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Adsorption Study using Water Hyacinth as an Adsorbent

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Abstract

Heavy metals are widely used in numerous industries such as paints and pigments, glass production, mining operation, electroplating, battery manufacturing and textile industries. The significant losses of heavy metals occur during the manufacturing processes and these lost heavy metals are discharged in the effluent. As they move from one ecological trophic level to another, metallic species start damaging the ecosystem. They also become difficult to track as they move up in trophic levels. They accumulate in living tissues throughout the food chain. Due to biomagnification, humans receive the maximum impact, since they are at the top of the food chain.Hence heavy metal contamination has been a critical problem. Adsorption of heavy metals is one of the techniques for treatment of waste water containing different types of selected heavy metals. In this study, the adsorbent water hyacinth is investigated as a viable material for removal of heavy metals. The effect of contact time, particle size and adsorbent dosageis studied. The aim of this study is to use water hyacinth as an adsorbent in removing heavy metal content from industrial waste water to see the effect of adsorption. The metal concentrations were determined using atomic absorption spectroscopy. The adsorbents were pretreated by way of cleaning, washing, sun-drying and then crushing to obtain particles in different size ranges in order to study the effect of different parameters on the adsorption. The main objective of this project is to use cheap and readily available solid waste such as water hyacinth, as adsorbent for the removal of heavy metals from the industrial waste water, and to test the effect of contact time, particle size and adsorbent dosage on the extent of adsorption.

Keywords: *Adsorption, adsorbent, water hyacinth, heavy metal, industrial waste water*

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INTRODUCTION

In the past century, there has been a rapid expansion in industries. This has led to an increase in the complexity of toxic effluents. Several industrial processes generate metal containing wastes. Heavy metal contamination has been a critical problem mainly because metals tend to persist and accumulate in the environment. Copper, nickel, mercury, lead [1], zinc, arsenic, chromium, cadmium, etc., are such toxic metals which are being widely used.

They are generated by the dental operation, electroplating, tanning, textile, paper and pulp industry and are potentially toxic to humans. These heavy metals are used in many industries for different purposes and are released into the environment with industrial waste. Therefore, the effluents being generated by these industries are rich in heavy metals and should be treated before being discharged into the common waste water.

On the other hand, aquatic systems are particularly sensitive to pollution possibly due to the structure of their food chain. In many cases harmful substances enter the food chain and are concentrated in fish and other edible organisms. As they move from one ecological trophic level to another, metallic species start damaging the ecosystem. They also become difficult to track as they move up in trophic levels. They accumulate in living tissues throughout the food chain. Due to biomagnification, humans receive the maximum impact, since they are at the top of the food chain. Hence heavy metal contamination has been a critical problem.

The efficient removal of toxic metals from waste water is an important matter and it is being studied. A number of technologies have been developed over the years to remove toxic metal from waste water. Physical treatment can also be used to remove small concentration of hazardous substances dissolved in water that never settles out.

The current physico-chemical processes for heavy metal removal like precipitation, reduction, ion-exchange, etc., are expensive and insufficient in treating large quantities. They also cause metal-bearing sludge which is difficult to dispose of. Some of these traditional methods are also extremely expansive, thereby proving uneconomical, especially for developing countries where large volumes of these wastes are generated. Therefore, there is a requirement for a newer and effective method which is also cost-effective and environment-friendly.

One of the most commonly used techniques involves the process of adsorption, which is the physical adhesion of chemicals on to the surface of solid. Recently, efforts have been made to use cheap and readily available agricultural wastes such as coconut shells, orange peel, rice husk, peanut husk and saw dust as adsorbents to remove heavy metals from waste water.

This work focuses on treatment of industrial waste water containing heavy metals using water hyacinthas an adsorbent.

The main objectives are:
1. Removal of heavy metals from waste water using water hyacinth as the adsorbent.
2. Optimization of various adsorption parameters like time of contact, particle size and adsorbent dosage.

METHODOLOGY

Water hyacinth was obtained from the BTM Lake. It was cleaned using tap water to eradicate possible strange materials present in it (dirt and sand). Washed sample material was sun-dried for 2–5 days and then crushed using ball mill to reduce the size. The particle sizes chosen were 100, 150 and 250 microns [2, 3].

