REMOVAL OF AMMONIA, COD AND PHOSPHORUS FROM LANDFILL LEACHATE USING CAMBINATION OF CHEMICAL AND PHYSICAL METHOD

By

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ABSTRACT

Ammonia is a common contaminant found in landfill leachate. Ammonia is toxic even in small quantity and can affect water life forms and also hazardous to human being. Leachate is a liquid formed when water due to precipitation passes through the waste in landfill and transport pollutant and continue to migrate to the base of the landfill cell and often percolate into the ground thus contaminate groundwater reservoir and the environment. In order to protect and preserve the environment, leachate must be thoroughly treated before discharging it to the environment. A study was conducted on removal of leachate quality parameters such as ammonia, total COD and phosphorus concentration at Pulau Burung Level III Sanitary Landfill by physico-chemical series of treatment starting from Magnesium Ammonium Phosphate (MAP) precipitation, followed by aeration process and finally adsorption using natural zeolite through batch and column test. Approximately 85-90% of ammonia was removed during the pretreatment of MAP alone, and the COD concentrations were reduced up to 60% during the aeration and zeolite adsorption. Phosphorus contents were no longer a threat as all the samples were reduced to 0 mg/L for all sample. Other than obtaining a final effluent of standard B, the treatment byproduct produced by the precipitation can be beneficial as the sludge have the same properties that of commercial fertilizer used for agricultural purposes.

ABSTRAK

Ammonia adalah komponen pencemar yang biasa dijumpai di dalam larut lesapan. Ammonia merupakan pencemar yang amat toksik walaupun pada kuantiti yang amat kecil dan boleh memudaratkan hidupan akuatik dan juga merbahaya kepada manusia. Larut lesapan terbentuk apabila air dari hujan melalui sampah sarap di tapak pelupusan dan membawa segala pencemaran ke dasar tapak pelupusan seterusnya menyusup ke bawah tanah lalu mencemarkan reservoir air bawah tanah dan juga alam sekitar. Bagi menjaga dan memelihara alam sekitar larut lesapan ini perlu dirawat secara rapi sebelum dilepaskan ke alam sekitar. Satu kajian untuk merawat bahan pencemar dalam larut lesapan yang diambil dari Tapak Pelupusan Sampah Sanitari Pulau Burung Peringkat III seperti ammonia, COD dan juga fosforus telah dijalankan. Kajian dilakukan dengan menggunakan kombinasi rawatan kimia fizikal bermula dengan pemendakan Magnesium Ammonia Fosfat (MAP), dan diikuti oleh proses pengudaraan dan akhirnya rawatan penjerapan menggunakan zeolit semulajadi. 85-90% ammonia berjaya disingkirkan dalam prarawatan MAP dan seterusnya 60% COD disingkirkan dalam proses pengudaraan dan juga penjerapan zeolite semula jadi. Kehadiran fosforus pula berjaya disingkirkan ke 0 mg/L bagi semua sampel yang dikaji. Selain mendapatkan effluent akhir mengikut standard B, rawatan ini juga menghasilkan enap cemar yang berguna kerana enap cemar yang terhasil memiliki sifat sepertimana yang terdapat dalam baja komersil dan boleh digunakan dalam sektor pertanian.

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CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

Malaysia is a newly industrialized nation. The change from an agro-based to an industrial nation, together with good health care, education and better employment opportunities has led to an increase in the population. Due to this rapid urbanization and development of economic activities, especially in the industrial sector had increase the population from 6,278,800 in 1957 to an estimated 25,920,246 in 2005 ***(DOS, 2005).*** Better employment opportunities and facilities have also motivated migration into urban areas, putting pressure on the infrastructures and municipal services such as water, electricity, sewage disposal and solid waste collection.

The environmental issues related with municipal solid waste and pollution are not new and the problem are recorded back when human first established settlements. The Babylonian and Assyrian civilizations faced the same problem with solid waste disposal ***(Kirov, 1975)***. During those times, waste disposal does not pose significant impact on the environment for the waste were readily degraded or consumed by animals ***(Melosi, 1981)***. Wastes nowadays influence by modern lifestyle and trends however are more complex, consisting of more sophisticated, non-biodegrable materials.

