7.0 SUMMARY

The fluoride content in ground water was assessed using GIS at Dharmapuri District, Tamil Nadu, India. The fluoride concentration in ground water at Dharmapuri ranged between 0-3.5 mg/l during January 2006 up to May 2008. Hence, the fluoride distribution pattern over a period of three consecutive years has been derived using GIS. It shows that the area of southwestern part and eastern half of Dharmapuri district has got very high level fluoride contamination in groundwater.

Fluoride and TDS are having very good correlation in their level of dissolution / concentration in ground water contamination. Thus, a similar GIS layer showing TDS concentration pattern has been prepared and presented. Similarly for the fluoride concentration pattern in Dharmapuri district are also prepared. Though it shows that almost entire area of Dharmapuri district has got very high concentration of TDS, but there are some pockets of Moderate TDS concentration zones seen in western half of the study area (relatively covering little more aerial coverage than the moderate TDS pockets seen in the eastern half). The relationships between fluoride distribution pattern and TDS pattern have also been brought out using GIS integration technique.

Elevated levels of fluoride in ground water from a soils or weathering, rock, Deposition of atmospheric volcanic particles, Runoff and infiltration of chemical fertilizers in agricultural areas, Septic and sewage treatment system discharges in communities with fluoridated water supplies, liquid waste from industrial sources, sandstone and mudstone aquifer system on Dharamapuri district are largely a result of base-exchange softening and the consequent high pH levels. It is evident that this process may be responsible for elevated fluoride levels in sandy aquifers around the world. The result shows that a pH of 8.1 in Dharamapuri taluks was reported during May (summer) in 2006. Hence, we suggest that the pH level which has been exceeding to 8.5 as per the limit is be used a rapid screening threshold to predict water-quality risks associated with fluoride in groundwater.
The study revealed that high fluoride concentration more than 1.5 mg/l in ground water causes serious health hazards. So far as the origin of fluoride contamination is concerned; it can mainly attribute to be of natural rather than anthropogenic. High profile of fluorides in shallow zone ground water is due to the geochemical deposition. The toxicity of fluoride is also influenced by high ambient temperature, alkanity, calcium and magnesium contents in the ground water. Abnormal level of fluoride in water is common in fractured Epidote Hornblende Gneiss, Hornblende Biotite Gneiss & Grantoid Gneiss, which petro chemically contains higher concentrations of fluorides.

In general ground water contains more fluoride than surface water resources due to greater contact times with fluoride bearing minerals. The occurrences of fluoride concentration are always point specific. It is observed that within one village different wells often show wide variation in fluoride content. This indicates that geological formation is not the only factor responsible for fluoride in ground water. The weathering of rocks, local hydrogeological conditions govern the fluoride content of ground water.

Fluoride content in water depends not only on the geochemical background and climate-biological factors such as hydrological condition, landform, rainfall, and evaporation, but also on the adsorption and leaching of fluoride in soil. The adsorption-leaching process directly affects fluoride migration and exchange from soil to water. Studies on adsorption of fluoride have shown that the nature of soil or rock relates to the release of fluoride from soils and rocks. We have reported the results with investigation of adsorption and leaching of fluoride in typical Chinese soils and their relation to physico-chemical soil parameters. A strategy for managing a part of a shallow aquifer through a systematic well-schedule based upon the characteristics of the aquifer and their variability in space through community participation has been proposed. The results from the present study proposed the highly ambitious Groundwater-linking a detail determination of safe and risk zones of Dharmapuri in TamilNadu.
The outcome of the research findings will be very useful to TWAD (TamilNadu Water supply and Drainage Board)/Central Government/State Government/Health Organization/NGO’s/Public and other organizations related structural function of water management authorities/agencies to develop Groundwater Management from the contamination by prevention strategies for the better future for the subsequently generation. The analysis of Groundwater from the contamination of fluoride dataset is an introduction to the recently available methods concerned to the study area. The methodology presented in various section of the thesis might be adopted for the contamination zones of dataset collected in any part of the world with special reference to “Health GIS”. Several illustrations are used to make etiology of the fluoride contamination understandable to water management authorities.
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Identification of Fluoride contaminations with the interaction of physio-chemical characteristic in Groundwater of Dharmapuri District, TamilNadu, INDIA

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ABSTRACT

The quality of groundwater depends on a large number of individual hydrological, physical, chemical and biological factors. Water dissolves the minerals present in the strata of soil it filters through in the case of ground water and, in the case of surface water, the minerals present in the soil over which it flows (rivers/streams) or over which it stands (lakes, ponds, reservoirs). Generally higher proportions of dissolved constituents are found in groundwater than in surface water because of greater interaction of ground water with various materials in geologic strata. The study carried out to find the relationship of fluoride contamination in groundwater through the interaction method with the help of the physio-chemical parameters using GIS tool. The study emerges with a new perception for the better prediction of contaminants to get a clear vision for the future study.

Keywords: Spatial Pattern, Fluoride, TDS, GIS.

INTRODUCTION

The major and essential one of the natural resources is water which has a unique place. The surface water and groundwater resources of the country play a major role such as in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation and recreational activities. According to National Water Policy in (2002) in the planning and operation of systems, water allocation priorities should be broadly as: (i) drinking water, (ii)
irrigation, (iii) hydropower, (iv) ecology, (v) agro-industries and non-agricultural industries and (vi) navigation.

