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DEFLUORIDATION OF GROUNDWATER USING SURFACE FUNCTIONALIZED LECA BALLS

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ABSTRACT

Since surface water sources are getting depleted over the typical climate change issues, urban people of Tamil Nadu already started depending largely on to ground water sources. It is on the other hand became necessary to monitor and maintain the groundwater level in adequate quantity as well as in quality. In this regarding, removing excess fluoride present in the groundwater is being the long-time challenge. Among the various methods for removing excess fluoride, adsorption technique is the predominant one due to its efficiency and less complex execution. In this paper, we have executed an adsorption technique for removing the excess fluoride from groundwater sample by using surface functionalized LECA (Lightweight Expanded Clay Aggregate) balls. In the methodology, we have followed a 2 step chemical process, mainly by using Aluminium Chloride (AlCl3) for functionalizing the surface of LECA. Results are showing that modified LECA can adsorb fluoride in better range comparing to the previously done techniques.

Key words: LECA, Surface Functionalization, Defluoridation, Adsorption Isotherm, Groundwater Quality.

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1. INTRODUCTION

As the population of the developing world continues to climb, people are forced to move into fluorotic areas. Fluoride in water is not considered toxic until it reaches concentrations of 2.5-4.5 mg/l. However, because much of the fluoride consumed is retained by the body, it still has a cumulative effect when consumed in far smaller concentrations resulting in fluorosis. Though necessary for the body to function and proven to be helpful in smaller doses, the WHO (World Health Organization) recommends the ingestion of no more than 4.0 mg of fluoride per person per day. Though much intake of fluoride comes from food, it has been shown that the majority of occurrences of fluorosis come from the consumption of water with excessive amounts of fluoride. Thus, the WHO limits fluoride concentrations in drinking and cooking water to 1.5 mg /l It has been suggested that the optimum amount of fluoride in drinking water is approximately 0.5-1.0 mg/l.

Table 1 Health effects of excess fluoride consumption (*Saravanan J et al.)*

Fluoride content (mg/l)	Corresponding health effects on human health
< 0.5	Dental caries
0.5 – 1.0	Safe limit
1.0 – 3.0	Dental fluorosis
3.0 – 4.0	Stiff and brittle joints
>4.0	Deformities in knees

2. MATERIALS AND METHODS

2.1. Materials

From the literature study, we have realized that the adsorbent materials which are tested for any contaminant / pollutant removal experiments must be evaluated in terms of its own eco-friendly disposal. By keeping this aspect, we have chosen LECA (Light weight Expanded Clay Aggregate) balls an inert material as base material for surface modification to remove excess fluoride from groundwater sample. The groundwater samples were collected from Veerapuram village in Avadi, which indicated the initial fluoride concentrations up to 4 to 5 mg/l. We induced certain samples to get higher initial fluoride concentration to estimate the activity of the adsorbent.

2.2. Methods

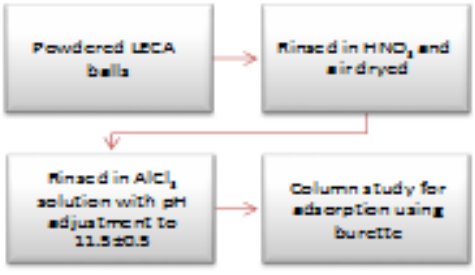

Figure 1 Methodology flow diagram

A step by step procedure for surface modification of LECA is given below:

Nitric Acid Treatment:

- Roughly powder the LECA balls as required.
- Weigh 10g of LECA powder
- Prepare 100ml 0.01M nitric acid solution
- Mix LECA powder with the nitric acid solution thoroughly.
- Keep the solution in the oven at 105°C for 48 hours
- After 48 hours, take the sample from oven and filter it 1mm (Pore Size) filter paper.
- Then was the content with distilled water roughly for 8 times (With 50ml of distilled water each time)
- Keep the final content again in oven at 105°C for another 48 hours.

Aluminium Chloride Treatment

- After taking out the content from the oven, powder it finely.
- Prepare 0.5M 80ml aluminium chloride solution
- Prepare 0.5M sodium hydroxide solution to adjust pH
- Carefully weigh 8g of finely powdered LECA and mix it with aluminium chloride solution.
- Adjust the pH using sodium hydroxide solution until it turn to alkaline.
- Stir the sample with magnetic stirrer for 4 hours by keeping the temperature at 70°C.
- Air dry the sample in oven for 48 hours
- Wash it with distilled water several times
- Centrifuge the sample for 10-15 minutes at 3500-4500 RPM
- Keep the sample in oven at 105°C for 24 hours.
- Sample is now ready to use as adsorbing medium in a simple filter setup for removing excess fluoride.

