# TREATABILITY OF LEACHATE USING EZ ENZYME™

MASLIANA BT ITHNIN

A dissertation submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Environmental Engineering

School of Graduate Studies
Universiti Teknologi Malaysia

MAY 2011

# TREATABILITY OF LEACHATE USING EZ ENZYME™

MASLIANA BT ITHNIN

School of Graduate Studies
Universiti Teknologi Malaysia

To my beloved family

## ACKNOWLEDGEMENT

**BISMILLAHIRRAHMANIRRAHIM**

Alhamdulillah, all praise to ALLAH the Almighty for His blessing and guidance in helping and giving me the strength to complete this thesis. Particularly, I would like to take this opportunity to express my deepest gratitude and appreciation to my supervisor, Prof. Dr. M. Rashid for his kindness, encouragement and guidance. Similarly, I thank En. Ismail for his valuable idea, guidance and motivation. Without their supports, this dissertation would not be completed on time.

My gratitude also goes to my family member for their endless love, moral support and encouragement throughout my study. Also, in the memory of my beloved father whom never surrender.

Also, I thank all my fellow friends who are always with me to give their moral supports and critics in order to improve my study. Last but not least thanks to those people who are directly or indirectly involve in my work.

# ABSTRACT

The aim of this research was to investigate the potential EZ enzyme in treating leachate by removing boron and reduction of chemical oxygen demand (COD). Two experiments were carried out (1) using a conventional biological treatment method and (2) using a sequencing batch rector (SBR) with additional of EZ enzyme in both method. The purpose of the first experiment was to obtain the optimum concentration of EZ enzyme to be used in second experiment. Results showed that the optimum concentration of EZ enzyme was 50 ppm, with the reduction of COD and boron was up to 70%, with the initial values of both parameters were 373.8 mg/l and 25 mg/l respectively. In the second experiment, two reactors (R1 and R2) were used, where R1 is a control, while in R2, EZ enzyme was added and the initial values of COD and boron were 433mg/l and 34mg/l. Both reactors showed a reduction of boron and COD. However, R2 was more efficient in removing the parameters. The reduction rates of boron and COD removed in R1 were 57% and 30%, while 84% and 69% reduction were recorded for R2.

# ABSTRAK

Tujuan utama kajian ini adalah untuk menguji keupayaan enzim EZ dalam merawat air sisa dengan mengurangkan kandungan boron serta keperluan oksigen kimia *(COD)*. Dua ujikaji dilakukan (1) menggunakan kaedah biologi biasa dan (2) menggunakan kaedah *sequencing batch rector* (SBR), dengan penambahan enzim EZ di kedua-dua kaedah. Tujuan ujikaji pertama yang dijalankan adalah untuk mendapatkan kepekatan enzim EZ yang optimum untuk digunakan di dalam ujikaji kedua. Keputusan yang diperolehi menunjukkan bahawa kepekatan enzim EZ yang optimum ialah 50 ppm di mana kandungan boron dan COD dapat dikurangkan sehingga 70% dengan bacaan awal bagi kedua-dua parameter tersebut ialah 373.8 mg/l dan 25 mg/l. Dalam ujikaji kedua pula, dua reaktor iaitu R1 dan R2 digunakan di mana R1 sebagai kawalan manakala dalam R2, penambahan enzim EZ dilakukan dan bacaan awal bagi *COD* dan boron ialah 433mg/l and 34mg/l. Kedua-dua reaktor menunjukkan penurunan kandungan boron dan *COD* tetapi didapati R2 lebih efisen kesan penurunannya. Penurunan boron dan *COD* ialah lebih kurang 57% dan 30% dalam R1, manakala 84% dan 69% penurunan direkodkan untuk R2.

# TABLE OF CONTENTS

**2 LITERATURE REVIEW**

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Research

Pollution occurs when a product added to our natural environment adversely affects nature's ability to dispose it. There are many types of pollution such as air pollution, soil pollution, water pollution, nuclear pollution and oil pollution. A pollutant is something which adversely interferes with health, comfort, property or environment of the people. Generally, most pollutants are introduced in the environment as sewage, waste, accidental discharge and as compounds used to protect plants and animals (El Sabahi *et al*., 2009)

The method of sanitary landfill for the disposal of municipal solid wastes continues to be widely accepted and used although in recent years thousands have been closed. To minimize the negative environmental impacts, it is necessary to give particular attention to the selection of disposal site, which should be properly designed, constructed, operated and monitored (Qasim and Chiang, 1994). The generated leachate

can caused significant environmental problems and must collected and appropriately treated before being discharged in the environment.

