OPTIMIZATION OF USAGE OF WOOD SAWDUST AS ADSORBENT OF HEAVY METAL IONS FROM WATER

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Abstract: *The wood sawdust is a potentially useful adsorbent for heavy metals. The aim of this work was optimization of usage of wood sawdust as heavy metal adsorbent. It was examinated influence of wood sawdust quantity on adsorption capacity and efficiency, and feasibility of multistage batch adsorption processes. Experiments were carried out with poplar sawdust and model water. For better adsorption efficiency it was recommended to apply larger amounts of sawdust, if it is not cause problems with delaying of used adsorbents. Smaller amounts of adsorbent were better utilized in two or three stage adsorption processes.*

Keywords: *water, heavy metals, adsorption, wood sawdust*

1. INTRODUCTION

The contamination of wastewater by toxic heavy metal ions is a world-wide environmental problem. They can be removed from wastewater by several methods, including basic precipitation, ion exchange, adsorption and so on. The removal of heavy metals by adsorption onto low-cost waste materials has recently become the subject of considerable interest. Natural materials that are availble in large quantities, or certain waste products from industrial or agricultural operations, may have potential as inexpensive adsorbents. Due to their low cost, after these materials have been expended, they can be disposed of without expensive regeneration.

Our previous studies have shown that the wood sawdust is a potentially useful biosorbents for treating wastewaters contaminated with heavy metals[2,3,4]. In these experiments it was determinated adsorption capacities of sawdust of different kinds of wood, at optimum pH, and with sufficient contact time. The aim of this work was further optimization of usage of wood sawdust as heavy metal adsorbent. It was examinated influence of wood sawdust quantity on adsorption capacity and efficiency, and feasibility of multistage batch adsorption processes.

2. MATERIAL AND METHODS

The sawdust of deciduous soft wood – poplar was used as adsorbent in copper(II) removal from water. Wood sawdust was sieved, and the fraction with particle size between 0.5 and 1.0 mm was used for experiments.

The stock solution of copper(II) (0.25 M) was prepared by dissolving $CuSO_4 \cdot 5H_2O$ in distilled water and its pH was adjusted to a desired value by adding 0.5 M CH_3COOH. All chemicals used were of analytical reagent grade.

Batch adsorption experiments were carried out by shaking different quantity of wood sawdust with aqueous solution of copper(II) of desired concentration at pH 4. After 3 hours of shaking, the adsorbent was separated by vacuum filtration through the gooch G3, and filtrate was analyzed. Coplexometric method was used for determination of copper(II) concentration before and after adsorption [1].

To determine the adsorption capacity of adsorbent for the removal of copper(II) from water, the Langmuir and Freundlich models were used, as

$$q = \frac{q_m \cdot K_L \cdot C}{1 + K_L \cdot C} \qquad (1)$$

$$q = K_F \cdot C^{1/n} \qquad (2)$$

where is: q – amount of Cu(II) adsorbed per specific amount of adsorbent (mg/g), C – equilibrium concentration (mg/l), q_m – amount of Cu(II) required to form a monolayer (mg/g), K_L – Langmuir equilibrium constant, and K_F and n – Freundlich equilibrium constants. Computer simulation technique was applied to fit the Langmuir and Freundlich equations for the adsorption data. The correlation coefficients (R^2) were computed, too.

3. RESULTS AND DISSCUSION

To investigate the effects of the initial copper(II) concentrations and amount of poplar sawdust on the uptake of this metal, the process was carried out with initial copper(II) concentrations between 5 and 200 mg/l and warious poplar sawdust concentrations: 1, 2.5, 5, 7.5, 10 and 15 g/l. Fig. 1 shows that the amount of adsorbed copper ions by the adsorbent increased with the increase of initial copper concentration in the solution, and with the decrease of adsorbent quantity. The data presented in Fig. 1 were used to determine the adsorption constants in Langmuir and Freundlich adsorption equations, displayed in Table 1.

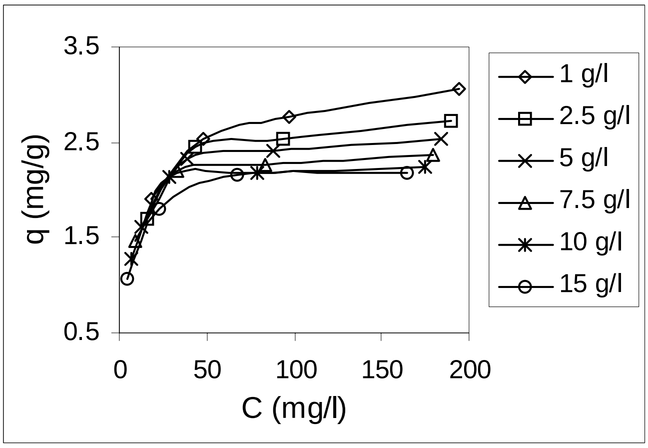


Fig. 1. *Adsorption isotherms of copper(II) at different quantity of poplar sawdust as adsorbent*

