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Removal of Fluoride from Water Using Low Cost Adsorbents

Nikhil Chavan[1], Hema Patel[2]

[1] Student, Environmental Engineering, D.Y. Patil College of Engineering, Maharashtra, India

[2]Assistant Professor, Environmental Engineering, D.Y. Patil College of Engineering, Maharashtra, India

Abstract: ***Fluoride is an essential constituent for both humans and animals depending on the total quantity ingested or its concentration in drinking water. The aim of this study is to find out the low cost treatment for removal of fluoride from drinking water. The current study can be implemented on a domestic basis. Batch and column adsorption studies were undertaken using the Beetroot seeds and Okra seeds as adsorbents. Studies were carried out under the varying conditions of the major parameters of adsorption, viz. pH, rate of stirring, contact time and dose of adsorbent. Initially the batch studies were undertaken for Beetroot seeds and were followed by Okra seeds. A combination of both adsorbents is also tried. All the experiments were carried out at pH=7. The fluoride adsorption is maximum for batch experiment at 90 minutes of contact time. It was found that the sufficient time for adsorption equilibrium of fluoride ion was around 2 hours. The removal of fluoride ions is maximum for the adsorbent dosage of both the seeds is around 8 gm/ lit. The adsorption of fluoride ion is maximum in the stirring speed of 150 rpm. Column analysis gave efficiency in initial stage of 78 percent for 0.4lit/hr flow rate and the efficiency goes on decreasing after some time. Fluoride determination was carried out with the help of visible Spectrophotometer (HACH DR 3900).***

Keywords: Beetroot seeds, Column adsorption, Okra seeds, SPADNS reagent.

1. Introduction

Fluoride is one of the most important constituent present in groundwater in India which creates a major health problem. There are various methods available for the removal of fluoride from water. Conventional treatment methods like adsorption, ion exchange, reverse osmosis, coagulation, precipitation, etc. can be implemented on household to community level to reduce fluoride concentration. These methods are effective but are also costly. Sludge generation in the Nalgonda technique can be a problem. To overcome all these difficulties defluoridation by naturally available adsorbents have been tried in this study which is also cost effective. The method used in this study for the estimation of fluoride in water sample is colorimetric SPADNS (sodium 2 (parasulfophenylazo)-l, 8-dihydroxy-3, 6-naphthalene disulfonate) method [4, 6, 7, 10]. Ion selective electrodes can also be an alternative to measure fluoride concentration in water.

2. Materials and Methods

All the reagents used for the present study is of AR grade from E. Merck Ltd. A standard fluoride stock solution is prepared by dissolving 2.21 g of anhydrous sodium fluoride in 1000 ml of double distilled water. Fluoride standard solution was prepared by diluting 100 ml stock solution to 1000 ml distilled water. This 1 ml solution has 0.1 mg of fluoride. The fluoride solution of required concentration is prepared by diluting this standard solution. The volume of sample taken for all the experiments is 1000 ml. All the adsorbents used in this study were collected locally, washed well with tap water and then with distilled water, dried in an air oven at 125°C for 24 hours. The synthetic solution of fluoride prepared from analytical reagent sodium fluoride was stored in glass bottles. The pH of the solution was adjusted to the required level, using 0.1N H_2SO_4 and 0.1N NaOH solutions.

Activation of Beetroot seeds and Okra seeds was carried out by adding concentrated sulfuric acid (H_2SO_4) in a ratio of 4:3 by weight and giving heat treatment in an oven for about 24 hours at 125^0C. Adsorbents were grinded in fine powder and sieved. The particle size obtained was of 0.425 mm. A glass column of diameter 18mm and having a length of 300mm is taken for the experiment in which a combination of adsorbents is tried.

2.1 Instrumentation

HACH DR3900 single beam spectrophotometer with 2.0 cm quartz cells is used for determination of fluoride in sampling water. All the readings were carried out at 580 nm wavelength.

3. Batch Studies

The batch experiments were carried out in 500 ml beaker and by adding a pre-weighed amount of the adsorbent. The solution was then kept in a jar apparatus for stirring at a constant rpm. Varying contact time was given so that adsorption process gets followed properly. The solution was kept still so that adsorbent can get settled easily and then the adsorbent was separated with a filter paper. The concentration of fluoride remaining in the filtrate was analyzed spectrophotometrically using SPADNS reagent at λ_{max} = 580 nm. All the analysis was performed at room temperature.