The water sources or alarming by the climate change is expected to affect precipitation and water availability. Due to spatial and temporal variability in precipitation the country faces the problem of flood and drought syndrome. Overexploitation of groundwater is leading to reduction of low flows in the rivers, declining of the groundwater resources, and salt water intrusion in aquifers of the coastal areas. With rapid growing population and improving living standards the pressure on our water resources is increasing and per capita availability of water resources is reducing day by day. Among these the surface water and groundwater are in extinct level.

Dhiman et al., [7] have used GIS to quantify the spatial geologic data and statistical analysis to determine the relation between groundwater quality parameters and geological units and they studied the degree of fluoride contamination and identification of hydro geochemical process in mobilizing the fluoride contamination. Karro et al. [19] A study was undertaken by to examine the content and spatial distribution of fluoride in drinking water using SPADNS method in Estonian territory. Fordyce et al. [9] reported that fluoride is a powerful calcium-seeking element and can interfere with the calcified structure of bones and teeth in the human body at higher concentrations causing dental or skeletal fluorosis. In the last two decades reports on the occurrence of excess fluoride in water resources in several states of India have been published by many research workers (Chari et al. [5] Handa, 1975 [13] Raju et al. [27] Sarma & Swamy, [34] Handa, 1988[14] Nawlakhe & Bulusu, [24] Gaumat et al [11] Rajagopalan et al., [26] 2.5 million People living in 8700 villages in India suffer the problem of excess fluoride intake. Karthikeyan et al. [20] A study was carried out by about fluoride dependence on water quality in the Krishnagiri block of TamilNadu in south India using Isopleth mapping.

There are many researches carried out worldwide under this topic of groundwater flow. Some of the research works done by the scientists are listed in the following review. Fritch et al., [10] had suggested a predictive approach to assess the groundwater pollution susceptibility of the Paluxy aquifer, Central Texas, using GIS. It has suggested a mass transport modeling to assess contamination of a water supply well in Sabarmati river bed aquifer, Ahmadabad city, India. This study emphasized the necessity of controlled release of surface water in Sabarmati river bed from Dharoi reservoir throughout the year.

The fluoride bearing minerals such as hornblende, apatite, fluoride and torn elite in high concentration lead to excess of fluoride in the rock, sink and metal of the area. Shah and Danishwar [36] reported that fluoride contamination in Naranji is due to fluoride bearing minerals, especially fluorite of the Ambela and Koga complexes. Edmunds and Smedley [8] reported that high fluoride ground water has been reported most often in crystalline basement aquifers, active volcanic zones with geothermal sources and arid, sedimentary bases. Kim and Jeong [21] explained the positive relationship between well depth and fluoride concentration that the same study estimates highly differentiated granitic systems often exhibit elevated fluorine concentrations.

Basiley [2] have profound the effects on the chemical and physical properties of the evolved melts. Bailey [1] reported that fluoride is important in a variety of minerals like, fluorite, topaz,
cryolite, Villimanite, Chiolite, mallaride, carob bite etc. Sreedevi et al., [37] the major part of ground water in India is found in granitic aquifers. Fluoride in ground water from a crystalline aquifer in a semi-arid region of granitic rocks in India, known as Maheshwaram water shed, was analyzed for spatial and temporal variability during 1999 - 2002 to assess the effects of hydrogeological factors on fluoride concentration.

Rao et al., [31] and Latha et al., [23] studied on fluoride contamination in groundwater in several parts of India have mainly emphasized by the geological, hydrological and hydro chemical aspects of the region. Jacks et al., [18] high fluoride ground waters are present especially in the hard rock areas of the Ganges valley and in the arid north – western part of the country. Rao [29] explains CaF$_2$ is the principal bearer of fluoride and is found in granite, granitic gneiss and pegmatite. The other minerals in which fluoride are an essential component of accessory minerals – fluorapatite, phlogophite, gryolite, and Villiaumite. Fluoride is released to the soil and ground water by the process of weathering of the primary rocks. Koritnig [22] suggested that fluoride is leached in the initial stages of weathering of granite massifs. Deshmukh et al., [6] suggested that fluoride is particularly leached out rapidly from micas. Preferential dissolution of fluoride can, however, explain high fluoride patches only in the Aravalli foothills and not within the Camby basin where in sediments eroded from diverse rock types in Aravalli have been transported and deposited by several rivers (Prasad et al., [25] Handa, [14] Fluoride is an essential nutrient and prevents dental caries but excessive concentrations (>1.0 mg L$^{-1}$) cause dental fluorosis and even skeletal fluorosis (>3.0 mg 1). Rao and John Devadas [28] reported in apatite and fluoride, besides the replacement of hydroxyl by fluorine ions in mica, hornblende and soil that they mostly consists of clay minerals, are the major sources of F- in circulating water and the same was reported by other authors namely Hubner [17]; Sahu and Karim [33]; Hem [16]; Rao et al.,[32]; Wodeyar and Sreenivasan[41]; Bardsen et al., [3]; Suma Latha et al., [39] Saxena and Ahmed [35] in their study. Gosselin [12] the factors which influence the fluoride concentrations in natural water are geographical, hydro geological geochemical and anthropogenic.

