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# Using *Phragmites australis* plants as activated carbon to remove Mn(II), and Cu(II) ions from different aqueous solutions

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## Abstract

This study investigates the use of agricultural byproducts of plants (*Phragmites australis*) as low-cost adsorbents for the removal of $Cu^{2+}$ and $Mn^{2+}$ from their aqueous solutions through the production of (AC). The results showed that the adsorption equilibrium time for both ions was 30 minutes. The results obtained showed that pH=5, pH=6 for $Cu^{2+}$ and $Mn^{2+}$ respectively were optimum to adsorption for these ions. The study showed that the weight (0.5 g) of the adsorbent was ideal to achieve the best adsorption and the ability of the adsorbents to adsorb metal ions was as follows: Cu(II) > Mn(II).

**Keywords**: *Phragmites australis*, adsorption, activated carbon, copper, manganese.

## 1. Introduction

Heavy metals contributed to the development of human civilizations and have been used by humans since the earliest times. Heavy elements were exposed to oxidation and air erosion until they leaked to the environment through the air and / or water. Heavy metals known as elements that have an atomic number more than twenty and densities higher than five grams per cubic centimeter. Heavy metals are perhaps classified into essential elements, ions of toxic elements, and trace elements. This study includes the use of manganese(II), and copper(II) ions as a high-risk ion to the environment, human, or species. Moreover, $Mn^{2+}$ is also known for its toxic behavior to the human brain. On the other hand, $Cu^{2+}$ ion can cause gastrointestinal disorders, kidney damage, and anemia. Therefore, the number of studies on removing heavy elements pollution is increasing [1].

Heavy metals are considered one of the most important environmental contaminants, as large amounts are released to the environment from industry. The releasing process without proper treatment will certainly cause numerous numbers of environmental problems such as water, soil, as well as plants contamination with heavy metals.

Global attention to heavy metals pollution has increased over the last twenty years due to environmental pollution. Some of these elements and the vital importance of others to sustain the growth of the body of the organism, these heavy metals have a significant impact on living organisms that live in water, such as fish. Heavy metal pollution is a global problem, especially in the aquatic environment. Although some heavy metals are essential for plant growth, at certain concentrations they become toxic to all living organisms. Another important risk associated with environmental pollution is the long-term accumulation of these substances [2]. Many methods were obtained to remove heavy metals from water such as chemical precipitation, ion exchange, adsorption, membrane filtration, and electrochemical treatment. However, this study will follow the adsorption method because of the effectiveness and short time. The adsorption process can be defined as a phenomenon that collects particles of matter in the form of molecules, atoms, or ions on the surface of another substance. These particles are called adsorbate and the surface that occurs on absorbent is called adsorbent. it combines material particles on the interface of another material [3].

Adsorption is classified depending on the type of correlation between the adsorbate and the adsorbent into two types of physical adsorption and chemical adsorption. Examples of these surfaces are activated charcoal, silica gel, zeolite, porous clays, and agricultural waste [4]. Activated Carbon is one of the carbon forms that is processed to increase surface area and to produce more suitable material for adsorption and chemical reactions. The activated carbon is prepared first by organic material such as almond, wood, coconut, walnut, bone, and charcoal. Carbonization occurs by heating the base material to red heat, with an exact amount of oxygen to maintain combustion [5].

The present study aims to find a new available, and a cheap adsorption surface. That is efficient and utilized to removal toxic heavy metals such as Mn(II), and Cu(II) ions from water solutions, using activated carbon from the plant (*Phragmites australis*).

**Figure 1**: Phragmites australis plant.

## 2. Materials and procedure

The Phragmites australis plant was obtained in agricultural drainage sewers, the raw material was crushed and screened to a fraction with a size of 250-500 micrometers. Then, the product was treated by (IDS) ligand, and burned using an incineration furnace atomic absorption spectroscopy to determine the removal rates for heavy metal salts used in this study.

