FLUORIDE REMOVAL FROM GROUND WATER USING ALUMINIUM IMPREGNATED AGRO WASTES

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Abstract—

Fluoride is the common contaminant of ground water, surface water and industrial waste water of high-tech industries. Fluorosis is a public health problem in many parts of the world. The major source of fluoride intake is drinking water. Fluoride contamination in drinking water due to natural and anthropogenic activities has been recognized as one of the major problems worldwide imposing a serious threat to human health. Excess fluorides can cause skeletal and dental fluorosis. There are many ways for fluoride removal viz Electrocoagulation, Ion exchange, adsorption etc. But among them adsorption is very popular, because of its simplicity and a lot of adsorbents available. Adsorption process has been explored widely and offers satisfactory results. The permissible limit of fluoride concentration in drinking water is 1.5mg/L according to WHO guidelines. As cost is an important consideration in most developing countries, efforts have been made to explore the possibility of using various low cost adsorbents that are abundant, readily available and are derived from agro waste materials like Ashoka (Polyalthia) leaves, Orange peels and Bael leaves (Aegle marmelos) leaves. There are using Aluminium impregnated agro wastes charcoal for fluoride remediation. These adsorbents efficiency of eliminating fluoride is studied with different parameters such as pH, agitation time, adsorbent dose, temperature and initial fluoride concentration. Moreover, desorption of fluoride from impregnated Bael leaves and orange peels gives 96% fluoride leaching at pH 5.5. Impregnated Ashoka leaves gives 92% fluoride removal at pH 5.5 but it takes a large agitation time and adsorbent dose with respect to Bael leaf or Orange peel.

Keywords: *Adsorption, Aluminium impregnated, Agro waste, Efficiency, Low cost adsorbents.*

1. Introduction

There are many natural resources of water among of them resources the water is one of the important resource for plants, animals and human beings. There are various contaminant substances which directly affect the health of human being. Fluoride is such type of contaminator that directly affects the human beings health after its consumption throughout the food and drinks [1, 2]. Through the guideline of WHO (World Health Organization) the permissible limit of fluoride is 1.5mg/l in drinking water [3].

Fluoride comes in water due to weathering of fluoride containing rocks and soils and leaching from the soil into ground water. Fluoride enters into ground water due to dissolution from minerals/rocks like topaz, fluorite, fluorspar, cryolite, fluorapatite etc [4]. Fluoride is more toxic than lead but less toxic than arsenic. Fluoride has influenced on human being because of its dual nature, it's inefficiency is harmful for bones and tooth on the other hand it's high concentration is causes of fluorosis, brittling of bones, curvature of bones, mental disorders etc. That's why fluoride is known as two edges sword. In small doses of fluoride, it prevents the tooth decay but in high doses it causes of fluorosis. So many treatment methods were followed as coagulation/precipitation, electrochemical, electrodialysis, invert assimilation, adsorption and ion-exchange but adsorption was found to be more suitable and efficient method for defluoridation. Removal of fluoride from drinking water especially in fluoride affected areas at low cost there are used agro wastes. Most of the adsorption studies were done with modification of the natural activated carbon by doping or impregnation/mixing with other chemicals to increase the surface area for higher removal efficiency, which has a longer procedure. With this point of view, present work was undertaken to investigate the potentiality of aluminium impregnated agro wastes charcoal for removal of fluoride from ground water.

2. Material and Method

2.1 Collection of adsorbent

The Ashoka leaves and Bael leaves are collected from the HBTU Kanpur hostel campus and college campus and Orange peels are collected from the hostel mess and the local fruit market shop of Nawabganj Kanpur.

After collecting the leaves and peels, cut them into small pieces individually and washed them with distilled water then dried it into the sunlight. After drying the leaves into the sunlight for 3-4 hr, dried it into the hot air oven at 353K around 60 minutes.

Then grind them with the help of grinder and sieved through mesh size 840μm. The grinded powder was burnt into the muffle furnace at 427 K for 45 minutes. The ash was removed by washing with distilled water and further dried in oven at 353 K for overnight. Throughout the whole process the material was found known as charcoal.

