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Technical Faculty in Bor

31st International conference

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PREFACE

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 focuses on showing the latest research findings and innovations in the field of ecology, environmental protection and sustainable development. The conference will be held in Sokobanja (Serbia) in hotel Sunce in the period of 18–21 June 2024.

The aim of the conference is to connect the experts in various fields in order to transform attitudes and behaviors in everyday practices, as well as in the industry and economy sector which is essential for achieving the desired changes that our society must undergo.

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 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 Society of Young Researchers – Bor.

These Proceedings encompass 119 papers from the authors coming from the universities, research institutes and industries in 15 countries: Brazil, Norway, USA, Spain, Austria, Libya, Italy, Israel, Slovenia, Croatia, Romania, Bulgaria, Montenegro, Bosnia and Herzegovina, North Macedonia, and Serbia. It is a great honor and pleasure to cordially wish a warm welcome to all the participants of the conference.

As a part of this year's conference, the 6th Student Section – EcoTERS'24 will be held. We appreciate the contribution of the students and their mentors who have also participated in the conference and hope that students will continue to explore and to be curious, since education is a never-ending process, and knowledge is continuously growing.

The organization of the EcoTER'24 conference has been financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

The support of the Donors and their willingness and ability to cooperate has been of great importance for the success of the EcoTER'24 conference. The organizing committee would like to extend their appreciation and gratitude to the Platinum donors of the conference – Serbia ZiJin Copper doo Bor and HBIS SERBIA, to the Gold donor of the conference – Elixir Group, as well as to the Silver donor of the conference – Serbian Chamber of Engineers.

We would like to express our sincere appreciation to all the authors who have contributed to the Proceedings. We would also like to express our gratitude to the members of the scientific, organizing and honorary committees, reviewers, speakers, chairpersons and all the conference participants for their support of the EcoTER'24. Sincere thanks go to all the people who have contributed to the successful organization of the EcoTER'24.

Prof. Snežana Šerbula,

President of the scientific and organizing committee

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EQUILIBRIUM ANALYSIS OF COPPER IONS BIOSORPTION ONTO HAZELNUT SHELLS

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Abstract

The equilibrium analysis of the copper ions biosorption process using hazelnut shells as a biosorbent is presented in this paper. The experimental data were analyzed using the non-linear forms of three empirical isotherm models, namely the Langmuir isotherm model, the Freundlich isotherm model and the Temkin isotherm model. The performed analysis indicated that the Temkin isotherm model was the best fit for the analyzed data (R^2=0.9847). The equilibrium analysis also showed a negligible difference between the experimentally obtained ($q_{e,exp}$) and model calculated ($q_{e,m}$) biosorption capacities, which indicates that the hazelnut shells are almost completely saturated with copper ions.

Keywords: equilibrium analysis, biosorption, isotherm models, hazelnut shells, copper ions.

INTRODUCTION

Some heavy metals are biologically significant as trace elements. However, their toxic effect on living organisms makes them an environmental problem. Years of scientific research indicates that these metals are released into the environment by natural and anthropogenic sources. The most common between them are mining and industrial activities, along with traffic exhaust fumes [1].

Water pollution is one of the biggest environmental problems today. Many industries, such as metallurgy processing plants, metal finishing plants, electronic industry, electroplating, phytopharmaceutical plants, and many others, release heavy metals along with their wastewaters, polluting the environment [2].

Wastewaters are being treated using the well known conventional technologies, in order to remove heavy metals. These treatments include: aeration, flotation, coagulation and flocculation, adsorption, ion-exchange, membrane processes, electrochemical methods, and others. However, these conventional methods come with certain disadvantages, including: high cost, continuous input of chemicals, incomplete metal removal, sludge generation, and others. Biosorption could be one of the possible alternatives to conventional methods for wastewater treatment, especially those with low heavy metal ions content [3,4].

Many biological waste materials, such as agrigultural waste, fungi, algae, peat and yeasts have been tested as potential adsorbents for heavy metal ions adsorption from water solutions [5].

