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REMOVAL OF CESIUM USING COCONUT FIBER IN RAW AND MODIFIED FORMS FOR THE TREATMENT OF RADIOACTIVE LIQUID WASTES

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ABSTRACT

Sorption is one of the most studied methods to reduce the volume of radioactive waste streams. Cesium-137 is a radioisotope formed by the fission of uranium and it can cause health problems due to its easy assimilation by cells. The aim of this study is to evaluate the potential of coconut fiber in removing cesium from radioactive liquid wastes; this process can help in disposing radioactive waste. The experiments were performed in batch and the particle size of the fiber ranged between 0.30 mm and 0.50 mm. The fiber was treated with hydrogen peroxide in alkaline medium. The following parameters were analyzed: contact time, pH and concentration of cesium ions in aqueous solution. After the experiments the samples were filtered and cesium remaining in solution was quantified by inductively coupled plasma optical emission spectrometry.

1. INTRODUCTION

In addition to the benefits produced by the use of nuclear energy, the generation of radioactive wastes is an important issue to be assessed. The waste must be treated according to standards and procedures.

Filtration, precipitation, evaporation, membrane separation and extraction (RAHMAN, et al., 2011) are methods described for the treatment of radioactive liquid waste. However, they are operationally complex and costly. The search for new alternatives to treat radioactive waste that combine low cost, efficiency and volume reduction, led us to the use of biomass as adsorbent.

The biosorption is defined as a process in which biomass is used for retention, removal or recovery of heavy metals and / or radionuclides from aqueous solutions without the action of the metabolism (VOLESKY, 1994). This process has mechanisms such as complexation, chelation, adsorption to the cell surface by physical forces, ion exchange and precipitation (VOLESKY, 2004), which depends on the origin of the biomass.

In this present work, coconut fibers were used in the raw and modified forms to remove cesium from aqueous solutions. These studies will aid the process of disposing and decreasing waste volume by changing its physical state.

2. EXPERIMENTAL

2.1– Materials

Stock solution of CsCl (Fluka) at concentration 1.0 mol L^{-1} was prepared by dissolving 132.9 g CsCl in distilled water (Distiller Fabbe Ltda). The coconut (West Garden) was bought at a local trade.

2.2- Pre-treatment and chemical treatment of the biomass

The raw coconut fibers (*Cocos nucifera L.*) were washed with distilled water to remove impurities. After washing, they were dried at 80° C for 24 h and sterilized with germicidal lamp for 2h and separated using a particle size sieves (Granutest). The fraction used was 0.500 mm (35 mesh) and 0.177 mm (80 mesh).

For the chemical treatment process, 10 g of fibers were suspended in 200 ml solution containing 1.5 g of hydrogen peroxide (50%) (Vetec) and 0.1 g of the sodium hydroxide (Dinamica) at room temperature. The temperature was slowly raised to 60°C and oxidation continued for 2 more hours. The material was filtered, washed thoroughly with hot water, rinsed in cold water and then dried at 70°C for 24 h. (SHUKLA, 2009)

2.3 – Biosorption process

The biosorption process was performed in batch using 0.2 g of biomass and 10 ml solution of chloride cesium under agitation at room temperature. For the pH, particle size of biomass and dosage effects studies, the Cs^+ concentration was 13 ppm. After the contact, the solution was filtered through paper filter. The cesium remaining in the solution was analyzed by using ICP–OES (inductively coupled plasma optical emission spectrometry) - Perkin Elmer, model Optima 7000DV. All experiments were performed in triplicate. The adsorption capacity (q) was calculate as:

$$q = \left(\frac{Ci - Cf}{m} \right) V \tag{1}$$

where: Ci is an initial solution concentration (ppm); Cf is a final solution concentration (ppm); m is the mass of adsorbent (g) and V is the volume of the adsorptive solution (L).

3. RESULTS AND DISCUSSION

In order to evaluate the capacity of Cs^+ removal by using coconut fibers, the experiments were carried out using in raw and modified forms.

The following parameters were studied: contact time, pH, particle size of biomass, dosage effect and concentration of the solution.

3.1 – Effect of pH

For the influence of pH (measured with pH tape – Macherey-Nagel) in the Cs^+ removal the experiments were performed in 45 minutes of contact time and the results were shown in Table 1.

