Experimental investigation on the Cu removal from wastewater using different adsorbents

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ABSTRACT

Having access to water is crucial for human survival. Water use has increased as a result of the recent increase in world population. Meanwhile, industrialization causes a significant amount of effluent containing heavy metals to be released. Numerous companies discharge enormous amounts of untreated wastewater into water streams with high copper (Cu) levels each year. In this regard, the current study was carried out to examine the fixed bed column's adsorption effectiveness for copper removal from metallic aqueous solution. Moringa oleifera seeds and natural zeolite were used as adsorbents. The Cu removal percentage from an aqueous solution was evaluated using an atomic absorption spectrometer. According to the results, Zeolite had the maximum removal effectiveness, with 97% removal at the optimal values of 5 ppm, 3 cm for bed height, and 1 ml/min for flow rate.

Keywords:

Wastewater
Copper
Fixed bed adsorption

1. Introduction

One of the most essential elements of life is regarded to be water. However, it is qualitatively and quantitatively vulnerable. Freshwater availability on a worldwide basis is insufficient to support the world's expanding population. Additionally, because of rapid economic expansion, population growth, and rising standards of living, there is a greater demand for high-quality water. By 2050, there will be an uptick in global water use of up to 55% [1]. Due to inappropriate handling of agricultural runoff and illegal discharges of untreated urban and industrial wastewater, surface water pollution in Pakistan from heavymetals is growing. In Pakistani rivers and lakes, heavy metals like Cd, Cu, Fe, Hg, Ni, Pb, and Zn have frequently been found. These metals are problematic because they have a negative impact on aquatic lifeand may build up or even bio-amplify in the food chain. Additionally, consuming aquatic animals that have high amounts of heavy metals may have harmful consequences on human health, including damage to the kidneys or pancreas, behavioural issues, stomach pain, nausea, or vomiting, skin irritation, and disruption of the endocrine system [2]. Metallic elements with a density higher than that of water are referred to as heavy metals [3]. Heavy metals found in wastewater are persistent and non-degradable, according to study [4]. The 59 heavy metals include cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and zinc (Zn), the last four being the most hazardous [5], As a result, blood composition, the kidneys, the liver, the lungs, and other essential organs are impacted [6]. Most copper releases from electroplating, mining, pesticides, anthropogenic activities, waste disposal, pesticides, industrial waste pipes and additives, smelting, agricultural industry, industrialization, and urbanization are the main sources of copper in water [7][8]. Cu2+ is a vital trace element, but itcan accumulate in living things and lead to a number of disorders. Therefore, the Central Pollution Control Board (CPCB), the United States Environmental Protection Agency (USEPA), the World Health Organization (WHO), Pakistan Standards Institutions (PSI), and the Environmental Pollution Act (EPA) all recommended a Cu2+ concentration of 1.5 mg/l in drinking water [6]. To remove these types of heavy metals various techniques were usedto remove the heavy metals such as floatation, ion exchange, reverse osmosis, coagulation-flocculation , membrane separation, electro dialysis, chemical oxidation and chemical precipitation. Meanwhile all the techniques are cost effective and difficult to handle so the best alternative for the removal of heavy metals from wastewater adsorption method is used as a safer alternative, cost-effective and easy to handle it [4]. Activated carbon, rice husk, coconut shells, agricultural waste, fly ash, red mud, iron ores, clay, nanomaterial, chitosan, bio adsorbents, minerals, and fibrous material are a few of the adsorbents used in diverse study to thoroughly extract these metals. Selecting an adsorbent is a difficult challenge for researchers since it must satisfy a number of requirements, including technological application, economic viability, and removal efficiency. All of these factors affect the choice of an acceptable adsorbent. It has been discovered that the overused adsorbent is zeolite which is remove effectively heavymetals from effluents. Because it has a ions exchange property, due to its property it is safe [9][10]. In addition to water, exchangeable alkaline and alkaline earth metal cations (typically Na, K, Ca, and Mg) are found in zeolite minerals [9]. Due to their multiple benefits, including biodegradability, higher availability, multifacetedness, and low toxicity, several natural coagulants are isolated from a variety of plants, including cactus, copra, jatropha curcas, andmoringa oleifera seeds, among others. One of the few naturally occurring water treatment adsorbents that has been regarded excellent are Moringa Oleifera seeds, which is significant. Natural coagulants like Moringa oleifera have long been researched as potential alternatives to inorganic and synthetic coagulants. Both inorganic and synthetic coagulants have the drawbacks of reducing pH, being expensive, producing massive amounts of sludge, and being ineffective at coagulating cold water, in addition to causing Alzheimer's disease and other health issues [11]. This study provides a brief comparative analysis Moringa seed based adsorbent and zeolite for their Cu removal performance from synthetic water samples with different Cu concentration using a fixed bed column.

2. Methodology

Polyacrylamide, a crystal-type polymer, was used to create the fixed bed adsorption column. The bed height, bed diameter, column diameter, and column height were all taken into account when designing a column. The adsorptioncolumn had an 11-cm height and a 1-cm diameter. Bed depths were 1 cm, 2 cm, and 3 cm. The bed had a 1cm diameter.

