DISCUSSION
In view of the documentary and research evidence of the hypothesis that fluorosis is an endemic public health problem in the districts of Alappuzha and Palakkad, the following inferences are made.

Department of Ground Water of Govt. of Kerala has estimated the fluoride level of water sources from different places of the state. Based on the observations of increased water fluoride level in certain areas of Alappuzha and Palakkad districts, these districts were suggested to be endemic to fluorosis.

4916 school children in the age group of 10-15 years were scientifically selected by cluster random sampling method to constitute the sample population. The researcher collected the data personally from the students and a dental specialist examined the presence of dental fluorosis in them. The fluoride level in drinking water was obtained from the Kerala Water Authority, Ground Water Department and from the Fluorosis Research Centre, T.D. Medical College, and Alappuzha.

Application of Dean’s Index in dental screening- A Rationale.

Dean (1934) developed a fluorosis index for measuring enamel defects which classified individuals into 5 categories, depending on the degree of enamel alteration, and which was based on the identification of the two most severely affected teeth. This index was later modified by Moller (1982). Thylstrup and Fejerskov (1978) developed another index (T-F) based on the biological aspects of dental fluorosis, classifying individuals into 10 categories.
characterizing the macroscopic degree of fluorosis in relation to histological aspects. Horowitz et al. (1984) developed a fluorosis index based on aesthetic aspects of tooth surface (TSIF) classifying individuals into 8 categories.

The T-F index would demand a great deal of time as they require brushing and drying of teeth prior to examination and artificial light for examination. Pereira et al (1999) conducted a comparative study with regard to the capability of the above three indices in determining the dental fluorosis in community studies. They have concluded that “the percentages of affected surfaces by dental fluorosis determined by each index were similar.” And that “the three fluorosis indices had similar prevalences using the same measuring methods for clinical examination.”

So Dean’s index was taken up as the measuring tool for dental examination in the present study. It also had the following advantages.

1. Procedure is simple and dental examination can be done in daylight unlike in other indexes where artificial light is insisted for dental examination.

2. Proved to be capable of outlining the severity of dental fluorosis in populations residing in areas having less than 3 ppm fluoride in the water supply.

3. No dental cleaning and drying are required prior to dental examination.
While using Dean’s index in the present study, the “questionable category” was excluded in the calculation of the prevalence of dental fluorosis. But this category was considered in computing the Community Fluorosis Index.

**Discussion on the basis of findings**

The overall prevalence of dental fluorosis among school going children in the age group of 10-15 years in the study area was estimated to be 22.3%. This prevalence value was estimated from the observations in four selected districts of Kerala viz. Alappuzha, Kollam, Palakkad and Thrissur. The mean fluoride level of drinking water in the fluorosis endemic areas combined was estimated to be 1.167ppm. In an evaluation of 214 studies conducted in the systematic review of water fluoridation in different parts of the world, it was established that at a fluoride level of 1ppm, an estimated 12.5 % (95% confidence interval 7.0% to 21.5%) of exposed people would have fluorosis.

In the present study the prevalence of dental fluorosis among the boys was 24.1% against 19.9% among the girls. In most of the studies all over the world the prevalence was noted to be higher among the boys. Haimanot et al. in their study have assessed the endemic fluorosis in the Ethiopean Rift Valley. In that study, 32% of the children showed severe dental mottling and they have found that males were affected more than the females. The reason for the higher prevalence of dental fluorosis among the males was attributed to the increased level of activity of the males when compared to the females and the resulting greater consumption of water in them than in the females. In
the present study also it was found that the boys consumed more water than
the girls. 40.5% of the boys consumed more than 7 glasses of water per day
whereas only 22.6% of the girls consumed more than 7 glasses of water daily.
Black tea consumption was also found to be more among the boys than
among girls. But this finding of increased prevalence of dental fluorosis
among the boys was not found to consistent in the district wise analysis.

In the present study, no significant variation in the prevalence of dental
fluorosis was observed in different age groups.

