



**UNIVERSITI PUTRA MALAYSIA**

**TREATMENT OF LEACHATE GENERATED  
FROM SEWAGE SLUDGE LAGOON**

**AIDAHAPINI DERUM**

**FK 2002 12**

**TREATMENT OF LEACHATE GENERATED FROM SEWAGE SLUDGE  
LAGOON**

**By**

**AIDAHAPINI DERUM**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
In Fulfilment of the Requirements for the Degree of Master of Science**

**January 2002**



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

**TREATMENT OF LEACHATE GENERATED FROM SEWAGE SLUDGE LAGOON**

**By**

**AIDAHAPINI DERUM**

**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,  $\mu_m$ . 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 airtsisa daripada enapcemar ini adalah dengan cara anarobic untuk kaedah yang pertama dan kaedah yang kedua dengan cara aeration. Sebanyak dua kali eksperimen 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 kolam 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 kinetik dengan menggunakan persamaan Monod untuk mendapatkan pemalar kinetik. Pemalar kinetik adalah seperti  $Y$ ,  $K$ ,  $\mu$  dan  $K_s$ . Dengan menggunakan persamaan Monod. Penelahan dengan menggunakan persamaan Monod. Seterusnya kesimpulan dan pandangan telah dibuat hasil daripada kajian ini.

## **ACKNOWLEDGEMENTS**

I would like to express my heartiest thanks and wish to acknowledge the support, guidance and dedication of:

Assoc. Prof. Dr. Azni Idris

My dedicated and inspiring project supervisor and coordinator.

Assoc. Prof. Dr. Sa'ari Mustapha

The Supervisor a committee member for this research.

Assoc. Prof. Dr. Fakhru'l-Razi Ammadun

The Supervisor a committee member for this research.

Lecturers and staff of the Department of Chemical & Environmental Engineering, UPM.

Friends and those who have contributed to the success for this research.



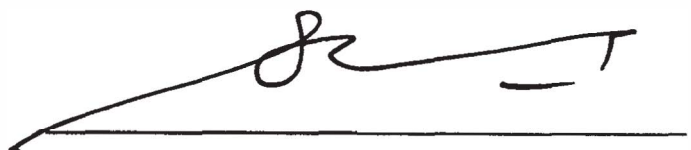
I certify that an Examination Committee met on 17<sup>th</sup> January 2002 to conduct the final examination of Aidahapini Derum on her Master of Science thesis entitled "Treatment of Leachate Generated from Sewage Sludge Lagoon" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 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:

Abdul Ghani Liew Abdullah, M.Sc.  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

Azni Idris, Ph.D.  
Associate Profesor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

Sa'ari Mustapha, Ph.D.  
Associate Profesor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

Fakhru'l – Razi Ahmadun, Ph.D.  
Associate Profesor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)



SHAMSHER MOHAMAD RAMADILI, Ph.D.  
Professor/Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 4 APR 2002



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.



---

**AINI IDERIS, Ph.D.**  
Professor/Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: **13** JUN 2002

## 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

## TABLE OF CONTENTS

ABSTRACT	ii
ABSTRAK	iv
ACKNOWLEDGEMENTS	vi
APPROVAL	vii
DECLARATION	xi
LIST OF TABLES	xii
LIST OF FIGURES	xvi
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	<b>1</b>
1.0 Introduction	1
1.1 Pilot Sludge Lagoon in Puchong	2
1.2 Objective of Study	4
1.3 Scope of Study	4
<b>2 LITERATURE REVIEW</b>	<b>6</b>
2.1 Characteristic of Leachate	6
2.2 Leachate Treatment by Anaerobic Digestion	7
2.3 Fertiliser Value of Leachate Sludge	9
2.4 Ponding System for Waste Treatment	10
2.5 Lagoon/Pond Troubleshooting	11
2.6 Aeration Lagoon	13
2.6.1 Biodegradation	16
2.6.2 Design of Aerated Lagoon	17
2.6.3 Operation and Maintenance of Aeration Ponds	21
2.6.4 Oxygen Requirement	22
2.7 Anaerobic Pond	23
2.7.1 Treatment Mechanisms in Anaerobic Ponds	26
2.7.2 Design Parameter for Anaerobic Ponds	28
2.7.3 Advantages and Disadvantages Treatment by Anaerobic Pond	29
2.7.4 Operation and Maintenance of Anaerobic Ponds	30
2.8 Sludge Characteristics	31
2.9 Drying Sand Bed	33
2.9.1 Design Criteria for Sand Beds	33
2.9.2 Cleaning Beds	35
2.10 Drying Lagoon	36
2.11 Theory of Drying	37
2.11.1 Rate of Drying	40



