ASSESSMENT OF THE QUALITY OF SURFACE AND GROUNDWATER IN R.S.PURA TEHSIL OF JAMMU DISTRICT (J&K, INDIA): FOCUS ON FLUORIDE CONCENTRATION AND PREVALENCE OF DENTAL FLUOROSIS

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ABSTRACT

Occurrence of fluoride in groundwater has drawn worldwide attention due to its considerable impact on human physiology. Fluorine occurs mainly as free fluoride ion in natural waters. In order to determine the fluoride concentration, hydrological investigations have been carried out in R.S. Pura Tehsil of Jammu district, J&K. Fluoride concentration was found to range from 0.02-0.45 mg/l. Groundwater was also found to be slightly alkaline in nature. In order to determine the effect of fluoride on human health, school survey were carried out. The data of the school survey revealed 20% of the prevalence of the dental fluorosis in the area under investigation.

KEYWORDS: Fluoride, Groundwater, Dental Fluorosis, R.S. Pura Tehsil

INTRODUCTION

Fluoride is regarded as a 'two-edge sword' - as its prolonged ingestion through drinking water in excess of the daily requirement is associated with fluoride poisoning (i.e. dental and skeletal fluorosis) whereas its inadequate intake is associated with dental caries (Shantakumari and Subramanian, 2007). High groundwater fluoride concentration is found in many parts of developing countries and fluorosis is endemic in at least 25 countries across the globe (Alvardo et al., 2010). The adversely affected areas includes arid parts of northern China (inner Magnolia), India, Sri Lanka, African countries, Northern Mexico and central Argentina (Devi and Kamble, 2006).

In India the problem of fluorosis has been in existence since early 1930s and was initially discovered in bullocks used for ploughing the land and later in human beings living in Madras province in Andhra Pradesh (Shortt et al., 1937). About 177 districts are affected with fluoride contamination of groundwater covering 20 districts in India.

Fluoride is the name for binary compound containing fluorine. Fluorine, the seventeenth abundant element in earth's crust, is the most reactive and the most
electronegative element and therefore it almost never occurs in nature in its elemental state. It combines with all elements except oxygen and noble gases, to form fluoride (WHO, 2000). The atomic number of fluorine is nine and it has a density of 1.51 g/cm\(^3\) and a melting and boiling point of -220\(^\circ\)C and -188\(^\circ\)C respectively (Saxena and Ahmed, 2001 and WHO, 2004). According to studies its odour detectable limits are 0.033-0.1333 mg/m\(^3\) while the irritating concentration is 4.17 mg/l\(^3\) (Ruth, 1986).

Both fluoride (F\(^-\)) and hydroxyl (OH\(^-\)) ions have the same ionic radii and are roughly of the same size, that is how they can easily replace each other in many rock forming processes (Gupta et al., 2012). Fluoride exists naturally in a number of different minerals (Muggler, 2009). The major fluoride containing minerals are: Fluorite (CaF\(_2\)); Fluorapatite [Ca\(_2\)F (PO\(_4\))]; Cryolite (Na\(_3\)AlF\(_6\)) and Topaz [Al\(_2\)SiO\(_4\) (OH.F) \(_2\)]. So, fluoride ions are widespread in lithosphere as compared to hydrosphere, atmosphere and the biosphere since most of the fluoride exists bound in different minerals (Devi and Kamble, 2006).

**GUIDELINE VALUES FOR FLUORIDE:**

The guideline value regarding the permissible limit of fluoride remains the subject of much controversy till date and consequently it has been suggested that in countries with a warm climate there might be need for local guidelines with a lower limit, due to larger water intake (WHO, 2004). Senegal reduced the upper permissible limit of fluoride in drinking water from 1.5 mg/l to 0.6 mg/l based on the prevalence of dental fluorosis at 0.6 mg/l of fluoride in drinking water (Brower et al., 1988). In India for instance the permissible upper limit was lowered from 1.5 to 1.0 mg/l in 1998 with a rider that 'less is better' (Bulusa and Biswas, 1994). The present study was carried out to determine the distribution of fluoride ion concentration in groundwater and surface water sources of the studied areas and to determine the prevalence of dental fluorosis.

**MATERIAL AND METHODS:**

**STUDY AREA**
In order to determine the distribution of fluoride ions, R.S.Pura tehsil of Jammu district was selected (Fig. i). The climate of the area is of sub-tropical type, characterized by three well defined seasons viz winter, summer and monsoon. May and June are the hottest months with more than 38°C temperature. The topography of R.S. Pura tehsil is mostly flat with partly undulations. The geology of the area consists of Siwaliks and is mostly composed of sandstone, siltstone and transported quartzite.

