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Assessment of Groundwater Quality with Special Reference to Fluoride Concentration in Parts of Kandukuruvagu Basin in Nalgonda District, Telangana State, India

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Abstract: ***Fluoride-enriched water has become a major public health issue in India. The present study tries to evaluate the geochemical mechanism of fluoride enrichment in groundwater of kandukuruvagu basin in nalgonda District, Telangana State, India. Total 50 groundwater samples were collected for the study spreading across the entire study area. The results of the analyzed parameters formed the attribute database for geographical information system (GIS) and Microsoft office excel analysis and final output maps. The fluoride concentration ranges from 0.44 to 5.4 mg/L (mean 2.85 mg/L), with 59 % of the samples containing fluoride concentrations that exceed the World Health Organization (WHO) drinking water guideline value of 1.5 mg/L and 81 % samples exceeding the Bureau of Indian Standards (BIS) guidelines of 1 mg/L. Presence of fluoride bearing minerals in the host rock, the chemical properties like decomposition, dissociation and dissolution and their interaction with water is considered to be the main cause for fluoride in groundwater. Chemical weathering under arid to semi-arid conditions with relatively high alkalinity favours high concentration of fluoride in groundwater. Dental and skeletal fluorosis are prevalent in the study area which can be related to the usage of high fluoride groundwater for drinking. The suggested remedial measures to reduce fluoride pollution in groundwater include dilution by blending, artificial recharge, efficient irrigation practices and well construction.***

Keywords: Groundwater, Fluoride, Dissolution, Alkalinity,Pedda Kandukuru1,2 and Mallapuram Nalgonda district, Telangana

1. Introduction

Fluoride helps in mineralization of bones and formation of enamel of teeth. A daily dose of 0.5 ppm is required for proper formation of enamel and bone mineralization which otherwise may result in formation of dental fluorosis characterized initially by opaque white patches, staining, mottling and pitting of teeth, lack of enamel formation, and bone fragility (Cao et al. 2000; Rwenyonyi et al. 2000; Vieira et al. 2005; Edmunds and Smedley 2005; Ayenew 2008; Banerjee 2014). Long-term intake of fluoride-enriched water may cause bilateral lameness and stiffness of gait (Suttie 1977; Oruc 2008). Common natural fluoride sources in groundwater are the dissolution of some fluoride bearing minerals, such as fluorite (CaF2), muscovite, biotite, hornblende, villianmite, tremolite, fluorapatite, and some micas weathered from silicates, igneous, and sedimentary rocks, especially shale (Handa 1975; Pickering 1985; Wenzel and Blum 1992; Datta et al. 1996; Zhang et al. 2003; Fawell et al. 2006; Msonda et al. 2007; Jha et al. 2010; Singh et al. 2011a, b, c). Unstable minerals such as sepiolite and palygorskite may also have a dominant control on fluoride concentration in groundwater (Kim et al. 2005; Jacks et al. 2005). Fluorine has been rated as the 13th most abundant element on earth and is dispersed widely in nature (Mason and Moore 1987; Ayoob and Gupta 2006; Viswanathan et al. 2009). Due to its maximum electronegativity and reactivity among all chemical elements, the elemental fluorine state occurs rarely in nature.

Intake of F ([1.5 mg/L in drinking water) for a prolonged period is known to cause damage to the teeth enamel (dental fluorosis), skeletal complications known as skeletal fluorosis and non-skeletal fluorosis (WHO 1994). In India about 62 million people including 6 million children face the problem of fluorosis due to consumption of fluoride contaminated drinking water. Traces of fluoride can be found in air, most foodstuffs and beverages, particularly in tea but the principal daily intake source for humans (75 %) is drinking water (Mahvi et al. 2006). It is known now that the 97 % of global freshwater is stored in subsurface and groundwater resources. Also, it has been estimated that more than 50 % of the world's population depends on groundwater for survival. Additionally, in many parts of the world, especially in arid and semi-arid climates, there is no alternative for communities to supply drinking water.