2.2 Preparation of aluminium coated agro wastes charcoal

With the guidelines of Ganvir and Das [5] for the aluminium impregnation there are used a stirrer tank reactor with stirring, vacuume pressure filter and oven drier. Firstly100gm of charcoal was taken into the stirrer tank reactor further 0.6M aluminium sulphate solution with the 500ml volume was added and stirred the mixture. There were required to control its pH, the pH remains 5-7 for controlling its pH 1.0M sodium hydroxide solution was used. When the pH reaches upto 5-7 stopped to add sodium hydroxide solution the reaction had completed. The whole slurry was filtered and got desired adsorbent at 400K. For the further used of the impregnated charcoal double distilled water was used to removal of sodium sulphate and dried it at 370K.

2.3 Adsorption Experiment

A synthetic fluoride solution was prepared by dissolving 2.21 g sodium fluoride solid granules in 1 L of deionised water and subsequently diluted to the required concentrations for the adsorption experiments. pH control was occurring with HCl or NaOH. The percentage of fluoride removal (% F) and the amount of F^- adsorbed per unit weight of adsorbent at time t (q_t, mg g^{-1}) and at equilibrium (q_e, mg g^{-1}) were calculated using the following equation, respectively:

$$\%F = \frac{(C_0 - C_e)}{C_0} * 100$$

$$q_t = \frac{(C_0 - C_t)v}{m}$$

$$q_e = \frac{(C_0 - C_e)v}{m}$$

Where v (L) is the volume of fluoride solution, and C0 (mg L^{-1}) is the initial concentration of F. Ct (mg L^{-1}) is the concentration of F at a given time t, Ce (mg L^{-1}) is the concentration of F^- at equilibrium and m (g) is the dry weight of the adsorbents.

3. Results and Discussion

3.1 Results for Polyalthia leaves (Ashoka leaves)

3.1.1 Effect of pH

pH gives the sharp effect on fluoride removal the figure 3.1.1 shows that at 7 pH the removal of fluoride is maximum 88% and the initial fluoride concentration 20mg/l, 75 minute contact time of adsorbent dose, 25˚C temperature and 8gm/l adsorbent dose were operating conditions.

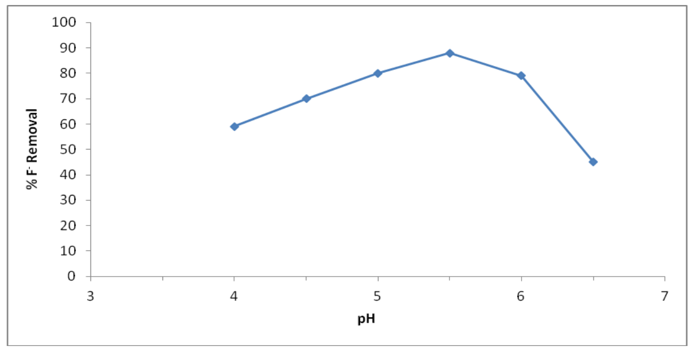

Fig. 3.1.1 Percentage Fluoride removal vs. pH (Polyalthia)

3.1.2 Effect of agitation time

Fig.3.1.2 shows that as time increases the removal of fluoride increases and after 75 minute percentage of fluoride removal was 80% and then further increases the time, removal of fluoride decreases. The initial concentration of fluoride was 20 mg/l, temperature was 25 ˚C, pH=6, adsorbent dose 8 g/l.

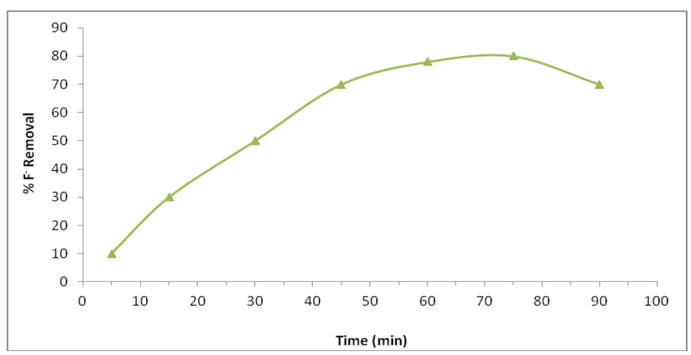

Fig. 3.1.2 Percentage fluoride removal vs. time (Polyalthia)

3.1.3 Effect of temperature

The figure 3.1.3 explains the effect of temperature, as temperature increases the percentage of fluoride removal increases upto the optimum temperature after that increases the temperature slightly decreases the removal of fluoride to find this effect of temperature keep the intial concentration of fluoride 15 mg/l ,ph=7,contact time 75 minute and the adsorbent dose was 8 g/l.

