Original Article

Comparative Analysis of Fluoride Removal Efficacy of Drinking Water with Moringa Oleifera Seeds, Leaves and its Barks as Economic and Cost-Effective Bioadsorbents

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ABSTRACT

Background: Fluorides are the most important pollutants present in the effluents from various industrial and groundwater sources. These are very poisonous to living beings and have a dangerous effect on their health. Fluoride in drinking water within permissible limits of 0.5-1.0 mg/L is useful for the production and of maintenance healthy, teeth and bones as extreme intake of fluoride causes dental and skeletal fluorosis. Thus the removal of fluoride using adsorbents is a main step towards the protection of environment. **Methods:** The water samples are collected from wells of Salem district. Previous to sampling, the water is left to run from the source for few minutes. The study for presence of fluoride in groundwater samples is carried out as per APHA standard methods. Fluoride concentration be determined with SPADNS method spectrometric ally by use zirconyl-SPADNS (sodium 2-(parasulphophenylazo)-1, 8-dihydroxy-3, 6-naphthalene-disulphonate) reagents. **Results:** The significant difference in average score is tested through the analysis of variance after testing the normality test and it shows there is highly significant difference is found in the Fluoride Removal with respect to Moringaoleifera seeds, Moringaoleifera leaves, Moringaoleifera barks since the p value is less than 0.01. **Conclusion:** Drinking water is an essential basic need. The use of adsorbents is simple, cheap, non-toxic and environmentally friendly, its adoption for the defluoridation of drinking water. Based on the results of this study, it can be concluded that the low-cost adsorbents are effective in removal of fluoride from water.

KEYWORDS: *Fluoride, Moringa oleifera seeds, leaves and its barks*

INTRODUCTION

Fluoride is most frequently found in ground water and has become one of the most serious environmental hazards globally. Nevertheless, groundwater is the main source of drinking water in rural areas, and few ground water sources in rural Indian villages have been found to be contaminated with fluoride in recent

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times.[1,2] Naturally, the ground water in India contains fluoride due to the geological distribution, i.e., presence of fluoride belt-3 across the country.[3] In addition, owing to anthropogenic activities, the toxic level of fluoride in groundwater has become an urgent scientific problem that has to be solved in the interest of public health. Ground water availability depends upon the precipitation and percolation of rain water through soil. Increase demand of groundwater for agricultural and industrial use may lead the sharp decline in ground water level and change in the natural geochemistry of groundwater. Natural contamination such as fluoride, arsenic, and nitrate salts are continuously increasing in groundwater in level which make unfit for drinking reason even pose a danger to health.[4] Plants are rich in secondary metabolites and are being used for the treatment of various ailments in the indigenous system of medicine. Many developing countries are facing illnesses, and deaths among children are caused by germs, which get into the mouth via water and food. In addition, it has been estimated that up to 80% of all disease and sickness in the world is caused by inadequate sanitation, polluted water or unavailability of water.[5]

Fluoride is thirteenth most abundant element in earth and is available as fluoride ion in earth crust in diversity of compounds such as sodium fluoride, fluorspar, sodium fluorosilicate etc. It is most electronegative of all elements.[6] Within limits, fluoride is essential for humans. It prevents infants from dental caries. Fluoride is a generally occurring element in minerals, geochemical deposits and usual water system and enters food chains through either potable water or eating plants or cereal. The groundwater containing high levels of fluoride is used for drinking purpose; this usage of fluoride contaminated water over a duration of time causes health problem such as fluorosis i.e., deformation of dental, skeletal, nonskeletal and also hazardous effects.[7] The removal of fluoride from water is single of the most significant issues due to its ill effects on human being health and environment. According to World Health Organization, the maximum permissible limit of fluoride concentration in drinking water is 1.5 mg/L.[8] This study is an attempt to remove the fluoride from water by using low-cost adsorbents.

Materials and Methods

Water sampling The water samples are collected from wells of Salem district. Previous to sampling, the water is left to run from the source for few minutes. Then, in the laboratory conditions, water sampling was done.

Materials

In this study, an attempt has been made to advise certain low-cost materials as impressive adsorbents of fluoride. Naturally occurring and abundantly available materials like *Moringa oleifera* seeds, leaves and barks can be used as adsorbents.

