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Removal of Excess Fluoride in Drinking Water: A Study in Monaragala District

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ABSTRACT

The water quality surveillance programmes carried out in Monaragala district during 1995 – 2005 show fluoride rich wells in abundance. Nearly 1100 water samples were analyzed in this area. Wells including hand pump wells with fluoride content of more than 2.0 mg/l were found in Madulla (2.1%) Siyabalanduwa (19.8%), Buttala (23.8%), Thanamalvila (34.0%) and Wellawaya (34.5%). In addition, the medical reports reveal that high prevalence of dental fluorosis exists in this area. Out of nine Divisional Secretary divisions, four divisions have fluoride content of wells more than 2.0 mg/l in the range of 20-35%. The most appropriate level of fluoride in drinking water is 1.0 mg/l for humans in Sri Lankan context. The community has to be advised not to drink from these wells thus health hazards can be avoided. The fluoride removal filter using brick chips were introduced in collaboration with health authorities, on pilot basis to reduce fluoride content of 2.5 mg/l to 0.5 mg/l. This methodology of value addition to the water sources has to be continued and the approaches have to be upgraded to eradicate dental fluorosis.

INTRODUCTION

In recent surveys carried out with respect to water quality in Sri Lanka many water sources specially groundwater does have excess fluoride in drinking water (Ratnayake, 1996) . In Sri Lanka out of the 22 districts, seven districts have the fluoride problem in endemic proportions as shown in Figure 01. In these studies, it is clearly revealed that more than 50% of drinking water wells have fluoride level exceeding 1.0 mg/l in these fluoride rich districts. The consumption of water exceeding permissible levels of fluoride 1.0 mg/l is a major cause of dental fluorosis. The fluoride content of 4.0 – 8.0 mg/l has been reported in several places such as Kithulhitiyawa and Andarawewa in Anuradhapura district, Wellawaya and Thanamalvila in Moneragala district, Polpithigama and Galgamuwa in Kurunegalla district, Athumlapitiya in Polonnaruwa district. Several cases of skeletal fluorosis patients have been reported from these areas as per medical evidence. The age group vulnerable for skeletal fluorosis is 'more than 40 years' according to medical records.

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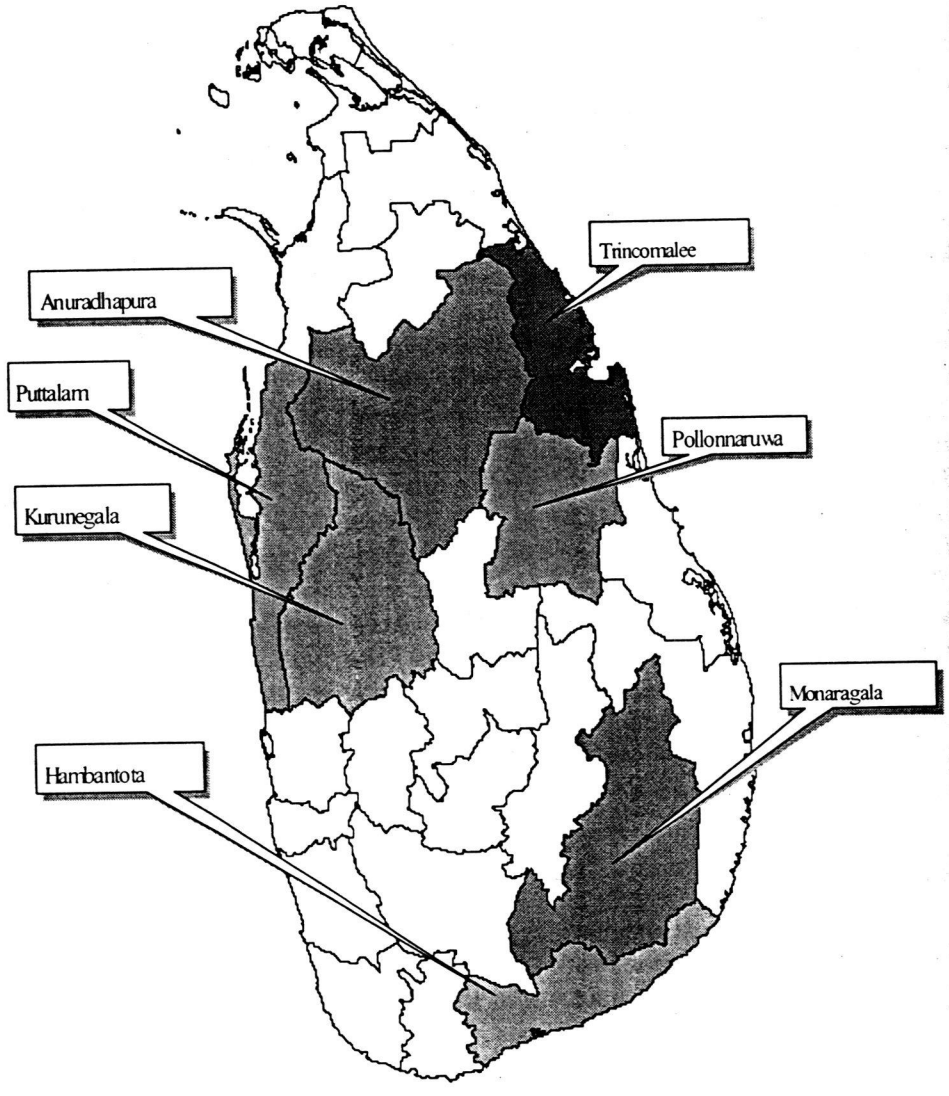


