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Free fluoride content in tea liquor and identification of efficient low cost defluoridating materials.

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Abstract

Fluoride is considered as a double edged weapon as in correct dosage it strengthens the enamel to prevent dental caries and in excess causes ugly brown stains of the teeth called dental fluorosis. Drinking water with high fluoride content has been the main reason for development of fluorosis, but food items may also contribute in areas with high concentration of fluoride in soil and water. The purpose of this study was to assess the fluoride content in tea liquor and identify low cost efficient defluoridating materials to remove excess fluoride in drinking water.

Fluoride content in tea liquor obtained from eleven brands of low grown tea and six brands of tea available in the market including green tea were determined. The fluoride content was found to increase with increase in brewing time for all types of tea. Market available tea showed higher levels of fluoride in tea liquor compared to low grown tea. Green tea showed the highest level of fluoride in tea liquor (0.19 mg).

Defluoridating ability of clay pots, asbestos, granite and ceramic powder was also examined. With clay pots, optimum fluoride concentration that can be tolerated is around 2.5 mg dm^{-3}. Of the three filtering media namely asbestos, granite and ceramic powder, asbestos showed the highest exchange and breakthrough capacities. Asbestos appears to be the best defluoridating material reported to date.

Key Words : fluoride, tea, clay pots, asbestos, granite, ceramic

1. Introduction

Fluoride is regarded as an essential trace element primarily because it is known to strengthen the enamel and prevent dental caries. Due to long continuous exposure of teeth, however, to high levels of fluoride mainly

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through drinking water during the period of tooth development (i. e during early childhood) give rise to ugly brown stains and disfigurement in the teeth called dental fluorosis. Furthermore, skeletal fluorosis although less common in Sri Lanka, (Padmasiri and Fonseka, 1995) is also linked with high fluoride intake over a considerable period of time. Traditionally, fluorosis has been connected with high intake of fluoride through drinking water.

Drinking water may not be the only fluoride source. Food of plant origin may conceivably accumulate fluoride and thereby contribute to the daily fluoride intake. A cogent example is tea (Weinstein, 1977; Singer et al., 1967). In our maiden attempt to identify fluoride in food, we report the fluoride content in low grown tea and market available brands after different periods of brewing. Dental fluorosis is widepread in certain parts of Sri Lanka mainly in the North Central Province. Hence, to address the problem of high fluoride levels in ground water to public health problems we have examined materials such clay pots, granite, ceramic and asbestos for efficient defluoridation. Preliminary account of this investigation has been presented (Deraniyagala et al., 2000)

2. Materials and Methods

Fluoride levels of samples encountered in this study was measured using an Orion 290 ion activity meter and fluoride ion selective electrode.

Fluoride in tea

The type of low grown tea samples analyzed are given in table 1. They were collected from Rathna tea factory, Galle. Fluoride in brewed tea liquor was determined according to the following method. Four 3.00 g samples of each brand of tea was mixed with 200 cm^3 of deionized boiling water (99°C) and measured the fluoride levels with constant stirring after the lapse of 0.5, 1.0, 2.0 and 5.0 minutes respectively. This procedure was carried out in quadriplicate for each brand and 95% confidence limits are summarized in table I. The results are expressed as milligrams (mg) of fluoride leached from 1.00 g of tea under the aforementioned conditions.

Fluoride removal by clay pots

A recently made clay pot was filled with 1 litre of 2.5 mg dm^{-3} fluoride solution and the fluoride content was measured after 24 hours. The above procedure was repeated with a fresh fluoride solution each time with the same pot until the concentration of fluoride solution has reached 1.5 mg dm^{-3} which is the World Health Organization accepted limit (WHO, 1993). Similar experiments were carried with 5.0 mg dm^{-3} and 7.5 mg dm^{-3} fluoride solution using similar type of clay pots.

