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Short Communication

Application of *Brachystegia eurycoma* seed hulls for the removal of cadmium in aqueous solution

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Abstract

Cadmium is amongst the most toxic and hazardous heavy metals found in surface and aqueous effluents from various manufacturing processes. In this study, the potential of Brachystegia eurycoma seed hulls to remove cadmium ions from aqueous solution was investigated. The effects of concentration of adsorbate (10-100mg/l), time of contact (20-100minutes), pH (2-10) and adsorbent dose (1-5g) on the adsorption of cadmium ions was studied. Within the range of variables studied, 98% cadmium ions were removed from aqueous solution at pH of 6, contact time of 40minutes, adsorbent dose of 1g and concentration of adsorbate of 30mg/l. The result indicated that Brachystegia eurycoma seed hulls were suitable for adsorption of cadmium from aqueous solution.

Keywords: *Brachystegiaeurycoma*, heavy metals, adsorption, cadmium, seed hulls.

Introduction

The amount of heavy metals released into the environment has been on the increase due to industrial activities and technological advancement. These heavy metals are introduced into water as a result of industrial activities such as mining, electroplating, petroleum refining[1] etc., and when absorbed into human body via food, water or air[2], accumulates and cause several health effects and even death[3]. Among the heavy metals, cadmium is listed among the 5 most hazardous[4], and at low and extreme concentration levels can cause diseases such as high blood pressure, sterility among males, kidney damage[4] etc. Existing technologies for the removal of heavy metals from aqueous solution include conventional methods such as chemical precipitation, ion exchange, membrane processes[5] etc. However, these technologies are costly. Adsorption has been proposed as a low cost method for water treatment[1]. Application of agricultural waste as adsorbent for heavy metals removal has the advantage of low cost, renewable, environmental friendly and availablability[1]. *Brachystegia eurycoma* is a seasonal plant predominantly found in West Africa. It is popularly known as 'Achi' in Eastern part of Nigeria and its usage ranged from food to medicine[6]. Figure-1 shows *Brachystegia eurycoma* plant and its seeds.

This paper reports *Brachystegia eyrycoma* seed hulls as a potential adsorbent for cadmium ions adsorption from solution.

Materials and methods

Cadmium solution (adsorbate) preparation: Stock solutions of cadmium were prepared by dissolving 2.0314g of cadmium chloride in 1 litre deionized water. Other concentrations were obtained by dilution.

Preparation of the adsorbent (*Brachystegia eurycoma* seed hulls): *Brachystegia eurycoma* seed hulls were obtained from SabonGari market in Zaria, Kaduna State, Nigeria. They were dried under the shade for seven days, grinded, and sieved to particle size of 710µm, then oven dried for 1hr at 120^0C. It was then washed with deionized water, filtered and stored in a beaker covered with aluminum foil paper to prevent contamination.

Adsorption experiment: Adsorption experiments were conducted at pH of 2-10, contact time of 20-100 minutes, adsorbate concentration of 10-100mg/l and adsorbent dose of 1-5g. The experiments were carried by batch method. Each working volume of adsorbate concentration was pipette into 100ml flask and topped up to 50ml with deionized water. Batch tests were carried out at room temperature by shaking cadmium solution with *Brachystegia eurycoma* seed hulls at varying pH and time of contact. The solution was filtered using filter paper and filtrate was taken for atomic absorption spectrophotometric (AAS) analysis to determine the final concentration of cadmium. The percent removal was calculated as follows[7]:

$$\% \text{ removal of } Cd^{2+} = \left[\left(c_i - c_f \right) \Big/ c_i \right] \times 100 \quad (1)$$

Where: c_i= initial concentration of Cd^{2+}, mg/l, c_f= final concentration of Cd^{2+}, mg/l.

Results and discussion

Effect of concentration of adsorbate on adsorption: Figure-2 presented the effect of varying the adsorbate concentration from 10 to 100mg/l on the percentage removal of cadmium ions while keeping the other variables constant.

Analysis of the figure showed that increasing concentration from 10 to 30mg/l results in an increase in % removal from 41 to 86%. However, beyond 30mg/l, % removal is slightly affected by increase in concentration up to 100mg/l. The increase in adsorption at lower initial concentration of adsorbate (10-30mg/l) could be due to the availability of bonding sites to interact with Cd^{2+} on the adsorbent surface, while a decrease in adsorption at higher concentration could be due to the saturation of the adsorption sites[5].

Effect of pH on the adsorption: Cadmium ions removal was studied within pH range of 2 to 10 (Figure-3) while keeping the other variables constant. The Figure shows that an increase in pH from 2 to 4 caused an increase in adsorption from 86 to 97.8%. An increase from 4 to 8, however, had little effect on the adsorption. Beyond pH of 8, adsorption decreased to 91.8% at pH of 10. The decrease in adsorption at pH above 8 could be attributed to the formation of insoluble metal hydroxides[5] which reverses the process[8].