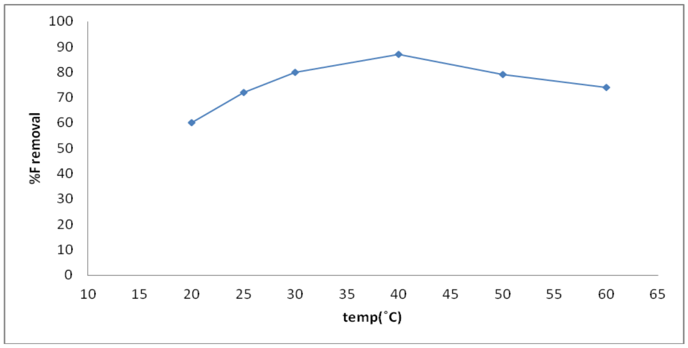

Fig. 3.1.3 Percent fluoride removal vs. temperature (Polyalthia)

3.1.4 Effect of adsorbent dose

Fluoride removal increases as increases the adsorbent dose but at an optimum dose the removal of fluoride become constant. As figure 3.1.4 shows that on the 2-8 gm/l adsorbent dose the removal of fluoride increases upto 88% and further increases the adsorbent dose the removal of fluoride remains constant or shows slight change. Keeping the initial conc. =20mg/L, temp=25˚C, pH=6, time=45min.

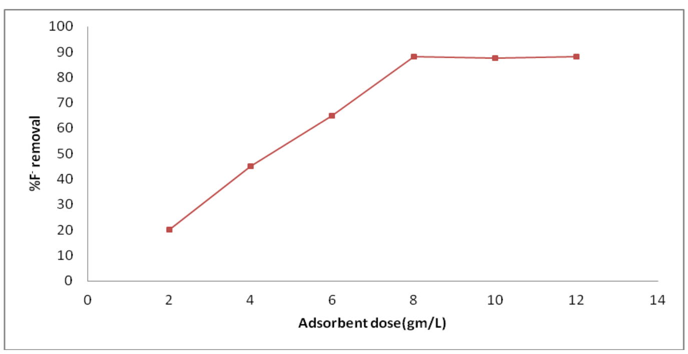

Fig. 3.1.4 Percentage Fluoride removal vs. Adsorbent dose (Polyalthia)

3.1.5 Effect of initial concentration of fluoride

Keeping the operating conditions as adsorbent dose 8 g/l, contact time 75 minute, ph =7, temperature 25 ˚C. The figure shows that at 15 mg/l initial concentration of fluoride at operating conditions gives 92% removal of fluoride. As this fig. 3.1.5 clearly shows that as initial concentration of fluoride increases the percentage removal of fluoride decreases.

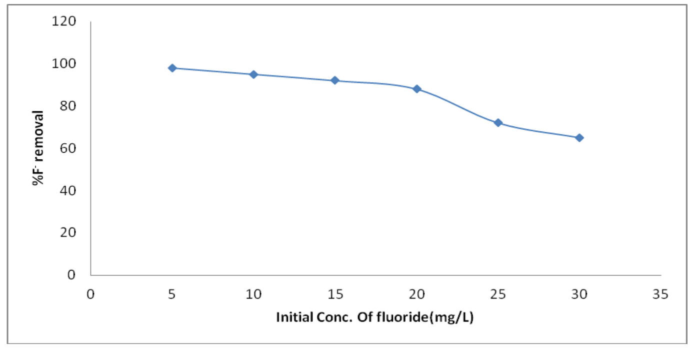

Fig. 3.1.5 Percent fluoride removal vs. initial concentration of fluoride (Polyalthia)

3.2 Results for Aegle Marmelos leaves (Beal leaves)

3.2.1 Effect of adsorbent dose

Fluoride removal increases as increases the adsorbent dose but at an optimum dose the removal of fluoride become constant. As figure 3.2.1 shows that on the 0.5-2 gm/l adsorbent dose the removal of fluoride increases upto 96% and further increases the adsorbent dose the removal of fluoride remains constant or shows slight change. The optimum adsorbent dose which gives the 96% removal of fluoride is 2 gm/l. Keeping the initial conc. =20mg/L, temp=25˚C, pH=6, time=45min.

