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A Study of The Effect of Home Water Filtration Systems On Fluoride Content of Drinking Water in Johor

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ABSTRACT

Introduction. With the general population concerned with polluted water, tendencies toward purchasing bottled water and water filtration systems are at a high. This poses a challenge to the water fluoridation programme as questions are being raised as to whether fluoride content in public water supplies is affected by these filters.
Objectives. To compare fluoride content of drinking water before and after passing through various water filtration devices, and also to compare fluoride content differences between various water filtration devices.
Methodology. A total of 49 water filters were included in this study. Fluoride levels were analyzed using the Hach's colorimeter. Statistical analysis was done using SPSS software. All procedures were computed to within the 95% confidence level.
Results. Of the 49 filters, 29 were carbon activated (CA), 11 reverse osmosis (RO) and 9 using other technologies. Fluoride levels before and after filtration through CA systems were not significantly different ($p>0.05$); while those through RO and other systems were significantly different ($p<0.05$). Fluoride levels between different filtration systems were found to be significantly different ($p<0.05$), with CA systems being significantly higher than RO and others.
Conclusions. The use of carbon activated water filtration systems has no effect on fluoride levels in drinking water. Water filtration systems using Reverse Osmosis and other technologies significantly lower fluoride levels of drinking water. Optimally fluoridated drinking water when subjected to home water filtration systems that reduce fluoride significantly may not offer the same caries preventive effect.

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INTRODUCTION

Water fluoridation remains the most cost-effective, equitable and safe means to provide protection from dental caries in a community. However, according to the U.S. Environmental Protection Agency (EPA), approximately one in eight Americans is exposed to potentially harmful microbes, pesticides, lead, or radioactive radon whenever they drink a glass of tap water or take a shower.[1] With the general population concerned with polluted water, tendencies toward purchasing bottled water and filtration systems is at a high.[2] This poses a challenge to the maintenance and expansion of our water fluoridation programme, as questions are being raised as to whether fluoride content in public water supplies is affected by these filters.

LITERATURE REVIEW

Types of domestic water filtration systems

Domestic water treatment systems include water conditioners and softeners and water filters. These systems fall into two basic categories: point of entry (POE) and point-of-use (POU). Point-of-entry water treatment systems treat all of the water entering and being used in the home. Point-of-use water

treatment systems, on the other hand, treat part of the water in the home water distribution system, usually at one faucet. The water is typically only used for drinking and cooking. Reverse osmosis, distillation and activated carbon filtration are examples of POU water treatment systems.

Carbon Filtration Systems is a pour-through carafe which most often resembles a water pitcher or large jug and use activated charcoal (CA) as the filtering medium. Gravity pulls the water through the activated carbon filter, removing chlorine, lead and mercury, as well as pesticides.[3,4] Reverse Osmosis (RO) Systems uses pressure to force water molecules first, through a microscopic membrane or screen, and then through a cellophane membrane that screens out even smaller pollutants from the water. They greatly improve the taste of water by removing infiltrates, lead and some pesticides, and natural minerals.[5]

Distillation is a process that removes contaminants from water. It heats up the water to boiling point, traps the rising steam, and uses a fan or other cooling device to condense the vapour back to its original form, minus everything else.[6]

Water softeners use a cation-exchange resin, regenerated with sodium chloride or potassium chloride, to reduce the amount of hardness (calcium, magnesium) in the water. The hardness ions in the water are replaced with sodium or potassium ions. Ionexchange water softeners simultaneously remove radium and barium while removing water hardness.[4,6] While being effective in eliminating metals, they can raise, however, the level of sodium in the water.

Popularity and reasons for using domestic water filtration systems

The sale of home water treatment units is expanding. The January 1999 National Consumer Water Quality Survey indicates that 38% of adults reported using a household water treatment device, a 28% increase since 1995. Forty-seven percent of respondents stated they would be more likely to buy a house with a water treatment device if they were in the market for a new home.[7]

A study in Pahang found that almost 50% of households surveyed had one or more forms of household water filters in place and another 44% which had not, planned to to do so.[8] The purpose of installing these filtration devices were solely for health reasons and for better water quality.

