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Research Article

Accumulation of Fluoride from Natural Water Sources in *Oreochromis mossambicus* (Peters, 1852)

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Abstract: O. mossambicus (Tilapia) samples from five study sites Ernakulam, Alappuzha town, Mannancherry, Ambalappuzha and Kuttanad were analyzed for the fluoride content. The water from which the fishes were collected was also analyzed for the content of fluoride. Although all water samples showed fluoride concentration below the WHO 1984 maximum permissible limit for drinking water of 1.5ppm, considerable amount of fluoride were found to be accumulated in the fish samples and a positive correlation (0.75) was observed between the fluoride concentration in water and the corresponding fish samples. Water samples from Ambalappuzha had the highest fluoride concentration of 0.4±0.01mg/L. Correspondingly the Tilapia samples from the same water body had the highest fluoride content of 174.3±0.47mg/Kg. The lowest content was found in water and tilapia samples from Alappuzha town, 0.05±0.01mg/L and 18.14±0.95mg/Kg respectively.
Keywords: Fluoride accumulation, Alappuzha, Fluorosis, Tilapia

INTRODUCTION

One of the most common problems for elderly are the defects in skeletal system and a major proportion of them are having skeletal fluorosis which was previously known to be endemic to certain areas due the its peculiar mineral composition in the rock and soil which leads to natural fluoridation of the water sources of the area. Along with skeletal fluorosis the high intake of fluoride can also lead to dental fluorosis in children which in most cases severely damage the teeth. Recent reports shows that fluorosis no longer can be considered endemic since an appreciable level of population is being affected with skeletal fluorosis though incidence of dental fluorosis remains lower. This is mainly because there are anthropogenic sources for fluoride in addition to the natural source.

Small amounts of fluoride are required by the body. It is known to prevent dental caries and promote bone health [1-3]. Since fluoride is known to strengthen teeth and prevent tooth decay, water fluoridation is being carried out in areas where water contains low level of fluoride naturally and is also used in tooth pastes and other oral formula [4]. Fluoride is a micronutrient and its increased input into the body is detrimental to teeth and bones. Increased exposure to fluoride in childhood adversely effects tooth development. High intake of fluoride can cause mottling and discoloration of teeth. Cases are reported in places where improper water fluoridation have caused fluorosis problems. Sodium fluoride, hexafluorosilicic acid and sodium hexafluorosilicate are commonly used fluoride compounds for water fluoridation [5-6]. Alappuzha district is a place known to be endemic for fluorosis and studies in Ambalappuzha taluk of the district shows that incidence of fluorosis is higher among children consuming pipe water which points to reconsideration of water fluoridation [7].

Maximum permissible dose of fluoride according to EPA is 0.000007 mg/kg of body weight per day day. Drinking water supplies generally limit the fluoride content between 0.01 – 0.3 ppm in accordance with the fluoride content in the natural water source of the area [8-9].

When fluoride is administered for osteoporosis showed, high doses of sodium fluoride are known to cause leg pain and irritation in the stomach [10]. Certain fluoride compounds may cause corrosion of piping and water treatment equipments.

Desirable limit of fluoride in well water and tap water is 0.6-1.2mg/L. A study shows that Mullackal of Alappuzha district and Kollengode of Palakkad district contains 1.4 and 1.6 mg/L fluoride in the well water. Tap water from Kalikadu (Thiruvananthapuram), Kollengode (Palakkad) and Kalpetta (Wyanad) had 1.4mg/L of fluoride which is above the desirable limit.

Thathampally, Kuppapuram and Kalikulam junction of Alappuzha district also had above permissible limit fluoride content of 1.6mg/L. Permissible limit of fluoride in surface water is 1.5mg/L. According to WHO 1984 and Indian standard drinking water specification 1991 the maximum permissible limit of fluoride in drinking water is 1.5 ppm and highest desirable limit is 1.0 ppm. Fluoride concentrations above 1.5 ppm in drinking water cause dental fluorosis and much higher concentration cause skeletal fluorosis. Low concentration (approximately 0.5 ppm) provides protection against dental caries. India is among the 23 nations around the globe where health problems occur due to the consumption of fluoride contaminated water and the extent of fluoride contamination in water varies from 1.0 to 400 mg/l [11]. In India, 20 million people are severely affected by fluorosis and 40 million people are exposed to risk of endemic fluorosis [12]. In India fluoride endemic states are Andhra Pradesh, Karnataka, Tamil Nadu, Punjab, Haryana, Maharashtra, Gujarat, Rajasthan, Uttar Pradesh, Kerala, Jammu and Kashmir, and Delhi [11].

