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Doping of Calcium of Hydroxide on Bio-adsorbent for Removal of Fluoride from Water

Snehal Thorat[1], KavitaKulkarni[2], Dr. A.D.Kulkarni[3]

Bharati Vidyapeeth University College of Engineering, Chemical Engineering Department,

Pune 411043, India

[1, 2, 3] Department of Chemical Engineering, Bharati Vidyapeeth College of Engineering, Pune, India

snehalthorat083@gmail.com

kskulkarni@bvucoep.edu.in

kdkulkarni@bvucoep.edu.in

Abstract

Fluoride is one of the anionic contaminants, whichis found in excess in surface or groundwater because of geochemical reaction or anthropogenic activities such as the disposal of industrial wastewater. Biodsorbent-*Butea-Monosperma* leaf powder was prepared by doping of calcium hydroxide in the microwave. A batch study on fluoride biosorption was carried out for different variables, like pH, initial fluoride concentration, dose of adsorbent, of horizontal shaker.In order to investigate the mechanism of fluoride removal, various adsorption isotherms such as Langmuir and Freundlich were studied.

Keywords: *Butea-Monosperma* leaf, Calcium hydroxide, kinetic Isotherm, fluoride removal.

1.Introduction

The natural presence of fluoride generally occurs through soil rock formation in the form of fluorapatite, geochemical deposits, natural water system and earth crust [1, 2]. In additional fluoride found in various industrial activities, specially semiconductor, electroplating, glass, steel, ceramic and fertilizers industries [3]. Fluoride is pale, yellow-green, corrosive gas which almost cannot be found in natural environmental in element from due to its high electronegativity and reactivity [4]. According to World Health Organization (WHO) the maximum permissible limit of fluoride is 0.5-1.5 mg/l as per APHA standards. Therefore higher fluoride concentration cause severe harmful effects in aquatic life as well as in human bodies. Excess intake of fluoride by human being may leads to dental caries, brain, bone fluorosis [5].

De-fluoridation techniques are classified as, Adsorption [6], membrane filtration [7], precipitation [8], Nano-filtration [9], electrocoagulation [10], ion-exchange [11], these are used for fluoride removal. Adsorption is applicable for low concentration of removal of fluoride. In recent year study on the removal of fluoride by using natural, synthetic and biomass material such as activated carbon or alumina [12], fly ash [13], alum sludge [14], red mud [15], zeolite [16]. A lot of adsorbents used by fluoride removal capacity, the lowest

limit for fluoride reduction by most of the adsorbent is 2 mg/l therefore, they are not suitable for drinking water. If pH < 3, it is more effective to removal of fluoride [17].

The biodsorbent*(Butea-Monosperma*) leaf doped by calcium hydroxide prepared in microwave activation was used for fluoride removal. A batch adsorption study was carried out at various parameters.

2. Materials and Methods

The biosorbent *Butea-Monosperma* leaves were collected from local area of district Satara, Maharashtra in India. The leaves were dried in open atmosphere for 5-7 days, crushed and washed with water and dried in sun light. 50 g of biosorbent was taken along with 50 g of calcium hydroxide was mixed with 500 ml of water adjust the neutral pH. These samples were shaken in horizontal shaker at 180 rpm for 2 hour and after mixing sample were heated from ambient temperature to the carbonization temperature of 140^0C at 5-10 minutes inmicro-oven.SPADNS method was used to analyze residual fluoride [18, 19].The samples were collected at every 20 minutes interval, filtered and analysed using UV-Vis Spectrophotometer (CE2021 2000 Series). Analysis was done and the removal of fluoride efficiency was calculated.

3. Results and Discussions

Fig 1represents FT-IR spectrum is an essential for identify the surface functional group in this case the NR_4 group is functional group of contribute extensively to adsorption efficiency. The broad band at 3431 cm^{-1} O-H stretching intermolecular hydrogen bonding of polymeric compound. The weak peak at 1715 cm^{-1} in spectrum to stretching C=O in carboxylic acid group corresponding to trace other acid for spectrum, the bands 1424 cm^{-1} and 1326 cm^{-1} with nearly equal intensity to $–CH_2$ and –OH respectively. In following peak 681 cm^{-1} stretched C-H out plane bonding, 3431cm^{-1} stretched O-H, 898 cm^{-1} and 839 cm^{-1} stretched C-H out of plane deformation.