Adsorption experiment was done by measuring 100 mL of waste water and poured into a 250-mL conical flask [4]. 2 g of pretreated adsorbent was added to the waste water.

The conical flask containing the waste water and adsorbent was placed in a wrist shaker and agitated for each of the different contact times chosen (40,80,120,160 and 200 min). The suspension was filtered. Atomic absorption spectroscopy (AAS) [5, 6]was used to analyze the concentration of different metal ions present in the filtrate. And thus the effect of contact time was studied (Figure 1).

The particle size was varied from 100 to 250 microns (100,150 and 250 microns) to study the effect of particle size on adsorption of metal ions.

Fig. 1: *Water Hyacinth after Cleaning and Drying.*

RESULTS

Effect of Contact Time

Waste water sample: 100 mL
Adsorbent dosage: 2 g
Particle size: 100 μm

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Table 1: *Concentration of Heavy Metal after Adsorption for Adsorbent Dosage of 2 g and 100 µm Particle Size.*

S. No	Contact time (min)	Concentration of metal remained (ppm)	
		Zn	Cr
1	40	0.11	0
2	80	0.09	0
3	120	0.28	0
4	160	0.14	0

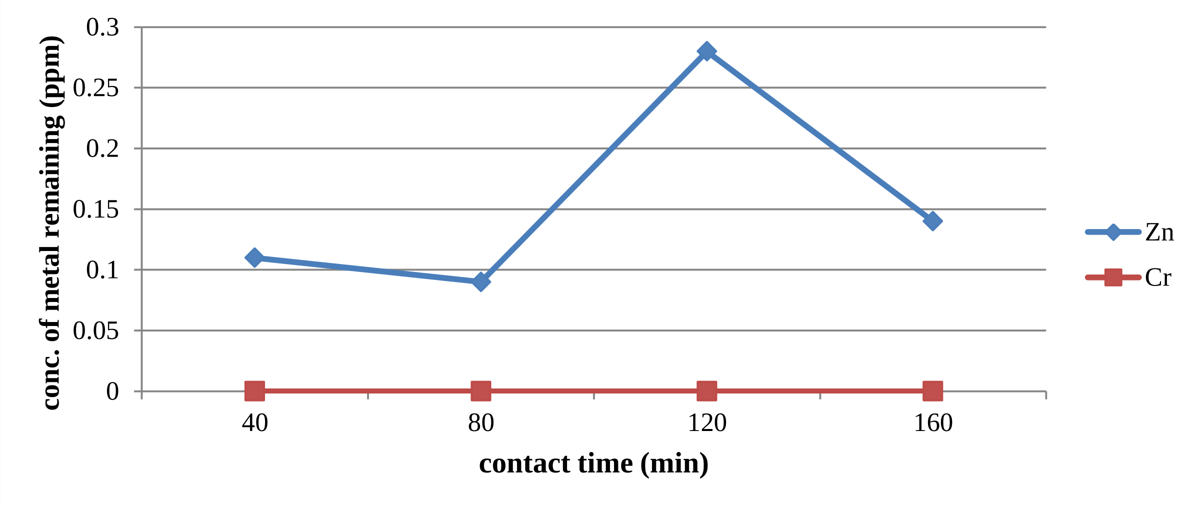

Fig. 2: *Concentration of Heavy Metal after Adsorption vs. Contact Time for Adsorbent Dosage of 5 g and 100 µm Particle Size.*

Table 2: *Concentration of Heavy Metal after Adsorption for Contact Time 80 min and Adsorbent Dosage 2 g.*