Fluoride removal by filter media

The filter media used in this study were ceramic powder, granite powder, and asbestos powder. The exchange capacity of these materials were determined by shaking 10.0 g of each filter media with 100.0 cm^3 of 100.0 mg dm^{-3} fluoride solution for 2 hours. The breakthrough capacity was determined by passing 5.0 mg dm^{-3} fluoridated water through a 2.5 cm diameter columm filled with 100 g of filter media. (flow rate ~3 cm^3 min^{-1})

3. Results

Table 1 shows the amount of fluoride leached from tea leaves in mg g^{-1} with increasing brewing time. Figures 1- 5 show graphical representation of the data given in table I.

Figure 6 shows the fluoride removal from clay pots using fluoride solutions of different strengths. (2.5, 5.0, 7.5 mg dm^{-3})

The total exchange capacity (Vogel, 1997) of ceramic, granite and asbestos were found to be 0.32, 1.02 and 10.63 mg g^{-1}. As evident from figure 7, the breakthrough capacities (Edirisinghe et al., 1990) of granite and asbestos are 1500 cm^3 and 23,000 cm^3 respectively for a 5.0 mg dm^{-3} fluoride solution for a column (diameter 2.5 cm) with 100 g of filter media. Moreover, breakthrough capacity for ceramic powder cannot be assigned because of its poor removal efficiency.

4. Discussion

It is clear from the results in table I and Figures 1- 5 the fluoride level in tea liquor increases with increase in brewing time. Notably, green tea showed the highest level of fluoride leaching among all species analyzed. Market available tea showed higher leaching compared to low grown brands of tea.

Under relatively low fluoride concentration (2.5 mg dm^{-3}), a clay pot could be used for about 10 days to maintain a fluoride level below 1.5 mg dm^{-3}. With increasing fluoride concentration, however, the period which the pot could be used to remove fluoride decreases. This is evident from figure 6 which shows that with 5.0 mg dm^{-3} fluoridated water, a clay pot can be used for 5 to 6 days and for 7.5 mg dm^{-3} level, the period is only one to two days. The clay pots were tested for regeneration by shaking separately with 0.05 M NaOH and 0.1 M NaCl. Preliminary data appears to indicate that 0.1 M NaCl may be a satisfactory choice.

The most interesting filter medium was asbestos because it appears to have the best defluoridating ability. Apart from the disadvantage due to its toxicity when inhaled, to our knowledge asbestos sheet powder appears to be the best defluoridating filter media to be reported to date. (Edirisinghe et al., 1999., Dharmagunawardhana and Dissanayake, 1996). Under the given experimental conditions it should be noted, however, percentage fluoride removal ability of granite (~7.5%) and asbestos (~11%) appears to be similar. It is estimated that approximately 200 litres of 5.0 mg dm^{-3} fluoridated water can be defluoridated using 1 kg of asbestos sheet powder. Practical suitability of asbestos, however, as a safe defluoridating material has to be carefully assessed in view of the known toxic effect of this material.

The liquor prepared using low grown tea in the recommended manner (3 g in 1 cup of boiling water~ 200 cm^3, brewing time 5 minutes) contain 0.08 - 0.11 mg of fluoride depending on the brand of tea. This range is in the same order to that reported using a colorimetric procedure (Karunanayake et al., 1972). A higher range (0.11 - 0.16 mg) is expected from market available tea (M1-M5) based on the data in table I. For fluoride, safe intake is said to be 1.5 to 4.0 mg/day for adults and less for children (NRC, 1989). Thus, a person drinking as high as 10 cups of tea a day will be within the safe range.

5. Conclusions

Fluoride in tea is extracted when infused into hot water. The time of brewing is an important factor in the extraction of fluoride into the tea liquor. Green tea liquor showed the highest level of fluoride. A tea liquor prepared using market available tea in the recommended manner contains 0.5 to 0.8 mg dm^{-3} of fluoride

Clay pots are capable of removing fluoride. The optimum fluoride concentration, however, that can be tolerated efficiently is around 2.5 mg dm^{-3}

Among the three filter media, asbestos sheet powder showed the highest exchange and breakthrough capacities.

