RAINFALL EFFECTS TO THE PERFORMANCE OF SUBSURFACE FLOW CONSTRUCTED WETLANDS IN LEACHATE TREATMENT

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A project report submitted in partial fulfillment of the requirements for The award of the degree of Master of Engineering (Environmental Management)

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OCTOBER, 2004

ACKNOWLEDGEMENT

I would like to dedicate deepest gratitude to my main thesis supervisor **Associate Prof. Dr. Mohd. Razman Salim,** for his encouragement, guidance and friendship. I also wish to express my sincere appreciation to my co-supervisor, **Prof. Dr. Zaini Ujang**, for his guidance, advices, critics and motivation.

I would like to thank my beloved family for their support throughout the years in Universiti Teknologi Malaysia. Not forgotten my project partner, **Miss Aeslina Abdul Kadir** for her companionship. Special thanks to **En. Razman,** from landfill authorities, **Dr. Eddy Soedjono**, **En Tamizee**, and **En, Mohd. Fadhil** for their assistances in preparing this thesis. My sincere appreciation also extends to all my course mates, friends and others who have provided assistance at various occasions.

I would also like to express my appreciation to IRPA for their support in this study.

ABSTRAK

Tanah bencah buatan sudah semakin luas diterima sebagai cara pengolahan air sisa. Kesan hujan perlu diambil kira dalam merekabentuk tanah bencah buatan tempatan terutamanya di negara-negara tropikal. Kajian ini dijalankan untuk mengkaji kesan-kesan cuaca tropikal (hujan) terhadap prestasi tanah bencah buatan aliran subpermukaan mendatar (HSFCW) yang ditanam dengan tumbuhan tempatan , *Typha angustifolia* untuk pengolahan air larut lesap. Prestasi tanah bencah buatan dikaji dengan tujuh parameter iaitu nitrat, fosforus, ammonia nitrogen, kromium, kadmium, permintaan oksigen biokimia (BOD_5) dan permintaan oksigen kimia (COD). Dua reactor HSFCW berskala loji pandu telah digunakan dalam eksperiment. Keberkesanan HSFCW dalam pengolahan lair larut lesap telah diselidik dengan membuat perbandingan dengan reaktor "blank" yang berfungsi sebagai kawalan. Eksperiment telah dijalankan di bawah "hujan monsoon buatan" di Malaysia. Keputusan menunjukkan kesan hujan terhadap prestasi tanah bencah berbeza daripada satu parameter ke parameter yang lain (-1% ke 41% peningkatan), bergantung kepada sifat-sifat masing-masing. Kesemua parameter kecuali kromium menunjukkan peningkatan dalam keberkesanan pengolahan selepas hujan. Kesan hujan (peningkatan keberkesanan pengolahan) adalah lebih ketara dalam reaktor kawalan berbanding dengan reaktor yang ditanam dengan tumbuhan.

ABSTRACT

Constructed wetlands have gained wide acceptance as a wastewater treatment practice. Rainfall effect needs to be taken into account in designing local constructed wetlands particularly in tropical countries. This study was carried out to evaluate the effects of tropical climate (rainfall) towards the performance of horizontal subsurface flow constructed wetlands (HSFCW) planted with local plant, *Typha angustifolia* for landfill leachate treatment. The performance of the constructed wetlands was evaluated using seven parameters i.e nitrate, phosphorus, ammonical nitrogen, chromium, cadmium, biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD). Two pilot scale constructed wetlands reactors were used in the experiments. Performance of HSFCW in leachate treatment was evaluated with comparison to a blank reactor (without plants) serving as control. Experiments were run under artificial "monsoon rainfall intensity" in Malaysia. Results show that rainfall effects towards the performance of wetlands in leachate treatment vary from parameter to another (-1% to 41% enhancement) depending on the characteristic of each parameter. All parameters except chromium have better performance in leachate treatment after rainfall. Rainfall effects (increasing of removal efficiency) are more critical in control reactor as compared to the vegetated reactors.

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INTRODUCTION

1.1 Background study

In many countries including Malaysia, sanitary landfills have been the most popular method of municipal solid waste disposal. Although attention has been drawn to increased recycling, waste reduction, and incineration, the sanitary landfill will remain its dominant in the solid waste disposal methods for the next decade due to the rapid population growth (Oasim, S.R. and Chiang, W. 1994). In conjunction with the increasing number of sanitary landfills, more leachates are generated. Landfill leachates will cause environmental problems if it is not properly handled. Increase in landfill leachate creates challenges for those seeking cost effective treatment methods to process this wastewater.

