UNIVERSITI PUTRA MALAYSIA

REMOVAL OF ORGANIC AND NUTRIENTS IN YOUNG LEACHATE USING COMBINED ANAEROBIC/ANOXIC/AEROBIC ATTACHED-GROWTH BIOREACTOR

BAHAREH SANAIE MOVAHED

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By

BAHAREH SANAIE MOVAHED

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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"Dedicated to my beloved and supportive parents and sister"

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Wan Azlina Bt. Wan Abdul Karim Ghani, PhD

Faculty : Engineering

The study was conducted to evaluate the biological nutrient removal of young leachate from transfer station that is considered as a high concentration wastewater due to high chemical oxygen demand (COD) and biological oxygen demand (BOD) content. The process has been performed in the combined anaerobic/anoxic/aerobic bioreactor. Biological nitrification and denitrification in combination with phosphorous removal have been shown appropriate to remove nitrogen and phosphorous in this single column bioreactor where Cosmo-ball media were launched into the aerobic zone to improve bacteria growth in this zone.

The anaerobic and aerobic acclimatized liquor seeded into the anaerobic and aerobic zone of bioreactor respectively and after 30 days of transition period, experimental procedure was started in two different phase. The diluted leachate injected to the up flow continuous anaerobic/anoxic/aerobic vertical reactor in process of two phases which each phase consist of three runs. The first phase involved three different organic loading rates (OLR) of 8, 13.3 and 26.6 kg COD/ m^3.day with constant 24 hour of hydraulic retention time (HRT). In the second phase three different HRT of 12, 24, and 36 hours; and constant OLR (=13.3 kg COD/ m^3.day) applied to the process to find out the best organic removal. Ammonical nitrogen removal investigated under different C/N ratio in the first phase and in the second phase were studied under different HRT. Phosphorous removal was examined in different concentrations due to leachate dilution in both phases. This experiment performed in the Environmental and Chemical UPM laboratory and samples were collected from the Taman Beringin Municipal Solid Waste Transfer Station, Klang, Selangor.

The results showed that, the highest removal of ammonical nitrogen in aerobic run was due to the presence of sufficient amount of oxygen. The results of the project indicated that by increasing C/N ratios, ammonia removal decreased due to the competition between autotroph and heterotroph microorganisms which was 85% in the lowest organic concentration. The results indicated as HRT increased, NH_4-N concentration of effluent decreased and the removal efficiency increased accordingly and the best removal efficiency of the system were achieved in 36 hour as much as 89%. The best organic removal were obtained at the lowest COD loading rate and the longest HRT in

phase one and two which was equal to 92% and 94% respectively. It was found that the anaerobic/anoxic/aerobic attached bioreactor with Cosmo-Ball as the media with significant acclimatizing and transition period for bacteria growth has succeeded in removing nitrogen and organic from diluted young leachate with high amount of COD and low amount of nitrogen.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENYINGKIRAN ORGANIK DAN NUTRISI DI DALAM AIR LARUT RESAP BARU MENGGUNAKAN BIOREAKTOR BESERTA PERTUMBUHAN GABUNGAN ANAEROBIK/ANOKSIK/AEROBIK

Oleh

BAHAREH SANAIE MOVAHED

November 2009

Pengerusi : Wan Azlina Bt. Wan Abdul Karim Ghani, PhD

Fakulti : Kejuruteraan

Kajian telah dijalankan bagi menilai penyingkiran nutrisi biologi air larut resap baru dari stesen pemindahan yang dianggap sebagai air sisa berkepekatan tinggi disebabkan oleh kandungan keperluan oksigen kimia (COD) dan keperluan oksigen biokimia (BOD). Proses telah dijalankan di dalam gabungan bioreaktor anaerobik/anoxik/aerobik. Gabungan nitrifikasi dan denitrifikasi bersama penyingkiran fosforus secara biologi menunjukkan kesesuaian dalam menyingkirkan nitrogen dan fosforus di dalam tangki bioreaktor tunggal di mana media *Cosmo-Ball* disalurkan di dalam zon aerobik untuk meningkatkan pertumbuhan bakteria di zon berkenaan.

