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RESEARCH ARTICLE

BIOSORPTION OF MERCURY USING A FEW AGRICULTURAL WASTE

***[1]Elavarasi, S., [2]Revathi, G., [2]Saravanan, K., [1]Horne Iona Averal and [2]Pushparani, L.**

[1]PG and Research Department of Zoology, Holy Cross College (Autonomous), Tiruchirappalli – 620002

[2]PG and Research Department of Zoology, Nehru Memorial College (Autonomous), Puthanampatti – 621007

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ABSTRACT

In the present study, the mercury removal efficiency of different agricultural waste materials sugar-cane bagasse (*Saccharum aruandinaceum*), coconut coir (*Cocos nuciferus*) and saw dust was analyzed under laboratory condition in the water. Three concentrations of mercuric chloride, such as 0.1mg/100ml, 0.2mg/100ml and 0.3mg/100ml under pH 6 are treated with three different types of selected agricultural waste. Generally by comparing these three types of biological materials, there is no significant difference among the concentration to absorb the mercury. Even though, the natural waste under study, absorb the heavy metal in all the concentrations at the pH 6 efficiently.

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INTRODUCTION

Environmentally threatened impacts of metal pollution are a well-known fact during last few decades globally. Mobilization of heavy metals in the environment due to industrial activities of serious concern as these metals is 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). Most of the industrial effluents contain toxic substances, especially heavy metals. 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; Michael Horsfall and Spiff, 2005). Mercury once discharged into the atmosphere, it persists in the environment for decades and creates long-term contamination problems in the different trophic levels of the food chain through bioaccumulation (Teixeira Tarley and Zezzi Arruda, 2004). Mercury vapour is easily inhaled enters with in cell through the blood stream in the lungs and is oxidized to reactive Hg^{2+} which can bind to the amino acid cysteine proteins (Horvat *et al*., 2003). Accordingly, various legislative control measures and improved innovative methods of reverse osmosis, precipitation, coagulation, ion exchange, solvent extraction, adsorption, membrane filtration and ultrafiltration are continuously being developed for cleaning the water and waste water contaminated with metal pollutants (Pacheco *et al.,* 2006). In recent years attention has been focused on the utilization of unmodified rice husk as a sorbent for the removal of pollutants like metals and heavy metals (Nouri *et al*., 2007). The effect of adsorption parameters such as pH, adsorbent concentration, adsorbed by using these agrobased materials as low cost adsorbents were reported (Amin, 2008). Agricultural wastes or byproducts have been investigated extensively for the removal of heavy metals due to their abundance in nature (Bailey *et al*., 1999). The mechanism of binding of metal ions by adsorbents may depend on the chemical nature, if metal ions (species, size and ionic charge) the type of biomass, environmental conditions (pH, temperature, ionic strength) and existence of competing organic or inorganic metal chelators (Wilde and Bremen, 1993). Commercial activated carbon is a well-known adsorbent for the removal of heavy metals from natural water and wastewaters. Nonetheless, its high price limits its function as an adsorbent. Hence, there is a growing need to develop low cost activated carbon adsorbent materials from cheaper and locally available agricultural waste materials. People can apply such bioabsorption technique in large scale in

***Corresponding author: Elavarasi, S.,**
PG and Research Department of Zoology, Holy Cross College (Autonomous), Tiruchirappalli – 620002

highly polluted areas (Elavarasi *et al.,* 2012). The aim of this work is to report the result of a feasibility study using three biological natural waste materials such as sugar cane bagasse, coconut coir and sawdust as inexpensive Sorbent materials for the removal of Hg ions from synthetic aqueous solutions.

MATERIAL AND METHODS

The removal of mercuric chloride by using agricultural byproducts *viz.,* sugarcane bagasse, coconut coir and saw dust was carried out in the laboratory conditions. The sugarcane bagasse was collected from the local sugarcane juice shop, Thuraiyur. The coconut coir waste was collected from the houses of local villages. Saw dust was collected from the local saw mill.

Preparation of Biological Materials

Different types of agricultural wastes *viz*., Sugarcane (*Saccharum aarundinaceum*), coconut coir (*Cocus nucifera*) and saw dust were selected for removing the heavy metal mercuric chlroride. They were brought to laboratory and dry under shade. After drying, they were finely powdered by using a mechanical grinder. In order to eliminate the soluble components and colouring substances the residues were washed with 0.5M HCL and distilled water. Subsequently the biological materials were oven dried at 105° C for 24 hours, stored in a desiccator for further biosorption studies.

Removal of Hg

100 ml of distilled water was taken in a conical flask and added 0.1 mg of mercuric chloride. In it 1gm of sugarcane bagasse was added and shake well for two hours constantly. Before mixing the adsorbent, the pH of each solution was adjusted to the required value (pH=6) with a diluted KOH solution, respectively. Performed another set of experiments to find out the exact concentration of Hg. Similarly, three sets of the same principle were carried out for the coconut coir waste and saw dust. 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 the standard. The amount of absorptions was calculated using the formula,

$$\text{Absorption} = \frac{\text{OD of sample}}{\text{OD of standard}} \times \text{Conc. of standard}$$

In the similar way 0.2mg and 0.3 mg of mercuric chloride was added in 100ml distilled water in the same procedure for each species of biological materials used under study.

