BIOSORPTION OF HEAVY METALS USING Pleurotus ostreatus SPENT MUSHROOM COMPOST FROM AGRICULTURAL WASTE

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Tuan

KELULUSAN MEMBIAYAI PROJEK-PROJEK SCIENCEFUND DI BAWAH RMKe-9

Dengan hormatnya perkara di atas adalah dirujuk.

Sukacita dimaklumkan Jawatankuasa Kelulusan MOSTI telah meluluskan kertas cadangan tuan dan membiayai projek penyelidikan di bawah dana *ScienceFund.*

Tuan dikehendaki untuk mengakui penerimaan kelulusan ini secara *online* di laman web http://ernd.mosti.gov.my/eScience sekiranya masih belum berbuat demikian. Tuan juga dibenarkan untuk memulakan penyelidikan dan membuat tuntutan atau permohonan pembelian menggunakan peruntukan penyelidikan ini.

Untuk makluman tuan, peruntukan akan dimasukkan selepas MOSTI selesai menyemak semua *Research Agreement* (RA) yang telah ditandatangani oleh Koordinator Penyelidikan UiTM dan Naib Canselor UiTM. Urusan bagi Research Agreement (RA) akan diuruskan oleh pihak IRDC. Penyelidikan yang diluluskan adalah seperti berikut:

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03-01-01-SF0234	Suhaimi Bin Abdul Talib	FKA	Biosorption of Cu(II), Pb(II) and Ni(II) using Sawdust Colonised by Pleurotus Ostreatus Fungal Mycelium from Mushroom Farming Waste.	24 bulan	184,000.00

Kami mengucapkan tahniah kepada tuan kerana berjaya mendapatkan peruntukan *ScienceFund* ini dan semoga berjaya menyiapkan projek penyelidikan ini dengan cemerlang.

Sekian, harap maklum.

Yang benar

PROF. DR. AZNI ZAIN AHMED
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Enhanced Executive Summary (Abstract of the research)

The potential *Pleurotus ostreatus* spent mushroom compost (PSMC) as biosorbent was investigated. The texture and composition characterization shows cellulose and lignin are major component for PSMC biosorbent. SEM micrographs indicate that chemisorptions process changed the surface morphology of biosorbent. The EDX and XPS spectra indicated that ion exchange occurred during biosorption process with no changes of heavy metals species. Surface characterization was evaluated by using zeta potential, FTIR and solid sate NMR analysis. Results show that lignin carboxyl and lignin C-1/C-4 of aromatic units of after Pb(II) biosorption play a major role in biosorption mechanism via complexation process due to the stiffening effects. For Cu(II) after biosorption, the paramagnetic effects on cellulose and the structural changes on lignin were observed. The coordination of complexation has resulted in decreased of biosorbent available binding sites and structural changes of biosorbent. The biosorption efficiency is evaluated via the half saturation constant of biosorption in order to minimize time and biosorbent usage. At half saturation of 0.08 g, Pb(II) achieved optimum biosorption efficiency at un-adjusted initial pH of 5 - 6, contact time of 10 minutes and 50 mg/L initial Pb(II) concentration. For Cu(II) and Ni(II), the best operating condition at 0.7 g biosorbent concentration as the half saturation constant, un-adjusted initial pH, 10 minutes contact time and 50 mg/L initial heavy metals concentration. The order of efficiency of biosorbent performance was in sequence of Pb(II), Ni(II) and Cu(II). Likewise, bi-heavy metals and multi-heavy metals solution showed similar observation as single heavy metals solution. The electronegativity which is a major player in mechanisms, affects the selectivity of biosorbent active binding sites. There are competitions among heavy metals for the active binding sites on the surface of biosorbent in bi and multi-heavy metals solutions. Results supported that this rapid biosorption process is highly potential in diluted heavy metals solution for wastewater purification system. Experimental data are better fitted to Langmuir isotherm than Freundlich isotherm model. This inferred that chemisorptions which governing the monolayer adsorption process is a key factor in heavy metals biosorption. Results are fitted well to pseudo second-order kinetic if compared to first-order kinetic model which further evaluate the chemisorptions process is the limiting factor. Complexation may occur through sharing of electron and coordination of molecules. Thermodynamic study shows biosorption is a spontaneous exothermic reversible reaction generally. This established models show biosorption involves complex mechanisms which may occur simultaneously. Furthermore, it explained that biosorbent are easily regenerated by using diluted acid and comparable to others biosorbent. The application of biosorbent in industrial wastewater shows lower percentage of biosorption if compared to synthetic solutions. This is because there are competition of other heavy metals and high concentration of light metals in industrial wastewater which competing with selected heavy metals for active binding sites of biosorbent. Besides, low pH in industrial wastewater and competition from protons also lowered the biosorption efficiency as not represent the optimum operating conditions. For ANN modeling with two output, a three-layer Back-Propagation Feed Forward Network, Levenberg-Marquardt algorithm, *tansig* and *purelin* function was prosposed. The optimized parameters were hidden layer of 16, learning rate of 0.3 and momentum rate of 1.0. The s.s.e values of the optimized condition for testing data and training data were 0.0116 and 0.0004 respectively. The best linear equation of training data was attained at y = 0.9995x with coefficient of 0.9999. For prediction data, the best linear equation and coefficient value were obtained at y = 0.9989x and 0.9960, respectively. The development of proposed two output for heavy metals biosorption ANN model is an knowledge contribution extended biosorption technology in industries. This study reported on two output of ANN model is crucial in evaluating the water quality of effluent and determining the most suitable time for elution of biosorbent. In short, degradable and renewable PSMC is highly potential as a green biosorbent which and contributes towards waste management through exploiting the agricultural waste. Furthermore, heavy metals biosorption process is in-line with the alternative sustainable technology development for wastewater purification system.