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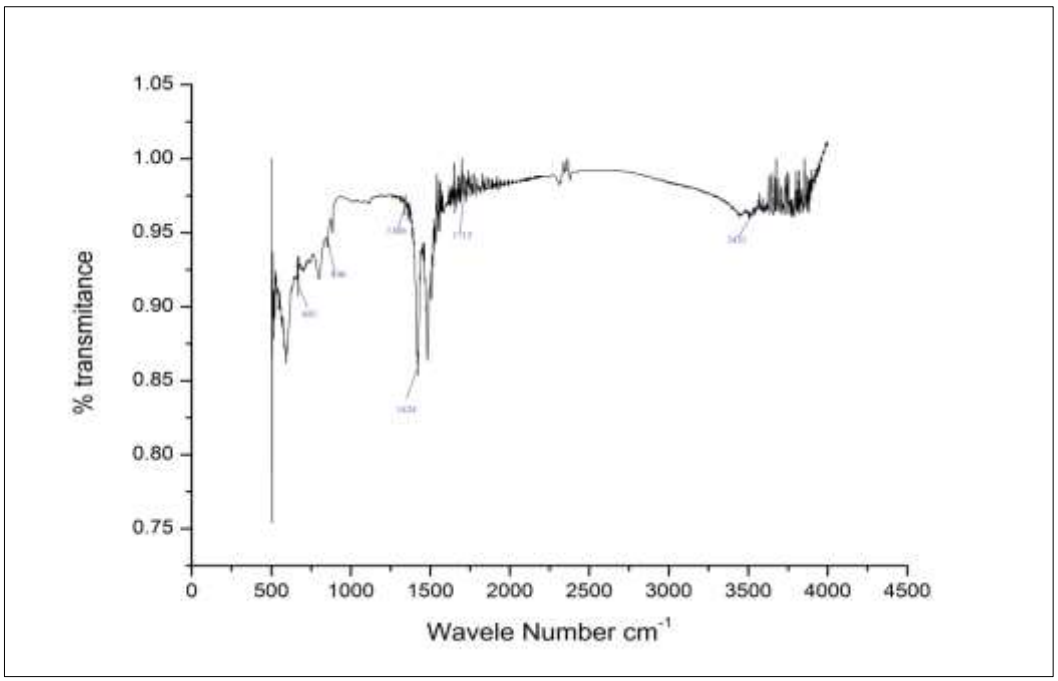
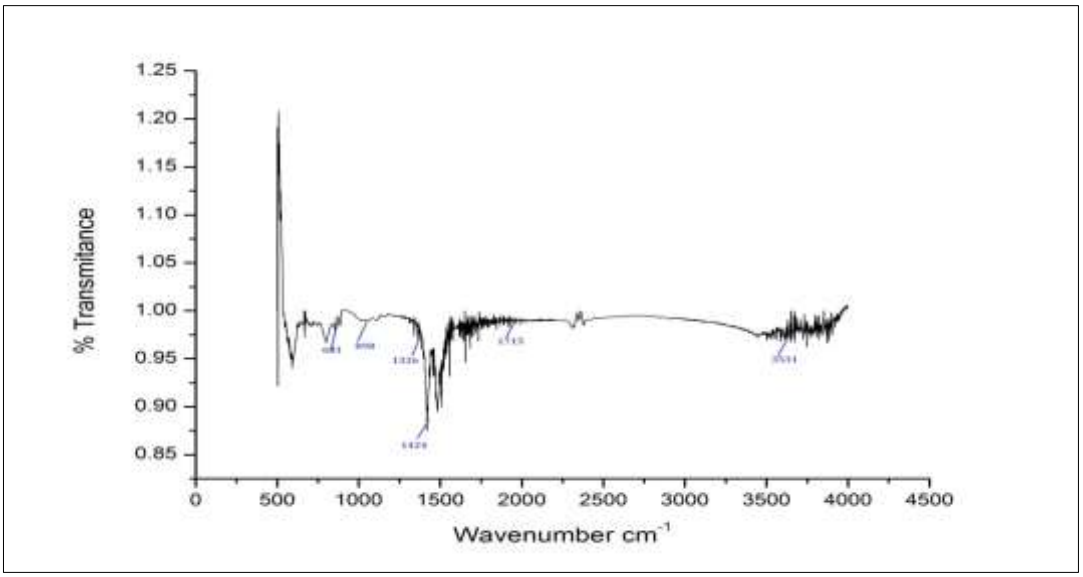


