Levels of fluoride in various sources of drinking water available in Chennai – A household survey

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Abstract:
Aim: The present study is aimed at estimation of levels of fluoride in various sources of drinking water available in various zones in Chennai, India.
Methods: In this study three types of drinking water namely Corporation water (tap water), bore water (underground water) and different brands of packaged drinking water were tested for fluoride using the Ion-Selective Electrode for fluoride ion (ELIT 8221 crystal membrane) at the Tamil Nadu water supply and drainage board, Chepuk Chennai. A total of 39 samples were tested from ten administrative zones of Chennai, selected by means of simple random sampling. Results: The mean fluoride level ranged from 0.13 to 1.13 parts per million (ppm). Concentration greater than 1 ppm was observed in four brands of packaged drinking water the levels ranging from 1.50 to 2.80 ppm. Hence it is required that the levels of fluoride to be strictly monitored in packaged drinking water.
Keywords: Fluoride; Drinking water, tap water, ground water, packaged water.

Introduction:
Prevention of dental caries is one of the most challenging tasks globally. The benefits of fluoride on dental caries have been established by the pioneer efforts of Mc Kay and T. H. Dean. As water is the elixir of human life, it is the most practical and economical, safe and effective vehicle for the fluoridation in comparisons with other available methods like salt and milk which are not very popular. Water fluoridation is in use in countries like United States, United Kingdom, Sweden, Canada, Ireland, Australia, New Zealand and Switzerland. Ireland is the sole nation to have a mandatory law with respect to water fluoridation.

India has a substantial proportion of dental caries and the state Tamil Nadu is no exception to this. The scores in Tamil Nadu were 5.2 in the year 2000. Measures to improve this situation are still in vogue, with no efforts directed to fluoridate the water supplies.

Though norms have been laid down concerning the levels of fluoride in drinking water, it has not been precisely monitored. According to the Indian standards for public drinking water (Bis 10500 : 1991) the fluoride levels should not be any greater than 2 ppm in natural drinking water and 1 ppm in treated drinking water.

Chennai, the capital of Tamil Nadu largely derives its water supply from the public drinking water supply, the metro water. This supply is not adequate to meet the demands and hence a major proportion of the population use ground water extracted via pumps, as a source of drinking water and most other opt for packaged drinking water.

Knowing the precise estimates of fluoride in the drinking water is of great benefit to the vulnerable society in terms of prevention and control of dental caries. Whatever be the type of water being consumed, it is has been urged time and again that the fluoride level in the drinking...
water is to be monitored. With this in mind and with Chennai as a prototype, this study is aimed to test the levels of fluoride in various sources of drinking water in Chennai.

**Materials and Methods:**

The water supply to Chennai is from four lakes namely Poondi Lake, Cholavaram Lake, Redhills Lake and Chembarambakkam Lake. A household survey was done in Chennai city to estimate the usage of different source of drinking water, it was estimated that 50% of the people use bubble top - type of packaged drinking water, 20% use tap water (metro water), and while 12% of the people use ground water and 18% use combined sources. A simple random sample was used to collect about 100 ml of water sample from the ten administrative zones of Chennai.

All the drinking water samples were collected from the same house or from different house depending on the availability. With respect to bottled water, it is purchased from leading supermarkets in Chennai city. Thereafter it was subjected to analysis for the estimation of fluoride at the Tamil Nadu Water supply and Drainage Board using the Ion-Selective Electrode for fluoride ion (ELIT 8221 crystal membrane). In this study 70% of the residents reported using packaged drinking water. 30% reported using tap and ground water (both). The reason for increased use of packaged water is dissatisfaction with the physical quality of water and due to increasing health concern.

**Results:**

Figure II shows that 70% of the residents reported using packaged drinking water. 30% reported using tap and ground water. The reasons for this are dissatisfaction with the physical quality of water and due to increasing health concern. It is to be noted that a substantial proportion are using packaged drinking water.

