BONE CHAR BASED BUCKET DEFLUORIDATOR IN TANZANIAN HOUSEHOLDS

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SUMMARY: A household defluoridator, made of a 20 L plastic bucket and 10 kg of bone char, is tested and found efficient to remove fluoride at a capacity of 1.1 mg/g. On an average, the defluoridator reduced the original contents of 8.5 mgF/L to 0.37 mgF/L, i.e. 95.6 %, for a period of 2 months, where 32.5 L were treated every day. The defluoridator could be manufactured locally in Ngurdoto village, Arusha Region Tanzania for a price of about 10 US $ per unit. The defluoridator is monitored as operated in 10 households. The defluoridator reduced the fluoride concentration from 10.5 mg/L to less than 1 mg/L for periods between 4 and 13 months. The users expressed their acceptability of the defluoridator and its performance.

Key words: Drinking water treatment; Fluoride; Defluoridation; Bone char; Field test, Household treatment.

INTRODUCTION

The use of bone char for defluoridation of drinking water at household level is known as a promising method for provision of safe water in fluorotic areas in developing countries.[1] It is also known that the non-availability and the non-acceptability of local production of bone char are main problems in implementation the process.[2]

Recently a charcoal packed kiln was developed at the Ngurdoto Defluoridation Research Station, Arusha Region, Tanzania, to produce bone char at low cost and with a minimum aesthetic problems.[3] As a follow up a simple bucket defluoridator, containing the locally produced bone char, was made available for sale in the Station. The objective of this paper is to describe the experiences gained from monitoring 10 of the sold defluoridators as operated by the different households.

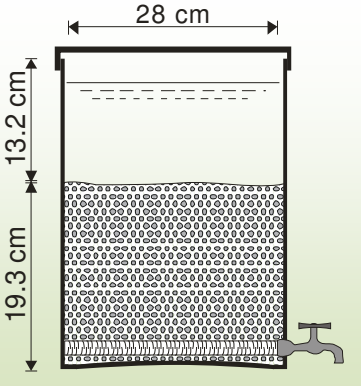

FIGURE 1. The Ngurdoto Station bucket defluoridator.

METHODS

Bucket defluoridator. The bucket defluoridator consists of a 20 litres cylinder plastic bucket as normally available in the market and used in households. A tap is placed 3-4 cm over the bottom. A perforated piece of PEL pipe is placed as a drain. Ten kg of bone char, grain size 1 to 4 mm is directly in the bucket. Hereafter raw water is added by the users until the bucket is full. Treated water is directly tapped for drinking and cooking in the household. The users are instructed to keep the bone char submerged, Figure 1.

Lab testing. The bucket defluoridator was tested at the Ngurdoto Defluoridation Research Station prior to its launching to households.

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The unit was loaded with water containing 8.5 mg/L. The water was added in small portions, 3-5 L each time, about 8 times per day, i.e. about 32 L per day. The water collected in one day was mixed and tested for fluoride contents, pH, colour and taste and smell. The filter was in use for 2 months.

Distribution to households. The bucket defluoridator was normally prepared and sold by a trained villager for a price of 6000 Tz.Sh. (10 US$), including the 10 kg of bone char. For the field testing however, 10 defluoridators were sold to different families in the Ngurdoto village at ½ price for, in return, to allow for monitoring its performance. Initially a meeting was held with the families in order to explain the idea of field-testing.

1. How often do you use the filter?
   - ☐ Never
   - ☐ Some times
   - ☐ When it is not raining
   - ☐ Always
2. Do you have any problem with the filter?
   - ☐ Yes: Mention Which
   - ☐ No problems
3. Do you have any problem with the taste of the water?
   - ☐ Yes
   - ☐ No

TABLE 1. The questionnaire used in the study.

Field testing. The selected households were visited 8 times during a period of 13 months, from September 1996 to October 1997. All visits were made without prior notice. During the visits the raw and treated water were checked for fluoride contents and the condition of the defluoridator was recorded.

Furthermore, the household was interviewed as given in Table 1.

Fluoride measurement. The fluoride concentration was measured using a fluoride selective electrode (Metrohm 6.0502.150) and an Ag/AgCl reference electrode (Metrohm 6.0726.100) connected to a Metrohm 704 pH-meter. 5 mL of sample were mixed with 5 mL of TISAB and compared with standards.

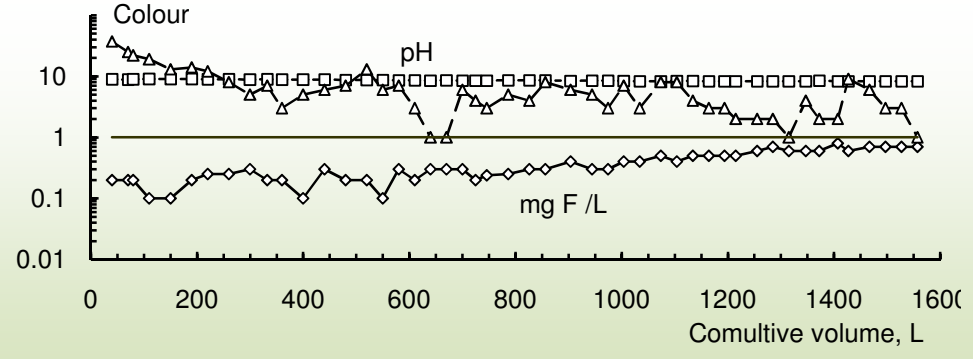

FIGURE 2. Performance data of the bucket defluoridator. Raw water contained 8.5 mgF/L.

