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Removal of toxic bivalent ions from wastewater by adsorption on bioadsorbents-a short overview

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ABSTRACT

In the study, the adsorption of heavy metal ions (Cu^{2+}, Cd^{2+} and Ni^{2+}) from cucurbita maxima husk(CMH), annona reticulate husk(ARH) and ananas comosus crown(ACC) was carried out, so as to comparatively evaluate the effectiveness of adsorbents for the purpose of removing Cu^{2+}, Cd^{2+} and Ni^{2+} from wastewater. The bioadsorbents like cucurbita maxima husk(CMH), annona reticulate husk(ARH) and ananas comosus crown(ACC) collected locally and crushed into particle size of about 0.36 to 0.48 mm, 1g of dosage, known concentration of metal ion, pH 6 at room temperature was investigated. The present study reveals that the low cost bioadsorbent of CMH is used for removing 89%, 81%, 80% of copper, cadmium and nickel respectively. ARH used for removing 84%, 82%, 79% copper, cadmium and nickel respectively. ACC is used for removing 84%, 80%, 78% copper, cadmium and nickel respectively from wastewater from the initial metal ion concentration of 50mg/L solution. The percentage removal of Cu^{2+}, Cd^{2+} and Ni^{2+} was found to increase with increase in contact time and attain equilibrium.

Key words: adsorption, heavy metals, adsorbents, waste water

INTRODUCTION

Water pollution due to the presence of heavy metals in water and wastewaters has been a major cause of concern for environmentalist. Several episodes of heavy metal contamination in aquatic environment have increased the awareness about heavy metal toxicity. Among these, Minamata tragedy due to mercury poisoning and “Itai-Itai” disease in Japan due to cadmium toxicity are well known[1]. More recently cases of lead poisoning were reported in Zamfara State, Nigeria; which led to the death of several people and animals as a result of lead contamination of water bodies (streams and rivers) and the environment[2]. The presence of heavy metals in the environment is thus of major concern because of their extreme toxicity and tendency for bioaccumulation in the food chain even in relatively low concentration[3,4]. Many efforts have been made recently to find cheaper pollution control methods and materials[5]. The importance of adsorption in environmental pollution control has been well highlighted in literature[6,7,8]. The use of adsorption for separation of pollutants from mixtures has been continuously increasing and that the main advantages of adsorption are its high selectivity compared with other separation techniques and relatively high capacity of the adsorbent for pollutants even at low concentration. In recent years, a number of adsorptive materials such as aquatic plants, agricultural by-products and residues, industrial by-products, saw dust, clay, zeolite, and micro organisms have been used for the removal of heavy metals from wastewaters. Agricultural residual materials being economical and eco-friendly due to their unique chemical composition, availability, renewability, and low cost seem to be a viable option for heavy metal removal from wastewaters. Hence, this study

is to evaluate the removal of Cu(II), Cd (II) and Ni(II) from synthetic wastewaters by CMH, ARH and ACC which are bioresource materials. The general objective of the study is to use CMH, ARH and ACC as source for removal of bivalent heavy metal ions from wastewaters.

MATERIALS AND METHODS

Preparation of aqueous solution

The stock solution(1000 mg/L) was prepared by dissolving 3.929 g of copper sulphate, 2.2818g of cadmium sulphate and 2.6364g of nickel sulphate in 1L of double distilled water. Different concentrations of metal solution were prepared by dissolving required amount of stock solution. All reagents used were of analytical grade (Merck) without purification[9].

Preparation of adsorbent material

The cucurbita maxima husk, annona reticulate husk and ananas comosus crown waste materials were used in this study was collected from local market. The collected bioadsorbents were cut into small pieces, washed three times with ordinary water and three times with distilled water to remove external dirt. The wetted bioadsorbents were kept in an air for removing the water from the surface and dried in the sun light. The dried bioadsorbents were grounded into powder and kept in an air tight bottle for experimental uses. No other chemical modification was taken place[10]. The bioadsobents were call it as cucurbita maxima husk as CMH, annona reticulate husk as ARH and ananas comosus crown as ACC for further studies.

