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Removal Of Fluoride From Ground Water By Using Adsorbent

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ABSTRACT

Presence of Fluoride in water is safe and effective when used as directed, but it can be harmful at high doses and at low concentration. In the present paper bark of babool as a adsorbent is used for removal of fluoride from groundwater. Defluoridation of groundwater using bark of babool as an adsorbent was studied in batch process. The effects of controlling parameters like optimum dose ,contact time, pH, temperature etc. were study. The result shows that bark of babool of 5g/L accomplished a removal of 77.04% of Fluoride from a 5mg/L of Fluoride concentration at normal pH of 8.0 requiring an equilibrium time of 8 hours. The experimental adsorption data fitted with Langmuir and Freundlich adsorption isotherms. The pseudo-second-order kinetic model fitted well as compared to pseudo first-order model. The effects of co-existing ions present in groundwater were also studied. Comparison was made with simulated and field water.

Keywords - Adsorption, fluoride removal, Isotherm pH, Temperature.

I. INTRODUCTION

Water need is precious because it is the main source of human as well as animals needs. Despite Earth's appearance of watery abundance, less than 1% of the water on Earth is actually fresh and usable. Fluorine is widely spread in nature and is a common constituent of most soils and rocks, plants and animals. It is the 13th most abundant element, averaging 650 mg/L in the earth crust [1].Exposure of living organisms to above normal concentrations of fluoride may result in alteration of the organism's biochemistry and morphology,which restrict the organism's ability to maintain its ecological position directly or indirectly. [2]. Global prevalence of fluorosis is reported to be about 32% [3]. Some governments are not yet fully aware of the fluoride problem or convinced of its adverse impact on their populations. Efforts are therefore needed to support more research on the subject and promote systematic policy responses by governments. [4]. The permissible limit of fluoride level is generally 1–1.5mg/L. In addition, WHO noted that mottling of teeth (i.e. dental fluorosis) is sometimes associated with fluoride levels in drinking-water above 1.5 mg/L and crippling skeletal fluorosis can ensue when fluoride levels exceed 10 mg/L.

2.0 . Material and Method of study

2.1 Material

Adsorption of Fluoride was studied using bark of babool as an Adsorbent. The bark is collected and grinded to a fine powder and sieved through the sieve of 150 µ size and Washed by double distilled water in orbital shaking incubator at 30^0C, 150rpm for 24Hrs. After washing dried in oven under the temperature of 100^0C for 24 hrs and kept it in muffle furnace at 700^0 C for 2 Hrs. After removing sample is again washed by double distilled water. Then the material was used as an adsorbent for the removal of Fluoride.

2.2 Method Of Study

The batch adsorption experiments were conducted to study.Fluoride stock solution was prepared by dissolving 221 mg anhydrous sodium fluoride in l litre of distilled water in volumetric flask. Initially 5 mg/L fluoride concentration solution is taken for the study. The temperature range for the studies was from 20 ºC to 40 ºC. Batch studies were performed at the shaking rate of 150 rpm. For each experimental run, 50 ml aqueous solution of the known 5mg/L fluoride concentration was taken in 100 ml capacity plastic bottles containing 50 ml of fluoride solution. These bottles were agitated at a constant shaking rate of 150 rpm in a temperature controlled orbital shaker maintained at a constant temperature. The pH of the adsorbate solution was adjusted by using 0.1 N HCl or 0.1 N NaOH aqueous solutions. To check whether the equilibrium has been attained, the samples were withdrawn from the flasks at different time intervals. Fluoride removal efficiency was found out by using Ion Selective Electrode Method.

3.0 Results & Discussions

3.1 Effect of Adsorbent Dose

The effect of adsorbent dose studied at 1,2.5,5,10,20 g/L From Fig.1 result shows that the optimum dose of adsorbent was found 5 g/L for fluoride concentration of 5mg/L,which gives 77.04% fluoride ion removal efficiency was required to bring down the fluoride level between 1.0 – 1.5 mg/L as per WHO guidelines. An adsorbent dose of 5 g/L was used for further study.