Accumulation of F in crops, particularly in areas where soil is irrigated with F contaminated water may pose an additional threat to human health. It is the total amount of F absorbed in a human body that needs to be considered i.e. the sum of F intake from water, food (Malde et al. 2011) as well as air (Batra et al. 1995; Srikantia 1977). In some areas where fluorosis is endemic, F ingestion through food constitutes a significant portion of the total daily intake (Kumari et al. 1995; Malde et al. 1997, 2011).

It is essentially related to declining groundwater level due to over exploitation, mainly for irrigation, resulting in virtual drying up of the shallow unconfined aquifers. This has led to exploitation of deeper aquifers containing high levels of fluoride (Gupta and Sharma 2005).

2. Literary Reviews

Banerjee A (2014) Groundwater fluoride contamination: a reappraisal.Geosci Front. doi:10.1016/j.gsf.2014.03.003. Ayenew T (2008) The distribution and hydrogeological controls of fluoride in the groundwater of central Ethiopian rift and adjacent highlands. Environ Geol 54:1313–1324.

Datta PS, Deb DL, Tyagi SK (1996) Stable isotope (O18) investigations on the processes controlling fluoride contamination of groundwater. J Contam Hydrol 24:85–96

3. Previous Study

The groundwater of Nalgonda district is well known for its very high fluoride content for the past five decades. Many researchers have contributed their scientific knowledge to unravel causes for fluoride enrichment of groundwater and the micro level watershed studies were also carried out in the Fluoride affected parts of the nalgonda district by (Reddy et.al.2010; Brindha et. Al. 2011; N. C. Mondal et.al.2009; Ramamohana Rao et.al.1993).

In the view of the results obtained in previous research, it is proposed to carry out detailed hydrogeochemical investigations in the aleru river watershed covering areas of Aleru, Yadagirigutta, Rajapeta, Bhuvangiri, Valigonda, Gundala, Atmakur Mandals for the study of Fluoride distribution in the groundwater. Hence, the present work is not repetition but envisages the quantitative and qualitative assessment of the groundwater resources of selected study area with an integrated approach of Hydrogeological, Geophysical and GIS techniques, which has not been studied so far.

Figure 1: Location Map of the Study Area

4. Hydrogeology

The Archean crystalline rocks, which occupy 90% of the district comprise granites, gneisses, schists and intrusives. Groundwater occurs in all the geological formations in the study area. The major rock type in the study area is granite. The overall drainage pattern in the districts is dendritic to sub -dendritic and rectangular. The crystalline rocks inherently devoid of primary porosity. However, subsequently, with dynamic process of weathering, the rocks undergo fracturing and fissuring and joints over a period of time, lead to the development of secondary porosity, which forms the repository for ground water.The ground water occurs under water table conditions in weathered zone and semi-confined and confined conditions in fractured zone.

The occurrence and behavior of groundwater is an outcome of combined interplay of hydrological, geological, structural, climatologically factors, which together form dynamic integrated system. All these factors are inter-dependent and inter-related, each adding its contribution in functioning of the dynamic system. In the granitic terrain, groundwater occurs under phreatic conditions in shallow weathered mantle and under semi- confined conditions in the fractured zones. These hard rock formations lack primary porosity. Hence, the aquifer system in these rocks is developed in secondary porosity due to various tectonic disturbances and weathering activity. The aquifer system at shallow levels is normally developed due to joints and insitu weathering of granite rock and the deeper aquifer system is developed due to major joints, fractures, crevices, shear zones etc.