The prevalence in the urban and rural areas were observed to be 22.7%
and 20.9% respectively, which shows that there was no significant difference
between the prevalence in urban and rural areas. But an increased
prevalence of 1.8% was observed in the urban area. This increase was
attributed to more extensive coverage of water supply system in the urban
area which depends on water from deep wells. The use of water from shallow
wells were more in rural areas and that the fluoride level in shallow wells were
found to be less when compared to deep wells.

The two main sources of drinking water of the students were the pipe
water supplied by Water Authority and well water. The prevalence was 25.8%
among the students who consumed pipe water and the prevalence was
20.6% among the students who consumed well water. Thus it was seen that
the prevalence of dental fluorosis was more among those students who
consumed pipe water than among those who consumed well water.
Consumption of pipe water was found to be a risk factor in the development of dental fluorosis.

The prevalence of dental fluorosis and two main sources of drinking water were evaluated in the district level. It was observed that the prevalence of dental fluorosis was 48.1% and 43.3% in the districts of Alappuzha and Palakkad respectively where pipe water was consumed. The prevalence of dental fluorosis was 13.4% and 38.5% in Alappuzha and Palakkad respectively where well water was consumed. Thus an increased prevalence of 34.7% and 4.8% in the districts of Alappuzha and Palakkad respectively was observed where pipe water was consumed.

The mean hardness of water was found to be 157.50 in the area where the mean water fluoride was 1.67 and dental fluorosis was present among the students. The mean hardness of water was 118.36 where the mean water fluoride was 0.61 and dental fluorosis found to be absent among the students. Even with fluoride level of less than 1 ppm, prevalence of 10% dental fluorosis was noted in Punjab with high hardness of water \(^{112}\).

It was observed that the drinking water was hard (157.50) in the area where the prevalence of dental fluorosis was seen. The mean water fluoride was also noted to be 1.67 ppm in those areas. The average hardness of water in the district of Palakkad was still higher with 165.85. The average hardness of water in Thrissur was found to be only 77.32 which come under medium
hardness. In Thrissur the prevalence of dental fluorosis was the lowest with 2.2%.

The prevalence was 22.9% among the students who consumed black tea compared to 19.2% among those who did not consume black tea. The p value was 0.26 and hence found to be a risk factor for the development of dental fluorosis. Out of 4913 students, 4158 (80.46%) consumed black tea in the study population. In all the four districts consumption of black tea were found to be very common. But the prevalence of dental fluorosis was found to be high in the district of Alappuzha and Palakkad with an association with black tea drinking. This was because of combined effect of fluoride in water and the fluoride in black tea. In this context it may be mentioned that the gap between the desirable dose and the toxic dose of fluoride in drinking water is narrow and thereby the comparatively high fluoride level in drinking water in the districts of Alappuzha and Palakkad pave way for the development of fluorosis by the consumption of black tea by the subjects.

The Indian style of preparation of tea with milk reduces the harmful effects of tea to a great extend. This is because, the bioavailability of fluoride will be decreased by 60-70% when it is taken with milk as discussed by Ekstrand J and Ehrnebo M$^{135}$ and that the fluoride from tea leaves acts with calcium in the milk to produce calcium fluoride which has an impaired absorption. Many of the families cannot afford to buy milk. This problem will be aggravated in Kerala because of the increased price and scarcity of milk in
our state coupled with the low economic standard of the people, particularly in Alappuzha and Palakkad.

On analysis of the prevalence of dental fluorosis in the selected districts it was observed that the prevalence were 37.4%, 4.4%, 39.2% and 2.2% in the districts of Alappuzha, Kollam, Palakkadu and Thrissur respectively. Prevalence was highest in Palakkad with 39.2%. The lowest prevalence was seen in Thrissur with 2.2%. Dean stated that for public health administrative guidance a community index of dental fluorosis of 0.4 or less is of no concern from the standpoint of mottled enamel; when the index rises above 0.6 it begins to constitute a public health problem warranting increasing consideration. Thus the prevalence of 37.4% and 39.2% dental fluorosis in Alappuzha and Palakkad respectively combined with Community Fluorosis Index of 0.61 and 0.63 suggests that dental fluorosis is a major public health problem in these districts.