There are few documented reports on waste generation rates from urban and rural areas. Most studies focused on waste collection rates rather than the generation of waste ***(Abdul***

et. al., 1996). Waste are collected by gathering the waste using collection trucks which transport it to processing plants, transfer stations or landfills. Most wastes collected in Malaysia are transported directly to landfills. Landfillings are the main method applied in Malaysia when it comes to solid waste disposal although it is rated the lowest rank in the solid waste management hierarchy as illustrated in **FIGURE 1.0**.

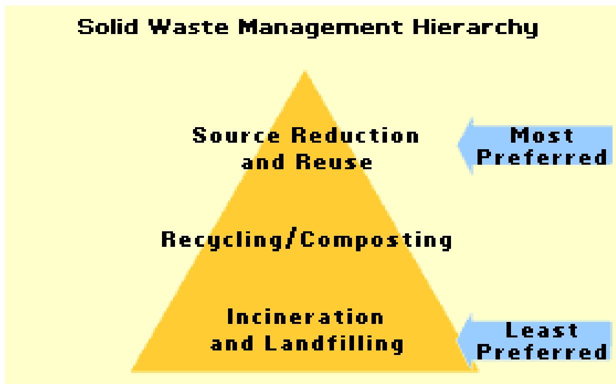

Figure 1.0: Solid Waste Management Hierarchy

Landfills are often designated as the least desirable method for the disposal of solid wastes. The generation of solid wastes presents challenges to solid waste managers and planners, due to lack of available landfill space, and also because solid waste management represents every significant increases in collection and disposal facilities. Still, landfills are the common denominator in all waste management approaches. A sanitary landfill is a method of solid waste disposal that should function without creating a nuisance or hazard to public health or to the environment. As systematic as it may sound, landfills still pose a significant threat to the environment by producing leaching chemicals which can severely contaminate surface and groundwater and also poisoning the air with toxic gases and generally being health hazards. Other than that, landfill have problems associated with odor and pests and considered an act of land scarcity. USEPA had begun to investigate problems related to the management of municipal solid wastes in the mid-1960s. Investigation on landfills included physical and chemical characterization of leachate, waste decomposition, leachate treatment, gas recovery, composting, source reduction, and related topics. They also found out that serious groundwater contamination that was directly attributable to landfill leachate whether the landfills were currently operational and even after the landfill were closed down.

Leachate is peaty-brown liquid formed when water due to precipitation passes through the waste in landfill. As the liquid moves through the landfill many organic and inorganic compounds, like heavy metals, are transported in the leachate and migrated to the base of the landfill cell and often percolate into the ground. As leachate generation cannot be controlled, serious attention should be given to solve the problem of making leachate non-hazardous and non pollutant.

1.2 BACKGROUND OF STUDY

Most wastes collected in Malaysia are transported directly to landfills. There are over 230 official dumping sites in Malaysia and only 10% of the sites provide proper leachate treatment facilities ***(Zaman, 1992)***. Leachate, that percolated and traveled through solid waste and collects contaminants can migrate and contaminate surface water and also pollute ground water. Being source of nutrient, leachate contains high concentration of ammonia, phosphorous and high COD thus, requires it to be properly treated before being discharge to the environment.

The most common toxic element in leachate is ammonia. The concentration of ammonia in leachate may vary depending on the age of the landfill ***(Irene & Lo, 1996).*** According to ***Li et. al. (1999)*** leachate generated at the domestic waste landfills alone contain 3000 to 6000 mg/l of ammonia-N while leachate generated at landfills receiving both construction waste and domestic wastes may contain less ammonia-N in the range of 1000 to 2500 mg/l. Ammonia dissolves in water and can seep into groundwater. It is necessary to remove ammonia for four reasons:

- Ammonia is hazardous to fish.
- Ammonia can be biologically oxidized and reduce the oxygen concentration in water and affect aquatic life forms.
- Can cause algae bloom in slow moving water bodies.
- Act as a catalyst to the oxidation process of steel and other construction material.

