may result in the health hazards. To ensure proper groundwater management in the area present study is carried out to understand the status of groundwater quality and possible causes for high fluoride concentrations. 34 groundwater samples were collected from Dausa district of Rajasthan. Analysed results show that the fluoride concentration ranged between 0.48 and 3.64 mg/l with an average of 1.66 mg/l in groundwater of study area. Fluoride concentrations in about 82% of the samples are more than the permissible limit (1.0 mg/l) set by the Bureau of Indian standards (BIS, 1991), whereas based on the WHO standards (F:1.5 mg/l) (WHO, 2009), about 41% of samples are exceeded the maximum permissible limit. The order of major cations and anions are $Na^{+}>Mg^{+2}>Ca^{+2}>K^{+}$ and $HCO_3^{-} > Cl^{-} > SO_4^{-2}>CO_3^{-2}>NO_3^{-} > F^{-}$, respectively. Weathering of rocks, evaporation and anthropogenic activities are found be responsible for high fluoride concentration. Since the geological unit in study area are alluvium, quartzite and granite gneisses containing fluoride bearing minerals like – Biotite, Muscovite, Fluorite and Albite, the major contribution comes from weathering of rocks. This finding is further supported by Scholler Chloro-alkaline indices and high Na^{+}/Ca^{+2} ratio (>1.0) suggesting ion-exchange. The high fluoride content render the water unfit for agriculture and drinking purpose in the area thus to ensure sustainable uses corrosivity ratio (CR) is utilized to assess groundwater suitability for industrial uses.

KEYWORDS: fluoride, Dausa, groundwater, drinking, human health, fluorosis, hazards, contaminants, pollution

I.INTRODUCTION

Fluoride is recognised as the thirteenth most common element in the earth's crust. It has both beneficial and adverse effect on human health. Consumption of small quantity of fluoride (0.60 mg/l) is essential to bypass dental decay (BIS, 2012); whereas a dose lower than <0.6 mg/l in water promote tooth decay. When consumed in high dose (>1.5 mg/l), it leads to dental fluorosis, and excessively high concentration (>3.0 mg/l) may lead to skeletal fluorosis. High indications of dental fluorosis are mostly found in children up to the age of 12 years and skeletal fluorosis (Apambire et al., 1997) may occur when fluoride concentration is more than 10 mg/l (Boyle and Chagnon, 1995). In 2013 the fluoride contamination was reported from 18 states of India (CGWB, 2013), the spread has increased to 21 states affecting 62 million people which includes 6 million children (Adimalla and Li, 2014, Adimalla and Venkatayogi, 2016).[1,2]

