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Research Article

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To Defluoridate Groundwater Employing Moringa Olefera Seeds and Potash Alum

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ABSTRACT

Clean drinking water is one of the most essential commodities enjoyed by human beings. Fluoride in excess of 1 mg/l in water causes fluorosis. Compared to surface water sources the ground water sources contain fluorides as high as 44 mg/l (Nagaur Region of Rajasthan). The problem of fluorosis is prominent and endemic in many parts of the world as well as in India. Although various defluoridation methods are available, in Indian context the Nalgonda Technique has been mostly adopted. Alum is used as the coagulant in this process. It has some disadvantages like high sludge volume, residual aluminum, wearing effects on the treatment structure. Therefore, an alternative to alum for defluoridation assumes importance. The main problem of the Nalgonda Technique is the residual Aluminum in treated water which at times is found to be higher than the permissible limit, i.e. 0.2mg/L. It's aimed to reduce the use of Alum by bringing down the fluoride level firstly with Moringa Oleifera seed powder and then using Alum later on. For reduction from low fluoride levels less Alum will be required as compared to reduction from high fluoride levels and hence, we would be able to reduce the residual aluminum in the treated water. Apart from solving the residual aluminum problem, coagulation by MO seeds solves the sludge volume problem also as it produces less amount of sludge for the same amount of removal in comparison to Alum.

Key words: Nalgonda technique, Defluoridation, Alum, Aluminum, Moringa Oleifera, Coagulation

INTRODUCTION

Of all elements, fluorine is the most electronegative and most reactive. Because of its high reactivity, fluorine is not found in nature in its elemental state and exists as fluorides and is harmful to human health. The guideline values for fluoride in drinking water are 2.0 mg/L in the United States and 1.0 mg/L in India. According to the WHO (2008) guidelines and recommendations in the areas with a warm climate, the optimal fluoride concentration in drinking water should remain below 1.0 mgL^{-1}, while in cooler climates it could go up to 1.5mg/L. The differentiation derives from the fact that people perspire more in hot weather and consequently drink more water. The problem is more acute in rural and small urban communities particularly in the third world countries. Severe chronic and cumulative over exposure can cause the incurable crippling of skeletal fluorosis. The dental and skeletal fluorosis is irreversible and no treatment exists. The only remedy is prevention by keeping fluoride intake within the safe limits. The Nalgonda technique is one such technique that helps in keeping fluoride within the safe limits (Veeraputhiran et al., 2011).

Nalgonda Technique

After extensive testing of many materials and processes including activated alumina since 1961, National Environment Engineering Research Institute (NEERI), Nagpur evolved an economical and simple method for removal of fluoride which is referred to as Nalgonda Technique.Nalgonda Technique involves addition of aluminum salts, lime and bleaching powder followed by rapid mixing, flocculation, sedimentation, filtration and disinfection. Aluminum salt may be added as aluminum sulphate or aluminum chloride or combination of these two. Aluminum salt is only responsible for removal of fluoride from water. The dose of aluminum salt increases with increase in the fluoride and alkalinity levels, which are manipulated by adding lime, the raw water. The selection of either aluminum sulphate or aluminum chloride also depends on sulphate and chloride contents of the raw water to avoid them exceeding their permissible limits. The dose of lime is empirically 1/20th that of the dose of aluminum salt, but also depends on the alkalinity of water. Lime facilitates forming dense floc for rapid settling and also, neutralization of H+ ions released during the coagulation process. Bleaching powder is added to the raw water at the rate of 3 mg/L for disinfection (http://www.globenet.org/preceup/pages/ang/chapitre/capitali/cas/indme_h.htm).
The chemical processes, though admittedly are not fully understood (Dahi et al.), can be seen below:

$$Al_2(SO_4)_3 18H_2O \Rightarrow 2Al + 3\ SO_4 + 18H_2O$$
$$2AL + 6H_2O \Rightarrow 2Al(OH)_3 + 6H^+$$
$$F^- + Al(OH)_3 \Rightarrow \text{Al-F Complex} + \text{undefined product}$$
$$6Ca(OH)_2 + 12H^+ \Rightarrow 6Ca^{2+} + 12H_2O$$

The amount of aluminum sulfate added must be carefully monitored as both left over aluminum can cause significant health problems including neurological, cardiovascular, and respiratory problems among others and must be kept under 0.2mg/L.