According to The Chambers Dictionary, leachate is define as a liquid that has percolated through or out of some substance or  a liquid that has been polluted or made toxic by percolating through rubbish.

Meanwhile, the United States EPA has defined leachate as any liquid including any suspended components in the liquid, that has percolated through or drained from hazardous waste.

Leachate generally generated from liquids existing in the waste as it enters a landfill or from rainwater that passes through the waste within the facility. The leachate consists of different organic and inorganic compounds that may be either dissolved or suspended. An important part of maintaining a landfill is managing the leachate through proper treatment methods designed to prevent pollution into surrounding ground and surface waters.

There are several factors that affecting the composition of leachate. The factors are the type of the waste that was put into the landfill, landfill condition including the pH, temperature, moisture, age as well as the climate and finally affected by the characteristics of the precipitation that entered the landfill.

Flows change based on the weather which increasing during rainy periods, decreasing during dry and waste concentrations can change dramatically over the life of the landfill.  As a result, no landfill leachate is constant over time, and no two leachates

are the same. Leachate can consist of many different organic and inorganic compounds that are typically either dissolved or suspended in the wastewater. High concentrations of chemical oxygen demand (COD) associated, BOD, nitrogen, phenols, pesticides, solvents and heavy metals are common in these systems.

Study by Ehrig (1989) found that freshly generated leachates are usually having high strength wastewater, characterized by low pH (5-6), high BOD5 (4000-13000 mg/l) and COD (10000-60000 mg/l) values, as well as the presence of several toxic/hazardous compounds.

Since leachate is considered as hazardous waste, it may affect our health in many ways. So, some studies have investigated the possible health effects caused by landfill sites. However, there is no direct links among diseases, like cancer, and landfill have been found. Table 1.1 below shows the possible health effects of some chemicals from household waste and which are dumped into the landfill and if not properly controlled could leak out as leachate.

**Table 1.1:** Health Effects Caused by Acute Exposure (www.portfolio.mvm.ed.ac.uk)

| Chemical | Source | Health effects from acute exposure |
|---|---|---|
| Toluene/xylene | Glues and paints | Euphoria, excitement, tremor, CNS depression, convulsions, coma |
| Phenols and cresols | Paint | Burning pain in mouth and throat, nausea, vomiting, diarrhea, pallor, sweating, shock, coma, |
| Benzene | Solvent, starting material in chemical manufacture | Single exposure unlikely to cause problem |
| Nickel | Manufacture of batteries, colouring ceramics and glass | Skin – irritation and dermatitis<br><br>Ingestion – stomatitis, gingivitis and possible diarrhea |
| Cadmium compounds | Paint and batteries | Inhalation- delayed features 12-36 hrs, hypersalivation, metallic taste, cough, dysponea, chest pain. Pneumonitis and pulmonary edema develop within 1-4 days<br><br>Ingestion – small amounts ingested GI irritation, nausea and diarrhea<br><br>Skin – irritation |
| Lead | Lead paint (apply to older landfill sites), pottery, cosmetics and some ethnic remedies | Severe abdominal pain, diarrhea with black stools, vomiting, hypotension, cramps, headache, confusion, drowsiness, coma and seizures secondary to cerebral edema. |
| Mercury | Lamps, thermometers | Bloody diarrhea, intestinal mucosal necrosis, dehydration, circulatory collapse, proteinuria and renal failure |

Leachates are a potential hazardous waste from landfill sites. If not dealt with properly they can cause pollution to groundwater, health problems and effect the environment. Several options have been applied for leachate treatment, presenting varying degree efficiency. The main applicable methods are biological, chemical, membrane separation and thermal treatment processes (Forgie, 1988). Physico-chemical processes are generally higher cost and lower effectiveness. Biological processes based upon suspended-growth biomass, such as conventional activated sludge processes, were proved to be effective for the removal of organic carbon and nutrients content. Nevertheless, the problem of inadequate sludge settling has been usually encountered, as well as the need for longer aeration times, for larger volume of settling tank and for total biomass recycling (Ehrig, 1989). Therefore, a number of innovative biological treatment methods have been investigated (Zouboulis *et al*., 2001).

