**Variation of fluoride and correlation with alkalinity in groundwater of shallow and deep aquifers- A case study in and around Anantapur district, Andhra Pradesh**

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**Abstract:** Fluoride in water is an essential element for human beings and its deficiency as well as high concentration both is injurious to human health. It is required for the protection against dental caries and weakening of bones. Groundwater in shallow aquifers that supply water to dug wells in and around Anantapur district, of Andhra Pradesh, has higher concentrations of fluoride (F) than those of bore wells from deep aquifers. Factors for variation in fluoride content between the two aquifer water types are discussed. The relative merits of the shallow water for potability are pointed out with respect to fluoride concentrations and public health. Fluoride occurs in almost all natural water supplies. Fluorides in high concentrations are not a common constituent of surface water, but they may occur in detrimental concentrations in ground waters.

**Key words:** Fluoride, groundwater, aquifers, variation.

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**1. Introduction**

Water is critical for sustainable development and is indispensable for human health and well-being. The United Nations has proclaimed the years of 2005-2015 as the international decade for action on “water for life” (UN 2004). The chemical composition of groundwater is one of the prime factors on which the suitability of water for domestic, industrial or agricultural purpose is determined. But in the era of economic growth, groundwater is getting polluted due to urbanization and industrialization. Groundwater though contributes only 0.6% of the total water resources on earth. It accounted for nearly 80% of the rural domestic water needs and 50% of the urban water needs in the developing countries like India (Meenakshi and Maheswari, 2006). The occurrence of high fluoride concentrations in groundwater is a problem faced by many countries, notably India, Sri Lanka and China, the Rift Valley countries in East Africa, Turkey and parts of South Africa. Fluoride epidemic has been reported in as many as 19 Indian states and Union Territories. India is one among the 23 nations in the world, where fluoride contaminated groundwater is creating health problems. The state of Art Report of UNICEF confirms the fluoride problem in 177 districts of 20 states in India. The high fluoride levels in drinking water and its impacts on human health have increased the importance of defluoridation studies (Adler, 1970; Bhussry, 1970 and EPA, 1975). The magnitude of the problem is sinking in and effects are being made towards defluoridation of drinking water, combating the debilitating fluorosis and taking steps to prevent and control the disease (AMA, 1975; Chand, 1999 and Hodge, 1965). Fluoride is one of the chemical elements necessary for human life. Deficiency or excess of fluoride in the environment is closely associated with human health (Zhang et al. 2003). While
the necessity of fluoride to human health is still open to debate, its toxicity is currently the cause of considerable concern in many countries where fluoride is found in excessive quantities in the drinking water (Chandrajith et al., 2007). The major health problems caused by excessive fluoride are dental fluorosis teeth mottling skeletal fluorosis (more than 6 mg/l) and deformation of bones in children and adults (Susheela, 1993). Higher concentration of fluoride also causes respiratory failure, fall of blood pressure and general paralysis loss of weight, anorexia, anemia and coxchexia are among the common findings in chronic fluoride poisoning continuous ingestion of non-fatal dose of fluorides causes permanent inhibition of growth. Fluoride ions inhibit a variety of enzymes often by forming complexes with magnesium ions and other metal ions (Ramesam, 1985; Rao et al., 1973 and Subba Rao, 1992).

Groundwater is the major drinking water source in the villages of Andhra Pradesh state. Endemic fluorosis as well as its prevalence and severity is poorly known in Anantapur district except for a few studies (Rao et al., 1973, Sunitha et al., 2012). In view of the increased interest in recent years in fluoride (F) concentrations in groundwater and impact to human health, the present study is focused on factors determining F Levels in the Groundwater of Shallow and deep aquifers in and around Southeastern part of Anantapur district, Andhra Pradesh and the identification of appropriate aquifer zones for fluoride safe drinking water. Factors for variation in fluoride content between the two aquifer water types are discussed.

2. Study Area
The study area located in southeastern part of Anantapur district, Andhra Pradesh, and lies between longitudes 77° 30′ – 78° 15′ East and latitudes 14° 0′ – 14° 30′ North and falls in the Survey of India toposheet Nos. 57 F/14, F/15, 57 J/3, J/4 as shown in figure 1.

![Figure 1: Location map of the study area](image_url)

The study area is covered by peninsular gneisses of Archean age consisting of pink granites, schists, composite gneisses of Dharwar system, intruded by a few pegmatite dykes and numerous dolerite dykes and the possible diamondiferous volcanic pipes. The geological map of the study area is shown in the figure 2. Geomorphic features observed from the study area are denudational hills, dissected pediments, pediplain, flood plain. The climate is semi arid with mean monthly temperatures of 15°C in January and
39°C in May. The normal rainfall of the district is 553 mm of the study area secures the rainfall of 340mm as compared to Rayalaseema and other parts of Andhra Pradesh.

3. Materials and methods

Thirty groundwater samples were collected from 15 each from shallow dug wells and deeper bore wells in close proximity were collected for comparative study and monitoring in May 2011. The dug wells range in depth from 2 to 14 m and the bore wells range from 20 to 60 m with averages of 9 and 34 m respectively samples were drawn with a precleaned plastic polyethylene bottle. Prior to sampling, all the sampling containers were washed and rinsed thoroughly with the groundwater (Brown et al., 1974 and Soman, 1977). pH was measured using digital meter immediately after sampling. The fluoride concentration was determined by ion-selective electrode method. It is based on potentiometric measurements with a membrane of European doped Lanthanum fluoride LaF₃. The purpose of Eu doping is to improve electrical conductivity (APHA, 1998; Merck, 1974).