Effect of home water filtration systems on fluoride content

The ability of the different water filtration systems to remove fluoride from tap water has been studied. There is strong evidence that systems such as those based on RO and distillation removed a substantial amount of fluoride[2,3,9] but tests of those based on activated carbon have given contradictory results. Some reports have demonstrated a reduction in fluoride levels with use of carbon filters,[2,3,8,9] while another study found no reduction.12-15 It has been suggested that the design of the carbon filter may be a factor affecting fluoride removal.2 Therefore, each carbon filter should be assessed individually.

Removal of fluoride from water is a difficult water treatment action.[13] Most POU treatment systems for homes that are installed for use by single faucets use activated carbon filtration, which will not remove the fluoride ion. The ability of other treatment systems such as reverse osmosis, ion exchange, or distillation systems to reduce fluoride levels vary in their effectiveness to reduce fluoride. A study by Robinson et al[12], in which water was passed through softeners and a conditioner, tested for fluoride concentration using a specific ion metering device. It revealed no alteration in levels when compared with controls. Similar experiments of filtered water demonstrated highly significant amounts of fluoride ion were removed. In one filter tested, 90% of the fluoride content was lost in the filtration process.

The study by Prabhakar et al[15] showed that the systems based on reverse osmosis, viz, reverse osmosis system and Reviva (R) showed maximum reduction in fluoride levels, the former proving to be more effective than the latter; followed by distillation and the activated carbon system, with the least reduction being brought about by candle filter. The amount of fluoride removed by the purification system varied between the system and from one source of water to the other.

The efficiency of removal of lead (Pb) and other elements from natural drinking waters using a bench-top water filter system was evaluated by Gulson et al.[16] It was shown that elements unaffected by filtration were Al, Si, Na, Fe, Cl and F.

Water conditioners and softeners have been shown to have little or no effect on fluoride.[12,17,18]

Role of relevant agencies in domestic water filtration systems usage

As far as the removal of contaminants, the National Sanitation Foundation (NSF), provides certification of contaminant removal for water purification systems. The label of the filter should specify NSF certification for the contaminants that are removed.[3] Glass emphasized the importance of dentists asking patients about their drinking water, in order to make recommendations on whether fluoride supplementation was needed.[3] Petrowski stated the purpose of water quality agencies and their roles. Instructions on purchasing and maintaining a system were also discussed and reference numbers of different companies for additional information on their products were provided.[4]

Proper usage of water filters and filtered water

Water that has passed through a domestic filter should be treated as a perishable foodstuff and kept in refrigerated conditions. This water should be consumed within 24 hours. The manufacturer's instructions for the filter equipment should be followed at all times.[19]

RATIONALE

With growing affluence coupled with smart marketing strategies, the sale of home water treatment units is fast expanding. In the quest for increased coverage of our fluoridation programme, there is also a need to look into whether the intended population is benefiting from fluoride in drinking water.

There are pockets of population in Johor who do not have access to optimally-adjusted fluoridated water supplies. This study also helps to monitor consistency of fluoride levels in fluoridated areas; hence, evaluating the quality control of the water fluoridation programme in the state.

Scientific evidence on the impact of different types of devices on fluoride content will enable healthcare professionals to educate patients on the possible removal of fluoride by some water treatment systems and to provide advice on the most suitable types of devices to purchase. This is to ensure that the benefits of fluoridated water actually reach the population. With more studies like these done, the Oral Health Division, Ministry of Health, will be better positioned to work with related agencies in the certification of contaminants and minerals removal by each system.

OBJECTIVE

General objective

The objective of this study is to determine the effect of various home water filtration systems on fluoride content in drinking water in Johor.