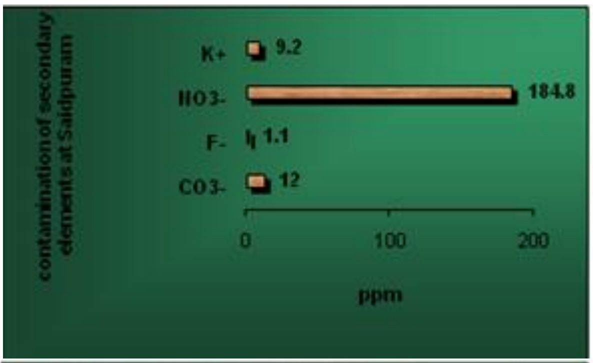
5. Materials and methods

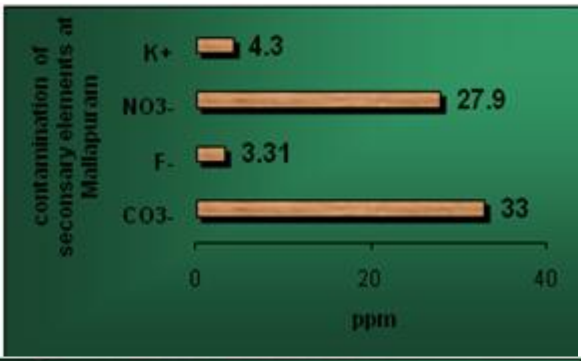
The samples were collected from bore wells and dug wells during decembar 2010. The average depth of the bore wells was 150 feet. First the water was left to run from sampling source for 4–5 min, before taking the final sample. Samples were collected in pre-cleaned sterilized polyethylene bottles of 1 L capacity. pH and EC were determined on site by portable pH meter and EC meter. Total dissolved solids were estimated by ionic calculation method. Bicarbonates were determined using titration method. Na and K were determined in Flame photometer. Total hardness (TH) and Ca2 were analysed titrimetrically using standard EDTA. Mg2 was computed, taking the difference between TH and Ca^{+2} values. Na and K were measured by flame photometer. Cl- was estimated by standard AgNO3 titration and $SO4^{+2}$was measured by the turbidimetric method.

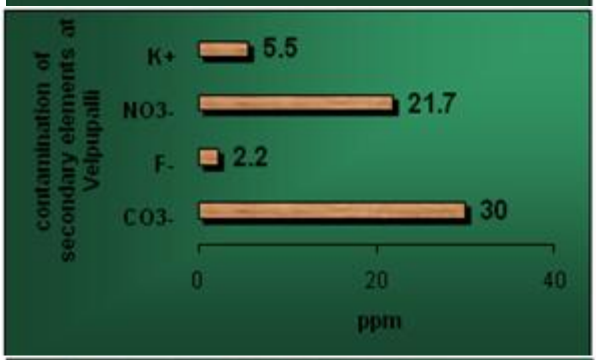
Fluoride concentration was determined by ionic chromatography. The sampling locations were mapped with the help of hand held Global Positioning system (GPS) reciever and are reported in Universal Transverse Mercator (UTM) coordinates. The spatial distribution of fluoride concentration in the study area is delineated. Piper tri-linear diagram to evaluate thegeochemistry of groundwater of the study area was plotted with the help of Arc GIS- software.