2.12	Underground Monitoring	41
2.12.1	Monitoring Well Installation	41
2.13	Kinetic Study	41
2.13.1	Kinetic Equation for Batch Reactor	47
2.13.2	Kinetic Equation of Bacterial Growth	48
2.13.3	Cell Growth and Substrate Utilization	49
2.14	Theory of Biological Filtration	50
2.14.1	Transport Mechanisms	51
<b>3.</b>	<b>METHODOLOGY AND MATERIALS</b>	<b>55</b>
3.1	Experiment Design	55
3.2	Overall Methodology	55
3.3	An Anaerobic Tank	61
3.3.1	Mode of Filling	64
3.4	Aeration Tank	64
3.7	Analytical Method	66
<b>4.</b>	<b>RESULT AND DISCUSSION</b>	<b>67</b>
4.1	Introduction	67
4.2	Characteristic of Sludge Used in Study	67
4.3	Performance of Leachate Treatment by Anaerobic Tank	71
4.3.1	Organic Matters	71
4.3.2	Factors Affecting Experimental Result	88
4.3.3	The Growth of Algae and Its Effect on Experiment	93
4.3.4	E-coli	94
4.4	Nutrients	99
4.4.1	Total Nitrogen	99
4.4.2	Ammonia & Nitrate	101
4.4.3	Phosphorus	111
4.5	Heavy Metal	114
4.6	Performance of Leachate Treatment Using Aeration Tank	121
4.6.1	TSS and VSS	129
4.6.2	E-coli	132
4.4.3	Ammonia & Nitrate	136
4.7	Kinetic Study	140
4.8	Prediction Model	157
<b>4.</b>	<b>CONCLUSION</b>	<b>161</b>
4.1	Conclusion	161
4.2	Recommendation	164



## LIST OF FIGURES

<b>Figure</b>		<b>Page</b>
2.1	Effluent TSS and BOD of Dual-power Aerated Lagoon System	14
2.2	Operation of naturally aerobic lagoon	16
2.3	Schematic Anaerobic Pond	23
2.4	Creating a Digestive Chamber in the Bottom of Anaerobic Ponds	25
2.5	Anaerobic System Biochemistry	27
2.6	Drying curve for Sludge	39
2.7	Single Screen Well	41
2.8	Well Clusters	42
2.9	Single and Multiple Installation Configuration for Air-lift Samplers	43
2.10	Concentration versus Time	47
2.11	Cell Growth and Substrate Utilisation	49
2.12	Relationship between Grain Size and Pore Size	51
2.13	Transport of Discrete Particle in Wastewater	52
3.1	Schematic of Overall Process Flow	56
3.2	Anaerobic Tank Used in This Study	62
3.3	Schematic Show Flow of Drainage Leachate	63