In a study conducted in the taluk of Ambalapuzha in the district of Alappuzha in the year 1998 the prevalence of dental fluorosis was found to be 35.6%. Thus the prevalence observed in the district of Alappuzha was near to the prevalence that was seen in the taluk of Ambalapuzha of that district with an increase of 1.8%. The Taluk of Ambalappuzha in Alappuzha district is considered as area with higher prevalence of dental fluorosis compared to the other places in the district. Thus it is observed that higher prevalence of dental fluorosis noted in the district of Alappuzha in an indication that the prevalence
of dental fluorosis is increasing in the area. This finding is in par with the observation that the prevalence of fluorosis is increasing world wide.

The mean fluoride level of drinking water in the area having dental fluorosis in Alappuzha was 1.20 ppm and that in Palakkad was 1.23 ppm. When perceived in to the water fluoride level of both the districts it could be seen that the fluoride level of water was not very high compared to the international accepted standard prescribed by the World Health Organization and the Government of India, which are respectively 1.5 ppm and 1 ppm. The requirement of fluoride in drinking water may vary according to the region where the people live. People in the tropical region consume more water compared to those residing in temperate regions. More over in the evaluation of the prevalence of dental fluorosis in different places in Alappuzha and Palakkad it was observed that the prevalence of dental fluorosis was confined to certain pockets in the community. For example, the prevalence of dental fluorosis among the students of Government Higher Secondary school, Muthalamada in Palakkad was 91.3% and that among the students of Leo XIII Higher Secondary School, Alappuzha was 65.3%. The water fluoride level in those areas was 3.1 ppm and 2.3 ppm respectively. Thus it was observed that the prevalence of dental fluorosis in a state or district is a local public health problem. Therefore in addressing the problem of fluorosis, the evaluation of fluorosis and fluoride level in drinking water of that particular area along with the food habit of the people have to be considered so as to change the source
of drinking water and reduction of fluoride rich food items in the endemic areas in the community.

In the evaluation of dental fluorosis and fluoride content of drinking water in four areas in Henan province in the People’s Republic of China, it was seen that at the mean water fluoride level of 0.76ppm, 1.47ppm, 2.58ppm and 4.51ppm: the prevalence of dental fluorosis was 15%, 41%, 79% and 94%¹³⁶. The rate of prevalence of fluorosis with water fluoride level in this study conforms to the findings of our study. Moreover, it may be inferred that factors other than water fluoride level may contribute to the prevalence of fluorosis.

Since fluoride in drinking water does not change its colour, smell or taste, normally there is no way to detect it unless the water is tested. The victims of fluorosis are often helpless and continue to suffer without their disease being diagnosed and without knowing the hazard of using fluoride contaminated water.

Considering the risk of drinking water in the development of fluorosis, Kerala Water Authority started issuing de-fluoridated water of five litre per person at a time in six pump houses in Alappuzha using Reverse Osmosis method. The fluoride content of this water was separately analyzed and found that the water was good in respect of fluoride content. The average fluoride level of drinking water supplied through the Reverse Osmosis method in Alappuzha was observed to be 0.4535ppm. But the problem is the lack of
awareness of the common people regarding the need of de-fluoridated water as well as the facility available. Thus only a very minority of the population at risk are utilizing this facility, who can afford collecting this water in vehicles and bicycles. Very large majority of the population are left out in this good venture. Hence water de-fluoridation has to be undertaken immediately so as to supply the whole water in the area de-fluoridated using Nalgonda technique or to find out safe water source for distribution. Nalgodada technique is a method of de-fluoridation of water developed in the district of Nalgonda in Andhra Pradesh in India, in which alum and calcium hydroxide are added to water and flocculated to remove sludge of calcium fluoride to derive safe water.