Specific objective

- To compare fluoride content of drinking water before and after passing through water filtration devices.
- To compare the difference in fluoride content of drinking water between water filtration devices.

METHODOLOGY

Sampling

Three districts in Johor were selected for the study; namely, Johor Bahru representing an urban population and with almost 100% fluoridation coverage, Muar with an equal mix of urban and rural population and about 90% fluoridated and lastly, Mersing with a mostly rural population and only half of which receiving fluoridated water.

Water samples were collected from households using WFS, identified from an earlier study through systematic randomized sampling. Sampling of water was carried out over three consecutive days by trained personnel in each district. Standard plastic bottles (100 ml) were used for collection of water samples, one for control i.e. before water passed through water filtration device and another for test i.e. after passing through device. Each bottle was labeled accordingly before collection of sample, with date, time, name of personnel and address of residence. Reused bottles were rinsed twice with distilled water to remove any fluoride residue.

At the start of experimentation, water samples were collected after running the water for 5 minutes. Unfiltered water samples were collected

from a second tap (in same room) receiving the same main supply.

Fluoride analysis

The samples were brought back to the clinics, where fluoride readings were taken. Fluoride content was analyzed using Hach's colorimeter. Each sample of water was measured twice and the recorded measurement being the average of the two readings. Fluoride levels are expressed as ppm F.

Data management

Data were entered into a dummy table and the SPSS software. Statistical analysis of effect of different types of water filtration devices on fluoride level was done using SPSS. Wilcoxon Signed-Rank test was used to compare fluoride content of drinking water before and after passing through various WFS. Mann Whitney tests were used to compare difference in fluoride content of drinking water between various WFS. All procedures were computed to within 95% confidence level.

Table 1. Types of water filtration systems used by oral health personnel in Johor

	Frequency	Percent	Valid Percent	Cumulative Percent
Activated carbon	83	72.2	72.2	72.2
Reverse osmosis	23	20.0	20.0	92.2
Others	9	7.8	7.8	100.0
Total	115	100.0	100.0	

Table 2a. Compare F level before and after filtration

Types of water filter	n	Day 1			Day 2			Day 3		
		Median F Level Before Filtration	Median F Level After Filtration	*P value (Compare before and after filtration)	Median F Level Before Filtration	Median F Level After Filtration	*P value (Compare before and after filtration)	Median F Level Before Filtration	Median F Level After Filtration	*P value (Compare before and after filtration)
Activated carbon	29	0.40	0.40	0.366	0.40	0.40	0.636	0.45	0.40	0.037
Reverse osmosis	11	0.40	0.15	0.011	0.40	0.10	0.007	0.40	0.10	0.003
Others	9	0.40	0.35	0.005	0.40	0.3	0.006	0.40	0.30	0.008
Total	49									

*Wilcoxon Signed Rank Test

Table 2b. Compare F level before and after filtration (Overall)

Types of water filter	n	Overall		
		Median F level before filtration	Median F level after filtration	*P value (Compare before and after filtration)
Activated carbon	29	0.43	0.43	0.152
Reverse osmosis	11	0.40	0.11	0.005
Others	9	0.40	0.30	0.003
Total	49			

Table 3. Compare types of filter

Types of water filter	P value			
	Day 1	Day 2	Day 3	Overall
Activated carbon versus reverse osmosis	0.001	<0.001	<0.001	<0.001
Activated carbon versus others	0.001	<0.001	0.001	<0.001
Reverse osmosis versus others	0.295	0.046	0.007	0.154
All three types	<0.001	<0.001	<0.001	<0.001

RESULTS

A total of 49 water filters were selected from a pool of 115 filters in Johor Bahru, Muar and Mersing, as shown in TABLE 1 and TABLE 2a and 2b below.