## 1.2 Problem Statement

Leachate consists of many different organic and inorganic compounds that may be either dissolved or suspended. Regardless of the nature of the compounds, they pose a potential pollution problem for local ground and surface waters which able to cause harmful effects on plants, animals and human. A number of studies had been conducted by researchers and experts in order to find solutions and overcome the problems.

Biological treatment based on suspended-growth biomass, such as conventional activated sludge processes was proven to be effective in removing organic carbon and nutrients content. Yet, some problem such as inadequate sludge settling has been usually encountered. As an alternative to prevent this problem, enzyme was used as an indicator to improves the sludge adequate.

This study was carried out to investigate the performance of EZ enzyme in treating the leachate. The performance of EZ enzyme was investigated through the reduction of chemical oxygen demand (COD) as well as boron in leachate sample.

## 1.3 Objectives of Study

The objectives of this study were:

- To investigate the potential use of EZ enzyme in treating the leachate
- To study the effect of different concentrations of EZ enzyme towards the performance of leachate treatment, and
- To study the performance of EZ enzyme in conventional biological treatment and in sequencing batch reactor system.

## 1.4 Scope of Study

Several scopes of this study are

- Study the potential of EZ enzyme in treating leachate using conventional and sequencing batch reactor
- Study the performance of leachate treatment by using various concentrations of EZ enzyme

- Study the reduction of concentration of chemical oxygen demand (COD) in leachate by using EZ enzyme
- Study the percentage of removal of boron concentration in using EZ enzyme during the leachate treatment

**References**

Achankeng, E. (2004). Sustainability In Municipal Solid Waste Management In Bamenda and Yaounde, Cameroon. PhD Thesis of Geographical and Environmental Studies, University of Adelaide, Australia.

Adeyemi, O., Oloyede, O.B., and Oladiji, A.T. (2007). Physicochemical and Microbial Characteristics of Leachate Contaminated Groundwater. *Asian J. Biochem.* 2(5):343-348

Aktas, O. and Cecen, F. (2001). Addition of Activated Carbon to Batch Activated Sludge Reactors in the Treatment of Landfill Leachate and Domestic Wastewater. J. Chem. Technol. Biotechnol. 76:793–802

Alvarez-Vazquez, H., Jefferson, B., Judd, S.J. (2004). Membrane Bioreactors vs Conventional Biological Treatment of Landfill Leachate: A Brief Review. *J. Chem. Technol. Biotechnol.* 79:1043–1049

Atwater, J.W., Jasper, S., Mavinic, D.S., Koch, F.A. (1983). Experiments Using Daphnia to Measure Landfill Leachate Toxicity. *Water Res*. 17:1855–1861

Aziz, H.A., Alias, S., Adlan, M.N., Faridah, Asaari, A.H., Zahari, M.S. (2007). Colour Removal from Landfill Leachate by Coagulation and Flocculation Processes. *Bioresour. Technol.* 98(1):218–220

Bevilaqua, J.V., Cammarota, M.C., Freire, D.M.G., Sant'Anna, G.L.Jr. (2002). Phenol Removal Through Combined Biological and Enzymatic Treatments. *Brazillian J. Chem. Eng.* 19(2):151-158

Bouguerra, W., Marzouk, I., Hamrouni, B. (2009). Equilibrium and Kinetic Studies of Adsorption of Boron on Activated Alumina. *ProQuest Sci J*, 12: 2455-2459

Cengeloglu, Y., Arslan, G., Tor, A., Kocak, I., Dursun, N. (2008). Removal of Boron from Water by Using Reverse Osmosis. *Sep and Purification Tech*, 64: 141-146

Chemical Market Reporter, 2006

Christensen, T.H., Kjeldsen, P., Albrechtsen, H.J., Heron, G., Nielsen, P.H., Bjerg, P.L., Holm, P.E. (1994) Attenuation of Landfill Leachate Pollutants in Aquifers. *Crit. Rev. Environ. Sci. Technol.* 24(2):119–202

Crawford, J.F. and Smith, P.G. (1986). Landfill Technology, Butterwoths, London.

Criscuoli, A., Rossi, E., Cofone, F., Drioli, E. (2009). Boron Removal by Membrane Contactors: The Water That purifies Water. *Clean Techn Environ Policy.*

Culver, B.D., and Hubbard, S.A. (1996). Inorganic Boron Health Effects In Humans: An Aid To Risk Assessment and Clinical Judgement. *J Trace Elem in Exp. Med*, 9:175 -184

Devare, M. and Bahadir, M. (1994). Biological Monitoring of Landfill Leachates Using Plant and Luminescent Bacteria. *Chemosphere*. 28:261–271.

