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# Defluoridation Of Water by Moringa Oleifera- A Natural Adsorbent

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***Abstract:*** ***The water available for daily consumption may be contaminated by natural sources or by industrial effluents. One such a contaminant is fluoride. Exposure to fluoride in drinking water has a number of adverse effects on human health. One of the naturally available alternatives for defluoridation of water is Moringa Oleifera. Using colourimetric method, tests were conducted to get optimal values of pH of water in acid and alkali treated powder of Moringa Oleifera. Optimal contact time for 212µ and 600µ were determined. For higher removal percentage efficiency of fluoride, optimal dose of adsorbent was also determined. From the results obtained it can be concluded that Moringa Oleifera can become a cheap alternative for defluoridation of water.***

*Keywords:* **Fluoride, adsorption, Moringa Oleifera, contact time**

## I. INTRODUCTION

Pure water is scarce and is not easily available to all. Deprived sections of the society consume contaminated water and take ill periodically, often resulting in epidemics. The water may be contaminated by natural sources or by industrial effluents. One such a contaminant is fluoride. Geological formation is the main source of fluoride in the groundwater. The other sources of fluoride occurrence in water are industrial discharge from aluminum industries, phosphate industries, coal plants as well as due to water, food, air, medicament and cosmetics. Removal of fluoride from water is important because of the ill effects it causes. Defluoridation is removal of fluoride from water. Although there are several sources of fluoride intake, it is roughly estimated that 60% of the total intake is through drinking water.

Since many other available methods of defluoridation are costlier, there is an urgent need of developing a low cost method. Fluoride is one such compound that is widely present in groundwater worldwide. Exposure to fluoride in drinking water has a number of adverse effects on human health including crippling skeletal fluorosis that is a significant cause of morbidity in a number of regions of the world. Fluoride is more toxic than lead, and just like lead, even in minute doses, accumulates in and is damaging to brain/mind development of children, i.e. produces abnormal behavior in animals and reduces IQ in humans [1].

For drinking water treatment, coagulants are used which may be chemical or naturally occurring coagulant. Some studies on natural coagulants have been carried out and various natural coagulants were produced or extracted from microorganisms, animals or plants. One of these alternatives is Moringa Oleifera seeds. It is a native tree of the sub Himalayan parts of Northwest India, Pakistan and Afghanistan.

Earlier studies have found Moringa Oleifera to be non-toxic and recommended it for use as a coagulant. The use of Moringa Oleifera has an added advantage over the chemical treatment of water because it is biological and has been reported as edible. The coagulation mechanism of the Moringa Oleifera coagulant protein has been described as adsorption, charge neutralization and interparticle bridging. Flocculation by inter-particle bridging is mainly characteristic of high molecular weight polyelectrolyte. Among all the plant materials that have been tested over the years, powder processed from the seeds from Moringa Oleifera has been shown to be one of the most effective as a primary coagulant for water treatment and can be compared to that of alum a conventional chemical coagulant. In view of all these, Moringa Oleifera is called a ‘multipurpose tree’.

## II. LITERATURE REVIEW

The Nalgonda technique [14] comprises sequential addition of sodium aluminates or lime, bleaching powder and filter alum to the fluoride water followed by flocculation, sedimentation and filtration. Sodium aluminates have settlement of precipitate and bleaching powder ensures disinfection. Mariappan [14] studied defluoridation technique using poly aluminum hydroxy sulphate (PAHS). It was concluded that, floc formation and settling are quick and volume of resulting sludge is less. Murugan [12] studied the use of Aloe Vera (Indian aloe) a medicinal plant and concluded that at neutral pH the defluoridation was maximum. Sanjaykumar [18] studied defluoridation methods by using indigenous chemicals and minerals. It was concluded that alum could insure effective defluoridation if alum dose, alkalinity of water pH and colloidal concentration are optimized. Muthuganesh [13] studied fluoride removal techniques by using, poly aluminum chloride (PAC) and compared with most commonly existing ‘Nalgonda technique’. The results indicated that PAC can be an effective