### 2.1 Preparation of activated carbon

Powders were burned to obtain activated carbon at 900 Celsius degrees, in the presence of nitrogen gas. Samples from biomass were collected and the surface area was measured before and after activation at the headquarters of the Ministry of Science and Technology. The surface area was measured as 230 $m^2/g$, 322 $m^2/g$, and 147 $m^2/g$. The resulted measurement of these values was higher in comparison to the values of other carbonate samples, with surface area (BET) from 10 to 100 $m^2/g$.

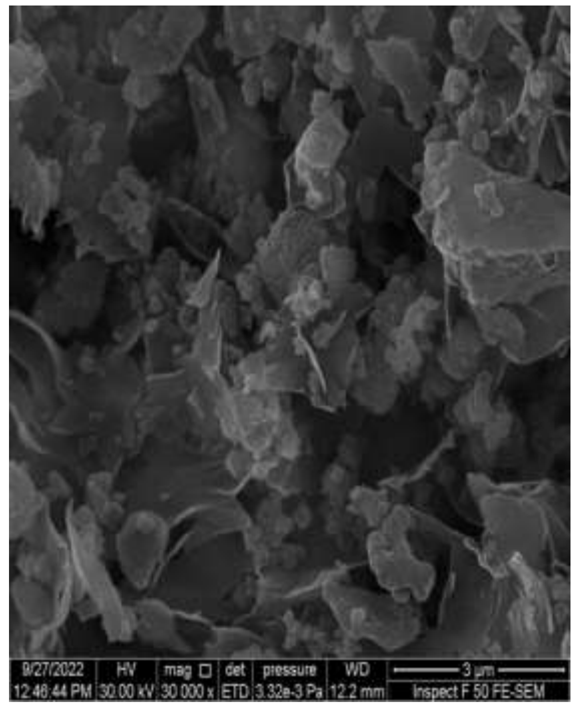


**Figure 2**: FE-SEM of activated carbon from *Phragmites australis*.

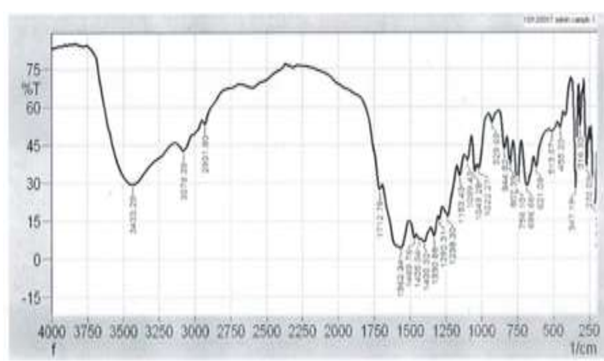


**Figure 3**: FT. IR spectrum of activated carbon obtained from *Phragmites australis* plant.

### 2.2 Factors affecting the adsorption of metals by adsorbents.

Experiments were carried out under various conditions that can affect the adsorption of metals, which can be described as follows:

**a. The pH effect.**

The experiment was carried out at pH (4, 5, 6, 7, 8, and 9) for heavy metals solutions. The acid function of the solution was adjusted by the addition of hydrochloric acid (0.1 M), and sodium hydroxide (0.1 M).

**b. The effect of initial concentration**

This study was conducted at different concentrations of (5, 10, 15, and 20 mg/L). Moreover, other factors remaining constant to determine the highest percentage of removal.

**c. The effect dosage of adsorbent**

The effect of different adsorbent masses of (0.1, 0.3, 0.5, 0.7, 0.9, 1.0, and 1.5 g) for the adsorbent and the percentage of adsorption was determined for different masses where, all remaining factors were constant.

**d. The effect of contact time**

The contact time of (5, 10, 20, 30, 40, 60, 90, and 120 minutes) different times were determined when removing metal ions between the adsorbent and the adsorbate as other factors were constant.

**e. The effect of temperature**

Heavy metals were absorbed tested at temperatures of (25, 30, 35, 40, and 45 °C). Moreover, other factors were constant during different rection temperatures. The removal percentage was calculated using the following relationship.

