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RESEARCH ARTICLE

REMOVAL OF DIVALENT CADMIUM FROM AQUEOUS SOLUTION BY BURNED PALM TREE LEAVES POWDER

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ABSTRACT

Removal of cadmium ions from aqueous solution using burned palm tree leaves powder (solid) was performed through batch studies. pH, contact time, metal concentration, dosage of solid and particle size of solid were studied to investigate the optimum conditions for removal percent and the maximum removal capacity of Cd^{II}. High removal percent was achieved at best parameters determined as follow: pH = 8.9, solid particle size= 75 µm, contact time= 120min, shaking rate= 300 rpm and cadmium concentration (C_o)= 90ppm. About 99% of Cd^{II} was removed from aqueous solution with maximum removal capacity of 26.6 mg/g at these conditions.

INTRODUCTION

Cadmium used as rechargeable nickel–cadmium battery in electroplating field due to the ability to resist corrosion and also used as a barrier to control neutrons in nuclear fission. The common toxic heavy metals found in industrial wastewater are Pb, Cd, Cr, Ni, Mn, Hg, Cu and Zn. The wastewater collected from electroplating unit containing more than 0.6 g/L of cadmium (Alagesan and Malairajan 2014) and this concentration revels huge contamination with this metal. The median lethal concentration (96-h LC50) of cadmium 0.0539 ppm (Jen 2014). Cadmium toxicity is due to direct inhibition of DNA mismatch remediation (Challa 2009). Elevated cadmium exposure induces increased oxidative stress and oxidative DNA damage (Wasana *et al.,* 2013) and may causes plasma membrane damage and lipid peroxidation (Anwei *et al.,* 2014). Removal of toxic divalent cadmium by chemical approach is very important, especially with using chemisorption methods. Several natural materials were used for this goal such as Desmostachya bipinnata (DB) (Jagjit *et al.,* 2012), calcite, zeolite, sand, and iron filings (Krishna *et al.,* 2014), oil cake of sesamum indicum activated by sulphuric acid (Tharanitharan *et al.,* 2014), cow horn (Jimoh *et al.,* 2014), rice husk activated with NaOH (Sneh L.ata and Samadder 2014), calcined coir pith (Eakkachai *et al.,* 2010), cassia siamea (Ajaelu *et al.,* 2011), aquatic mosses (Martins1 *et al.,* 2014). In Iraq and due to the highly abundance of date palm tree, their leaves are very cheap and easily obtained. According to the chemical functional groups present in these leaves, it is considered as a good source of metals chelator (Manal 2009).

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MATERIALS AND METHODS

Solid preparation

Date palm leaves from diyala city were collected and washed several time with distilled water and then dried at 120 C°, crushed, ground with an electrical grinder and sieved down to 300, 180 and 75µm, calcinated at 260 C°, then washed several time and regrinding by mortar.

Batch experiments

All experiments were done at room temperature, Batch tests were carried out in conical flasks to check the influence of pH, contact time , initial cadmium concentration, solid dosage level and solid particle size. 1000 ppm Cd^{+2} stock solution was prepared by dissolving 50 ml standard ampoule contains 1 gm bivalent cadmium in 1 liter distilled water. Cadmium solution was shaken with solid for desired contact time at a constant agitation speed 300 rpm at room temp and after filtration with filter paper, Cd^{+2} ions concentration before and after run was analyzed by using atomic absorption phonex-986. The functional groups on the surface of the calcinated leaves. was performed by FTIR analysis type ABBVactroLabMB3000.

Metal% removal was calculated by using simple concentration difference method while the maximum removal capacity (q_m) was calculated due to the following equation (Jimoh *et al.,* 2014):

$q_m = C_o - C_e * V / m$…….(1)

where V is the solution volume (L) , C_o and C_e are the initial and final Cd concentration at equilibrium (ppm) respectively and m is the mass of the solid (g).

RESULTS AND DISCUSSION

Effect of contact time (t)

The experimental runs measuring the effect of contact time on the batch removal of Cd^{+2} at initial metal concentration of 97 ppm (20 ml) at pH solution equal 1.4 mixed with 1 gm of 300 µm solid powder is shown in Fig-1, the removal of Cd^{+2} ions increases with time and attains equilibrium after 90 min.