Table 1 - Influence of pH in Cs^+ removal

		Cs uptake (mg/g)	
Nº Exp	**pH**	**Raw Biomass**	**Modified Biomass**
1	3.5	0	0.06
2	7.0	0.33	0.29
3	9.5	0.39	0.50

The best results for Cs^+ uptake were obtained at pH 7 for raw coconut fiber and pH 9.5 for modified one. This can be explained because coconut fiber is a composition of cellulose, hemicellulose and lignin. The active centers of these compounds: carboxyl, amine and hydroxyl groups are likely to be positively charged at very low pH values because of high proton concentration, hence hinders the adsorption of metal cations on these binding sites (AKAR and TUNALI, 2006; KAPOOR et al., 1999). However, as the surface becomes negatively charged, it facilitates the uptake of metal cations through surface complexation and exchange which caused for enhanced uptake of Cs^+ at higher pH values. (MISHRA and TIWARI, 2002; SHARMA and FORSTER, 1994).

3.2 – Effect of particle size

The figure 1 shows the experiments that were carried out in different contact times and at pH 9.5.

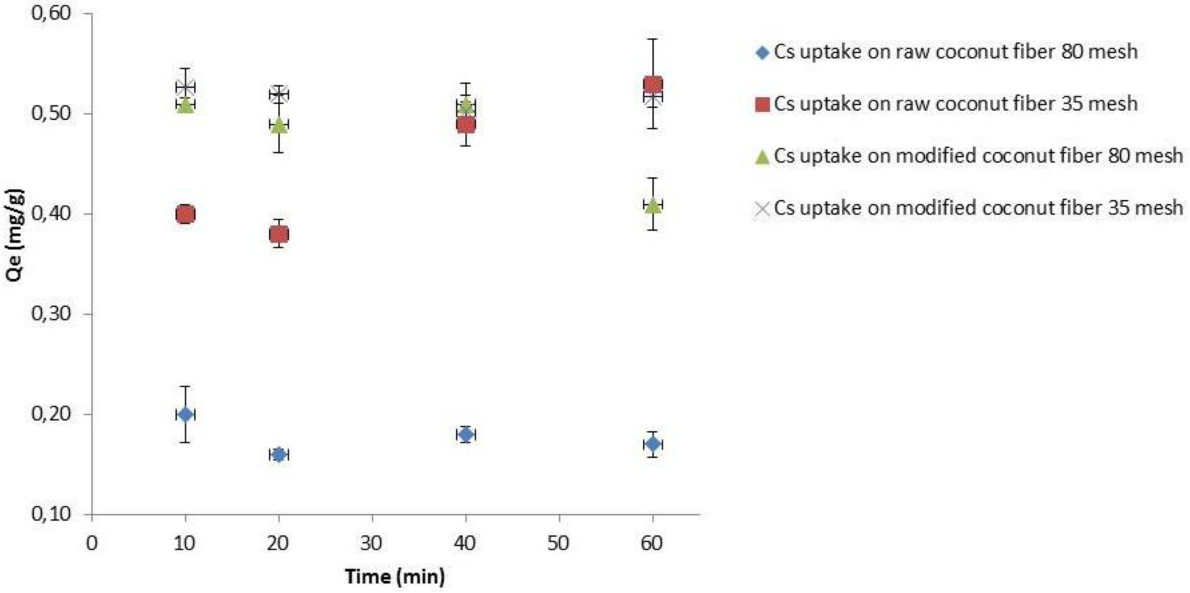

Figure 1 - Effect of particle size of the biomass on sorption of Cs^+

The largest particle size promoted a higher removal. According to PINO (2005), the larger size particles, in general, have greater adsorption due to an increased mass transfer of small particles. It was observed using raw coconut fiber, but for the modified coconut fiber there is not dependence on particle size. The maximum amount removed using modified coconut fiber with 35 mesh is 0.53 mg/g of cesium.

3.3 – Contact time for Cs^+ removal

The experiments were carried out in different contact time: 10, 20, 30, 60 and 120 minutes at pH 9.5.