The removal of ammonia mechanism depends on how nitrogen is made available; it can be in the form of nitrate, ammonia or even organic form. Nitrogen however can be commonly found in the form of ammonia or organic nitrogen such as urea and protein ***(Metcalf & Eddy, 1991).***

The common method widely used for removing ammonia from wastewater are biological nitrification and denitrification process and air-stripping process ***(Kargi et al., 2002)***. The main consideration of ammonia using air-stripping is the release of ammonia into the air and resulting in severe air pollution if not controlled. Settlement of carbonate in large scale from the process also reduces the efficiency of system and provides high cost to the operation and maintenance.

Researches have been carried out and an alternative solution for ammonia removal has been obtained. Ammonia removal by chemical precipitation by producing MAP sludge has been successfully and practically used for treatment of different types of wastewater ***(Siegrist et al., 1994, Tünay et al., 1997, Li et al., 1999,)***. These researches indicated that ammonia removal is at a very high efficiency.

1.3 OBJECTIVE OF STUDY

The main driving factor of this study is to reduce the concentration of ammonia in landfill leachate by using combination of both chemical and physical sequence of treatment. Knowing that ammonia is hazardous and toxic even for a concentration as low as 2 mg/L, leachate from landfill should be treated before discharging to the environment.

The current situation in Malaysia is that there is no on-site treatment process that is capable to effectively remove pollutant in leachate. Most of the landfills are equipped with conventional aerators only to reduce the smell of the leachate but do not treat or improve the quality of the effluent.

This study hopefully can be used as an alternative solution for leachate treatment and provide guidelines for designing future treatment systems in order to remove ammonia concentration and other contaminants in landfill leachate and finally discharging a safe effluent to the environment.

Other main objectives are:

1. To determine the effectiveness of MAP formation as a pre-treatment in removal of ammonia-N in landfill leachate.
2. To determine the degree of effectiveness of using zeolite as a filtration media.
3. To find out the effectiveness of the physico-chemical combination process in removing COD and phosphorus in landfill leachate.

1.4 SCOPE OF STUDY

Leachate samples were taken from Pulau Burung Landfill in Seberang Perai Selatan in the state of Pulau Pinang. The landfill is a level III sanitary landfill which covers an area of approximately 62.4 hectares and caters 1100 tonnes of municipal solid waste a day. The landfill receive 300 tonnes of municipal solid waste from Seberang Perai Selatan, 500 tonnes from Penang Island and 800 tonnes of waste from Seberang Perai Utara each day. This landfill is equipped with a semi-aerobic recirculartory system to speed up the degrading of waste in a natural way. The landfill is currently managed by Idaman Bersih Sdn. Bhd.

Pulau Burung Landfill in Pulau Pinang is one of the landfills in Malaysia that is equipped with leachate treatment facilities. The installed conventional system is not capable to remove COD, ammonia and phosphorous content in the leachate. An alternative method using combination of physical and chemical to decontaminate the leachate should be applied to obtain an effluent that can safely be discharged to the environment and meet the standard of DOE.

For the purpose of this study leachate samples were tested in a series of treatment starting with chemical precipitation followed by aeration process and finally adsorption using natural zeolite through batch and column test for the removal of common leachate parameters such as ammonia-N, COD and phosphorus concentration.

1.5 PROBLEM STATEMENT AND IMPORTANCE OF STUDY

The change from an agro-based to an industrialize nation has increase Malaysian population rapidly. With the increasing population, the waste generation will also increase in volume by the years to come. A solution on a more effective and systematic solid waste management should be found to overcome the problem.