6. Acknowledgements

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7. References

1. Deraniyagala, S. P., Chinthaka, S. D. M. and Pathiratne, K. A. S., 2000. *Determination of free fluoride in tea liquor and identification of low cost defluoridating material.* Chemistry in Sri Lanka, **17(2), 37**

2. Dharmagunawardhane, H. A. and Dissanayake, C. B. 1996 Sri Lanka Dental Association, Seminar on Prevention and treatment of dental fluorosis.

3 Edirisinghe, E. A. D. P., De silva, S. S. K. and Hewage, S. 1999. *A new household defluoridator with zeolite as a defluoridating agent.* Sri Lanka Association for the Advancement of Science, **55(1)**, 237

4. Karunayake, E. H, Mahadeva, K., Weerakoon, S. N. and Wickramasinghe, R. L. 1972. *Fluoride in black tea.* Tea Quaternary, 43(3), 111-113

5. National Research Council (1989). Recommended dietary allowances, 10^{th} edition National Academy press, Washington D. C.

6. Singer, L., Armstrong, W. D., and Vatassery, G. T., 1967 Economic Botany, **21**, 285-287.

7. Padmasiri, J. P. and Fonseka, W. S. C. A., 1995. *Natural filter media for fluoride removal.* Chemistry in Sri Lanka, **12(1),** 38

8. Weinstein, L. H., 1977. *Fluoride in plant life.* Journal of occupational Medicine, **19,** 49-78

9. Vogel's Textbook of Quantitative Chemical Analysis (1997), Fifth edition, Pg 197

10. World Health Organization (1993). Revision of the WHO Guidelines for Drinking Water Quality, WHO, Geneva, Zwitzerland.

Table I Fluoride content in tea solutions (mg g^{-1}) after different times of brewing expressed as 95% confidence limits.

Brands of tea	0.5min	1.0 min	2.0 min	5.0 min
Pekoe brand tea				
OP	0.0175±0.0019	0.0202±0.0006	0.0247±0.0008	0.0283±0.0019
OP A	0.0251±0.0008	0.0267±0.0016	0.0327±0.0008	0.0358±0.0016
Pekoe	0.0136±0.0014	0.0184±0.0011	0.0216±0.0021	0.0265±0.0016
Broken brand tea				
BOP	0.0297±0.0016	0.0325±0.0019	0.0343±0.0014	0.0384±0.0013
BOP A	0.0295±0.0003	0.0307±0.0025	0.0360±0.0010	0.0360±0.0014
FBOP 1	0.0150±0.0022	0.0194±0.0016	0.0229±0.0011	0.0269±0.0032
Fannings brand tea				
BOPE	0.0228±0.0022	0.0270±0.0011	0.0278±0.0019	0.0286±0.0013
BOPF sp	0.0202±0.0006	0.0245±0.0025	0.0289±0.0018	0.0282±0.0019
Fannings	0.0202±0.0005	0.0207±0.0018	0.0225±0.0022	0.0292±0.0018
Other brands				
BM	0.0241±0.0016	0.0259±0.0024	0.0265±0.0010	0.0316±0.0019
Dust	0.0173±0.0024	0.0207±0.0010	0.0254±0.0011	0.0251±0.0005
Market available tea				
M1	0.0287±0.0025	0.0322±0.0025	0.0364±0.0045	0.0415±0.0032
M2	0.0325±0.0024	0.0349±0.0018	0.0386±0.0033	0.0450±0.0054
M3	0.0274±0.0018	0.0300±0.0022	0.0331±0.0011	0.0383±0.0021
M4	0.0243±0.0024	0.0273±0.0022	0.0310±0.0025	0.0390±0.0016
M5	0.0355±0.0019	0.0393±0.0024	0.0454±0.0025	0.0524±0.0018
Green tea	0.0411±0.0003	0.0478±0.0008	0.0541±0.0022	0.0645±0.0030

OP = Orange Pekoe, BOP = Broken orange pekoe, FBOP = Fannings broken orange pekoe, BM = Broken mix

• low grown species include pekoe brand, broken brand, fannings brand and other brands