(a)



(b)

Fig 1 FTIR spectrum of *Butea-Monosperma* leaf powder doped with calcium hydroxide

(a) before fluoride adsorption (b) after fluoride adsorption

3.1Effect of biosorbent Dose

Initial fluoride concentration 5 mg/l and at room temperature is shown in Fig.2. The pH of solution was kept constant at 7. The adsorbent dosages was varied from 0.5 g/l, 1 g/l, 1.5 g/l, 2 g/l, 2.5 g/l and equilibrated for 120 min. The percent removal of fluoride increased with increase in adsorbent dose and a maximum removal of 97.2% was obtained with an adsorbent dose of 2.5 g/l. The higher removal capacity at higher

adsorbent dose attributed to the availability of more effective surface area of the preparation adsorbent for adsorption [20].

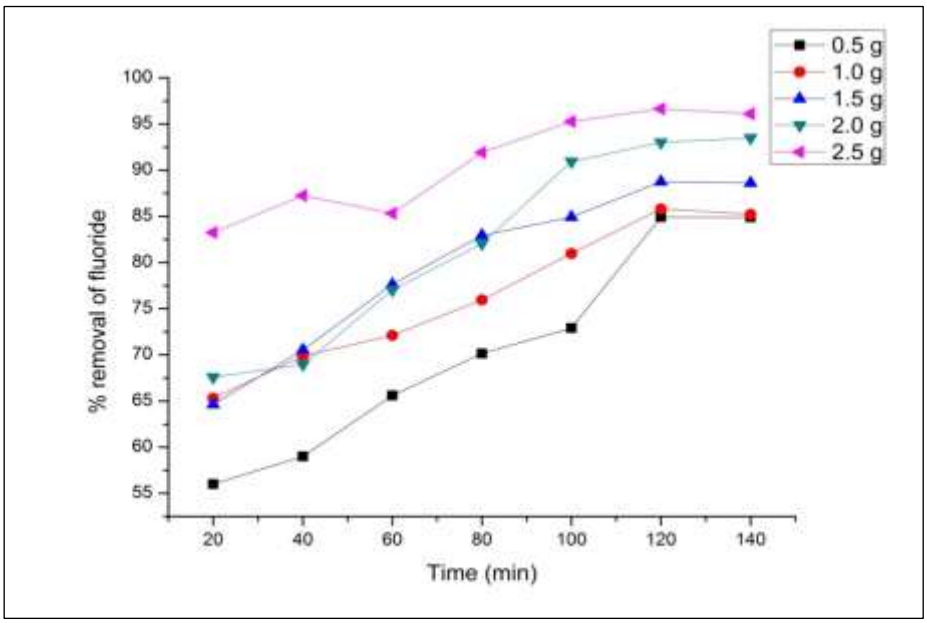


Fig.2. Effect of biosorbent Dose on % removal of fluoride

3.2Effect of pH

The adsorption of fluoride was studied over a pH range as shown in Fig. 3 The fluoride removal increases with decreasing in pH values and pH was increased from 3-5, the fluoride removal efficiency was decreased from 93.6 % to 86.3 %.The adsorption of other ions gets affected due to the strong affinity for H^+ and OH^- ions on adsorption sites. Because of H^+ ions concentrations at lower pH the negative chargers on the adsorbent surface get neutralized. This is in turn reduces the diffusion of negatively charged fluoride ions and gives rise to the more active surface for adsorption [21].

