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Bio-sorption of cadmium ions from aqueous solution using dried *Eichhornia crassipes*

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ABSTRACT

Batch experimental technique was used to remove cadmium ions from aqueous solution using dried plants of *Eichhornia crassipes* (dried and pulverized into fine powdery form) as a low cost adsorbent. Fresh plants of *Eichhornia crassipes* were procured from the local pond of Raipur. The sample was thoroughly washed in de-ionized water then chopped into small pieces and air dried in shade at room temperature for three (3) days. The plant material was further dried in the oven at 60°C for 04 hours in order to blend them into a powdery form in a food blender. This powdered biomass was further used as bio-sorbent. The effects of different experimental conditions i.e. amount of adsorbent, particle size and contact time on metal adsorption was evaluated in this study. Removal of the cadmium ions with the sorbent increases with the increase in contact time. The highest removal of Cd was recorded with maximum taken contact time (240 minutes), smallest particle size (0.5mm) and highest taken amount of adsorbent (2.0gm).

Keywords: Cadmium, toxic metal, bio-sorption, *Eichhornia crassipes,* batch experiment

INTRODUCTION

Technological and industrial advancement over the past centuries has led to a record level of pollution that now poses a serious threat to man and the environment. Some wastes are released into aquatic bodies which ultimately find their way into other ecosystems and eventually man. Raipur is a rapidly developing industrial city largely affecting the water quality and aquatic health. Hence, environmental scientists and other experts on water health studies are constantly looking for effective, simple, applicable and cheap methods for the removal of toxic elemental and organic contaminants in environmental waters. Elements such as lead and cadmium exhibit human toxicity at extremely low concentrations. Silver, chromium, lead, copper, and zinc also exhibit toxic properties to humans although the concentrations are in orders of magnitude higher than that required for cadmium or mercury toxicity (Murugesan et al., 2006).

Conventional physical and chemical methods of metal removal from aqueous streams that have been applied include chemical precipitation, ion exchange, adsorption and electrochemical techniques, (Reed and Nonavinakere, 1992; Atwood et al., 2002). These methods, which are plagued with incomplete removal, involve the use of large volume of chemicals, high cost especially when contaminant concentrations are within the ranges of 10-100mgl^{-1}. They are laborious and generate other wastes that require further disposal (Rostami and Joodaki, 2002). Lately, the use of waste materials from plant origin and other agro wastes as sorbents of toxic metals from aqueous medium is gaining attention due to their ability to adsorb toxic metals from *aqueous* systems. This is also because agro-wastes are readily available, cheap, biodegradable, sludge free and involve small initial cost and land investment (Uppendra 2006; Horsfall, *et al*., 2006). Several plant based materials have been explored and reported in this regard. Cassava tuber back wastes (CTBW) was investigated (Horsfall *et al*., 2005). *Alfalfa, Medicago saliva* (Gardea-Torresdey, et al., 1996) and *Moringa oleifera* seeds (Srivastava, *et al*., 2008).

Drinking water that contains greater than 0.05 mg/L of cadmium is very dangerous and will be carried in the blood to the liver on consumption. There, it bonds to proteins to form complexes that are transported to the kidneys. It accumulates in kidneys where it damages filtering mechanisms. This causes the excretion of essential protein and sugars from the body and further kidney damage. It takes a very long time before accumulated cadmium in kidney is excreted from a human body (Lenntech, 2008).

The major advantages of biosorption over conventional treatment methods include low cost, high efficiency of metal removal from dilute solution, minimization of chemical and /or biological sludge, no additional nutrient requirement, regeneration or biosorbent and the possibility of metal recovery (Kratochvil and Volesky, 1998; Radway *et al.,* 2001, Omar, 2002 and 2008).

A number of researchers hypothesizes that *Eichhornia crassipes* (water hyacinth) dried leaves/plant is potential in removing some of these heavy metals (HM), including lead, copper, cadmium, chrome, metalloides and some other physico-chemical impurities from aqueous solutions via biosorption influenced by some variable experimental factors (Low et al., 1994, Schneider et al., 1995, Shawky et al., 2005, 2005, Achanai Buasri et al., 2012, OBI and C, 2015, Hassanein and Najem, 2017, Kipkorir et al., 2017, Tseveendorj et al., 2018).

MATERIAL AND METHODS

Fresh plants of *Eichhornia crassipes* were procured from the local pond of Raipur. The sample was thoroughly washed in de-ionized water to remove dirt particles contained in them. The sample was then chopped into small pieces and air dried in shade at room temperature for three days and was further dried in the oven at 60°C for 04 hours in order to blend them into a powdery form in a food blender. The powder was then sieved using three different sieves of 0.5mm, 1.0mm and 2mm size and kept in an air tight glass container which was kept in desiccators in order to preserve it from humidity. To avoid sample contamination, all handling and preparation steps were carried out on clean benches.

Batch experiments were performed for the bio-sorption of cadmium. Working solution was prepared from the stock standard solutions (1000 mg/L) of the metal.

Contact Time: To know the effect of different contact time on metal adsorption by the adsorbent, working solution of 20 mg/L (100 ml) for cadmium was prepared and taken separately into four different conical flasks, 2 gm each of the grinded adsorbents was added to it and were agitated using Orbital Shaker at 120 rpm at ambient temperature with the evaluating contact time of 60, 120, 180 and 240 minutes.

Amount of Adsorbent: To evaluate the effect of different amount of adsorbent on metal adsorption by the adsorbents, 20 ppm solution of cadmium was prepared. Four different amounts of the adsorbent (0.5, 1, 1.5 and 2 gram) were weighed and added to the above sets of cadmium solution. The flasks were then placed in Orbital Shaker for 120 minutes, at 120 rpm and ambient temperature.

