# Removal of Fluoride using Bioadsorbents

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*Abstract*— Water is scares and not readily available for everyone. As young children we have always learnt various ways to conserve water and thinking of it now it is required for all human chores and processes .It is required for both domestic as well as industrial purpose. But now days it is being infested with waste ranging from floating plastic waste to chemical waste and have turned our water bodies in a pool of poison. These water bodies contain a number of contaminants like aluminum, copper, lead, zinc, etc. Fluoride is one such contaminant present in the water. Fluoride may also be present in the effluent discharged by the various industries which when enters the water bodies increases the concentration of fluoride in the water bodies. Industries are considered as a major source of increase in the fluoride level of the water. There are many methods of treatment available for removal of flouroide. But due to many disadvantages as mentioned in this paper, other less tedious and economical methods like use of bioadsorbents like rice hisk, red mud, etc. are being used widely now a days.

***Key words:*** bioadsorbents, Removal of Fluoride using Bioadsorbents

## I. INTRODUCTION

The following shows the estimated Total Inorganic Fluoride discharge from Major Industries:

| Sources | Discharge in tone/year |
|---|---|
| Steel | **40100** |
| Ceramics | 21200 |
| Phosphate fertilizer and processing | 18700 |
| Aluminium Industries | 16000 |
| Combustion of coal | 16000 |
| Non Ferrous metal foundries | 4000 |

Table 1: Total inorganic fluoride discharged by industries

The information regarding occurrence of fluoride in ground water in India is given below:

| State | No. of Habitation with excess of fluoride | State | No. of Habitation with excess of fluoride |
|---|---|---|---|
| Andhra Pradesh | 7548 | Madhya | 201 |
| Gujarat | 2378 | Orissa | 1138 |
| Karnataka | 860 | Punjab | 700 |
| Kerala | 287 | Rajasthan | 16560 |
| Meghalaya | 33 | Tamil Nadu | 527 |
| Haryana | 334 | Uttar | 1072 |
| Himachal Pradesh | 488 | West Bengal | 21 |

Table 2. Occurrence of fluoride in ground water

### *A. Effects of excess and deficit of fluoride*

If fluoride is consumed in excess i.e. if it is consumed more than 1.5 mg/l, it causes dental fluorosis and skeletal fluorosis. It results in dental, skeletal and no skeletal forms of fluorosis i.e. high fluoride ingestion, in children as well as adults. Fluorosis in mild version can be evidenced by mottling of teeth and in high version by embrittlement of bones and neurological damage , in some of the cases it may even interfere with carbohydrates, proteins, vitamins and mineral metabolism and to DNA creation as well if intake excessively . Studies have shown that major of the Kidney diseases have a great inclination of toxicity of fluoride. On high doses and short term exposure fluoride can exterminate the kidney function. Fluoride can interfere with the function of pineal gland as well as of brain(one of the major fluoride accrued site in body with concentration more than that of teeth and bones). Workers exposed to high fluoride concentration areas are diagnosed with bladder cancer. Various diseases such as osteoporosis, arthritis, brittle bones, cancer, infertility, brain damage, Alzheimer syndrome, and thyroid disorder can attack human body on excessive intake of fluoride. Fluoride contamination in ground water is a world-wide issue. On the other hand deficit of fluoride i.e. When fluoride is consumed less than 0.5 mg/l, it causes dental carries (decaying of the teeth) 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. Therefore the removal of fluoride is very essential.

## II. VARIOUS CONVENTIONAL METHODS FOR THE REMOVAL OF FLUORIDE

Various techniques are available for the removal of fluoride from water

- Nalgonda technique
- Bone char
- Activated alumina
- Contact precipitation
- Chemical additive methods

1) Nalgonda Technique

Nalgonda technique, involves adding lime (5% of alum), bleaching powder (optional) and alum (Al2 (SO4)3.18H2O) in sequence to the water, followed by coagulation, sedimentation and filtration. A much larger dose of alum is required for fluoride removal (150 mg/mg F-), compared with the doses used in routine water treatment. Nalgonda technique is carried out with easily available chemicals and the method is economically attractive. The limitations of the method are varying alum doses depending on fluoride levels in water, daily addition of chemicals and stirring for 10-15 min, which many users may find difficult. The Nalgonda technique has been successfully used at both individual and community levels in India and other developing countries like China and Tanzania. Domestic defluoridation units are designed for the treatment of 40 liters of water (Fig. 1) whereas the fill-and-draw defluoridation plant (Fig. 2) can be used for small communities. Alum treatment is seldom used for defluoridation of drinking water in developed countries.

