



University of Belgrade, Technical Faculty in Bor
29th International Conference Ecological Truth
& Environmental Research



EcoTER'22

Proceedings



Editor

Prof. Dr Snežana Šerbula

21-24 June 2022, Hotel Sunce, Sokobanja, Serbia



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PREFACE

In today's world, the environment has been endangered by the use of outdated technology, fossil fuels and environmental law violations. Therefore, environmental and many other scientists all over the world have been concerned about finding sustainable technology in resolving these issues. That is why environmental research and ecological truth are at the focus of the 29th International Conference Ecological Truth & Environmental Research 2022 (EcoTER'22), which will be held in Sokobanja, Serbia, 21–24 June 2022. On behalf of the Organizing Committee, it is a great honor and pleasure to wish all the participants a warm welcome to the Conference.

We hope to convey the message of the conference, which is that a transformation of attitudes and behavior would bring the necessary changes. This is also an opportunity for the participants who are experts in this field to exchange their experiences, expertise and ideas, and also to consider the possibilities for their collaborative research.

The 29th International Conference Ecological Truth & Environmental Research 2022 is organized by the University of Belgrade, Technical Faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology, the University of Montenegro, Faculty of Metallurgy and Technology – Podgorica, the University of Zagreb, Faculty of Metallurgy – Sisak, the University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Association of Young Researchers, Bor.

These proceedings include 85 papers from the authors coming from the universities, research institutes and industries in 6 countries: Bulgaria, Italia, Albania, Bosnia and Herzegovina, Montenegro and Serbia.

As a part of this year's conference, the 4th Student section – EcoTERS'22 is being held. We appreciate the contribution of the students and their mentors who have also participated in the Conference.

Financial assistance provided by the Ministry of Education, Science and Technological Development of the Republic of Serbia is gratefully acknowledged by the Organizing Committee of the EcoTER'22 conference.

The support of the Platinum donor and their willingness and ability to cooperate have been of great importance for the success of EcoTER'22. The Organizing Committee would like to extend their appreciation and gratitude to the Platinum donor of the Conference for their donation and support.

We appreciate the effort of all the authors who have contributed to these Proceedings. We would also like to express our gratitude to the members of the scientific and organizing committees, reviewers, speakers, chairpersons and all the Conference participants for their support to EcoTER'22. Sincere thanks go to all the people who have contributed to the successful organization of EcoTER'22.

Prof. Snežana Šerbula,

President of the Organizing Committee

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ADSORPTION ISOTHERMS FOR COPPER IONS BIOSORPTION ONTO WALNUT SHELLS

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Abstract

Equilibrium analysis of copper ions biosorption onto walnut shells is presented in this paper. The experimental data were analyzed using three isotherm models, namely, the Langmuir adsorption isotherm model, the Freundlich adsorption isotherm model, and the Temkin adsorption isotherm model. Obtained results indicate that the Langmuir model fits best the experimental data ($R^2 = 0.993$), indicating that the biosorption of copper ions occurs in a monolayer. The small difference between $q_{e,exp}$ and $q_{e,m}$ point to that the walnut shells are almost completely saturated with copper ions.

Keywords: adsorption isotherms, biosorption, walnut shells, copper ions

INTRODUCTION

The growing development of many industrial processes, including mining and metallurgy, has led to the generation of huge amounts of wastewater. Water pollution, i.e. wastewater, is thought to be one of the biggest environmental issues today. This type of pollution occurs as a result of the discharging of many different pollutants into surrounding watercourses without prior treatment [1,2].

Due to the complexity of the process of heavy metal removal from wastewater, a significant number of conventional methods are being applied to water treatment, which include ion exchange, membrane processes, chemical precipitation, solvent extraction, cementation, etc. [3].

Biosorption of heavy metals from aqueous solutions is a new, still in developing process, which has been proven effective on a laboratory scale for treating wastewaters with a low concentration of heavy metals [4].

In the biosorption process, waste biomass is used as an adsorbent. Biomass which has the ability to adsorb metal ions from water solutions is considered as biosorbent. The biosorbent consist of cellulose, hemicellulose, and lignin. These components are made of functional groups, which are capable of binding metal ions into their structure [5].

Adsorption isotherm models give insight into the process mechanism, as well as information about the maximum biosorption capacity. Many empirical models are used to determine the process equilibrium [6].