Adsorption Removal (%) = $(C_o - C_e)/C_0 \times 100$

$(C_e)$ = Equilibrium concentration (mg/L).

$(C_o)$ = Initial concentration (mg/L).

## 3. Result and discussion

### 3.1 The Effect of contact time

The equilibrium periods of this study are demonstrated in figure (4). On the other hand figure (5) shows the removal rate of Mn(II), and Cu(II) ions by the activated carbon as a function of contact time. However, the highest recorded absorption rate of metal ions was at 30 minutes.

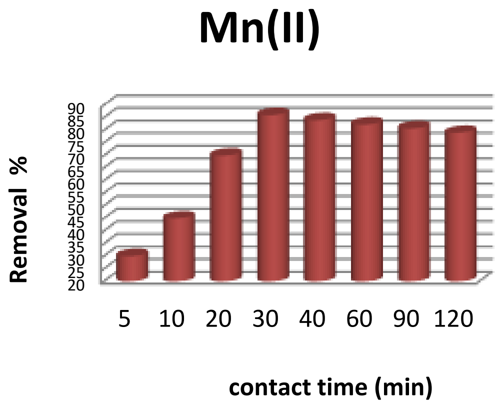


**Figure 4**: The effect of changing contact time on Mn(II) removal at temperature (25 ± 2 °C), (pH = 6), initial con. (10 mg/L) and dosage of adsorbent (0.5 g).

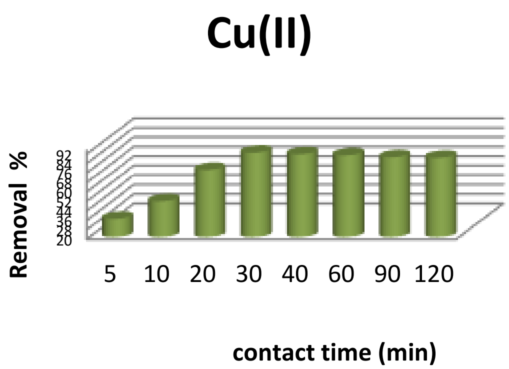


**Figure 5**: The effect of contact time on removal of Cu(II) ion at 25±2 °C, pH=5, 10 mg/L, and dosage of adsorbent 0.5 g.

## 3.2 The pH effect

The pH of the solution may increase the absorption of heavy metals because it has a major role in determining the surface charge of the adsorbent material, the type of adsorbate material and the degree of ionization. Changing the pH of the solution impact the degree of adsorption of Mn(II), and Cu(II) on *Phragmites australis* were examined in different pH values between 4, and 9 as shown in figures 6, and 7. These results showed that at pH 5, and pH 6 for Cu(II) and Mn(II) were the optimal increase in the amount of adsorption for both metals. However, the adsorption rates of all metal ions were decreased at higher pH 7.0, due to a decrease in negative surface charge or contamination resulting from the precipitation of metal ions in alkaline solutions (a mechanism important for the metal can lead to a precipitation disorder). The change in adsorption capacity of heavy metals at different pH values can be attributed to the presence of competitive adsorption between hydrogen ions and metal ions.

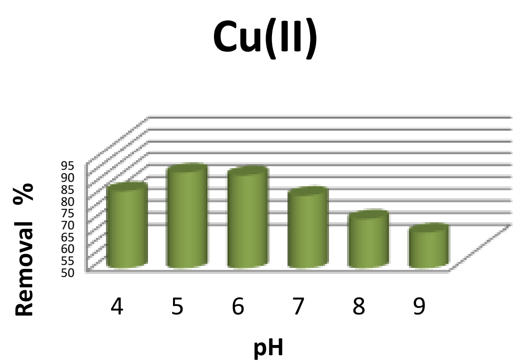


**Figure 6:** The pH effect on Cu(II) removal rate at (25±2 °C), dosage of adsorbent (0.5 g), and the initial concentration is 10 mg/L for in 30 minutes.

