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# Fluoride Contamination in Groundwater in and Around Badvel, Kadapa District, Andhra Pradesh

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***ABSTRACT***

*The fluoride concentration in underground water was determined in Badvel revenue Mandal. Kadapa district, Andhra Pradesh (India) where it is the only source of drinking water. The various parameters determined were pH, EC (electrical conductivity), total dissolved solids (TDS), total hardness (TH), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), bicarbonate ($HCO_3^-$), chloride ($Cl^-$), and Fluoride ($F^-$). Fluoride concentrations in the study area are varied between 0.245 to 3.28 mg/l. Higher fluoride concentration (4.22 mg/l) was observed in the groundwater sample collected at village Gandlatimmayyapalle, while the lower concentration (0.245 mg/l) was observed at Venkatasettipalli. About 24% of the samples of the study area are exceeding the permissible limits of fluoride 1.5 mg/l in drinking water W.H.O (2004).Overall water quality was found unsatisfactory for drinking purposes without any prior treatment.*

***Key Words:*** *Badvel, Fluoride, Kadapa district, A.P*

## 1. INTRODUCTION

Water, the precious gift of nature to human being, is going to be polluted day-by-day with increasing urbanization. Although three-fourth part of earth is being surrounded by water but a little portion of it can be used for drinking purpose. 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" [1]. To provide safe drinking water especially to rural population, groundwater has been sought as the source in many developing and under developed countries. Millions of hand pumps and deep tube-wells have been installed all over India since last few decades to provide bacteriologically safe water. However, ground waters can have some dissolved chemical constituents, which may be unacceptable due to their chronic health effects, taste and aesthetic reasons.

Fluorine is the 13th most abundant naturally occurring element in the Earth's crust and is the lightest member of the halogens. It is the most electronegative and reactive of all the elements and as a result, elemental fluorine does not occur in nature, but is found as fluoride mineral complexes. Fluorides account for 0.06-0.08% of the Earth's crust, but their average abundance is low (300 mg $kg^{-1}$) (2). Unlike some of the other halogens, the majority of fluoride in the Earth's surface is derived from rock minerals whereas other sources such as air; seawater and anthropogenic activities constitute a relatively small proportion [3, 4]. Contamination of water resources with fluoride beyond acceptable limits is a health associated problem in many areas of South Asia and other regions of the world [5, 6]. The amount of fluoride present naturally in groundwater is governed by climate, pH, composition of the host rock and hydrogeology [7, 8]. Some anthropogenic activities are also contributed to cause an increase in fluoride concentration in groundwater such as use of phosphatic fertilizers, pesticides, sewage and sludges, depletion of groundwater table etc [9]. Fluoride ion in drinking water is known for both beneficial and detrimental effects on health. It is essential for normal mineralization of bones and formation of dental enamel with presence in small quantity [10]. However, when consumed in higher doses (>1.5 mg/l), it leads to dental fluorosis or mottled enamel and excessively high concentration (>3.0 mg/l) of fluoride may lead to skeletal fluorosis [8]. For fluoride, WHO has set a guideline value of 1.5 mg/l and BIS desirable and permissible limits are 1.0 and 1.5 mg/l respectively. The main objectives of this research are: (1) To determine fluoride concentration in groundwater, (2) To explore the connection between fluoride concentration and lithology.

## 2. EXPERIMENTAL

### *2.1. Study Area*

The study area consists of Schists amphibolites,

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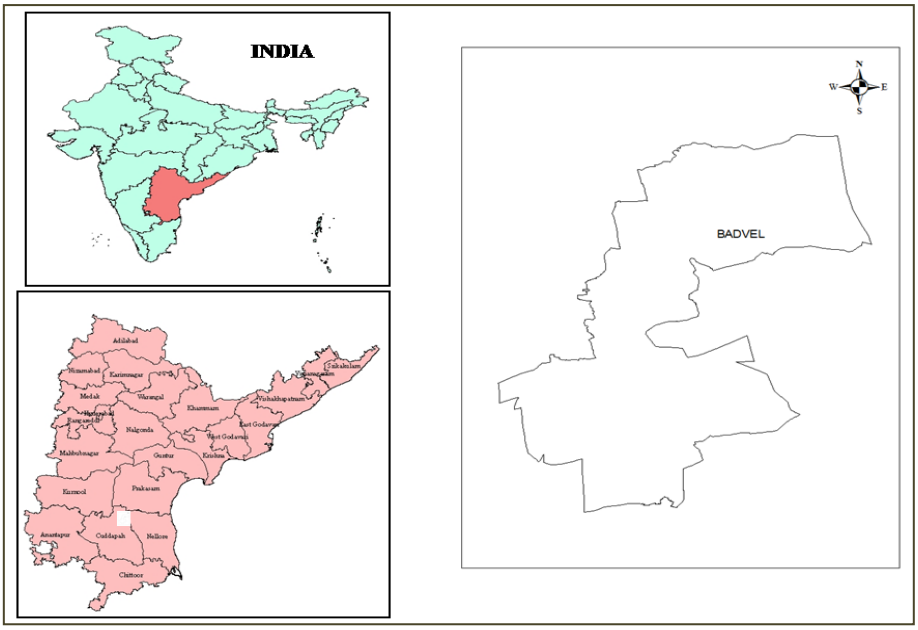


