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Calcium Ion Impregnated on Water Hyacinth for Defluoridation of Water

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Abstract

Fluoride ion has adverse effect to human body if it exceeded beyond the permissible limit. Adsorption technique is one of the efficient method for removal of fluoride from water by using biomass. In present work water hyacinth (*Eichhornia Crassipes*) leaf powder was used as biomass along with the loaded calcium ion. Calcium carbonate ($CaCO_3$) was used as doping reagent in microwave. Batch experiments were carried out for 5-25 mg/l of fluoride concentration. It was observed that using water hyacinth loaded with the calcium ion 83.34 % fluoride removal was achieved. The effect of various parameters on fluoride removal was studied in batch experiments.

Keywords: Biosorption, Calcium Carbonate, Defluoridation, Synthesis, Water hyacinth leaf.

Introduction

Fluoride ion in drinking water has special effect on human health. It is an important element which is used for the growth of human organs such teeth and bones. Permissible limit of fluoride in drinking water is 1.5 mg/l [1]. But if it exceeded beyond permissible limit causes adverse affect on human health such as dental, skeletal, and non skeletal fluorosis to children as well as adults [2].High fluoride concentration in water also affects plants and animals. Increased in fluoride concentration prevents plant metabolism. In animals, it interferes with carbohydrates, lipids, proteins, vitamins, enzymes and mineral metabolism at higher percentage [3]. Fluoride generally enters into the atmosphere through water, food, exposure from industries, drugs, cosmetics, etc., but drinking water is the main source of fluoride consumption [4].

As awareness of fluoride problem comes to the head, there should be development of efficient techniques for removal of fluoride from water. Various techniques are use for fluoride removal such as precipitation [5],

ion exchange [6], reverse osmosis [7], donnan dialysis [8], electro dialysis [9], nano filtration [10], membrane based methods [11], electro coagulation [12] and adsorption by using different adsorbents [13] [14] [15] [16]. It is very important to select choose an suitable technique based on economical, cheap, easy to handle, availability of materials and reuse of materials etc. So adsorption is one of the technique which comes to desired needs. Adsorption by using biomass as adsorbent is very cheap, environmental friendly and efficient for defluoridation [17] [18].

But improvement of a new form of adsorbent using biomass is important. Synthesized biosorbent used for removal of fluoride from water gave high recovery as compare to normal biosorbent.

In recent research has shown that biomass which in loaded with Calcium (Ca) ions has high affinity towards fluoride ions [19]. Water hyacinth leaves are one of the biomass which used as biosorbent for defluoridation of water. It is easily available in nature and consider as waste because it disturb aquatic life. Development for use of water hyacinth as an inexpensive source of biomass.

This present work was carried out to find out the potential of water hyacinth loaded with calcium ions for defluoridation of water.

Materials and Methods

Water hyacinth leaves were collected from Katraj Lake, Pune. Washed with water then sun dried for 4 to 5 days in an open atmosphere and then crushed and washed with distilled water until the pH of water became neutral. Then the powder was dried in hot air oven at 90°C for 5 hours which used as base biomass material. Loaded biomass with calcium ions were formed by adding 25 gm of calcium carbonate ($CaCO_3$) to 200 ml of distilled water and stirred in horizontal shaker for 30 minutes. Then 50 gm of biomass was added into the above solution and stirred in horizontal shaker for 2 hours in order to get an aqueous solution. Aqueous solution was heated in scientific microwave (450 KW) at 100°C until the dried powder formed. Then dried powder was crushed again and sieved to obtain a particle size of below 600 µm.

The characterization of biosorbent was done by using Fourier Transform Infrared Spectrometer (FTIRS) to determine the elemental constituents of biosorbent.

Stock solution was prepared by adding 2.21g of sodium fluoride solution in 1000 ml of distilled water. As per the requirement the stock solution was diluted to get solution of required concentration.

Batch experiments were carried out in order to optimize the effect of various parameters such as pH, dose of adsorbent, initial concentration of fluoride, contact time, temperature and rpm using horizontal shaker (*Labline*, LS-104) on fluoride removal. The concentration of fluoride from water was determined by UV-Spectrophotometer (*Perkin Elmer*, CE2021 2000 Series) using SPANDS method [20].

Results and Discussion

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1. FTIR analysis

The FTIR spectrum of water hyacinth loaded with calcium ion powder were obtained to determine the nature of elemental constituents present in it as shown in figures 1. The band peaks around 500 cm^{-1} to 800 cm^{-1} showed that calcium ion doped on biomass.