Table I shows the concentration of fluoride in tap water, ground water (bore water) and packaged drinking water (bubble top) in ten zones of Chennai city. The mean concentration of fluoride in bore water is 0.14 ± 0.15 mg/l. The concentrations of fluoride in bore water range from 0.35 mg/l recorded in zone IV to 0.83 mg/l in zone 10. The mean concentration of fluoride tap water is 0.56 ± 0.17 mg/l. The concentration of fluoride in tap water ranges from 0.34 mg/l recorded in zone IV to 0.92 mg/l in zone I. The mean fluoride concentration in packaged drinking water is 1.13 ± 0.89 mg/l. The fluoride concentration in packaged drinking water (bubble top) ranges from 2.40 mg/l as recorded in zone III to 0.35 mg/l in zone V.

Table II shows the Fluoride content of bottled water available in leading supermarkets in Chennai city. The mean levels of fluoride of leading bottled water available at various supermarkets across Chennai city is 0.13 mg/l ± 0.16. Four bottles of the nine bottles did not contain fluorides. In the bottles that contained fluoride, the levels were sub –optimal. The maximum recorded concentration of fluoride was of that of Nature power with a concentration of 0.44 mg/l and the least seen in Himalayan 0.07 mg/l. The levels of fluoride were not labeled for all tested bottles.
Table I – concentration of fluoride in tap water, ground water (bore water) and packaged drinking water in ten zones of Chennai city.

<table>
<thead>
<tr>
<th>Chennai City Zone</th>
<th>Bore water</th>
<th>pH</th>
<th>Metro water</th>
<th>pH</th>
<th>Packaged drinking water (bubble top)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.60</td>
<td>7.40</td>
<td>0.92</td>
<td>7.20</td>
<td>1.50</td>
<td>6.50</td>
</tr>
<tr>
<td>2</td>
<td>0.41</td>
<td>7.10</td>
<td>0.56</td>
<td>6.50</td>
<td>0.42</td>
<td>7.20</td>
</tr>
<tr>
<td>3</td>
<td>0.51</td>
<td>6.90</td>
<td>0.45</td>
<td>6.40</td>
<td>2.80</td>
<td>6.40</td>
</tr>
<tr>
<td>4</td>
<td>0.35</td>
<td>8.10</td>
<td>0.34</td>
<td>6.80</td>
<td>0.45</td>
<td>6.90</td>
</tr>
<tr>
<td>5</td>
<td>0.43</td>
<td>6.90</td>
<td>0.56</td>
<td>6.40</td>
<td>0.35</td>
<td>7.20</td>
</tr>
<tr>
<td>6</td>
<td>0.35</td>
<td>7.60</td>
<td>0.56</td>
<td>7.20</td>
<td>0.49</td>
<td>7.20</td>
</tr>
<tr>
<td>7</td>
<td>0.42</td>
<td>7.60</td>
<td>0.44</td>
<td>6.60</td>
<td>1.50</td>
<td>6.80</td>
</tr>
<tr>
<td>8</td>
<td>0.49</td>
<td>6.90</td>
<td>0.74</td>
<td>6.40</td>
<td>2.40</td>
<td>7.90</td>
</tr>
<tr>
<td>9</td>
<td>0.39</td>
<td>7.80</td>
<td>0.59</td>
<td>6.80</td>
<td>0.92</td>
<td>7.60</td>
</tr>
<tr>
<td>10</td>
<td>0.83</td>
<td>7.50</td>
<td>0.40</td>
<td>7.10</td>
<td>0.45</td>
<td>6.70</td>
</tr>
</tbody>
</table>

mean 0.14 7.38 0.56 6.74 1.13 7.04
± 0.15 0.42 0.17 0.33 0.89 0.47

Table II – Fluoride content of bottled water available in leading supermarkets in Chennai city