Using a peristaltic pump, copper feed stock solution was pumped at various feed flow rates into a fixed bed adsorptioncolumn. Stock solution flows through the adsorbent-filled bed and collects in the beaker.

2.1. Collection of adsorbents

Moringa pods that were ripe and dried were procured locally in Larkana, Sindh, Pakistan. The pods were gently splitapart to release the seeds. The interior substance was collected after the hand-sized seeds were dehusked. The dehuskedseeds were filtered after being rinsed in distilled water for five minutes. The seeds were cleaned and left in the sun forsix hours before being placed in an airtight container until used. A chemical store sold the zeolite. This experiment employed aquarium zeolite. Zeolite was employed in a grain size of millimetres. After that, distilled water was used to wash the zeolite powder seven to eight more times, or until the water's colour looked clear. The sealed bag held thecleansed zeolite until it was used again. The washed Moringa seeds and zeolite were then placed in an oven at 100°c for 24 hours in order to dry up the adsorbents. To make the Moringa seeds smaller, a Hammer mill was applied to them. The Moringa seeds were crushed in a hammer mill, and the fine powder was sieved using a mechanical sieve shaker through a precise 1mm mesh adsorbent.

2.2. Activation of Adsorbents

60g of sieved Moringa seed, 0.5 ml of sulfuric acid (H2SO4), and 6 grammes of zinc chloride (ZnCl2) were also added to the beaker for activation. The mixture was then stirred with a magnetic stirrer for a further hour at 150 rpm. The adsorbent was left to settle for an additional hour. To keep the pH at 4, the adsorbent was given time to settlebefore being washed again. The settled moringa powder was allowed to sun dry for two hours before being dried in the oven for four hours.

A beaker containing 10 grammes of sieved zeolite received diluted HCl addition. The mixture was then stirred with amagnetic stirrer for an hour at 100 rpm. The adsorbent was then dried for six hours at 100 0C in an oven after it had settled.

2.3. Preparation of feed stock solution

The Copper stock solution was prepared by dissolving copper sulfate penta-hydrate in distilled water. Several samples were prepared by using a batch approach using copper sulphate pent-hydrate Stock solution in distilled water to obtain5 and 10 ppm solution at room temperature.

2.4. Setup of fixed bed column

A polyacrylamide glass column with height of 11 cm and inner diameter of 1 cm was used in this study,. Glass wool was used to support the adsorbentthat was placed in the middle of the column and also serves as a filter for the adsorbent particle. Vertical mounting was used for the column. The experiment employed a flow rate of 1 ml/min and bed heights of 1, 2, and 3. The flow rates were managed by peristaltic pumps. When the flow rate is particularly maintained, the feed with an initial concentration of Cu (II) (5 and 10 ppm) is fed into the column. Every hour a sample was taken. The experiment wasconducted in a warm setting. Experimental setup is depicted in fig. 01.

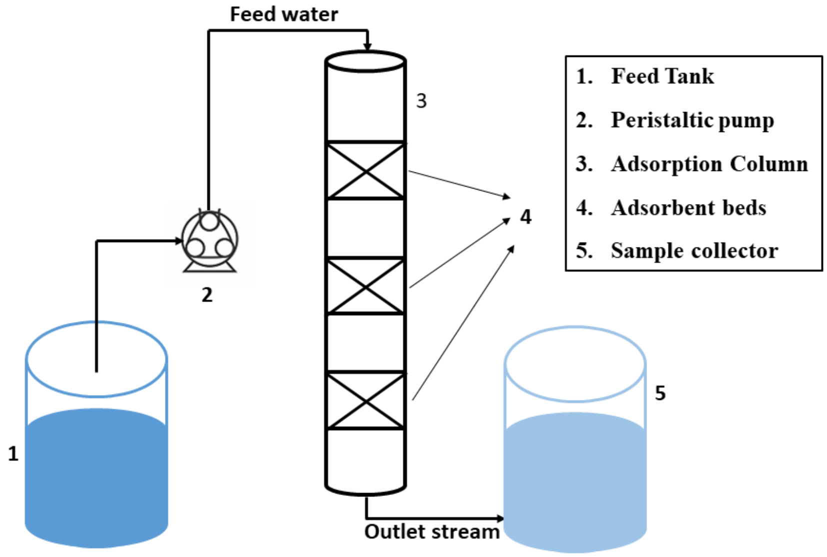

Fig. 01: Scheme of Fixed bed adsorption column experiments

3. Results and Discussion

The effect of bed height was investigated using three different bed heights (1, 2 and 3 cm). The importance of the bedheight was due to the fact that as the bed height increased, so did the removal efficiency. The maximum 5 ppm elimination efficiency According to the data in, copper solution was obtained at 3 cm bed height and 94.2% flow rate(Fig. 02). Since the number of binding sites increases with relation to adsorbent dose and the improved surface area of the adsorbent, which delivered more binding sites for adsorption, the capacity of the continuous fixed bed column to remove copper ions increases with bed height.

