

Short communication

Adsorption of copper from aqueous solution on *Brassica cumpestris* (mustard oil cake)

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Abstract

The adsorption behavior of various heavy metals on mustard oil cake (MOC) was studied. The maximum adsorption of Cu(II) was observed followed by Zn(II), Cr(VI), Mn(II), Cd(II), Ni(II) and Pb(II). The adsorption of Cu(II) was found to be dependent on initial concentration of solution, pH, adsorbent dose, temperature and contact time. The adsorption followed pseudo-first-order and second-order kinetics but pseudo-second-order kinetic model was better obeyed since experimental data agreed well with theoretical data. Thermodynamic parameters were also evaluated. The adsorption process was found to be endothermic and spontaneous in nature. Attempts were also made to desorb Cu(II) from the adsorbent and regeneration of the spent adsorbent. The breakthrough and exhaustive capacities were found to be 5 and 10 mg g⁻¹, respectively.

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1. Introduction

Industrialization has a tremendous impact on the concentration and distribution of heavy metals in the atmosphere, on the land and in the water bodies. The extent of this widespread but generally diffuse contamination has caused concern about its possible effects on the plants, animals and human beings. Among these contaminants, copper is a metal of concern. Copper is generally considered to be non-toxic for man but at concentration exceeding 5 mg l⁻¹ impart color and undesirable taste to water. The World Health Organization's guideline for drinking water based on its staining properties is 1 mg l⁻¹ [1]. Beyond the permissible level (5 mg l⁻¹), copper causes acute and chronic disorders in human beings such as gastrointestinal catarrh, cramps in the calves, hemochromatosis and skin dermatitis brasschills, usually accompanied by high fever [2,3]. Industries discharging copper in the wastewater are electroplating industries, pulp and paper mills, fertilizer plants, steel work foundries, petroleum refineries, aircraft

plating and finishing, motor vehicles and non-ferrous metal works [4–6].

Processes generally used for the removal of Cu(II) from wastewater include precipitation, evaporation, reverse osmosis and ion exchange. But most of these processes are economically non-feasible for small scale industries to treat the waste effluents. The adsorption process has been found to be economically appealing for the removal of heavy metals from wastewater. For the treatment of copper rich effluents at the solid-solution interface, several adsorbents have been used earlier [7–13]. The adsorption behavior of orange fruit peel, sawdust, kyanite and rice husk for the removal and recovery of Hg(II), Cr(VI), Ni(II), Cu(II), Cd(II), Pb(II), Zn(II) and Mg(II) from rivers and industrial wastewater have been studied in our laboratory [14–18].

In the present study, a new adsorbent mustard oil cake (MOC) prepared from the seeds of *Brassica cumpestris* (mustard) is used. It is a valuable by-product left after the extraction of oil and is known as mustard oil cake. It contains significant amount of proteins, of value as animal feed if edible and as nitrogenous manure otherwise. The chemical

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composition of mustard oil cake shows nitrogen (4.5%) and phosphorous penta oxide (1.5%) [19].

2. Material and method

2.1. Adsorbent

Oil was extracted from the *B. cumpestris* (mustard) seeds and waste matter left after extraction is known as mustard oil cake. The mustard oil cake was treated with hot double distilled water in order to remove the oil and finally dried in air over at 60–65 °C for 24 h. After drying, the adsorbent was sieved through 40–60 mesh size (BSS) and used as such.

2.2. Adsorbate solution

Stock solution of Cu(II) was prepared (1000 mg l⁻¹) by dissolving the desired quantity of copper nitrate trihydrate (AR grade) in distilled water. Solutions of other metal ions were prepared (1000 mg l⁻¹) by dissolving their chlorides or nitrates.

2.3. Adsorption studies

Adsorption studies were carried out by batch process. 0.5 g adsorbent was placed in a conical flask in which 50 ml solution of metal ion of desired concentration was added and the mixture was shaken in shaker. The mixture was then filtered and final concentration of metal ion was determined in the filtrate by atomic absorption spectrophotometer (GBC 902). The amount of metal ions adsorbed was calculated by subtracting final concentration from initial concentration. All the experiments were carried out in triplicate and mean concentration was calculated by averaging them. The relative standard deviation (R.S.D.) for each sample was calculated. The values of R.S.D. (on percent basis) in all the experiments were found to be in the range 0.548–1.252%.

2.4. Effect of pH

The effect of pH on the adsorption of Cu(II) was studied as follows: 100 ml of Cu(II) solution was taken in a beaker. The pH of solution was adjusted by adding dilute solution of hydrochloric acid or sodium hydroxide. The concentration of Cu(II) in this solution was then determined (initial concentration). Fifty millilitres of this solution was taken in a conical flask and treated with 0.5 g of adsorbent and after equilibrium, the final concentration of Cu(II) was determined.

2.5. Effect of time

A series of 250 ml conical flask, each having 0.5 g adsorbent and 50 ml solution (of known Cu(II) concentrations)

were shaken in a shaker incubator and at the predetermined intervals, the solution of the specified flask was taken out and filtered. The concentration of Cu(II) in the filtrate was determined by atomic absorption spectrophotometer (GBC 902 model). The amount of Cu(II) adsorbed in each case was then determined as described earlier.

2.6. Effect adsorbent dose

A series of 250 ml conical flasks each containing 50 ml of Cu(II) solution of 50 mg l⁻¹ concentration were treated at 20 °C with varying amount of adsorbent (0.1–1.0 g) at pH 4. The flasks were shaken in a shaker incubator and after equilibrium, the solutions were filtered. The amount of Cu(II) in the filtrate was then determined by atomic absorption spectrophotometer. The amount of Cu(II) adsorbed in each case was then calculated as described above. The same procedure was repeated at 30 and 40 °C.

2.7. Breakthrough capacity

0.5 g of adsorbent was taken in a glass column (0.6 cm internal diameter) with glass wool support. One litre of Cu(II) solution with 50 mg l⁻¹ initial concentrations (C_0) was then passed through the column with a flow rate of 1 ml min⁻¹. The effluent was collected in 50 ml fractions and the amount of Cu(II), C was determined in each fraction with the help of atomic absorption spectrophotometer. The breakthrough curve was obtained by plotting C/C_0 versus volume of the effluent.

2.8. Desorption studies

Desorption of Cu(II) was carried out as follows: 0.5 g of adsorbent was treated with 50 ml Cu(II) solution (50 mg l⁻¹) in a conical flask. The solution was filtered after 24 h. The adsorbent was then washed several times with distilled water to remove any excess of Cu(II). It was then treated with 50 ml of 0.1 M sodium chloride solution and then filtered after 24 h. The filtrate was analyzed for Cu(II) desorbed. The same procedure was repeated with potassium sulphate and hydrochloric acid solutions.

2.9. Regeneration studies

0.5 g of adsorbent was treated with 50 ml Cu(II) solution (50 mg l⁻¹) in a conical flask and after equilibrium, it was filtered. The adsorbent was then treated with 50 ml hydrochloric acid solution (0.05 M) for 24 h. It was filtered and filtrate was analyzed for Cu(II) desorbed. The adsorbent was washed several times with distilled water in order to remove excess acid. It was again treated with 50 ml of Cu(II) solution and the above procedure was repeated a number of times (five times or cycles). The same procedure was repeated with 0.1 M hydrochloric acid solution.

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