<table>
<thead>
<tr>
<th>Sr. no</th>
<th>Brand</th>
<th>Type of water</th>
<th>Fluoride mg/l</th>
<th>Fluoride content on the label (mg/l)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Premium</td>
<td>Distilled</td>
<td>0.19</td>
<td>NL*</td>
<td>7.1</td>
</tr>
<tr>
<td>2</td>
<td>Kingfisher</td>
<td>Spring</td>
<td>0.00</td>
<td>NL*</td>
<td>6.9</td>
</tr>
<tr>
<td>3</td>
<td>Kingley</td>
<td>Spring</td>
<td>0.00</td>
<td>NL*</td>
<td>6.8</td>
</tr>
<tr>
<td>4</td>
<td>Himalyan</td>
<td>Natural</td>
<td>0.07</td>
<td>NL*</td>
<td>7.2</td>
</tr>
<tr>
<td>5</td>
<td>Bisleri</td>
<td>Natural</td>
<td>0.25</td>
<td>NL*</td>
<td>7.2</td>
</tr>
<tr>
<td>6</td>
<td>Royal challenge</td>
<td>Spring</td>
<td>0.00</td>
<td>NL*</td>
<td>6.5</td>
</tr>
<tr>
<td>7</td>
<td>Aquafina</td>
<td>Spring</td>
<td>0.00</td>
<td>NL*</td>
<td>7.2</td>
</tr>
<tr>
<td>8</td>
<td>Qua</td>
<td>Natural</td>
<td>0.25</td>
<td>NL*</td>
<td>7.4</td>
</tr>
<tr>
<td>9</td>
<td>Nature Power</td>
<td>Natural</td>
<td>0.45</td>
<td>NL*</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.13</td>
<td>NL*</td>
<td>7.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
</tbody>
</table>

Mean ± s.d 0.16 0.28

*NL – not labeled.
Discussion:
Fluorine is an essential element of increasing interest in the prevention of dental caries. Fluoride is a double edged sword; it is both beneficial and deleterious to health. This has been proven time and again by various studies to name a few. Studies done in Vadodara district, Gujarat \( ^7 \) shows that dental fluorosis prevalence increases with subsequent dental caries increase when compared to areas with optimum fluoridation. Studies done by Saxena S et al \(^8 \) on 12-year-old school children of Madhya Pradesh residing in low and high fluoridated areas, shows that increased levels of fluoride had reduced the intelligence level among children. Megalamanegowdru J et al \(^9 \) showed that the severity of periodontal disease is inversely associated with the fluoride concentrations in drinking water This often has been attributed to the drinking water resulting in dental and skeletal fluorosis, which is documented in India by studies done by Majumdar KK \(^10 \), Chouhan S \(^11 \), Dey RK et al \(^12 \), Pandey J \(^13 \) and Sudhir KM \(^14 \).

Various studies have worked to indentify the fluoride endemic areas. Saini P et al \(^15 \) used water, soil, and vegetation samples to indentify fluoride endemic areas in Rajasthan. This is an old method of estimation in recent times Gopalan Viswanathan et al \(^16 \) used Google earth and isopleth technique were used for mapping of fluoride endemic in Tamil Nadu and they found that that Nilakottai block of Dindigul district was highly endemic. Pillai AB et al \(^17 \) devised a new technique to assess fluoride levels in drinking water. Here two novel absorption sensors have been fabricated and their characterization done. The first one is a light emitting diode based sensor and the other one is an evanescent wave fiber optic sensor, this method proved to be economic, reliable, accurate and easy to use sensors for the in situ determination of fluoride in water. Thippswamy HM et al \(^18 \) extended their study by including beverages and fresh juice, it was found to be within permissible limits. Various studies were done on drinking water assessment across the country based on the WHO and BIS norms showed that they differed the norms (Sivasankar V et al \(^19 \), Majumdar KK \(^10 \), Dey RK \(^12 \), Rajesh Kr. Yadav \(^20 \), Hussain I \(^21 \), Borah KK \(^22 \)).

