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Biosorption Of Cadmium Using A Few Agricultural Waste

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Abstract: In the present study, Cadmium removal efficiency of different agricultural waste was analyzed under laboratory condition with the help of biological materials viz., Beet root (Beta vulgaris), Carrot (Daucus carota), Amla (Phyllanthus emblica) and Tapioca (Manihot esculenta). Three concentrations of Cadmium nitrate such as 0.1 mg/100ml, 0.2mg/100ml and 0.3 mg/100ml under pH 8 and treated with three different types of agricultural waste. Generally by comparing these four types of biological materials, there is no significant difference among the concentration in the pH of 0.8 to absorb the Cadmium nitrate. Eventually, the natural waste under study absorb the heavy metals in all the concentrations at the pH 8 efficiently.

Keyword: Cadmium nitrate, agricultural waste, biosorption, pH.

I. INTRODUCTION

Environmental pollution with heavy metals has become a global phenomenon. In the field of environmental pollution, there are few subjects that, during recent years have been developed as rapidly as the study of toxic metals. The contamination of water by toxic heavy metals is a world-wide environmental problem. Mobilisation of heavy metals in the environment due to industrial activities of serious concern as these metals are toxic to all forms of life including human beings. Biosorption or biological method of removal has distinct advantages over conventional methods. The current pattern of industrial activity alters the natural flow of materials and introduces novel chemicals into the environment (Faisal and Hansain, 2004). The presence of heavy metals in the environment is of major concern because of their toxicity, accumulating tendency, threat to human life and the environment (Igwe and Abia, 2003 and Horsfall and Spiff, 2005). Cd (II) is listed as the sixth most poisonous substance jeopardizing human health. Exposure to lower amounts of cadmium may cause gastrointestinal irritation, vomiting, abdominal pain and diarrhea (Prasad *et al*., 2010). The permissible limit for Cd (II) as described by WHO is 0.01 mg/dm^3 (Charemisionoff, 1995). Cadmium in particular has received a great deal of attention due to its highly toxic nature and its tendency to accumulate in the tissues of living organisms.

Recently, several methods employed for the removal of cadmium such as precipitation, ion exchange, adsorption, etc. However, these technologies are generally practical and cost-effective only with concentrated waste water and are ineffective when applied to low strength wastes with heavy metal ions concentrations less than 100mg/l (Volesky *et al*., 1990). This situation has in recent years led to a growing interest in the application of waste materials of biological natural origin for removal of trace amounts of toxic metals from dilute aqueous wastes. Biosorbent is naturally available biological materials are prepared from naturally abundant and/or waste biomass. Due to the high uptake capacity and very cost-effective source of the raw material, biosorption is a progression towards a perspective method (Volesky *et al.*, 1990). A number of natural materials (agricultural/forestry waste) and byproduct have been studied in the literature for their capacity to remove cadmium from aqueous solutions, such as eucalyptus bark. Almond peel, bagasse sugar (Gupta *et al.*, 2003), saw dust (Taty – costodes *et al*., 2003), spent grain

(Low *et al*., 2000), pine bark (Al-asesh *et al*., 1997), rice polish (Singh *et al*., 2005), tree fern (Ho *et al*., 2004), modified corn cobs (Vaughan *et al*., 2001), etc. Therefore, there is a need for the search of low cost and easily available biomaterials, which can remove cadmium. The aim of this work is to report the result of a feasibility study using four biological natural wastes such as beet root, carrot, amla tree bark and tapioca as inexpensive sorbent materials for the removal of Cd ions from synthetic aqueous solutions.

II. MATERIAL AND METHODS

The removal of Cadmium nitrate by using agricultural byproducts was carried out in the laboratory conditions.

PREPARATION OF STANDARD SOLUTION

Solution of Cadmium (1000 mg/L) was prepared by dissolving cadmium nitrate in distilled water.

