

ADSORPTION OF COPPER IONS FROM AQUEOUS SOLUTIONS USING SUNFLOWER HEADS AS AN ADSORBENT

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ABSTRACT

In this paper, the results of changes in pH and conductivity values of the solutions during the rinsing of the adsorbent, as well as during the adsorption of copper ions were presented. Prior to the adsorption experiments, the sunflower heads were rinsed with 200 cm³ of distilled water in ten equal portions (20 cm³ each). After each water volume passes through the layer of the adsorbent, the pH and conductivity value of filtrate was measured. After the rinsing, the same adsorbent was then used for the adsorption experiments. As an aqueous phase, synthetic solutions of Cu²⁺ ions were used, with an initial concentration of 0.2 g dm⁻³. The obtained results show that from the beginning of rinsing the adsorbent, the pH value of rinsed water increases, reaching a constant value after passing 100 cm³ of water, and remains constant with further rinsing. It is assumed that an increase in pH value, during rinsing, occurs due to a transfer of H⁺ ions from the aqueous phase to the molecular structure of adsorbent to be exchanged there with alkali and alkaline earth metal ions. As for conductivity change during the rinsing of the adsorbent, it can be seen that a sudden increase in the aqueous phase conductivity occurs just after the first two portions of water passed through a bed of the adsorbent, reaching the peak around the volume of 0.05 dm³, it drops down rapidly. After V > 0.05 dm³ the conductivity of leachate continues to decrease but now more and more slowly, tending to achieve the initial conductivity of distilled water used for rinsing. This increase in the conductivity of the rinsed solution occurs most likely due to increasing in the concentration of alkali and alkaline earth metal ions in the solution, which are being transferred from the structure of the adsorbent into the solution during the rinsing. With further rinsing, the conductivity decreases, as a result of the decrease in the concentration of alkali and alkaline earth metal ions in the solution due to the dilution of the solution.

During the adsorption of copper ions, quite a different behavior in changing of the pH and conductivity value in relation to the pH and conductivity change when rinsing the adsorbent with distilled water was noticed. The pH value rapidly drops down at the very beginning of the process, reaching a constant value in the next 30 minutes, and remains unchangeable with further process time. A very quick decrease in the initial pH occurs due to the releasing of H⁺ ions in the aqueous phase as a result of the deprotonation of functional groups existing in the molecular structure of adsorbent, where they are exchanged with copper ions. As for change of the conductivity of the solution, during the adsorption of copper ions, it can be seen that conductivity increases at the very

beginning of the process, reaching a constant value after 30 minutes. This increase can be attributed to the increase in the concentration of alkali and alkaline earth metal ions in the solution, which are exchanged with copper ions during the adsorption process.

1. INTRODUCTION

Rapid urbanization and industrialization of the world have led to an increased amount of disposed of heavy metals into the environment, via untreated industrial effluents [1].

Various sources of heavy metal pollutants are recognized today: electroplating, metal surface coating treatments, battery production plants, mining, metallurgy, textile, pigments, plastic manufacturing industries, etc. Heavy metal removal from industrial wastewaters is of great importance, because of their toxic impact on the environment, and also human health [2].

A number of conventional technologies have already been developed, and are being used, for the removal of heavy metals from industrial wastewaters. Some of them are: coagulation/flocculation, ion-exchange, precipitation, solvent extraction, electrochemical processes, and membrane technology [3].

The search for new technologies in the field of wastewater treatment has, in recent years, turned its attention to biosorption. Biosorption is a process in which natural materials (biosorbents) are used for the adsorption of heavy metals from water solutions. The biosorption process involves two phases, a solid phase, which is the biosorbent, and a liquid phase, which is the solvent (normally water) containing a dissolved species (usually heavy metal ions, or industrial dyes) to be adsorbed. The sorbent is attracted and bound to the sorbate by different mechanisms, due to its higher affinity towards the sorbate species. The process continues until the equilibrium between the amount of solid-bound sorbate species and its portion remaining in the solution is established [4].

Biomass which has the ability to adsorb metal ions from water solutions is considered as a biosorbent. Cellulose, hemicellulose, and lignin usually make up the structure of these materials. These components consist of functional groups, which are capable of binding metal ions into their structure [5].

Compared to the conventional methods of wastewater treatment, the advantages of the biosorption process are reflected in its effectiveness in reducing the concentration of heavy metal ions to a very low level and the use of inexpensive materials as sorbents, low operating costs, minimization of the volume of chemical and/or biological sludge [6]. Biosorption processes are particularly suitable for the treatment of wastewater streams containing more dilute solutions of heavy metals, or when a very low concentration of heavy metals is required in an exit stream prior to its releasing into a recipient.

In this paper, sunflower heads are used as a biosorbent for copper ions adsorption from aqueous solutions. The pH and conductivity values were monitored during the rinsing of the sunflower heads, as well as during the adsorption process.