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coagulant for fluoride removal with higher removal efficiency of about 65% -75% with less detention time. Also it was observed that fluoride removal was dependent on initial fluoride ion concentration and dose of coagulant. Prabavathi [16] studied defluoridation techniques by using lignite rice husk and rice husk powder as adsorbent by varying pH, concentration of fluoride, weight of adsorbent and contact time. A better result was obtained after 2 hrs at pH 6 by using lignite. Jamode [6] used fresh leaves chosen based on their crude fiber content and tress were obtained from neem (Azadirachta Indica), khair (Acacia Catechu Willd), and Pipal (Ficus Religliusa) for uptake of fluoride ion from fluoridated water. During the study by using adsorption method it was found that various parameters like pH, contact time, adsorbent dose, type and size of adsorbents and initial fluoride ion concentrations affect the controlling removal efficiency at optimum conditions. Bhargava [2] used fishbone charcoal prepared from fishbone in coastal areas. The fluoride removal was found to be function of pH, contact time, initial fluoride ion concentration and adsorbent (fishbone charcoal) dose. Ganguly [3] used boiler bottom ash as an adsorbent material for separating fluoride from water. The removal was found to be pH between 6 and 7. Gopal [4] used activated carbon developed from leaves of Agave Sisalana by batch process. Maximum fluoride adsorption was observed in the pH 6.76, optimum dosage of 5gm/lit and optimum contact time was observed to be 40 minutes. Defluoridation up to 86% can be achieved by this process.

***A. Regions of fluoride problem***

In the world, fluoride occurs in some region of Afghanistan, Algeria, Australia, Burundi, and chin, Japan, India, Kenya, Morocco, Mozambique, Nepal, New Australia, Pakistan, Turkic, Thailand, Uganda, Zimbabwe and Zambia. In India, fluoride occurs in some regions of Assam, Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu Kashmir, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamilnadu, Uttar Pradesh and West Bengal [19] .

***B. Effects of Fluoride on Human Health***

The effects of fluoride on human health are dependent on the concentration of fluoride in water [20].

**Table 1 – Biological Effects on Human Health**

| Fluoride conc. (mg/lit) | Source | Effects |
|---|---|---|
| 1 | Water | Prevention of dental caries |
| 2 | Water | Effect dental enamel |
| 3 to 6 | Water | Osteoporosis |
| 8 | Water | 10 % Osteoporosis |
| 20 to 80 | Air & Water | Crippling skeletal fluorosis |
| 50 | Food & Water | Changes in thyroid |
| 100 | Food & Water | Defective development |
| >125 | Food & Water | Changes in Kidney |
| 2500 | Acute dose | Death |

**Permissible Limits for Fluoride Concentration in Drinking Water** [19]

- Bureau of Indian Standards (BIS)-0.6 to 1.2 mg/lit
- World health Organization (WHO-1984 ) for drinking water-1 to 1.5 mg/lit
- Indian Council of Medical Research (ICMR-1975)-1 mg/lit
- World Health Organization (WHO) European Standards- 0.7 to 1.7 mg/lit related to temperature.

## III. MATERIALS AND METHODS

Adsorption is defined as the change in concentration at the interfacial layer between the two phases of a system due to surface forces. Adsorption is mass transfer operation in that a constituent in the liquid phase is transferred to solid phase. The adsorbate is substance that is being removed from the liquid phase and transferred to the solid phase. The adsorbent is the solid, liquid, or gas phase onto which the adsorbate accumulates. Factors affecting adsorption methods are i) Surface Area ii) Nature of the adsorbate iii) pH iv) Temperature v) Presence of mixed solutes and vi)Nature of adsorbent. The Moringa Oleifera tree grows in tropical and subtropical regions around the world and its seeds have been used in drinking water treatment in small scale in Sudan and India for generations. It is believed that the seed is an organic natural polymer. The active ingredients are dimeric proteins. The protein powder is stable and totally soluble in water. In the present study synthetic sample is prepared and used for experimental purpose of defluoridation of water.

## IV. MATERIALS USED

- For preparing synthetic fluoride water sample anhydrous sodium fluoride (NaF) and distilled water were

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used.