Till today there is no total solution for treatment of leachate in Malaysia. Leachate is harmful to the environment and public health if not treated properly. The end result will be the contamination of water bodies and the depletion of water as a resource. This research is to find an alternative method for leachate treatment and to determine the effectiveness of the proposed train of treatment using physico-chemical method. Having high content of nutrient, leachate can be treated by extracting Magnesium Ammonium Phosphate from it. Recovered nutrient (MAP) can be use as soil conditioner for agricultural use. The treated leachate will hopefully safe enough to be discharge without having significant impact on the environment.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

Municipal solid wastes did not pose a significant problem until humans established settlements. During those times, the types and quantities of wastes were readily degraded or consumed by animals or naturally degraded without causing significant impact to the environment. As population became more clustered, the amount and concentrations of wastes became increasingly problematic. The Greeks developed municipal dumps around 500 B.C. and the ancient Romans used open dumps; and in the 1400s A.D. the mounds of waste in Paris were so high they obscured the views from the city. With the industrial revolution, not only the quantity and quality of the wastes changed, but also the number and sizes of urban areas increased dramatically. During the mid-1800 to early 1900s the urban population of the United States increased from less than 2 million to more than 54 million persons ***(Melosi, 1981).*** Municipal solid wastes have been burned, buried and dumped indiscriminately in piles and into the sinkholes, quarries, coal mines, rivers, lakes and the ocean creating acute environmental and health impacts ***(Roy, 1994)***

Open burning of landfilled wastes was common practice until the 1970s. However, of the mid-1900s, the most common waste-management practice was landfilling. For an example in 1984, between 6000 and 9000 municipal landfills existed in the United States ***(Roy, 1994)***. During the twentieth century, thousands of new chemical products were introduced, and it is estimated that there are currently more than 65,000 manufactured chemicals in common use and more than 1000 new chemicals introduced annually. The wastes from manufacturing these products and the products themselves have been mixed with common household refuse and co-disposed in tens of thousands of landfills throughout the world ***(Neal & Schubel, 1987)***.

In 1986, about 143 million metric tons of municipal solid wastes were generated in the United States alone and about 83% of the wastes were placed into landfill ***(USEPA, 1988)***. In North America there are at least 20 million waste disposal facilities at which more than 10 billion cubic metres of liquid and solid wastes are drained or buried in the ground each year. As time goes on, the quality of the vast subsurface reservoir of fresh water, which a few decades ago was relatively unblemished by man's activities is gradually becoming degraded ***(Cherry, 1983).***

In Malaysia, about 6 million tonnes of Municipal Solid Waste (MSW) were generated per year or about 15,000 tonnes daily. Of the latter, 12, 000 tonnes were domestic waste and the rest was commercial waste, an average of 1.8 dumping sites per municipal council to accommodate the bulk of the municipal solid waste (MSW) generated ***(Ministry of Housing and Local Government, 1990).*** The urban population, which was almost 50% of the total population of 20 million people in Peninsular Malaysia, generated about 3 million tonnes of domestic refuse annually. The average per capital generation was 1.00 kg/day, however the per capital rate varies between 0.27 kg/day in the rural areas to as high as 1.2 kg/day in some urban centres ***(Agamuthu, 1999).***

According to ***Hassan et al. (1998)***, in 1990, there were about 230 municipal dumping sites in Malaysia with an average area of 15 hectares. More than 80% of these sites have remaining operation lifetime of less than 2 years. However, the management and operation practices at most of these sites are relatively poor. About 60% of these sites are open dumps and thus did not have site suitability studies, lack of cover materials, inadequate facilities such as weighing bridge and fence, and lack of pollution control measures in particular leachate and landfill gases. Such a management and operation practices will pose a severe problem to environment especially the surface and ground water resources.

2.1 COMPOSITION OF MUNICIPAL SOLID WASTE

The many sources of municipal solid wastes result in a heterogeneous composition. Regional differences in climate, season, and socioeconomic factors contribute to this variability ***(USEPA, 1988b).*** Components of garbage have been classified in studies, but these studies often are not comparable because definitions of wastes differ from study to study, as do the measurement techniques used. Municipal landfills typically receive household refuse and non-hazardous commercial wastes. They may also receive a limited amount of sewage sludge and industrial waste. Municipal wastes can be approximated (by weight) as 36% paper, 20% yard waste, 8% glass, 9% metals, 9% food wastes, 4% wood, 7% plastic, and 7% rubber, leather, textile, and miscellany ***(Franklin Associates, 1986, 1988***). Paper products are the major component of municipal solid waste, varying from 25 to 61 % of the total mass by weight ***(Mac Namara, 1971; Solid Wastes Management, 1972; Rovers and Farquhar, 1973; Pohland and Harper, 1986)***. Paper has been the major component of refuse since at least 1938 ***(Solid Wastes Management, 1972).***