2. MATERIALS AND METHODS

The sunflower heads were firstly ground and then sieved through a set of laboratory sieves, and the fraction -1+0.4 was used for further adsorption experiments.

Prior to the adsorption experiments, biosorbent samples were rinsed with 200 cm³ of distilled water, in ten equal portions (20 cm³ each). After each water volume passes through the layer of the biosorbent, the pH and conductivity value of filtrate was measured.

The adsorption of copper ions were performed by bringin into contact 0.5 g of sunflower heads with 50 cm³ of a syntheticsolutions of Cu²⁺ ionswith an initial concentration of 0.2 g dm⁻³.After a certain contact time, the suspension was filtered and the filtrate was analysed on the residual metal ion content. During the adsorption, change of the solution pH and conductivity values with time was also monitored.



Figure 1. Sunflower head sample

3. RESULTS AND DISCUSSION

3.1. Change of the initial pH value of rinsed water

It has been observed that rinsing the biosorbent with distilled water causes the change of rinsed water pH as it is shown in Figure 2. It can be seen in Fig. 2 that from the beginning of rinsing the adsorbent, the pH value of rinsed water increases, reaching a constant value after passing 100 cm³ of water, and remains constant with further rinsing. It is assumed that an increase in pH value, during rinsing, occurs due to a transfer of H⁺ ions from the aqueous phase to the molecular structure of adsorbent to be exchanged there with alkali and alkaline earth metal ions.

Based on the change in pH value, the concentration of H⁺ ions that have been transferred from the aqueous phase to the biosorbent was 0.00080 mmol H⁺ g⁻¹ of biosorbent, and it corresponds to the adsorption percentage of H⁺ ions about 97 %.

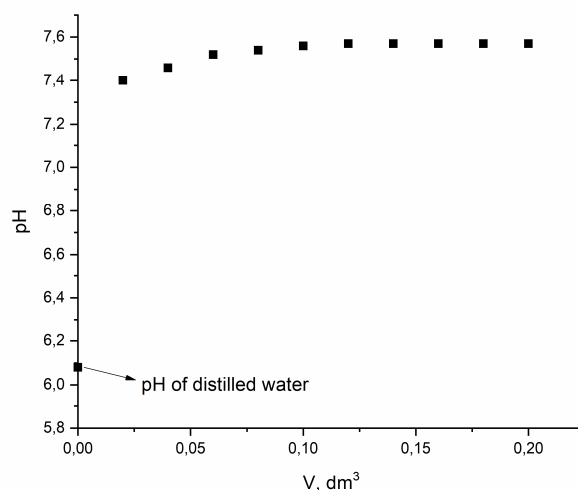


Figure 2. The pH value change during the rinsing of the sunflower heads with distilled water

3.2. Change of the conductivity value of rinsed water

As for conductivity change during the rinsing of the adsorbent, it can be seen in Figure 3 that a sudden increase in the aqueous phase conductivity occurs just after the first two portions of water passed through a bed of the adsorbent, reaching the peak around the volume of 0.05 dm³. After $V > 0.05$ dm³ the conductivity of leachate starts to decrease, tending to achieve the initial conductivity of distilled water used for rinsing. This increase in the conductivity of the rinsed solution occurs most likely due to increasing in the concentration of alkali and alkaline earth metal ions in the solution, which are being transferred from the structure of the adsorbent into the solution during the rinsing. With further rinsing, the conductivity decreases, as a result of the decrease in the concentration of alkali and alkaline earth metal ions in the solution due to the dilution of the solution.

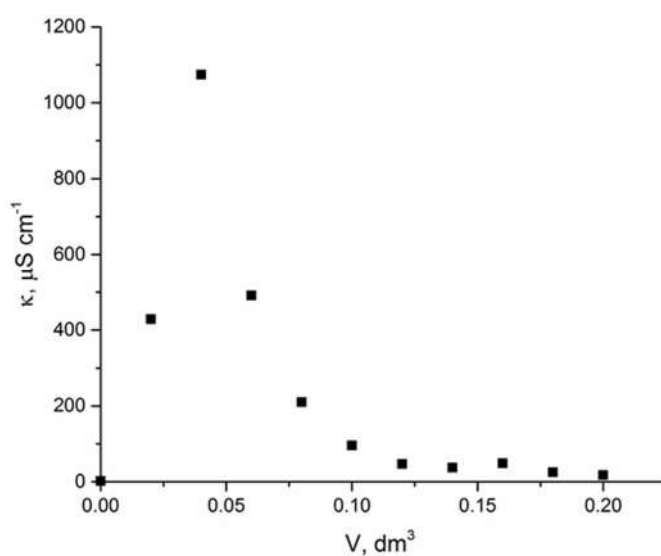


Figure 3. Change in conductivity during the rinsing of the sunflower heads with distilled water

3.3. Change of the pH value of solution with time during the adsorption of copper ions

During the adsorption of copper ions, quite a different behavior in changing of the pH value in relation to the pH change when rinsing the adsorbent with distilled water was noticed. As can be seen in Figure 4, the pH value rapidly drops down at the very beginning of the process, reaching a constant value in the next 30 minutes, and remains unchangeable with further process time. A very quick decrease in the initial pH occurs due to the releasing of H^+ ions in the aqueous phase as a result of the deprotonation of functional groups existing in the molecular structure of adsorbent, where they are exchanged with copper ions.