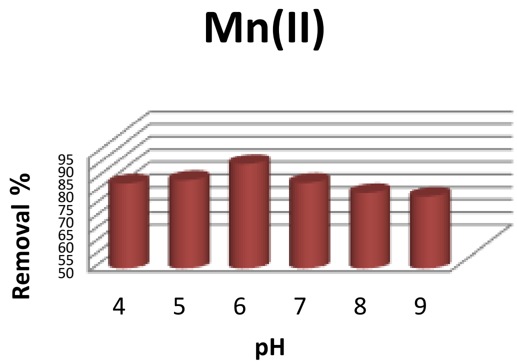


**Figure 7**: The pH effect on Mn(II) ion removal rate at (25±2 °C), where the dosage of adsorbent is 0.5 g, and initial concentration is 10 mg/L for 30 minutes.

### 3.3 Dosage effect of adsorbent

The scope of the research is determining the weight of the adsorbent for the purpose of obtaining surface saturation under certain conditions. Moreover, experiments were conducted, and their results are shown in figure 8, and figure 9. The doses of the tested adsorbents were 0.5 g and the weight of the adsorbent were also ideal to achieve the best adsorption process for all metal ions tested.

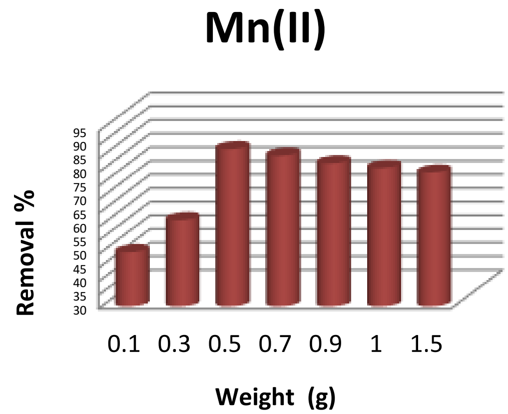


**Figure 8**: The effect of adsorbent weight in removal rate of Mn(II) ion at (25±2 °C), where the pH 6, and initial concentration is 10 mg/L for 30 min.

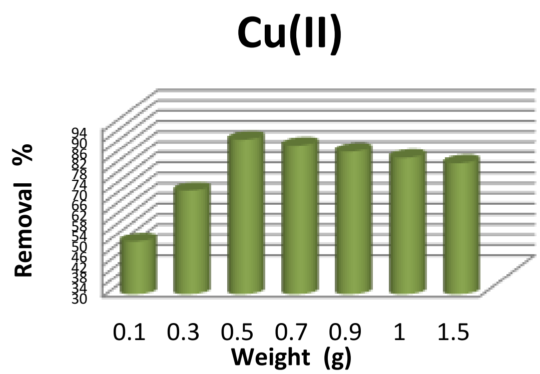


**Figure 9:** The weight effect of adsorbent in removal rate of Cu(II) ion at 25±2 °C, at pH=5 where the initial concentration is 10 mg/L for 30 min.

### 3.4 The initial concentration effect

The concentration effect on the two ions was observed using batch adsorption experiments conducted at a temperature of (25±2 °C). Using different initial concentrations of metal ions in the optimal of 5, 10, 15, and 20, as well as pH values are shown in figure 10, and figure 11. pH values showed that the adsorption ratio decreases with increasing initial ion concentration because there are no more adsorption sites on the adsorption surface of the adsorbent. The results also showed that the maximum adsorption percentage of Mn(II) ion using the adsorbent was 85.4 %, and the maximum Cu(II) ion removal rate was 89.7 % at a metal concentration of 5 mg/L for the two heavy metals tested. Moreover, this optimum concentration was used in all experiments.

Mn(II)

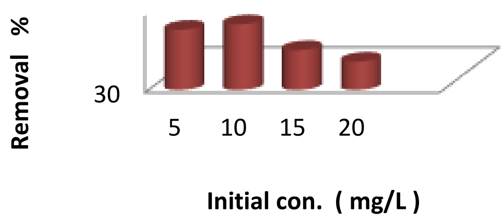


**Figure 10:** The effect of initial concentration changes for Mn(II) in removal process at 25±2 °C, where the pH 6 and the dosage of adsorbent 0.5 g for 30 minutes.

