UNIVERSITI PUTRA MALAYSIA

TREATMENT OF LEACHATE GENERATED FROM SEWAGE SLUDGE LAGOON

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January 2002

Chairman: Associate Professor Dr. Azni Idris, Ph.D.

Faculty: Engineering

The main objective of this research was to study the treatment of leachate generated from sludge lagoons using anaerobic and aerobic processes. Two methods were used to separate the sludge and leachate in sludge lagoons. The first method used a clay layer at the bottom of the lagoon. While, the second method used a filter media (sand and gravel) and underdrainage. The leachate was generated from four sets of tank with different depths (0.375 m and 0.75 m of sludge).

The quality of leachate was measured in terms of BOD, COD, TSS, VSS, E-coli, ammonia, nitrate, TKN, phosphorus and heavy metal. The results showed that the quality of treated leachate from the sand tanks is better than that of clay tanks. The percentage of BOD, COD, TSS, VSS and E-coli removed for sand tanks ranged from 96-97%, 95-96%, 95-97%, 94-96% and 99-99.5% respectively. While the percentages of BOD, COD, TSS, VSS and E-coli in the clay tanks ranged from between 91-93%,

90-93%, 86-89%, 86-90% and 90-92% respectively. Results show that filtration using sand and gravel is more effective in removing organic pollutant in leachate. Treatment using aeration tanks is effective in removing BOD, COD, TSS, VSS and E-coli. The percentage of removal of BOD, COD, TSS, VSS and E-coli were 95-96%, 96-97% and 99% respectively using 1 day retention time.

Kinetic studies were carried out using Monod equations in order to find kinetic constants such as half velocity, K_s, Yield, Y, maximum rate of substrate utilisation, K, microorganism decay, K_d and maximum growth rate, μ_m. In addition, a prediction model is also studied by using Monod equations.

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

RAWATAN BAGI AIR SISA YANG TERHASIL DARIPADA KOLOM ENAPCEMAR

Oleh

AIDAHAPINI DERUM

Januari

Pengerusi: Profesor Madya Dr. Azni Idris Ph.D.

Fakulti Kejuruteraan

Objektif utama kajian ini adalah untuk mengkaji kualiti air sisa yang telah dihasilkan daripada kolam enapcemar. Di mana, kolam enapcemar ini terdiri daripada dua kaedah untuk memisahkan enapcemar dan air sisa. Kaedah yang pertama ialah dengan menggunakan lapisan tanah liat di bahagian bawah kolam dan kaedah yang kedua ialah menggunakan media penapisan (pasir dan batu kecil). Kaedah yang digunakan untuk merawat airsisa daripada enapcemar ini adalah dengan cara anarobic untuk kaedah yang pertama dan kaedah yang kedua dengan cara aeration. Sebanyak dua kali experimen dijalankan bagi kaedah yang menggunakan anarobic.

Kualiti air sisa diambil kira daripada kandungan BOD, COD, TSS, VSS, E-coli dan logam. Daripada keputusan didapati, kualiti air sisa daripada tangki penapisan

menggunakan pasir dan batu adalah lebih baik daripada tangki yang berlapisan tanah liat. Peratus pengurangan BOD, COD, TSS, VSS, dan E-coli masing-masing di antara 96-97%, 95-96%, 95-97%, 94-96% dan 99-99.5%. Manakala, peratus pengurangan BOD, COD, TSS, VSS, dan E-coli di antara 91-93%, 90-93%, 86-89%, 86-90% dan 90-92% untuk kolem berlapisan tanah liat. Ini menunjukkan, kaedah yang menggunakan penapisan dengan pasir dan batu-batu kecil adalah sangat berkesan. Rawatan yang menggunakan Aeration adalah lebih berkesan untuk peratus pengurangan BOD, COD, TSS, VSS, dan E-coli ialah 95-96%, 96-97% dan 99% dengan masa tahanan 1 hari sahaja. Ini berbanding dengan rawatan anaerobic selama 67 hari.

Selain itu, dalam kajian ini jugamengkaji kinatik dengan menggunakan persamaan Monod untuk mendapatkan pemalar kinetik. Pemalar kinetik adalah seperti Y, K, μ dan K_s Dengan menggunakan persamaan Monod. Penelahan dengan menggunakan persamaan Monod. Seterusnya kesimpulan dan pandangan telah dibuat hasil daripada kajian ini.

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The Supervisor a committee member for this research.

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I certify that an Examination Committee met on 17th January 2002 to conduct the final examination of Aidahapini Derum on her Master of Science thesis entitled "Treatment of Leachate Generated from Sewage Sludge Lagoon" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

AIDAHAPINI DERUM

Date: 4 APR 2002

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Leachate is the liquor from the sludge solids drawn off from the lagoon drainage, which has been separated from the sludge solid. The leachate is required to be treated to ensure the discharge in lagoon escaped in accordance with the regulation standard. There are several methods used for the treatment of leachate. Couillard et al., 1991, have studied leachate treatment using anaerobic digestion. Anaerobic digestion installation with ammonia stripping of supernatant from sludge has been studied by Jansen et. al., (1993) and also, in a study conducted in Denmark (Thorndahl, 1992).

