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Comparative Study on the Adsorption Efficiency of Cr (VI) from Water by Chicken Egg Shell and Papaya Seed

Litty Das and Nithya Kurup

Abstract: Water bodies are getting polluted day by day, due to the continuous discharge of waste water from industries and other areas. These discharges may be either with or without proper treatment. Heavy metals are one of the major pollutants entering the water bodies and if not removed, may cause health hazards. Chromium, a heavy metal, was found to present in the drinking water supplies of many areas. It is usually found in water in 2 oxidation states, +3 and +6. Cr(III) is usually less toxic compared to Cr(VI). High concentration of Cr (VI) is harmful to animal and human health. Hexavalent chromium is also carcinogenic and mutagenic. This necessitates the removal of chromium from water supplies before it is supplied to the public. Different physical, chemical and biological methods have been adopted for its removal, but all those methods were found to be expensive. Now days, use of plants waste products such as: barks, manures etc, for the removal of heavy metals from polluted water are becoming of more concern. In the present study, low cost and easily available materials like egg shell and papaya seeds were adopted for the removal of chromium from the water sample. Adsorption efficiency of each material will be found using UV spectrophotometer and they are compared to determine the best natural adsorbent. Batch studies were conducted using the adsorbents at three different particle sizes namely 300, 150 and 90 microns. The adsorption efficiency of papaya seed at 300, 150 and 90 microns were found to be 24.4%, 24.8% and 26.8% respectively and for chicken egg shell, the efficiencies were found to be 30.4%, 30.8% and 32% respectively. It was concluded in the study that adsorption efficiency of both the material was maximum at 90 micron size and chicken egg shell is found to be more effective than papaya seed, with an adsorption efficiency of 32% at 0.5g dosage and 20min contact time.

Index Terms: adsorption, Chromium, egg shell, papaya seed, water, UV spectrophotometer, best adsorbent

1. Introduction:

Waste water contamination is ever increasing problem which the whole world is now facing. Waste water comprises liquid waste discharged by domestic, industrial waste, agricultural activity and commercial properties. Industrial waste constitutes the major source of metal pollution in natural water. Toxic heavy metals (Cd, Zn, Pb and Ni) are major pollutant of waste water which is very hazardous [1]. The presence of toxic heavy metals such as chromium, copper and lead contaminants in aqueous streams, arising from the discharge of untreated metal containing effluents into water bodies, is one of the most important environmental problems. Environmental pollution is currently one of the most important issues facing humanity. It was increased exponentially in the past few years and reached alarming levels in terms of its effects on living creatures. Toxic heavy metals are considered one of the pollutants that have direct effect on man and animals.

- *Litty Das is currently pursuing masters degree program in environmental engineering and management in Kerala Technical University, India, mob: 9895854895. E-mail: littydas1994@gmail.com*
- *Nithya Kurupis currently working as assistant professor at ukfcet ,email: nithya.kurup104@gmail.com*

Inputs of these trace metals into ecosystem are largely as a result of mining operations, refining ores, sludge disposal, fly ash from incinerators, processing of radioactive materials, metal plating, or manufacture of electrical equipment, paints, alloys, batteries, pesticides and preservatives . The discharge of metallic ions in industrial effluent is of great concern because their presence and accumulation have a toxic effect on living species [2]. Chromium is an essential nutrient required for normal sugar and fat metabolism and works primarily by potentiating the action of insulin. It is present in the entire body but with the highest concentrations in the liver, kidneys, spleen 88 and bone. Chromium may exist in water supplies in both the hexavalent and the trivalent state although the trivalent form rarely occurs in potable water [3]. The maximum concentration of chromium (VI) permitted in potable water is 5 μg/L [4]. The most important application of chromium in the metallurgic industry is its use as an alloying element in steels. The two most important function of chromium in steels are improving the mechanical properties particularly hardenability and increasing the corrosion resistance [5]. Chromium generally occurs in water in two main oxidation states, +3 and +6.

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Trivalent chromium is required in trace amounts for sugar and lipid metabolism in humans and its deficiency may cause a disease called chromium deficiency [6]. Hexavalent chromium compounds are both skin and pulmonary sensitizers, producing a generalized irritation of the conjunctiva and mucous membranes, nasal perforations [7] and a contact dermatitis [8]. Cr [VI] is also carcinogenic and mutagenic. This necessitates the removal of hexavalent chromium from water. Many advanced techniques are available for the removal of chromium from water, such as, reverse osmosis, electro coagulation, membrane processes etc. but all these methods are found to be too expensive. An attempt to reduce the cost of such treatment process has led to the use of naturally available materials for the removal of chromium.

2. Materials and Methods

2.1 Materials

Potassium dichromate has been used for the preparation of stock solution. DPC, acetone, acetic acid and HCl has also been used, for the analysis of chromium. The analysis was carried out using **a UV spectrophotometer.**

2.2 Preparation of adsorbent

The egg shell and papaya seed were taken as adsorbents for this work. The chicken eggshell were collected and washed with distilled water several times to remove dirt particles. The collected egg shell and papaya seed were dried and grinded into fine particles. The grinded particles were categorized into three as particles retaining 300μ, particles retaining 150μ and particles retaining 90μ. The chicken eggshell powder comprises of 94% $CaCO_3$ with small amount of $MgCO_3$ calcium phosphate and other organic matter including protein. Particles were stored in air tight containers. No chemical modifications were given to the materials.