To examine the effects of concentrations, two different copper starting concentrations (5 & 10 PPM) were employed. The concentrations were important because the ultimate efficiency dropped as the concentration rose. With a flow rateof 1 ml/min and a bed height of 3 cm, the best removal efficiency of a 5 ppm copper solution was attained, as shownin fig. 02. It demonstrates that the real amount of metal ions absorbed per unit mass of adsorbent rose as the concentration of metal ions increased. The concentration of metal ions at the beginning of the process, then, has a considerable impact on the adsorption. This is because at lower concentrations where there is a low initial ratio of metal ions to accessible surface area, fractional adsorption ceases to be dependent on initial concentration. The adsorption of metal ions is dependent on the beginning concentration since there are fewer adsorption sites available at high concentrations.

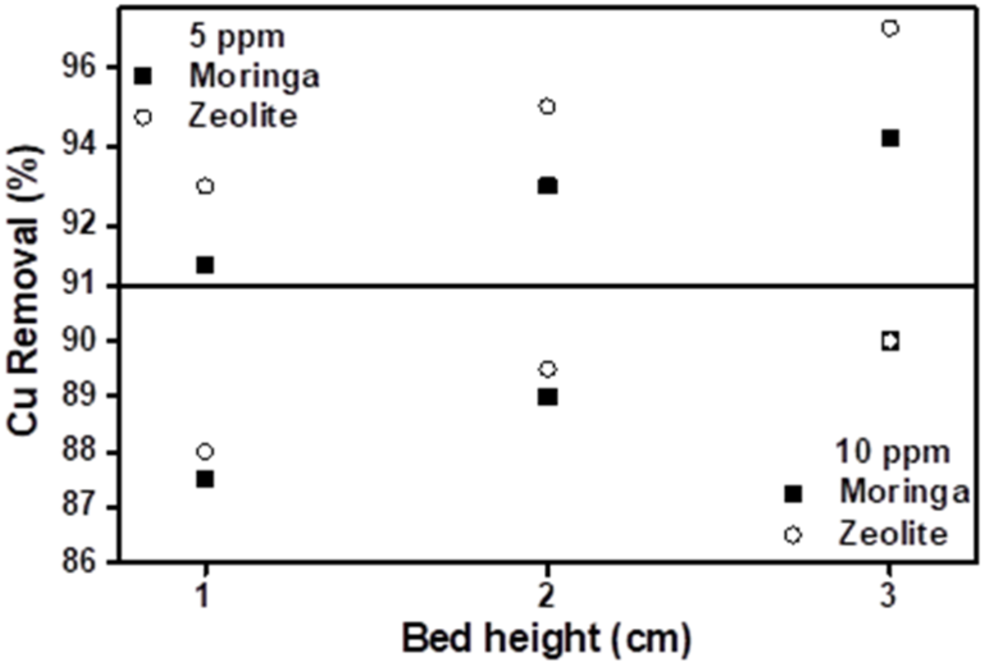

Fig. 02: Copper Removal Percentage (cm)

Three different bed heights were used to examine the impact of bed height (1, 2 and 3 cm). The bed height was crucial because it affected how effectively items were removed as the bed height rose. At a flow rate of 1 ml/min and a bed height of 3 cm, the greatest removal efficiency of a 5 ppm copper solution was 97 percent, as demonstrated in fig. 02. The capacity of the continuous fixed bed column to remove copper ions increased with bed height due to the increasing surface area of the adsorbent, which supplied more binding sites for adsorption, and the link between the number of binding sites and adsorbent dose.

Three different copper concentrations were used to evaluate the impact of starting concentrations (5, & 10 ppm). Because the clearance efficiency declined as the concentration rose, the concentrations were crucial. At a flow rate of 1 ml/min and a bed height of 3 cm, the greatest removal efficiency of a 5 ppm copper solution was 97%. It demonstrates that as the Cu initial conc. increased, so did the real amount of Cu adsorbed per unit mass of adsorbent. As a result, the adsorption was greatly influenced by the initial metal ion concentration. This is due to the fact that fractional adsorption becomes independent of initial concentration at lower concentrations where there is a low initial ratio of metal ions to accessible surface area. Since there are fewer sites available for adsorption at high concentrations, the adsorption of metal ions depends on the initial concentration.

4. Conclusion

The major goal of this study was to investigate the copper (Cu) removal efficiency of various adsorbents. The ongoing filtering trial was examined to assess the efficacy of the zeolite and Moringa oleifera adsorbents. Zeolite has been found to be more effective than Moringa oleifera. The initial concentration and feed flow rate showed reasonable effect adsorption. It was found that initial concentrations and higher flow rates decreased the efficiency of copper (II) removal. At a given flow rate of 1 ml/min and initial concentration of 5 ppm, the highest Cu removal was obtained which was 97%. Also, bed height exhibited a positive effect on Cu removal performance.

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