The composition of the waste placed in landfills has changed over time, reflecting changes in technology and product packaging and marketing. Solid Wastes Management (1972) noted that since the 1930s, the quantity of putrid materials declined, as had ash derived from the domestic combustion of coal and wood; plastics and paper increased in quantity.

Hazardous wastes generated by households can also be a component of municipal wastes. The hazardous waste content of municipal solid waste has been estimated to range from 0.1 to 0.4% by weight ***(USEPA, 1988a).*** The quantity of household hazardous waste generated in 1986 in the United States could have been anywhere from 1,800 to 508,000 metric tons. Motor oil, paint, household maintenance items, batteries, and miscellaneous electrical items pre-dominate the household hazardous waste stream ***(USEPA, 1988b).***

Generally, municipal solid waste in Malaysia is approximately similar to that of other countries in the world ***(Mohd Tadza et al, 1999).*** The municipal solid wastes can be approximated (by weight) consists of .30.2% organic waste, 27.5% paper, 13.3% wood, 12.1% plastic, 7.7% miscellany, 3.4% textile, 3.3% metals, 1.7% glass, and 0.8% rubber ***(Dini Ramya & Ping, 1997)***

2.2 COMPOSITION OF LEACHATE

After municipal solid waste (MSW) is placed into a landfill, biological reactions occurred and produce landfill gases and liquids (leachate). The rate of leachate production depends on the composition of the waste, the operation of the landfill, ambient temperature, climatic and hydrogeological factors. The field capacity of waste is the most important factor in leachate generation. Field capacity is the ability of solid waste to retain water or moisture when subjected to the force of gravity. Excess water exceeding the field capacity will be release from the waste as leachate. However, landfill leachate forms primarily from rainwater that percolates through the waste. Leachate can extract and mobilize inorganic and organic contaminants from a disposal site into groundwater. The natural dewatering of wet MSW during compaction and settling can also contribute to the volume of leachate. The microbial degradation of biodegradable organics can also generate water that will contribute to leachate generation ***(Lu et al., 1985).*** Leachate may also be derived from recharge into the landfill cell if the MSW has been buried beneath the zone of saturation.

Landfill leachate derived from fresh municipal refuse is generally a mildly acidic (pH 5.0) aqueous solution that contains a high content of dissolved solids and biologically degradable organics ***(Fuller, 1978; USEPA, 1979).*** The range of hydrogen ion activity in leachate samples reported in the literature spans almost 11 orders of magnitude, and the inorganic chemical composition of landfill leachate has been quite variable The range of values in **Table 2.0** reflects that the samples were collected from many different landfills that were in different climates and at different stages of stabilization and operated by different methods.

The composition of the leachate and the analytical methods used to generate these values also contributed to their variability. However ***Gaby, 1975*** noted that municipal landfill leachate generally contains hundreds of different inorganic and organic chemicals at some finite concentration beside a large microbial population and may be heavily contaminated with pathogenic organisms