Studies done by various authors in Tamil Nadu also showed violation of norms and subsequent increases fluoride levels (Veeraputhiran.V \(^23 \), Ramesh K \(^24 \), Alagumuthu G \(^25 \), Sendesh Kannan \(^26 \), Karthikeyan G \(^27 \), Subarayan Bothi Gopalakrishnan \(^28 \)) except for study done by Balan et al \(^29 \) and Ismail et al \(^14 \) who found the levels in permissible limits. Sulekh Chandra et al \(^30 \) also assessed Chembrambakkam Lake in Chennai which is the main source of drinking water in Chennai. Such violations are bound to happen if the optimum levels of fluoride are not determined.

According to the American Water Works Association (1971) \(^31 \), the optimum level of fluoridation is dependant on the mean temperature of that area. This level is calculated by the formula:

\[
\text{Ppm fluoride} = \frac{0.34}{E}
\]

Where, \( E = 0.038 + 0.0062 \) multiplied by the mean maximum temperature in ° F. (Where \( E \) is determined by the daily consumption for children up to 10 years of age in terms of ozs of water/pound of body weight). The mean temperature of Chennai as measured by Ismail \(^32 \) is 115°F, as per the formula the optimum fluoride concentration is 0.45 ppm. The results of this study shows that only three of the 39 samples abide by the above recommendations.

The reasons for the increase in the levels of fluoride concentration, in the present study could be due to the increase in the industrial effluents and the increased usage of agricultural pesticides leading to a shift in the geophysical nature of the soil and water. This is supported by studies done by Borah KK \(^22 \), Pandey J \(^13 \), Sivasankar V \(^19 \). The concentration of fluoride in drinking water in the present study is 0 to 2.80 ppm which is consistent with previous studies \(^33-35 \). The levels of fluoride was higher only in the bubble top form of packaged drinking water when compared to the sub – optimal fluoride concentration in ground water, metro water and in bottled water. Toumba (1994) \(^36 \) showed sub-optimal fluoride concentrations in bottled waters. With respect to tap water and ground water sub optimal levels were seen in Tibet \(^37 \), and higher concentration were seen in Mexico \(^38 \), Japan \(^39 \). It has been shown that the fluoride content of water depends on weather changes, hence one reason for such variations across the globe could be seasonal fluctuation. Moreover, Public health significance of this study was that the bottled water samples were not labeled for fluoride concentrations indicating the indifference towards the implications of this element on dental heath.
Dental fluorosis is quiet marked in the state of Tamil Nadu, with endemic areas like Dharmapuri and Salem. As the supply of packaged drinking water in Chennai comes from agencies that supply throughout Tamil Nadu, it is required that the levels of fluoride be monitored time and again. Defluoridation techniques that are cost effective and simple like using aluminum hydroxide coated rice husk ash (Ganvir V), adsorption using low-cost materials like kaolinite, bentonite, charfines, lignite and nirmali seeds (Srimurali M) and tamarind leaf (Vasant RA).

The results of this study have limitation such as the collection of samples was done only from nine locations and the samples were collected only during premonsoon season. The value of these parameters might change significantly between pre and postmonsoon seasons. Further, this study provides only baseline information on groundwater quality in Chennai and hence further studies covering a larger number of samples should be done. With increase in the plethora of the different forms of drinking water, there is an increasing concern over the monitoring of fluoride intake especially in children. Along with the fluoride concentrations coming from the food supplements, the packaged drinking water also add to that leading to increased fluoride consumption greater than the above recommended levels. Hence usage of such packaged drinking waters containing high fluoride concentration is not warranted and should be discontinued.

In the view of the aforementioned differences it is suggested that an interdisciplinary investigation involving medical professionals, environmental biologist, engineers, planning officers, environmental health officers would be able to restore the fluoride concentration in drinking at least to a permissible level. Until then, the localities identified with lower and higher levels of fluoride in water should be educated about the preventive and management procedures through health education programmes.

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