In this paper, Langmuir, Freundlich and Temkin adsorption isotherm models were used to analyse experimental data.

MATERIALS AND METHODS

Biosorption isotherm data were obtained by bringing into contact 0.5 g of sample (with granulation $-1 + 0.4$ mm) with 50 mL of the synthetic solution of copper ions (initial concentration 5–200 mg dm⁻³). The suspension was stirred for 60 minutes, then filtrated, and the filtrate was analysed for the remaining concentration of copper ions.

RESULTS AND DISCUSSION

Adsorption isotherm for copper ions biosorption onto walnut shells

Experimentally obtained adsorption isotherm for copper ions biosorption onto walnut shells is shown in Figure 1a.

Langmuir adsorption isotherm model

This model assumes that the adsorption takes place in a monolayer, at a limited number of definitely localized sites [7].

The Langmuir isotherm model can be expressed as:

$$q_e = \frac{q_m K_L c_e}{1 + K_L c_e} \quad (1)$$

The linear form of the equation (1) is:

$$c_e / q_e = \frac{1}{K_L q_m} + \frac{1}{q_m} c_e \quad (2)$$

where C_e - is the equilibrium concentration of metal ions in the solution (mg dm⁻³), q_e - is the equilibrium adsorption capacity defined as mass of the adsorbed metal per unit mass of the adsorbent (mg g⁻¹) at equilibrium, q_m - is the maximum adsorption capacity (mg g⁻¹), and K_L - is the Langmuir equilibrium constant (dm³ g⁻¹).

The obtained experimental isotherm data were fitted using this model, and the results are shown in Figure 1b and in Table 1.

Freundlich adsorption isotherm model

This model is based on the assumption that the surface of the adsorbent is heterogeneous, with adsorption sites of different adsorption energies present [8].

This model is represented by the equation:

$$q_e = K_f c_e^{1/n} \quad (3)$$

In its linear form, equation (3) becomes:

$$\log q_e = \log K_F + \frac{1}{n} \log c_e \quad (4)$$

where C_e - is the equilibrium concentration of metal ions in the solution (mg dm⁻³); q_e - is the adsorbent capacity (mg g⁻¹) at equilibrium; and K_F - is the Freundlich equilibrium constant ((mg g⁻¹) (dm³ mg⁻¹)^{1/n}).

Linear dependence $\log q_e$ vs. $\log C_e$ is given in Figure 1c, and the obtained isotherm model parameters are shown in Table 1.

Temkin adsorption isotherm model

This model is most often used for analysing multilayer chemical adsorption processes that are based on strong electrostatic interactions between positive and negative charges [9].

This model can be expressed as:

$$q_e = B \ln(K_T c_e) \quad (5)$$

The linear form of the equation (5) is:

$$q_e = B \ln K_T + B \ln c_e \quad (6)$$

where: $B = RT/b$ - is the Temkin constant, which refers to the adsorption heat (J mol^{-1}); b - is the variation of adsorption energy (J mol^{-1}); R - is the universal gas constant ($\text{J mol}^{-1} \text{K}^{-1}$); T - is the temperature (K); K_T - is the Temkin equilibrium constant ($\text{dm}^3 \text{g}^{-1}$); q_e - is the adsorption capacity (mg g^{-1}) at equilibrium; and C_e - is the equilibrium concentration of metal ions in the solution (mg dm^{-3}).

Linear plot $q_e = f(\ln c_e)$ shown in Figure 1d gives the values of the constants B and K_T , shown in Table 1.