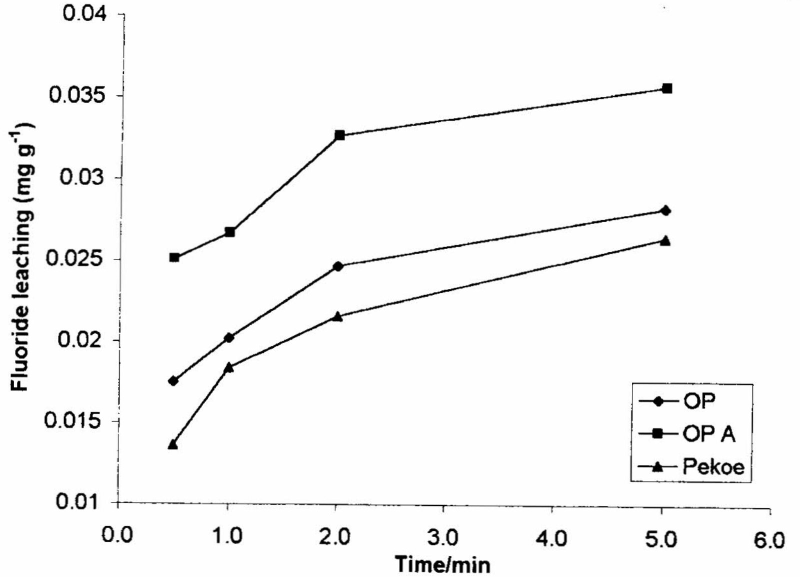

Figure 1: Fluoride leaching from pekoe brand tea

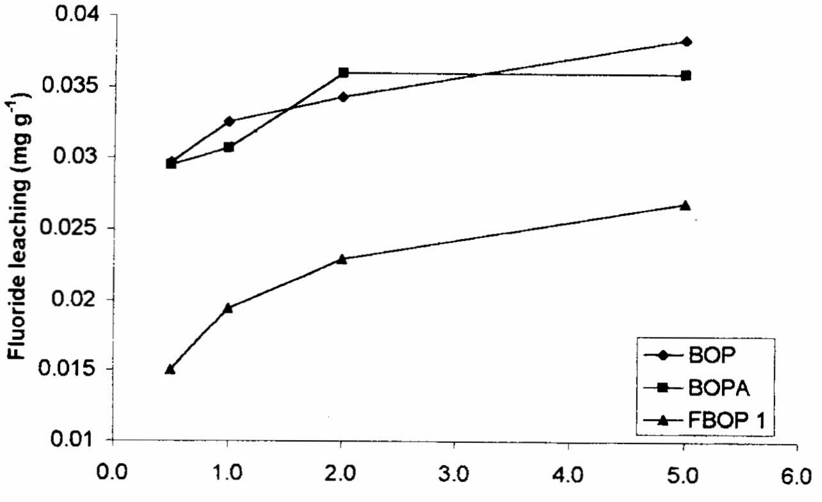

Figure 2: Fluoride leaching from broken brand tea

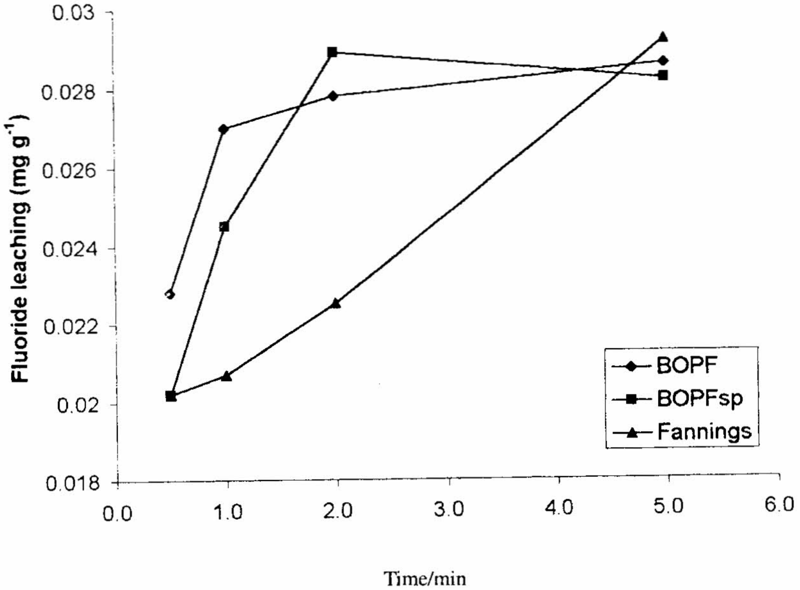

Figure 3: Fluoride leaching from fannings brand tea