PREPARATION OF BIOLOGICAL MATERIAL

Different types of agricultural byproducts viz., Beet root (*Beta vukgaris*), carrot (*Dacus carota*), Amla tree bark (*Phyllanthus emblica*) and Tapioca (*Manihot esculenta*) were selected as biological materials for removing the heavy metal mercuric chloride. The agricultural waste products were collected from the local mill. In order to eliminate the soluble components and colouring substances the residues were washed with 0.5 M HCl, 0.5 M sulphuric acid and distilled water. Subsequently the biological materials were oven dried at 105° C for 24 hours, stored in a desiccator and use for biosorption studies.

EXPERIMENTAL DESIGN

100 ml of distilled water was taken in a conical flask and added 0.1 mg of mercuric chloride. In it 1 gm of beet root was added and shaked well for two hours constantly. Before mixing the adsorbent, the pH of each solution was adjusted to the required value (pH=8) with diluted KOH solution, respectively. Performed another set of experiments to find out exact concentration of Cd. Likewise three set of experiments were carried out for beet root. Similarly three set of same principle was carried out for the carrot, amla tree bark and tapioca.

The appropriate sample solution was analyzed in spectrophotometer at 575 nm. The OD (optical Density) values of all the samples were compared with the OD value of standard. The amount of absorptions were calculated using the formula,

$$\text{Absorption} = \frac{\text{Sample OD}}{\text{Standard OD}} \times \text{Concentration of the standard}$$

In the similar way 0.2mg and 0.3 mg of mercuric chloride was added in 50 ml distilled water in the same procedure. And three different species of biological materials were involved for the experiment. The OD values of all the samples were compared with the OD value of standard.

STATISTICAL ANALYSIS

Three set of results were brought down as mean by way of giving standard deviation. The different means of different biological materials in three concentrations were compared by T- test.

III. RESULTS AND DISCUSSION

In the present study, Cadmium nitrate removal efficiency of different biological materials was analyzed under laboratory condition. The absorption of Cd was done with the help of biological materials such as Beet root, carrot, amla and tapioca. It was attempted with three concentrations of Cd such as 0.1 gm/100 ml, 0.2gm/100ml and 0.3 gm/100 ml in the pH 8.

ABSORPTION OF DIFFERENT CONCENTRATION OF CADMIUM BY AGRICULTURAL WASTES

The result revealed that the absorption of Cd by beet root was 0.822±0.358 mg, 0.058±0.062 mg and 0.470±0.057 mg at 0.1%, 0.2% and 0.3% concentration of cadmium respectively. However, there was no significant difference observed among the different concentration of Cd used ('t' test). It indicates the bioabsorption efficient of beet root is constant but not concentration dependent. The results are shown in table 1. Mahvi *et al*., (2008) have studied about the biosorption of cadmium by ulmus leaves and suggested that it is a better biosorbent. Benaissa *et al* (2009) have proved that bean husk was the most effective agricultural waste to remove cd ions with a maximum sorption capacity.

In the sample of carrot the absorption of the Cd was 0.946± 0.006 mg, 0.035±0.018 mg and 0.039±0.010 mg at 0.1%, 0.2% and 0.3% concentration of cadmium respectively. However there was no significant difference observed among the different concentration of Cd used (t test). It indicates the bioabsorption efficient of carrot is constant but not concentration dependent. The results are shown in table 2.

In the sample of amla tree bark, the absorption of Cd was 1.741±0.413 mg, 0.728±0.121 mg and 1.552±0.740 mg at 0.1%, 0.2% and 0.3% concentration of cadmium respectively. However there was no significant difference observed among the different concentration of Cd used (t test). It indicates the bioabsorption efficient of tree bark is constant but not concentration dependent. The results are shown in table 3. Shin *et al* (2005) have observed the biosorption of Cd by juniper wood bark.