Leachate may be defined as liquid that has percolated through waste and has extracted dissolved or suspended materials from it. It arises from the biochemical and physical breakdown of wastes (Lu *et. al.*,1985). The leakage of leachate which contains high organic, inorganic, suspended solids, heavy metals and other pollutants will contaminate ground water and surface water sources.

For the past fifty years, conventional wisdom has mandated the development of extensive waste water collection systems directed to a centralized treatment plant. More attention is now being given to the benefits of a decentralized approach in waste water treatment where on site treatment is applied. In many situations, a decentralized systems of waste water treatment, potentially with constructed wetlands, can provide not only a more economical and energy efficient means of achieving treatment objectives, but also a resource in the form of reclaimed water available for landscape irrigation or creation of wildlife habitats (Campbell C.S., 1999).

The principal development of wetlands systems in Europe begun in the late 60^{th}. The wetlands systems were develop rapidly in Europe in the 70^{th}. Since then a large variety of design lines has been established. Especially in the late 15 years there has been a significant interest in reed bed (Platzer C.2000).

As a developing country, Malaysian government has shown interest in wastewater treatment using constructed wetland. This can be seen in the construction of Putrajaya wetlands which is the largest constructed freshwater wetlands in the world, which cover a total of 650 hectares. Under the concept of sustainable development, Putrajaya Wetlands was created using the latest environmental technology to function as a flood control system and a natural filter system for the Putrajaya Lake and provides flood mitigation measures for the whole area. It contains over 12 million plants from some 70 exclusively indigenous species.

Constructed wetlands system has high efficiency in treating wastewater from unknown sources with low operating and maintenance cost. It can be used in the wastewater treatment by treating the organic content, non-organic content, heavy metals, nutrients, suspended solids and other pollutants from point source and non point source before allowing the wastewater to flow into the natural water body. The characteristic properties of wetlands make them unique ecosystems; they contain anoxic soil, have varying hydrology, distinct nutrient cycling and are composed of plants tolerant of flooded conditions. Since wetlands are often found as a transitional zone between aquatic and terrestrial ecosystems, they can receive a wide array of dissolved substances through storm water runoff as well as through rivers, streams and water channels. Wetlands are able to transform and reduce these compounds, so they have been utilized for water treatment (Fraser *et. al.*, 2004).

Generally, constructed wetlands can be divided into two major types which are free water surface (FWS) constructed wetlands and subsurface flow (SF) constructed wetlands. There are two types of subsurface flow constructed wetlands, which are horizontal systems and vertical systems. In this study, horizontal subsurface flow constructed wetlands (HSFCW) is being used to treat landfill leachate collected from one of the sanitary landfill in Johore Bahru.

1.2 Problem Statement

Malaysian government has introduces recycling campaign to reduce the solid waste generation due to the population growth in the country. However, the recycling programme is not able to balance the increased solid waste generation due to the rapid population growth. As a result, more sanitary landfills need to be prepared for solid waste disposal. In conjunction with the increasing number of landfills, leachate treatment has become an important issue.

Many studies have been conducted for leachate treatment in wastewater treatment using constructed wetlands (Rash and Liehr, 1999). Nevertheless, this technology is not utilised in Malaysia. Thus, study is required to develop leachate treatment facilities using constructed wetlands by incorporating local components and expertise. It had been proven that local tropical plants such as *Scirpus* *globulosus, Ericaulon sexangulare, Scleria Sumatrensis Retz and T. angustifolia* are suitable to be used in constructed wetlands for various applications which including heavy metals, nutrients, organics and solids removal. However, the effect of local tropical climate to the performance of the constructed wetlands has not been emphasised. Therefore this study was carried out to study the tropical rainfall effect to leachate treatment using HSFCW planted with *T. angustifolia*.

1.3 Objective

Hypothetically, the performance of subsurface flow constructed wetlands in leachate treatment will be enhanced after rainfall. Two objectives were set in this study as listed below.

i. To study the performance of HSFCW planted with *T. angustifolia* in leachate treatment.

ii. To study the tropical rainfall effect to the performance of the HSFCW system

1.4 Scopes of Work

The scopes of the study are:

i. To study the efficiency of leachate treatment in the HSFCW by checking 7 parameters: BOD, COD, chromium, cadmium, phosphorus, ammonical - nitrogen and nitrate.

ii. To evaluate the removal efficiency of the HSFCW system under an artificial monsoon rainfall

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