S. No.	Particle size (µm)	Concentration of metal remained (ppm)	
		Zn	Cr
1	100	0.09	0
2	150	0.14	0
3	250	0.26	0

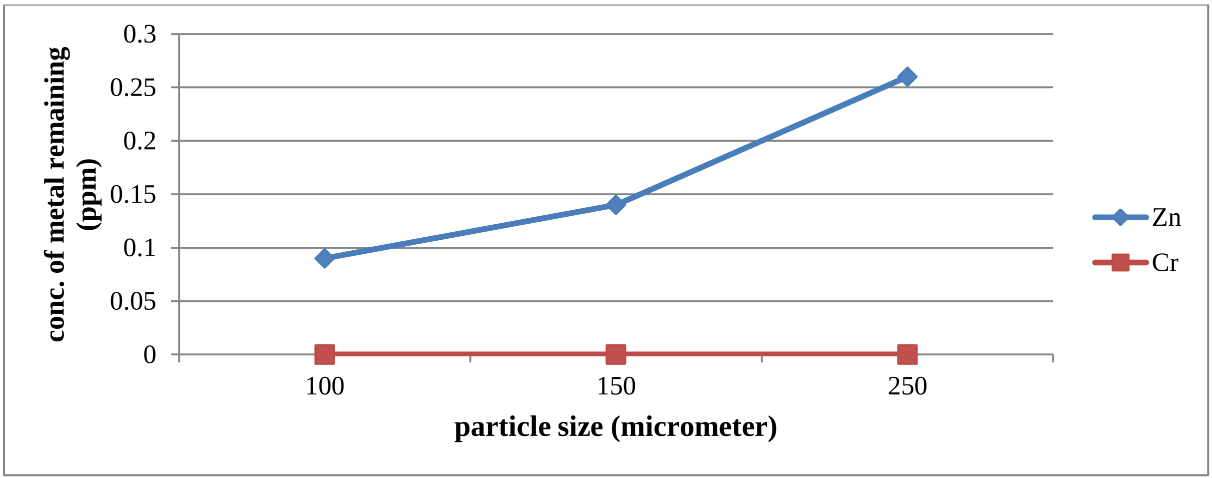

Fig. 3: *Concentration of Heavy Metal after Adsorption vs. Contact Time for Contact Time of 80 min and Adsorbent Dosage 2 g.*

Effect of contact time on adsorption of zinc and chromium was studied by changing the contact time at interval of 40 min keeping adsorbent dosage as 2 g and particle size 100 µm (Table 1). From Figure 2, it is observed that the removal of Zn wasmaximum for the contact time of 80 min. The Cr removal was 100% for the contact time of 40 min (Table 2).

Effect of Particle Size
Volume of waste water: 100 mL
Adsorbent dosage: 2 g
Contact time: 80 min

The particle size profile for the adsorption of chromium[7, 8] and zinc is shown in Figure 3. From the graph, it is clear that as the particle size increased from100 micron to 250 micron, the adsorption was minimum. Therefore, it is evident that as the particle size is decreased, the adsorption of heavy metals can be increased and this is because as the particle size decreased, the surface area available for physical adsorption is increased.

CONCLUSIONS

1. According to the study made, water hyacinth can be a potential adsorbent for removal of heavy metals.
2. The current adsorption studycan beexplained using Langmuir Isotherm.
3. In the micrometer scale, the variation in particle size had no major effect.
4. This project promises to deliver an efficient method of removal of heavy metal contents from industrial waste water before it is discharged into the water bodies in a safe way. The electroplating industry in Doddaballapur, from which the waste water sample was taken, is said to be spending a lot of money on a monthly basis to remove the heavy metal contents from the waste water, in order to adhere to the pollution control norms. This project offers a cheap and reliable way in which solid wastes (which are essentially free) are used as an adsorbent to remove the heavy metal contents from the waste water sample.
5. Further work can be carried out on column studies and designs of adsorption towers to see its applicability in the removal of heavy metals using combination of different adsorbents as such.
6. The individual adsorbent could be further studied in order to get a clear understanding of their surface properties, porosity, etc., to determine their full potential for use as an adsorbent. The structural properties of adsorbents are also needed to be studied for the same reason. Moreover, if the industrial waste water contains a large number of heavy metals that need to be removed, other effects may come into the picture. We need to consider the affinity of a certain type of adsorbents for a particular heavy metal, and also which heavy metal will bind to adsorbents first and to the largest extent, and similarly comparative studies need to be done.

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