**METHODOLOGY:**

Water samples were collected from hand pumps, boreholes and Ponds of different sampling sites of study areas. First the water was left to run from the sampling source for 4-6 minutes to pump out the volume of water standing in the casing before taking the final sample and then the water samples were collected systematically in pre-clean, acid washed (HNO₃ acid) polythene bottles of one litre capacity. Some of the parameters were measured in the field and for other parameters water samples were brought to the laboratory for further analysis. Fluoride was estimated both in the field as well in the laboratory. In the field, fluoride field test kit was used. In the laboratory Fluoride was estimated using Zirconyl-Alizarin Acid Chloride method (Nollet and Gelder, 2007 and Gopalan and Sugumar, 2008).

- **PREVALENCE OF DENTAL FLUOROSIS:**
  
  The methodology includes two main steps:
  
  1. Survey for dental fluorosis.
  2. Estimation of dental fluorosis.

1. **SURVEY FOR DENTAL FLUOROSIS**

   Surveys were conducted among the middle and high school students in the R.S. Pura tehsil. Four schools had been selected for study purpose (two from each study area). 12-15 year-old children served as the target group. Only those school children who had reported continuous residence since birth in the corresponding areas were included in the study.

2. **ESTIMATION OF DENTAL FLUOROSIS**

   Clinical intra-oral examination was conducted at the schools in day light. The adequate diagnosis of fluorosis requires inspection of dry and clean dental surface. The teeth were wiped with cotton before recording the relevant information. Teeth examined were upper central and lateral permanent incisors and the recordings were made on the basis of the two teeth which were the most affected.
INDEX USED

The index used in this study was taken from WHO oral health assessment form, 1997, i.e. Dean's Index (1934). It's a specific fluoride index which measures the defects of the enamel arising from excessive fluoride ingestion. Form of dental fluorosis ranges from very mild to severe (Plate 14). The criteria for index is shown in the below mentioned table:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Criteria-description of enamel</th>
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<tbody>
<tr>
<td>Normal</td>
<td>Smooth, glossy, pale creamy-white translucent surfaces.</td>
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<td>Questionable</td>
<td>A few white flecks or white spots.</td>
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<td>Very Mild</td>
<td>Small opaque, paper white area covering less than 25% of tooth surface.</td>
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<td>Mild</td>
<td>Opaque white areas covering less than 50% of tooth surface.</td>
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<tr>
<td>Moderate</td>
<td>All tooth surfaces affected; marked wear on biting surfaces; brown stain may be present.</td>
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<tr>
<td>Severe</td>
<td>All tooth surfaces affected; discrete or confluent pitting; brown stain present.</td>
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RESULTS AND DISCUSSION

The present investigation on seasonal variation of fluoride ions in groundwater samples revealed that the concentration of fluoride fluctuated from 0.08-0.45 mg/l with minima recorded from Kullian area (borehole) and maxima from Miran Sahib area (handpump). High fluoride concentration was observed during monsoon season and low during winter season (Table 1). Slight rise in concentration of fluoride was also observed during summer season. Monsoon rise in fluoride concentration may be attributable to the dissolution of fluoride ions due to the weathering of rocks containing fluoride minerals whereas increased surface temperature during summer season may results in the evaporation of the water in the unsaturated zones of the water table which ultimately leads to the precipitation of calcium ions as calcite. Decreased concentration of calcium ions elevates the level of fluoride ions in groundwater as both of these ions are negatively correlated (Dey et al., 2012).

In surface water bodies its value ranged from 0.02 mg/l (pond, Miran Sahib) to 0.04 mg/l (Stream, Simbal). Surface water bodies reflected a slight rise in fluoride concentration during summer season while its complete absence was observed during winter season. Complete absence of fluoride ions during winters season may be due the intensive growth of the aquatic macrophytes e.g. Hydrilla verticillaria has been found to remove fluoride to some extent (Sinha et al., 2000 and Khandare and Rao, 2006).
Table 1: Seasonal variation in fluoride ions (in mg/l) at different stations from May, 2012 to April, 2013 in R.S. Pura tehsil