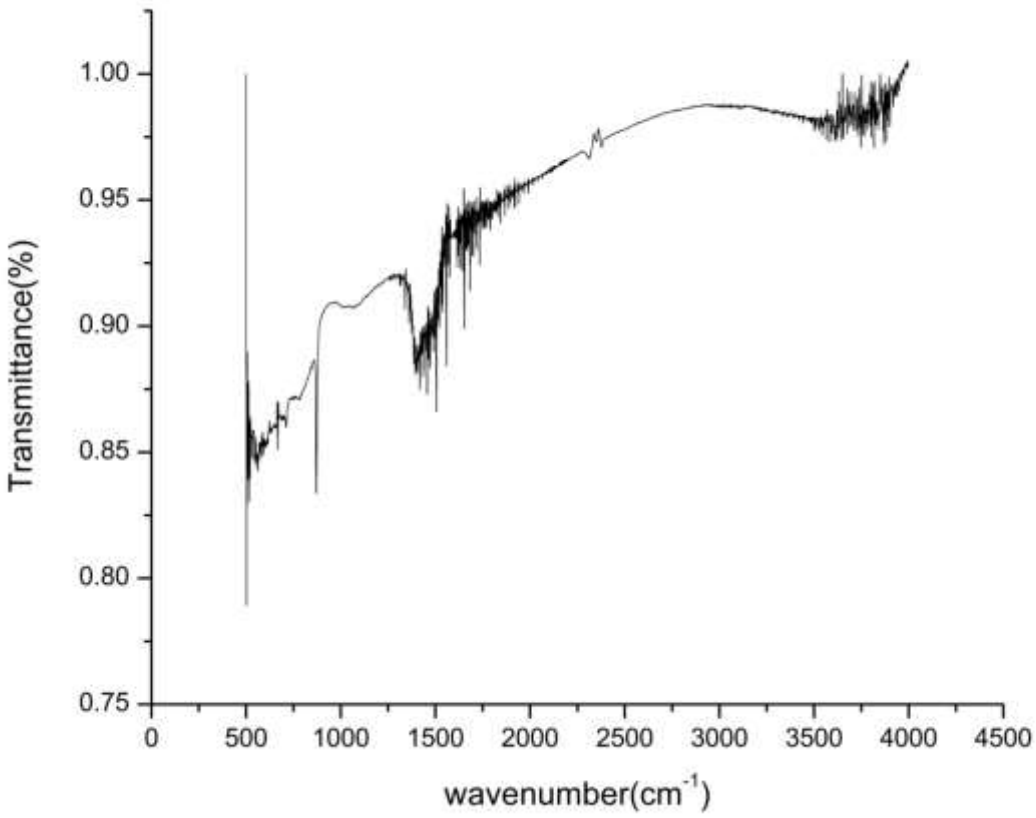

Figure.1. FTIR spectrum of biosorbent

2. Effect of biosorbent dose

The fluoride ions removal efficiency was studied by varying the biosorbent dosage from 0.5-3 gm/100ml by keeping other parameters constant such as initial concentration of fluoride ion 5.0 mg/l, 100 rpm, contact time 120 min and 28°C temperature was maintained. In figure 2 it was the percentage removal of fluoride increases till 83.34%. It was seen that initial percentage of fluoride removal increases with increase in biosorbent dosage but after 120 min the percent removal of fluoride ion was decreased due to lack of active sites of biosorbent. It was observed that fluoride get attracted by positively charged calcium (Ca) which doped in biosorbent due to its strong electro negativity.