For preparing adsorbent powder, drumstick (Moringa Oleifera) powder was collected from local trees. 40 gm of powder sample was added to 400 ml of 1N $HNO_3$ 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 color was removed and clear water was obtained. Finally, it was dried again in an oven at 50°C for 6 hrs.

- The nitric acid (1N $HNO_3$) was used for acid washing of adsorbent.
- The sodium hydroxide (0.5 N NaOH) was used for alkali washing of adsorbent.
- For fluoride detection studies with spectrophotometer, various solutions were prepared.
- Reference solution was prepared by using conc. hydrochloric acid (HCl), SPADNS reagent zirconyl chloride, octahydrate reagent were used.

Synthetic fluoride bearing water sample having initial fluoride ion concentration of 10 mg/lit used. The sample was filtered by using Whatmann's filter paper no.41 for further uses. In this filtrate, SPADNS and zirconyl acid solution of 5ml each was used. The sample was checked for fluoride detection in spectrophotometer at wavelength 570nm. Absorbance readings were compared with standard curve and the removal efficiency was found.

## V. DEVELOPMENT OF STANDARD CURVE

The fluoride standard sample in the range of 1 mg/lit to 11 mg/lit was prepared by taking appropriate quantities of standard fluoride solution with distilled water. Then pipette 5 ml each of SPADNS solution and zirconyl acid solution to each standard and mixed well. Contamination avoided. The spectrophotometer was set to zero absorbance with reference solution and absorbance readings of standard were obtained. Reference solution was used as a blank solution. Spectrophotometer used at 570 nm wavelength was taken as per standard method procedure.

**Table 2- Standard curve**

| Sr. No. | Initial Fluoride Ion Concentration (mg/lit) | Absorbance Reading |
|---|---|---|
| 1 | 1 | 0.250 |
| 2 | 2 | 0.345 |
| 3 | 4 | 0.480 |
| 4 | 6 | 0.670 |
| 5 | 8 | 0.865 |
| 6 | 10 | 1.035 |

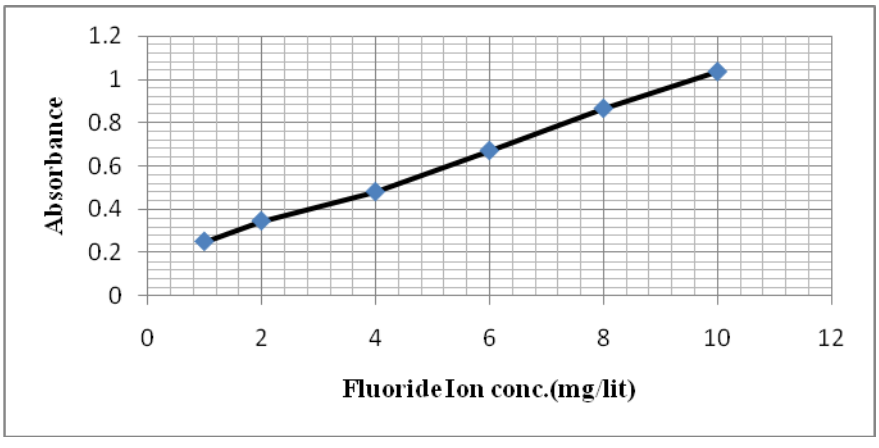


**Fig.1- Standard curve**

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## VI. EXPERIMENTAL SETUP

The fluoride removal studies by adsorption were conducted in 250 ml conical flask using 100 ml of synthetic water sample containing different pH and initial concentrations of fluoride ion. In these conical flasks adsorbent with varied dosage was added. Then the contact period was given for different particle sizes. After giving a required contact time, the contents of the flasks were filtered using Whatmann's filter paper number 41. The filtrate was used for fluoride ion estimation using SPADNS method. The above procedure was repeated for different pH, contact times, adsorbent doses, particle sizes and different initial fluoride ion concentrations. The pH was varied from 1 to 10. The contact time was varied from 0.5 hr to 3.5 hrs for various adsorbent sizes. The adsorbent dosages used were 0.5 gm/lit to 4 gm/lit in multiple of 0.5 gm/lit. The initial fluoride ion concentration was varied from 2 mg/lit to 11 mg/lit for the drumstick (Moringa Oleifera) seed powder. The parameters were varied to find the maximum fluoride removal efficiency. Synthetic fluoride bearing water sample having initial fluoride ion concentration of 10 mg/lit was used.