Particle size of Adsorbent: To determine the effect of particle size of adsorbent on metal adsorption by the adsorbents, 20 ppm solution of cadmium was prepared (three sets each for the adsorbent). The powdered sample was sieved through three different (0.5, 1.0 and 2.0 mm) sized sieves. Three different particle sizes of adsorbent were then added to the above three sets of 100 ml (each) 20 ppm metal solution. The flasks were then placed in Orbital Shaker for 120 minutes, with speed 120 rpm at room temperature.

After the required evaluation time, the flasks were taken out and the mixture was sieved using whatman no.1 filter paper. All the resulting solutions were then analyzed for their metallic content using Atomic Absorption Spectrometer.

RESULTS AND DISCUSSION

Effect of operating variables i.e. contact time, particle size and amount of the adsorbents on removal of cadmium from 20 ppm aqueous solution are presented here Table 1.

Table 1: Remaining concentrations and percent removal of cadmium after different contact times with *E. crassipes* as adsorbent

Contact Time	Initial concentration - 20ppm		
	Remaining Cd (mg/Kg)	SD	Removal of Cd (%)
60 min	7.61	0.875	61.95
120 min	7.82	0.884	60.90
180 min	7.44	0.868	62.80
240 min	7.43	0.868	77.80

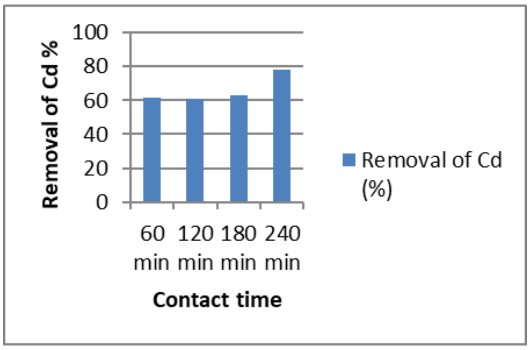

Fig. 1: Percent removal of cadmium after different contact times with *E. crassipes* as adsorbent

Table 2: Remaining concentrations and percent removal of cadmium with different particle size of *E. crassipes* as adsorbent

Particle Size	Initial concentration - 20ppm		
	Remaining Cd (mg/Kg)	SD	Removal of Cd (%)
0.5 mm	08.04	0.905	59.80
1.0 mm	08.56	0.911	57.20
2.0 mm	10.71	0.980	46.45

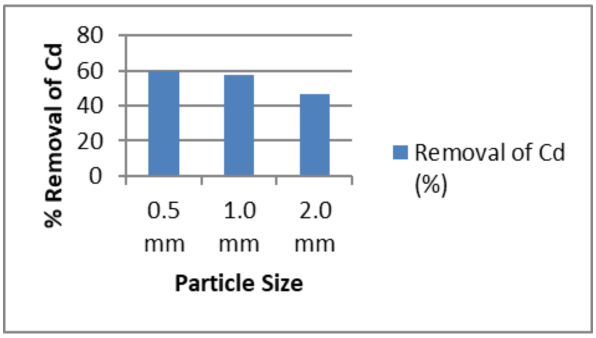

Fig. 2: Percent removal of cadmium with different particle size of *E. crassipes* as adsorbent

Table 3: Remaining concentrations and percent removal of cadmium after variable dose with *E. crassipes* as adsorbent.

Adsorbent Amount	Initial concentration - 20ppm		
	Remaining Cd (mg/Kg)	SD	Removal of Cd (%)
0.5 gm	19.44	1.623	00.03
1.0 gm	13.04	1.000	34.80
1.5 gm	10.04	0.959	49.80
2.0 gm	07.57	0.874	62.15

It was observed that when sorbent was used for metal removal the highest removal of Cd was reached within 240 minutes. As the contact time increases removal of the cadmium ions enhances. More time allows the adsorbent particle to interact with the metal ion and increase chances of more adsorption (Jimoh, 2012). Result presented in Table 2 shows that the highest removal (59.80%) was observed for 0.5mm size adsorbent and lowest removal (46.45%) for 2.0 mm size adsorbent. The smaller the particle size the higher the surface area per unit weight of sorbent and hence higher percentage removal is expected (Bhatti et al, 2007) and this decrease in removal with increasing particle size was observed for *E. cressipes*. Result at Table 3 shows that as the sorbent dose were increased from 0.5 g to 2.0 g, the percentage removal of cadmium ions increased (00.03, 34.80, 49.80 and 62.15% respectively) and thus the optimum sorbent dose for the removal of Cd was 2 g. However, a further increase beyond the optimum sorbent dose decreases the percentage removal and this is attributed to the fact that there is possibility of the particle overlapping and overcrowding resulting in a reduction of the total adsorbent surface area and hence decreases the percentage removal (Rahman and Islam, 2009).

CONCLUSION

E. crassipes in its non-living form is efficient in the removal of cadmium ions. As the plant is infested throughout the world in every corner and every side, utilization of the plant should be done from every angle seeing the positive attributes. This work examined the efficiency of this sorbent in removal of Cd ions from aqueous environment. The results indicated that several factors such as initial biomass concentration, contact time and particle size of biomass affect the bio-sorption process. The optimum conditions for bio-sorption of Cd ions using *E. cressipes* as bio-sorbent were determined to be a contact time more than 3 hrs, a dose of 2.0 gm and particle size of 0.5mg. The physico-chemical characteristics of wastewaters from varying sources can be much more complex compared to the aqueous metal solution used in this study. Therefore, this plant should be studied for the removal of other heavy metals which are discharged from mining and other industrial activities. The further research will be conducted to characteristics of adsorption-desorption cycles to metals recovery and to reutilize of sorbent biomasses.

Conflict of Interest

The author declares that there is no conflict of interest.

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