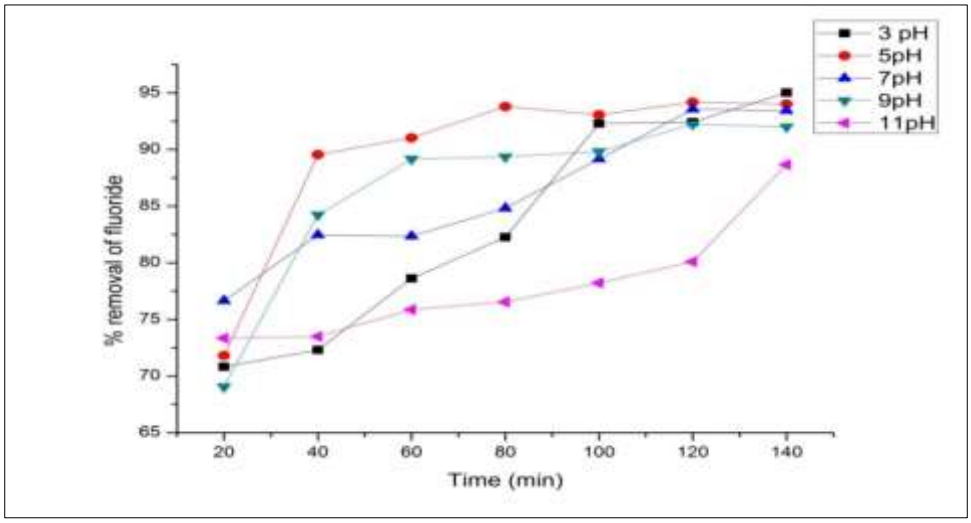


Fig.3 Effect of pH on % removal

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3.3Effect of Initial Fluoride concentration

The effect of initial concentration on the adsorption of fluoride ions is shown in Fig. 4. It was quite evident from that the uptake of fluoride ions increased with the lapse of time and reached to saturation after 120 minute. It was further the percentage fluoride removal was decreased with the increase in initial concentration of fluoride. At higher fluoride concentration the availability of active site on the adsorbent is less which causes lower adsorption efficiency [22, 23].

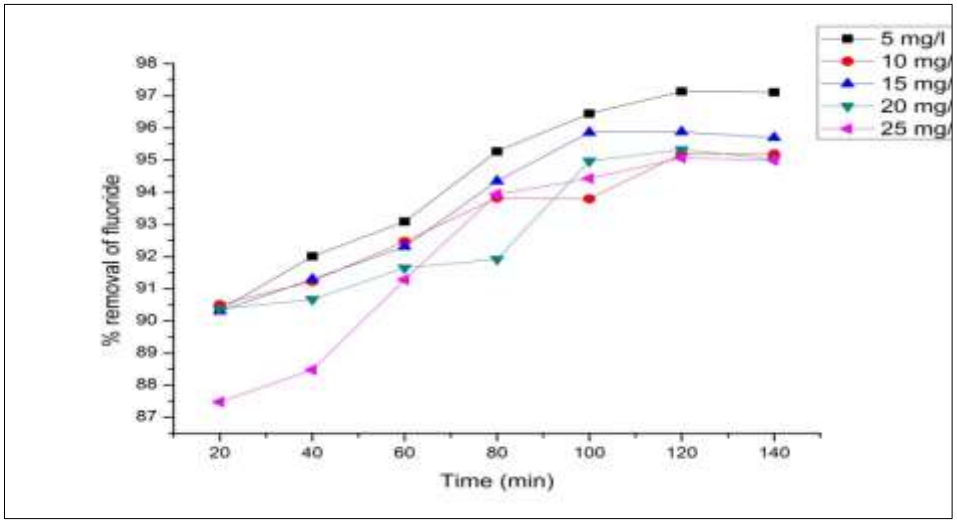

Fig. 4 Effect of fluoride ion concentration on % of removal

3.4Adsorption Models

Langmuir isotherm was represented in figure 5. Experimental data fitted with relatively good correlation coefficient as 0.9979.It showed that the Langmuir model can be accepted for this process. Adsorption Capacity =0.9552 mg/g

Freundlich adsorption: Freundlich isotherm is shown by equation 2.

$$\log(q_{eq}) = \frac{1}{n}\log(C_{eq}) + \log(k_f) \ldots\ldots(2)$$

Where K_f and 1/n are empirical constant.Freundlich adsorption isothermal model was not linear to the experimental data and correlation factor was 0.997. Isotherm was shown in figure 6.