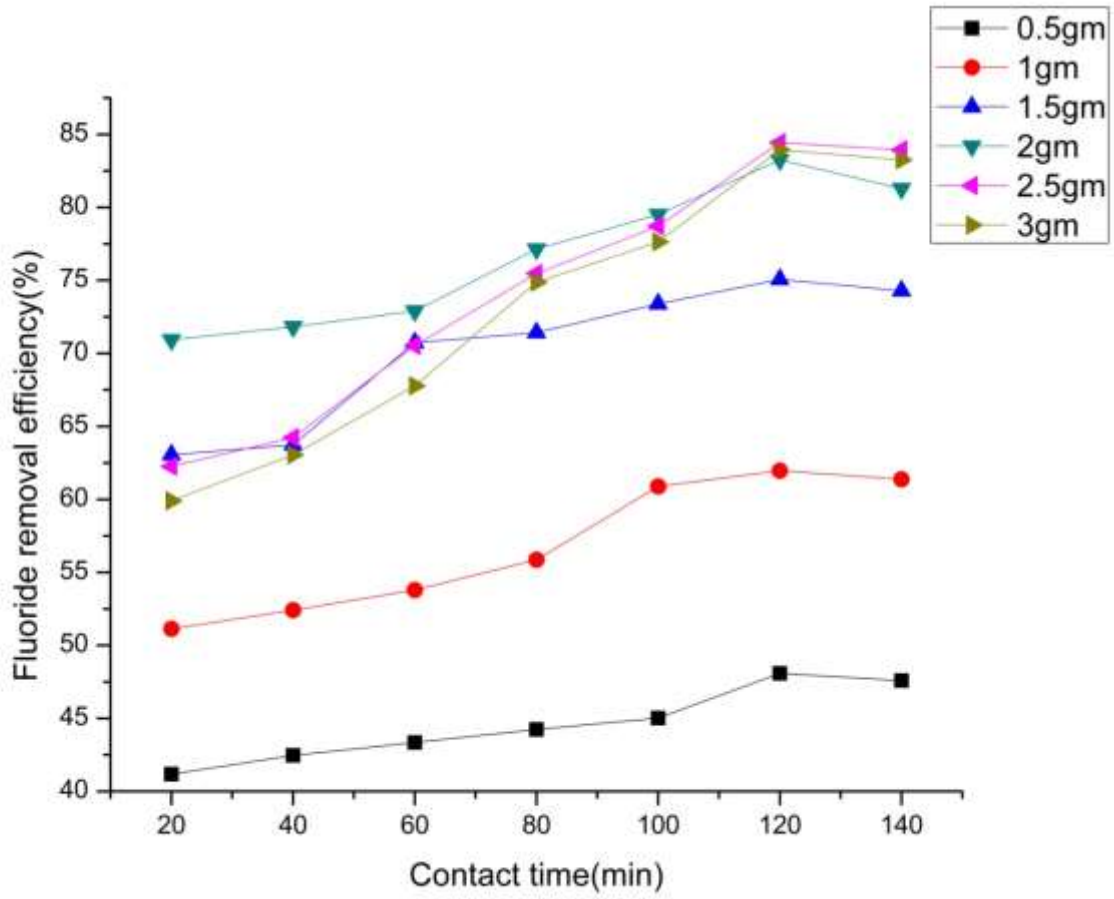

Figure.2. Effect of Dose on Fluoride Removal Efficiency

3. Effect of rpm

The fluoride removal efficiency of water on effect of rpm speed as shown in figure 3. The percentage removal of fluoride was increased with increase in rpm and attained equilibrium at 100 rpm after two hours. As the rpm increased beyond 100 rpm the percent removal of fluoride was decreased. As the centrifugal forces were generated within the system the contact area between adsorbent and adsorbate was reduced.