Though the drinking water supply system in various fluoride endemic areas have introduced techniques for the reduction of fluoride, many remains affected which is evident from the mottled teeth of children. This confirms that fluoride find its entry into the body through other sources such as various food items, soft drinks etc. Research shows that different kinds of tea other than reputed brands can aggravate the problems of fluorosis. *Camellia sinensis* can accumulate fluorine compounds which are released in infusions. Therefore tea can be considered as a potent source of fluoride [1]. The lethal dose of fluoride for human beings is estimated to be 5-10g. High amounts of fluoride in the body combine with the calcium ions in the blood and form insoluble calcium fluoride. This can result in hypocalcaemia which leads to fatal condition [13].

This work aims at studying the accumulation of fluoride from water into the fresh water edible fish *O.mossambicus* in the natural environment conditions.

MATERIALS AND METHOD

Study site

Five study sites were selected. Four of them - Kuttanad, Mannancherry, Ambalappuzha and Alappuzha town are coming under Alappuzha District which is known to be endemic for fluorosis [7]. Quality of underground water in Alappuzha district was not safe due to high concentration of chloride, fluoride and iron. Fluoride content was above the permissible limit of 1 ppm (mg/1) in almost all wells as reported by Kerala Water Authority (KWA). Because of the high fluoride content, Alappuzha was declared as an endemic area with respect to fluoride [14].

A recent study by a medical team revealed that 35.64 per centof the school children in Ambalapuzha taluk were affected by dental fluorosis and its prevalence was 55.28 per cent in urban area [7]. High incidence of fluorosis is not reported in Ernakulam city. Alappuzha town is a comparatively developed area of Alappuzha district which includes Convent square, Kallupalam, Thathampally, Beach ward, Kommady and Thumpoly. There is high input of chemical as well as oganic fertilizers, insecticides, pesticides into the ecosystem of Kuttanad known as the rice bowl of Kerala [15]. Mannancherry is a village in Alappuzha district situated 10 km away from Alappuzha town.

Sampling

Samples (n=10) were collected from randomly selected fresh water bodies of the study sites and immediately transferred to the laboratory for estimation. Water as well as fish samples were collected from the same fresh water bodies of the study site.

Oreochromis mossambicus (Peters, 1852)

The African mouth brooder cichlid *O.mossambicus* (Peters, 1852) or the Mozambique tilapia is native to the eastward flowing rivers of central and southern Africa. Due to their utility as aquaculture species, it is now widely distributed around the world. They show a number of characteristic features such as tolerance to wide range of ecological conditions, generalist dietary requirements, rapid reproduction with maternal care and ability to successfully compete with native fish through aggressive behavior.

Determination of fluoride

Fluoride content in water samples were estimated using a fluoride ion selective electrode (Frant and Ross, 1966) [16]. A combination fluoride electrode was used to determine the fluoride concentrations in water samples. The samples and fluoride standard solutions were diluted 1:1 with the TISAB. The solutions, which contained 25 mL of the sample and 25 mL of TISAB solutions, were mixed with a magnetic stirrer for 3 min. The electrode potentials of the sample solutions were directly compared with those of fluoride standard solutions. Ion exchange chromatography was used for the fluoride estimations in fish samples and it was carried out in Central Institute of Fisheries Technology, Kochi, India.

RESULTS AND OBSERVATION

Mean fluoride concentration of water samples collected from various study sites are shown in Table 1. Ambalappuzha water samples showed the highest mean fluoride content content of 0.416±0.011and Alappuzha town with fluoride content 0.0506±0.01 showed the lowest (Table 1). Table 2 shows the mean fluoride content (mean±SD) in Tilapia caught from the water source from various study sites for which water fluoride content was analyzed. Fish samples from Alappuzha town with 18.14±0.95 exhibited the lowest

accumulation and Ambalappuzha fish samples exhibited the highest accumulation with fluoride content of 174.345±0.47 (Table 2). The water and fish samples were analyzed in July when there was monsoon season in the selected study sites.

Table 1: Mean (n=10, ±SD) fluoride content in the water samples analyzed

Study Site	Fluoride content (mg/l)
Ernakulam	0.137±0.10
Alappuzha Town	0.0506±0.01
Mannacherry	0.0715±0.12
Ambalappuzha	0.416±0.011
Kuttanad	0.155±0.023

Table 2: Mean (n=10, ±SD) fluoride content in Tilapia samples collected from various study sites

Study Site	Fluoride content (mg/l)
Ernakulam	154.54±0.21
Alappuzha Town	18.14±0.95
Mannacherry	19.73±0.24
Ambalappuzha	174.345±0.47
Kuttanad	22.30±0.46