## VII. RESULTS AND DISCUSSION

### *A. Optimal pH*

The experiments were carried out for acid treated and alkali treated Moringa Oleifera seeds powder for determining optimum pH. The procedure was similar for acid and alkali treated powder. The pH was varied from 1 to 10 for acid treated Moringa Oleifera seed powder and 2 to 10 for alkali treated Moringa Oleifera seed powder. The adsorbent having 600 µ size, acid washed as well as alkali washed, was used to determine optimal pH at which the adsorption was maximum. For these experiments initial fluoride ion concentration was 10 mg/lit, with adsorbent dose of 2.5 gm/lit and contact time of 1 hr. In case of acid washed adsorbent the maximum removal efficiency was 39 % at pH 1. Whereas in case of alkali washed adsorbent the maximum removal efficiency was 51 % at pH 10. The extreme pH values will give rise to higher costs for post treatment. Therefore it is not advisable to adopt extreme pH values. It is generally recommended to maintain near neutral pH for the solution. Therefore at pH of 8, the percentage removal was 13 % and 49.5 % for acid washed and alkali washed adsorbents respectively.

In case of acid treated, the results were due to neutralization of the negative charge at treated Moringa Oleifera bioadsorbents surface by greater hydrogen ion concentration at lower pH values, thus reducing hindrance to diffusion of the negatively charged fluoride ions on to the increased active surface of acid treated Moringa Oleifera bioadsorbents.

In case of alkali treated Moringa Oleifera bioadsorbents, the maximum removal observed at high pH. It was due to increase of hydroxyl ion concentration in the solution, hence the rate of fluoride ion sorption was maximum on the active surface, due to cation ion exchange phenomenon of alkali treated Moringa Oleifera bioadsorbents at high pH value. Therefore, it was decided to use alkali washed adsorbent and to maintain pH 8.

**Table 3- Optimum pH**

| Sr. No. | pH | Acid washed powder (600 µ) | | Alkali Washed Powder (600 µ) | |
|---|---|---|---|---|---|
| | | Absorbance | % Removal Efficiency | Absorbance | % Removal Efficiency |
| 1 | 1 | 0.680 | 39 | - | - |
| 2 | 2 | 0.765 | 31 | 0.760 | 31 |
| 3 | 4 | 0.815 | 24 | 0.730 | 37 |
| 4 | 6 | 0.850 | 20 | 0.665 | 41 |
| 5 | 8 | 0.905 | 13 | 0.595 | 49.5 |
| 6 | 10 | 0.920 | 12 | 0.580 | 51 |

### *B. Optimal Contact Time*

The adsorbent dose of 2.5 gm/lit was taken and kept constant throughout the experimental work. The contact time was varied from 0.5 to 2.5 hrs for alkali treated Moringa Oleifera seed powder of 600µ and 212µ respectively. The experimental study was carried out to determine optimal contact time using adsorbents with different particle sizes. The pH was 8 and dose was 2.5 gm/lit for the study. It is seen that the contact time reduces with decrease in particle size. For the given particle size, after a particular contact time, the removal

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efficiency remains almost constant. Contact time of 2 hrs and 2.5 hrs were optimal for adsorbents having particle size of 212 µ and 600 µ respectively.