**Figure 1:** Location map of the study area.

granites, and doleritic type of rock formations. The schists and amphibolites have been intruded by granites on a large scale. The granites and older rocks were intruded by basic igneous rocks as dykes. These dykes are generally represented by dolerites. The soil type is ferruginous loam. This soil is generally of poor quality and extends only to a small depth below the ground level. The top soil has a thickness of 1-2 m and is followed by weathered shales, fractured shales and Phyllites. The river Sagileru and the River Penna are the main rivers passing near Badvel, these are not perennial. The average rainfall in badvel town area is about 700mm. The Temperature varies from 20 $^{o}$C to 45 $^{o}$C. (Badvel Municipality Project Report).

**Table 1:** International guideline for fluoride concentrations in drinking water and possible health effects (from WHO, 2004)

| Guideline value | F mg /l water | Possible health effects |
|---|---|---|
| Recommended minimum | 0.5 | Dental cavities may occur at lower concentrations |
| Optimal range | 0.5–1.5 | No adverse health effects, cavities decrease |
| Recommended Maximum | 0.5 | Mottling of teeth and dental fluorosis may occur at higher concentrations. Association with skeletal fluorosis at >3 mg $1^{-1}$ concentrations |

### *2.2. Methodology*

Twenty five groundwater samples were collected from 25 different locations of the study area which includes badvel revenue Mandal of Anantapur District, Andhra Pradesh, during April-May 2012. The samples were collected from bore wells which were extensively used for drinking and other domestic purposes. The samples were collected in pre-cleaned and sterilized polyethylene bottles of two litre capacity. The depth of the bore wells varied between 250 and 700 feet. The groundwater samples were analyzed using APHA (1992) procedure [11], and suggested precautions were taken to avoid contamination. The various parameters determined were pH, EC (electrical conductivity), total dissolved solids (TDS), total hardness (TH), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), bicarbonate ($HCO_3^-$), chloride ($Cl^-$), and Fluoride ($F^-$). pH and EC were determined by pH, conductivity meter, TDS by TDS meter, TH, $Ca^{2+}$, $Mg^{2+}$, $CO_3^{2-}$, $HCO_3^-$ and $Cl^-$ were estimated by titrimetry. $F^-$ was estimated by using ion selective electrode (Orion 4 star ion meter, Model: pH/ISE). All the experimental were carried out in triplicate and the results were found reproducible with in a ± 3% error limit.

### *2.3. Fluoride Ion selective electrode Method*

#### *2.3.1. Apparatus*

Ion- Selective meter, Fluoride electrode, Magnetic stirrer.

#### *2.3.2. Reagent*

Fluoride Standards of various ranges (0.2-20 ppm) Fluoride Buffer (TISAB- Total ionic strength adjustment buffer).

#### *2.3.3. Procedure*

Calibrate the instrument take 10 ml sample in a beaker at 10 ml buffer solution. Put stirring bar into the beaker immerse electrode and start the