 

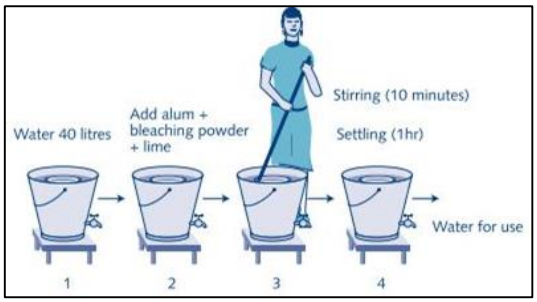


Fig. 1: Domestic defluoridation units

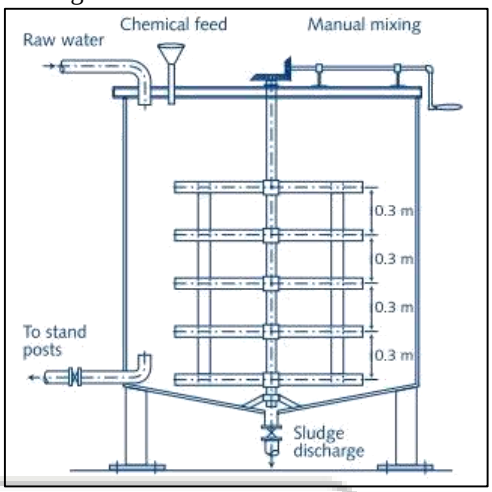


Fig. 2: Fill and draw defluoridation plant

2) Bone char

Bone char (Latin: carbo animalis) is a porous, black, granular material produced by charring animal bones.

Its composition varies depending on how it is made; however, it consists mainly of tricalcium phosphate (or hydroxylapatite) 57–80%, calcium carbonate 6–10% and activated carbon 7–10%.The tricalcium phosphate in bone char can be used to remove fluoride[3] and metal ions from water, making it useful for the treatment of drinking supplies. Bone charcoal is the oldest known water defluoridation agent and was widely used in the US from the 1940s through to the 1960s. As it can be generated cheaply and locally it is still used in certain developing countries, such as Tanzania. Bone chars usually have lower surface areas than activated carbons, but present high adsorptive capacities for certain metals, particularly those from group 12 (copper, zinc, and cadmium). Other highly toxic metal ions, such as those of arsenic and lead may also be removed.

Fig. 3: Bone char

3) Activated alumina

Activated alumina is manufactured from aluminium hydroxide by dehydroxylating it in a way that produces a highly porous material; this material can have a surface area significantly over 200 $m^2/g$. The compound is used as a desiccant (to keep things dry by absorbing water from the air) and as a filter of fluoride, arsenic and selenium in drinking water. Activated alumina, when used as a fluoride filter, under field conditions can best be regenerated by a solution of lye (sodium hydroxide; NaOH), sulphuric acid ($H_2SO_4$). The fluoride uptake capacity (FUC) of activated alumina can be up to 5000 mg/kg.

Fig. 4: Activated alumina

4) Chemical precipitation

Contact precipitation is a recently reported technique in which fluoride is removed from water through the addition of calcium and phosphate compounds. The presence of a saturated bone charcoal medium acts as a catalyst for the precipitation of fluoride either as CaF2, and/or fluorapatite. It gives high efficiency.

5) Chemical additive method

These methods involve the addition of soluble chemicals to the water. Fluoride is removed either by precipitation, co precipitation, or adsorption onto the formed precipitate. Chemicals include lime used alone or with magnesium or aluminum salts along with coagulant aids. Treatment with lime and magnesium makes the water unsuitable for drinking because of the high pH after treatment. The use of alum and a small amount of lime has been extensively studied for defluoridation of drinking water.

*A. Merits and Demerits*

| Method | Merits | Demerits | Relative Cost |
|---|---|---|---|
| Nalgonda | Low Technology, Adaptable at Point of Use & Point of Source Level | – Large quantity of sludge<br>– High chemical dose<br>– Dose depend on F-Level<br>– Daily addition of chemicals and stirring in point of source units | Low to medium |
| Bone Char | Local Available Media | – May impart taste and odor and result in organic leaching if not prepared properly<br>– Requires regeneration periodically<br>– May not be acceptable in some countries | Low to medium |
| Activated Alumina | Effective | – Periodic regeneration<br>– Properly trained staff for regeneration of point of use units<br>– Suitable grades may not be indigenously available in less developed countries | Medium – High |

