LEACHATE TREATMENT USING CONSTRUCTED WETLAND WITH MAGNETIC FIELD

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Dedicated to my beloved :

Maa, Abah,

Kak Long, Lah, Kak Chik,

Fitri, Faiz,

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Haji Ismail's Family

and

Haji Sahri's Family.

I really love you all…

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ABSTRACT

Leachate is one of the major problems to overcome in managing the landfill. Treatment that low cost, need less maintenance and environmental friendly are the target on how to treat the leachate. This research was focused on the capability of the magnetic technology to remove pollutant combined with constructed wetland. The study carried out through two type of systems, which were pre-treatment magnetic field with wetland (PTM-W) and continuous circulation magnetic field with wetland (CRM-W). A PTM-W system consists of two stages of treatments which are pre-treatment using magnetic field (PTM) followed by treatment using wetland. The circulation flowrate for pre-treatment and CRM-W were fixed to 1.8 mL/s with exposure time of 6 hours fabricated from 6 paired of magnet with strength 0.55 Tesla. The constructed wetlands were planted with *Eichhornia crassipes* (floating type). The efficiency of the systems to reduce the concentration of orthophosphorus, nitrate nitrogen, ammonia nitrogen, BOD, COD, ferum and manganese were analysed, whilst, heavy metal uptakes was analyst in plant tissues. From the study it was found that the wetland is significantly contributed in removal efficiency of BOD, orthophosphorus and nitrate nitrogen. Circulation with magnet has the ability to reduce time of treatment in removal efficiency of COD, ammonia nitrogen, ferum and manganese. The results showed CRM-W systems can reduce up to 60% of ammonia nitrogen removal, 68.7 % of ferum and 60% of manganese after 6 hours of treatment). Wetland was able to remove 99% of nitrate nitrogen, 96% of ammonia nitrogen and 83% of BOD after end of experiment. It can be conclude that magnetic field posed a great role in removing heavy metal, whilst wetland has a great ability in removing orthophosphorus, nitrate nitrogen, ammonia nitrogen, BOD and COD.

ABSTRAK

Air larut resap merupakan satu masalah utama yang dihadapi dalam pengurusan tapak pelupusan. Rawatan yang berkos rendah, penyelenggaraan yang minima dan mesra alam adalah rawatan yang menjadi sasaran dalam merawat air larut resap. Kajian ini memfokuskan kepada keupayaan magnet dan tanah bencah buatan untuk menyingkirkan bahan pencemar. Dua jenis sistem rawatan digunakan iaitu pra rawatan medan magnet bersama tanah bencah buatan (PTM-W) dan aliran pengelilingan medan magnet bersama tanah bencah buatan (CRM-W). Sistem PTM-W terdiri daripada 2 peringkat rawatan iaitu pra-rawatan air larut resap menggunakan magnet diikuti dengan rawatan menggunakan tanah bencah buatan. Kadar alir untuk pra-rawatan dan CRM-W adalah 1.8mL/s dengan masa pendedahan selama 6 jam dengan menggunakan sistem magnet yang terdiri daripada 6 pasang magnet kekal berkekuatan 0.55 Tesla. *Eichhornia crassipes* (tumbuhan terapung) digunakan dalam kajian ini. Keberkesanan sistem ini untuk menyingkirkan orthophosphorus, nitrate nitrogen, ammonia nitrogen, BOD, COD, Fe dan Mn dikaji manakala tisu tumbuhan dikaji untuk menentukan keupayaan tumbuhan dalam menyerap logam berat. Keputusan menunjukkan tanah bencah buatan adalah berupaya untuk menyingkirkan kepekatan BOD, orthophosphorus dan nitrate nitrogen di dalam air larut resap. Kaedah magnetik aliran pengelilingan berupaya untuk mengurangkan masa rawatan dan menyingkirkan kepekatan COD, ammonia nitrogen, Fe dan Mn di dalam air larut resap. Sistem CRM-W berupaya menyingkirkan sehingga 60% ammonia nitrogen, 68.7 % Fe dan 60% Mn setelah 6 jam rawatan. Tanah bencah buatan berupaya untuk menyingkirkan 99% nitrate nitrogen, 96% ammonia nitrogen dan 83% BOD setelah eksperimen selesai. Kesimpulannya medan magnet mempunyai kecekapan untuk menyingkirkan logam berat dan tanah bencah buatan mempunyai kecekapan untuk menyingkirkan orthophosphate, nitrate nitrogen, ammonia nitrogen, BOD dan COD di dalam air larut resap.