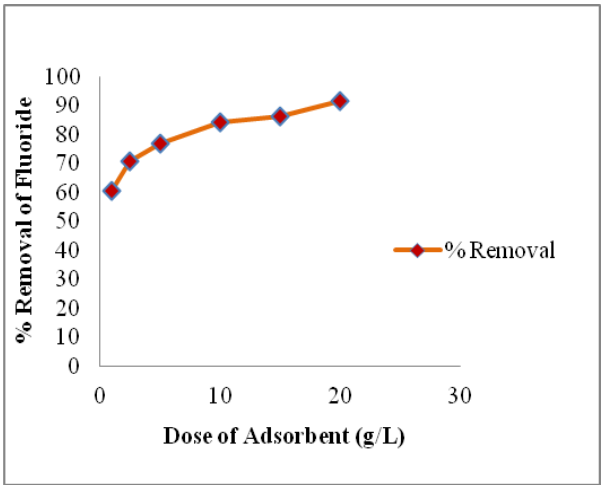

Fig.1**:** Fluoride Conc.– 5mg/L ,pH–8.0,Temp – 30^{O}C,time – 24 hrs, rpm – 150

3.2 Effect of pH

To find pH effect the study was conducted from pH 2 to12 in acidic and alkaline conditions respectively. The graphical representation is shown in Fig.2 found that the removal of fluoride was increased up to pH 8 and then decreases.Highest adsorption of fluoride was found to be 70.6% to 75.6 % in the pH range 6.0 and 8.0. It is seen that the sorption of fluoride is good in the pH range 6.0-8.0.This may be due to neutralization of the negative charge at the surface of adsorbent material by greater hydrogen concentration at lower pH values. In the acidic pH range, the amount of fluoride adsorbed slightly decreased and this can be due to the formation of weak hydrofluoric acid. In the alkaline condition pH range there was sharply drop in adsorption which may be due to the competition of the hydroxyl ions with the fluoride for adsorption.

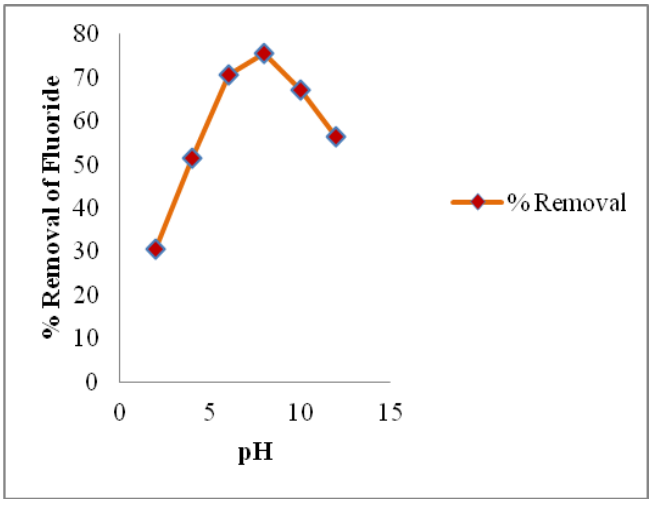

Fig.2**:** Fluoride Conc.– 5mg/L , Dose of adsorbent– 5g/L ,Temp – 30^{O}C,time – 24 hrs, rpm – 150

3.3 Effect of Time of Contact

The graphical representation is shown in Fig.3 it shows that as the contact time increased the adsorption of fluoride also increased. After 480 min. (8 hrs.) the adsorption of fluoride was 77.6 % and remaining fluoride concentration in water was 1.12 mg/L which was within permissible limit (1-1.5 mg/L).After this the adsorption of fluoride increased as the contact time increased but the remaining concentration of fluoride range was below 1 mg/L . Hence 480 min. (8 hrs) was selected the time of contact at 303K.