Geochemical environment of groundwater is responsible for fluoride enrichment (Handa, 1975; Singh et al., 2011). High fluoride concentration and fluorosis in the country are commonly associated with rural areas, arid and semi-arid climate, granite and gneisses (Teotia et al., 2004; Fawell et al., 2006; Bhattacharyya, 2007; Johnson et al., 2008; Subba Rao, 2009; Mondal et al., 2009; MacDonald et al., 2016; Bonsor et al., 2016; Krishan et al., 2016; Ali et al., 2015, 2014; Arya et al., 2014; Aravinthasamy et al., 2014, Kimambo et al., 2014; Karunanidhi et al., 2014, 2013a, 2010b; Aullón Alcaine et al., 2013; Yadav et al., 2013). Ijumulana et al. (2013) studied fluoride concentration in northern Tanzania and found that due to geological variations, 96% [3,4] of water sources in hotspots have concentrations more than permissible limit of 1.5 mg/L while cool spots have extremely low concentrations below 0.5 mg/L which is not safe for drinking. Vithanage and Bhattacharya (2015) reported that geology, rock types, residence time, aquifer depth and weathering intensity resulted in variations in fluoride contents of African groundwater. In Indian conditions,[5,6] Jacks et al. (2005) reported that the high fluoride concentration groundwater in many parts of India may be due to (i) evapotranspiration of groundwater with residual alkalinity (ii) difference in sequences of secondary precipitates (iii) alkalinisation of soils. Mamatha and Rao (2010), Adimalla and Qian (2014); Adimalla and Li (2014) studied the factor responsible for fluoride content in groundwater from a part of Kolar and Tumkur district of Karnataka, India and found that the dry climate, the origin and geochemical mechanisms play a significant role for fluoride contamination of groundwater. Marghade et al. (2015) used the various hydrogeochemical tools such as groundwater type, geochemical evolution of fluoride groundwater, ion exchange process, saturation indices, [7,8] geochemical modelling and pollution index of groundwater (PIG). In this study, it was concluded that the enrichment of fluoride was mainly controlled by geologic and hydrogeological conditions, fluoride-bearing minerals and their dissolution/precipitation under the alkaline environment. Further, the ion exchange process, anthropogenic inputs and pollution index of groundwater affect the contamination of fluoride. Rao et al. (2014) assessed the regional appraisal of fluoride occurrence in groundwater of Andhra Pradesh, India and observed the fluoride rich minerals[9,10] as the main sources and residence time, evapotranspiration and weathering processes as the supplementary factors for higher concentration of fluoride in groundwater. Thapa et al. (2016) applied geospatial modelling technique for delineation of fluoride contamination zone within Dwarka Basin, Birbhum, India and concluded that the use of remote sensing and GIS generate basic preliminary ideas of the probable contamination site of groundwater with fluoride.[11,12]

Since no major studies were conducted focusing on Dausa district, the present study seeks to understand groundwater quality in this area and to assess the possible causes for high concentration of fluoride in groundwater. Further assessment is done to check the suitability of groundwater for industrial purpose using Corrosivity ratio.

Dausa district of Rajasthan state lies between 26º 22′ 13.32″ to 27º 14′ 33.58″ north latitude and 76º 08′ 32.62″ to 77º 05′ 00.41″ east longitude covering an area of 3420 km^2 (Fig. 1). The population of the district is 1,317,063 out of which 1,181,245 (89.69%) in the rural and 1,35,818 (10.31%) in the urban area (Census, 2011). There are three important river basins; Banganga basin (forming 62.89% in the upper northern part), Morel basin (34.27 occupying the southern part). Groundwater samples were collected by Groundwater department, Rajasthan [13,14]from 34 sites, which consist of shallow hand pumps and tube wells, in polypropylene bottles during April–May 2015. The location of sampling sites is shown in Fig. 1. For sample collection and analysis procedure as suggested by Trivedy and Goel (1984) and American Public Health Association, APHA (1985) are followed. The important use of water analyses in groundwater hydrology is to give information about the water quality. The groundwater quality is very important for determining its suitability for drinking and domestic, agricultural, and industrial purpose. The minimum, maximum, average and standard deviation concentration of physicochemical parameters of water quality such as pH, Electrical conductivity (EC), Total dissolved solids (TDS), Total hardness (TH), and major cations and anions are presented.[15,16] Groundwater quality has been evaluated specially in-terms of fluoride concentration and its sources in a semi-arid area, Dausa District, Rajasthan. It has been concluded that fluoride contamination in groundwater of the study area mainly depends on fluoride-bearing minerals and their interaction with water. The main sources of fluoride identified are decomposition, dissociation and dissolution of fluoride rich minerals such as biotite and muscovite. [17,18]