**Table 1:** Chemical analysis of groundwater samples of the study area.

| S.No | Name of the Villages | $P^H$ | EC µS/cm | TH mg/l | $Ca^{2+}$ mg/l | $Mg^{2+}$ mg/l | $HCO_3^-$ mg/l | $Cl^-$ mg/l | $F^-$ mg/l | TDS mg/l |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Apparajupeta | 8.4 | 3000 | 60 | 60 | 30 | 150 | 603 | 1.49 | 1920 |
| 2 | Rajupalem | 7.8 | 2000 | 72 | 20 | 17 | 196 | 419 | 1.22 | 1280 |
| 3 | Venkatasettipalli | 7.7 | 1200 | 54 | 20 | 12 | 85 | 227 | 0.24 | 768 |
| 4 | Tippanapalli | 8.0 | 1700 | 18 | 20 | 13 | 110 | 312 | 0.89 | 1088 |
| 5 | Veerapalli | 8.5 | 2000 | 30 | 40 | 20 | 134 | 568 | 3.58 | 1280 |
| 6 | Konasamudram | 8.5 | 1000 | 30 | 80 | 40 | 110 | 107 | 1.95 | 640 |
| 7 | Gopalapuram | 8.2 | 1700 | 36 | 28 | 20 | 110 | 405 | 1.06 | 1088 |
| 8 | Vanampula | 8.2 | 1000 | 36 | 60 | 35 | 36 | 241 | 1.60 | 640 |
| 9 | Kottapalle | 8.5 | 1100 | 24 | 23 | 20 | 42 | 206 | 0.95 | 704 |
| 10 | Chennampalli | 8.7 | 900 | 30 | 40 | 6.8 | 60 | 135 | 1.27 | 576 |
| 11 | Guntapalli | 7.9 | 1600 | 78 | 40 | 17.9 | 54 | 355 | 1.81 | 1024 |
| 12 | Badvel | 7.4 | 2900 | 132 | 10 | 29.6 | 42 | 760 | 0.42 | 1856 |
| 13 | Barakarapalli | 8.0 | 1100 | 72 | 30 | 16.7 | 61 | 178 | 1.55 | 704 |
| 14 | Badvel east | 7.7 | 1900 | 90 | 60 | 20.4 | 73 | 412 | 1.35 | 1216 |
| 15 | Agraharam | 8.5 | 600 | 36 | 30 | 8 | 110 | 71 | 0.72 | 384 |
| 16 | Anantharajupuram | 7.9 | 900 | 36 | 50 | 7.5 | 122 | 27 | 1.16 | 576 |
| 17 | Gundemrajupalli | 7.6 | 2300 | 90 | 40 | 20.8 | 73 | 98 | 1.14 | 1472 |
| 18 | Yettirajupalle | 8.1 | 1300 | 42 | 30 | 9.4 | 61 | 52 | 1.49 | 832 |
| 19 | Gandlatimmayyapalle | 8.6 | 900 | 30 | 60 | 5.8 | 85 | 28 | 4.22 | 576 |
| 20 | Bhakarapeta | 8.1 | 400 | 30 | 60 | 5.8 | 37 | 16 | 1.50 | 250 |
| 21 | Bayanapalli | 7.9 | 1200 | 42 | 60 | 8.7 | 73 | 30 | 1.13 | 768 |
| 22 | Chintalacheruvu | 7.9 | 1400 | 60 | 20 | 14 | 73 | 55 | 1.04 | 896 |
| 23 | Ramakrishnapuram | 8.3 | 900 | 48 | 60 | 10.2 | 61 | 40 | 0.55 | 576 |
| 24 | Kongalaveedu | 8.3 | 1800 | 36 | 30 | 8 | 85 | 89 | 0.78 | 1152 |
| 25 | Badvel town north | 8.7 | 600 | 48 | 30 | 5.5 | 60 | 20 | 0.84 | 384 |