Healy and Cook [15] have described that the recharge estimation methods are based on the groundwater level data. The recharge methods were applied not only in river basins, but also in desert basins using recharge techniques through multi stage reservoirs. Jacks et al.,[18] studied that the High fluoride ground waters are present especially in the hard rock areas south of the Ganges valley and in the arid north – western part of the country. The data obtained was entered into a Geographical Information System (GIS), Site Analyzer, to map the fluoride content of ground water in the Lower Yakima Valley. Correlations were tested between the fluoride concentration and concentrations of other groundwater constituents. Many works were carried out in artificial recharge using GIS and Remote Sensing in various parts of the world.

Geographic Information System (GIS) is a tool that is rapidly becoming a valuable management asset to many water utilities. Simply used as a spatial database, GIS can greatly assist in various modeling applications through the development of automated tools for constructing and maintaining reliable hydraulic network models of water distribution systems.
2.0 Statement of the problem
The present study was undertaken to explore and understand the possible relationship between fluoride and geological types and processes with respect to the suspected occurrence of endemic fluorosis. Recent literature reports that fluorosis is a global problem affecting more than seventy million people in 25 countries. In India about 62 million people are consuming excess of fluoride in drinking water.

2.1 Fluoride in Tamil Nadu
In Tamil Nadu, the high concentration of fluoride in groundwater is found to be in Dharmapuri and Salem district closely followed by Coimbatore, Madurai, Trichy, Dindukal and Chidambaram district. The districts having low fluoride are Thirunelveli, Pudukottai, North Arcot, and Ramnad districts. The district wise fluoride status in Tamil Nadu is presented in Table 1

<table>
<thead>
<tr>
<th>S.No</th>
<th>Status</th>
<th>Districts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Severe</td>
<td>Dharmapuri, Salem</td>
</tr>
<tr>
<td>2</td>
<td>Moderate</td>
<td>Coimbatore, Madurai, Trichy, Dindukal, Chidambaram</td>
</tr>
<tr>
<td>3</td>
<td>Less</td>
<td>Thirunelveli, Pudukottai, Thirunelveli, North Arcot, Ramnad</td>
</tr>
</tbody>
</table>

3.0 objective of the study
3.1 Aim of the Study
➢ To Build model on the fluoride contamination pattern in Dharmapuri District for three years through which vulnerability can be easily assessed
➢ To establish the relationship between fluoride source and dissolved fluoride movement in groundwater and the controlling terrain parameters for its movement and contamination

4.0 study area
4.1 Location
Dharmapuri district, lies at the trijunction of Karnataka, Andhra Pradesh and Tamil Nadu states of South India. The district is situated in the Northwestern portion of Tamil Nadu. (Map1)

4.2 Geographic Overview
The study area lies at a geographical extent from 11° 45’ to 12° 53’ N and 77° 13’ to 78 °45’ E. The total area of the district is 9581.26sq.km. The district is surrounded by Vellore, Tiruvannamalai and Villupuram districts in the East, Salem district in the South, the states of Karnataka and Andhra Pradesh in the North. The altitude of the district ranges from 300-1200m above mean sea level.
Table 2. the block wise population, area and the overall recorded primary and secondary of ground water sampling data for identification of fluoride for the month of January and May for the year 2006 to 2008 (N=417)

<table>
<thead>
<tr>
<th>SL. NO</th>
<th>TALUK</th>
<th>BLOCK</th>
<th>POPULATION</th>
<th>AREA (sq. km)</th>
<th>PRIMARY DATA</th>
<th>SECONDARY DATA (TWAD)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dharmapuri</td>
<td>Dharmapuri</td>
<td>213775</td>
<td>320.95</td>
<td>8</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Nallampalli</td>
<td>Nallampalli</td>
<td>161343</td>
<td>420.27</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>2</td>
<td>Harur</td>
<td>Harur</td>
<td>165736</td>
<td>775.63</td>
<td>18</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Morappur</td>
<td>Morappur</td>
<td>155000</td>
<td>472.27</td>
<td>21</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>Palacode</td>
<td>Palacode</td>
<td>164074</td>
<td>400.62</td>
<td>9</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Pappiredipatti</td>
<td>Pappiredipatti</td>
<td>102866</td>
<td>509.55</td>
<td>21</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Pennagaram</td>
<td>Karimangalam</td>
<td>137506</td>
<td>317.66</td>
<td>12</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Pennagaram</td>
<td>Pennagaram</td>
<td>194882</td>
<td>1119.29</td>
<td>19</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8-BLOCKS</td>
<td></td>
<td>1295182</td>
<td>4336.24</td>
<td>108</td>
<td>95</td>
<td>134</td>
</tr>
</tbody>
</table>

5.0 Data Preparation
The main aim of this chapter is to detect fluoride content from the collected samples of ground water sources of Dharmapuri district. The data which has been collected in different block for the year 2006 to 2008. The total number of sampling locations is 417 from five taluks. Under the five taluk expect there are eight blocks. Expect Nallampalli the remaining blocks namely Dharmapuri, Harur, Morappur, Palacode, Pappiredipatti, Karimangalam and Pennagaram in Dharmapuri district are taken for our study. The block wise population, area and the overall recorded primary and secondary of ground water sampling data for identification of fluoride contaminations for the month of January and May are shown in the Table 2.
MATERIALS AND METHODS