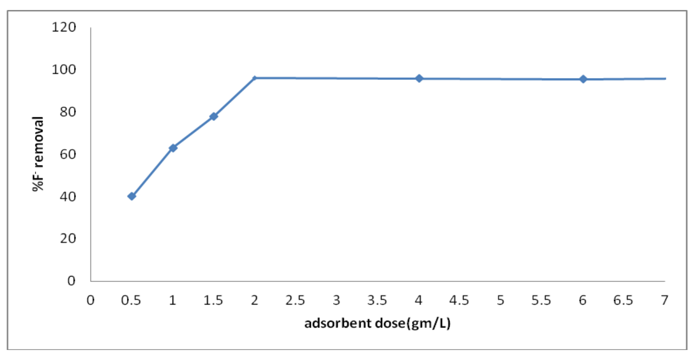

Figure 3.2.1- Percent F^- removal vs. adsorbent dose (Agele Marmelos

3.2.2 Effect of Contact time on fluoride removal

Figure 3.2.2 shows that as time increases the removal of fluoride increases and after 45 minute the removal of fluoride was 94% and then further increases the time, removal of fluoride decreases. The initial concentration of fluoride was 20 mg/l, temperature was 25 ˚C, pH=6, adsorbent dose 2 gm/l.

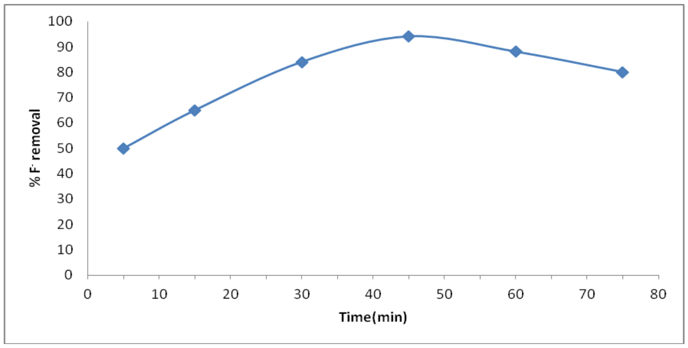

Figure 3.2.2- Percentage F^- removal vs. time (Agele Marmelos)

3.2.3 Effect of pH on fluoride removal

pH gives the sharp effect on fluoride removal the figure 3.2.3 shows that at 6 pH the removal of fluoride is maximum 80% and the initial fluoride concentration 20mg/l, 45 minute contact time of adsorbent dose, 25˚C temperature and 2 gm/l adsorbent dose were operating conditions.

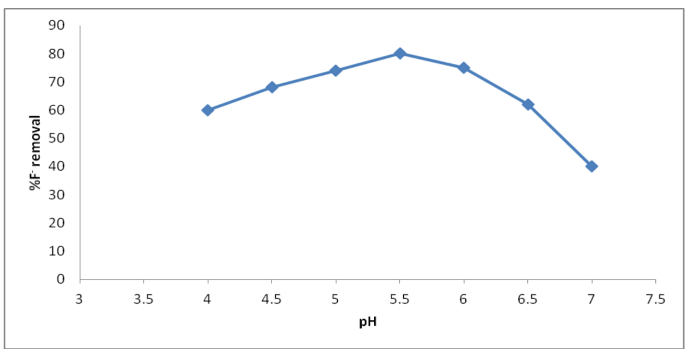

Figure 6.3.3- Percentage F^- removal vs. pH (Agele Marmelos)

3.2.4 Effect of initial concentration of fluoride

Keeping the operating conditions as adsorbent dose 2 gm/l, contact time 45 minute, pH =6, temperature 25 ˚C. The figure shows that at 10 mg/l initial concentration of fluoride at operating conditions gives 90% removal of fluoride. As this figure clearly shows that as initial concentration of fluoride increases the percentage removal of fluoride decreases.