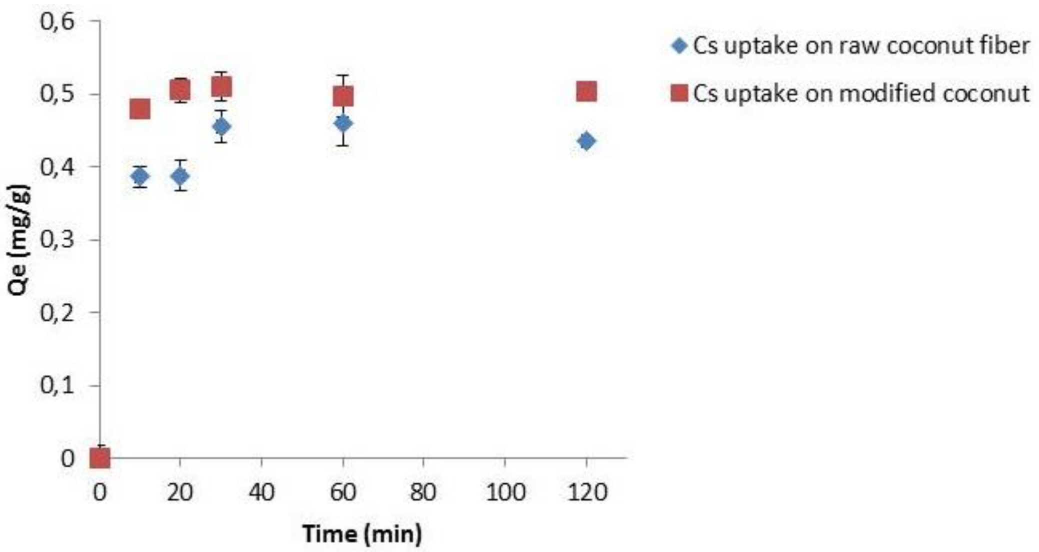

Figure 2 - Effect of time on batch adsorption

The maximum Cs^+ removal was 0.46 mg/g for raw coconut fiber and 0.52 mg/g for modified coconut fiber, both at 30 minutes of contact time, the equilibrium was then reached.

3.4 – Effect of dosage

The dose variation (biomass x solution) experiments were carried out in 5 ml of alkaline solution (pH 9.5) and 45 minutes of contact time. The results in table 2 showed that the maximum of cesium uptake was obtained with 0.1 g of biomass and the minimum with 0.5g. These results can be explained by the fact that under the agitation, the smaller amount of biomass in the solution showed a greater mobility.

Table 2 - Influence of dosage in Cs^+ removal

Cs uptake (mg/g)			
Nº Exp	Dosage (g)	Raw Biomass	Modified Biomass
1	0.1	0.37	0.50
2	0.3	0.08	0.10
3	0.5	0.04	0.07

3.5 – Effect of concentration

To study the concentration effect on the Cs^+ removal the experiments were performed using both raw and modified form of coconut fibers as shown in Figure 3.

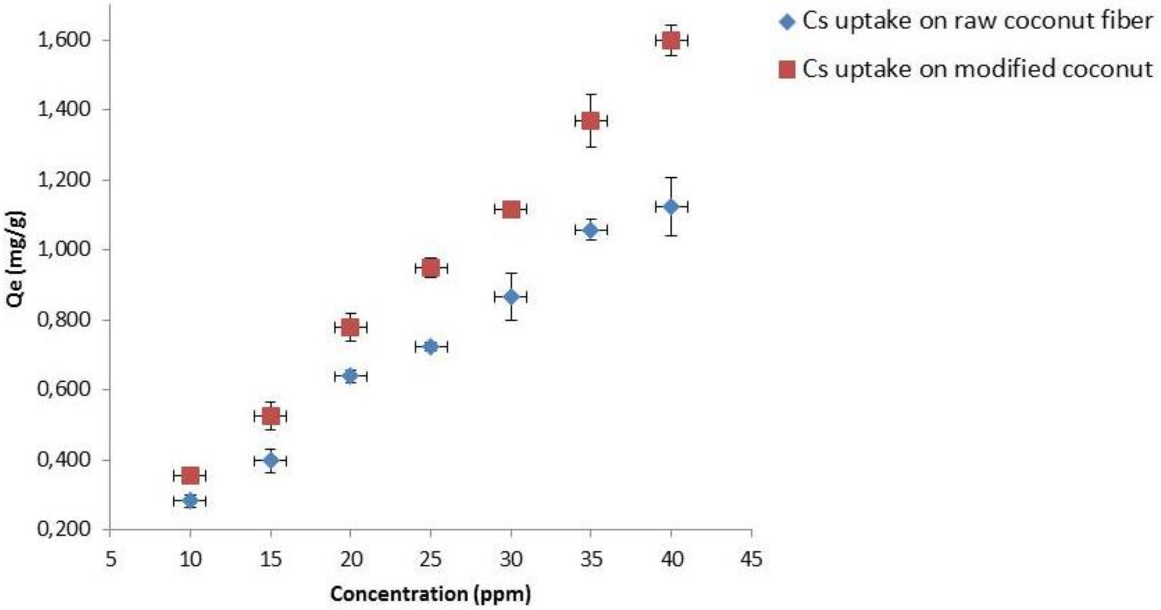

Figure 3 - Influence of the concentration of the solution

The amount of Cs^+ uptake increased with the concentration and the adsorption is exponential.

4. CONCLUSIONS

The results suggested that biosorption process is more efficient at pH 9.5 using modified coconut fiber for all concentrations and 45 minutes were sufficient to remove almost 80% of Cs^+ from the aqueous solution.

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