Bioremediation of Water Contaminated with BTEX, TPH, and TCE under Different Environmental Conditions

by

Lei, Cheng Keng (Elena)

A thesis submitted for partial fulfillment of the requirements for the degree of

Master of Science in Civil Engineering

2010

Faculty of Science and Technology
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Approved by _____ Prof. H. Shim
Supervisor

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Address: Rua Nova da Areia Preta No165, Ed. U Wa, Bl. 1, 11/ Andar B, Macau SAR, China
Telephone: (853) 66609962
Fax: (853) 28450371
E-mail: chengkeng.lee@gmail.com

Signature _____

Date _____

CONTENT

VITA

Lei, Cheng Keng (Elena) was born in Macau on 4 November 1984. She graduated from Keang Peng School (Secondary Section) in Macau in the year of 2004 and received the degree of Bachelor of Science in Material Science and Engineering from the National Taiwan University in the year of 2008. She continued her studies since then at the University of Macau and did her master degree under the supervision of Professor Hojae Shim.

Related Publications:

Journal:

- Li, J., **Lei, C.**, Dong, S., & Shim, H. (2010). Bioremediation of mixed wastes (BTEX, TPH, TCE, and *cis*-DCE contaminated water. ASCE's Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management. In revision.

Conference/Symposium Presentation:

- Li, J., **Lei, C.**, Dong, S., & Shim, H. (2010). Bioremediation of mixed wastes (BTEX, TPH, TCE, and *cis*-DCE) contaminated water. BIT's 1st Annual World Congress of Petroleum Microbiology (WCP), Dalian, China. July 24-27. (Abstract accepted).

- **Lei, C.K.,** Li, J.H., Dong, S.S., & Shim, H. (2009). Bioremoval of BTEX, TPH, and TCE in Contaminated Water under Different Environmental Conditions. Proceedings of the Second Symposium on Urban Environmental Science and Technology, Xiamen, China. November 28-December 1.

- **Lei, C.K.,** Li, J., Dong, S.S., & Shim, H. (2009). Bioremediation of Water Contaminated with BTEX, TPH, and TCE under Different Environmental Conditions. Proceedings of the International Symposium on Geoenvironmental Engineering, Hangzhou, China. September 8-10.

- Li, J., **Lei, C.**, Dong, S., & Shim, H. (2009). Interactions of BTEX, TPH, and CAHs during Their Bio-removal under Different Environmental Conditions. The First Environmental Criteria and Ecological Restoration Forum for PhD Candidates, Tianjin, China. November 29-December 1.

University of Macau

ABSTRACT

Bioremediation of Water Contaminated with BTEX, TPH, and TCE under Different Environmental Conditions

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Thesis Supervisor: Prof. Hojae Shim

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Many sites are polluted by a large number of mixed contaminants. As mixed wastes, such petroleum/gasoline compounds as benzene, toluene, ethylbenzene, and three isomers of xylene (BTEX) and such chlorinated compounds as trichloroethylene (TCE) are among the most frequently found subsurface contaminants. Although many technologies have been developed for the remediation of contaminated sites, only a few of these technologies are applicable for mixed contaminated sites. Furthermore, even though lots of studies have been done with the removal of BTEX (singly and in mixtures), total petroleum hydrocarbons (TPH), or TCE (singly and in mixtures with other chlorinated aliphatic compounds; using such substrates as toluene) individually, unfortunately almost no study seems dealing with the interaction (stimulatory or inhibitory to each other's removal) among BTEX, TPH, and TCE when they exist in such mixtures as BTEX/TPH and BTEX/TPH/TCE, especially under different environmental conditions. Even for the BTEX compounds alone, when BTEX were present in mixtures, the interaction results have been shown contradictory.

Since knowing their detailed fates / behaviours during removal process is essential even before the remediation technology can be applied on site for the successful remediation of contaminated environment, BTEX and TPH as the representative petroleum hydrocarbons and TCE as the representative chlorinated hydrocarbon were tested in lab-scale under different conditions for concentration, pH and temperature in this study, to further elucidate the exact interaction during their bio-removal process when they co-exist in mixtures.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BH medium	Bushnell-Haas medium
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
DO	Dissolved Oxygen
D.W.	Distilled Water
EPA	Environmental Protection Agency
GC	Gas Chromatography
IC	Ion Chromatography
µL	Microliter
mL	Milliliter
mol	Molarity
MSM	Mineral Salts Medium
MOs	Microorganisms
*m*X	*meta*-Xylene
NB	Nutrient Broth
OD	Optical Density
ORE	Overall Removal Efficiency
*o*X	*ortho*-Xylene
*p*X	*para*-Xylene
rpm	Revolutions Per Minute
TPH	Total Petroleum Hydrocarbons

UST	Underground Storage Tank
UV	Ultra Violet
v/v	Volume / Volume
w/w	Weight / Weight

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I wish them all the best as they continue in both their research endeavors and future works.

Chapter 1: Introduction

In recent decades, the rapid industrialization and urbanization increased the usage of organic compounds, and the accidental spillage and leaking of these compounds as environmental contaminants is unavoidable. Major causes of crude oil-contaminated soil include leaking storage tanks and pipelines, land disposal of petroleum waste, and accidental or intentional spills. Those sites are usually polluted by a large number of mixed contaminants, for examples. Such petroleum/gasoline compounds as benzene, toluene, ethylbenzene, and three isomers of xylene (*ortho-, meta-*, and *para-*), known as BTEX, and such chlorinated compounds as trichloroethylene (TCE) are among the most frequently found subsurface contaminants.

Among all those remediation technologies available to remove contaminants from water and soil, bioremediation is considered one of the most economical and environmentally sound sustainable treatments. Bioremediation is using indigenous microorganism to degrade the contamination in the environment and the microbes under applicable environmental conditions will clean up the pollutants.

Although many studies have been developed for the remediation of contaminated sites, only a few of these studies are applicable for mixed contaminated sites, which is more practical to the real situation of environmental contamination. Furthermore, even though lots of studies have been done with the removal of BTEX (singly and in mixtures), Total Petroleum Hydrocarbons (TPH), or TCE (singly and in mixtures with other chlorinated aliphatic compounds; using toluene as substrates) individually, almost no study seems dealing with the interaction (stimulatory or inhibitory to each other's removal) among BTEX, TPH, and TCE when they exist in mixtures, especially under different environmental conditions. It is very important and necessary to know the detailed behaviors during removal process, which will help for applying the remediation technology on site for the successful remediation of contaminated environment.