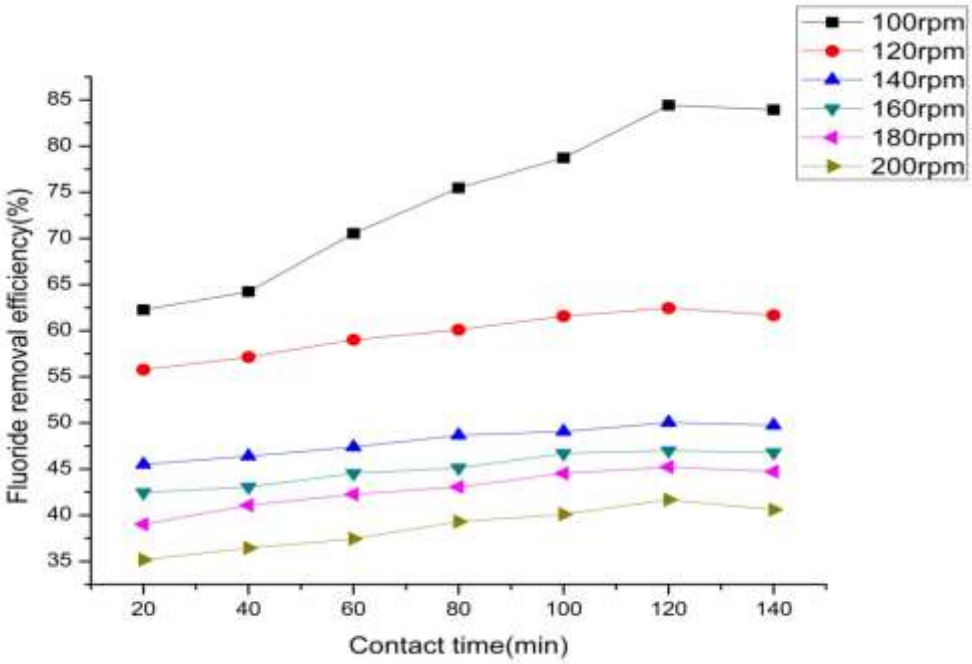

Figure.3. Effect of rpm on fluoride removal efficiency

4. Effect of fluoride concentration

The effect of initial fluoride concentration was studied using the fluoride concentration 5 mg/l to 25 mg/l while other parameters were kept constant such as pH 7, biosorbent dose 2.5 gm/100ml, 100 rpm at room temperature. Every experiment was carried out at stable contact time of 120 minutes. It was found that effect on fluoride removal efficiency was decreased by increased in fluoride concentration. It observed that maximum fluoride removal efficiency at 5 mg/l initial fluoride concentration as shown in figure 4.

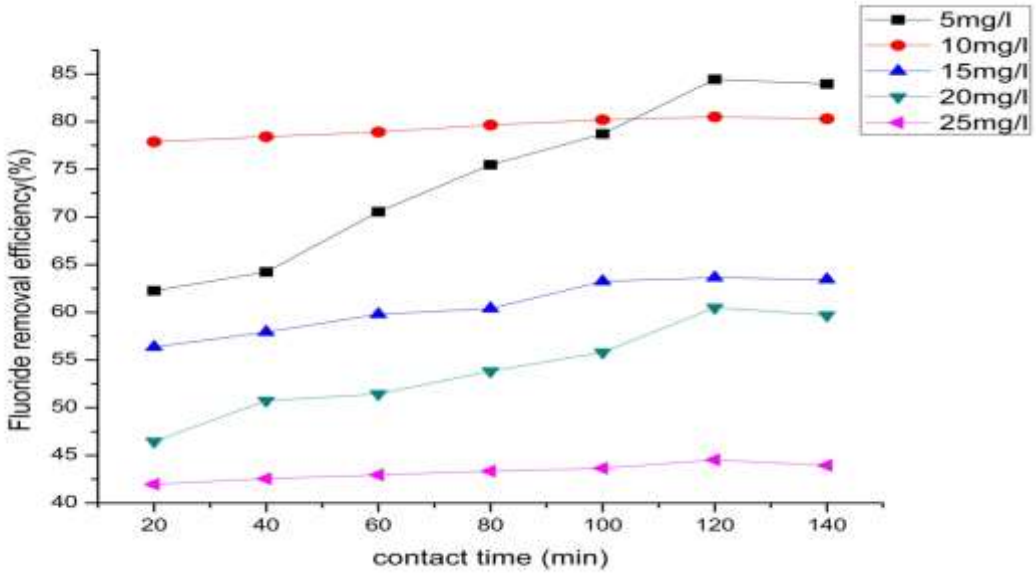

Figure.4. Effect of Concentration on Fluoride Removal Efficiency

5. Effect of pH

Effect of pH on biosorption on removal of fluoride with variation of contact time shown in figure 5. It observed that amount of fluoride sorption on the system decreased by increased in pH from 3 to 11. At pH 3 maximum sorption occurred due formation of hydrogen ion so that fluoride easily adsorbed by calcium ion loaded biosorbent. Whereas, at basic pH range the fluoride removal efficiency decreased due to increase in hydroxyl ion which form complex compound with water which retard the sorption.