Of the 49 filters, twenty-nine were activated carbon, 11 reverse osmosis, and 9 'Others'. Results showed that fluoride levels before and after filtration with CA systems were not significantly different ($p>0.05$). Comparisons for RO systems showed significant differences ($p<0.05$), similarly with WFS using other technologies ($p<0.05$). Refer to TABLE 2a and 2b.

TABLE 3 shows comparison between various types of WFS, where significant differences ($p<0.05$) were obtained. Filtered water from CA systems had higher fluoride levels than those from RO systems and WFS using other technologies ($p<0.05$). However, test results from RO and systems using other technologies were not significantly different ($p>0.05$).

DISCUSSION

The study was set up to investigate the effect of home WFS on fluoride levels in drinking water in Johor. This study used tap water from the homes as distinct from laboratory fabricated deionised samples in an earlier paper.[2,12] Most studies had used findings of the effect of WFS on fluoride levels to advise against unnecessary prescription of fluoride supplements.[10,13-15] This study serves to identify effect of commonly-used WFS on fluoride level and to address concerns in relation to the maintenance and expansion of our fluoridation programme.

Findings of this study showed that activated carbon (CA) had no significant effect on fluoride level in drinking water. Previous tests based on CA systems have given contradictory results. This finding concurs with results reported in several studies[12-15] but is in contrast to others.[2,3,8,9] It has been suggested that the design of the carbon filter may be a factor affecting fluoride removal.[2] Variation in fluoride reductions by WFS is also dependent on differing pressure lines and regular maintenance of equipment may also influence its efficacy in fluoride reduction.[3]

For the purpose of analysis, this study had grouped CA filters using ion-exchange technology together with those using distillation as 'WFS using other technologies'. They were found to reduce fluoride content significantly but to a lesser degree than reverse osmosis (RO). A standard CA system does not remove fluoride. A more complex filtration system, which employs an ion exchange technology, adding potassium ions to the water can remove 40-60% fluoride.[20] Fluoride content of water filtered through WFS using RO was significantly reduced in this study, with most filters totally removing fluoride from water samples. This further strengthens evidence found in other studies.[2,3,9,15]

It has been recognized that the water source used is of critical importance.[21] This study sampled tap water from public water supplies and has the disadvantage of being less well controlled for other water constituents, but may provide a better reflection of the effects of filtration in 'real-life' use. It may be suggested that complexation of fluoride with high levels of aluminium and iron in unfiltered water will render some free fluoride ions still unavailable for detection.

Readings taken over three consecutive days showed consistent fluoride readings before filtration, complied with the range of 0.4-0.6 ppm F (Quality Assurance Programme, MOH). This reflects on the well-controlled dosing of fluoride in public waters in the districts concerned. Hach's colorimeter was used in this study, as opposed to ion-specific electrode in other studies, due to cost factor. However, stringent measures were taken to ensure accuracy and consistency in sampling and analysis. Dental Surgery Assistants involved in routine fluoride analysis were re-trained and calibrated prior to the study by a senior technician from the supplier company. All colorimeters used were serviced and calibrated shortly before the sampling exercise.

CONCLUSION

The results of the study showed that the use of carbon activated water filtration systems has no effect on fluoride levels in drinking water. Water filtration systems using Reverse Osmosis and other technologies significantly lower fluoride levels of drinking water. Optimally fluoridated drinking

water when subjected to home water filtration systems that reduce fluoride significantly may not offer the same caries preventive effect.

RECOMMENDATIONS

Based on the findings in this and related studies, several recommendations are proposed. The Oral Health Division at district/state/MOH level may play a more active role in the following:

- Work with local water agencies in educating and reassuring the public on quality of public water supplies.
- Advise patients on suitable water filtration systems to use and that some systems (using reverse osmosis and distillation) will reduce the benefits of fluoride in drinking water.
- Work with water quality agencies in certification of contaminant removal for water filtration systems. Authorities need to ensure instructions on maintaining a system after purchase are provided and reference numbers of different companies for additional information on their products were provided.

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