4. Results

Table 1 shows the concentration of fluoride in ppm and pH of groundwater from dug wells and bore wells in the study area. For the shallow aquifers of study area, pH ranged from 7.1 to 8.2 where as pH values for deep aquifers were ranging between 1.8 and 5.2 where as in deep aquifers ranged between 1.2 and 4.3. The observed range of fluoride concentration in shallow aquifers are comparatively high as compared to deep aquifers. Fluoride concentration at all shallow and deep aquifers are almost similar for all
the study area. Critical analysis of data of fluoride concentration clearly indicates that the deep aquifers are deficient of fluoride at all the study area.

Elemental fluorine plays a vital role in higher life forms, especially in the skeletal systems. Both deficiencies and excess of $F^-$ might be harmful. Effects associated with the impact of the ion on human health greatly depend on total in take through various media such as water, air and food. For instance, the common food stuffs have fluorine contents as follows: milk 0.01 to 0.02 ppm, wheat 0.05 ppm, rice 0.7 ppm, eggs 1.2 ppm; tea 3.2 to 178.8 ppm. Garlic and onion contain 10 to 17 ppm (Kariyanna, 1987). Under these circumstances it is advisable to consume waters having a low concentration of $F$ to prevent fluorosis problems. The desirable limit of $F$ in water for drinking purpose is 0.6 to 1.2 ppm, while the optimal range for it the present study area as per temperature conditions (Public Health service, 1962) is 0.7 to 0.8 ppm. Therefore, the ideal concentration of $F$ may be considered to be 0.6 to 0.7 ppm. Since nearly 13% of the deep aquifer water has an $F$ concentration between 0.6 and 0.7 ppm compared to the shallow aquifer water, the former would be more suitable than the latter for drinking purposes. By analyzing the data it has been found that nearly all the fluoride concentration had pH level more than seven means all the pH in the alkaline side for both the aquifers correlation analysis had been carried out to find out correlation coefficient value (Table 1). By analyzing the data it was found that correlation value is 0.1197 in shallow aquifiers and correlation value has been found in deep aquifiers. The graph has been plotted showing the basicity is the major factor for fluoride increase in the ground water shown in figures 2 and 3. Mean, maximum, average value has been calculated in the table for fluoride and pH value (Table 2).

**Table 1:** The concentration of fluoride in ppm and pH of groundwater from shallow and deep aquifers in the study area

<table>
<thead>
<tr>
<th>Sample Nos. shown in figure</th>
<th>pH</th>
<th>Fluoride (F^-)</th>
<th>Correlation value</th>
<th>Sample Nos. shown in figure</th>
<th>pH</th>
<th>Fluoride (F^-)</th>
<th>Correlation value</th>
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<td>4.0</td>
<td></td>
<td>16 B</td>
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<td>1.5</td>
<td></td>
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<tr>
<td>2B</td>
<td>7.1</td>
<td>3.2</td>
<td></td>
<td>17 D</td>
<td>8.0</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>8.0</td>
<td>3.0</td>
<td></td>
<td>18 B</td>
<td>6.8</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>4B</td>
<td>7.4</td>
<td>2.2</td>
<td></td>
<td>19 D</td>
<td>7.2</td>
<td>5.0</td>
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</tr>
<tr>
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<td>8.2</td>
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<td></td>
<td>20 B</td>
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</tr>
<tr>
<td>6 B</td>
<td>8.1</td>
<td>3.0</td>
<td></td>
<td>21 D</td>
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</tr>
<tr>
<td>7 D</td>
<td>7.4</td>
<td>5.0</td>
<td></td>
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<td>30 B</td>
<td>6.0</td>
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0.2072 0.019

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**Figure 2:** Graphical representation of pH in shallow and deep aquifer

![Graphical representation of pH in shallow and deep aquifer](image)

**Figure 3:** Graphical representation of F in shallow and deep aquifer

![Graphical representation of F in shallow and deep aquifer](image)

**Table 2:** Mean Maximum and Average value for pH and Fluoride

<table>
<thead>
<tr>
<th></th>
<th>For pH</th>
<th>For Fluoride</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shallow Aquifers</td>
<td>Deep Aquifers</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>116.6</td>
<td>111.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>7.7</td>
<td>7.4</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>8.2</td>
<td>8.2</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>7.2</td>
<td>6</td>
</tr>
</tbody>
</table>
5. Conclusion

It can be concluded that fluoride bearing water are usually high in the alkalinity and low in hardness and chloride, sulphate In mineralogical study of this area, we found that fluoroapatite and biotite micas contain fluoride ion. It may be because that apatite may perhaps exchange some of its hydroxyl ion for fluoride. Presence of high bicarbonates contributing to the alkalinity can also play an important part in the mineralization process similar studies in other fluoride problem areas would help to identify safe aquifer zones for drinking water. However, the bore wells sampled should tap the fracture zones only. A few exploration deep bore wells are also advisable where even the shallow fracture zones which are in close proximity with the weathered zones are sealed to avoid the effects of vertical leakage. It is also recommended to compare groundwater from bore wells in outcrop areas (no weathered zone) to areas with weathered zones to understand the behavior of fluoride concentrations. Such studies will help solve the fluoride problem in groundwater by using hydrogeological and geochemical information for well placement rather than spending huge sums of money on alternate supply schemes.

Acknowledgements

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6. References

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