Figure 01: Districts of Sri Lanka where fluoride is in endemic proportions

A dental survey conducted in 1986 (Abeyratne, 1986) reveled that in five communities in Embilipitiya, the Community Fluorosis Index (CFI) ranged from 1.30 in Katalgara to 2.35 in Galvanguwa. Other communities in Anuradhapura where the CFI has been determined were Hedogama (1.89), Galkulama (2.29) and Thalawa (1.85). Chandanapokuna in Polonnaruwa had a CFI of 2.17. The CFI value of more than 0.8 is found to be a major health problem to be concerned in these areas. Table 01 gives the dental fluorosis data collected in schools in 1996.

Table 01: Data Collected by Dental Fluorosis Surveys

Location	Number examined	Number of dental fluorosis cases	Percentage affected
Sooriyawewa	2,158	546	25.3
Kiri-Ibbanwela	4,387	1,068	24.3
Mahaweli B, C, H & L	49,280	12,320	25.0

The study done by Wim Van Der Hock *et.al.* (2003) in the Walawe river basin in Southern Sri Lanka shows high prevalence of dental fluorosis. Table 02 shows the data collected in the survey carried out at six schools in Udawalawe, among 14 year old children. A total of 518, 14 year old children were present at the six schools. Overall prevalence of dental fluorosis was 43.2%.

Table 02: Prevalence of dental fluorosis

	Gender			Percentage prevalence of dental fluorosis
School	Female	Male	Total	
1	80	78	158	38.6
2	22	19	41	51.2
3	50	49	99	54.5
4	35	34	69	36.2
5	50	44	94	35.1
6	30	27	57	52.6
Total	267	251	518	43.2

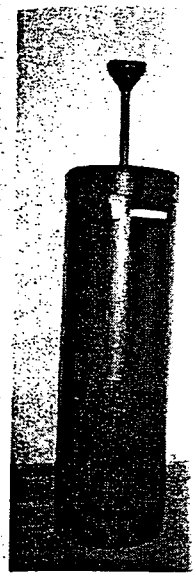
In order to prevent dental fluorosis of this nature, a domestic defluoridator has been developed locally to reduce fluoride (Pathmasiri, 1997; Pathmasiri, 1998; Pathmasiri and Dissanayake, 1995 contents of 1.0-3.5 mg/l to acceptable levels of less than 0.5 mg/l in drinking water (. This is a value addition to the water sources in respective areas in Sri Lanka. This was introduced to the communities in 1994 by National Water Supply and Drainage Board including Moneragala district. The defluoridation programmes conducted in these areas showed encouraging results thus reducing the dental fluorosis among the young generations. Presently, domestic defluoridator is made out of polyethylene material and available in the market for a price of Rs. 2500. In this defluoridation programmes, the fluoride rich wells were identified initially n the villages. Thereafter, the families with children of age group less than four years using these fluoride rich wells were selected with the help of health workers and non governmental organizations. The domestic defluoridators were distributed to these communities while carrying out awareness programme on operations and maintenance of these units. It is expected to prevent dental fluorosis in these areas by this delfuoridation programmes.