The study will estimate F concentrations and variability in Dharmapuri district, of TamilNadu has been identified through different area based samples in each of seven taluk from five blocks of ground water. This multi-center effort has collected more than 417 samples from 37 locations for three years from 2006 to 2008. The primary data collected from different sources of well for three years are collected as for the seasonal studies by (post-monsoon and pre-monsoon) are in January 108 and May 95. The secondary data were collected from the reviews of the water quality samples are collected for three years which has been handled by TWAD board (post-monsoon and pre-monsoon) are in January 134 and May 80. The primary and secondary data has been intersecting for the similar location to exclude the number of sampling locations at the source level for the further analysis which has presented as in the Table 3. Both the samples (n=307) have been collected and prepared for the analysis. The physio-chemical characteristics study has been carried out for the pattern to identify better correlations of hazard risk of the study area. The primary analysis of the physio-chemical characteristics has to be analyzed and the detail summary statistics of the data have been identify for the parameters such as pH, TDS, T.Alk, TH, Ca and Na.

Further the analysis has been extended to identify the risk zones of fluoride contaminations have been analyzed by using SPADNS for the collected of data Post monsoon (January) and Pre monsoon (May) of January-May 2006, January-May 2007, January-May 2008. Based on the primary and secondary data of the fluoride contaminated water sources of the area are to be mapped for the better visualization of the risk zones. This, through publicity, will help people to avoid using water sources, contaminated with fluoride, for drinking purpose. Cases of dental fluorosis due to the use of water contamination with fluoride have been reported from the primary health centers of the area.

Table 3 the recorded ground water sampling data for identification of fluoride for the month of January and may for the year 2006 to 2008 (n=307)

<table>
<thead>
<tr>
<th>SL. NO</th>
<th>YEAR 2006 to 2008</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MONTH</td>
<td>TALUK</td>
</tr>
<tr>
<td>1</td>
<td>2006</td>
<td>Dharmapuri</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2006</td>
<td>Harur</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2008</td>
<td>Palacode</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Pappiredipatti</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Pennagaram</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>8-BLOCKS</td>
<td></td>
</tr>
</tbody>
</table>

* NA-NOT APPLICABLE

From the ground water chemistry data are collected from TWAD board for 36 well sample locations in Dharmapuri district, the fluoride availability in ground water in mg/l has been used for the preparation of fluoride contamination map with the help of ArcGIS software. Following the monsoon seasons of TamilNadu, it is intended to prepare these fluoride distribution maps for dental fluorosis due to the use of water contamination with fluoride have been reported from the primary health centers of the area.
pre monsoon (May) and post monsoon (January) periods for three years (2006, 2007 and 2008). In ArcGIS, isoline maps for the fluoride distribution during the above said six periods have been prepared using contour option after the generation of raster image of the same using the IDW (Inverse Distance weighted) module.

6.1 Preliminary Preparation of Geographical Base Map
Taluk map of the study area was prepared from the Survey of India topography sheets and digitized using ArcGIS software. The preliminary preparation of the digitized Map 1 which shown eight taluks in the Dharmapuri district such as Dharmapuri, Harur, Karimangalam, Morappur, Nallampalli, Palacode, Pappireddipatti and Pennagaram.

6.1.1 Total Dissolved Solids
Keeping the natural fact that the increased availability of TDS in groundwater may indirectly indicate the increased availability of dissolved fluoride in fluoride source rock areas, the total dissolved solids maps have also been prepared. From the secondary data collected from TWAD Board on groundwater quality, the data on total dissolved solids in ground water have also been entered into computer and isolines are generated using IDW method in ARCGIS and then mapped in the similar way followed for the preparation of fluoride maps. The total dissolved solids availability in groundwater for the same six periods so prepared are shown in the (Map 2 to Map 8).

RESULTS
A description of the study protocol (database generation) and the results of the analysis are presented as in the (Table 2 and Table 3). Major elements of water geochemistry are analyzed and the results are shown in the Table 4 for the post-monsoon of January and Table 5 for the pre-monsoon of May. The detailed summary statistics of the result has been prepared from the analyzed parameters such as pH; TDS, T.Alk, TH, Ca, Na and Fl are shown as a fore mentioned (Table 4 and 5). The majority of the ground waters that we sampled are dominated by fluoride, although a few of other parameters pH, TDS, T.Alk, TH, Ca, Na has exceed the levels of the standard WHO [40], BIS [4] are presented briefly in the (Table 6). From the Table 6 the results are detailed below:

The level of pH which finds randomly from the sample at the maximum level 7.6 to 8.1 which shows the exceed level for drinking. The level of pH which shown in the post-monsoon and the pre-monsoon are at the level of the standard and the maximum level 8.1 which shows in year of pre-monsoon May 2006.
Map 2 Total Dissolved Solids Availability in Ground Water for Post-Monsoon in the Year 2006

Map 3 Total Dissolved Solids Availability in Ground Water for Post-Monsoon in the Year 2007
The Total dissolved solids level are find mostly very high from the samples. The maximum levels of TDS are found very high which carried out 2077 mg/l in 2007. The study of TDS from the sample of different taluks which shows high except Harur in post and pre-monsoon are shown below the limit and the remaining taluks of different period which shown very high which exceed of WHO standard.

Total alkalinity which exceed the level of WHO in each taluks except Harur and the maximum value which has find on the sample in the taluk of Pennagaram pre-monsoon of May is 588 mg/l in the year 2007. On that particular pre-monsoon of 2006 the minimum value which shows the level of fluoride are 340 mg/l and the remaining samples of the taluk are shown below the level of standard.