RESULTS

Lab testing. Figure 2 shows the results from the controlled monitoring of the prototype defluoridator. On an average the defluoridator could reduce the original content of 8.5 mgF/L in the raw water to 0.37 mgF/L in the treated water, i.e. 95.6 % r

TABLE 1. Monitoring of the fluoride concentration in the raw and outlet water from the10 household defluoridators.

Unit no.	Users no.	Residual conc. in mgF/L at day no.: 122	154	182	212	243	279	318	408
1	8	0.4	0.3	0.4	0.5	0.2	1.2	0.6	1.4
2	10	0.2	0.1	0.1	0.1	0.2	1.2	1.5	2.7
3	7	1.0	2.1	1.1	2.2	4.7	7.0	- [d]	- [d]
4	9	0.3	0.4	0.5	0.7	0.4	5.0	2.0	1.1
5	9	- [b]	0.1	0.2	0.5	0.2	1.8	0.9	0.7
6	10	0.2	0.2	0.1	0.1	- [d]	0.6	0.8	2.0 [c]
7	10	0.3	0.1	0.1	0.1	0.1	0.6	0.3 [c]	0.4 [c]
8	4	0.7	1.0	2.1	1.5	1.7	2.2	2.7 [c]	- [c]
9	5	0.9	0.8	- [d]	- [d]	1.0	1.3	1.1 [c]	2.0 [c]
10	3	0.2	0.1	0.1 [c]	0.1 [c]	0.8	- d	1.5	1.8
Average conc.:		0.47	0.52	0.52	0.64	0.93	2.32	1.27	1.51
Raw water conc.:		9.4	9.9	10.4	11.8	11.2	10.5	10.2	9.3
Aver. Remov. %:		95.0	94.7	95.0	94.6	91.7	77.9	87.5	83.8

[a] Defluoridator was said to be in use always, apart from [b], [c] and [d].
[b] In use only some times. [C] Using seasonal rain water. [d] Defluoridator was not in use.

removal efficiency. After 59 days of operation, where 32.5 L were treated every day, the residual concentration was still ≤ 0.7 mgF/L. The sorption capacity under these conditions was measured to be 1.1 mgF/g bone char. The treated water had pH between 9.0 and 8.3, on an average 8.56. During the 5 days of operation the treated water had a minor discoloration. Apart from the first operation day, the water was fully palatable.

TABLE 2. Answers to the question: How often do you use the household defluoridator?

Defluoridator in use ?	Not in use	Sometime	Not in rain season	Always	Total
No. Of visit	5	1	9	65	80
%	6	1	11	81	100

Efficiency in field. As the households were all feeding their defluoridators from the same piped water supply, the fluoride concentration in the raw water was the same in all defluoridators each monitering day. The concentration varied from one monitoring day to another as shown in Table 1. The table shows the efficiency of the removal during the monitoring period of 408 days. On an average the fluoride concentration was reduced from 10.3 to 1 mg/L, i.e. 90 %.

TABLE 3. Content of water in the defluoridator during inspection.

Water content	Empty	¼ full	½ full	¾ full	Full	Total
No. Of inspections	2	8	20	26	16	80
% of inspections	2.5	10	25	32.5	20	100

Acceptability and use pattern. During the 408 days monitoring period, the households were inspected in total 80 times. Table 2 shows that the household answered that the units were not in use only 5 times. Table 3 shows how much water was found in the defluoridators at the time of inspection. The only complaints expressed was that the discharge from the tape was too slow.

DISCUSSION

In spite of the fact that the bone char was prepared locally, the quality of the treated water was in general good and acceptable to the users. The villagers had no difficulties in operating the filter and in keeping the filter bed submerged.

From the lab testing, where the loading was similar to that of the household, it was estimated that the removal capacity is expected to be high, resulting in less than 0.7 mg F/L, until a removal capacity of at least 1.1 mg/g is reached.

The household testing did not allow for precise calculation of the filter capacity. On an average the 10 units reduced raw water fluoride of 10.3 mg/L to less than 1.5 mg/L for period a period of 13 months. However there was a wide variation in their operation period, before saturation. If a treated water concentration of 1 mg/L is adopted as a point of saturation, the effective operation periods varied between 4 months and more than 13 months. The saturation point was reached after 4 months (1 unit), 5 months (1 unit), 8 months (1 unit), 9 months (1 unit), 11 months (2 units), 13 months (2 units). Probably this reflects the different loading and defluoridated water consumption patterns in the different household.

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