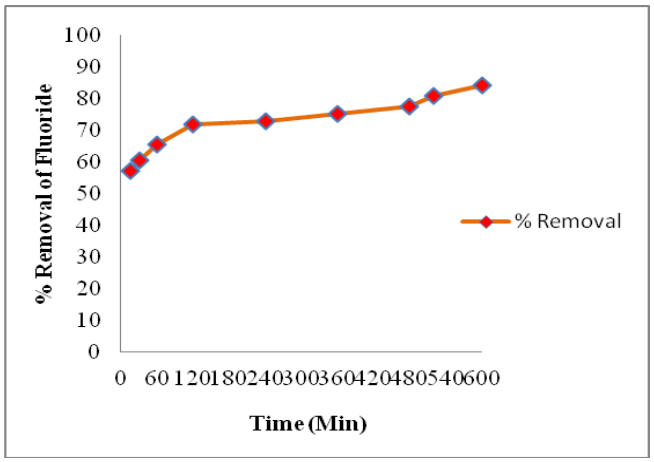

Fig.3**:** Fluoride Conc.– 5mg/L , Dose of adsorbent– 5g/L, pH – 8.0,Temp – 30^{O}C, rpm – 150

3.4 Effect of Different Initial Concentration

The effect of different initial concentration was studied at 1,3,5,10,15 mg/L.From Fig.4 it shows that adsorption of fluoride decreased with the increased in adsorption concentration because capacity of adsorbent material get exhausted slowly with the increase in the initial fluoride concentration.

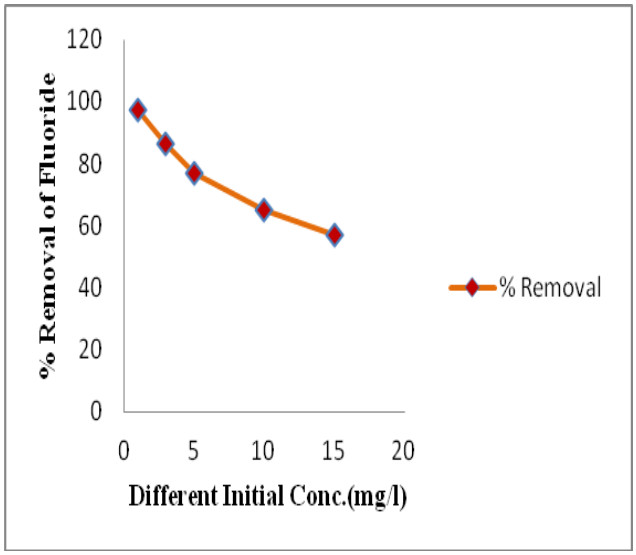

Fig. 4 : Dose of adsorbent – 5g/L, pH –8.0, Temp – 30^{O}C, optimum time – 8 hrs, rpm– 150

3.5 Effect of Co-Existing Ions

Present of Co-existing ions in grounwater cause positive or adsversed effect on adsorption. The study was carried out on anions and cations (Mg^{++}, Fe^{++}, NO_3 & SO_4)

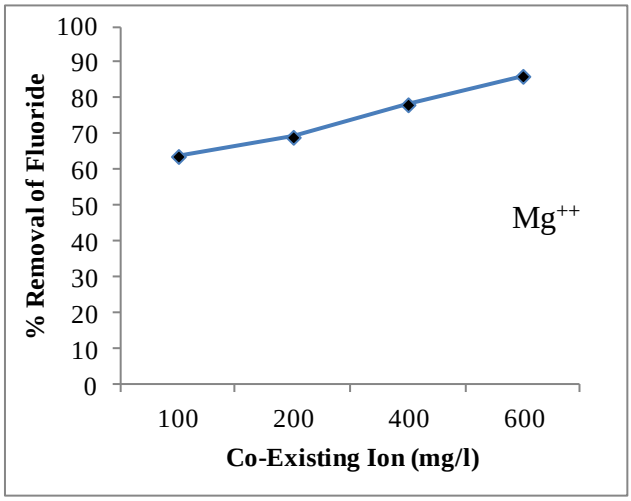

Fig. 5 : Fluoride Conc. – 5mg/L , Dose of adsorbent– 5g/L, Temp – 30^{O}C,optimum time – 8 hrs, rpm – 150