4.16	E-coli Count for the Leachate Generated from Deep Lagoon (0.75m) with Time	95
4.17	E-coli Count for the Leachate Generated from Shallow Lagoon (0.375m) with Time	96
4.18	E-coli Count for the Leachate Generated from Shallow Lagoon (0.375m) with Time	97
4.19(a)	Variation of TKN versus Time	99
4.19(b)	Variation of TKN versus Time	99
4.19	Removal of Ammonia & Nitrate for the Leachate Generated from Deep Sand Lagoon (0.75m) with Time	103
4.20	Removal of Ammonia & Nitrate for the Leachate Generated from Deep Sand Lagoon (0.75m) with Time	103
4.21	Removal of Ammonia & Nitrate for the Leachate Generated from Shallow Clay Lagoon (0.375m) with Time	104
4.22	Removal of Ammonia & Nitrate for the Leachate Generated from Shallow Clay Lagoon (0.375m) with Time	104
4.23	Removal of Ammonia & Nitrate for the Leachate Generated from Shallow Sand Lagoon (0.375m) with Time	105
4.24	Removal of Ammonia & Nitrate for the Leachate Generated from Shallow Clay Lagoon (0.375m) with Time	105
4.26	Concentration of phosphorus versus Time	111
4.27	Concentration of phosphorus versus Time	112
4.28(a)	Graph Variation of Zinc with Time	115
4.28(b)	Graph Variation of Manganese with Time	116
4.28(c)	Graph Variation of Copper with Time	116
4.28(d)	Graph Variation of Iron with Time	117
4.28(e)	Graph Variation of Cadmium with Time	117
4.28(f)	Graph Variation of Lead with Time	118



4.28(g)Graph Variation of Nickel with Time	118
4.29 Removal of BOD with Time for Leachate Generated Clay Tank (0.375m)	121
4.30 Removal of BOD with Time for Leachate Generated Sand Tank (0.375m)	122
4.31 Removal of COD with Time for Leachate Generated Clay Tank (0.375m)	123
4.32 Removal of BOD with Time for Leachate Generated Sand Tank (0.375m)	124
4.33 Removal of COD with Time for Sand (0.375m)	126
4.34 Removal of COD with Time for Clay (0.375m)	126
4.35 Removal of BOD with Time for Sand (0.375m)	127
4.36 Removal of BOD with Time for Sand (0.375m)	128
4.37 Variation of TSS versus Time for Clay Tank (aeration)	129
4.38 Variation of TSS versus Time for Sand Tank (aeration)	127
4.39 Removal of VSS with Time for Clay tank (0.375m)	128
4.40 Removal of VSS with Time for Sand tank (0.375m)	129
4.41 Removal of E-coli with Time for the Clay Tank	130
4.42 Removal of E-coli with Time for Sand Tank	130
4.43(a)Removal of Ammonia & Nitrate (clay tank)	132
4.43(b)Removal of Ammonia & Nitrate (sand tank)	132
4.44(a)Removal of TKN (sand tank)	136
4.44(b)Removal of TKN (sand tank)	137



4.45(a) Concentration of phosphorus for sand tank	138
4.45(b) Concentration of phosphorus for clay tank	138
4.46 X versus $S_0-S$ (S0.375)	141
4.47 X versus $S_0-S$ (C0.375)	141
4.48 X versus $S_0-S$ (C0.75)	142
4.49 X versus $S_0-S$ (S0.75)	142
4.50 $X(ds/dt)$ versus $l/S$ (S0.375)	147
4.51 $X(ds/dt)$ versus $l/S$ (C0.375)	147
4.52 $X(ds/dt)$ versus $l/S$ (C0.75)	148
4.53 $X(ds/dt)$ versus $l/S$ (S0.75)	149
4.54 $\ln(X/X_0)$ Versus Time (S0.375)	150
4.55 $\ln(X/X_0)$ Versus Time (S0.375)	150
4.56 $\ln(X/X_0)$ Versus Time (C0.75)	151
4.57 $\ln(X/X_0)$ Versus Time (S0.75)	151
4.58 Prediction of COD versus Time for S0.75	158
4.59 Prediction of COD versus Time for S0.75	158
4.60 Prediction of COD versus Time for S0.375	159
4.61 Prediction of COD versus Time for S0.375	159