**Table 4- Optimum contact time**

| Sr. No. | Contact Time (min) | 600 µ | | 212 µ | |
|---|---|---|---|---|---|
| | | Absorbance | % Removal Efficiency | Absorbance | % Removal Efficiency |
| 1 | 30 | 0.680 | 39 | 0.565 | 53 |
| 2 | 60 | 0.615 | 48 | 0.480 | 62 |
| 3 | 90 | 0.545 | 56 | 0.520 | 68 |
| 4 | 120 | 0.495 | 61 | 0.415 | 70 |
| 5 | 150 | 0.485 | 62 | 0.415 | 70 |

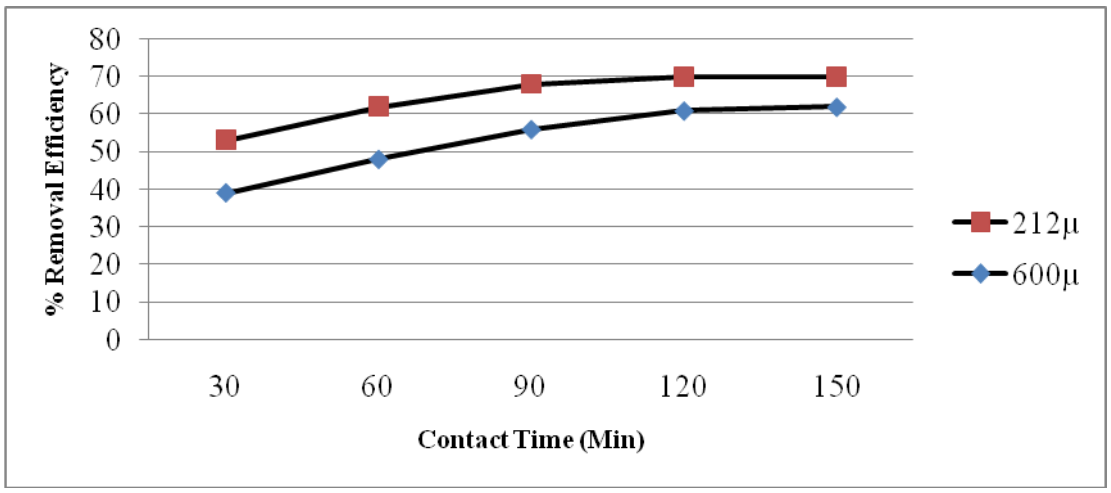


**Fig.2 -Optimum contact time**

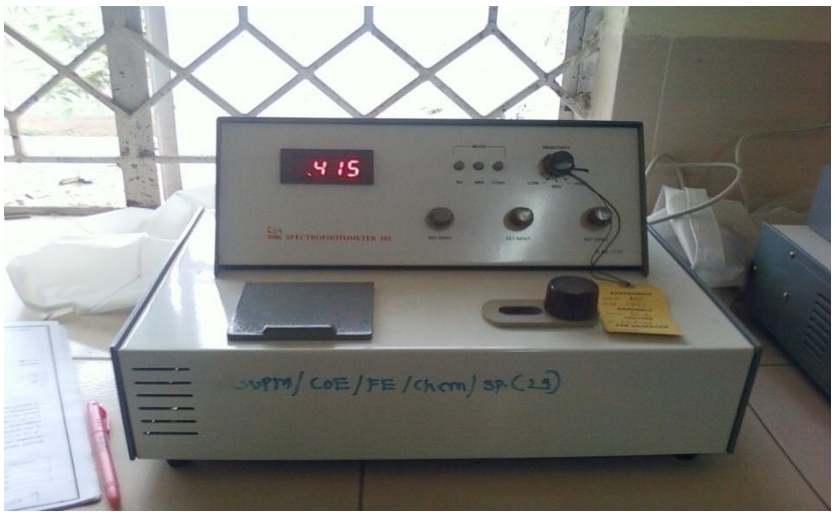

**Fig. 3- Spectrophotometer**

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### *C. Optimal Adsorbent Dose*

It was seen that the removal of fluoride increases with an increase in the amount of adsorbent. For all the experiments, initial fluoride ion concentration was fixed at 10 mg/lit, pH was 8, and optimum contact time was 2.5 hrs and 2 hrs for 600 µ and 212 µ respectively. The amount of adsorbent dose was varied from 0.5 gm/lit to 4 gm/lit in aqueous solutions. Results show that for 212µ alkali treated Moringa Oleifera bioadsorbent, the maximum removal efficiency of fluoride was 76 % at 400 mg/lit whereas maximum removal efficiency of fluoride was 40 % at 50 mg/lit. Similarly, for 600µ alkali treated Moringa Oleifera bioadsorbent, the maximum removal efficiency of fluoride was 68 % at 400 mg/lit.