Batch adsorption studies

The metal solutions used in this study were prepared as the stock solutions containing 1000mg/L of each metal. 200 ml of 50mg/L of adsorbate solution of known concentration was taken in the 250 mL conical flask, and 1g of each adsorbent was added separately and maintained the pH 6, then solution was stirred in mechanical shaker with 120rpm at room temperature. For a wide range, contact time is 0-60 minutes. After that the solution was filtered and the concentration of the filtered solution was determined by atomic absorption spectrophotometer (Perkin Elmer, model AA400)[9]. Each experiment was repeated and the mean value was calculated in order to minimize errors. The amount of adsorbed(mg/g) of the bioadsorbents for Cu(II), Cd(II) and Ni(II) ions was calculated from the mass balance equation.

$$q=(C_0-C_e)Xv/m \quad (1)$$

The percentage removal of metal ion was calculated from

$$\% \text{ of removal} = [(C_0 - C_e) / C_0] \text{ X } 100 \quad (2)$$

where q is the amount adsorbed(mg/g), C_0 and C_e are the initial and equilibrium concentration (mg/L) of metal ions in solution, ‘v’ is the volume of metal solution (L) and ‘m’ is the weight of adsorbent(g).

RESULTS AND DISCUSSION

Effect of pH

For adsorption of heavy metal ions, pH is one of the most important environmental factors[11]. The pH value of solution strongly influences not only the site dissociation of the biomass surface, but also the solution chemistry of the heavy metals: hydrolysis, complexation by organic and/or inorganic ligands, redox reactions, precipitation, the speciation and the adsorption availability of the heavy metal[12]. The adsorptive capacity of metal cations increases with increasing pH of the sorption system, but not in a linear relationship. The percentage adsorption increases with pH to attain a maximum at pH 6-7 and thereafter it decreases with further increase in pH.

Effect of contact time

Fig. 1 shows the effect of contact time on adsorption of Cu(II), Cd(II) and Ni(II) ions by CMH, ARH and ACC. The amount of adsorption of Cu(II)-CMH, Cd(II)-ARH, Ni(II)-ACC were found to be 6.92, 3.24, 3.88mg/g respectively. The rate of Cu(II), Cd(II) and Ni(II) ions removal were very rapid during the first 20 minutes and after one hour it attain equilibrium. **Fig 2** shows the maximum percentage removal of Cu(II), Cd(II) and Ni(II) ions 89%, 82% and 80% respectively. Initially there were large number of vacant active binding sites in CMH, ARH and

ACC and consequently large amount of metal ions were bind rapidly onto the bioadsorbents[11]. The binding sites was shortly become limited and the remaining vacant surface sites are difficult to be occupied by metal ions due to the formation of repulsive force between the metal on the solid surface and the liquid surface[13,14]. Beside the mesopores become saturated at the initial stage of adsorption where the metal ions were adsorbed. As a result, the driving force of mass transfer between liquid and solid phase in an aqueous adsorption system decreases with time elapse. Further, the metal ions have to pass through the deeper surface of the pores for binding and encounter much larger resistance which slowing down the adsorption during the later phase of adsorption[14].

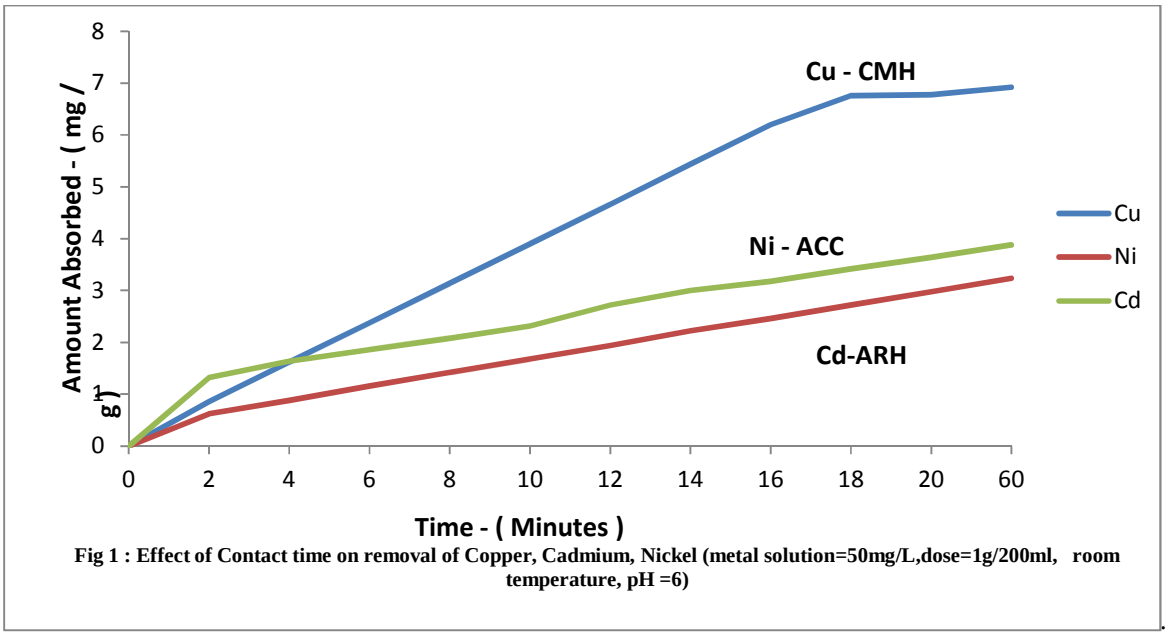

Fig 1 : Effect of Contact time on removal of Copper, Cadmium, Nickel (metal solution=50mg/L,dose=1g/200ml, room temperature, pH =6)