Cu(II)

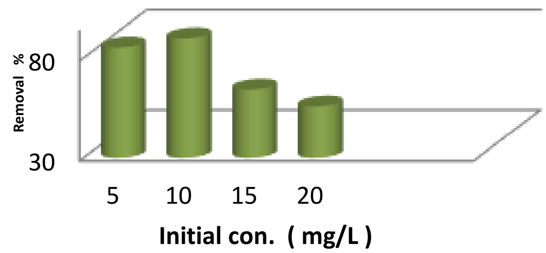


**Figure 11:** The effect of initial concentration changes for Cu(II) ion in removal process at 25±2 °C, where the pH 5, and dosage of adsorbent is equal to 0.5 g for 30 minutes.

### 3.5 Adsorption isotherm

As the temperature continues to rise, there is a decrease in the amount of heavy metal ions removed by the activated carbon the adsorption process was observed and appeared it was an exothermic process [7]. Low temperatures are therefore the preferred location for the adsorption of metal ions on plants. The decrease in adsorption of heavy metal ions with increasing temperature can be explained by the fact that the thickness of the boundary layer decreases with increasing solution temperature, which is due to the tendency of the increased metal ions to desorption solid phase into the solid phase, liquid phase [8]. This interaction of chemical and physical forces with Cu(II) ions leads to the complexity of the results. Therefore, removal of metal ions can occur through one of four processes: Ion exchange adsorption, absorption, and chelation. This change in the rate of adsorption of heavy metal ions, this is because there are one or more very different processes taking place, the most effective and widespread method being adsorption and ion exchange.

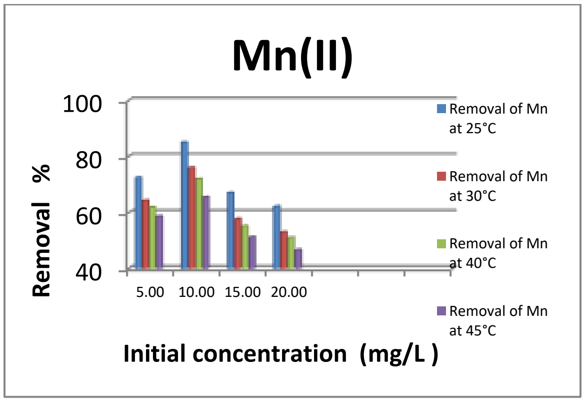


**Figure 12**: Removal of Mn(II) ion at different temperatures.

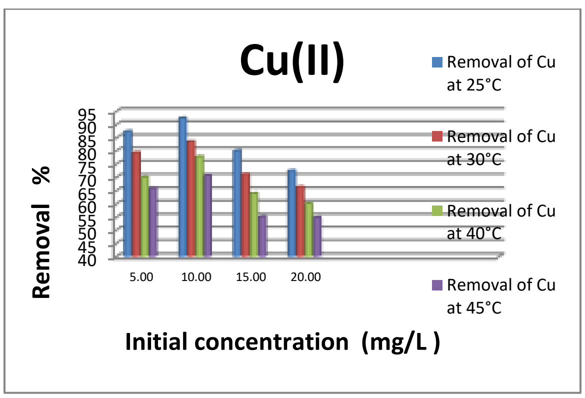


**Figure 13**: Removal of Cu(II) ion at different temperature.

## 4. Conclusion

In conclusion the obtained results showed that at pH 5, and pH 6 are the optimum adsorption pH range for Cu(II), and Mn(II) ions respectively. Moreover, the highest mass removal of 0.5 g is the highest rate with the ability of the adsorbents to adsorb metal ions is in the following order: Cu(II) > Mn(II). This change in the rate removal of copper and manganese metal ions could be due to the presence of one or more of these completely different processes. The most affected method can be adsorption and ion exchange and this activated sample can adsorb these heavy metals.

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