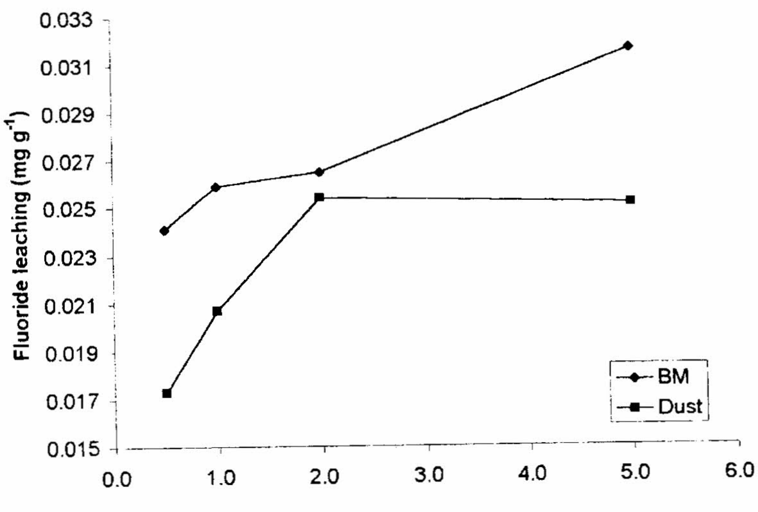

Figure 4: Fluoride leaching from other brands tea

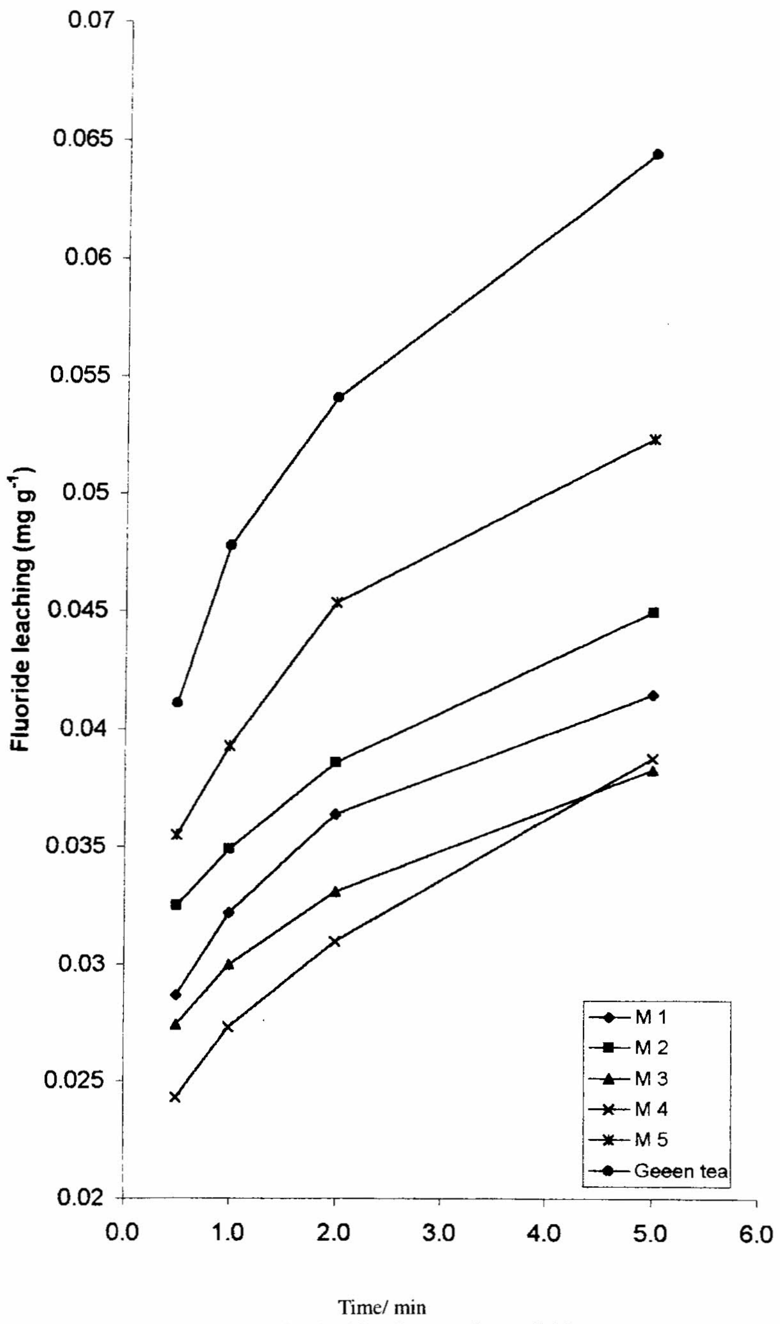

Figure 5: Fluoride leaching from market available tea

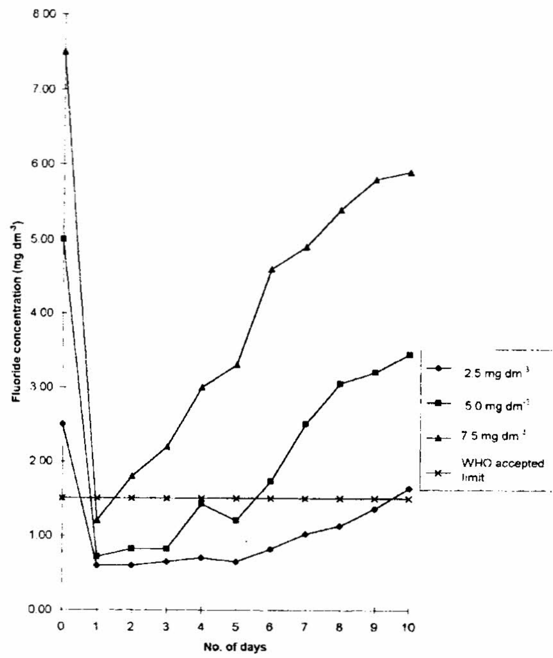