Table 2.0: Comparison of domestic landfill leachate characteristics

PARAMETER	Normal Leachate concentration	Gemencheh Leachate Concentration #	Permatang Pauh Leachate Concentration**	Pitsey (UK) Leachate Concentration*	Vejen (Denmark) Leachate Concentration ##	USA Leachate Concentration +
pH	5.8-7.5	5.0-5.6	7.2-7.5	6.9-8.0	6.7-6.9	5.0-7.5
Conductivity	-	2290-2650	-	-	5450-7600	2000-8000
Carbonate	-	<1.0	-	-	-	-
Bicarbonate	-	136-501	-	-	-	-
Ammonia	5-1000	0.5-8.8	-	90-1700	140-450	100-400
Chloride	100-3000	322-357	2900-3900	400-1300	420-1200	100-2000
Sulphate	60-460	106-115	-	150-1100	<5	10-1000
Nitrate	-	107-118	-	-	-	0.1-10
Calcium	1.0-165	126-143	472	-	240-330	100-3000
Magnesium	10-480	21-30	2.21	-	50-80	30-500
Kaliuin	-	266-316	-	-	70-360	-
Sodium	-	147-164	-	-	380-680	200-1500
Ferum	0.1-2050	<0.1-1.5	3.5	0.6-1000	0.5-86	0.1-1.0
Nickel	0.05-1.70	<0.1	0.38	0.5	10.0	0.1-1.0
Cadmium	0.005-0.01	<0.01	0.023	-	<0.2	0.001-0.1
Zink	0.05-130	0.1-0.5	0.64	1.0-10	-	0.5-30
Lead	0.05-0.6	0.02-0.03	**NR**	0.5	1.3	0.1-1.0
Mercury	-	4 -5xl0-4	**NR**	0.5	-	-
Chromium	0.05-1.0	0.04-0.28	**NR**	-	-	0.05-1.0
Copper	0.1-9	<0.1	-	-	-	0.02-1.0

NOTES:

* Source : DOE (1986)
** Source: Dini Ramya Hasan Basri & Ping, T.A. (1997)
# Source: Mohd Tadza Abdul Rahman (1998, 1999)
Source: Kjeldsen, P. (1993)
+ Source: Lee, A. J. & Lee, F.G. (1993)

NR – Non recorded
all values are recorded in mg/L

2.3. MIGRATION OF LEACHATE

In humid and semi-humid regions, infiltration through landfills normally results in the migration of leachate from the refuse into or underlying groundwater zones. Landfills were investigated for leachate migration by using geophysical measurements and hydrogeological modeling to determine the extent of leachate plumes into groundwater reservoir ***(Abbaspour et al., 1999)***. Leachate derived from these mixed MSW has been responsible for contaminating thousands of municipal and individual water supplies. Tracing of leachate and pollutant migration in soil and groundwater have been studied using isotop by ***Vilomet et al. (2003).*** Studies of landfills on unconsolidated sand and gravel aquifers by ***Golwer et al. (1980b), Cherry et al. (1984),*** and ***Pellegrini et al. (1999)*** have established that zones of leachate contaminated groundwater can extend many hundreds of metres. Other examples of leachate migration were done by ***Exler (1980)*** and ***Mac Farlane et al. (1983)***. Studied done by ***Exler (1980)*** at Grosslappen domestic and industrial landfill in Munich showed that the contaminants derived from the landfill leachate traveled at least 5000metres. While ***Mac Farlane et al. (1983)*** recognized that contaminants from Borden landfill leachate in Canada migrated at least 700metres from the tip of the MSW.

Various techniques and methods have been applied, designed and developed in order to reduce the impact of contamination of groundwater due to leachate migration. Landfills were designed with liners to prevent the movement of leachate from the landfill sites Clays are normally used due to its ability to adsorb and retain contaminants in leachate and also its resistance in leachate flow. Geomembranes and geotextile are also used as liners in landfills for the same purpose ***(Isa, 2003).*** Nevertheless, old sanitary landfills are generally lacking a leachate collection system ***(Vilomet et al., 2003).*** Appropriately designed liner system can prevent the migration of leachate into groundwater and can preclude the further spreading of a leachate plume. However, if the system is not designed appropriately, it may cause a further serious spreading of the contamination.

2.4 TREATMENT OF LEACHATE

Leachate contamination can cause serious deterioration of aquifers used for groundwater resources as in the described by ***Baedecker & Apgar (1984)*** and ***Mohd Tadza et al. (1999)*** owing to the hazardous and toxic composition. The migration of leachate from municipal landfills is a potential threat to groundwater and surface water due to its toxic properties. Being a source of nutrient, leachate contains high concentration of toxic elements such as ammonia, phosphorous, heavy metals and high COD thus, requires it to be properly treated before being discharge to the environment.

