UNIVERSITI TEKNOLOGI MARA

BIOSORPTION OF IRON(II) AND MANGANESE(II) USING *PLEUROTUS OSTREATUS* SPENT MUSHROOM COMPOST IN A CONTINUOUS FLOW FIXED BED COLUMN

AIN NIHLA BINTI KAMARUDZAMAN

PhD

May 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Ain Nihla Binti Kamarudzaman
Student I.D. No.	:	2011158873
Programme	:	Doctor of Philosophy (Civil Engineering) - EC990
Faculty	:	Civil Engineering
Thesis Title	:	Biosorption of Iron(II) and Manganese(II) using *Pleurotus Ostreatus* Spent Mushroom Compost in a Continuous Flow Fixed Bed Column
Signature of Student	:	.....
Date	:	May 2020

ABSTRACT

Heavy metals pollution poses a major threat to human health and the environment. Unlike many other pollutants, heavy metals cannot be biologically degraded to more or less toxic products and persistent in the environment. Conventional technologies for removing heavy metals are not economical and tend to generate huge quantity of toxic chemical sludge. Biosorption is an alternative treatment technology for not only removal but also recovery of heavy metals from industrial effluents. In this study, the potential of *Pleurotus ostreatus* spent mushroom compost from mushroom cultivation farm for iron(II) and manganese(II) removal were studied in a column operation mode. The characterisations of *Pleurotus ostreatus* spent mushroom compost were investigated using surface analyser, Scanning Electron Microscope, Energy Dispersive X-ray Spectroscopy and Fourier Transformed Infrared Spectroscopy. Biosorption performance studies for removing of iron(II) and manganese(II) were conducted in single and binary mixtures heavy metals systems. For optimisation studies, various experimental parameters were studied including flow rate (1 - 20 mL/min) with surface loading (1.27 - 25.48 $cm^3/cm^2.min$), bed height (100 - 300 mm) and initial heavy metals concentration (10 - 100 mg/L). The regeneration study was performed by pumping 0.5 M HNO_3 at a flow rate of 10 mL/min for five successive biosorption - desorption cycles. The performance of *Pleurotus ostreatus* spent mushroom compost for treating steel industrial effluent was also investigated in this study. The experimental data were also analysed using Thomas, Yoon - Nelson, Modified Dose - Response and Bohart - Adams models. Results from characterisation indicated that the *Pleurotus ostreatus* spent mushroom compost biosorbent has a surface area of 0.7209 m^2/g and the hydroxyl, carboxyl, amino and amide were identified as functional groups involved in the biosorption of heavy metals. The optimal iron(II) and manganese(II) biosorption operating conditions were achieved at a flow rate of 1 mL/min (surface loading of 1.27 $cm^3/cm^2.min$) and bed height of 300 mm. The results also inferred that the breakthrough time, exhaustion time, retention time as well as the iron(II) and manganese(II) uptake capacities and percentage of removal are highly influenced by different flow rate, bed height and initial heavy metals concentration. The binary mixtures heavy metals biosorption indicated that the active binding sites on the surface of *Pleurotus ostreatus* spent mushroom compost had a strong affinity for iron(II) compared to manganese(II). However, the biosorption of iron(II) and manganese(II) in the binary mixtures heavy metals systems were significantly lower compared to the single heavy metal system. The *Pleurotus ostreatus* spent mushroom compost column was successfully reused for at least five biosorption - desorption cycles for the removal and recovery of iron(II) and manganese(II) ions. The bed column also efficiently remove different heavy metals from the steel industrial effluent in application study. In this study, the experimental data were successfully fitted to the Modified Dose - Response model and compared to other models, and the maximum uptake capacity obtained from the experimental was also very close to the value predicted by the Modified Dose - Response model. A new mathematical model also developed in this study for a better description of biosorption performance and prediction of breakthrough profiles for biosorption of heavy metals. It was concluded that biosorption using *Pleurotus ostreatus* spent mushroom compost in a fixed bed column could be an effective method for iron(II) and manganese(II) removal.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious, the Most Graceful. I am very grateful to Allah s.w.t that had granted me His Guidance, rahmah, strength and determination for me to complete this study.

First of all, I would like to extend my gratitude to everyone who has been helping me directly or indirectly from the beginning until the final stage in this study. All the help and cooperation from various parties had been a motivation factor for me to complete this project. I would like to express my deep gratitude and appreciation to my respected supervisor Professor Sr. Ir. Dr. Suhaimi Abdul Talib for his guidance, encouragements, and excellent facilities during my study. Special thanks also to my co-supervisors, Dr. Tay Chia Chay and Dr. Amnorzahira Amir for their constant help, advice and inputs given throughout the study. Thank you very much.

Next, I would like to acknowledge my beloved family for their endless support and encouragement especially during the difficult times faced during this work. Moreover, my special thanks goes to the research group of MyBiorec, Faculty of Civil Engineering, UiTM (Salina, Liew Hong Hooi, Satira Hambali, Caroline Marajan, Nadiah, Sherina, Ros Adibah and Emylia) for their friendship, support and help especially during conducting research discussions. Special appreciation also to all laboratory technicians from myBIOREC and Environmental Engineering Laboratory, Faculty of Civil Engineering UiTM, Mrs Ramliza Ramli, Mr Muhamad Hazli Shariei and Mrs Aishah Idris. May all the good deeds that were done will be blessed by Allah.

A special thank also goes to my employer, Universiti Malaysia Perlis for giving me permission to commence this study. Last but not least, I would like to acknowledge the financial support from the Government of Malaysia, through the Ministry of Higher Education.

Wassalam.

TABLE OF CONTENTS