Table 1. *Adsorption constants for adsorption of copper(II) by poplar sawdust*

Amount of adsorbent (g/l)	Langmuir constants			Freundlich konstants		
	K_L (l/mg)	q_m (mg/g)	R^2	K_F (l/g)	1/n	R^2
1	0.0715	3.241	0.999	0.0177	0.19	0.949
2.5	0.1045	2.860	0.999	0.0172	0.18	0.843
5	0.1469	2.605	0.999	0.0180	0.16	0.842
7.5	0.1890	2.415	0.999	0.0183	0.16	0.825
10	0.2357	2.288	0.999	0.0157	0.17	0.768
15	0.2231	2.224	0.999	0.0134	0.20	0.900

It can be noted that the maximum adsorption capacity (q_m) increased with a decrease in the adsorbent concentration, since the availble surface area was smaller, and the adsorption intensity (K_L) decreased. Therefore, for determination of maximum capacity of some adsorbent, lower adsorbent quantity is recommended. However, the total amount of the metal removed decreased with an decrease in adsorbent concentration, as seen in Fig. 2. In practise, for good removal of metal ions from water the larger quantity of adsorbent is recommended. Because of that it is important of knowledge of adsorbent maximum capacity when is larger adsorbent quantity is applied. In cases presented in Figures 1 and 2, adsorption efficiency were increased for 8.5 to 10.5 times (in dependence of initial copper(II) concentration) when was adsorbent quantity increased for 15 times (since 1 g/l to 15 g/l). At the same time q_m was decreased for 45 to 25 %.

In Fig. 3 is present dependence of maximum capacity (Langmuir constant q_m) on adsorbent quantity. According to regresion analysis (in Excel program), it is evident that the dependence q_m vs adsorbent quantity is not linear (Fig. 3a) than power (Fig. 3b). Similar relation exist between Langmuir constant K_L and adsorbent quantity (not show). However, Freundlich constants vs adsorbent quantity shows polynomial dependence (also not show).

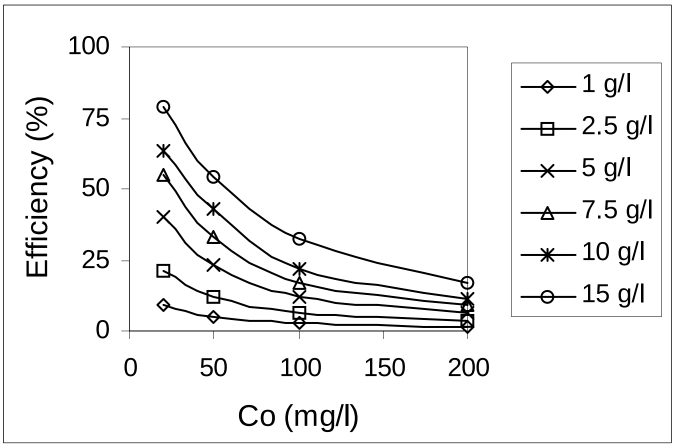
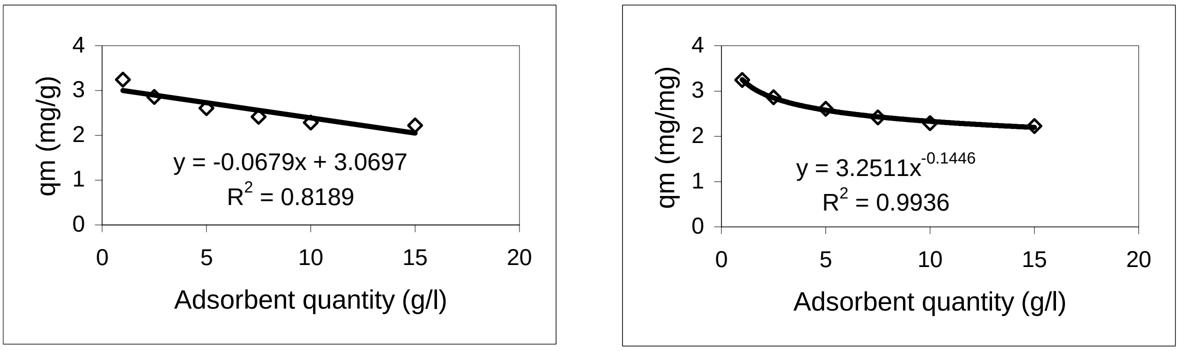


Fig. 2. *Adsorption efficieny of copper(II) by different adsorbent quantity*



a) b)

Fig. 3. *Dependence of maximum capacity (Langmuir constant q_m) on adsorbent quantity: a) linear, b) power*

From efficasy removal of copper ions from water it is recommended application of higher adsorbent concentration. It is necessary to have sufficiently, local available wood sawdust as adsorbent and to have solution for further treatment and disposal of used adsorbent.