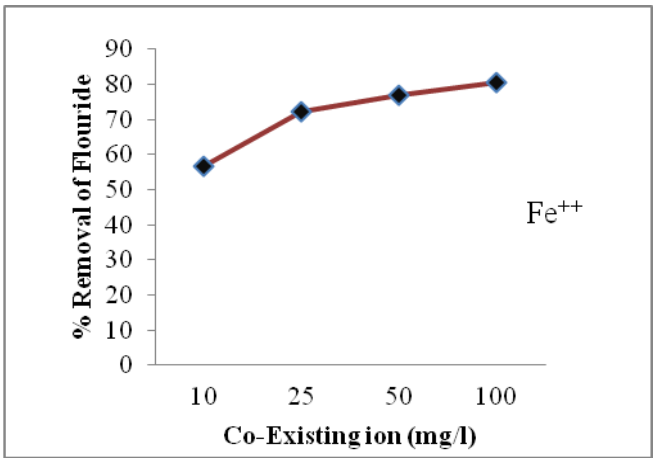

Fig. 6 : Fluoride Conc. – 5mg/L , Dose of adsorbent – 5g/L, Temp – 30^{O}C, optimum time– 8 hrs, rpm – 150

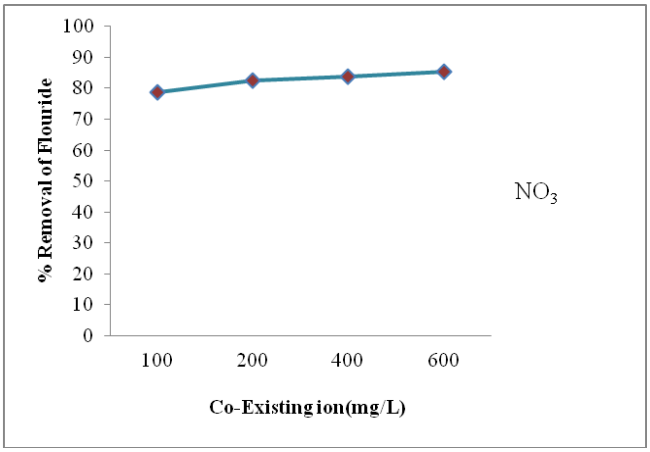

Fig. 7: Fluoride Conc. – 5mg/L, Dose of adsorbent 5g/L,Temp – 30^{O}C, optimum time – 8 hrs, rpm – 150

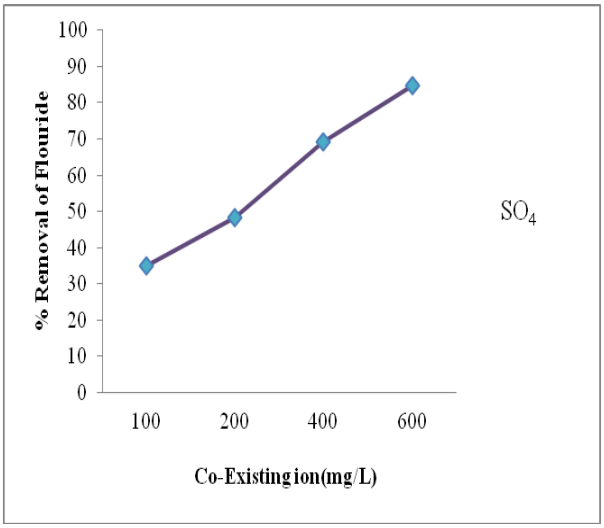

Fig. 8: Fluoride Conc. – 5mg/L , Dose of adsorbent –5g/L, Temp – 30^{O}C, optimum time – 8 hrs rpm – 150

3.6 ADSORPTION MODEL

The adsorption of Fluoride can be mathematically expressed in terms of adsorption isotherms. Adsorption isotherm data are commonly fitted to the Langmuir model (equation 1) and the Freundlich model (equation 2).Study carried on various dose of adsorbent and various temperature.

$$Q_e = \frac{Q_m K_A C_e}{1 + K_A C_e} \quad \text{.....(1)}$$

Where,

Q_e = Amount of adsorbate adsorbed per unit amount of adsorbent at equilibrium.

Q_m = Amount of adsorbate adsorbed per unit amount of adsorbent required for monolayer adsorption.

K_A = Constant related to enthalpy of adsorption.