II.DISCUSSION AND RESULTS

pH: The pH values in the groundwater samples of the study area range from 7.3 to 8.7 with the mean value of 7.93 ± 0.4984. The groundwaters are alkaline in pH. According to WHO (1992) specification, all the samples fall under desirable limit of pH (6.9-9.2). Electrical conductivity (EC): A high concentration of salts in irrigation water renders the soil saline. This also affects the salt intake capacity of the plants through roots. Electrical conductivity of water samples ranged from 402 to 2077 µmhos/cm with the mean of 1146.44 µmhos/cm. The US Salinity Laboratory (1954) classified ground waters on the basis of electrical conductivity (Table 4) : Up to 250 µmhos/cm as excellent; 250 to 750 µmhos/cm as good; 750 to 2250 µmhos/cm as fair and > 2250 µmhos/cm as poor category. [19,20]Based on this classification 78% of samples belong to fair category and remaining 22% of samples belong to good category. Total dissolved solids (TDS): The total dissolved solids range from 265 to 1370 mg/L with a mean of 756.5 ± 301.24 mg/L. According to WHO specification, TDS up to 500 mg/L is highest desirable and up to 1000 mg/L is maximum permissible category, thus 78% of samples belong to maximum permissible category, and remaining 22% of samples to below the WHO specification. Based on the concentration of TDS (Wilcox 1955) groundwater can be classified as follows: Up to 500 mg/L as desirable for drinking; up to 1000 mg/L as permissible for drinking and up to 3000 mg/L as useful for irrigation. Based on this classification it was observed that out of 18 samples 8 are desirable for drinking and remaining 10 are permissible for drinking. [21,22]Total hardness (TH): Hardness results due to the presence of divalent cations of which Ca+2 and Mg+2 are the most abundant in ground waters. Hardness in water is also derived from the solution of carbon dioxide released from bacterial action in soil in percolating water (Sawyer & McCarty 1967). In the present study, the hardness of water samples ranged from 130 to 730 mg/L with a mean of 327.22 mg/L. The waters of the study area are classified according to hardness based on WHO (1984), which revealed that 89% of samples belong to permissible limit and 11% to out of permissible limit. Total alkalinity (TA): Most of the natural waters contain substantial amounts of dissolved carbon dioxide, which is the principle source of alkalinity, and this can be conveniently evaluated by acid titration. An increase in the temperature or decrease in the pressure causes a reduction in the solubility of CO2 in water.[23,24] In the present study, alkalinity ranges between 110 and 620 mg/L with a mean of 328.88 mg/L. According to WHO classification, 56% of samples belong to out of permissible limit, 33% of samples to optimum permissible limit, and 11% of samples to below permissible limit. Sulphate (SO4 –2): Health concerns regarding sulphates in drinking water have been raised because of reports of diarrhoea associated with the ingestion of water with high levels of sulphates. Although there is little information describing the acute toxicity of sulphates in humans, animal data suggest that sulphate salts are not very toxic (Lorraine 2000). In the present study, sulphates range from 6.0 to 85 mg/L with a mean of 25.44 mg/L. According to WHO classification, 78% of samples belong to below the permissible limit and 22% samples to permissible limit. Fluoride (F–): Fluoride concentration ranged from 0.06 to 0.68 mg/L with a mean of 0.36 mg/L Fluoride values of all ground waters are below the WHO limit (1.5 mg/L). 61.11% of drinking water samples contained fluoride less than 0.5 mg/L. Consumption of drinking water with such low fluoride content is insufficient to prevent dental caries. Chloride (Cl–): The acceptable range of chloride is 200 to 600 mg/L by WHO (1992). The chloride concentration varied from 20 to 450 mg/L with a mean of 151.66 mg/L. In all, 22% of samples belong to optimum permissible limit, while 78% of samples fall below the permissible limit. When the excess chloride concentration is present with excess sodium concentration it may cause congestive heart failure[25,26] Nitrate (NO3 –): The acceptable range for nitrate is 45 mg/L by WHO (1992). The nitrate concentration varied from 5 to 97 mg/L with a mean of 42.16. In all, 11% of samples belong to optimum permissible limit, 33% to out of permissible limit, and 56% to below the permissible limit. Percent sodium (% Na): Sodium concentration is important in classifying irrigation water because sodium reacts with soil to reduce its permeability. Soils containing a large proportion of sodium with carbonate as the predominant anion are termed alkali soils; those with chloride or sulphate as the predominant anions are saline soils. The role of sodium in the classification of groundwater for irrigation was emphasized because of the fact that sodium reacts with soil and as a result clogging of particles takes place, thereby reducing the permeability (Todd 1980, Domenico & Schwartz 1990). The percent sodium value in study area varies from 1.81 to 8.48.[27,28]