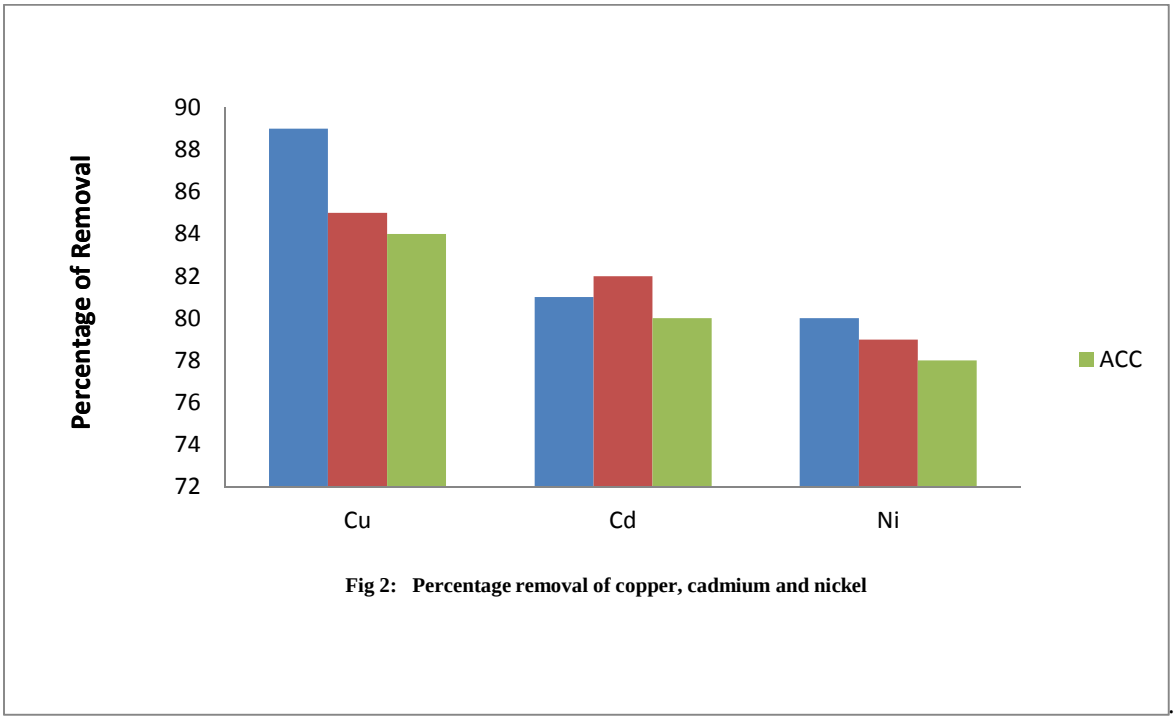

Fig 2: Percentage removal of copper, cadmium and nickel

CONCLUSION

This study indicated the suitability of using adsorbents for the removal of Cu(II), Cd(II) and Ni(II) in aqueous solution through batch adsorption studies. A particle size of 0.36 to 0.48 mm was observed to be highly efficient for the removal bivalent heavy metal ions. sA decrease in the size of the particle increased the adsorption, as a decrease in size of the particle increased the availability of the number of active sites. The percentage adsorption increase with increase in contact time, pH 6 at room temperature. Finally, this works shows that locally available materials such as cucurbita maxima husk, annona reticulate husk and ananas comosus crown which can be used as efficient adsorbents for copper, cadmium and nickel ion removal from wastewater, representing an environmentally effective means of utilizing these agricultural residues. These adsorbents appear to be technically feasible, eco-friendly, economical process and with high efficiency. This work showed that the potential and capacity of CMH, ARH, ACC bioadsorbents could be used as a good adsorbent material for removal of heavy metal ions from aqueous solution. Therefore the present findings suggest that CMH, ARH, ACC used as an inexpensive and eco-friendly and effective adsorbent without any treatment or any other modification for the removal of Cu(II), Cd(II) and Ni(II) from wastewater and industrial effluent.

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