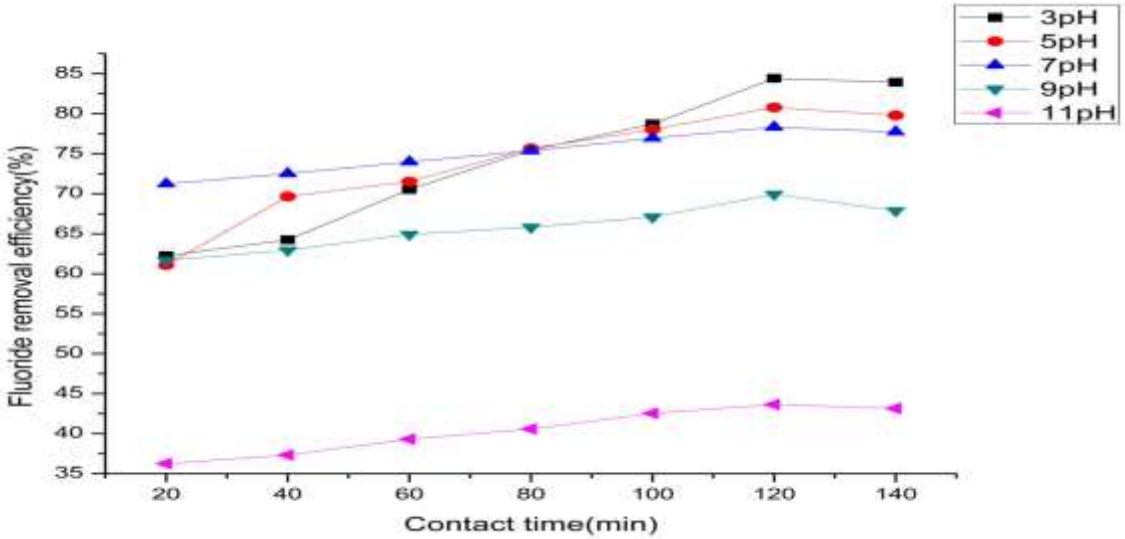

Figure.5. Effect of pH on Fluoride Removal Efficiency

6. Effect of Temperature

The effect of temperature on fluoride removal efficiency was carried out at three different temperatures (30°C, 40°C and 50°C) by keeping all other experimental parameters constant such as pH 7.0, agitation speed 100 rpm, biosorbent 2.5 gm, concentration 5mg/l as shown in figure 6. It was observed that as increased in time the adsorption capacity was also increased. The increase in rate of biosorption capacity with increase in time may be due to increase in active site of biosorbent available for biosorption but after 120 minutes adsorption capacity decreased due to saturation of loaded biosorbent.

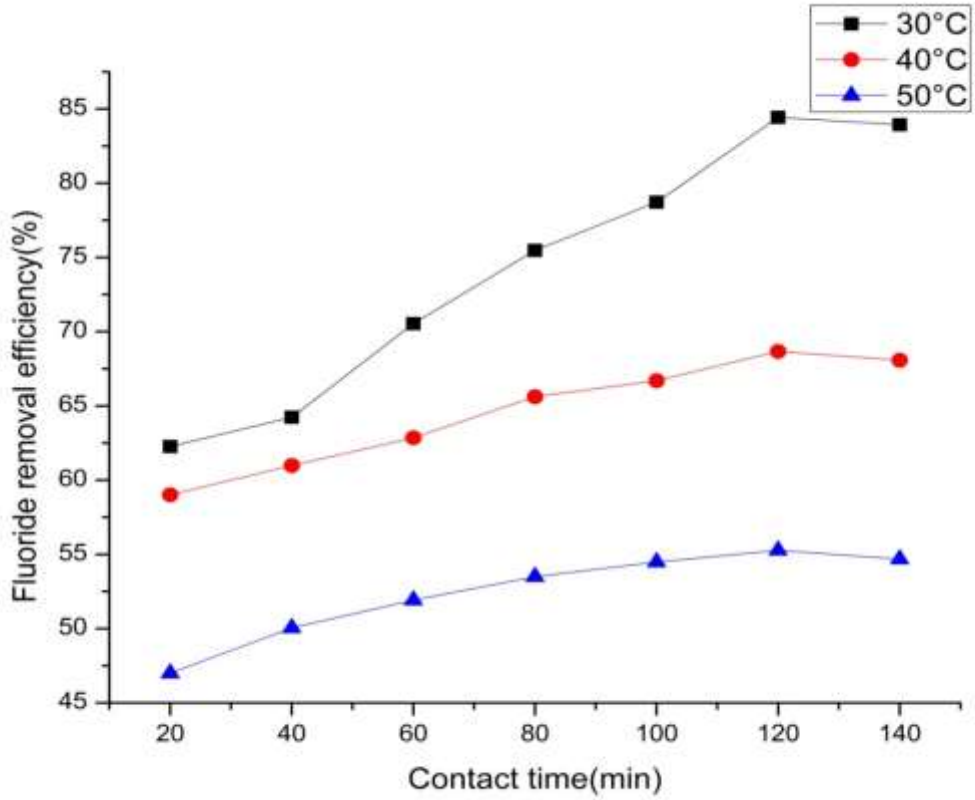

Figure.6. Effect of Temperature on Fluoride Removal Efficiency

Conclusion

Batch experiment studies carried out on the water hyacinth loaded with calcium ion showed varied fluoride sorption capacity at varied various parameter such as fluoride concentration, pH, rpm, temperature, dosage with contact time. At lower pH range fluoride sorption capacity increased.

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