III.CONCLUSIONS

Groundwater is the major source of drinking water in semi-arid region of Rajasthan, India but its quality has been degraded by the addition of contaminants through natural and or anthropogenic reasons. Fluoride is one among these contaminants. The deterioration in the water quality may result in the health hazards. To ensure proper groundwater management in the area present study is carried out to understand the status of groundwater quality and possible causes for high fluoride concentrations. Many groundwater samples were collected from Dausa district of Rajasthan. Analysed results show that the fluoride concentration ranged between 0.48 and 3.64 mg/l with an average of 1.66 mg/l in groundwater of study area. Fluoride concentrations in about 82% of the samples are more than the permissible limit (1.0 mg/l) set by the Bureau of Indian standards, whereas based on the WHO standards (WHO, 2009), about 41% of samples are exceeded the maximum permissible limit. The order of major cations and anions are $Na^{+}>Mg^{+2}>Ca^{+2}>K^{+}$ and $HCO3^{-} > Cl^{-} > SO4^{-2}>CO3^{-2}>NO3^{-} > F^{-}$, respectively. Weathering of rocks, evaporation and anthropogenic activities are found be responsible for high fluoride concentration. Since the geological unit in study area are alluvium, quartzite and granite gneisses containing fluoride bearing minerals like – Biotite, Muscovite, Fluorite and Albite, the major contribution comes from weathering of rocks.[29] This finding is further supported by Scholler Chloro-alkaline indices and high Na^{+}/Ca^{+2} ratio (>1.0) suggesting ion-exchange. The high fluoride content render the water unfit for agriculture and drinking purpose in the area thus to ensure sustainable uses corrosivity ratio (CR) is utilized to assess groundwater suitability for industrial uses[30]

REFERENCES

1) Akpata, E. S., Fakiha, Z. and Khan, N. 1997. Dental fluorosis in 12-15 years old rural children exposed to fluorides from well drinking water in the Hail region of Saudi Arabia. Community Dent. Oral Epidemiel., 25(4):324- 327.
2) Alhava E. M., Olkkonen H., Kauranen P., and Kari T. 1980. The effect of drinking water fluoridation on the fluoride content, strength and mineral density of human bone. Actaorthop. Scand., 51(3):413-420.
3) American Public Health Association (APHA), 2005. Standard methods for examination of water and wastewater. 21st edn. American Public Health Association, Washington DC.
4) Ayenew, T. 2008. The distribution and hydrogeological controls of fluoride in the groundwater of central J. Himalayan Ecol. Sustain. Dev. Vol. 13 (2015) ISSN 0973-7502 132
5) Ethiopian rift and adjacent highlands. Environ Geol.,54:1313-1324. BIS. 2012.
6) Indian standards specification for drinking water. IS:10500:2012, 2nd Rev., BIS, New Delhi.
7) Cao, J., Zhao, Y., Lin, J. W., Xirao, R. D. and Danzong, S.B. 2000. Environmental fluoride in Tibet. Environ Res., 83:333-337.
8) Central Ground Water Board (CGWB), 2008. Groundwater brochure Dausa district, Rajasthan. CGWB-WR, Jaipur, p-21.