Adsorption isotherm models are mostly used in order to obtain information about the process mechanism, as well as the maximum biosorption capacity. Many empirical models can be used to describe the biosorption process [6].

In this work, the equilibrium of the biosorption of Cu^{2+} ions using hazelnut shells as a biosorbent was modelled using the non-linear Langmuir, Freundlich and Temkin adsorption isotherm model, as models most frequently used in literature.

MATERIALS AND METHODS

Prior the biosorption experiments, hazelnut shells were ground and sieved on a set of laboratory sieves, and the fraction (-1+0.4) was used for the biosorption equilibrium experiments.

The equilibrium data was obtained by bringing into contact 0.5 g of hazelnut shells with 50 mL of synthetic solutions of different Cu^{2+} concentrations, ranging from 5 to 200 mg dm^{-3}. The suspension was stirred on a magnetic stirrer for 60 minutes, considering this time long enough to reach the equilibrium between phases [4], then filtered, and the filtrate analysed for the remaining copper ions content.

RESULTS AND DISCUSSION

Biosorption isotherm for copper ions biosorption onto hazelnut shells

The obtained experimental equilibrium data is shown on Figure 1.

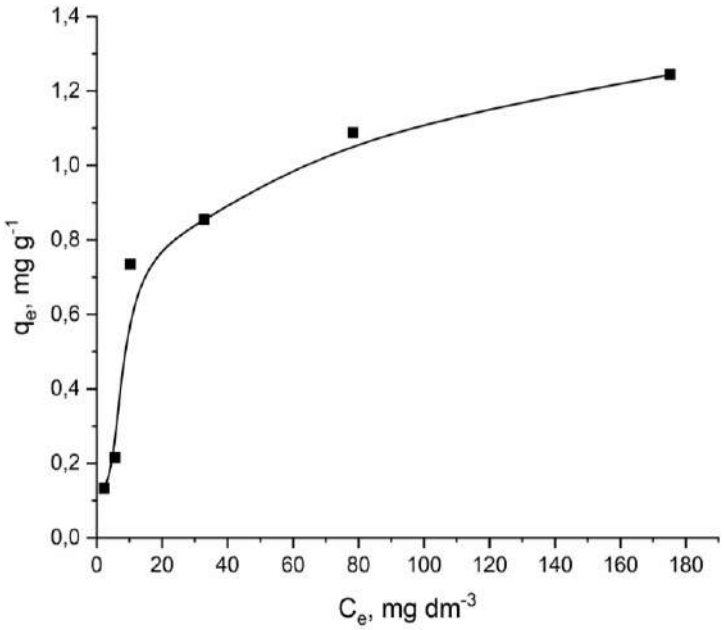

Figure 1 *Biosorption isotherm for copper ions biosorption onto hazelnut shells*

Langmuir model

The Langmuir adsorption isotherm model is based on the assumption that the biosorption process occurs in a monolayer, at a finite number of definite localized sites [7].

This model can be expressed as:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \tag{1}$$

where C_e is the equilibrium concentration of metal ions (mg dm^{-3}), q_e is the equilibrium adsorption capacity (mg g^{-1}), q_m is the maximum adsorption capacity (mg g^{-1}) and K_L (dm^3 g^{-1}) is the Langmuir equilibrium constant.

The non-linear Langmuir model analysis of copper ions biosorption onto hazelnut shells is shown on Figure 2. The obtained model parameters are given in Table 1.

Freundlich model

The Freundlich isotherm model is used to describe adsorption on heterogeneous surfaces. This model can describe adsorption processes in a limited range of concentrations [7].

The Freundlich adsorption isotherm model can be expressed as:

$$q_e = K_f C_e^{1/n} \tag{2}$$

where C_e is the equilibrium concentration of copper ions in the solution (mg dm^{-3}); q_e is the adsorbent capacity defined as mass of the adsorbed metal per unit mass of the adsorbent (mg g^{-1}) at equilibrium; K_F is the Freundlich equilibrium constant ((mg g^{-1}) (dm^3 mg^{-1})$^{1/n}$), and $1/n$ is the coefficient of heterogeneity in the Freundlich adsorption isotherm equation.