4. Column Experiment

A glass column of diameter 18mm and having a length of 300mm is taken for the experiment in which a combination of adsorbents is filled. Continuous flow rate of 0.4, 0.6 and 0.8 lit/hour was maintained. Column is filled with pre-weighted amount of adsorbent which is 8gm of beetroot seeds and 8gm of okra seeds. Samples were collected at an interval of 1 hour for fluoride determination.

5. Results and Discussion

5.1 Batch Study

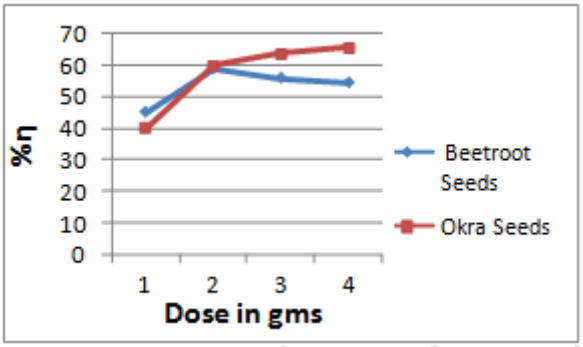

Figure 1: Effect of dose

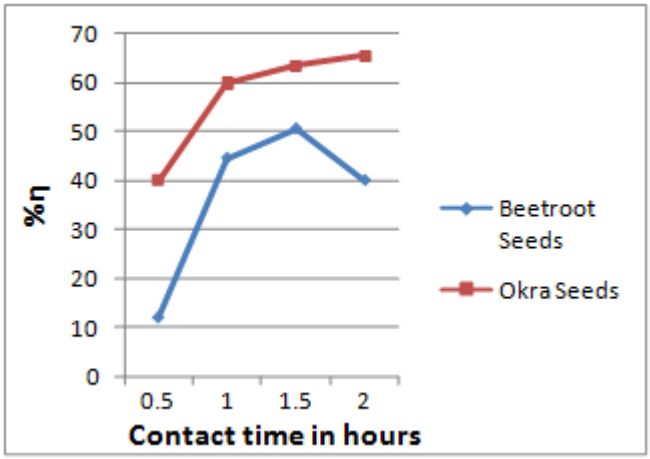

Figure-2: Effect of contact time

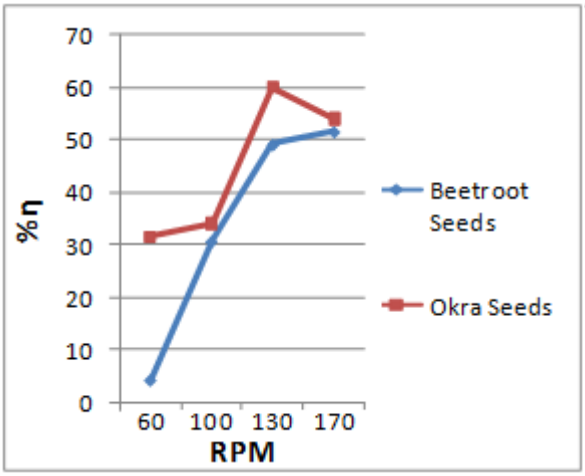

Figure 3: Effect of RPM

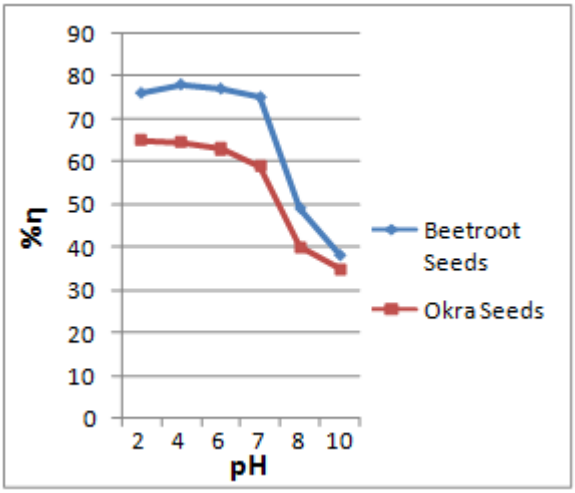

Figure 4: Effect of pH

5.2 Column Study

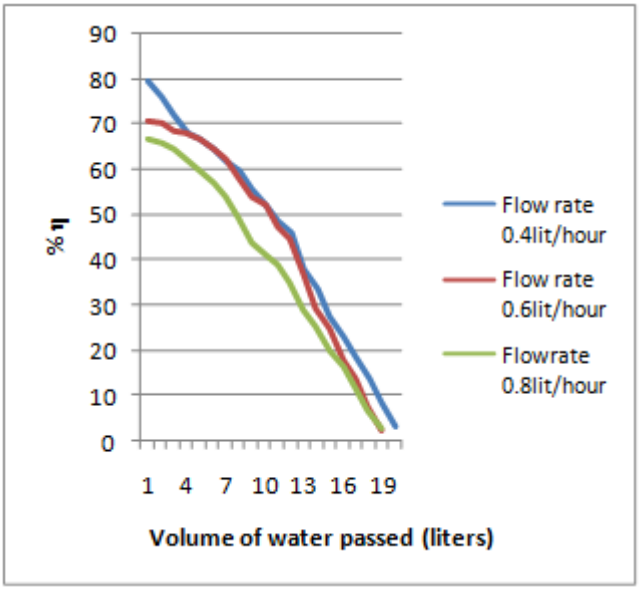

Figure 5: Column study for various flow rates

5.3 Isotherms

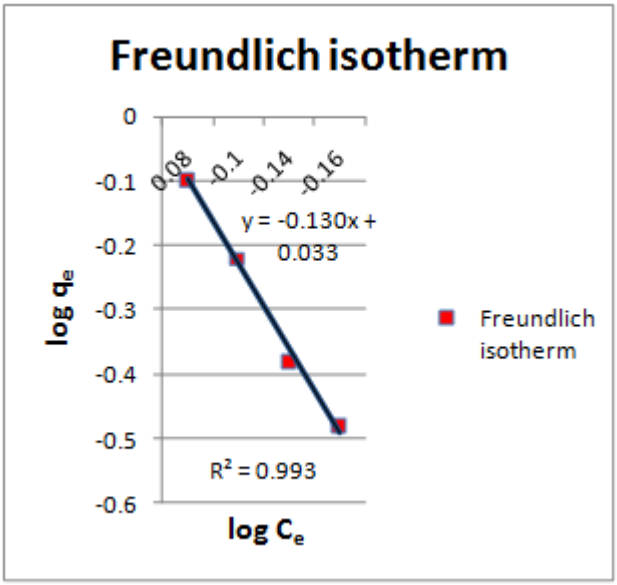

Figure 6: Freundlich isotherm for Okra seeds