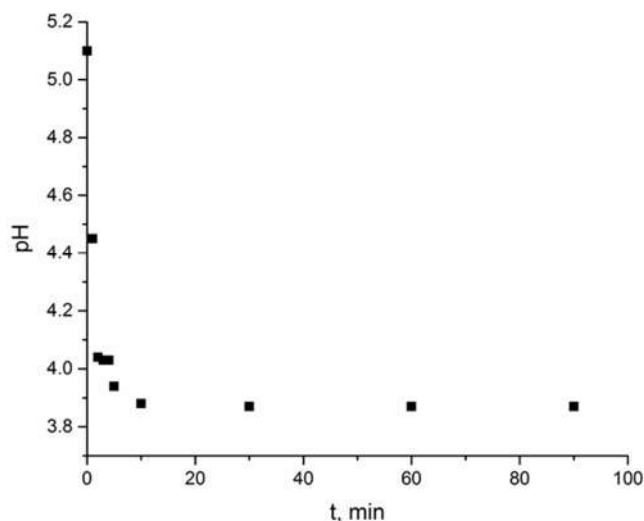


Figure 4. Change of the pH value of solution with time during the adsorption of copper ions

3.4. Change of the conductivity value of solution with time during the adsorption of copper ions

Change of the conductivity value of solution with time during the adsorption of copper ions is given in Figure 5. It can be seen that conductivity increases at the very beginning of the process, reaching a constant value after 30 minutes. This increase can be attributed to the increase in the concentration of alkali and alkaline earth metal ions in the solution, which are exchanged with copper ions during the adsorption process.

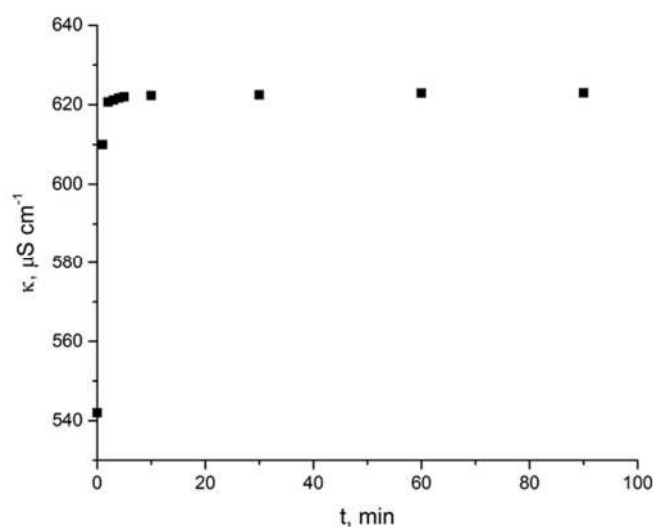


Figure 5. Change of the conductivity value of solution with time during the adsorption of copper ions

4. CONCLUSIONS

1. From the beginning of rinsing the adsorbent the pH value of rinsed water increases due to a transfer of H^+ ions from the aqueous phase to the molecular structure of adsorbent to be exchanged there with alkali and alkaline earth metal ions.

2. As for conductivity change during the rinsing of the adsorbent, it can be seen that a sudden increase in the aqueous phase conductivity occurs just after the first two portions of water passed through a bed of the adsorbent, reaching the peak around the volume of 0.05 dm^3 . After $V > 0.05 \text{ dm}^3$ the conductivity of leachate starts to decrease, tending to achieve the initial conductivity of distilled water used for rinsing. This increase in the conductivity of the rinsed solution occurs most likely due to increasing in the concentration of alkali and alkaline earth metal ions in the solution, which are being transferred from the structure of the adsorbent into the solution during the rinsing. With further rinsing, the conductivity decreases, as a result of the decrease in the concentration of alkali and alkaline earth metal ions in the solution due to the dilution of the solution.

3. During the adsorption of copper ions, the pH value rapidly drops down at the very beginning of the process, reaching a constant value in the next 30 minutes, and remains unchangeable with further process time. A very quick decrease in the initial pH occurs due to the releasing of H^+ ions in the aqueous phase as a result of the deprotonation of functional groups existing in the molecular structure of adsorbent, where they are exchanged with copper ions.

4. The change in the conductivity of the solution during the adsorption of copper ions was also noted to be different from the conductivity change during the rinsing of the adsorbent.

The conductivity increases at the very beginning of the process, reaching a constant value after 30 minutes. This increase can be attributed to the increase in the concentration of alkali and alkaline earth metal ions in the solution, which are exchanged with copper ions during the adsorption process.

5. ACKNOWLEDGMENT

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