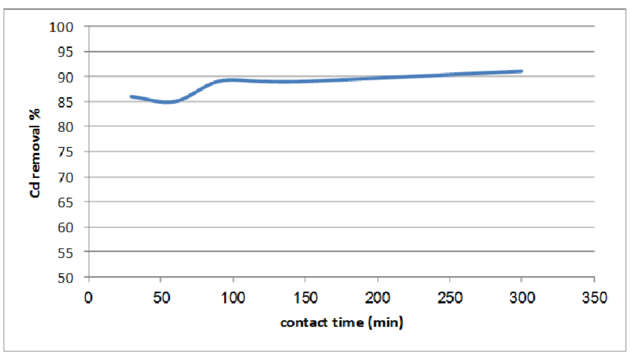

Fig.1. Effect of mixing time (min) on removal of Cd^{+2} from aqueous solution

C_o=97 ppm, V =0.020 L, pH=1.4, m=1 gm (300 µm)

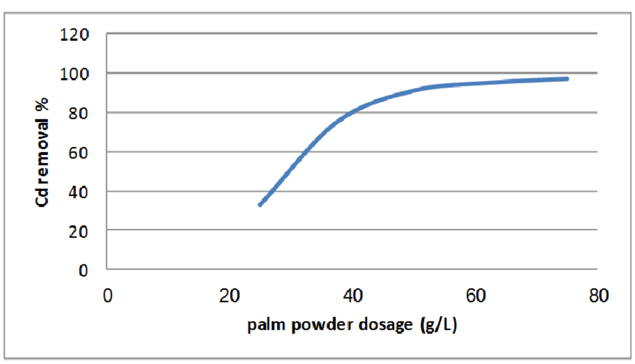

Fig.2. Effect of solid dosage on removal of Cd^{+2} from aqueous solution

C_o=97 ppm, V =0.020 L, pH=1.4

Effect of solid dosage

The influence of leaves powder surface area onto metal removal efficiency was studied due to both powder dosage and available active sites. by varying the powder dosage from 25 to 75 g/L using solid particle size of 300µm and C_o=97 ppm (20 ml) at pH=1.4, it can be easily inferred that the removal percentage of metal ions increases with increasing weight of solid as shown in (Fig-2), more dosage means more surface area, thus faster reaction.

Effect of initial metal ion concentration

The efficiency of Cd removal was affected by the initial ion concentrations with decreasing removal percentages as concentration increases from 50, 100, 150, 200 ppm. The study was carried out at tow particle sizes, 180 and 75 µm, both cases reflects the same mentioned behavior, but by using 75 µm the cadmium removal be larger as shown in (Fig-3), it decreased from 100% to 66% with increasing C_o from 50 to 200 ppm respectively, while by using 180 µm solid mesh, the percentage decreased from 99.7% to 26.3% at the same above graduated concentrations (Fig-4), that means high removal capacity was obtained for smaller particle size.

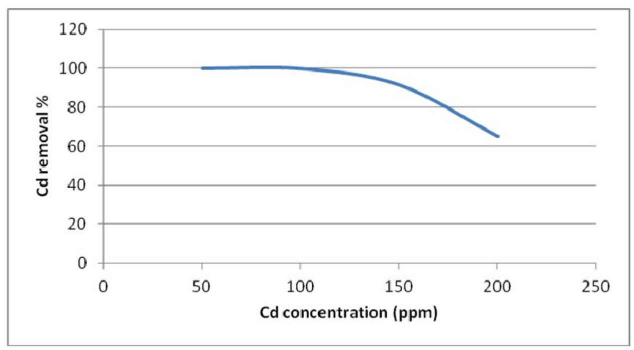

Fig.3. Effect of Cd^{+2} concentration on its removal at 75 micron of solid

t=120 min, V =0.020 L, m=0.3 gm (75 µm)

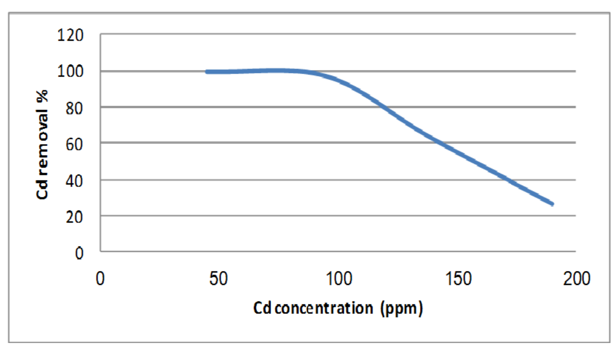

Fig.4. Effect of Cd^{+2} concentration on its removal at 180 micron of solid

t=120 min, V =0.020 L, pH=1.4, m=0.3 gm (180 µm)

Effect of pH

To follow the influence of pH on cadmium removal from aqueous solution, experiment were carried out by varying the pH over the range of acidic and basic medium, C_o=98 ppm (20ml), m = 0.5 g, solid particle size=300µm. As shown in (Fig-5), the results obtained reflect that the efficiency of cadmium removal being highly notice after pH = 4 and reach maximum at pH=8.9.