Ehrig, H.J. (1989). Leachate Quality In: Christensen, T.H., Cossu, R., Stegmann, R., (Eds.), Sanitary Landfilling: Process, Technology and Environmental Impact. *Academic Press, London*. 213:229

El Sabahi, E., Abdul Rahim, S., Wan Zuhairi, W.Y., Al Nozaily, F., Alshaebi, F. (2009). The characteristics of leachate and groundwater pollution at municipal solid waste landfill of Ibb City, Yemen. *American Journal of Environmental Sciences*

Environmental Protection Agency (EPA), Ireland. (2000). Landfill Manuals, Landfill Site Design. EPA An Ghníomhaireacht um. Chaomhnú Comhshaoil, Ireland.

EPA, Onsite Wastewater Treatment Systems: Sequencing Batch Reactor Systems, Technology Fact Sheet 3

Erses, A.S., Fazal, M.A., Onay, T.T., Craig, W.H. (2005). Determination of Solid Waste Sorption Capacity for Selected Heavy Metals in Landfills. *J. Hazard. Mater*.121(1–3):223–232

EVM, Expert Group on Vitamins and Minerals, Revised Review of BORON, 2002

Fatta, D., Papadopoulos, A. and Loizidou, M. (1999). A Study On The Landfill Leachate And Its Impact On The Groundwater Quality Of The Greater Area. *Environ. Geochem.Health*, 21:175–190

Fong. T. H and Rashid. M. (2009). Bioremediation of Contaminated Soil with Oily Sludge Using Ez-200 Enzyme. Dept Chem Eng. *Universiti Teknologi Malaysia.*

Foo, K.Y. and Hameed, B.H. (2009). An Overview of Landfill Leachate Treatment via Activated Carbon Adsorption. *Journal of Hazardous Materials*, 171:54-60

Forgie, D.J.L. (1988). Selection of the most Appropriate Leachate Treatment Methods. Part 1: A Review of Potential Biological Leachate Treatment Methods. *Water Pollut. Res. J. Can*. 23:308-329

Garabrant, D. H. (1984). Respiratory effects of borax dust. *Br J Ind Med*, 42: 831-836

Gotvajn, A.Z., Tisler, T., Koncan, T. (2009). Comparison of Different Treatment Strategies for Industrial Landfill Leachate. *J. Hazard. Mater*. 162:1446–1456

Gupta, N., Balomajumder, C., Agarwal, V. K. (2010). Enzymatic Mechanism and Biochemistry for Cyanide Degradation : A Review. *J. Hazard. Mater*. 176:1–13

Ho, J. and Rashid, M. (2008). Application of EZ-Enzyme in Bioremediation of Oily Sludge. *Jurnal Teknologi*, 48(F), 21 – 32. *Universiti Teknologi Malaysia.*

Irvine, R.L. and Ketchum, L.H. (2004). The Sequencing Batch Reactor and Btach operation for the Optimal Treatment of Wastewater. *SBR Technology Inc*.

Jensen, D.L. and Christensen, T.H. (1997) Speciation of Heavy Metals in Landfill Leachate. *International Landfill Symposium, Italy*. 6(2):161–168

Jorstad, L.B. (2006). Analysis of Variation in Inorganic Contaminant Concentration and Distribution in A Landfill Leachate Plume. PhD thesis of Earth and Environmental Science, University of New SouthWales,Wales.

Kang, K.H. , Shin, H.S., Park, H. (2002). Characterization of Humic Substances Present in Landfill Leachates With Different Landfill Ages and Its Implications. *Water Res*. 36:4023–4032

Kavak, D. (2007). Removal of Boron from Aqueous Solution by Batch Adsorption on Calcined Alunite Using Experimental Design. *Journal of Hazardous Materials*, 163: 308-314

Kjeldsen, P., Barlaz, M.A., Rooker, A.P., Baun, A., Ledin, A., Christensen, T.H. (2002). Present and Long-Term Composition of MSW Landfill Leachate: A Review. *Crit. Rev. Environ. Sci. Technol.* 32(4):297–336

Mohapatra, D., Chaudhury, G. R., Park, K. H. (2007). Recovery of Boron from Wastewater Using 2,2,4-trimethyl-1,3-pentanediol in Carbon Tetrachloride. *Indian Journal of Chemical Technology*, 15: 483-487

Mohobane, T. (2008). The Characteristics and Impacts of Landfill Leachate From Horotiu, Newzealand and Maseru, Lesotho: A Comparative Study. MSc thesis of Environmental Science, University of Waikato, New Zealand.