The levels of Total Hardness are found very high on the study period especially in Palacode 780 mg/l in 2007 of pre-monsoon and the remaining taluks are shows randomly higher except Harur in pre-monsoon remaining taluks shows above the limit of the standard.
Table 4. The summary statistics for the collected data for the month of January for the year 2006 to 2008 (n= 197)

<table>
<thead>
<tr>
<th>SL. NO</th>
<th>YEAR</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>JAN</td>
<td>JAN</td>
<td>JAN</td>
</tr>
<tr>
<td>PARAMETER</td>
<td>pH</td>
<td>TDS</td>
<td>T.Ak</td>
<td>Ca</td>
</tr>
<tr>
<td>1 Dharmapuri</td>
<td>7.6</td>
<td>919.92</td>
<td>427</td>
<td>382</td>
</tr>
<tr>
<td>2 Karimangalam</td>
<td>7.4</td>
<td>882.77</td>
<td>430</td>
<td>382</td>
</tr>
<tr>
<td>3 Palacode</td>
<td>7.3</td>
<td>705.64</td>
<td>366.5</td>
<td>384</td>
</tr>
<tr>
<td>4 Pappireddipatti</td>
<td>7.3</td>
<td>829</td>
<td>455.5</td>
<td>396</td>
</tr>
<tr>
<td>5 Harur</td>
<td>7.6</td>
<td>792.3</td>
<td>349.2</td>
<td>413</td>
</tr>
<tr>
<td>6 Pennagaram</td>
<td>7.3</td>
<td>751.67</td>
<td>321.1</td>
<td>410</td>
</tr>
<tr>
<td>7 Nallampalli</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8 Morappur</td>
<td>7.7</td>
<td>957.65</td>
<td>379.2</td>
<td>375</td>
</tr>
</tbody>
</table>

Table 5. The summary statistics for the collected data for the month of May for the year 2006 to 2008 (n=110)

<table>
<thead>
<tr>
<th>SL. NO</th>
<th>YEAR</th>
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<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MAY</td>
<td>MAY</td>
<td>MAY</td>
</tr>
<tr>
<td>PARAMETER</td>
<td>pH</td>
<td>TDS</td>
<td>T.Ak</td>
<td>Ca</td>
</tr>
<tr>
<td>1 Dharmapuri</td>
<td>8.1</td>
<td>927</td>
<td>331</td>
<td>327</td>
</tr>
<tr>
<td>2 Karimangalam</td>
<td>7.7</td>
<td>908</td>
<td>343</td>
<td>434</td>
</tr>
<tr>
<td>3 Palacode</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 Pappireddipatti</td>
<td>7.6</td>
<td>2616</td>
<td>587</td>
<td>715</td>
</tr>
<tr>
<td>5 Harur</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6 Pennagaram</td>
<td>7.2</td>
<td>917</td>
<td>340</td>
<td>402</td>
</tr>
<tr>
<td>7 Nallampalli</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8 Morappur</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>

**pH-** Hydrogen/ **TDS-** Total Dissolved Solids/ **T.Ak-** Total Alkalinity/ **TH-** Total Hardness/ **Ca-Ca-** Calcium/ **Na-** Sodium/ **FL-** Fluoride
Table 6. The maximum level of samples for the collected data for the month of January and May for the year 2006 TO 2008 (N=307)

<table>
<thead>
<tr>
<th>SL.</th>
<th>PARAMETER</th>
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<th>JAN 2007</th>
<th>JAN 2008</th>
<th>MAY 2006</th>
<th>MAY 2007</th>
<th>MAY 2008</th>
<th>Limit mg/l</th>
<th>Limit mg/l</th>
<th>Limit mg/l</th>
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<td>9.0 10.0</td>
<td>9.0 10.0</td>
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<td>8.0 9.0</td>
<td>8.0 9.0</td>
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<td>7.7</td>
<td>7.7</td>
<td>7.7</td>
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<td>8.0 8.5 8.0</td>
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<tr>
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<th>BIS</th>
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Aquifers, but are elevated in some samples. Calcium and sodium are the major cations. Some of the samples are strongly dominated by sodium. Most of the samples of (post-monsoon and pre-monsoon) January and May in seven taluk of Dharmapuri district, Dharmapuri, Karimangalam, Palacode, Pappireddipatti, Harur, Pennagaram and Morappur are the higher level of calcium than the limit of BIS and WHO expect the Harur in (pre-monsoon) May which shown below the limit. In palacode the samples have maximum calcium levels ranging up to 180 mg/L and in Pappireddipatti maximum sodium levels ranging up to 500 mg/L, and there is a weak negative correlation between these variables. The level of sodium is below the limit in Harur, of the entire study period.

There is a positive and negative correlation between pH, TDS, T.Alk, TH, Ca and Na. The samples with sodium levels above 500 mg/L have pH below the limit, while almost all samples with sodium levels below the limit have pH less greater than 7.5. There is a positive correlation between TDS, T.Alk, TH and calcium. Most of the samples with pH above 7.5 have calcium levels above and below the limit of the standard there is positive and negative correlations have identified clearly.

There is strong positive correlation between fluoride and pH is found from the study in each taluks of our study period. The maximum level of fluoride has seen on the taluk of Karimangalam which shows 2mg/l on this taluk there is a negative correlation has been identified. The fluoride availability in ground water varies from 0 to 2mg/l, and it is clearly observed that the distribution pattern also varies from place to place and from period to period.