Test Water Fluoride (mg/L)	**Test water alkalinity (ppm)**							
	125	**200**	**300**	**400**	**500**	**600**	**800**	**1000**
2	145	220	275	310	350	405	470	520
3	220	300	350	405	510	520	585	765
4	*	400	415	470	560	600	690	935
5	*	*	510	600	690	715	885	1010
6	*	*	610	715	780	935	1065	1210
8	*	*	*	*	990	1120	1300	1430
10	*	*	*	*	*	*	1510	1690

Table 1: Approximate Alum dose (mg/L) required to obtain acceptable quality (~1.0 mg/L) of drinking water from raw water at various alkalinity and fluoride levels
(http://www.globenet.org/preceup/pages/ang/chapitre/capitali/cas/indme_h.htm)

*To be treated after increasing the alkalinity with lime.

There are limitations chemically as the Nalgonda Technique has been shown to not be sufficient for the treatment of water with a fluoride concentration greater than 10.0 mg/L.Also the pH is very difficult to regulate with the addition of lime and sludge created needs to be properly disposed of.The main problem of the Nalgonda Technique is the residual Aluminum in treated water which at times is found to be higher than the permissible limit, i.e. 0.2mg/L.

Moringa Oleifera

Moringa oleifera (MO) is a multipurpose, medium or small-sized tree, from regions of north- west India and indigenous to many parts of Asia, Africa, and South America. Its pods have been employed as an inexpensive and effective sorbent for the removal of organics, and coagulant for water treatment. It is a non-toxic natural organic polymer. Moringa oleifera (MO) is a tropical plant belonging to the family Moringaceae, a single family of shrubs with 14 known species. MO is native to India but is now found throughout the tropics. It is a non-toxic natural organic polymer. The tree is generally known in the developing world as a vegetable, a medicinal plant, and a source of vegetable oil. It is drought tolerant and has nutritional, medicinal, and water-cleaning attributes. Its leaves, flowers, fruits, and roots are used locally as food articles. The medicinal and therapeutic properties of this plant have led to its application as a cure for different ailments and diseases, physiological disorders, and in eastern allopathic medicine (Vieira et al., 2010). The powdered seed of the plant M. oleifera has coagulating properties that have been used for various aspects of water treatment such as turbidity, alkalinity, total dissolved solids and hardness. However, its bio-sorption behavior for the removal of toxic metals from water bodies has not been given adequate attention (Kumari et al., 2005). Purification of artificially fluoridated water done by Bazanella et al., 2012, at a starting fluoride concentration of 10 mgL−1by submitting it to a coagulation process with aqueous extracts of M. oleifera seeds. The coagulation process was followed by ultra filtration with membranes at different pressures. The coagulation process with 2.5 gL−1 of M. oleifera promoted a reduction of 90.90 % in the fluoride content of the treated water, making it possible for poor communities to consume this water. For their method, the combined coagulation/filtration process using raw coagulant showed the highest values of colour and turbidity, which, however, were still below the limits set for drinking water by Brazilian legislation.

An active component of *Moringaoleifera* (MO) was used by Ghebremichael and Hultman, 2004in comparison with synthetic polymers and alum for the conditioning of chemical sludge from a drinking water treatment plant. The comparison was based on dewatering characteristics of the conditioned sludge determined by capillary suction time (CST), specific resistance to filtration (SRF), sand column drainage and shear strength tests. The results indicated that MO showed comparable conditioning effect as alum. Polyelectrolyte's were more effective than MO and alum. Sludge conditioned with MO and alum, as in dual chemical conditioning, showed better results than MO alone. According to CST, SRF and sand drainage results, optimum doses for MO, alum andpolyelectrolytes were 125, 63, and 1.8 kg/t, respectively. Comparison of the twopolyelectrolytes showed that the cationic polyelectrolyte was more effective. For sand drainage tests both polyelectrolytes improved the drainage rate by 2orders of magnitude. MO and alum improved the drainage rate by about 4.2 times. On the other hand, the improvements in cake solids concentration were similar for all the chemical conditioners. Flocs from MO and alum were relatively stronger compared to those of the polyelectrolyte's. From the results of the study it could be concluded that MO alone or in combination could be effectively used and replace alum for dewatering of chemical sludge.

CONCLUSION

From the details of the above experiments, it can be inferred that Moringa Oleifera seeds can be tried to be used in tandem with Alum in the Nalgonda Technique, which can lead to aluminum free treated water and less sludge generation. Also, as we know it is not possible to treat water having fluoride level above 10ppm by Nalgonda Technique, hence, Moringa Oleifera seeds can be used at the start where there is fluoride level above 10ppm to bring down the fluoride level as much as possible to below 10ppm, and then use alum to reduce the level further. And once the level is lowered by Moringa seeds, the amount of Alum required to reduce further will be less, and hence, less chances of high residual concentration of Aluminum being found in treated water. Moringa Oleifera seeds can be used alone, but it has been seen generally that it does not reduce well at low concentrations.

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