UNIVERSITI TEKNOLOGI MARA

MECHANISMS AND KINETICS OF ENHANCED OXIDATIVE DEGRADATION OF TETRACHLOROETHENE BY IRON BEARING SOIL MINERALS AND GLUTATHIONE IN HYPORHEIC ZONE

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Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy of Civil Engineering
(Environmental Engineering)

Faculty of Civil Engineering

February 2021

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 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.

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ABSTRACT

The feasibility study on the physical and chemical characterization of hyporheic zone at the Klang River Basin was conducted to evaluate the controlling factors to the oxidative degradation of PCE as natural attenuation process in the hyporheic zone. The presence of iron-bearing soil minerals (IBSMs) (magnetite (Fe_3O_4), hematite (Fe_2O_3)), electrolytes (Fe, NO_3^- and SO_4^{2-}) and natural organic matter were detected in the hyporheic zone as important environmental factors that significantly influenced the mechanisms and kinetics of oxidative degradation of PCE. The oxidative degradation of PCE was initiated by nano-IBSMs (nano-Fe_3O_4 and nano-Fe_2O_3) via Fenton-like reaction. However, PCE was incompletely degraded due to the instability of Fe^{3+}/Fe^{2+} redox in the nano-IBSMs suspension. The oxidative degradation of PCE was enhanced through the coupling of redox reactions between nano-IBSMs and glutathione (GSH). The potential role of GSH as a reductant could sustain the redox of Fe^{3+} to Fe^{2+} and promote the generation of reactive oxygen species (OH• and O_2^-•) for the enhanced oxidative degradation of PCE by nano-IBSMs. The oxidative degradation kinetic rate constant of PCE in the nano-Fe_3O_4-GSH suspension was 11.7 times faster (0.035 ± 0.001 hr^{-1}) than that in the nano-Fe_3O_4 suspension (0.003 ± 0.08 hr^{-1}). Contrarily, PCE was oxidatively degraded 600 times faster (0.014 ± 0.003 hr^{-1}) in the nano-Fe_2O_3-GSH than that in the nano-Fe_2O_3 (0.00023 ± 0.00008 hr^{-1}). The oxidative degradation of PCE was predominantly controlled by the concentration of OH• than the O_2^-• in the nano-IBSMs-GSH suspension. The comparison of enhanced oxidative degradation of PCE between nano-Fe_3O_4-GSH and nano-Fe_2O_3-GSH revealed that the oxidative degradation kinetics of PCE by the nano-Fe_3O_4-GSH was 2.5 times faster (0.035 ± 0.001 hr^{-1}) than the nano-Fe_2O_3-GSH (0.014 ± 0.003 hr^{-1}), indicating nano-Fe_3O_4 was more reactive as iron catalyst than nano-Fe_2O_3. The enhanced oxidative degradation of PCE by nano-IBSMs-GSH were conducted at different environmental conditions to evaluate the kinetics of the oxidative degradation. The enhanced oxidative degradation kinetics of PCE significantly increased by the increased of concentration of nano-IBSMs and GSH in alkaline condition. Interestingly, a remarkable enhancement of the oxidative degradation of PCE by the nano-IBSMs-GSH in the presence of NO_3^- and SO_4^{2-} due to the generation of NO_3• and SO_4^-• radicals. However, the presence of HA and increased concentration of PCE significantly decreased the kinetics of the oxidative degradation of PCE. PCE was completely transformed to oxalic acid as a major by-product via hydroxylation and oxidation reactions.

ACKNOWLEDGEMENT

Firstly, I wish to thank Allah for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My gratitude and thanks go to my supervisor, Dr Amnorzahira binti Amir and co-supervisors, Dr Zuhaida Mohd Zaki and Dr May Raksmey.

I would like to acknowledge the Ministry Higher Education, Malaysia for funding my research works. My appreciation goes to the Bioremediation Reseacrh Centre (BioREC), Faculty of Civil Engineering, UiTM Shah Alam that provided the laboratory facilities and assistance throughout my research works. I would also like to acknowledge my colleagues (Nurul Aqilah binti Abdul, Roasadibah binti Mohd Towel, Nurul Atiqah Iliyani binti Malekke, Noor Saadah binti Hamid for helping me throughout my research.

Finally, I would like to express my deepest appreciation and gratitude to my husband, Khairul Ridhwan bin Madzlan, my parents (Salbiah Abang Karim and Mohamad bin Tarap) and other family for their support and encouragement in my pursuit to complete my PhD. Alhamdulillah.

TABLE OF CONTENTS

Page

CONFIRMATION BY PANEL OF EXAMINERS **ii**
AUTHOR'S DECLARATION **iii**
ABSTRACT **iv**
ACKNOWLEDGEMENT **v**
TABLE OF CONTENTS **vi**
LIST OF TABLES **xi**
LIST OF FIGURES **xv**
LIST OF ABBREVIATIONS **xxii**

CHAPTER ONE INTRODUCTION **1**
1.1 Research Background 1
1.2 Problem Statement 2
1.3 Objectives 4
1.4 Scope of Study 5
1.5 Significance of Study 9
1.6 Limitation of the study 11
1.7 Concluding remarks 12

CHAPTER TWO LITERATURE REVIEW **13**
2.1 Introduction 13
2.2 Chlorinated Organic Compounds (COCs) 15
2.3 COCs in groundwater, hyporheic zone and surface water 16
2.4 Sources and uses of COCs 20
2.5 Toxicity and metabolism of COCs to human health and environment 21
2.6 Distribution mechanisms of COCs at the hyporheic zone 23
2.7 Fate and transport of COCs in the environment 25
2.8 Biochemical factors influencing degradation of COCs in hyporheic zone 27
    2.8.1 Iron-bearing soil minerals (IBSMs) 28
    2.8.2 Bacterial enzyme 29