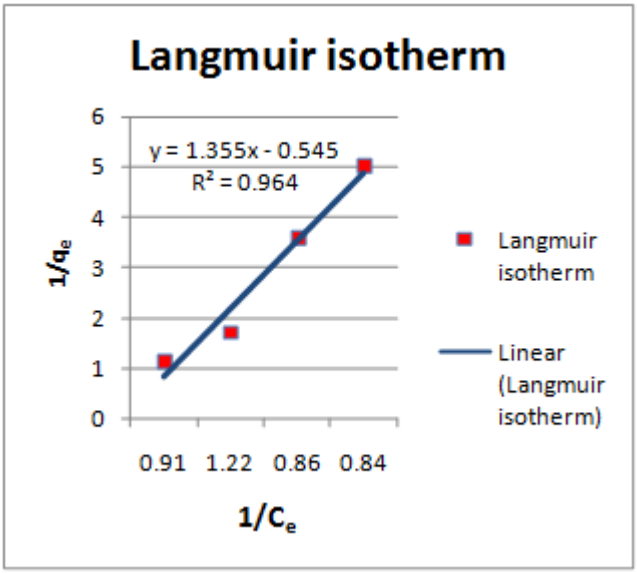

Figure 7: Langmuir isotherm for okra seeds

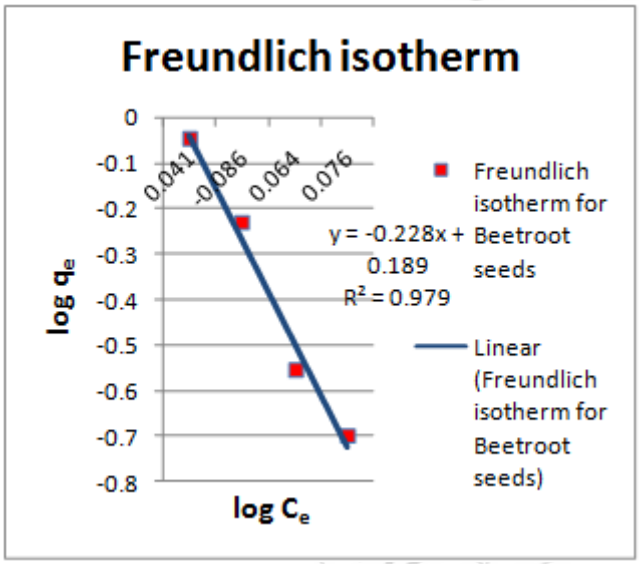

Figure 8: Freundlich isotherm for Beetroot seeds

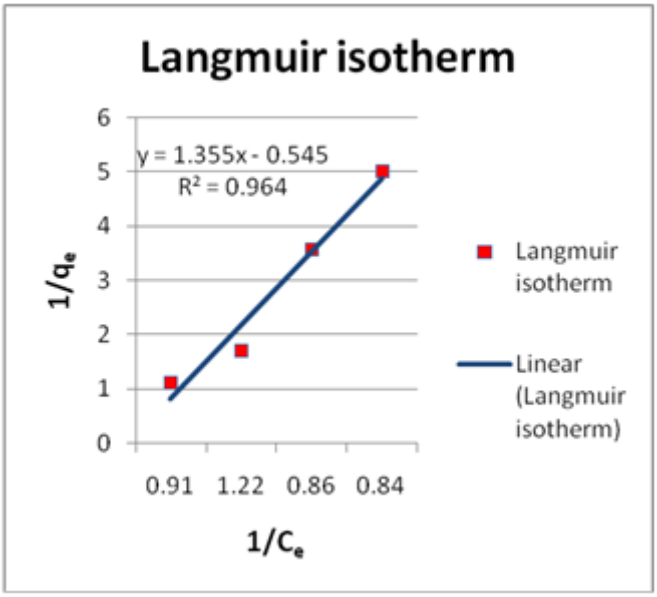

Figure 9: Langmuir isotherm for Beetroot seeds

6. Regeneration of adsorbent

The used adsorbents were regenerated by treating it with 0.1N H_2SO_4 and keeping it in oven for 24 hours at temperature of 125^0C and then reused.

7. Future Scope

Future scope of this study may include trying different fluoride concentrations and performing scanning electron microscope (SEM) experiments.

8. Conclusions

Beetroot seeds and Okra seeds can be used effectively to reduce fluoride content in drinking water. A maximum of 87 percent and 83 percent removal is accomplished by using Beetroot seeds and Okra seeds respectively at an optimum contact time of 90 minutes. The amount of fluoride adsorbed was found to be optimum at a dose of 8 gm/lit. Maximum removal efficiency was achieved at pH= 7 for both the adsorbents. The maximum fluoride removal efficiency for combined adsorbents is found to be satisfactory at 150 rpm. Column analysis gave efficiency in initial stage of 78 percent and the efficiency goes on decreasing after some time. Column analysis can be used in the form of a cartridge in domestic water purifiers in areas that have high fluoride content. This method can be a substitute for chemical treatment in which sludge generation takes place.

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Author Profile

Nikhil R. Chavan is Student, M.E. Environmental Engineering, D.Y. Patil college of Engineering, Akurdi, Pune-44. He received B.E. Environmental Engineering degree from Kolhapur Institute of Technology, Kolhapur in 2013.

Mrs. Hema Patel is Assistant professor, D.Y. Patil college of Engineering, Akurdi, Pune-44