Preparation of MO seeds, leaves and barks powder

The dry drumstick (*Moringa oleifera*) pods, leaves and barks are collected from local tree. Pod shells are removed manually, and kernels are grounded in a domestic blender. Leaves and barks are separately grounded in a domestic blender. 40 gm of each MO powder sample was added to 400 ml of 1N HNO3 for acid treatment and 0.5N NaOH for alkali treatment. The mixture was boiled for about 20 minutes. Washing of the powder sample was carried out by using distilled water until maximum colour was removed and clear water was obtained. Finally, it was dried again in an oven at 50°C for 6 hrs [Figure 1].

Extraction

Analysis of fluoride concentration of groundwater

The study for the presence of fluoride in groundwater samples is carried out as per APHA standard methods. Fluoride concentration is determined with SPADNS method spectrometric ally by use zirconyl-SPADNS (sodium 2-(parasulphophenylazo)-1, 8-dihydroxy-3, 6-naphthalene-disulphonate) reagents [Figure 2].

Results and Discussion

The test of Kolmogorov–Smirnova test is used to test the normality for applying the analysis if variance for testing the significance of the difference in means score for more than two groups such as three different Moringaoleifera [Table 1]. It is found from the result that the normality condition is satisfied for fluoride removal.

Table 2 shows the fluoride removal with respect to Moringaoleifera like Moringaoleifera seeds, Moringaoleifera leaves, and Moringaoleifera barks. The significant difference in average score is tested through the analysis of variance after testing the normality test, and it shows that highly significant difference is found

Table 1: Spectrophotometer analysis

Plant Name	Triplicate Values		
	1	2	3
Moringa oleifera seeds	0.762	0.765	0.776
Moringa oleifera leaves	0.792	0.797	0.798
Moringa oleifera barks	0.794	0.796	0.799

in the fluoride removal with respect to Moringaoleifera like Moringaoleifera seeds, Moringaoleifera leaves, and Moringaoleifera barks since the *P* value is less than 0.01. Further to test the significance among the Moringaoleifera, the Duncan *post hoc* test is used and it shows that among all the three Moringaoleifera regarding the fluoride removal, no significant difference is found between Moringaoleifera leaves and barks but significant difference is found between the Moringaoleifera seeds and other two Moringaoleifera leaves and barks, and it is given in Table 3.

The conventional technique of fluoride removal includes reverse osmosis, ion-exchange and adsorption. The reverse osmosis, ion-exchange is comparatively exclusive. Then, still adsorption is the workable method used for the removal of fluoride. Defluoridation of drinking waters is generally able by either precipitation or adsorption process.[9] Single of the well-known methods called Nalgonda technique was developed by National Environmental Engineering Research Institute; Nagpur, India, is precipitation processes employing alum followed by sedimentation and filtration. Difficulty of this method is that treated water has high residual aluminium concentration (2-7 mg/L) and then the WHO standard of 0.2 mg/L.[10] Alum coagulant can be used to remove fluoride selectively from aqueous solutions. Still at 60–70% removal, the left over fluorides were within the permissible limit for drinking water.[11] Aluminum in drinking water poses possible risks to humans. Aluminium is strongly neurotoxic and possibly involved in the development of Alzheimer's disease.[12] Currently, adsorption method is more effect or attractive method for removal of fluoride from water. The higher value of fluoride in summer season period may be due to the evaporation, lowering of water table and geological rock system.[13]

Table 2: Fluoride removal

	n	Mean	SD	SE	ANOVA	*P*
Moringaoleifera seeds	3	0.768	0.007	0.004	33.93	0.001**
Moringaoleifera leaves	3	0.796	0.003	0.002		
Moringaoleifera barks	3	0.796	0.003	0.001		
Total	9	0.787	0.015	0.005		

Table 3: Fluoride removal - Duncan *Post Hoc* tests

Herb	*n*	Subset for alpha=0.05	
		1	2
Moringaoleifera seeds	3	0.768	
Moringaoleifera leaves	3		0.796
Moringaoleifera barks	3		0.796



Figure 1: Extraction of MO

Owing to rich biodiversity of India, a big number of plant spices are available for treatment of different toxicities and musculoskeletal disorders. Research information indicates that herbal and low-cost plant products may be used for mitigation of fluoride toxicity.[14] The purpose of the current study was to investigate the efficiency of naturally occurring and low-cost materials like Moringa oleifera seed, leaves and barks for removal of fluorides from water.