The non-linear Freundlich model analysis is shown on Figure 2. The obtained model parameters are given in Table 1.

Temkin model

This model is based on the assumptions that the heat of sorption of all molecules linearly decreases with the coverage of the adsorbent, which is conditioned by adsorbent-adsorbate interactions, and (2) there is a uniform distribution of binding energies up to some maximum binding energy [8].

The Temkin model is given as:

$$q_e = B \ln\left(K_T C_e\right) \tag{3}$$

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 (J mol^{-1} K^{-1}); T is the temperature (K); K_T is the Temkin equilibrium constant (dm^3 g^{-1}); q_e is the adsorption

capacity defined as mass of the adsorbed metal per unit mass of the adsorbent (mg g^{-1}) at equilibrium; C_e is the equilibrium concentration of copper ions in the solution (mg dm^{-3}).

The analysis of the experimental data using the non-linear Temkin model is shown on Figure 2. The isotherm model parameters are given in Table 1.

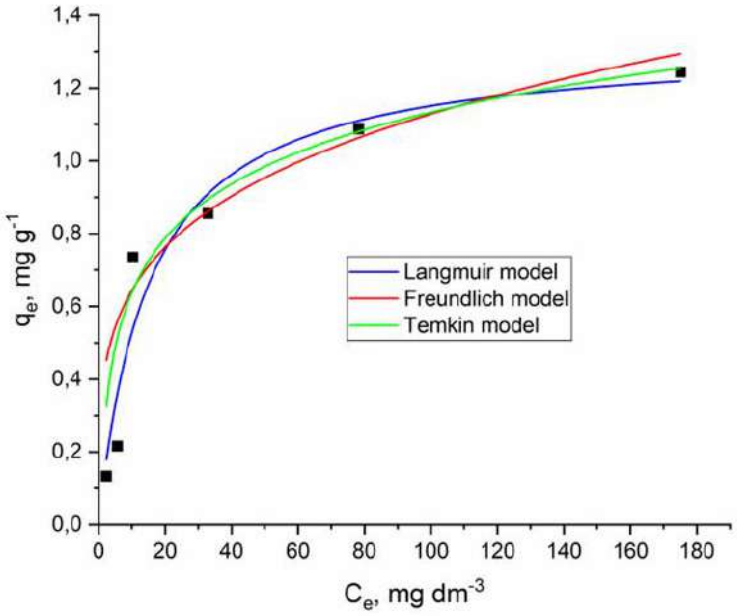

Figure 2 *Non-linear adsorption isotherm models for copper ions biosorption onto hazelnut shells*

Table 1 *Obtained equilibrium parameters for the non-linear Langmuir, Freundlich and Temkin isotherm models for copper ions biosorption onto hazelnut shells*

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
0.067	1.244	1.324	0.935	0.367	0.244	0.916	0.215	1.936	0.985

Based on the results given in Table 1, it can be concluded that the Temkin adsorption isotherm model shows the best agreement with the experimental data (R^2=0.9487), and is the best model for describing the equilibrium of the biosorption of Cu^{2+} ions onto hazelnut shells in the observed concentration range. This result indicates that the heat of sorption of all molecules linearly decreases with the coverage of the adsorbent, and that there is a uniform distribution of binding energies up to some maximum binding energy [8].

CONCLUSION

Hazelnut shells were used as a biosorbent, in order to remove copper ions from synthetic aqueous solutions. The process equilibrium was analysed using three non-linear isotherm models, i.e. the Langmuir, the Freundlich and the Temkin adsorption isotherm model. The obtained results indicate that the Temkin adsorption isotherm model is the best fit for the analysed process, with the correlation coefficient R^2=0.9487. This model indicates that the

heat of sorption of all molecules linearly decreases with the coverage of the adsorbent, and that there is a uniform distribution of binding energies up to some maximum binding energy.

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