 

| | | | |
|---|---|---|---|
| Contact Precipitation | Much Experience Not Needed | – Algal growth can occur in phosphate solution<br>– Bone char used as a catalyst may not be acceptable in many countries | High – Very high |
| Chemical Additive Method | Effective | – High operational and maintenance cost<br>– Low fluoride removal capacitites<br>– Undesirable effects on water quality<br>– Generation of large volume of sludge | Very High |

Table 3: Merits and demerits of conventional methods

## III. INNOVATIVE METHODS

Since there are many disadvantages, various innovative methods are now being studied in which adsorption is used which makes use of various low cost adsorbents. Different low cost adsorbent materials are available for effective removal of fluoride from water. The naturally available adsorbents are horse gram powder, ragi powder, multhani matti, red mud, calcined clay, concrete, pine apple peel powder, chalk powder, orange peel powder, rice husk, red mud, Moringa oleifera extract, goose berry, activated alumina coated silica gel, activated saw dust, activated coconut shell carbon, coffee husk, bone charcoal, activated soil sorbent, etc. are some of the different materials investigated for adsorptive removal of fluoride from water.

### *A. Benefits of low cost adsorbents*

*1) Cheap*
The cost of adsorbent is low since they are often made from locally, abundantly and easily available materials.
*2) Metal Selective*
The metal adsorbing performance of different types of bio-mass can be more or less.
*3) Regenerative*
Sorbent material can be possible to reuse after regeneration.
*4) No Sludge Generation*
Unlike the problems in other techniques (ex: precipitation), there is no issue of sludge generation in adsorption process.
*5) Metal Recovery*
If adsorbate is a metal ion, it is possible to recover the metal ion after being desorbed from the adsorbent materials.
*6) Competitive Performance*
Performance of adsorption process in terms of efficiency and cost is comparable with the other methods available.

### *B. Factors to be considered while choosing your adsorbent*

*1) Fluoride Removal Capacity*
Since every solid is a potential adsorbent, simply choosing any material for the removal is of no use if it doesn't remove the fluoride content to the required level. The adsorbent should be able to drop the fluoride concentration to the desired level.
*2) Availability and acceptability w.r.t cost*
The adsorbent should be often made from locally, abundantly and easily available materials
*3) Regenerative*
It should have the ability to regenerate itself so that it can be reused.

## IV. EFFECTIVE LOW COST ADSORBENTS FOR REMOVAL OF FLUORIDE FROM WATER

### *A. Methodology*

Four Columns were taken for 4 materials viz red soil, orange peel powder, chalk powder and ragi seed powder. Water containing fluoride was allowed to pass through columns. Samples were collected from all the 4 columns .They were analyzed and compared in order to find out the fluoride concentration.

### *B. Observation*

*1) Red Soil*
Red soil is highly porous and contains iron oxides, and also contains chemical reactants of fluoride which may form other useful products. The maximum adsorption of fluoride occurred over the pH range 5.0-7.0. The fluoride adsorption process took place in two stages. The first rapid stage in which 70-80% adsorption that was achieved in 20 min, and second stage (comparatively slower), with equilibrium attained in 2 h. The first stage was due to the initial accumulation of fluoride at the mud surface, as the relatively large surface area was utilized. With the increasing occupation of surface binding sites, the adsorption process slowed. The second stage was due to the penetration of fluoride ions to the inner active sites of the adsorbent.
*2) Orange Peel Powder*
It was found that due to certain porosity of orange peel powder, it adsorbs fluoride from aqueous solution.
*3) Chalk Powder*
The adsorption taking place by Chalk powder was due to certain porosity adsorbs fluoride from aqueous solution
*4) Ragi Seed Powder*
Ragi seeds are the low cost material act as a bioadsorbent. It is responsible for fluoride adsorption from aqueous solution.

### *C. Observation Table*

| Sr. No | Adsorbent | Initial concentration of fluoride in mg/l | Final concentration of fluoride in mg/l | Efficiency % |
|---|---|---|---|---|
| 1 | Red mud | 20 | 9.4 | 53 |
| 2 | Orange peel powder | 20 | 6.5 | 67.5 |
| 3 | Chalk powder | 20 | 4.6 | 77 |
| 4 | Ragi seed powder | 20 | 10.2 | 49 |

Table 4: Fluoride removal by various materials

 

Chalk powder is most efficient as compared to other materials.

*D. Result*

Most of the adsorbents performance is depend on the pH and temperature. The removal capacity increases by increasing dose of the adsorbent and decreasing size of the adsorbent. The new treated adsorbents are also available and can help in more rapid and extensive developments for the treatment of fluoride.

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