**CONCLUSION**

Elevated levels of fluoride in ground waters from a soils or weathering, rock, Deposition of atmospheric volcanic particles, Runoff and infiltration of chemical fertilizers in agricultural areas, Septic and sewage treatment system discharges in communities with fluoridated water supplies, Liquid waste from industrial sources, sandstone and mudstone aquifer system on Dharamapuri district are largely a result of base-exchange softening and the consequent high pH levels. It is evident that this process may be responsible for elevated fluoride levels in sandy aquifers around the world. The result shows that a pH of 8.1 in Dharamapuri taluks is identified from the result of the (pre-monsoon) May in 2006. Hence, we suggest that the pH level which has been exceeding to 8.5 as per the limit is to be used a rapid screening threshold to predict water-quality risks associated with fluoride in groundwater.

From the above results it is clear that the ground water from most parts of study area has quality problems like, high fluoride content. People have to be advised to avoid these sources, as use of these may result in dental fluorosis. To avoid cases of fluorosis like, at low concentrations fluoride can reduce the risk of dental cavities, Higher amounts of fluoride can cause dental fluorosis, Even higher intakes of fluoride taken over a long period of time can result in changes to bone, a condition known as skeletal fluorosis, Cause joint pain, restriction of mobility and Possibly increase the risk of some bone fractures from this study area of Dharmapuri. People have to be advised to use surface water especially river water supply schemes as far as possible. Serious attempts are needed to develop community based de-fluoridation systems as a permanent solution to the problem.
Acknowledgement
I am thankful to DRDO-BU Center for Life Sciences, Bharathiar University, Coimbatore for providing the grant and facilities to carry out this research work.

REFERENCES

ASSESSMENT OF FLUORIDE CONTAMINATION IN GROUNDWATER USING GIS, DHARMAPURI DISTRICT, TAMILNADU, INDIA

Sendesh Kannan, K. and Ramasubramanian, V.
Environmental management and Biotechnology Division, DRDO-BU Center for Life Sciences, Bharathiar University, Coimbatore – 46

ABSTRACT
Water is essential natural resource for sustaining life and environment which we have always thought to available in abundance and free gift of nature. However, chemical composition of surface or subsurface, geothermal or non - thermal, is one of the prime factors on which the suitability of the water for domestic, industrial or agriculture purpose depends. Groundwater forms a major source of drinking water in urban as well as in rural areas. More than 90% of the rural population uses groundwater for domestic purposes. However, around 300 million people still live in absolute poverty in both urban and rural areas, and often lack access to clean drinking water and basic sanitation; nearly half the population is illiterate, not at all aware of the water borne diseases affecting their health. Fluoride is a chemical element that has shown to cause significant effects on human health through drinking water. Fluoride has beneficial effects on teeth at low concentrations of 1mg/l by preventing and reducing the risk of tooth decay. Fluoride can also be quite detrimental at higher concentrations exceeding 1.5 to 2mg/l of water. High concentrations of fluoride pose a risk of dental fluorosis as well as skeletal fluorosis and osteoporosis.

Key Words: Groundwater, Fluoride, Fluorosis, Mottled teeth, GIS

1. INTRODUCTION
Water is the most precious gift of nature, the most crucial for sustaining life and is required in almost all the activities of man - for drinking and municipal use, for irrigation, to meet the growing food and fibre needs, for industries, power generation, navigation and recreation. Moreover, the rainfall is mostly confined to the monsoon season and is unevenly distributed in space and time even during the monsoon season. As a result, the country is affected by frequent droughts. Nearly one third of the country is drought prone. In the very near future, water will be a scarce resource and therefore, needs to be harnessed in the most scientific and efficient manner.

Groundwater is the major source of drinking water in both urban and rural India. The demand for water has increased over the years and this has led to water scarcity in many parts of the world. The problem of excessive fluoride in groundwater in India was first reported in 1937 in the State of Andhra Pradesh (Short et al., 1937[6]. In India, approximately 62 million people including 6 million children suffer from fluorosis because of consumption of water with high fluoride concentrations (Susheela, 1999[7]) Due to its strong electronegativity, fluoride is attracted by positively charged calcium in teeth and bones causing dental fluorosis, teeth mottling, skeletal fluorosis and deformation of bones in children as well as in adults (Susheela et al., 1993[8]). Excess fluoride affects plants and animals also. The severity of injury is determined by duration of fluoride exposure and concentration. The major sources of fluoride in groundwater are fluoride bearing rocks such as fluorspar, cryolite, fluorapatite and hydroxylapatite (Agarwal et al., 1997[1]). Fluoride is a common constituent of rocks, soils and waters with rock being the primary reservoir and ultimate source. The presence of fluoride in groundwater is governed by several factors like igneous rocks formation, magmatic processes i.e., and formation of magma, pegmatite, hydrothermal fluids, metamorphic rocks and weathering processes. The permissible limit for fluoride in drinking water is 1.0 mg/l (WHO, 1971[9]) and 1.5 mg/l (Indian standard[4]). In some parts of India, the fluoride levels are below 0.5 mg/l, while at certain other places, fluoride levels are as high as 30 mg/l have been reported (Handa, 1975[5]).