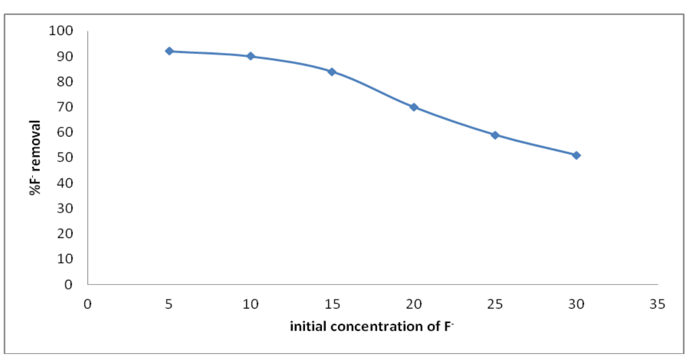

Figure 3.2.4- Percent F^- removal vs. initial concentration of fluoride (Agele Marmelos)

3.2.5 Effect of Temperature

The figure 3.2.5 explains the effect of temperature, as temperature increases the percentage of fluoride removal increases upto the optimum temperature after that increases the temperature slightly decreases because the adsorption process is an exothermic process the removal of fluoride to find this effect of temperature keep the initial concentration of fluoride 10 mg/l, pH=6, contact time 45 minute and the adsorbent dose was 2 gm/l.

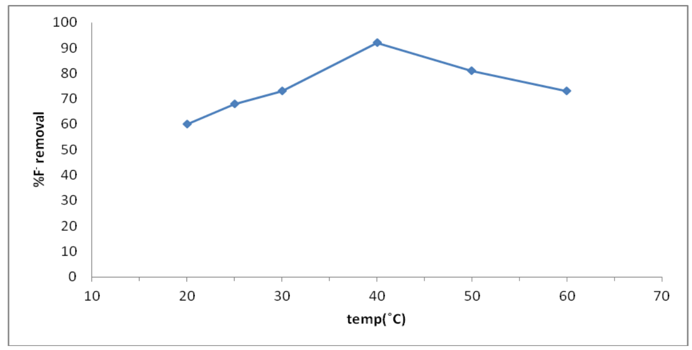

Figure 3.2.5- Percent F^- removal vs. temperature (Agele Marmelos)

3.3 Results of orange peels

3.3.1 Effect of adsorbent dose

Fluoride removal increases as increases the adsorbent dose but at an optimum dose the removal of fluoride become constant. As figure 3.3.1 shows that on the 0.1-1 gm/l adsorbent dose the removal of fluoride increases upto 85% and further increases the adsorbent dose the removal of fluoride remains constant or shows slight change. The optimum adsorbent dose which gives the 85% removal of fluoride is 1 gm/l.
Keeping the initial conc. =20mg/L, temp=25˚C, pH=6, time=30min.

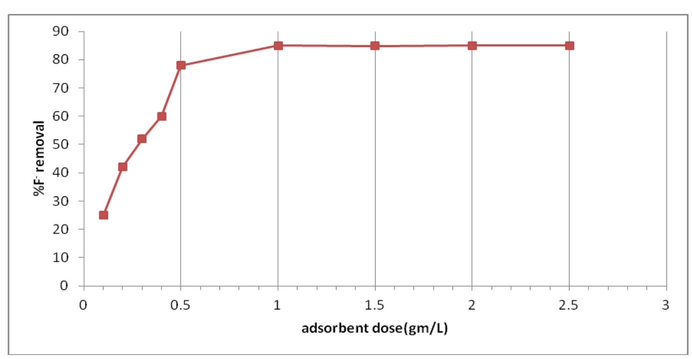

Figure 3.3.1- Percent F^- removal vs. adsorbent dose (Orange peel)

3.3.2 Effect of Contact time on fluoride removal

Figure 3.3.2 shows that as time increases the removal of fluoride increases and after 45 minute the removal of fluoride was 78% and then further increases the time, removal of fluoride decreases. The initial concentration of fluoride was 20 mg/l, temperature was 25 ˚C, pH=6, adsorbent dose 1 gm/l.

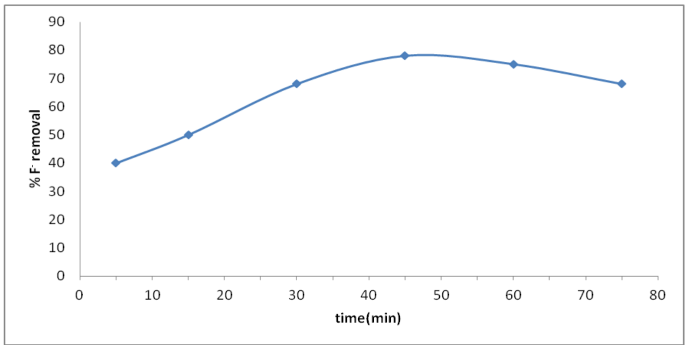

Figure 3.3.2- Percentage F^{-}removal vs. time (Orange peel)

3.3.3 Effect of pH on fluoride removal

pH gives the sharp effect on fluoride removal the figure 3.3.3 shows that at 5.5 pH the removal of fluoride is maximum 92% and the initial fluoride concentration 20mg/l, 45 minute contact time of adsorbent dose, 25˚C temperature and 1 gm/l adsorbent dose were operating conditions.