Effect of adsorbent dose on Cd^{2+} removal: Adsorbent dosage was varied from 1 to 5g at constant concentration of adsorbate of 3omg/l, pH of 6 and 20 minutes time of contact (Figure-4).

Figure-1: *Brachystegia eurycoma* tree (left side) and seeds (right side).

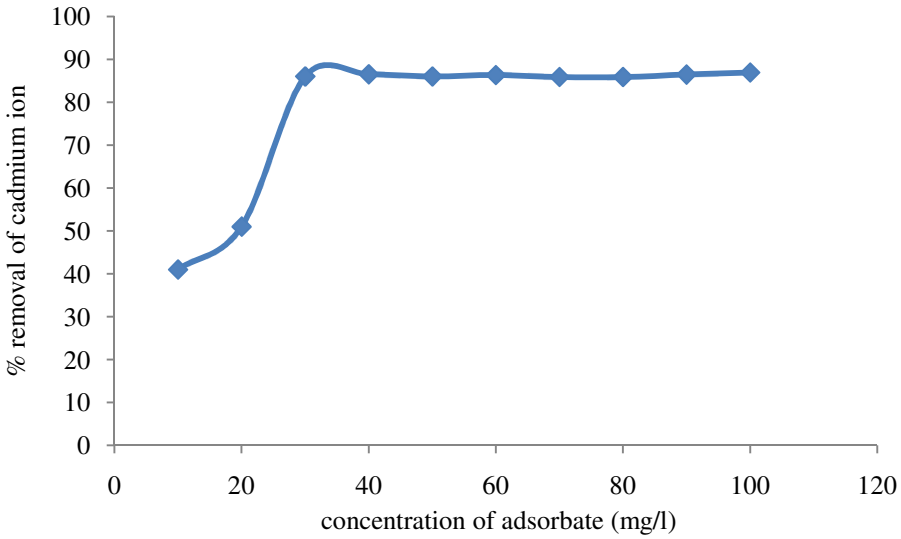

Figure-2: Variation of Cd^{2+} removal with change in adsorbate concentration.

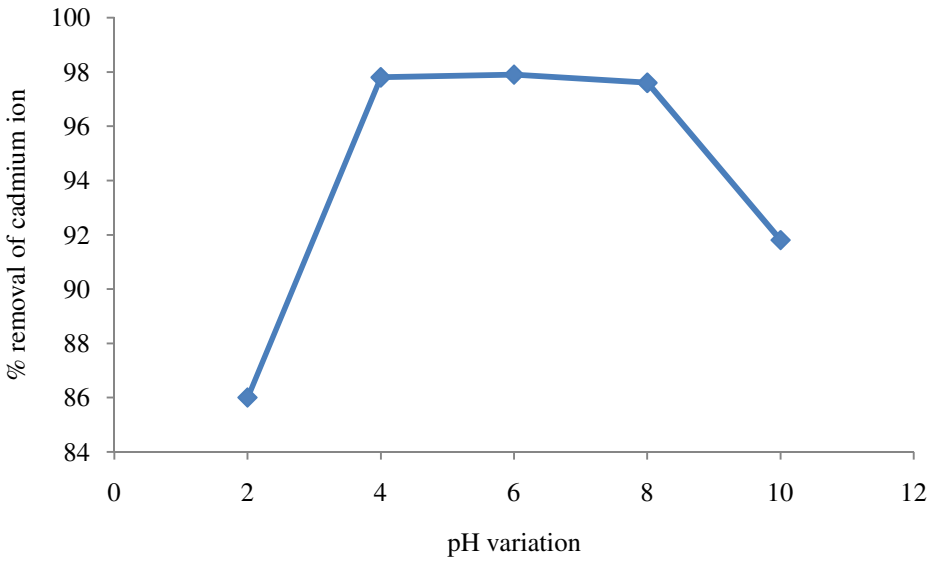

Figure-3: Variation of Cd^{2+} removal with change in pH.

