UNIVERSITI TEKNOLOGI MARA

BIOLOGICAL-CHEMICAL TREATMENT OF POLYCYCLIC AROMATIC HYDROCARBON CONTAMINATED SOIL

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ABSTRACT

Industrialization has caused a great deal of environmental pollutions such as soil contamination via deposition and spillage of contaminants. One of the major contaminants is high molecular weight (HMW) polycyclic aromatic hydrocarbon (PAH), specifically the benzo(a)pyrene. Benzo(a)pyrene is known for its carcinogenic effect. Several soil remediation strategies have been proposed. However, to date, remediation of benzo(a)pyrene contaminated soil using zero-valent iron (ZVI) and hybrid bacteria-ZVI has not been investigated. The capability of bacteria, namely, *Corynebacterium urealyticum* and *Sphingobacterium spiritovorum* to degrade benzo(a)pyrene in soil were firstly investigated in three conditions, single, binary and ternary substrate experiments. Binary and ternary substrate experiments involved the degradation of benzo(a)pyrene, a HMW-PAH with the presence of low molecular weight (LMW) PAH. It was found that both bacteria were capable of degrading the benzo(a)pyrene in the presence of anthracene and phenanthrene (both are LMW-PAHs). However the degree of degradation varied. For instance, the degradation of benzo(a)pyrene was enhanced with the presence of anthracene and phenanthrene in ternary substrate experiment, where 30% of benzo(a)pyrene was degraded. In the single and binary substrate experiment which only phenanthrene was present, about 24% and 14% of benzo(a)pyrene was degraded. Both bacteria degraded the benzo(a)pyrene at the rate of 1.508 – 3.229 mg/kg/day. Then, the ability of ZVI, an engineered iron particles to facilitate in the oxidation of benzo(a)pyrene, was evaluated in single and mixed PAHs experiments with different ZVI concentrations. In this case, it was found that the higher the dosage of ZVI in the soil, the more benzo(a)pyrene was oxidized. The degradation rates for ZVI oxidation were at 0.154 – 0.718 mg/kg/minutes which is 150 times higher than the biological treatment. The soil contaminated by benzo(a)pyrene was then sequentially and simultaneously remediated with bacteria and ZVI in hybrid treatment approaches. A slight enhancement in the removal of benzo(a)pyrene was found in the hybrid treatment compared to the individual treatment approach. However, the most effective hybrid approach was through the sequence treatment with bacteria (*Sphingobacterium spiritovorum*) followed by ZVI. In this, 48% of benzo(a)pyrene was removed. The maximum biotic and abiotic conditions for the efficient remediation strategy of benzo(a)pyrene were also investigated. It was found that concentration of bacteria at CFU 10^8/g, temperature 35°C and pH 4 were the maximum conditions for the hybrid bacteria-ZVI. Mathematical models to predict benzo(a)pyrene removal using *S. spiritovorum*-biological treatment, ZVI-chemical treatment and hybrid *S. spiritovorum*-ZVI were successfully developed and validated in this study. The proposed models were able to provide prediction of benzo(a)pyrene removal that will help engineers to plan and design the remediation strategy in order to minimize the impact of PAH contamination on human and environment.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 MOTIVATION

In pursuing development, humans have neglected the importance of preserving soil quality. Soil quality has been gradually degraded by organic and inorganic contaminants (Lors et al., 2012; Mohd-Kamil et al., 2010; Sojinu et al., 2010; Maliszewska-Kordybach et al., 2009). The degradation in soil quality is particularly concern especially in the case of improper planning of industries in the past. This can be seen from large patches of 'stains' on the soil.

In Malaysia, authorities are becoming aware that soil is experiencing deterioration due to organic and inorganic contaminants (Balasingam and Seng, 2011; Chun-Yang and Abdul-Talib, 2006; Sabtu, 2006). Therefore, under the Ninth Malaysia Plan, Department of Environment (DOE) studied the criteria and standards for managing and restoring contaminated land in Malaysia. Based on the study, guidelines on soil screening levels for contaminated land have been documented (DOE, 2009). Soil contamination or deterioration causes a great deal of losses in economy as it has disturbed natural ecological balance in which higher cost is needed for reclamation and revitalization of contaminated land. In reality, the soil contamination causes serious implication on water and food security which in turn bring potential health hazard to the public and environment (Frits and Molden, 2002). As the demand for water supply is increasing, concerns about groundwater quality have been raised because the groundwater has been proposed to be used commercially in order to meet the increasing demand. The pith of the matter is that the contaminants can eventually lead to severe impact on water resources and impose hazard to groundwater reservoirs. In addition, the contaminated soil has reduced soil fertility hence reducing agricultural yield and producing unhealthy food. Thus the use of fertilizer is needed to enhance the infertile soil but this continues to degrade the ecosystem due to the presence of chemical subtances in the fertilizer.