C_e = Concentration of adsorbate solution at equilibrium.

$$Q_e = K_F C_e^{\frac{1}{n}} \quad \text{….....(2)}$$

where ,

K_F and n are the constants

C_e = the concentration of adsorbate solution at equilibrium

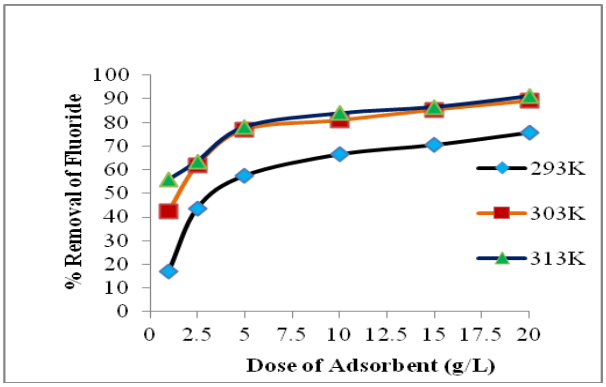

Fig. 9: Fluoride Conc. – 5mg/L , rpm – 150

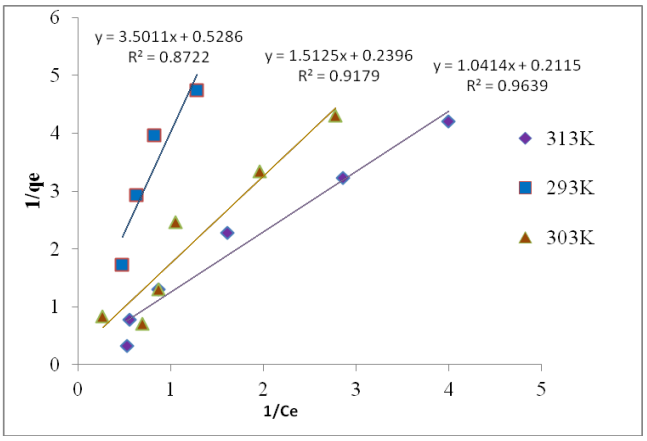

Fig. 10: Langmuir Fit for Adsorption of Fluoride at 293K, 303K and 313K

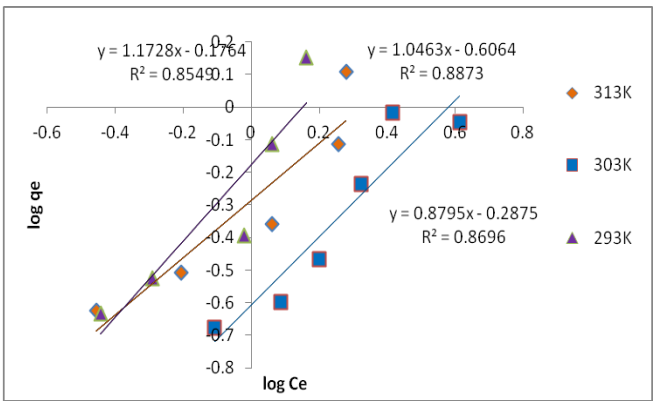

Fig. 11: Freundlich Fit for Adsorption of Fluoride at 293K, 303K and 313K

Temp	K_f (mg/g)	n	1/n	R^2
293K	1.192	1.172	0.85	0.9701
303K	2.847	1.046	0.955	0.8804
313K	1.333	0.879	0.937	0.869

Table 1: Langmuir Adsorption isotherm parameters for fluoride adsorption by bark of babool

Temp.	q_{max} (mg/g)	b	r	R^2
293K	1.891	0.1509	0.5698	0.8722
303K	4.17 3	0.1584	0.5580	0.9179
313K	4.728	0.203	0.4961	0.9639

Table 2:Freundlich adsorption isotherm parameters for fluoride adsorption by bark of babool

3.7 Kinetic Adsorption Model

It is apparent from the values of correlation coefficients that the pseudo-second-order kinetic model fitted well as compared to pseudo first-order model .