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BOD	-	Biochemical Oxygen Demand
$CaCO_3$	-	Calcium carbonate
C/C_O	-	Present concentration over initial concentration
COD	-	Chemical Oxygen Demand
CRM-W	-	Continuous circulation magnetic field with wetland
CW	-	Constructed wetland
F	-	Magnetic field force
Fe	-	Ferum
FWS	-	Free Water Surface
mg/g	-	milligram per gram
mg/L	-	milligram per liter
mL/s	-	milliliter per second
Mn	-	Manganese
NH_4^+	-	Ammonia
NH_3-N	-	Ammonia Nitrogen
NO_3 -N	-	Nitrate Nitrogen
PO_4^{3-}	-	Orthophosphate
PTM-W	-	Pre-treatment magnetic field with wetland
SF	-	Sub Surface Flow
SS	-	Suspended solid
TN	-	Total nitrogen
TP	-	Total phosphorus
VFA	-	Volatile fatty acid

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CHAPTER 1

INTRODUCTION

I.1 Introduction

Municipal landfills are designed to protect human populations and the environment by collecting and confining wastes within a managed facility. The standard landfilling method involves the excavation of a large depression, into which refuse is deposited and covered with soil. Although this practice effectively confines solid waste, it also produces a highly polluted liquid by-product known as landfill leachate, which is created as precipitation percolates through the decomposing waste.

Typical municipal landfill leachate constituents include Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), metals (ferum, manganese, chopper) and organics matter (Hooper, 1999). When left uncontrolled, these constituents can leach into and seriously degrade groundwater aquifers and aquatic habitats. Consequently, leachate collection and treatment systems are essential components of responsible landfill management.

Conventional leachate treatment systems are typically based on concrete and steel infrastructure, which rely on intensive inputs of chemicals and nuclear or fossil fuel energy. An ideal leachate treatment system should have the ability to treat a wide range of chemical constituents, accept varying quantities and concentrations of

leachate, and be inexpensive to construct and easy to maintain with low energy and personnel requirements.

In recent years, however, leachate treatment wetlands have been considered as a natural alternative to these conventional technologies. As a chemical-free technology, it is aesthetically pleasing and less expensive to operate and maintain. It is therefore not surprising to see a growing interest in the potential use of constructed wetlands for leachate treatment. Constructed wetlands treatment systems have also been used as filters for a wide variety of pollutants. Wetlands have been shown to improve leachate and wastewater quality through processes that include microbially mediated transformation, plant uptake, precipitation and adsorption reactions.

I.2 Problem Statement

Water is the second most important after the oxygen. Fundamental for human civilization start near by the river such as River Nile, Mississippi River, Thames River and Klang River in Malaysia. Nowadays, water has been the global issues in the world. Even high develop countries had been very concern about their source of water. In Malaysia, which receive high rainfall every year also start to manage the sources in good practices. An increasingly challenging issue due to rapid economic growth causes point and non-point of pollutant. Major sources pollution are from organic pollution such as agro industrial waste mainly oil palm and rubber; manufacturing and processing industry; animal husbandry; residential and pollution from sediment such as land development; agricultural and logging.

Increase generation and accumulation of solid wastes are beginning to produce environmental problems. The volume of municipal waste generated is mainly attributable to the increase in population and other waste generation activities as these countries advance into the direction of industrialization. Malaysia has about 24 million of population, with an average rate of waste generation of 1 kg/capital/day. The volume of municipal solid waste (MSW) will obviously increased significantly in the near future.

The volume of solid waste in major cities in Malaysia has been increasing steadily over the years with the increase in population, socioeconomic activities and physical development. It is also seen that in municipal with high population density, the rate of increase of wastes per capita per day is more. Economic growth and resultant urbanization has increased the volume of solid waste – more advanced a region, higher the size of waste per capita per day. In most cities especially in high rise buildings, the increment in waste generation has resulted in serious overspill since refuse chutes are unable to cope with rising waste generation rate. Solid waste will always be generated as long as human activities exist. Higher waste generation has given rise to disposal of solid waste.

Landfill is one of the methods to dispose the waste generated. But landfilling too poses as a potential threat to the quality of the environment, as leachate produced through biological degradation of waste in a landfill. Leachate characteristic was similar to toxic waste due to content of heavy metal such as cadmium and lead (Razman *et al.*, 1993). Landfill leachate may contaminate not only surface water and groundwater supplies (Tatsi and Zouboulis, 2002) but may also cause marine water pollution and trans-boundary contamination (Al-Muzaini *et al.*, 1995).

I.3 Objectives of the Study

The purpose of this study is to identify the effectiveness treatment of leachate using constructed wetland with magnetic field. The objectives of the study are:

(i) To determine the removal efficiency of Orthophosphorus, Nitrate nitrogen, Ammonia nitrogen, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and heavy metals (Ferum and Manganese) with pre-treatment magnet (PTM);

(ii) To determine the effective of pre-treatment magnetic field with wetland (PTM-W) and continuous circulation magnetic field with wetland (CRM-W) on leachate; and

(iii) To study the heavy metal (Fe and Mn) uptake by *Eichhornia crassipes* in roots and leaves.