3. RESULTS AND DISCUSSION

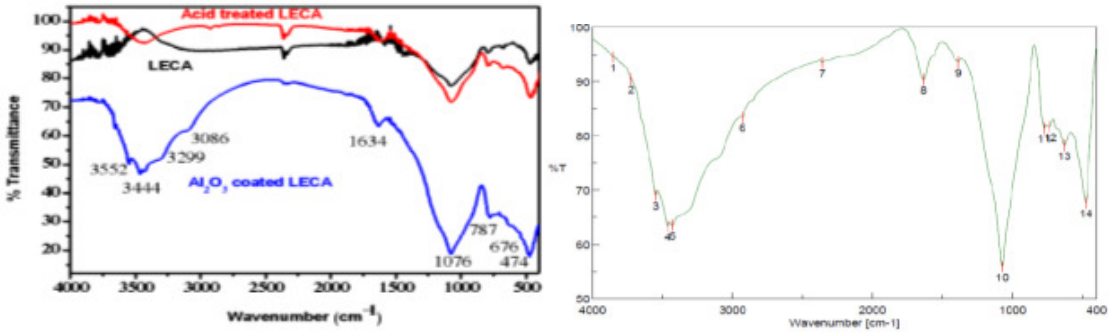

Figure 2: (a) FTIR result before fluoride adsorption (b) FTIR result after fluoride adsorption

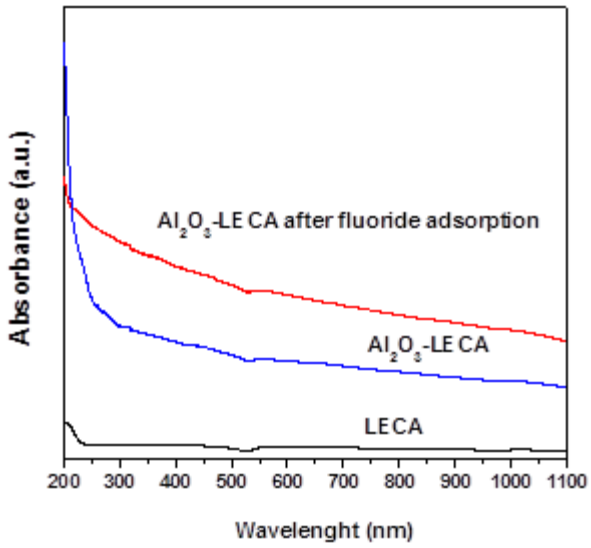

Figure 3 UV Spectra showing fluoride adsorbed on LECA

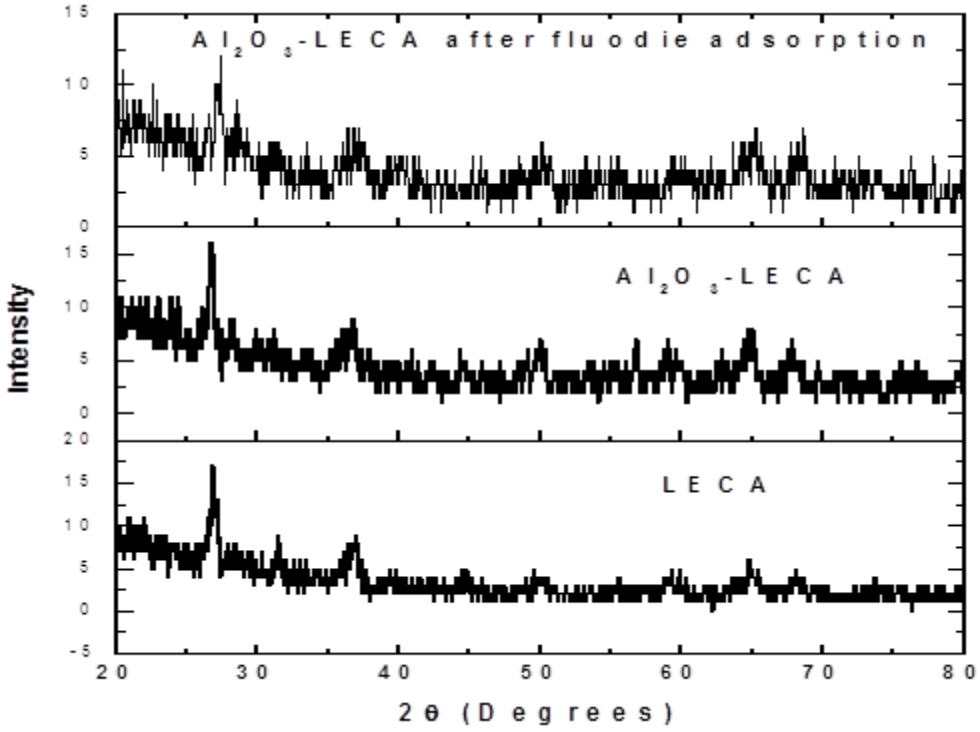

Figure 4 XRD peaks showing fluoride adsorbed on LECA

Our column study revealed that 4.5g of surface modified LECA balls with 7cm depth in column studies have given the best fluoride removal rate.

Table 2 Column Study for fluoride adsorption

Height of the adsorbent (cm)	Initial fluoride value (mg/l)	Final fluoride value (mg/l)
2	5	3
4	5	2.5
7	5	1
10	5	4

4. CONCLUSION

Our proposed surface modified LECA has provided better removal efficiency with higher initial values (5ppm or more). The adsorbent media after three consecutive usages, have to be replaced with fresh adsorbent. The regeneration of adsorption media is not recommended since the LECA balls are cost efficient material and will not pose any threat to environment while it is disposed off as solid waste.

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