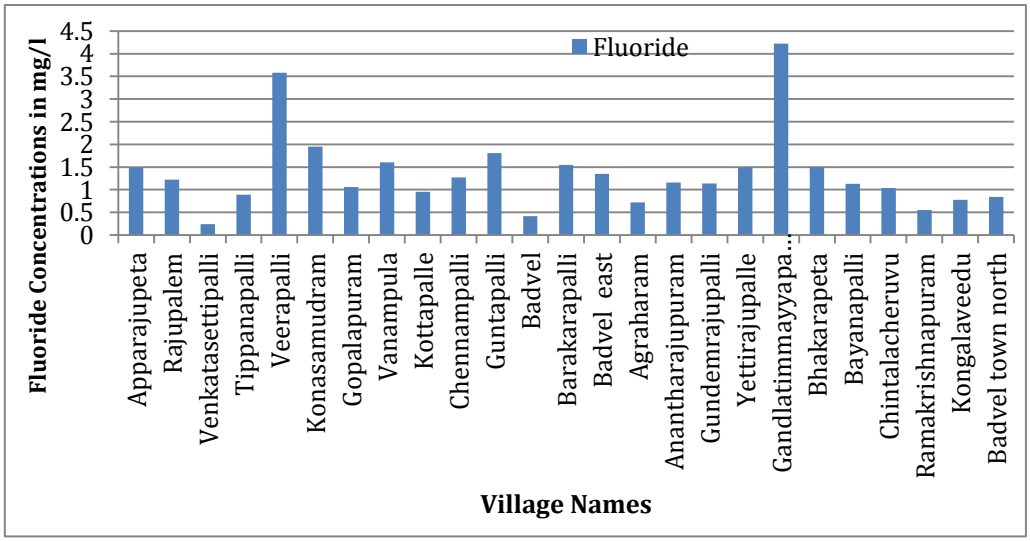


**Figure 2:** Fluoride concentration in groundwater of Badvel mandal of Kadapa district, Andhra Pradesh.

magnetic stirrer and wait until reading is constant withdrawal electrode rinse with distilled water.

## 3. RESULTS AND DISCUSSION

Various physicochemical parameters such as pH, electrical conductivity, total hardness as well as calcium, magnesium, chloride, bicarbonate, fluoride were analyzed. The pH varies from 7.8 to 8.7, indicating an alkaline condition which favours the solubility of fluoride-bearing minerals. and thus alkaline pH is more favorable for fluoride dissolution activity. The electrical conductivity of the groundwater varies from 600 µs/cm to 3000 µs/cm. Elevated concentration of electrical conductivity may possibly be credited to high salinity and high mineral content. Total dissolved solids, a salinity indicator for the classification of groundwater, varies from 250 mg/l to 1920 mg/l in the study area. The bicarbonate content varies from 36 mg/l to 150 mg/l, and this high value indicates intense chemical weathering of the parent granite rock. The calcium content in the ground water of

the study area varies from 70 mg/l to 360 mg/l Fluoride concentrations in the study area varied between 0.245 to 3.28 mg/l. Higher fluoride concentration (4.22 mg/l) was observed in the groundwater sample collected at village Gandlatimmayyapalle, while the lower concentration (0.245 mg/l) was observed at Venkatasettipalli. About 24% of the samples of the study area are exceeding the permissible limits of fluoride 1.5 mg/l in drinking water. [12] W.H.O (2004).

### *3.1. Fluoride Sources and Geological Influence:*

Fluoride incidence in groundwater is mainly a natural phenomenon, influenced basically by the local and regional geological setting and hydro-geological conditions. The chief sources of fluoride in groundwater are the fluoride-bearing minerals in the rocks and sediments. The important fluorine-bearing minerals are fluorite, apatite, certain amphiboles and micas. The concentration of fluoride in groundwater is limited due to the low solubility of most fluorides. The solubility values of sodium fluoride, magnesium fluoride and calcium fluoride at 18 °C are 42,200 mg/l, 87 mg/l and 15 mg/l respectively. Magnesium fluoride is more soluble than calcium fluoride. Sodium fluoride is very soluble [13]. Results from groundwater of study area suggest that the fluoride content of 24% of analyzed groundwater samples exceeds the permissible limit of 1.5 mg/l. The source of fluoride in the natural water can be traced to the occurrence of fluorine-rich granitic rocks and soils derived from those rocks. The semi- arid climate with high temperature and low rainfall and the generally alkaline nature of the soil are contributing factors to enhance the fluoride content of groundwater.

## 4. CONCLUSIONS

The groundwater is the main source of drinking water for people of rural areas of Badvel mandal of Kadapa district, A.P. After evaluating data of fluoride concentration in groundwater, it is clear that the level of fluoride is higher than that of recommended upper limit by WHO. Groundwater (well, hand pump and tube well) is the main source of drinking water for village residents. The various parameters determined were pH, EC (electrical conductivity), total dissolved solids (TDS), total hardness (TH), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), bicarbonate ($HCO_3^-$), chloride ($Cl^-$), and Fluoride ($F^-$). Most of the chemical concentrations collected from the study area do not comply with the water quality standards. Fluoride concentrations in groundwater samples of these villages varied between 0.5 mg/l and 7.2 mg/l. Geological formation is found to be a basic cause for the higher concentration of fluoride in most of the sampling points. The high fluoride content in the groundwater of this area has affected villagers in the form of primary level of fluorosis resulted in stained and darkened tooth enamel. The source of fluoride in the natural water can be traced to the occurrence of fluorine-rich granitic rocks and soils derived from those rocks. The high fluoride content in the drinking water should also be given attention and defluoridated water should be provided for drinking purposes in the rural areas. An urgent need is to educate the people on the causes of fluorosis, and providing fluoride free drinking water in the study area.

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***Bibliographical Sketch**

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