## LIST OF TABLES

<b>Table</b>	<b>Page</b>
2.1 Typical Characteristics of Leachate from Wastewaters Sludge	6
2.2 Composition of Metal in Leachate Sludge after Filtration	7
2.3 Total Solid Concentration in Leachate	8
2.4 Nutritive Element of Leachate Sludge	9
2.5 Pond Troubleshooting	12
2.6 Operating and Design Conditions of Hitomi Plant, Japan	18
2.7 Treatment Performance of Hitomi plant	19
2.8 Operating and Design Conditions of Kanzanji plant	19
2.9 Treatment Performance of Kanzanji plant	19
2.10 Operating and Design Conditions of Kotoh Plant, Japan	20
2.11 Treatment Performance of Kotoh Plant, Japan	20
2.12 Performance Data for Anaerobic Ponds Treating in Australia	24
2.13 Design Parameter for Anaerobic Ponds	28
2.14 Percentage Sludge Concentration	32
2.15 Metal Composition in Sludge	32
2.16 The Design Sludge Loading for Different Type of Digestion	34
2.17 Advantages and Disadvantages of Monitoring	43
3.1 Design and Sludge Level for First Run	61



3.2	Design and Sludge Level for Second Run	61
3.3	Mode of Filling Used in Run 1 and Run 2	64
3.4	Parameter, Analytical Method and frequency of Sampling	66
4.1	Characteristic of Septic Tank Sludge Used in Study	68
4.2	Typical Composition of raw sewage Sludge	69
4.3	Typical Composition of Treated Sludge	69
4.4	Characteristic of raw Sludge Sewage	70
4.5	Summarised of Final Effluent BOD from the Literature	72
4.6	Mechanisms Involve in Reduction of Organic Matter (1 <sup>st</sup> run)	88
4.7	Mechanisms Involve in Reduction of Organic Matter (2 <sup>nd</sup> run)	88
4.8	Summarised of Effluent TKN	98
4.9	Efficiency and Effluent Quality for the Sand Filter System	101
4.10	Mass Balance of Ammonia for S0.75 (1 <sup>st</sup> run)	107
4.11	Mass Balance of Ammonia for C0.75 (1 <sup>st</sup> run)	107
4.12	Mass Balance of Ammonia for C0.375 (1 <sup>st</sup> run)	108
4.13	Mass Balance of Ammonia for S0.375 (1 <sup>st</sup> run)	108
4.14	Mass Balance of Ammonia for C0.375 (2 <sup>nd</sup> run)	109
4.15	Mass Balance of Ammonia for S0.375 (2 <sup>nd</sup> run)	109
4.16	Summarise of Phosphorus Removal in the Sand Filter	111
4.17	Heavy Metal Concentration in Anaerobic Pond (1 <sup>st</sup> run)	113
4.18	Percentage Removal of Heavy Metal	114
4.19	Concentration Heavy Metal for Clay Tank (2 <sup>nd</sup> Run)	118



4.20	Concentration Heavy Metal for Sand Tank (2 <sup>nd</sup> run)	119
4.21	Percentage Removal of Heavy Metal	119
4.22	Summary of BOD and COD Removal in Aeration Tank	120
4.23	Mass Balance of Ammonia	134
4.24	Summarised of Ammonia, TKN, Nitrate and Nitrogen Removal	135
4.25	Maximum Yield Coefficient, Y	144
4.26	The Summary of Y Coefficient from Literature	144
4.27	The Kinetic Equation	152
4.28	K and K <sub>d</sub> Value	153
4.29	K and K <sub>d</sub> Value	153
4.30	Kinetic Constant for $\mu_m$ and K <sub>s</sub>	154
4.31	The Summary of Value $\mu_m$ and K <sub>s</sub> Collected from Literature	154
4.32	Prediction Model	157



# 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 from 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<sup>3</sup> 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<sup>3</sup> liquor was expected from 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)  $\mu_m$  = 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 accordance 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**

<b>Parameter</b>	<b>Unit</b>	<b>Overall Average</b>
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.*