I.4 Scope Of The Study

The study was on the effect of the wetland with magnetic field for leachate treatment. In each experiment, the same magnetic strength, flowrate, concentration of leachate and plant species were used. The scopes for this study were:

(i) There were three type of wetland system, Control which was the constructed wetland, PTM-W and CRM-W (without any pre-treatment applied). For the PTM-W, the sample was treated (pre-treatment) with magnetic field for 6 hours before discharge into the wetland system. The results for PTM were analyzed. For the CRM-W, sample used was directly discharge into the wetland system and sample was circulated to the magnetic field for a period of 6 hours a day. The experiments were carried out for duration of 27 days;

(ii) Six sets of permanent magnet with 0.55 Tesla was used in the experiment;

(iii) Heavy metals uptake by *Eicchornia crassipes* was studied. The equipment used for analysis were HACH DR/4000 spectrophotometer and BOD_5 incubator; and

(iv) The parameter concerns were Orthophosphorus, Nitrate nitrogen, Ammonia nitrogen, BOD, COD and heavy metals (Ferum and Manganese) for leachate sample, whilst heavy metals for root and leaves.

The experiments had been carried out at Environmental Engineering Laboratory, Faculty of Civil Engineering, Universiti Teknologi Malaysia. The leachate was taken from Pasir Gudang Sanitary Landfill, Johor.

I.5 Importance of the Study

This study is to carry out a preliminary research in treatment of leachate. Much interest has developed in recent years in using constructed wetlands to remove contaminants from water, whether it is effluent from municipal or private waste systems, industrial or agricultural wastewater, or acid mine drainage (Kenneth, 2000). In Malaysia, there are more landfill has been developed to fulfill the population growth. With high population, it means more waste will be produce. Leachate that contains hazardous components needs expensive, high technology treatment and equipment to comply with the Department of Environment (DOE) standard which to maintain the water quality. Leachate that contains hazardous components needs expensive, high technology treatment and equipment to comply with the DOE standard which to maintain the water quality. Leachate can contain high levels of organic matters, nutrients and heavy metals. Leachate has several adverse effects on the human health such as carcinogenic systems, skin disorders, neuro-toxicity, kidney damage, suppressed immunity, digestive disorders, as well as adverse effects on flora and fauna.

A pilot constructed wetland, was introduced for landfill leachate treatment as an innovative technology that provides simple and inexpensive waste water treatment at the Dragonja landfill site on the Adriatic coast (Bulc *et al*, 1997). The results show that constructed wetland was fairly efficient, which removed 68% COD, 46% BOD_5, 81% NH_3-N, 80% Fe and 85% bacteria. Wetland also is one of the practical methods to reduce total phosphorus and total nitrogen in lakes (Mwanuzi *et al*., 2003), from plant nursery runoff water (Huett *et al.*, 2005) and soil leachate in subsurface wetland microcosms (Fraser *et al.*, 2004; Picard *et al.*, 2005).

Constructed wetlands have been used as an attractive low-cost method for controlling water pollution from both point and nonpoint sources (Olsan, 1992; Mitsch, 1992). Dunbabin and Bowmer (1992) have revealed that constructed wetland also show good potential for concentrating metals from industrial wastewaters. Wetlands prevent the contamination of groundwater or to prevent groundwater from infiltrating into the wetland (Kadlec *et al*., 2000). Constructed wetlands system may be a solution, and are growing in popularity as a natural and economical alternative for leachate treatment. Constructed and natural wetlands also can contribute in reducing heavy metal and nutrient significantly to watershed water quality (Olsan, 1992). Wetland also was categorized in the Best Management Practices (BMP) which is one of the best methods to reduce non-point source pollution (Ayob and Supiah, 2005).

According to research done by Johan (2003), magnetic field gives excellent result in formation of sediment in waste water. The study revealed that higher magnetic strength and lower flowrate will enhance the settling of suspended particles and reduction of SS, BOD_5, NH_3-N and COD concentration in sewage. The magnetic field affected the equilibrium and stabilization of suspended particle that cause the particles to settle after aggregation process. Research done by Ying (1999) proved that particles settlement efficiency increases with increasing magnetic field strength. High gradient magnetic separation (HGMS) for treating food processing wastewater can cause reductions in TP, SS and chemical oxygen demand (Petruska and Perumpral, 1978).

More research and study should be carried out to explore various treatment techniques. With application of magnetic field, it can affect the equilibrium and stabilization of suspended particle that cause the particles to settle after aggregation process. Therefore, with these two combinations, constructed wetland and magnetic field will be the alternatives method to treat the leachate with proper treatment and low cost.

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