Scientists and researchers around the world are trying to find a solution to leachate problems because the degree of contamination is significant and the costs of remediation of polluted water bodies are very high. In most studies conducted for leachate treatments were to reduce the concentration of toxic elements in leachate such as ammonia, COD, heavy metals and phosphorus. The primary concern is to remove the concentration of ammonia and reduce the chemical oxygen demand (COD) value to comply with Standard B stipulated by the Department of Environment.

A high quality database is a valuable management tool for predicting the future pattern of leachate composition, where the treatment facilities must be designed in advance ***(Irene & Lo, 1996)***. This information is crucial to identify the impact and the severity of leachate contamination to the surrounding environment.

There are many ways and methods for treating leachate. The three main methods applied are biological method, chemical method and physical method. Combination of all these methods are usually used to get the most effective and satisfactory effluent in leachate treatment ***(Kargi et al., 2002)***. The representative of all the methods, processes and operations used for leachate treatment are shown in **Table 2.1**. The major physical methods used are sedimentation, air stripping, adsorption and membrane filtration, while major chemical methods are coagulation-flocculation, chemical precipitation, and chemical oxidation. Aerobic, anaerobic and anoxic processes are classified as the major biological methods applied in leachate treatment. Advance technologies like membrane or nanofiltration ***(Kargi et al., 2002)*** and photo-fenton reaction (Fe_2/H_2O_2/UV-VIS) have successfully applied to decontaminate wastewater and landfill leachate.

Biological treatment is suitable for treating wastewater with a high BOD: COD ratio as mentioned by ***Dini & Ping, (1997).*** Several anaerobic and aerobic treatment systems have been studied in landfill leachate. These systems have demonstrated high performance, although some problems have been detected depending on the leachate characteristics mainly due to the age of landfill ***(Ozturk et al., 2003).*** Aerobic process occurred when oxygen is applied into the system and aerobic bacteria degrade the organic material. Biological process includes conventional system such as extended aeration, activated sludge, sequencing batch reactor (SBR) and rotating biological contactor (RBC) which are used to treat sewage and also capable of treating leachate.

The biological treatment process have been studied by ***Li et al. (1999)*** and found out that the efficiency of removing high concentration of ammonia nitrogen in leachate declines drastically. This is due to the characteristics of the leachate having low BOD_5/COD and low COD/TOC ratios. Thus physico-chemical methods are widely been used for treating leachate with high concentration of ammonia-nitrogen and COD.

TABLE 2.1: Representative biological, chemical, and physical processes and operations used for the treatment of leachate

Treatment process	Application	Comments
Biological processes Activated Sludge	Removal of organics	Defoaming additives – need separate clarifier
Sequencing Batch Reactor (SBR)	Removal of organics	Similar as activated sludge, no separate clarifier needed, only applicable to relatively low flow rates
Aerated stabilization basins	Removal of organics	Requires large land area
Fixed film process	Removal of organics	Used on industrial effluents, similar to leachate, not tested on landfill leachate
Anaerobic lagoons and contactors	Removal of organics	Lower power requirements and sludge production than aerobic systems but slower
Nitrification/denitrification	Removal of nitrogen	Nitrification/denitrification can be accomplished simultaneously with the removal of organics
Chemical processes Neutralization	pH control	Of limited applicability to most leachates
Precipitation	Removal of metals & some anions	Produces sludge, possibly requiring disposal as hazardous waste
Oxidation	Removal of organics, detoxification of some inorganic species	Works best on dilute waste streams; use of chlorine can result in formation on chlorinated hydrocarbons
Wet air Oxidation	Removal of organics	Costly; works well on refractory organics
Physical operations Sedimentation/flotation	Removal of suspended matter	Of limited applicability alone; used in conjunction with other treatment processes
Filtration	Removal of suspended matter	Useful only as polishing step
Air Stripping	Removal of ammonia/volatiles	May require air pollution control equipment
Stream stripping	Removal of volatile organics	High energy costs; condensate steam requires further treatment
Adsorption	Removal of organics	Proven technology; variable costs depending on leachates
Ion exchange	Removal of dissolved inorganics	Useful only as a polishing step
Ultrafiltration	Removal of bacteria and high molecular weight organics	Subject to fouling; of limited applicability of leachates
Reverse Osmosis	Dilute solutions of inorganics	Costly; extensive pretreatment necessary
Evaporation	Where leachate discharge is not permissible	Resulting sludge may be hazardous; can be costly except in arid regions

Source: Tchobanoglous G., *et al* (1993) “Integrated Solid Waste Management – Engineering Principles and Management Issues”, McGraw-Hill International Editions.