2.3 Preparation of standard solution

Stock solution is prepared by dissolving 141.4mg of potassium dichromate in distilled water and diluting it to 100mL (concentration of solution is 500mg/L). Standard solution is obtained by diluting 1 mL of stock solution to 100mL (concentration of the solution is 5mg/L)

2.4 Preparation of calibration curve

Diphenylcarbazide method has been used in this study for the analysis of chromium. Chromium solutions of different concentrations were prepared by taking different volumes of standard solution (2ml, 4ml, 6ml, 8ml and 10ml) and diluting it to 100ml. 2ml of DPC solution and 2ml of HCl (diluted in 1:1 proportion) were added. DPC solution was prepared by adding 1g of DPC to 100ml acetone and acidifying the same with acetic acid. The solutions are then analysed in UV spectrophotometer and the calibration curve was plotted.

2.5 Batch studies

The present study mainly concentrate on the effect of particle size on the adsorption efficiency.50mL of adsorbate solution of known concentration was taken in a conical flask. 0.5g of adsorbent was added to the conical flask and the contents are mixed properly by using a shaker for 20min at 180rpm. Same procedure was repeated for the second adsorbent. Adsorption study was conducted for three different particle sizes (300μ, 150μ and 90μ). After giving an adsorption period of 20min, the solution is filtered through a filter paper.50 ml of filtered water was taken and 1ml of DPC & 1ml of HCl was added. This gives a pink colour to the solution. The concentration of chromium in the filtered water was then found out using UV spectrophotometer.

Adsorption percentage = $\{(C_o - C_e)/C_o\} * 100$

C_o – initial concentration of Cr in mg/L

C_e – final concentration of Cr after adsorption in mg/L

3. Result and Discussion

The particle size is an important parameter in the adsorption process because it affects the surface area and hence the adsorption sites available. Chromium solution analysed has an initial concentration of 2.5mg/l. the adsorption study has been conducted for three different particle sizes as 300, 150 and 90 microns at room temperature. The following table shows the adsorption efficiencies of egg shell and papaya seed at different particle sizes.

Table 1: effect of particle size of papaya seed on adsorption efficiency

Particle size(microns)	Initial Cr conc. (mg/L)	Final Cr conc. (mg/L)	Absorbance	Adsorption efficiency(%)
300	2.5	1.89	.239	24.4
150	2.5	1.88	.238	24.8
90	2.5	1.83	.233	26.8

Table 2: effect of particle size of egg shell on adsorption efficiency

Particle size(microns)	Initial Cr concentration(mg/L)	Final Cr concentration(mg/L)	absorbance	Adsorption efficiency (%)
300	2.5	1.74	.222	30.4
150	2.5	1.73	.220	30.8
90	2.5	1.7	.217	32

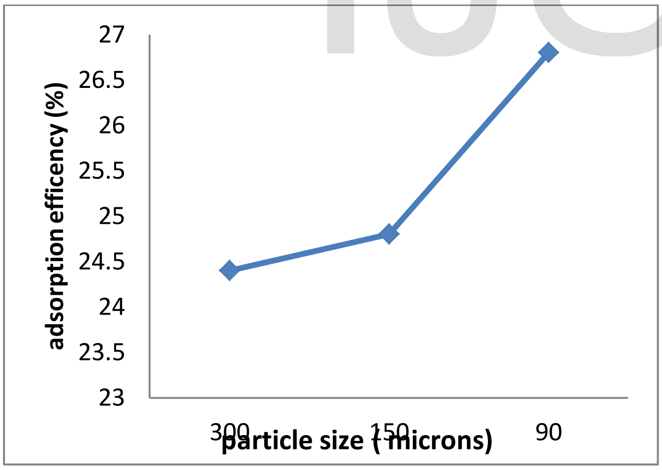

Fig. 1. Adsorption efficiency and particle size for papaya seed

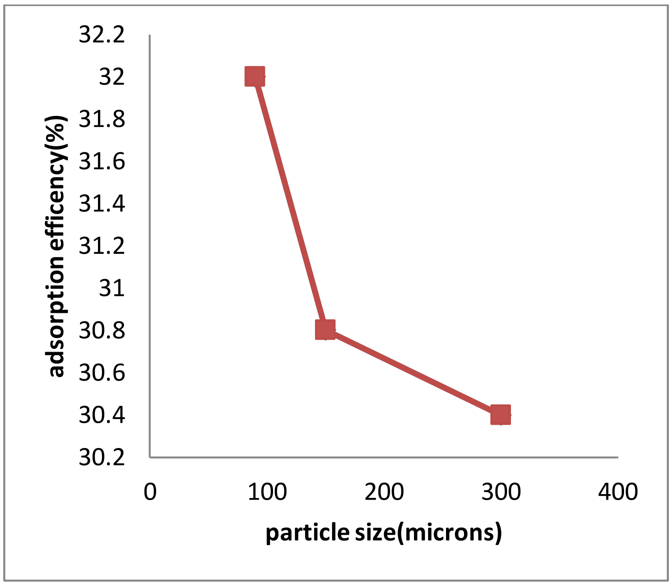

Fig. 2. Adsorption efficiency and particle size of egg shell

4. Conclusion

The removal of chromium from water by using chicken egg shell and papaya seed has been experimented under different particle sizes of adsorbent. The adsorption efficiencies for the papaya seed were found to be 24.4%, 24.8% and 26.8% for particle sizes 300micron, 150micron and 90 microns respectively. The adsorption efficiencies for egg shell was found to be 30.4%, 30.8% and 32% for particle sizes 300microns, 150microns and 90 microns respectively. It has been found that the adsorption efficiency increases with decrease in particle size. This is due to the fact that, as particle size decreases the surface area increases. An increase in surface area implies an increase in the number of adsorption sites available. Hence the adsorption efficiency also increases. It can be concluded that egg shell is more efficient in adsorbing hexavalent chromium from water than papaya seed. Since the adsorption depends on the active sites available on the adsorbents, chemical treatments can be given to the materials which help in increasing the number of active sites.

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