The permissible limits of fluoride in drinking water by various organizations are given in table 1
Table I. Permissible level of fluoride in drinking water by various organizations

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of the Organizations</th>
<th>Permissible limit of Fluoride (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>World Health Organization (WHO) International Standards for drinking water</td>
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</tr>
<tr>
<td>2.</td>
<td>Bureau of Indian Standards (BIS)</td>
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</tr>
<tr>
<td>3.</td>
<td>The committee on Public Health Engineering (PHE), Govt. of India</td>
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</tr>
<tr>
<td>4.</td>
<td>Indian Council of Medical Research (ICMR), Govt. of India</td>
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</table>

2. STATEMENT OF THE PROBLEM

The present study was undertaken to explore and understand the possible relationship between fluoride and geological types and processes with respect to the suspected occurrence of endemic fluorosis. Recent literature reports that fluorosis is a global problem affecting more than seventy million people in 25 countries. In India about 62 million people are consuming excess of fluoride in drinking water.

2.1 Fluoride in Tamil Nadu

In Tamil Nadu, the high concentration of fluoride in groundwater is found to be in Dharmapuri and Salem district closely followed by Coimbatore, Madurai, Trichy, Dindukal and Chidambaram district. The districts having low fluoride are Thirunelveli, Pudukottai, North Arcot, and Ramnad districts. The district wise fluoride status in Tamil Nadu is presented in table II.

TABLE II. Status of Fluoride in various districts of Tamil Nadu

<table>
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<th>S.No</th>
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<th>Districts</th>
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</tr>
<tr>
<td></td>
<td></td>
<td>Coimbatore Madurai Trichy Dindukal Chidambaram</td>
</tr>
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</tr>
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<td>Less</td>
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</tbody>
</table>

3. MATERIALS AND METHODS

3.1 STUDY AREA

Dharmapuri district, lies at the trijunction of Karnataka, Andhra Pradesh and Tamil Nadu states of South India. The district is situated in the Northwestern portion of Tamil Nadu.

3.2 Geographic Overview

The study area lies at a geographical extent from 11° 45’ to 12° 53’ N and 77° 13’ to 78° 45’ E. The total area of the district is 9581.26sq.km. The district is surrounded by Vellore, Tiruvannamalai and Villupuram districts in the East, Salem district in the South, the states of Karnataka and Andhra Pradesh in the North The altitude of the district ranges from 300-1200m above mean sea level.
A base map has been prepared using survey of India topographic sheets 1:50,000 scale from the toposheet the major roads, rivers, block headquarter locations are traced in tracing films, scanned georeferenced and digitized using ARCGIS 9.2

3.3 WATER SAMPLING
Randomly collected groundwater samples for fluoride is estimated using Calorimetric (SPADNS2-(4-Sulfophenylazo)-1, 8-Dihydroxy-3-6-Naphthalene- Disulphonic acid, Trisodium salt method). The sampling technique and the fluoride estimation procedure are given below in detail.

3.4 Sampling technique
In the present study, random sampling design is applied. This method which is a “Probability sampling” has an equal chance of inclusion of every item of an object in the sample. Random sampling ensures the “Law of statistical regularity”, which states that “If an average of the samples chosen is a random one, the sample will have the same composition and characteristics of the object under consideration”. This is the reason why random sampling is considered as the best technique of selecting a representative sample.
In Dharmapuri district, the groundwater samples from different bore wells were collected in seven out of eight taluks (Dharmapuri, Palacode, Harur, Pappireddipatti, Karimangalam, Pennagaram except Nallampalli), as per the guidelines of random sample method. For fluoride analysis, Acid washed new one litre polythene- cans were used for collection of groundwater samples. Bore wells fitted with motors for water lifting were allowed to run the water for five minutes in order to flush out stationary water. Further, the sample cans were also flushed with several volumes of water before the collection of samples. The sample bottles are closed tightly and labeled. The samples were preserved, cooled and protected from breakage while transporting the bottles to the laboratory. After arrival to the laboratory, the groundwater samples were refrigerated at 4° C. After refrigeration, the samples were used for Fluoride analysis.

3.5 Fluoride Estimation using Calorimetric Method (UV- Visible Spectro photometer)
The methods suggested for the fluoride ion determination are
- The Colorimetric method (SPADNS) and
- The Ion Selective Electrode method
as they are best applicable to variety of samples. The Colorimetric methods are subjected to errors due to the presence of interfering ions. So, it is necessary to distill the sample before estimating the fluoride. The addition of the prescribed buffer frees the electrode from the interference caused by the common ions such as aluminum, hexametaphosphate, and orthophosphate that adversely affect the calorimetric methods simultaneously. The distillation procedure is carried out in the following manner.
400ml of distilled water was taken in the distillation flask and 200ml of concentrated sulphuric acid was added to it carefully. The mixture was swirled and homogenized, then 25-30 glass bits were added (to control the excess boil) and then the apparatus was connected. The apparatus was heated slowly at first and then rapidly until the temperature of the flask reaches exactly 180° C. Then, the distillates were discarded. This process removes the fluoride contamination and adjusts the acid water ratio for subsequent distillations.
After cooling the acid mixture to 120°C or below, 300ml of groundwater sample was added, thoroughly mixed and distilled before the temperature reaches 180°C. After the distillation of high fluoride samples, the still was flushed with 300 ml of distilled water and then the two fluoride distillates were combined. Similarly, after the periods of inactivity, the still was flushed and the distillate was discarded.
The prepared samples are ready for reading the fluoride concentration. 10ml of acid zirconyl SPADNS reagent was added to all the samples. The sample was mixed well and then read the optical density of bleached colour at 570nm using reference solution (for setting zero absorbance). 1ml of sample was added with 10ml of acid Zirconyl- SPADNS reagent, mixed well the solution and percentage transmission or absorbance was recorded. Using the Spectrophotometer, the fluoride mg/l was calculated.

