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Adsorption of Zinc Ions in Fixed Beds[#]

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Abstract: In this study the removal of zinc from aqueous solutions was investigated. Horse chessnut, oak valonia, peduncle of oak valonia, pericarp of oak valonia, seed of oak valonia, diatomite, brownish and beige sepiolites were used as adsorbents. Zn^{2+} solution which is prepared by dissolving the pure Zinc nitrate in distilled water, was used as the wastewater sample. Experiments were carried out at continuously operating fixed bed. As a result of this study, adsorption capacities of horse chessnut, oak valonia, peduncle of oak valonia, pericarp of oak valonia, seed of oak valonia, diatomite, brownish and beige sepiolites were found that the maximum amounts of zinc adsorbed by 1 gram of adsorbent are 12.25 mg, 22.75 mg, 87.75 mg, 49.14 mg, 3.34 mg, 5.81 mg, 6.55 mg and 7.15 mg respectively. It was concluded that the oak valonia was an effective adsorbent for the removal of zinc ions from aqueous solutions.

Keywords*: Adsorption, water pollution, zinc, fixed bed*

Introduction

Among the technologies used for heavy metal control such as precipitation and ion exchange, the adsorption seems to be an attractive method especially when low cost materials can be used as adsorbent. Many studies have been performed on adsorption of heavy metals in waters. Decaying leaves have been proven capable of partially removing heavy metal from polluted water and several factors affecting the removal process have been studied by various researches (Murathan A.S. 2004; Murathan 2005; Alıcılar and Özer, 2001**)**. *Salvinia and spirodela* have been used for the removal of lead from its synthetic solution by Stivastav et al.(1994). Murathan and Bütün (2005), studied, removal of lead ions from dilute aqueous solution in packed columns by using natural fruit shells through adsorption . In another study removal of Cu2+, Pb2+ and Zn^{2+} from water onto diatomite by adsorption (Murathan and Benli 2005). The study into the sorption of three divalent metal ions-namely cadmium, copper and zinc-onto peat, in single component, binary and ternary systems was made by Mckay and Porter (1997). The Langmuir, Freundlich and Redlich-Peterson equilibrium isotherms for each metal ion in each system have been determined and correlated. The Langmuir isotherms have been found to have the highest regression correlation coefficients. The adsorption process of four metals in solution (Pb, Cu, Zn, Cd) to Chlorella Vulgaris has been described and compared to a previous study using three metals (Pb,Cu,Zn) in solution by Pascucci (1993). As a result of the study, it has been found that the binding capacity of Chlorella Vulgaris to four elements simultaneously increases with time, mass of algae up to a temperature of about 20.0 °C. The effectiveness of peat in adsorbing copper, nickel and zinc from wastewater has been studied by Viraraghavan and Dronamraju (1993). Chen and Wang (2000) carried out the adsorption experiments by pretreated fixed-bed columns for various species of metal ions. Ileri and Akkoyunlu (1999) studied the removal of lead ions from solution by dead Rhizopus arrhizus immobilized in reticulated polyurethane foam sheets. Biosorption of heavy metals such as lead, cadmium and copper on pretreated biomass was studied by Kapoor et al. (1999).

In this study the removal of zinc ions from artificial wastewater was investigated. Horse chestnut **(***Aesculus hippocastanum),* oak valonia *(Quercus petraea),* peduncle of oak valonia, pericarp of oak valonia, seed of oak valonia, *d*iatomite, brownish and beige sepiolites were used as adsorbents.

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Materials and Methods

Stock solutions were prepared by dissolving the pure zinc nitrate in distilled water. All chemicals used were of analytical reagent grade Zinc analysis of the water samples taken from the bottom of the column was made according to the dithizon method. . The pH of solutions was adjusted with nitric acid. A fixed bed was used in experiments. Packed column was made of pyrex-glass and filled with spherical glass beads. Adsorbents was placed to the middle part of the bed.

Adsorbents were separately used as packing materials under the same operating conditions. Zinc solutions was fed to the top of the packed column by using peristaltic pump. Zinc analysis of the samples taken from the bottom of the column was made according to the Dithizon method. The amount of zinc adsorbed was calculated by the concentrations of solution in and outlet of the column. The operating conditions are summarized in Table 1 and the apparatus used in the experiments is schematically shown in Figure 1.

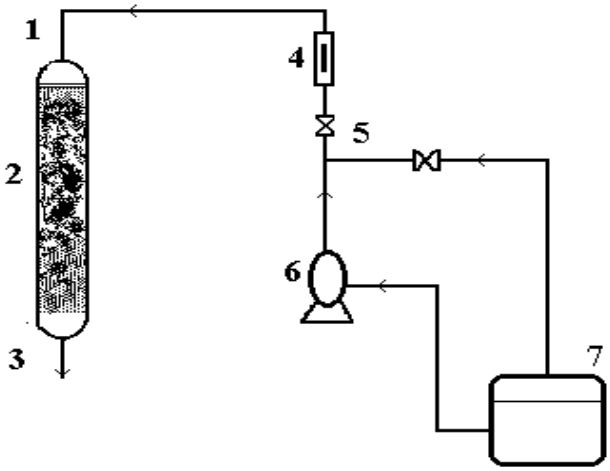

Figure 1. Experimental System (Liquid inlet, 2. Packed column, 3. Liquid outlet, 4. Rotameter, 5. Valve , 6. Peristaltic pump, 7. Tank)