The absorption rate of tapioca at 0.1%, 0.2% and 0.3% concentration of cadmium was 0.511±0.040 mg, 0.080±0.048 mg and 0.594±0.013 mg, respectively. However there was no significant difference observed among the different concentration of Cd used (t test). It indicates the bioabsorption efficient of tapioca is constant but not concentration dependent. The results are shown in table 4. Tree leaves can be used in the waste water treatment process for the removal of metal ions. The percent of adsorption for Cd ion decreased with the decrease in pH, because protons compete with metal ion for sorption sites on the adsorbent surface as well as the

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concomitant decrease of negative charge of the same surface (Namachivayam and Ranganathan, 1995). The optimum pH in this study was 6. It has been reported that precipitation of Cd starts at pH 7.5 (Ajmallet *et al*., 2003).

It is the time needs to be investigated further in order to promote large scale use of non-conventional adsorbents. In spite of the scarcity of consistent cost information, the widespread uses of low cost adsorbents in industries for waste water treatment applications today are strongly recommended due to their local availability, technical feasibility, engineering applicability and cost effectiveness. If low cost adsorbents perform well in removing heavy metals at low cost, they can be adopted and widely used in industries not only to minimize cost inefficiency, but also profitability.

In addition, if the alternative adsorbents mentioned previously are found highly efficient for the heavy metal removed, not only the industries, but the living organisms and the surrounding environment will be also benefited from the decrease or elimination of potential toxicity due to the heavy metal. Thus, the use of low cost adsorbent may contribute to the sustainability of the surrounding environment. Undoubtedly low cost adsorbents offer a lot of promising benefits for commercial purpose in the future.

Concentration	pH	Adsorption rate	df	T value	P value
0.1	8	0.735	1	0.0719	12.706
0.1	8	1.216	1		
0.1	8	0.514	1		
Mean=0.822±0.358					
0.2	8	0.131	1	0.651	12.706
0.2	8	0.024	1		
0.2	8	0.020	1		
Mean = 0.058± 0.062					
0.3	8	0.041	1	0.0572	12.706
0.3	8	0.155	1		
0.3	8	0.082	1		
Mean =0.470± 0.057					

Table 1: Comparison of different concentration of biosorption rate of beet root

Concentration	pH	Adsorption rate	df	T value	P value
0.1	8	0.278	1	0.0015	12.706
0.1	8	0.273	1		
0.1	8	0.286	1		
Mean =0.946± 0.006					
0.2	8	0.053	1	0.5330	12.706
0.2	8	0.016	1		
0.2	8	0.036	1		
Mean =0.035± 0.018					
0.3	8	0.048	1	0.00046	12.706
0.3	8	0.028	1		
0.3	8	0.040	1		
Mean =0.039± 0.01					

Table 2: Comparison of different concentration of biosorption rate of carrot

Concentration	pH	Adsorption rate	df	T value	P value
0.1	8	1.873	1	0.0569	12.706
0.1	8	2.073	1		
0.1	8	1.278	1		
Mean= 1.741± 0.413					
0.2	8	0.591	1	0.187	12.706
0.2	8	0.824	1		
0.2	8	0.77	1		
Mean= 0.728± 0.121					
0.3	8	1.191	1	0.8025	12.706
0.3	8	1.061	1		
0.3	8	1.404	1		
Mean= 1.552± 0.740					

Table 3: Comparison of different concentration of biosorption rate of beet root

Concentration	pH	Adsorption rate	df	T value	P value
0.1	8	0.531	1	0.0027	12.706
0.1	8	0.538	1		
0.1	8	0.465	1		
Mean =0.511± 0.040					
0.2	8	0.135	1	0.0047	12.706
0.2	8	0.065	1		
0.2	8	0.041	1		
Mean =0.080± 0.048					
0.3	8	0.579	1	0.0886	12. 706
0.3	8	0.604	1		
0.3	8	0.6	1		
Mean =0.594± 0.013					

Table 4: Comparison of different concentration of biosorption rate of amla tree bark

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