Materials and Methods

In these studies the water sample were collected in cleaned plastic bottles from students in rural schools and then subjected to conductivity and fluoride tests in situ. Then awareness programmes were carried out in schools thus identifying good wells (less than 1.0 mg/l fluoride) and bad wells (more than 1.0 mg/l Fluoride) so that those who live close by can choose the good wells in the vicinity for drinking and cooking purposes. The wells considered for these studies were shallow, deep and borehole wells. These samples were analyzed for fluoride levels by colourimetric method (SPANDS reagent) using fluoride pocket colourimeter.

The same procedure was followed for the defluoridated water samples from filter units in these areas.

The presently manufactured domestic defluoridator is shown in Figure 02 and the cross section of the filter units is shown in Figure 03. At the start, broken brick chips of sizes 15 -20 mm of reddish coloured bricks are packed in to the filter. Fluoride rich water is poured through the funnel attached to 20 mm diameter PVC pipe which runs to the bottom of the filter. Thus the fluoride rich water enters the unit through the bottom compartment and moves upwards as the water is released form the tap at the top. This unit has capacity of 15 liters and this quantity of filtered water could be used by a household for drinking and cooking purposes. The cost of the filter unit is Rs. 2500/-. The efficiency of the unit can be tested by analyzing the well water that was fed and the defluoridated water that was collected from the outlet pipe at various time intervals.



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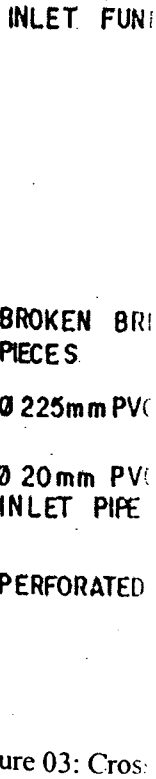

Figure 03: Cros

RESULTS AND DISCUSSION

Table 03 shows the results of the fluoride surveys for the wells in three districts of Sri Lanka carried out in 1998 – 2003. It clearly shows the Moneragala district has 25.8% of the wells of fluoride content of more than 2.0 mg/l. Only 40% of the wells of fluoride content less than 1.0 mg/l are suitable for drinking. The fluoride content of the wells more than 1.0 mg/l need not be abandoned and water from these wells can be used by filtering through the defluoridator. By doing so, the wells with fluoride rich water become usable and nearly 95% of the wells become usable by this approach.

Table 03: Fluoride content of wells in three districts 1998/2003

District	Number of wells	% of wells with indicated fluoride levels in mg/l		
		<1.0	1.0 – 2.0	>2.0
Anuradhapura	5571	43.3	37.3	19.4
Polonnaruwa	1154	38.0	44.6	17.4
Moneragala	1325	40.7	33.5	25.8

Table 04 shows the fluoride content of wells in Moneragala district. In some of these DS divisions the samples were anlaysed from hand pump wells only. In Buttla, Thanamalvila and Wellawaya divisions, the samples were analysed from all the wells including hand pump wells. More than 90% of wells in Medagama, Bibila and Badalkumbura contained desirable amount of fluoride i.e. less than 1.0 mg/l. In addition, in Wellawaya, Thanamalvila and Buttala 34.9, 34.0 and 23.8 percent of the wells were found to contain fluoride content of more than 2.0 mg/l, respectively. More than 50 percent of these wells in five divisional secretary divisions contain fluoride levels higher than desirable level of 1.0 mg/l.