Cairan anaerobik dan aerobik yang telah disesuaikan iklimnya dibajakan ke dalam zon anaerobik dan aerobik pada bioreaktor dan selepas 30 hari jangka masa peralihan,

prosedur eksperimen telah dimulakan dalam dua fasa berlainan. Air larut resap tercair disuntik secara arah menaik ke dalam aliran berterusan reaktor menegak anaerobik/anoxik/aerobik di dalam proses dua fasa di mana setiap fasa mengandungi tiga peringkat. Fasa pertama melibatkan tiga kadar bebanan organik (OLR) iaitu 8, 13.3 and 26.6 kg COD/ m^3.hari dengan pemalar masa tahanan hidraulik (HRT) selama 24 jam. Pada fasa kedua tiga masa tahanan hidraulik (HRT) yang berlainan iaitu 12, 24, dan 36 jam; dan pemalar OLR (=13.3 kg COD/ m^3.hari) digunakan didalam proses bagi mendapatkan penyingkiran organik yang terbaik. Penyingkiran ammonikal nitrogen telah dikaji pada nisbah Karbon/nitrogen (C/N) yang berbeza di dalam fasa pertama dan masa tahanan hidraulik (HRT) yang berbeza telah dikaji di dalam fasa kedua. Penyingkiran fosforus diuji pada kepekatan yang berbeza yang terhasil dari pencairan air larut resap dalam kedua-dua fasa. Eksperimen ini dijalankan di Makmal Kejuruteraan Kimia dan Alam Sekitar UPM dan sampel diambil dari Stesen Pemindahan Sisa Pepejal Bandar Taman Beringin, Klang, Selangor.

Keputusan yang didapati menunjukkan penyingkiran ammoniakal nitrogen yang tertinggi diperoleh di peringkat aerobik adalah disebabkan oleh kehadiran kandungan oksigen yang mencukupi. Keputusan daripada projek ini menunjukkan bahawa dengan meningkatkan nisbah C/N, penyingkiran ammonia berkurangan kerana persaingan antara mikroorganisma autotrof dan heterotrof sebanyak 85% dalam organik berkepekatan terendah. Keputusan menunjukkan apabila HRT ditingkatkan, kepekatan keluaran NH_4-N menurun dan kecekapan penyingkiran meningkat seperti yang sepatutnya dan kecekapan terbaik penyingkiran bagi sistem dicapai dalam masa 36 jam

iaitu sebanyak 89%. Penyingkiran organik terbaik telah dicapai apabila kadar bebanan COD terendah dan HRT terlama dalam fasa satu dan dua iaitu masing-masing bernilai 92% dan 94%. Kajian ini telah mendapati anaerobik/anoxik/aerobik bersama bioreaktor dengan *Cosmo-Ball* sebagai media dengan pengikliman yang nyata dan jangka masa peralihan untuk pertumbuhan bakteria telah berjaya bagi menyingkirkan nitrogen dan organik dari air larut resap baru yang telah dicairkan dengan kandungan COD yang tinggi dan kandungan nitrogen yang rendah.

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Sincerely

Bahareh Sanaie Movahed

I certify that an Examination Committee has met on 02/09/2009 to conduct the final examination of Bahareh Sanaie Movahed on his Master of Science thesis entitled " removal of organic and nutrients in young leachate using combined anaerobic/anoxic/aerobic attached growth bioreactor" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for other degree at Universiti Putra Malaysia or at any other institution.