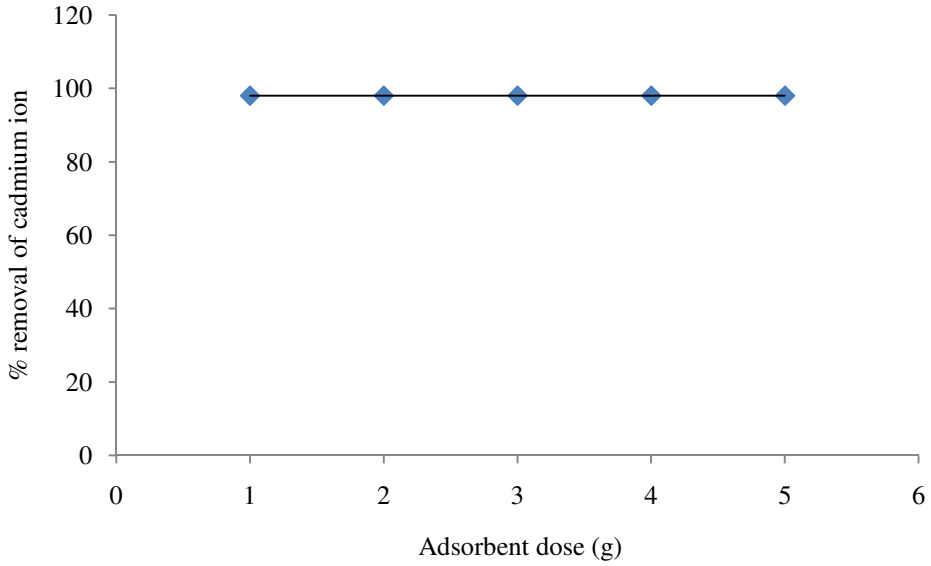

Figure-4: Variation of Cd^{2+} removal with change in adsorbent dose.

Analysis of the Figure-4 revealed a constant % cadmium ions removal of 98% as adsorbent dosage is increased from 1 to 5g. Hence, at 30mg/l concentration of the adsorbate, 1g adsorbent dosage is the optimal value as all binding sites available for interaction are occupied.

However, at higher dosage above 1g, there was no change in % removal of cadmium ions which could be due to overlapping of active sites[8] as a result of saturation of the adsorbate.

Effect of time of contact on Cd^{2+} removal: The effect of time of contact on Cd^{2+} removal was studied between 20 to 100minutes (Figure-5), while keeping the other variables constant.

The effect of time of contact on Cd^{2+} removal was studied between 20 to 100 minutes (Figure-5) while variables were kept constant. From the figure, it was observed that adsorption was rapid within the first 40 minutes with 98% Cd^{2+} removed, after which there was gradual decrease. The initial increase in adsorption could be as a result of large surface area of the adsorbent available for adsorption of Cd^{2+} and the gradual decrease could be due to the quick exhaustion of the absorption sites as a result of reaching equilibrium[2] at 40 minutes.

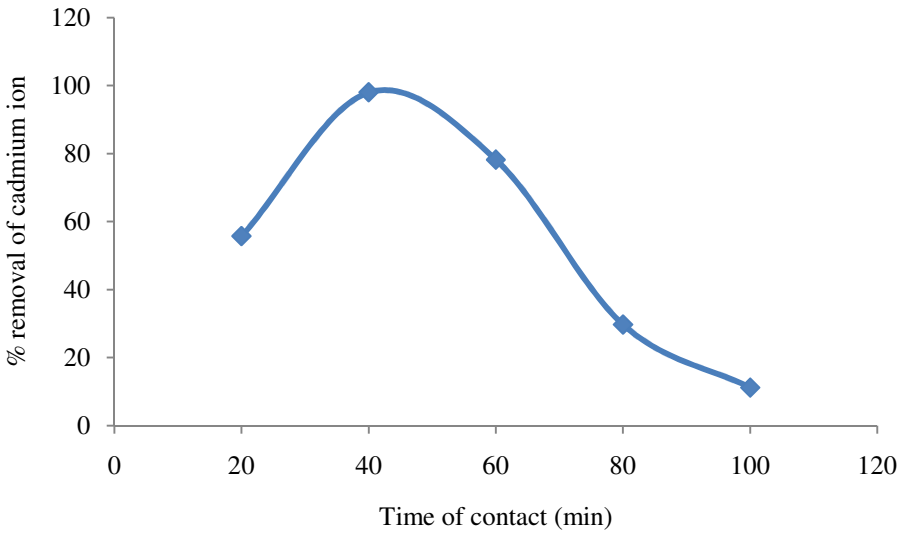

Figure-5: Variation of Cd^{2+} removal with change in time of contact.

Conclusion

The effectiveness of *Brachystegia eurycoma* seed hulls on the adsorption of cadmium ions from aqueous solution was investigated. The adsorption was found to be strongly dependent on the concentration of the adsorbate, pH of the solution, time of contact and adsorbent dosage. Maximum adsorption of 98% was obtained at pH of 6, concentration of adsorbate of 30mg/l, time of contact of 40minutes and adsorbent dosage of 1g.

Based on the result, it can be concluded that *Brachystegia eurycoma* seed hulls is a potential low cost adsorbent that can be effectively used to remove cadmium ions from aqueous solution.

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