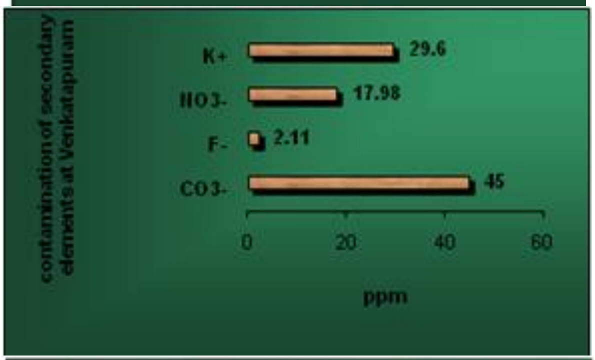
6. Results & Discussion

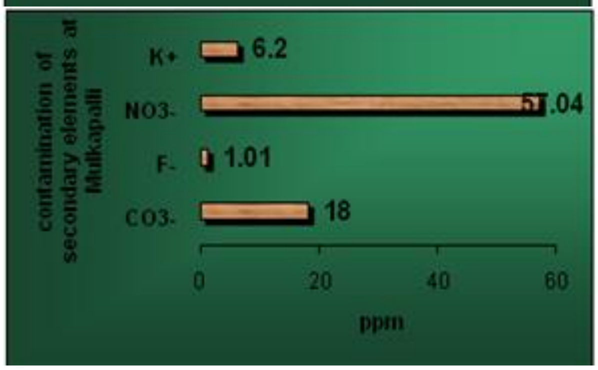
The fluoride concentration in the groundwater samples ranges from 0.44 to 5.44 mg/L (mean 2.85 mg/L), with 59 % of the samples containing fluoride concentrations that exceed the WHO drinking water guideline value of 1.5 mg/L and 81 % samples exceeding the BIS guidelines of 1 mg/L. Almost, central- part of the study area exhibits fluoride concentration more than the permissible values as per WHO guidelines, with few exceptions in the central and north eastern region of the study area. The lowest concentration of Fluoride is reported from sadupally village i.e.0.44 ppm which is below the WHO & BIS standards and Maximum concentration of fluoride i.e. 5.44 ppm is reported from pedda kandukuru 1 village, located to the central part of the study area. The highest concentration of fluoride i.e. 5.44 ppm found in the Granitic terrine and more than 1.5 ppm concentration of Fluoride reported from from the following villages such as Bahadurpet (1.81 ppm), Masaipet (1.6 ppm), Gaurayapalli (1.6 ppm), Sadupalli (0.44ppm), Kacharam (3.1 ppm) and Komtamagudem (4.1 ppm), P-kandukuru-1 (5.4 ppm), P-kandukuru-2 (4.81 ppm), Saida puram (1.1 ppm), Mallapuram (3.31 ppm), Velpupalli (2.2 ppm), Venkatapuram (2.11 ppm), Mulkapalli (1.01 ppm), Turkapalli (0.46 ppm) Kundapuram(1.41 ppm) Kahharam(1.29 ppm) Dattayapalli (0.91 ppm) Venkatapuram(2.11 ppm) Mulkapalli(3.1 ppm) Malkapuram(0.82 ppm) Turkapalli(2.39 ppm) Vasalamarri(1.1 ppm)