**Table 5- Optimal adsorbent dose**

| Sr. No. | Absorbent Dose (mg) | 600 µ | | 212 µ | |
|---|---|---|---|---|---|
| | | Absorbance | % Removal Efficiency | Absorbance | % Removal Efficiency |
| 1 | 100 | 0.620 | 47 | 0.615 | 48 |
| 2 | 200 | 0.525 | 58 | 0.485 | 62 |
| 3 | 300 | 0.490 | 61 | 0.525 | 67 |
| 4 | 400 | 0.520 | 68 | 0.365 | 76 |

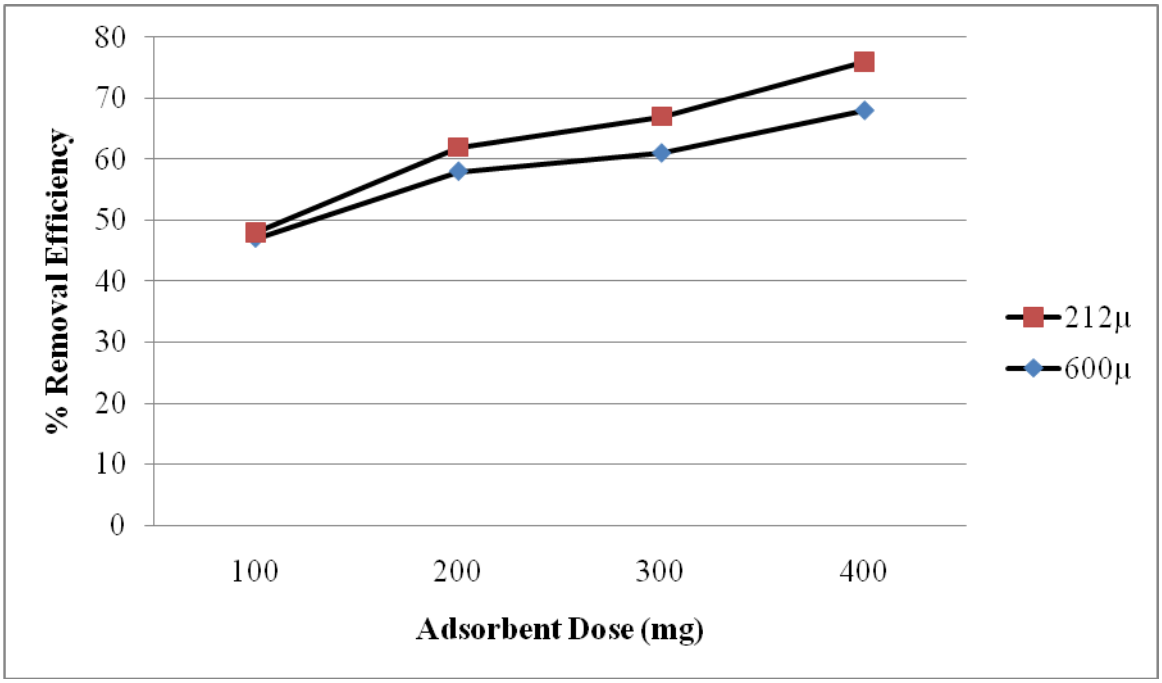


**Fig.4- Optimal adsorbent dose**

## VIII. CONCLUSION

Based on the present study following conclusions are drawn.

1. Use of the Moringa Oleifera seed powder as bioadsorbent for removal of fluoride is feasible.
2. The alkali treated Moringa Oleifera seed powder was found better than acid treated Moringa Oleifera seed powder for fluoride ion removal.
3. The removal by adsorption increases as the pH value increases.
4. The removal by adsorption was found to be optimum at adsorbent dose of 400 mg/lit.
5. The optimum contact times were 2 hrs and 2.5hrs for 212 µ and 600 µ respectively.

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