1.0 Introduction

Industrial wastewater containing heavy metals are hazardous, which pose a detrimental health implication to human and environment. Global industrialization development has increased the discharge of this dangerous industrial wastewater to surface water. It is of great concern nowadays due to its toxicity, non-biodegaradable and cumulative characteristics. Heavy metals, such as lead, cadmium, copper, nickel and mercury, are from metal plating, painting and metal finishing industries. The most commonly used method in heavy metals treatment for industrial wastewater is precipitation with caustic *soda*. However, this method generates a large amount of hydroxide sludge which need further disposal.

In view of this, interest which focus on green sustainable biosorption process, has been intensified among researchers recently. Biosorption is a passive metabolic independent process involving physico-chemical binding of metal ions with biosorbent, which from non-living biological materials. The biosorbent offers two major advantages, namely, renewable and cost effective. It is easily regenerated by using diluted acid for reuse and transformed from available large amount of bio-waste to wealth.

Biosorbents from agricultural and industrial waste which are available in respective countries, such as Brazil, India, Pakistan, Iran, China and Turkey have been investigated. Fungal *Pleurotus ostreatus* (Chia-Chay *et al.*, 2011, Javaid *et al.*, 2011) and sawdust (Zakaria *et al.*, 2009) are promising biosorbents due to their high heavy metals removal efficiency if compared to other plant or bacteria derived biosorbents. To date, there is lack of information on biosorption of *Pleurotus ostreatus* Mushroom Spent-Substrate (PSMC) in wastewater heavy metals treatment.

Generally, the PSMC is an agricultural waste of mushroom cultivation farm in Malaysia, which majorly consists of rubber tree sawdust and *Pleurotus ostreatus* mycelium. The disposal of PSMC is currently handled by open-burning or converted into low commercial value organic fertilizer in order to reduce cost for solid waste disposal. Studies on PSMC as a potential biosorbent for heavy metals treatment is yet to be explored. Meanwhile in biosorption study, the half saturation constant of biosorption evaluation is seemed hardly been carried out as a time saving approach for this alternative sustainable technology.

Presently, little research is applying the Artificial Neural Networks (ANN) in biosorption study. Kardam and co-researchers (2010) reported that constructed ANN models were highly precise in predicting the single output variable. In fact, such single output ANN network has a limitation in simulation of biosorption operating system for prediction of effluent quality and the best time for elution of biosorbent under any operating conditions. This study is thus expected to make contribution to the knowledge of scale-up biosorption of heavy metals technology.

This study focuses on biosorption characteristics of heavy metals biosorption from aqueous solution by deploying PSMC. The half saturation constant of heavy metals biosorption and the best operating parameters of initial pH, contact time and initial heavy metals concentration were optimized. Biosorption data were fitted to established isotherm, kinetic and thermodynamic models. Concurrently, mechanisms of heavy metals biosorption were studied. Application of biosorbent was evaluated in industrial wastewater. Furthermore, a constructed ANN modelling with two output in biosorption study is explored. This study is not only parallel with green sustainable technology for heavy metals treatment but also waste management.