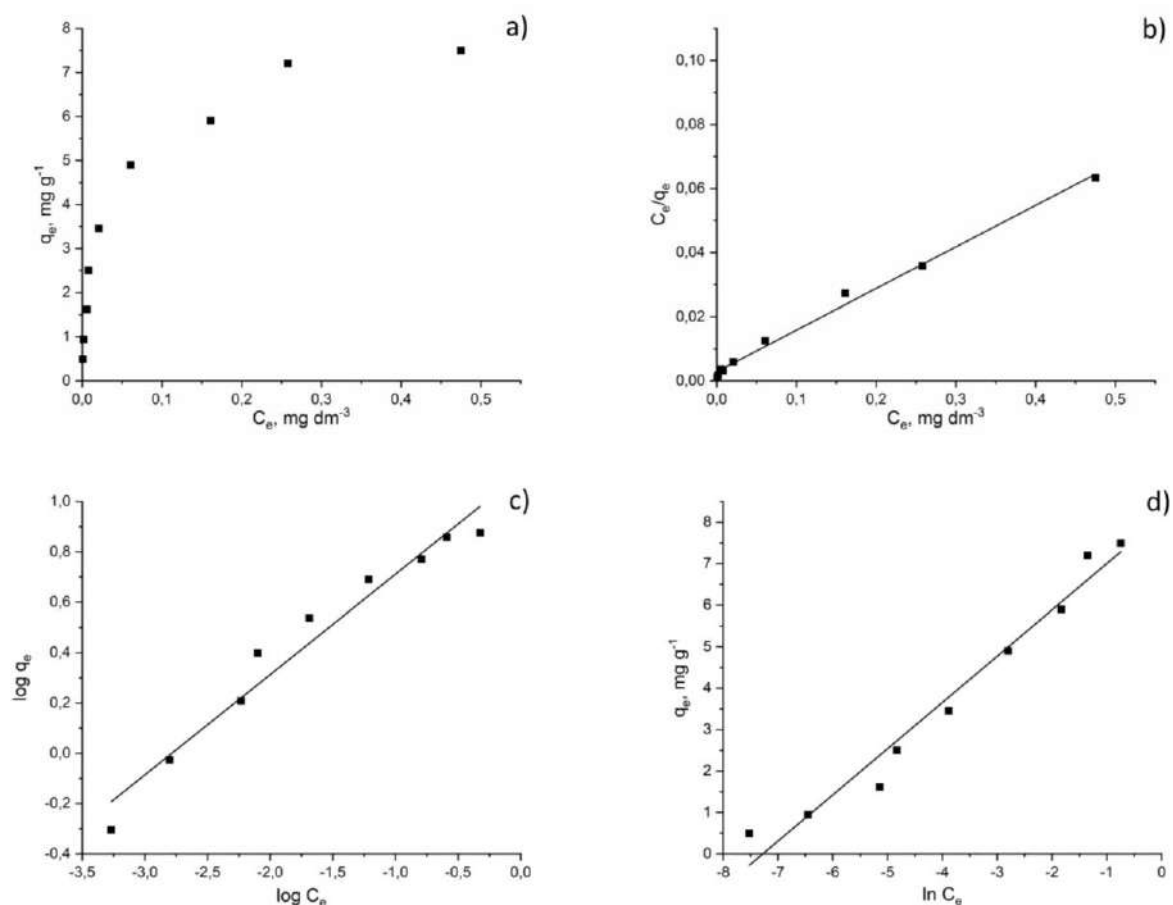


Figure 1 a) Adsorption isotherm for copper ions biosorption onto walnut shells; b) Langmuir adsorption isotherm model; c) Freundlich adsorption isotherm model; d) Temkin adsorption isotherm model

Table 1 Values of isotherm model parameters for the Langmuir, Freundlich and Temkin model

Langmuir		Freundlich			Temkin				
K_L (dm ³ mg ⁻¹)	q_{exp} (mg g ⁻¹)	q_m (mg g ⁻¹)	R^2	K_F	1/n	R^2	B (J mol ⁻¹)	K_T (dm ³ g ⁻¹)	R^2
45.19	7.50	7.71	0.993	12.87	0.4	0.960	1.11	8.11	0.968

Based on the data shown in Table 1, it can be concluded that the Langmuir model fits best the analysed experimental data ($R^2 = 0.993$). This leads to the conclusion that the biosorption of copper ions onto walnut shells takes place in a monolayer, at a limited number of definitely localized sites. The negligible difference between q_{exp} and q_m also speaks in favor of the good functionality of this model.

CONCLUSION

In this research, walnut shells were used as a biosorbent for copper ions biosorption from aqueous solutions. The obtained equilibrium data for this process was analysed using Langmuir, Freundlich, and Temkin adsorption isotherm model. The Langmuir model was proven to be the best fit for the analysed equilibrium data ($R^2 = 0.993$), which led to the conclusion that the biosorption process of copper ions onto walnut shells occurs in a monolayer, at a limited number of localized sites.

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