Statistical analysis

Three sets of results were given as Mean ± SD. Mean values of different biological materials in three concentrations were compared by Students't-test. The statistical methods were followed by Sokal and Rohlf (1995).

RESULTS AND DISCUSSION

In the present study, the mercury removal efficiency of different biological materials was analyzed under laboratory condition. The absorption of Hg was done with the help of biological materials such as sugarcane bagasse, coconut coir and saw dust. It was attempted with three concentrations of Hg such as 0.1gm/100ml, 0.2gm/100ml and 0.3 gm/100 ml at pH of 6.

Sugarcane bagasse

The result revealed that the absorption of Hg was 2.175±2.088 mg, 2.684±0.592 mg and 1.163±0.316 mg by sugarcane bagasse at the concentration of 0.1%, 0.2% and 0.3% respectively. However, there was no significant difference observed among the different concentration of Hg used ('t' test). It indicates that the bioabsorption efficiency of sugarcane bagasse is constant but not concentration dependent. The results obtained were shown in the table 1. Similarly, Opeolu *et al*., (2010) have studied about the heavy metal removal from aqueous solutions by various biomaterials. Bagasse pith, which is the main waste from sugarcane industry in Egypt, has been used as a raw material for the preparation of different activated carbons. Elavarasi *et al*., (2012) also proved that the different types of agricultural wastes (cereal husks) has a capacity to absorb heavy metal and are good candidate for treating waste waters containing heavy metals.

Coconut coir

In the sample of coconut coir the result of Hg absorption showed that 4.733±2.959 mg, 3.302±1.848 mg and 4.577±2.651 at a concentration of 0.1%, 0.2% and 0.3% respectively. However, there was no significant difference observed among the different concentration of Hg used ('t' test). It indicates that the bioabsorption efficiency of coconut coir is constant but not concentration dependent. The results obtained were shown in the table 2. According to Bhakta *et al*., (2009) the biosorption of mercury by coconut coir activated carbon showed higher limiting capacity for adsorption of mercury chloride than that of the commercial activated carbon. Fibres of *Cocos nucifera* is a low cost biosorbent that has been used for the removal of zinc and copper for metal ions from aqueous solutions. According to Singh *et al*., (2011) fibre of *Cocos nucifera* has a promising potential for being a metal ion sorbent.

Saw dust

In the sample of saw dust, the results showed that the absorption rate of mercury was 1.720±0.496 mg, 2.751±0.371 mg and 4.557±2.651 mg at a concentration of 0.1%, 0.2% and 0.3% respectively. However, there was no significant difference observed among the different concentration of Hg used ('t' test). It indicates that the bioabsorption efficiency of saw dust is constant but not concentration dependent. The effects obtained were shown in the table 3. Nwosu *et al*., (2007) have studied the possibility of using saw dust as a support for the sorption of heavy metal ions may provide effective and of economic means of removing valuable toxic metal ions from sewage, industrial and mining waste water. Ansari (2010) have study about the removal of Cerium (IV). The sorption capacity of the saw dust was compared with a commercial grade of activated carbon. It was found that saw dust is a very efficient adsorbent for uptake of cerium ion in aqueous solutions such as nuclear power plants waste water. Similarly, the present results suggested that mercury can also be absorbed by the saw dust. Thus, the results suggested that there is no significant difference in the absorption of Hg among the concentration in the pH of 6.

Table 1. Comparison of biosorbents of sugarcane bagasse

Conc.	pH	Adsorption	Df	'T' value	P value
0.1	6	0.872	1	0.646	12.706
0.1	6	3.709	1		
0.1	6	4.945	1		
Mean=2.175±2.088					
0.2	6	0.200	1	0.021	12.706
0.2	6	2.509	1		
0.2	6	3.345	1		
Mean=2.684±0.592					
0.3	6	0.800	1	0.189	12.706
0.3	6	1.309	1		
0.3	6	1.381	1		
Mean=1.163±0.316					

Table 2. Comparison of biosorbents of coconut coir

Conc.	pH	Adsorption	Df	'T' value	P value
0.1	6	7.109	1	0.155	12.706
0.1	6	5.672	1		
0.1	6	1.418	1		
Mean=4.733±2.959					
0.2	6	4.800	1	0.041	12.706
0.2	6	3.872	1		
0.2	6	1.236	1		
Mean=3.302±1.848					
0.3	6	11.036	1	0.066	12.706
0.3	6	17.036	1		
0.3	6	10.581	1		
Mean=12.884±3.602					

Table 3. Comparison of biosorbents of saw dust

Conc.	pH	Adsorption	Df	'T' value	P value
0.1	6	2.290	1	0.173	12.706
0.1	6	1.381	1		
0.1	6	1.490	1		
Mean=1.720±0.496					
0.2	6	2.327	1	0.404	12.706
0.2	6	2.909	1		
0.2	6	3.018	1		
Mean=2.751±0.371					
0.3	6	7.418	1	0.152	12.706
0.3	6	2.181	1		
0.3	6	4.072	1		
Mean=12.884±3.602					

The absorption capacity of the samples are similar in different concentrations. More studies are needed to optimize the system from the regeneration point of view, to investigate the economic aspects and to confirm the applicability of this new sorbent under real conditions, such as the industrial effluent treatment. 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 heavy metal removal, not only the industries, but the living organisms and the surrounding environment will also be 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 will offer a lot of promising benefits for commercial purpose in the future.

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