Figure 6: Fluoride removal from clay pots using fluoride solutions of different strengths.

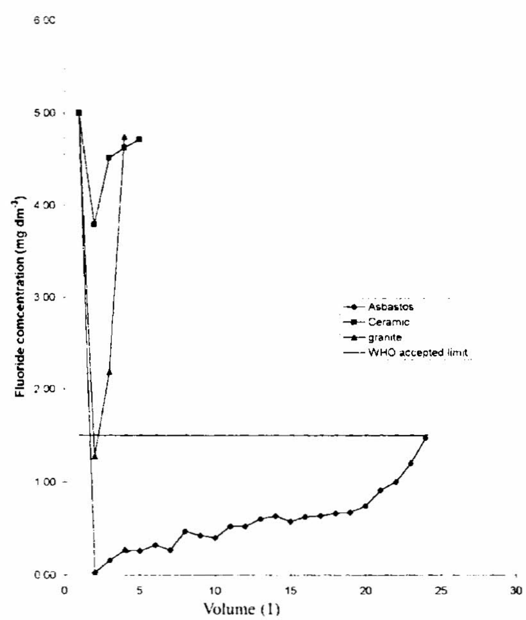

Figure 7 : Fluoride concentration when 1 litre portions of 5.0 mg dm^{-3} fluoride solution is passed through various filter media