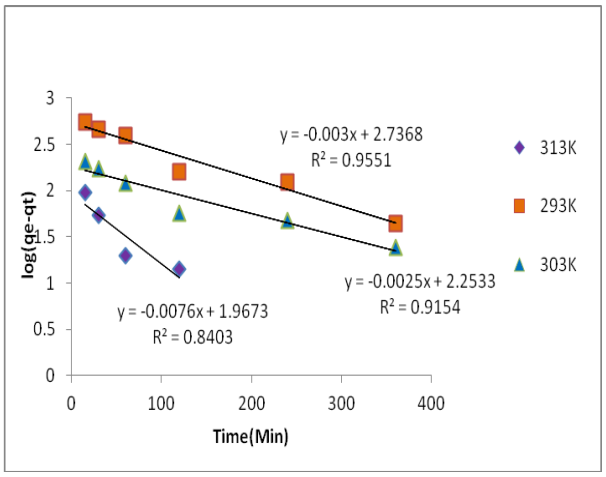

Fig.12 :Pseudo-first kinetic model for fluoride removal by bark of babool

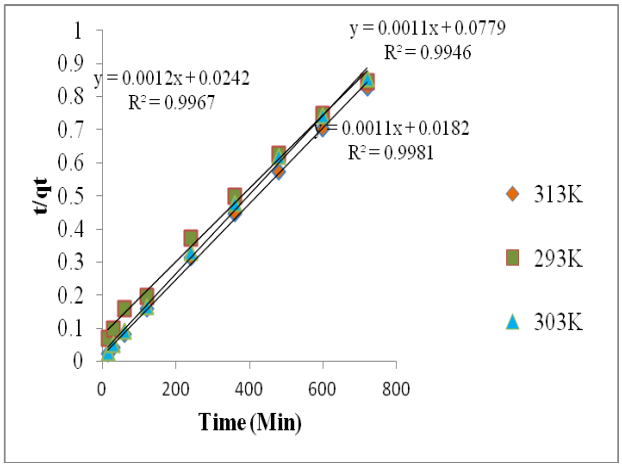

Fig.13:Pseudo-Second kinetic model for fluoride removal by bark of babool

3.8 Comparison of Simulated and Field Water

The adsorption experiments were study on simulated and field water containing fluoride concentration of 5mg/L, at optimum pH-8.0, by adding optimum dose of adsorbent (5g/L) which was put inside the bottles in 50 ml. which operated at 150 rpm and with constant temperature 303K up to 8hrs. (Time of equilibrium). From Fig.14 the removal of fluoride was more in simulated water than the fluoride present in field water. This may be due to the presence of cat ions and anions present in field water.

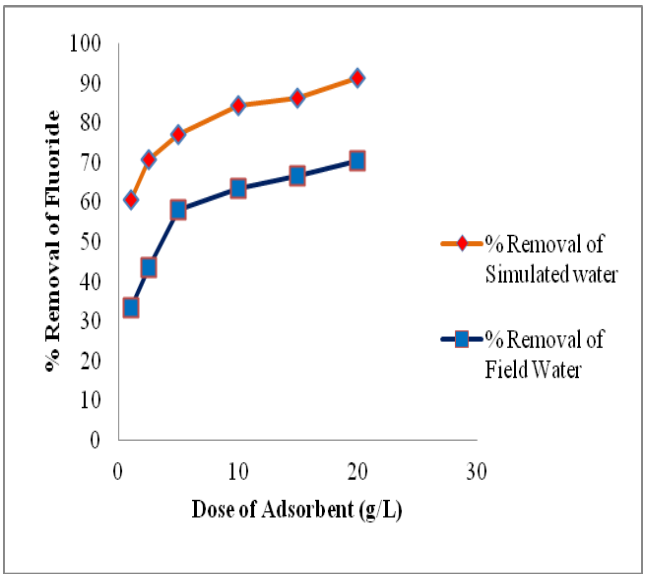

Fig.14:Fluoride Conc. – 5mg/L , Dose of adsorbent– 5g/L, Temp – 30^{O}C,time– 8 hrs, rpm – 150

CONCLUSION

From the present result it is concluded that bark of babool as a adsorbent are promising materials for Fluoride removal. These adsorbent material is locally available but requires Pre-treatment to raw material before using for removal of fluoride. Optimum dose of bark of babool was found 5g/L for removal of fluoride concentration of 5 mg/L. Adsorption capacity was more in the pH range of 6-8.Optimum time of contact was found 8 hrs. The removal increased with time and adsorbent dose, but with higher initial concentration decreased with time and adsorbent dose. The present study on defluoridation using bark of babool shows that the equilibrium data fits better to Langmuir isotherm as compared with Freundlich isotherm.The pseudo-second-order kinetic model fitted well as compared to pseudo first-order model **.**

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