Physico-chemical methods including adsorption, precipitation, oxidation, evaporation, and membrane filtration, have been suggested for removal of organic material, nitrogen and toxicity ***(Marttinen et al., 2002)***. ***Connolly et al. (2003)*** suggested that adsorption played a key role in removal of ammonia-N in waste water. Adsorption using limestone filter have been proposed by ***Hamidi et al. (2003)*** to remove iron from leachate as an alternative to activated carbon ***(Kargi et al., 2002)*** and zeolite filter ***(Lahav & Green, 1997; Rozic et al., 1998).*** While chemical precipitation by forming magnesium ammonium phosphate (MAP) has been successful in removing ammonia-N in leachate ***(Li et al., 2001)***.

Each method has their own efficiency in removing contaminants. The performance of treatment are assessed by monitoring on the efficiency of removing organic matter such as COD, total organic carbon (TOC), ammonia-nitrogen and heavy metals ***(Silva et al., 2003).*** The quality of leachate depends on the age of the landfill where young leachate can be treated more effectively compare to old ones. The longer the lifespan, the lower the biochemical oxygen demand (BOD_5) and BOD_5/COD value are obtained. This may be due to the high amount of readily degradable matters in waste and high moisture content which allows more organic compounds to dissolve in leachate and accelerates the microorganism decomposition ***(Irene & Lo, 1996).***

Leachate parameters such as BOD, COD and TOC can be used to evaluate the strength of leachate. The ratio of COD to TOC shows the organic matters in leachate and the BOD to COD ratio indicates changes in biodegradability. Older landfills have lower ratios compare to young landfills. **Figure 2.1** and **Figure 2.2** portraits the relationship between the parameters with time. Both ratios also show direct measurement for treatability of leachate. Higher ratio values indicate that leachate is easily biodegradable and can be treated using biological process.

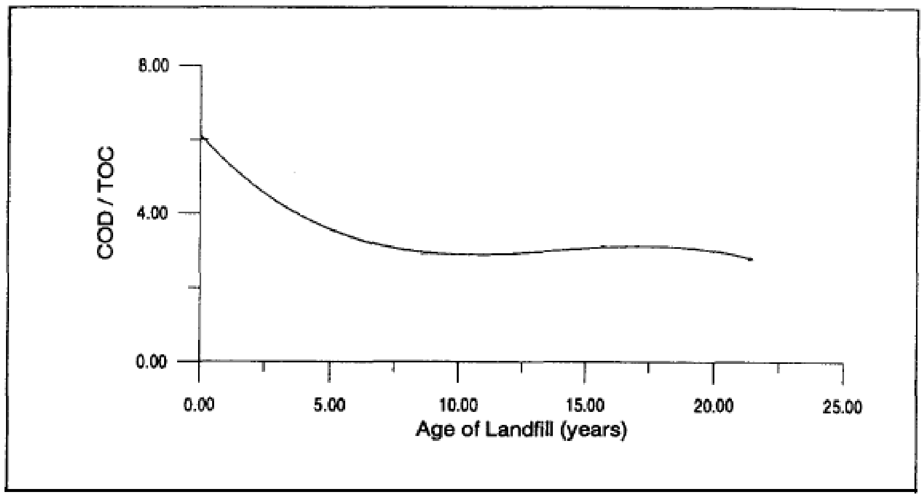

FIGURE 2.1: Change in COD/TOC ratio with age of landfill

Source: Irene & Lo, (1996). “Characteristics and treatment of leachates from domesticlandfills”