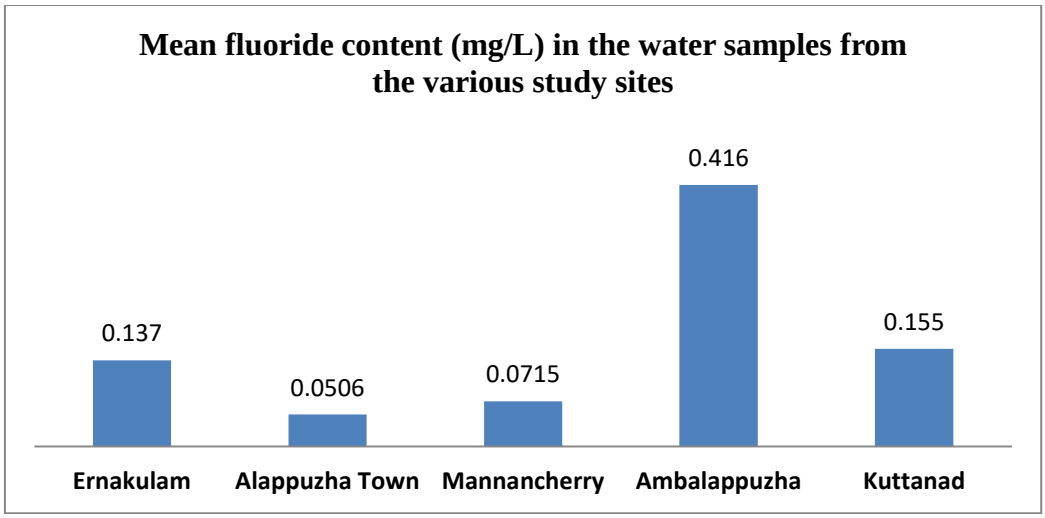

Fig-1: Mean fluoride concentration (n=10) in the water samples analyzed

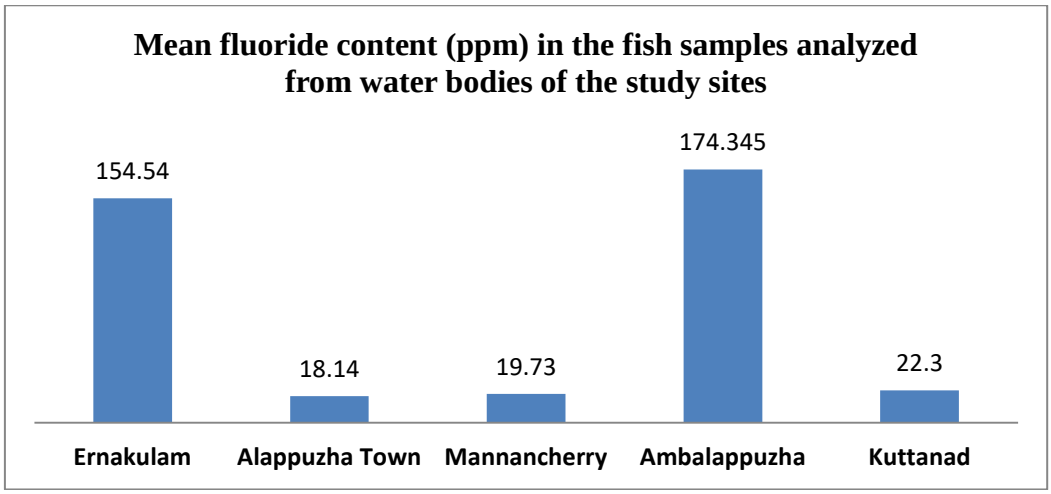

Fig-2: Mean fluoride (n=10) concentration in the fish samples caught from the water bodies of the study site

DISCUSSION

The results revealed that the fluoride content in water and fishes are significantly related with a positive coefficient correlation of 0.75. Tilapia accumulated considerable amount of fluoride though the presence of fluoride in the water is at a very low concentration. Gopalakrishnan *et. al.* [7] reported that fluorosis in Ambalapuzha did not have any significant association between brick tea and fish consumption. But the present study revealed that fish can come under the 'other sources' of fluoride for humans since the accumulation in fish was found to be 174.35mg/Kg for Tilapia from water containing fluoride concentration of 0.416mg/L. Samples from Ernakulam exhibited fluoride concentration closer to that of Ambalapuzha samples, ie. the second highest concentration, but the incidence of fluorosis in Ernakulam area is very low or nil. Water samples from Kuttanad had fluoride concentration closer to that of Ernakulam water samples, but the accumulation into fishes was found to be comparatively low. This may be due to the interaction of the pesticides, fertilizers and other chemicals related with agricultural activities of the area with the fluoride. Water samples from Alappuzha town and Mannancherry showed the least mean fluoride content, 0.05 and 0.07 respectively. Correspondingly the tilapia samples from the above two areas showed the least mean fluoride accumulation, 18.14 and 19.73mg/Kg.

CONCLUSION

Tilapia accumulated considerable amount of fluoride from the surrounding water with fluoride content ranging between 0.05 to 0.4mg/L. The least accumulation is 18.14 mg/Kg and the highest accumulation is 174.35 mg/Kg.

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