In this research a ponding method was used to treat the leachate generated from sludge tanks. Anaerobic and aerobic methods were used to treat the leachate generated from the sludge lagoon. Ponds are a popular alternative to other biological treatment systems. Pond treatment is particularly favoured in Australia (Parker *et al.* 1950, 1957), in Central and Southern Africa (Stander and Meiring, 1965, Marais, 1970), in India (Arceivala *et al.* 1970), USA (*Oswald* 1963), and Canada (*Townshend and Knoll* 1987).

It is becoming increasingly popular in Europe, especially in West Germany and France where 2000 and 1500 waste stabilisation ponds are in operation respectively.

Anaerobic ponds have been used for wastewater treatment in a purposeful manner for more than a century. Even before that, overloading facultative stabilisation ponds had created anaerobic ponds, which were found to be effective in wastewater treatment. An early paper by Parker et al. (1950) described the application of anaerobic lagoons for sewage treatment in Melbourne, Australia and a later (Parker et al., 1959) gave performance details on a large Melbourne pond system. Amalorpavan (1963) reported on anaerobic pond performance in India. Parker et al. (1979) reported on the application of anaerobic ponds in Southern Africa and Bendoriccho et al. (1997) discussed the performance of combined aerobic-anaerobic ponds in Coastal areas.

1.1 Pilot Sludge Lagoon at Puchong

The full-scale sludge lagoon was used as a joint venture research project between IWK and UPM. The full-scale sludge treatment facility was constructed at the Puchong Sewage Treatment Plant. In the full-scale treatment facility, two parallel sludge lagoons, one with a clay lining and the other without a clay lining were constructed. An anaerobic pond was also constructed next to the lagoons for treatment of the leachate before returning it to the oxidation pond located in the same area.

Leachate is the liquor from the sludge solids that percolates down through the lagoon and into the groundwater. One of the objectives of full-scale study is to measure the extent of groundwater contamination by the leachate form both the clay-lined and unclay-lined lagoons. A detailed drawing with the dimensions of the lagoons is shown in Appendix G.

Each of the sludge lagoons was sized to hold 4000 m^3 of sludge with operational procedure scheduled as follow:

1. Three months sludge fillings and digestion
2. Two months of anaerobic digestion, evaporation and dewatering

An estimated 200 m^3 liqour was expected form the lagoon drainage. The proposed operating depth of the lagoon was 1.5 m, as compared to the typical working depth of 0.75 m to 1.25 m as reported by some studies. (Pescod, 1996)

An anaerobic pond was proposed for treatment of the high strength liquor drawn off from the sludge lagoon. The design of this anaerobic pond was based on the average liquor drainage from the sludge lagoons. However, the actual flow was expected to be much higher in the beginning and much less in the final stage.

1.2 Objectives of Study

In this project, two experiments will be carried out. In the first experiment, the anaerobic tank method was used for the treatment of the leachate generated from sludge lagoon. In the second experiment, an anaerobic tank and an aeration tank were used for treating the leachate generated from the sludge lagoon.

The objectives of the study are listed as follows:

1. To determine the quality of leachate generation from sand and clay tanks.
2. To study the effectiveness of leachate treatment under anaerobic and aerobic Conditions.
3. To study the degradation kinetics for leachate treated with anaerobic processes.

1.3 Scope of Study

The scope of this study is outlined below:

Stage 1

1. To measure the quality of leachate generated from the sludge lagoon: BOD, COD, TSS, VSS, E-coli, Amonia, Nitrate, Phosphorus, and Heavy metal.

2. To compare the quality of leachate generated from the sand filtration and clay lined system.

3. To determine the kinetics constant involved in anaerobic digester as follows:

a) K_s = half velocity coefficient

b) Y = yield coefficient

c) K = maximum rate of substrate utilization per unit of weight microorganism

d) K_d = microorganism decay coefficient

e) μm = maximum growth rate

Stage 2

a) To compare the quality of treated leachate from anaerobic tanks in the first and second runs of the experiment (using different filling period).

b) To compare the quality of treated leachate from anaerobic tanks with that from aeration tanks.

CHAPTER 2

LITERATURE REVIEW

2.1 Characteristics of Leachate

Leachate is produced during solid-liquid separation of sewage sludge. The objective of separating the liquid from the sludge is to reduce its volume. But, the leachate produced from sludge separation requires treatment to ensure the discharge is in according with standards. Before treating the leachate, the characteristics of the leachate generated from sludge need to be determined. Typical leachate characteristics are shown in Table 2.1

Table 2.1: Typical Characteristics of Leachate from Wastewater Sludge

Parameter	Unit	Overall Average
BOD	mg/l	500
Filtered BOD	mg/l	51
COD	mg/l	2600
SS	mg/l	46 - 11
TKN	mg/l	170
Total P	mg/l	98
pH	mg/l	5.9-7.7

Source: U.S. Environmental Protection Agency, 1981.