Table 04: Fluoride content of wells in Moneragala district 1998/2003

District	Number of wells	% of wells with indicated fluoride levels in mg/l		
		<1.0	1.0 – 2.0	>2.0
Medagama *	25	96.0	4.0	-
Bibile *	37	94.6	5.4	-
Badulkumbura *	35	94.3	5.7	-
Madulla *	47	76.6	21.3	2.1
Moneragala *	59	76.3	22.0	1.7
Siyambalanduwa*	86	40.7	39.5	19.8
Buttala	252	36.9	39.3	23.8
Kataragama*	38	34.2	47.4	18.4
Thanamalvila	580	32.7	33.3	34.0
Wellawaya	166	21.7	43.4	34.9

* - In these divisional Secretary divisions the samples were analyzed from hand pump wells only.

Nearly 400 domestic defluoridator units were distributed in Hambegamuwa, Thanamalvila and Balaharuwa in 1994 – 2003. Subsequently, another set of 100 filters were distributed from World Bank Funds by the Provincial Director of Health Services in 2005. Initially, fluoride levels of water samples were measured and the results were discussed with the community. The households are divided into three categories according to fluoride content of their wells. The households using water with fluoride less than 1.0 mg/l were advised to continue using their wells for drinking purposes. When the fluoride content of the wells was found to be more than 4.0 mg/l the households were notified not to use their wells. They were advised to find alternative sources for drinking and cooking purposes. Then the households using wells with fluoride content of 1-4 mg/l and who have children of age group less than 4 years were provided with domestic defluoridators.

Case studies of three selected filters are discussed below to highlight the sustainability of these units. Figure 04 gives the performance of the defluoridators Nos 52, 54 & 79. The break points in the thin line denote the replacement of the filter medium. The samples were obtained periodically and this was a study lasted 1000 days. Filter No 54 has performed very successfully in all four cycles. Filter no 52 had a bad cycle to start with, the fluoride removal was very poor due to high consumption rate. As this was a novel item in the household, they started drawing out water more frequently without giving much concern for the optimum quantity to be withdrawn. The optimum withdrawal should be about 15 liters per day, whereas nearly 20 liters per day were removed during the first cycle. After further guidance, the filter unit was used correctly, resulting in efficient removal of fluoride subsequently. In filter no 79 the performance was poor during the first cycle due to use of large brick chips, instead of the recommended size of 10-15 mm. This was corrected during the second cycle but was repeated in the third and fourth cylces, showing lack of commitment. In this unit the consumption, too was above optimum level. The operation and maintenance of the unit has to be imported to get the best benefits to the community. On a recent visit to Athumalpitiya in Polonnaruwa district it was observed that a beneficiary is using the filter unit for last 12 years and presently gives the filtered water to her grand children. In another case at Kahatagasdigiliya, the beneficiary is using the filter for last 5 years and now has a child of 08 months.