The experiments were performed at different material (Drumstick seed, leaves and barks), adsorbent dosage (1 g), for removing fluoride from groundwater. The present study provides the comparison of fluoride removal efficiency of adsorbent such as Moringa oleifera seeds leaves and barks.[15]

Conclusion

Drinking water is an essential basic need. Hence, public should consume protected water containing fluoride within the prescribe limits. If not, they will be affected by dental and skeletal fluorosis. The use of adsorbents is simple, cheap, nontoxic and environmentally friendly, its adoption for the defluoridation of drinking water. Based on the results of this study, it can be concluded that the low-cost adsorbents are effective in removal of



Figure 2: Spectrophotometer analysis

fluoride from water. Moringa oleifera leaves and barks give the maximum removal of fluoride from water when compared to Moringa oleifera seeds with a significant *P* value of 0.01. The current study can find use in the development of sustainable, low-cost, ecofriendly and household water treatment system for removal of fluoride most suitable for rural population of developing country.

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Conflicts of interest

There are no conflicts of interest.

References

1. Hussain A. Fluoride contamination in drinking water in rural habitations of Central Rajasthan, India. Environ Monit Assess 2012;184:5151–8.
2. Saralakumari D, Rao PRM. Endemic fluorosis in the village Ralla Anantapuram in Andhra Pradesh: An epidemiological study. Fluoride 1993;26:177–80.
3. Chowdhury A, Adak MK, Mukherjee A, Dhak P, Khatun J, Dhak D. A critical review on geochemical and geological aspects of fluoride belts, fluorosis and natural materials and other sources for alternatives to fluoride exposure. J Hydrol 2019;574:333–59.
4. Arslan I, Balcioglu I, Tuhkanen T, Bahnemann D. A treatment for reactive dye wastewater. J Environ Eng 2009;126:903-10.
5. Bayramoğlu G, Yakup Arica M. Biosorption of benzidine based textile dyes “Direct Blue 1 and Direct Red 128” using native and heat-treated biomass of Trametes versicolor. J Hazard Mater 2007;143:135-43.
6. Bidhendi G, Ehsani TAH, Razmkhah N. Evaluation of industrial dyeing wastewater treatment with coagulants and polyelectrolyte as a coagulant aid. Iran J Environ Health Sci Eng 2011;4:29-36.
7. El-Gohary F, Tawfik A. Decolourisation and COD reduction of disperse and reactive dyes wastewater using chemical-coagulation followed by sequential batch reactor (SBR) process. Desalination 2009;249:1159-64.
8. Gao BY, Yue Q, Wang Y, Zhou WZ. Color removal from dye-containing wastewater by magnesium chloride. J Environ Manag 2009;82:167-72.
9. Georgiou D, Melidis P, Aivasidis A, Gimoupoulos K. Degradation of azo-reactive dyes by ultraviolet radiation in the presence of hydrogen peroxide. Dyes Pigm 2011;52:69-78.
10. Gholami M, Nasseri S, Fard M, Mesdaghinia A, Vaezi F, Mahvi A, *et al*. Dye removal from effluents of textile industries by ISO9888 method and membrane technology. Iran J Public Health 2001;30:73-80.
11. Gurses A, Yolcin M, Dogar D. Removal of remazol red RB by using Al (III) as coagulant-flocculant: effect of some variables on settling velocity. Water Air Soil Pollut 2001;146:297-318.
12. Huang H, Schwab K, Jacangelo J. Pretreatment for low pressure membranes in water treatment, a review. Environ Sci Technol 2009;43:3011-9.
13. Joo D, Shin W, Choi J, Choi S, Kim M, Han M, *et al*. Decolorization of reactive dyes using inorganic coagulants and synthetic polymer. Dyes Pigm 2007;73:59-64.
14. Leiknes T. The effect of coupling coagulation and flocculation with membrane filtration in water treatment: A review. J Environ Sci 2009;21:8-12.
15. Ranganathan K, Jeyapaul S, Sharma DC. Assessment of water pollution in different bleaching-based paper manufacturing and textile dyeing industries in India. Environ Monit Assess 2007;134:363-72.