There are two different views among researchers in the controversial issue of fluoridation of water and dental products. Certain authors support water fluoridation and certain others are totally against it. The researchers who support water fluoridation found evidence that fluoridation of water reduces inequalities in dental health by narrowing the dental health gap between young children living in poverty and their more affluent peers. They found no evidence to support claim that water fluoridation caused any harm. They also claimed that women aged 65 years or older who had been continuously exposed to fluoridated water for twenty years had higher bone mineral density at the lumbar spine and hip and hence reduced the risk of hip
and vertebral fractures than women who had not been exposed to fluoridated water\textsuperscript{116}.

There are a section of authors who oppose water fluoridation of any level as fluoride causes damage to teeth, bone and internal organs. In an evaluation of 214 studies it was found that at a water fluoride level of 1ppm an estimated 12.5% exposed people would have fluorosis\textsuperscript{47}. Their studies concluded that children developed dental fluorosis and adult people developed skeletal fluorosis, neurological problems and various other health hazards due to fluoride toxicity in drinking water.

On evaluation of the two different views it may be suggested that a way between these two different opinions seems better as fluoride is a double edged sword. The water fluoride level of a community shall be decided locally on the basis of the prevalence of dental fluorosis and dental caries in that community, but not exceeding 0.4ppm. It is a well accepted fact that poor dental hygiene and nutrition deficiency are the main reasons for the development of dental caries. Thus while evaluating the prevalence of caries this point has to be taken in to consideration.

In the district of Alappuzha, the prevalence of dental fluorosis was 38.9% among those children who used tooth paste for dental cleaning and 30.6% among those who did not use tooth paste. There was significant relation between the prevalence of dental fluorosis and use of tooth paste in Alappuzha. In the other districts there was no significant relation observed
between the prevalence of dental fluorosis and the use of tooth paste. The fluoride content of most of the toothpaste is 1000ppm. The manufacturing and sales of fluoridated tooth paste has originated in the United States of America as a part of the preventive measures taken to control dental caries among children. That was adopted by many developed nations in the world where the natural water fluoride content was less than 0.4ppm. Distribution and use of fluoridated tooth paste in places and countries with more than 1ppm of natural fluoride in water is an added risk factor for the development of fluorosis. India being a fluorosis endemic nation, the distribution of fluoridated tooth paste is an added risk factor for the development of fluorosis. Thus there should be national policy to ban the sales or distribution of fluoridated toothpaste at least in the fluorosis endemic places in India.

Analysis was done to observe the association between dental fluorosis and consumption of milk, fruits, fish, dry fish and tamarind in the present study. Milk is a good source of calcium and fruits are better sources of vitamin C. These nutrients help to reduce the harmful effects of fluoride. But in the present study, no association was observed between the prevalence of dental fluorosis and consumption of milk and fruits by the students. Fish and dry fish are noted for the high content of fluoride. But there also no association was observed between the consumption of fish and prevalence of dental fluorosis. Like wise, study conducted by Khandare AL et al. concluded that tamarind intake appears to have an additional beneficial effect on the mobilization of
deposited fluoride from bone, by enhancing urinary excretion of fluoride.\textsuperscript{115} But it did not mention the beneficial effects of tamarind in controlling dental fluorosis. However no association was observed between the prevalence of dental fluorosis and consumption of Rasam and Sambar, preparations which are seasoned with tamarind that are used with the staple meals in south India.

It was noticed that siblings from same family had different grades of dental fluorosis; sometimes one was with it and sometimes one was without it. Thus on observation of students with dental fluorosis individually it was felt that apart from the causative risk factors identified, certain genetic reasons may also be there, which make individuals susceptible to dental fluorosis. Further studies on this aspect with special focus on biomarker like blood group of individuals and its relation with dental fluorosis have to be carried out.