BAHAREH SANAIE MOVAHED

Date: 28 December 2009

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LIST OF ABBREVIATIONS

A/O	Anaerobic/Aerobic
AA/O	Anaerobic/ Anoxic/Aerobic
An	Anaerobic
Ax	Anoxic
BNR	Biological Nutrient Removal
BOD	Biological Oxygen Demand
BPR	Biological Phosphorous Removal
C/N	Carbon To Nitrogen Ratio
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EBPR	Enhance Biological Phosphorous Removal
HRT	Hydraulic Retention Time
kPa	Kilopascals
MSW	Municipal Solid Waste
OLR	Organic Loading Rate
Organic N	Organic Nitrogen
Ox	Aerobic
Oxic	Aerobic Condition
PAOs	Phosphorus-Accumulating Microorganisms
Pa	Pascals
pH	Potential Of Hydrogen

PHAs	Polyhydroxyalkanoates
Q	Flow Rate (L/day)
SBR	Sequencing Batch Reactor
TAN	Total Ammonia Nitrogen
TIN	Total Inorganic Nitrogen
TKN	Total Kejeldalh Nitrogen
TN	Total Nitrogen
TNCU	Taiwan National Central University
TON	Total Organic Carbon
TP	Total Phosphorous
TSS	Total Suspended Solid
U.S. EPA	United State Environmental Protection Agency
UCT	University Of Cape Town
VFAs	Volatile Fatty Acids
VIP	Virginia Initiative Process
VSS	Volatile Suspended Solid

CHAPTER 1

INTRODUCTION

1.1. Background of the study

Leachate from the transfer station is considered as a young leachate. The leachate characteristics represent high variation due to the age and type of the waste and climate conditions; therefore it requires different treatment systems. There are wide scientific literatures on leachate treatment, but young leachate treatment considers as a new section in treatment process due to the high biodegradability. To remove the main pollutant compounds from leachate, biological methods are usually preferred over other treatments processes. Different studies have been done recently on biological nutrient removal (BNR), which is usually occurred in anaerobic/anoxic/aerobic bioreactor. Leachate from municipal solid waste (MSW) has been accompanied by rapid increase in waste production due to population growth in many countries. It is considered as high risk pollution for surface and groundwater. In order to minimize the negative effects on the environment, leachate must be treated to remove nutrient and organic compounds before being discharged. The content of pollutants in leachate is however different from that of municipal sewage water. Since studies showed different problems in mix leachate with municipal wastewater plants, treatment systems and experimental results designed for sewage water are not necessarily good for treating leachate (Uygur and Kargi,2004; He and Shen., 2006; Kabdasli et al., 2008; Renou et al., 2008; Gotvajn et al., 2009).

There are various treatments have been applied using chemical, physical and biological systems to limit or control the amount of nutrients discharged by the treatment system. However, recently the most popular method to treat nutrient in wastewater is biological treatment due to the lower cost. In biological treatment, mixed microbial culture are feed to the influent and finally removed from the effluent solution. Thus, microorganisms are used to consume organics, nitrify ammonia, and denitrify nitrate, and release and uptake phosphorous. The wastewater nitrogen concentration, biological oxygen demand (BOD) concentration, alkalinity, temperature, and potential for toxic compounds are major issues in the design of biological nitrification process (Metcalf and Eddy, 2004).

Recent improvements in biological waste treatment technology are capable to provide enhanced nutrient removal using some modification in their process. These processes are called biological nutrient removal (BNR) process. Many of methods use the activated sludge process but they employ combinations of anaerobic, anoxic and aerobic zones to accomplish nitrogen and phosphorus removal. This is due to the natural formation of anaerobic-anoxic-aerobic vertical biological zones in landfill ecosystem (He and Shen., 2006).

As a basic requirement, biological wastewater treatment involves bringing the active microbial growth in to contact with wastewater. Therefore, microorganisms can consume the impurities as food in leachate after acclimatizing. A great variety of microorganisms including bacteria, protozoa, rotifers, nematodes, fungi and algae play a role in these wastewater treatment systems. The basic benefits of biological nutrient