Table 1. The operatin condition

Column diameter, cm	5.5
Column cross section, cm^2	23.76
Packing size min, mm	3.15- 5
Height of bed, cm	15.0
Liquid flow rate, l/s	0.075
Concentration, mg Zn/ l	97.8
Temperature, ^oC	25.0
Packing type	horse chessnut, oak valonia, peduncle of oak valonia, pericarp of oak valonia, seed of oak valonia, diatomite, brownish and beige sepiolites,

Results and Discussion

As shown in Figure 2, although both, horse chestnut and oak valonia were good adsorbents for the removal of zinc ions from the aqueous solution, oak valonia is more effective. Oak valonia and horse chestnut have high tannin contents. Tannins have high binding capacity for heavy metals and are abundant in nature (Hus, 1969, Murathan et al 2001). Therefore we can easily conclude that oak valonia and horse chestnut may be effective and cheap adsorbents for many metals.

Figure 3, shows the adsorption capacities of different layers of oak valonia decreases from the outer layer (peduncle) to the inner layer (seed). The outer layer of the oak valonia has the highest adsorption capacity whereas the innermost layer has the lowest. This may be explained by the decrease in the tannin content of different layers of oak valonia as we travel from outer layer to the inner layer (in order: peduncle, pericarp and seed). Figure 4 shows that, diatomite, brownish and beige sepiolites can

be used as adsorbents for the removal of zinc ions from the aqueous solutions but these adsorbents are less effective than oak valonia.

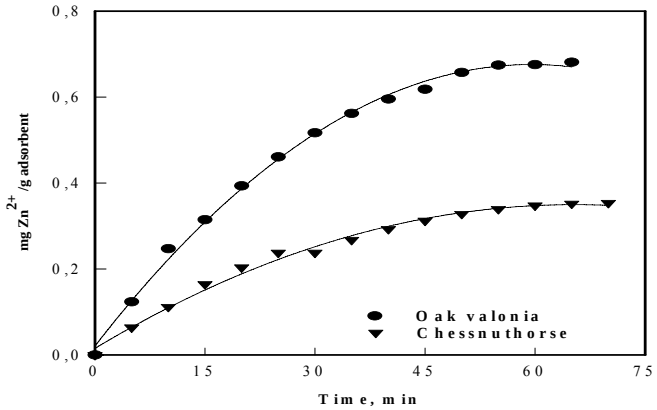

Figure 2. Effect of packing type on zinc adsorption on valonia acron and chessnuthorse

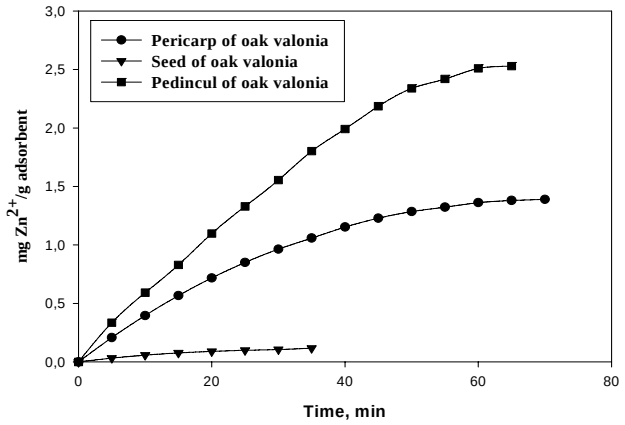

Figure 3. Effect of different layers of oak valonia on zinc adsorption.

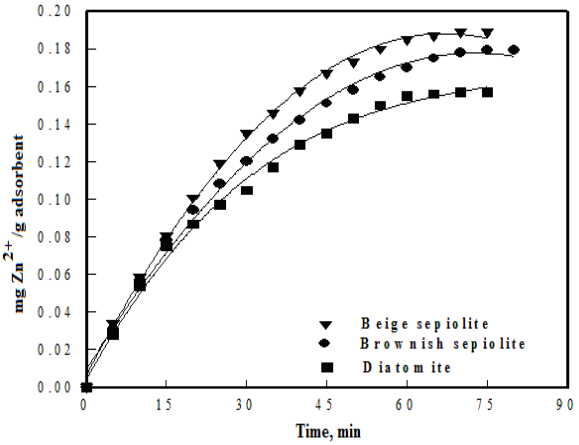

Figure 4. Effect of packing type on zinc adsorption on various clays

As a result of this study, adsorption capacities of horse chessnut, oak valonia, peduncle of oak valonia, pericarp of oak valonia, seed of oak valonia, diatomite, brownish and beige sepiolites were found that the maximum amount of zinc adsorbed by 1 gram of horse chessnut, oak valonia, peduncle of oak valonia, pericarp of oak valonia, seed of oak valonia, diatomite, brownish and beige sepiolites are 12.25 mg, 22.75 mg, 87.75 mg 49.14 mg 3.34 mg 5.81 mg, 6.55 mg and 7.15mg respectively.

Conclusions

From the above study, the following conclusions can be drawn:

Oak valonia is an effective low cost adsorbent for the removal of zinc ions from the aqueous solutions. Horse chessnut, diatomite, brownish and beige sepiolites can be used as adsorbents for the removal of zinc ions from the aqueous solutions but these adsorbents are less effective than oak valonia. All of these adsorbents are used in natural form and also the other important result of this study is using of environmental friendly and low cost adsorbents.

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