\textbf{Temperature and Altitude}

Increased temperature and altitude leads to increased prevalence of fluorosis in the respective area. This is because of the consumption of more water by the inhabitants living in hot climate than those residing in temperate climate. In areas of low altitude the presence of surface water sources such as river, lakes, ponds and shallow wells are very common compared to areas of high altitude. The fluoride level of drinking water from surface source will be less than that in water from deep wells in places of high altitude.

The annual average minimum and maximum temperature and altitude of the districts surveyed are depicted in the table. The district of Palakkad is having the highest maximum temperature of 32.4 degree centigrade and altitude of 97 metre. Fluorosis
was found to be the highest in this district of Palakkad with a prevalence of 39.2%. In the district of Alappuzha the prevalence was found to be 37.4% with a lowest altitude of 4 metre with a maximum temperature of 30.9 degree centigrade. In the non endemic neighbouring district of Thrissur with a temperature of 31.1 and altitude of 40 the prevalence of dental fluorosis was found to be only 2.2% and in Kollam with average maximum temperature of 30.5 degree centigrade and altitude of 34 metre the prevalence was found to be 4.4%.

Though the district of Alappuzha is a low lying area with an altitude of 4 metre with plenty of surface water sources, the water supply system depend on deep wells as the source and hence majority of the subjects in that area consume water from the source of deep wells.

**Temperature and Altitude of the Areas Surveyed**

<table>
<thead>
<tr>
<th>Name of the district</th>
<th>Average temperature per year</th>
<th>Altitude (m)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Minimum (°c)</td>
<td>Maximum(°c)</td>
</tr>
<tr>
<td>Alappuzha</td>
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<td>30.9</td>
</tr>
<tr>
<td>Kollam</td>
<td>23.9</td>
<td>30.5</td>
</tr>
<tr>
<td>Palakkad</td>
<td>23.2</td>
<td>32.4</td>
</tr>
<tr>
<td>Thrissur</td>
<td>23.5</td>
<td>31.1</td>
</tr>
</tbody>
</table>

(Source: National data Centre, India Meteorology Department, Pune. 1990-2005)

**LIMITATIONS OF THE PRESENT STUDY**

1. In the selection of sample population, samples were selected from only four districts of Kerala: Alappuzha, Palakkad, Kollam and Thrissur. This was done on the basis of information that water fluoride content in certain parts of the districts of Alappuzha and Palakkad were high and hence suggested that these districts may be endemic to dental fluorosis.
The districts of Kollam and Thrissur were selected being the non-endemic neighbouring districts of Alappuzha and Palakkad respectively.

2. The association of dental fluorosis with the fluoride level of drinking water was calculated with the water fluoride values estimated recently. The children were exposed to the risk of fluoride in the drinking water they consumed about ten years back. Our estimation was done on the presumption that the water fluoride was not changed considerably during this period.

3. Estimation of fluoride level of drinking water consumed by individual student could not be carried out or obtained to evaluate the risk. The water fluoride level of a particular area was considered with the prevalence of dental fluorosis in that area in inferring to its association.

SUGGESTIONS: - Water has to be de-fluoridated to desirable level of fluoride in public water supply system before distribution. Consumption of black tea has to be discouraged in fluorosis endemic areas by proper education. Rainwater contains negligible amount of fluoride. Total intake of fluoride can be reduced by the consumption of rainwater for drinking and cooking during rainy season, which lasts normally for about six months in Kerala. The distribution and sales of fluoridated toothpaste should be controlled in fluorosis endemic districts.

Details regarding water fluoride levels of almost all places in Kerala are available with the Water Authority and Department of Ground Water of Kerala. All places with high fluoride content in ground water need not be fluorosis endemic areas because the people may be depending on surface water with less fluoride content in certain places. Studies have to be undertaken by the integrated effort of Kerala Water Authority and Ground Water Department with the Departments of Medical Education and Health Services of Kerala to determine the prevalence of dental fluorosis at least in such places where the average water fluoride level exceeds 1ppm. This would be beneficial to find out the pockets in the community with dental fluorosis and to take action for controlling the hazards of fluorosis.