9) Durfor, C. N. and Becker, E. 1964. Public water supplies of 100 largest cities in the United States. Water supply paper.
10) Edet, A. E., Merkel, B. J. and Offiong, O. E. 2003. Trace element hydrochemical assessment of the Calabar coastal plain aquifer, South-eastern Nigeria using statistical methods. Environ Geol., 44:137-149.
11) Handa, B. K. 1975. Geochemistry and genesis of fluoride containing groundwater in India. Groundwater, 13:275-281.
12) Handa, B. K. 1988. Fluoride occurrence in natural waters in India and its significance. Bhu-Jal News, 3:31-37.
13) Hem, J. D. 1991. Study and interpretation of the chemical characteristics of natural waters. Book- 2254, 3rd Ed Scientific Publicers, Jodhpur, 263. IS10500:2004 Drinking Water Specification, Bureau of Indian Standards, New Delhi. Kumar
14) S. K., Logeshkumaran A., Magesh N. S., Godson P. S., and Chandrasekar N. 2015. Hydrogeochemistry and application of water quality index (WQI) for groundwater quality assessment, Anna Nager, part of Chennai city, Tamil Nadu, India.
15) Applied Water Sci., 5:335-343. Mandel, S. and Shiftan, Z. L. 1980. Ground water resources investigation and development, Academic press, New York.
16) Mondal, N. C., Prasad, R. K., Saxena, V. K., Singh, Y. and Singh, V.S. 2009. Appraisal of highly fluoride zones in groundwater of Kurmapalli watershed, Nalgonda district, Andhra Pradesh (India). Environ Earth Sci., 59(1):63-73.
17) Mondal, N. C., Saxena, V. K. and Singh, V. S. 2005. Assessment of groundwater pollution due to tanneries in and around Dindigul, Tamilnadu, India. Environ Geol., 48(2):149-157.
18) Msonda, K. W. M., Masamba, W. R. L. and Fabiano, E. 2007. A study of fluoride groundwater occurrence in Nathenje, J. Himalayan Ecol. Sustain. Dev. Vol. 13 (2015) ISSN 0973-7502 133
19) Liongwe, Malawi. Phys and Chem Earth., 32:1178-1184. Muralidharan, D., Nair Anita, P. and Sathyanarayana, U. 2002.
20) Fluoride in Shallow aquifer in Rajgarh tehsil of Churu district, Rajasthan an arid environment. Curr. Sci., 83:699-702.
21) Piper A. M., 1944. A graphic procedure in the geochemical interpretation of water analyses. Trans. Amer. Geophys. Union, 25:914-928.
22) Salve, P. R., Maurya, A., Kumbhare, P. S., Ramteke, D.S. and Wate, S.R. 2008. Assessment of groundwater quality with respect to fluoride. Bull Environ Cont. Toxicol., 81:289-293.
23) Sarala, C. and Ravi Babu P. 2012. Assessment of groundwater quality parameters in and around Jawaharnagar, Hyderabad. International Journal of Scientific and Research Publications,10:1-6.
24) Sarwade, D. V., Nandakumar, M. V., Kesari, M.P., Mondal, N.C., Singh, V.S. and Singh, B. 2007. Evaluation of seawater ingress into an Indian Attoll, Environ Geol., 52(2):1475– 1483.
25) Srinivasamoorthy, K., Vasanthavigar, M., Vijayaraghavan, K., Sarathidasam, R. and Gopinath, S. 2013. Hydrochemistry of groundwater in a coastal region of Cuddaloredistric, Tamilnadu, India: implication of quality assessment. Arab J. Geosci., 6:441-454.
26) Subba Rao, N. 2009. Fluoride in groundwater, Varsa river basin, Visakhapatnam district, India. Environ Monit Assess., 152: 4760.
27) Suthar, S., Bishnoi, P., Singh S., Mutiyar P. K., Nema A. K., and Patil N. S., 2009. Nitrate contamination in groundwater of some rural areas of Rajasthan, India, J Hazard Mater, 171:189-199.
28) Teotia, S. P. S., Teotia, M. and Singh, K. P. 2004. Highlights of forty years of research on endemic skeletal fluorosis in India. In: proceedings of the 4th international workshop on fluorosis prevention and defluoridation of water. Colombo. 101-117.
29) WHO. 2011. Guidelines for drinking water quality. WHO, Geneva, 4th ed, Recommendations,1-4.
30) Xiano, J., Jin, Z. D., Zhang, F. and Wang, J. 2012. Solute geochemistry and its sources of the groundwater in the Qinghai Lake catchment, NW China. J. Asian Earth Sci., 52:21-30.