<table>
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<tr>
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<td>GROUNDWATER SAMPLES</td>
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<td></td>
<td>Miransahib (H.P)</td>
<td>0.66</td>
<td>0.48</td>
<td>0.73</td>
<td>0.54</td>
<td>0.75</td>
<td>0.68</td>
<td>0.4</td>
<td>0.03</td>
<td>0.06</td>
<td>0.32</td>
<td>0.33</td>
<td>0.46</td>
<td>0.45±0.24</td>
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<td></td>
<td>Tallimorh (T.W)</td>
<td>0.7</td>
<td>0.3</td>
<td>0.18</td>
<td>0.69</td>
<td>0.71</td>
<td>0.66</td>
<td>0.12</td>
<td>0.16</td>
<td>0.09</td>
<td>0.52</td>
<td>0.45</td>
<td>0.5</td>
<td>0.42±0.24</td>
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<td></td>
<td>Maralia (B.H)</td>
<td>0.9</td>
<td>0.6</td>
<td>0.0</td>
<td>0.85</td>
<td>0.25</td>
<td>0.65</td>
<td>0.0</td>
<td>0.34</td>
<td>0.5</td>
<td>0.08</td>
<td>0.07</td>
<td>0.6</td>
<td>0.40±0.32</td>
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<td></td>
<td>Link road (H.P)</td>
<td>0.3</td>
<td>0.12</td>
<td>0.12</td>
<td>0.3</td>
<td>0.5</td>
<td>0.09</td>
<td>0.19</td>
<td>0.07</td>
<td>0.01</td>
<td>0.17</td>
<td>0.14</td>
<td>0.16</td>
<td>0.18±0.13</td>
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<tr>
<td></td>
<td>Simbalmorh (B.H)</td>
<td>0.0</td>
<td>0.43</td>
<td>0.73</td>
<td>0.13</td>
<td>0.65</td>
<td>0.08</td>
<td>0.0</td>
<td>0.47</td>
<td>0.34</td>
<td>0.0</td>
<td>0.012</td>
<td>0.03</td>
<td>0.23±0.27</td>
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<td></td>
<td>Kullian (B.H)</td>
<td>0.0</td>
<td>0.2</td>
<td>0.14</td>
<td>0.3</td>
<td>0.04</td>
<td>0.04</td>
<td>0.17</td>
<td>0.08</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.08±0.09</td>
</tr>
<tr>
<td></td>
<td>R.S.Pura (H.P)</td>
<td>0.01</td>
<td>0.07</td>
<td>0.5</td>
<td>0.12</td>
<td>0.11</td>
<td>0.09</td>
<td>0.3</td>
<td>0.0</td>
<td>0.04</td>
<td>0.01</td>
<td>0.03</td>
<td>0.09</td>
<td>0.11±0.14</td>
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<td>SURFACE WATER SAMPLES</td>
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<tr>
<td></td>
<td>Simbal (S)</td>
<td>0.05</td>
<td>0.02</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.09</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.03</td>
<td>0.02</td>
<td>0.07</td>
<td>0.02±0.03</td>
</tr>
<tr>
<td></td>
<td>Maralian (P)</td>
<td>0.08</td>
<td>0.09</td>
<td>0.06</td>
<td>0.06</td>
<td>0.04</td>
<td>0.06</td>
<td>0.07</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.03</td>
<td>0.04</td>
<td>0.04±0.03</td>
</tr>
</tbody>
</table>


PREVALENCE OF DENTAL FLUOROSIS:
The prevalence of dental fluorosis among children of R.S.PURA Tehsil was 20% (). A total of 225 children were examined for dental fluorosis, out of which most cases (38 children) were diagnosed for mild degree of dental fluorosis.

Only seven children had moderate level of dental fluorosis whereas no student was diagnosed for the severe degree of fluorosis.

Table 2 : Prevalence of Dental Fluorosis in School going children living in R.S. Pura tehsil:

<table>
<thead>
<tr>
<th>School Surveyed</th>
<th>Mean F-(mg/l) level in water</th>
<th>Total No. of students examined</th>
<th>Age Group (No. of Students affected)</th>
<th>Level of Dental Fluorosis</th>
<th>%age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Govt. Boys High School Bansultan</td>
<td>0.32</td>
<td>115</td>
<td>6-9 Yrs (8) 9-12 Yrs (15) 12-15 Yrs (1)</td>
<td>Mild (19) Moderate (5) Severe (1)</td>
<td>24</td>
</tr>
<tr>
<td>Govt. Middle School, Malikpur</td>
<td>0.27</td>
<td>110</td>
<td>6-9 Yrs (8) 9-12 Yrs (4) 12-15 Yrs (5)</td>
<td>Mild (19) Moderate (2) Severe (1)</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>225</td>
<td></td>
<td>6-9 Yrs (38) 9-12 Yrs (7) 12-15 Yrs (1)</td>
<td>Mild (38) Moderate (7) Severe (1)</td>
<td>45</td>
</tr>
</tbody>
</table>

The present observations thus indicate that cases related to mild degree of dental fluorosis were more prevalent in the area under investigations followed by moderate degree of dental
fluorosis. It has also been put on record that very rarely the present author came across the patients suffering from severe degree of dental fluorosis.

These results are testimony to the fact that there is a link between fluoride contaminated water and the occurrence of the dental fluorosis in the area under present investigations and the prevalence of dental fluorosis case thus supports our observations of fluoride contamination of the drinking water available to the population inhabiting the various locations in R.S. PURA Tehsil of Jammu district of J&K state.

CONCLUSION
Therefore, it is evident from the present analysis that though the fluoride concentration at all the stations did not exceed 1.5 mg/l, which is quite obnoxious level of fluoride for the drinking purpose but even the concentration range of 0.45 mg/l has resulted in varied degree of dental fluorosis and is not safe for drinking purposes. If there is no way of preventing fluoride from being ingested it can to some extent be prevented from being absorbed by the body. Diet rich in calcium ions and vitamin C should be taken as it can markedly decrease gastrointestinal fluoride absorption (Whitford, 1997 and IPCS, 2002).

REFERENCES