Morais, J.L. and Zamora, P.P. (2005). Use of Advanced Oxidation Process to Improve the Biodegradability of Mature Landfill Leachate. *J. Hazard. Mater*. B123:181–186

Nam, F. W. and Rashid, M. (2009). Removal of Boron from Leachate Using Waste Materials. Dept Chem Eng. *Universiti Teknologi Malaysia.*

Okay, O., Gu¨c¸lu¨, H., Soner, E., Balkas, T. (1985). Boron pollution in the Simav River, Turkey and Various Methods of Boron Removal. *Water Research*, 19:857–862

Park, J.Y. and Batchelor, B., (2002). A Multi-Component Numerical Leach Model Coupled With A General Chemical Speciation Code. *Water Res*.36:156–166

Poznyak, T., Bautista, L., Cordova, R.I., Rios, L.E. (2007). Decomposition of Toxic Pollutants in Landfill Leachate by Ozone After Coagulation Treatment. *J. Hazard. Mater.*152(3):1108–1114

Qasim, S.R. and Chiang, W. (1994). Sanitary Landfill Leachate. *Technomic Publishing, Pennsylvania, PA, USA.* 4:83-97

Remy, P., Muhr, H., Plasari, E., Ouerdiane, I. (2004). Removal of Boron from Wastewater by Precipitation of a Sparingly Soluble Salt. *Env Progress*, 24(1):105-110

Renoua, S., Givaudan, J.G., Poulain, S., Dirassouyan, F., Moulin, P. (2008). Landfill Leachate Treatment: Review and Opportunity. *J. Hazard. Mater.* 150:468–493

Silva, A.C., Dezotti, M., Sant'Anna, G.L. (2004). Treatment and Detoxification of A Sanitary Landfill Leachate. *Chemosphere*. 55:207–214.

Tatsi, A.A.and Zouboulis, A.I. (2006). A Field Investigation of the Quantity and Quality of Leachate Fromamunicipal Solid Waste Landfill in Amediterranean Climate (Thesaloniki, Greece). *Adv. Environ. Res*. 6:207–219

Thomas, E.S. (2005). Biotreating Process Wastewater: Airing the Option. *Chem. Eng.* 44-52

Ujang, Z., Ng, S. S., Nagaoka, H. (2005). Package Plant of Extended Aeration Membrane Bioreactors: A Study on Aeration Intensity and Biofouling Control. *Water Sci & Tech*, Vol. 51, 10:335-342

Wingender, J and Flemming, H.C. (2000). Relevance of Microbial Extracellular Polymeric Substances (EPSs) – Part 1: Structural and Ecological Aspects. *Water Science and Technology*. 43(6):1-8

Wiszniowski, J., Robert, D., Surmacz-Gorska, J., Miksch, K., Weber, J.V. (2006). Landfill Leachate Treatment Methods: A Review. *Environ. Chem. Lett*. 4:51–61

Wong, M.H. (1989). Toxicity Test of Landfill Leachate Using Sarotherodon Mossambicus (Freshwater Fish). *Ecotoxicol. Environ. Saf*. 17:149–156

Woods, W.G. (1994). An Introduction to Boron: History, Sources, Uses and Chemistry. *Env. Health Pers*, 102:7:5-11

Wu, J.J., Wu, C.C., Ma, H.W., Chang, C.C., Masten, S.J. (2001). Treatment of Landfill Leachate By Ozone-Based Advanced Oxidation Processes. *IOA World Congress, London, UK*. 15:339–349

www.dfredlee.com

www.leachate.co.uk

www.mineralszone.com

www.portfolio.mvm.ed.ac.uk

www.wikipedia.com

Yilmaz, A.E., Boncukcuoglu, R., Kocakerim, M.M. and Keskinler, B. (2005). The Investigation of Parameters Affecting Boron Removal by Electrocoagulation Method. *Journal of Hazardous Materials*. B125: 160-165

Zouboulis, A.I., Loukidou, M.X., Christodoulou, K. (2001). Enzymatic Treatment of Sanitary Landfill Leachate. *Chemosphere.* 44:1103-1108