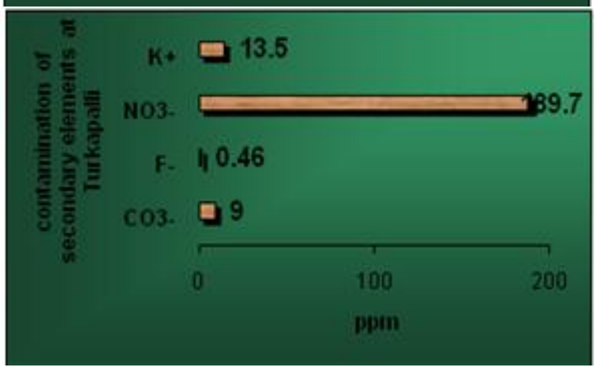


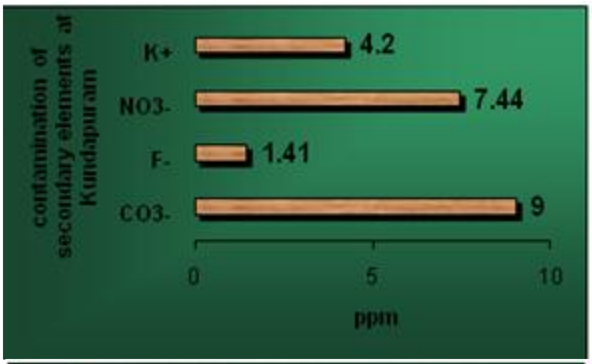


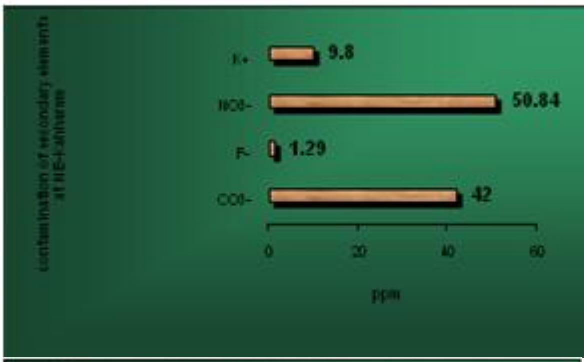


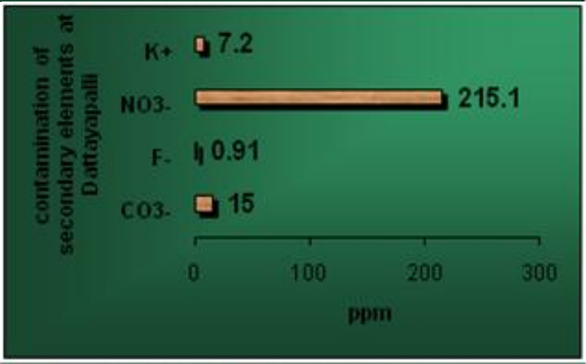


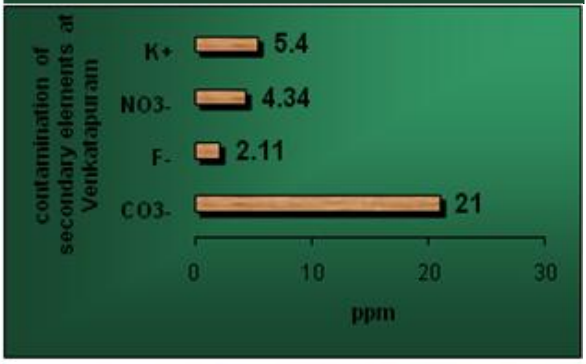


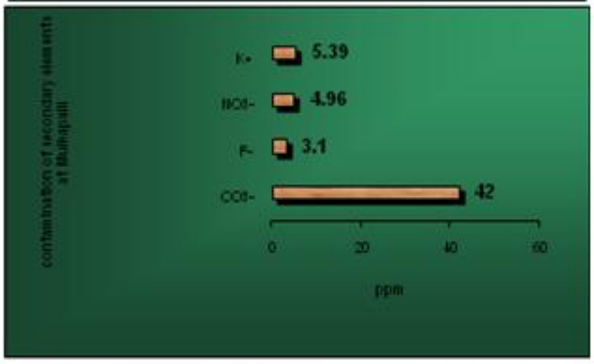


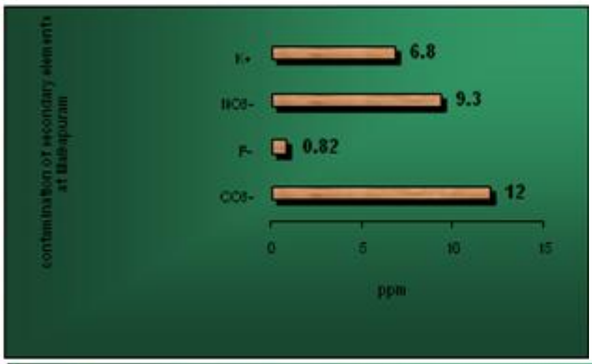


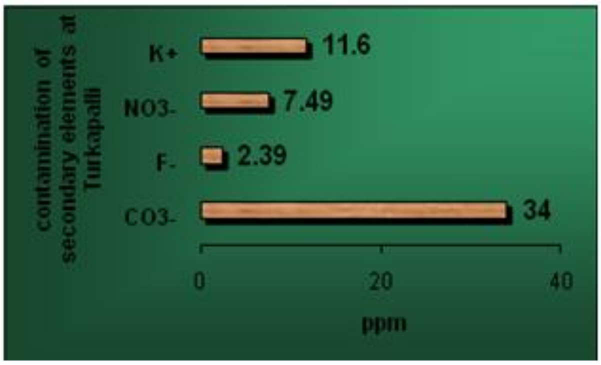












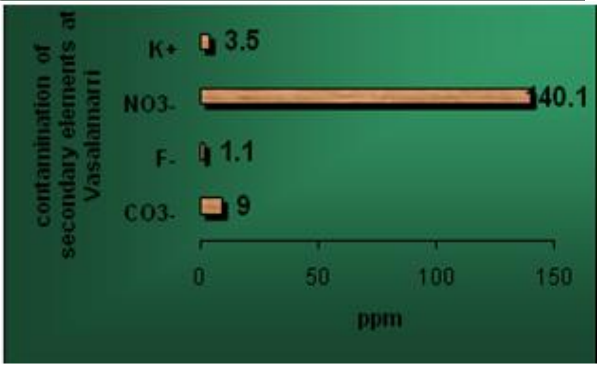


Table 1: Analytical data of fluoride in the study area
Fluoride Analytical Data for the Groundwater Samples from the study area

S. No	Sample ID	Village Name	Fluoride (ppm)
1	1 B.W	Bahadurpet	1.81
2	2 B.W	Masaipet	1.6
3	3 B.W	Gaurayapalli	1.6
4	4 B.W	Sadupalli	0.44
5	5 B.W	Kacharam	3.1
6	6 B.W	Komtamagudem	4.1
7	7 B.W	P-kandukuru-1	5.4
8	8 B.W	P-kandukuru-2	4.81
9	9 B.W	Saida puram	1.1
10	10 B.W	Mallapuram	3.31
11	11 B.W	Velpupalli	2.2
12	12 B.W	Venkatapuram	2.11
13	13 B.W	Mulkapalli	1.01
14	14 B.W	Turkapalli	0.46
15	15 B.W	Kundapuram	1.41
16	1 D.W	Kahharam	1.29
17	2 D.W	Dattayapalli	0.91
18	3 D.W	Venkatapuram	2.11
19	4 D.W	Mulkapalli	3.1
20	5 D.W	Malkapuram	0.82
21	6 D.W	Turkapalli	2.39
22	7 D.W	Vasalamarri	1.1

7. Conclusion

These analyses were performed to provide scientific evidence for policy support in groundwater resources management and planning in the region. High levels of fluoride in groundwater lead to health hazards such as dental fluorosis and skeletal fluorosis, leading to molting and pitting of teeth, stiffness and rigidity of joints, and bending of spinal cord. The concentration of fluoride (almost 42 % of the samples) was well above the maximum permissible limit set by Bureau of Indian Standards and World Health Organization. The study also finds that field kits can be a reliable method for onsite testing of fluoride and the households could be conveyed the results so that they avoid drinking and cooking with fluoride enriched groundwater and thus lower exposure to fluoride and its health impacts. The results indicate that the high fluoride in groundwater is basically geogenic in nature. Hydro-geological settings coupled with high evaporation rate and high temperature are controlling factors for fluoride enrichment. The interaction of water with fluoride-rich minerals enforces the geochemical facies of water towards Na-HCO3 type, which in turn favors dissolution of these minerals. The presence of high HCO3, sodium, and pH favors the release of fluoride from aquifer matrix into groundwater. The granite in the area contains abundant fluoride and during weathering, fluoride can leach and dissolve the aquifers. The oversaturation of samples with respect to calcite and undersaturation with respect to fluorite makes it feasible for fluoride to get released in groundwater. The climate coupled with geochemical processes is found to be main controlling factors for higher concentration of fluoride. It is recommended therefore, that piped water should be provided to the residents for drinking and cooking purposes after proper analysis only. Besides, the use of existing handpump and tubewells, having high fluoride sources, may be restircted for washing, bathing and other such purposes.

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