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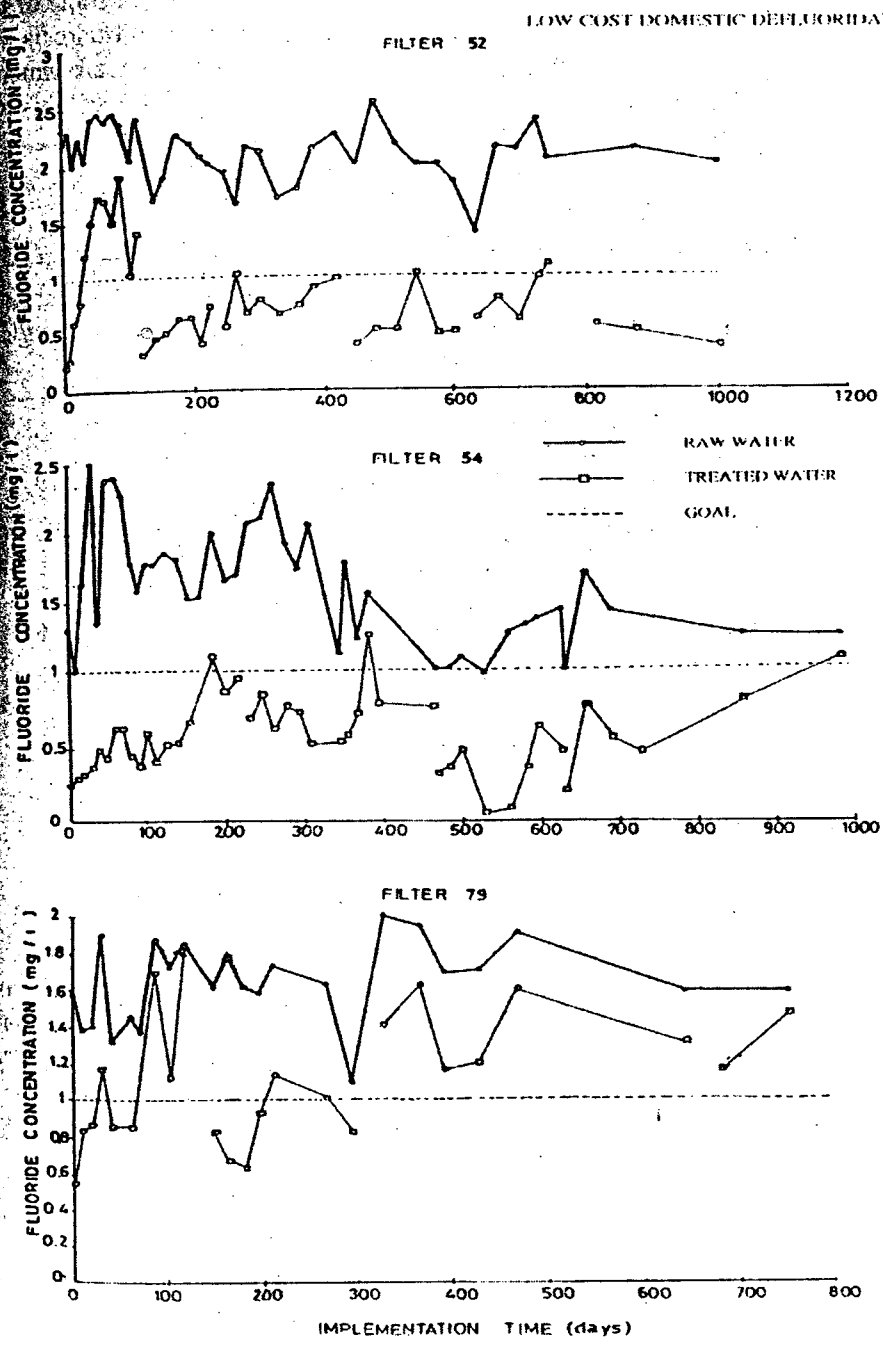

Figure 04: Performance of Filters

Presently, community based organization (CBOs) are in operation to run water supply schemes in rural villages. These are catering to 100-150 household units in a village thus giving the luxury of providing tap water at the village level.

However, the fluoride content of the water is more than 1.0 mg/l in some of these schemes as shown in Table 05. This type of water leads to dental fluorosis in the young children in these areas thus defeating the goal of supplying safe water. In addition, high hardness content in water allows the community to reject this water on their own.

Table 05: Water quality of Community (Prajamoola) WSS

Date	Prajamoola WSS	District	Conduct _ivity µs/cm	Fluorid e mg/l
16.01.2010	Suwasetha, Padavi Ruwanpura	A'pura	620	1.10
24.04.2010	Padavi Parakramapura	A'pura	680	1.19
07.05.2010	Bandaranaikepura, Vanathavilla	Puttalam	1730	0.80
28.05.2010	Udara Prajamoola, Vanathavilla	Puttalam	1295	0.16
10.05.2010	Nirmal Diyadahara, Pannawa	K'gala	660	0.16
10.05.2010	Nirmal Diyadahara, Pannawa	A'pura	2300	0.39
15.05.2010	Murungahitikanda, Kekirawa	A'pura	680	2.15
10.06.2008	Medawachchiya	A'pura	780	1.85
24.03.2010	Asokamalagama, Villachchiya	A'pura	790	5.25

CONCLUSIONS

Several districts in Sri Lanka are affected by high fluoride content in water which brings health issues such as dental and skeletal fluorosis. Some of the community water supply systems also provide water with high fluoride content and hardness.

The simple and low cost defluoridator unit discussed in this paper is a low cost simple to use solution to reduce fluoride in water less than mg/ l.

However, it is essential to maintain these filter units by maintaining an optimal withdrawal of water and using suitable size brick chips.

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ura	780	1.85
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