In a batch adsorption process is better to apply multistage countercurrent operation. What results is possible to realize in this case it was investigated by following experiments. As first it was investigated ability to reutilize poplar sawdust as adsorbent, without regeneration. The tests were performed using an initial copper(II) concentration of 50 mg/l, at pH 5, in a 5 g/l sawdust suspension. Adsorption was carried out for 3 hours and then the sawdust was separated, rinsed with double disstilate water and trasferred to another portion of solution. The process was repeated for three times. Each time the sawdust was able to adsorb some copper(II). The largest amount of copper (II) was adsorb in first cycle and with each of its subsequent reutilization the sawdust performance was lower (Fig. 4).

After first cycle adsorbent have a certain number of active sites. In second cycle adsorbent bind still 15% from firstly adsorbed copper(II), and in third cycle still 18%. Amount of adsorbed copper(II) – q, after third cycle is still lower from corresponding q_m presented in Table 1. It is mean that the adsorbent after third cycle, still have a some free active sites for adsorption.

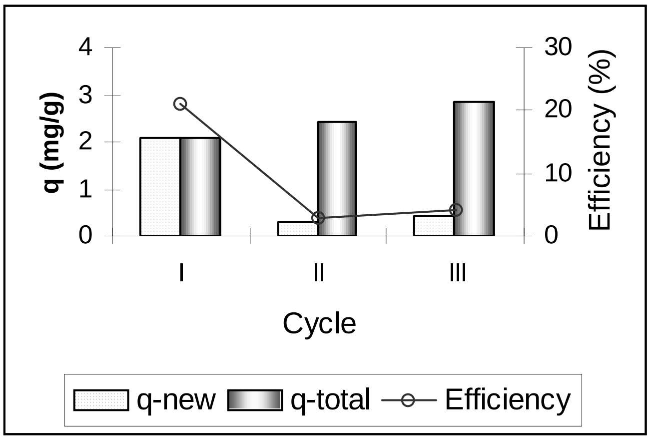


Fig. 4. *Reutilization of poplar sawdust for copper(II) adsorption*

Influence of adding of fresh adsorbent in treated water on amount of adsorbed copper ions was tested too. In this experimens, after first cycle (like above) in treated water was added a fresh poplar sawdust. The process was repeated for three times. Results is present on Fig.5.

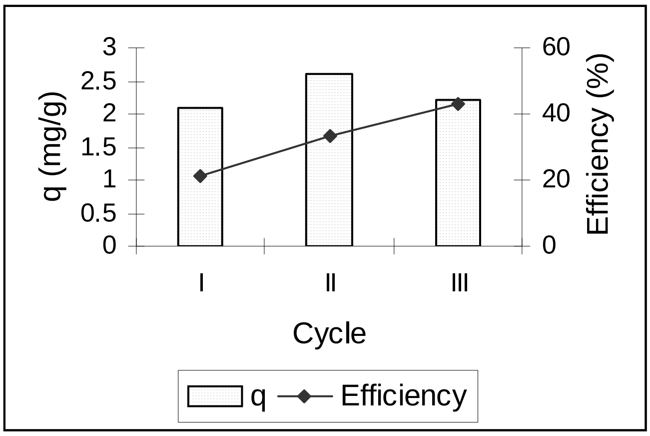


Fig. 5. *Efficiency of copper(II) adsorption by fresh poplar sawdust in three cycle*

If sawdust added immediately in quantity of 10 g/l, instead 5 g/l in twice, adsorption efficiency will be lower for about 10%. If sawdust was added immediately in quantity of 15 g/l, instead three times by 5 g/l, adsorption efficiency will be lower for about 20%.

On the base of the results presented on Fig. 4 and Fig. 5 it was concluded that the adsorbents like wood sawdust can be applied in multistage countercurrent adsorption operation. Sawdust separation from water is easy, what represent one more advantage of this materials as adsorbents for heavy metal ions from water.

4. CONCLUSION

Inexpensive, readily available materials like wood sawdust can be used for the removal of heavy metal ions from water. Numerous parameters have influence to adsorption phenomenon, and it is necessary to find a optimum operation conditions for application of some adsorbent. On the base of the presented results it was recommended to apply larger amounts of sawdust, e.g. 10-15 kg/m^3 for adsorption of copper(II) from water, if it is not cause problems with delaying of used adsorbents. Smaller amounts of adsorbent were better utilized in two or three stage adsorption processes. The results suggest that already used sawdust could be applied to fresh heavy metal solution, whereas used metal solutions that still contain residual metal ions could be treated with a fresh sawdust.

5. REFERENCES

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