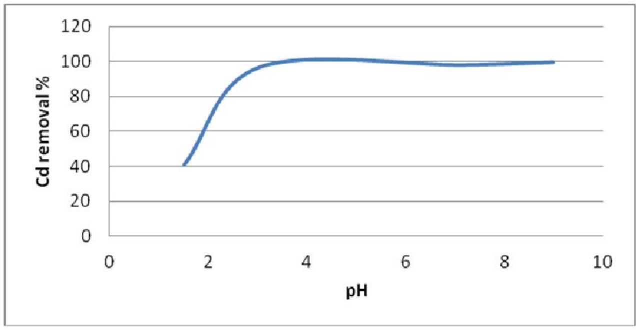

Fig.5. effect of pH on removal of Cd^{+2} from aqueous solution

C_o=98 ppm, V =0.020 L, m=0.5 gm (300 µm)

Optimum conditions

To take advantage of the whole results obtained from the previous runs and in order to reach the optimal conditions, experiment was done by using particle size of 75 µm by varying the solid dosage from 5 to 25 g/L, t=120 min, C_o=90 ppm (30ml) and pH = 8.9, as can be observed in (Fig-6) higher removal efficiency was obtained with decreasing solid particle size. Increasing the number of active sites give good performance of the metal separation by making easier penetration of ions toward the used solid powder. Maximum removal capacity obtained through the application of the equation 1 which reach 26.6 mg/g.

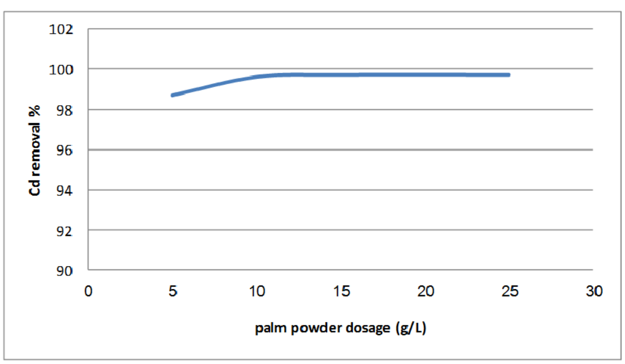

Fig.6. Effect of solid dosage on removal of Cd^{+2} from aqueous solution

C_o=90 ppm, V =0.030 L, pH=8.9, t=120min

To investigate the efficiency of cadmium removal from aqueous solutions, several materials from literature were compared with this work, as shown in Table (1) it can be considered that our solid powder is one of the best natural materials for isolate toxic cadmium from aqueous solutions.

Table 1. Comparison of removal capacity between this study and others

Adsorbent	Removal capacity mg/g	Refrence
Calcite	18.52	Krishna
Oil cake of Sesamum Indicum by sulphuric acid	*35.32*	Tharanitharan
Rice husk with NaOH	20.24	Sneh
Calcined coir pith , capacity	19.80	Eakkachai
Cassia siamea to remove Cd (II) ions from aqueous, capacity	37.7	Ajaelu
Aquatic Mosses	23.7	Martins
Treated poly (ethylene terephthalate)	23.44	Arash
Burned tree leaves	26.6	This work

FTIR

To assign the functional groups involved in the burned palm tree leaves powder, FTIR analysis were established as shown in (Fig-7). Primary amine is clearly appears due to the two N-H stretch absorptions at 3478 cm^{-1} and 3416 cm^{-1}, also N–H bend appears at 1619 cm^{-1}, in addition to the band at 1110 cm^{-1} which observed to the C–N stretch. It is clear that the functional group recommended for chelating with metal is due to amine group.

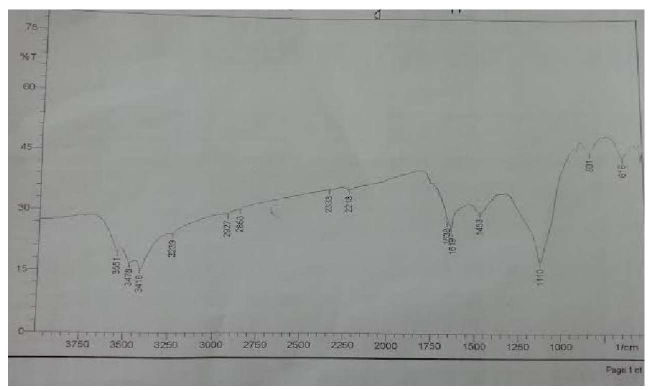

Fig.7. FTIR analysis of burned palm tree leaves powder

Conclusion

The results obtained in this study demonstrated that the burned palm tree leaves powder could be used as efficient solid materials for removal of toxic Cd^{+2} from aqueous solutions , such materials are great important due to their availability and low cost.

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