APPROVAL

PHOSPHORUS REMOVAL BY ELECTRIC ARC FURNACE STEEL SLAG ADSORPTION

by

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DECLARATION

I, the undersigned, hereby declare that this report is my own independent work except as specified in the references and acknowledgements. I have not committed plagiarism in the accomplishment of this work, nor have I falsified and/or invented the data in my work. I am aware of the University regulations on Plagiarism. I accept the academic penalties that may be imposed for any violation.

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ABSTRACT

As to overcome and control the arising environmental issue - eutrophication in lakes and reservoirs that resulted from excessive input of phosphorus (P) due to rapid urbanization and uncontrolled agricultural activities. Electric Arc Furnace Steel Slag (EAFS), a steelmaking by-product, rather than dispose this industrial waste which is economically unfavourable, it's physical and chemical properties exhibits high potential to be great P adsorbent. The objective of this study was to investigate the effect on phosphorus removal efficiency and P removal capacity by EAFS adsorption through variation of parameters such as pH, size of slag and initial concentration of phosphorus and to identify most suitable mathematical model in description of adsorption by using traditional batch experiment. Results demonstrated that, Langmuir is suitable in describing P-removal mechanisms model with the Maximum Adsorption Capacity, Q_m of 0.166 mg/g and Langmuir Constant, K_L of 0.03519 L/mg. While small size of adsorbent shows higher percentage (up to 37.8 %) of P-removal compared to the larger size. Besides that, the experiment showed a more acidic environment is favorable for P-removal and the amount of P adsorbed at pH 3.0 was the highest. In addition, the adsorption capacity increases steadily as the initial P concentration increase but it remained steady at 100mg P/L. Eventually this study should help in better preliminary understanding on P removal mechanisms by EAFS.

Keywords: Phosphorus, Adsorption, Steel Slag, Batch Experiment, Adsorption Isotherm

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DEDICATION

This thesis is dedicated to my family for their endless support throughout the research project.

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LIST OF ABBREVIATIONS

UNEP	United Nations Environment Programme
TP	Total Phosphorus
TSI	Carlson's Trophic State Index
P	Phosphorus
N	Nitrogen
CW	Constructed Wetlands
EAFS	Electric Arc Furnace Steel Slag
ATP	Adenosine Triphosphate
DNA	Deoxyribonucleic
EAF	Electric Arc Furnace
BOFS	Basic Oxygen Furnace Slag
BF	Blast Furnace
BET	Brunauer-Emmett-Teller
XRD	X-ray Diffraction
SEM	Scanning Electron Microscopy
EDX	Energy Dispersive X-ray
HAP	Hydroxylapatite

NOMENCLATURE

Symbol	*Definition*
Q	Concentration of compound retained on solid particle (mol/kg or kg/kg)
C	Final/ Remaining concentration of the compound (mol/L or kg/L)
C_{a_0}	Initial solute concentration
Q_{a_0}	Initial concentration of compound retained by the solid (mol/kg)
ΔG°	Standard Free Energy of the reaction (J/mol)
K	Dimensionless Constant
R	Gas Constant (J/mol.K)
T	Temperature (K)
E_1	Adsorption activation energy
E_{-1}	Desorption activation energy
D	Dimensionless collision probability factor
v	Agitation Speed (rpm)
t	Period of Time (H)
C_1	P Concentration of stock solution (mg P/L) before
C_2	dilution
V_1	P Concentration desired (mg P/L)
V_2	Volume of stock solution required (mL)
	Filled volume of distilled water (mL)
RP	Removal Percentage (in %)
C_o	Initial concentration of phosphorus (mg/L)
C_e	Final concentration of phosphorus (mg/L)
q_e	Amount of P adsorbed by EAFS in equilibrium (mg P/g)
m	Mass of the EAFS used (g)
Q_m	Maximum adsorption capacity (mg P/g)
V	Volume of solution (L)
C_e	Equilibrium concentration (mg/L)

K_L	Langmuir constant relate to the rate of adsorption (L/mg)
K_F	Freundich constants – Adsorption capacity (mg/g)
n	Adsorption intensity

CHAPTER 1

INTRODUCTION

1.1 Background

According to United Nations Environment Programme (UNEP), lakes could be defined as "natural, standing, freshwater or saline enclosed water body surrounded by land found on the Earth's continental land masses." Unless the lake is connected with a river or stream, if not the lakes did not have the direct access to sea. Lakes consists of these characteristics that make it stood out from other water bodies including: Complex response dynamics, long hydraulic retention time and integrating nature of water body. (Sharip & Zakaria, 2008)

Lakes playing an important role to the aquatic ecosystem by providing habitat for aquatic livings. Besides that, it served as huge storage basins for municipal and industrial water supply; flood mitigation; agriculture field or power generation. Furthermore, it could be one of the tourisms spot or water based recreational sites by implementation commercial or sports activities accordingly. (Sharip & Zakaria, 2008)

1.1.1 Current Status of Lakes in Malaysia

In Malaysia, there were over 90 lakes which contained more than 30 billion cubic metres of water and covered over 100,000 ha of land. However, this inventory excluded ex-mining ponds where there were roughly 4000 ex- tin mining ponds in Malaysia. (Huang, et al., 2015)

Based on a recent research, even though most of the water quality of lakes studied classified under Class II which is appropriate for water supply with treatment system and serve for recreational purposes. However, studies indicated that most lakes and reservoirs studied consist of high total phosphorus (TP) concentrations which exceeding 0.1mg/L or could be classified as hypereutrophic which lead to algae boom including Aman and Ayer Keroh lakes, eventually affecting human uses for drinking, aesthetic and recreation values. (Sharip, et al., 2014) Another research indicated 62% of lakes were eutrophic out of 90 lakes and reservoir evaluated in Malaysia by using Carlson's Trophic State Index (TSI), which is developed from TP and chlorophyll

relationship. (Sharip & Zulkifi, 2007) Hence, it reflected the severity of eutrophication phenomenon in Malaysia, constant follow-up, enforcement of laws and regulation or any appropriate solutions should be implement as soon as possible to prevent status of lakes gone severely.

1.2 Problem Statements

Lake Eutrophication is one of the arising global environmental issues, as it will lead to creation of undesirable disturbance to both aquatic ecosystem and human community as well as deterioration of water quality. As result of population growth, urbanization and advancement in vegetation, especially in drought or semi-drought countries, the demand for surface water for different needs increase dramatically which about eight times higher of total impact that brought by humanity on natural ecosystem in comparison with 50 years ago. (UNEP, United Nations Environment Programme, n.d.)

Generally, eutrophication is caused by excess of nutrients: phosphorus (P) and nitrogen (N) from point and non-point sources. In order to tackle and combat this global phenomenon, several methods have been implemented by the authorities and government in controlling sources of pollution such as building wastewater treatment facilities and development of constructed wetlands (CW).

Although phosphorus removal can be achieved in various approaches including biological, chemical and physical technologies but these methods had several drawbacks and disadvantages particularly. Therefore, the application of steel slag in phosphorus adsorption seems to be a potential alternatives in tackling eutrophication. While steel slag is an industrial by-product in the steelmaking process, since 1980s, different researches have been conducted to investigate the potential of steel slag in P-removal from wastewater. (Lim, et al., 2016)

In this report, the P-removal through adsorption of Electric Arc Furnace Steel slag (EAFS) will be evaluated accordingly. Effect on EAFS P-removal efficiency will be investigated through variation on several parameters such as initial P concentration, pH and size of steel slag. Furthermore, adsorption isotherm studies will be conducted on P-removal mechanisms by selecting well established mathematic model in describing the adsorption process.