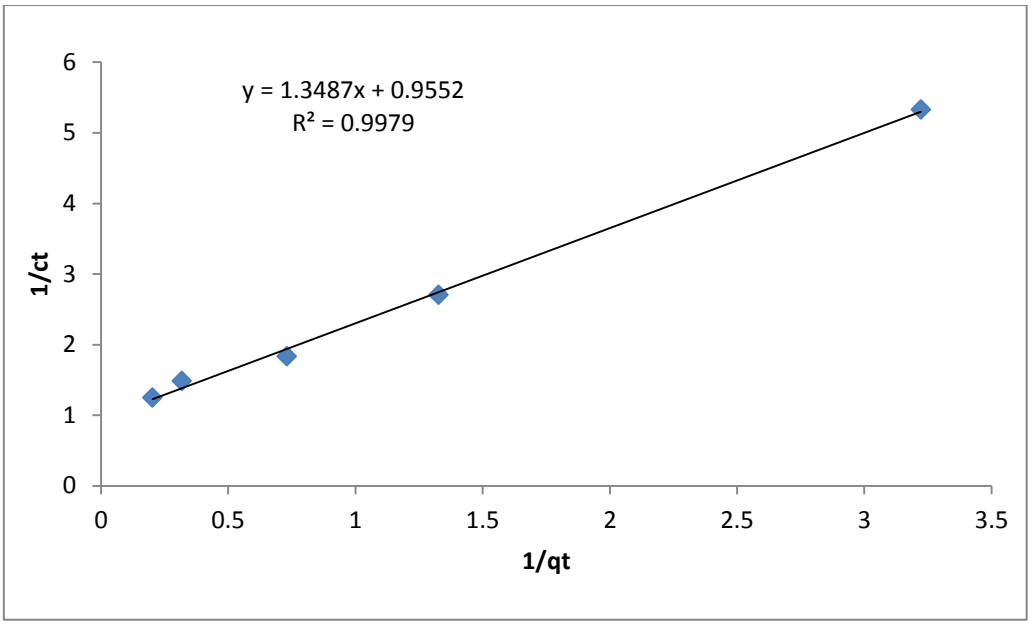

Fig. 5 Langmuir adsorption isotherm for *Butea-Monosperma* leaf powder doped with calcium hydroxide

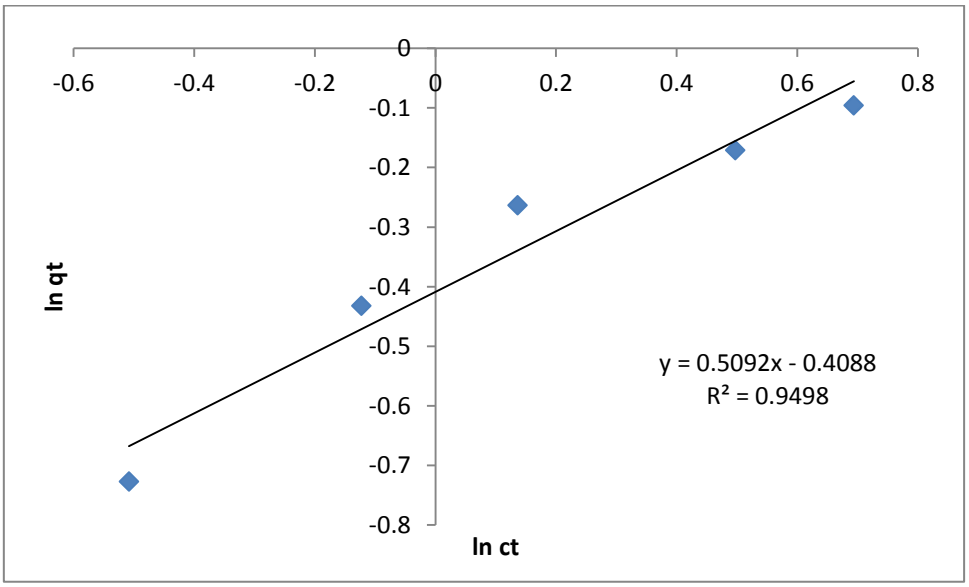

Fig. 6 Freundlich adsorption isotherm for *Butea-Monosperma* leaf powder doped with calcium hydroxide

4. Conclusions

Bio-adsorbent prepared from *Butea-Monosperma* leaf powderdoped withcalcium hydroxide with the help of microwave has shown better adsorption capacity of fluoride as compare to other adsorbents. The adsorption removal of fluoride increases with decreases pH value and the maximum fluoride removal occurred at pH 3. The fluoride removal increases with increases temperature, contact time and adsorbent doses. It was further observed that equilibrium behaviour can be predicted by Langmuir adsorption isotherm.

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