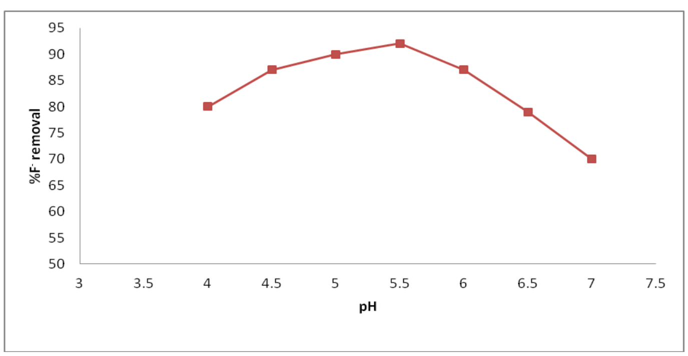

Figure 3.3.3- Percentage F^{-} removal vs. pH (Orange peel)

3.3.4 Effect of initial concentration of fluoride

Keeping the operating conditions as adsorbent dose 1 gm/l, contact time 45 minute, pH =6, temperature 25 ˚C. The figure 3.3.4 shows that at 15 mg/l initial concentration of fluoride at operating conditions gives 90% removal of fluoride. As this figure clearly shows that as initial concentration of fluoride increases the percentage removal of fluoride decreases.

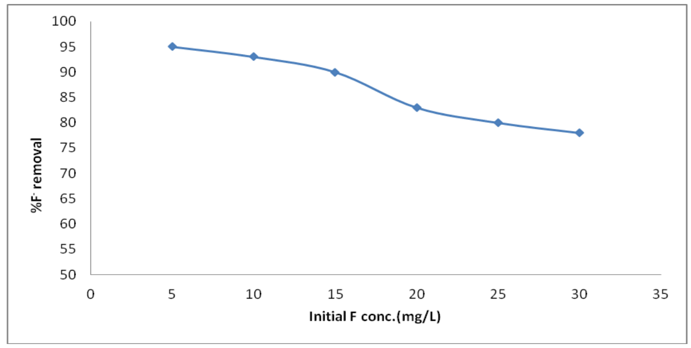

Figure 3.3.4- Percent F^{-} removal vs. initial concentration of fluoride (Orange peel)

3.3.5 Effect of Temperature

The figure 3.3.5 explains the effect of temperature, as temperature increases the percentage of fluoride removal increases upto the optimum temperature after that increases the temperature slightly decreases because the adsorption process is an exothermic process the removal of fluoride to find this effect of temperature keep the initial concentration of fluoride 15 mg/l, pH=6, contact time 45 minute and the adsorbent dose was 1 gm/l.

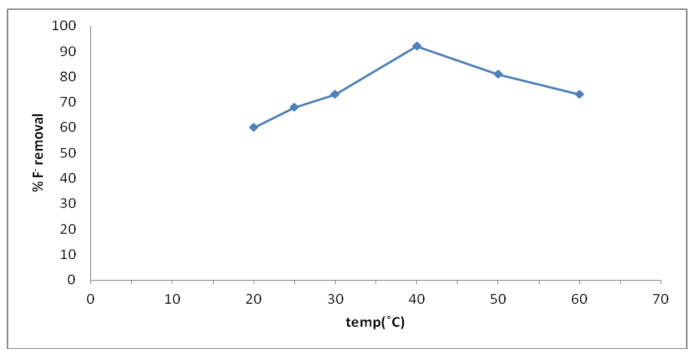

Figure 3.3.5- Percent F^{-} removal vs. temperature (Orange peel)

4. Conclusion

Following conclusions given below are found with this experiment:

Impregnated Orange peel charcoal give the maximum removal of fluoride with respect to the other two impregnated agro waste charcoal.

Impregnated Orange peel charcoal give the 96% of fluoride removal with the 15 mg/L of initial concentration of fluoride at pH 7 and using the adsorbent dose 1 gm/L with 45 min contact time at 40˚C temperature.

5. Acknowledgements

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6. References

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