4. RESULT AND DISCUSSION

4.1 FLUORIDE CONTAMINATION IN GROUND WATER
The fluoride availability in ground water in mg/litre has been used for the preparation of fluoride contamination map with the help of samples, locations, details, the fluoride distribution in ground water for 6 contagious seasons January 2006, May 2006, January 2007, May 2007, January 2008, May 2008. Following the monsoon seasons of Tamilnadu it is intended to prepare these fluoride distribution maps for pre monsoon (May) and post monsoon (January) periods for three years (2006,2007 and 2008) have been prepared using
IDW (Inverse Distance weighted) method available in ArcGIS (Figure a-f) the fluoride availability in groundwater is varying from 0 to 3.5 mg/l, and it is clearly observed that the distribution pattern is varying from place to place.
4.2 GENERATION OF CLASSIFIED GIS IMAGES SHOWING FLUORIDE RISK AND SAFE ZONES

According to the BIS, 1.0 mg/l is the potable limit of ground water. The presence of high fluoride concentration in ground water is varying depending upon weathering and recharge of the terrain. In order to understand the pattern of high fluoride zone for different seasons such as pre monsoon and post monsoon, all the six independent GIS layers showing fluoride availability in ground water 2006-2008 (Fig. g-l) were classified based on the BIS standard as mentioned above. The areas above 1 mg/l of fluoride availability has been labeled as risk zones (represented with red colour in map) and the areas below 1 mg/l as safe zones (green colour) in all the six fluoride layers using the dissolve option available in GIS (Fig. m-q).
4.3 GIS INTEGRATION AND DETERMINATION

After the classification of fluoride risk and safe zones for all the six periods, they have been integrated in five levels using union option available in analysis tool of Arc GIS. The same is shown in following (Fig. m-q)

<table>
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<th>Level Of Integration</th>
<th>Input 1 Fluoride risk and safe zones during the period</th>
<th>Input 2 2006-2008</th>
<th>Resultant map</th>
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<tr>
<td>Level 1</td>
<td>Jan 2006</td>
<td>May 2006</td>
<td>Union map</td>
</tr>
<tr>
<td>Level 2</td>
<td>Level 1</td>
<td>Jan 2007</td>
<td>I union output</td>
</tr>
<tr>
<td>Level 3</td>
<td>Level 2</td>
<td>May 2007</td>
<td>II union output</td>
</tr>
<tr>
<td>Level 4</td>
<td>Level 3</td>
<td>Jan 2008</td>
<td>III union output</td>
</tr>
<tr>
<td>Level 5</td>
<td>Level 4</td>
<td>May 2008</td>
<td>IV union output</td>
</tr>
</tbody>
</table>
The resultant level five image may have 64 number of maximum possible classes with so many finely divided polygons. The dissolved image has got 43 classes of 43 number of polygons (Fig. q)

The final integrated image named level five was dissolved to avoid complexities in duplication of similar classed polygons.

The first class shown in (Fig r) is labeled as ‘RRRRRR’ and displayed in dark brown colour that means all the dark brown colored polygons have got high fluoride content (>1mg/l) through out the six monsoon period of three years (2006-2008). Each letter either ‘R’ or ‘S’ represents high Risk ness in the particular monsoon period, i.e., the first letter stands for Risk ness during January 2006 and second ‘R’ stands for risk ness during May 2006, third ‘R’ stands for Risk ness during January 2007, Fourth ‘R’ stands for Risk ness during May 2007, Fifth ‘R’ stands for Risk ness during January 2008 and sixth ‘R’ stands for Risk ness during May 2008. This is from the legend one can understand the areas of repeated pattern of fluoride risk and safe zones occurred during six monsoon seasons. If the letter ‘R’ is repeated many times (up to 6 times) then the same is understood as very high risk zones. According Very high, High, Moderate, low, very low risk zones are reclassified based on the number of occurrence of risk ness.
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5. CONCLUSION

Geographic Information System (GIS) approach to develop spatial information and knowledge based on the ground water quality of Dharmapuri has been found to be very useful. GIS database also helps in decision-making process by identifying the most sensitive zones that need immediate attention.

ACKNOWLEDGEMENT

I am thankful to DRDO-BU Center for Life Sciences, Bharathiar University, Coimbatore for providing the grant and facilities to carry out this research work.

6. REFERENCES

APPENDIX -I

PLATE: I

EFFECT OF DENTAL FLUOROSIS IN SCHOOL CHILDREN AT DHARMAPURI DISTRICT

PLATE - II

EFFECT OF DENTAL FLUOROSIS IN ADULT OF HARUR AND PALACODE TALUK AT DHARMAPURI DISTRICT
PLATE – III

LOCATION OF GROUND WATER SAMPLES RECORDED USING GEOGRAPHICAL POSITIONING SYSTEM IN DHARMAPURI DISTRICT

Ground Level Information Recorded Using (GPS)

Collection of water sample on the Study area