# BIOREMEDIATION TREATMENT OF OILY SLUDGE USING COMPOSTING METHOD

by

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FINAL YEAR RESEARCH PROJECT REPORT

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

JULY 2009



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# CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Programme
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Approved:

AP Dr Nasiman Sapari
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

July 2009

# CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained here in have not been undertaken or done by unspecified sources or persons.

Nor Asmat binti Adnan

## ABSTRACT

Oil extraction and processing operations in Malaysia have resulted in the production of large volumes of oily sludge, which constitute a severe pollution problem for this industry. The oily sludge contains crude oil (10-60%), water (30-90%) and petroleum solid particles (5-40%) in various proportions depending on its origin. The accumulation of oily residues in petroleum refineries poses a serious environmental problem, and it was the oily sludge generated from several activities in the oil industry that motivated this work, which has the overall aim of studying the bio treatment of oily sludge from PETRONAS Penapisan (Melaka) Sdn. Bhd. Previous investigations have found several factors limiting land farming which is large space requirements, the conditions advantageous for biological degradation of contaminants are largely uncontrolled, which increase the length of time to complete remediation, particularly for recalcitrant compounds and inorganic contaminants are not biodegraded. This paper presents the bioremediation treatment of oily sludge using composting method as the disposal process. The method that is use in this research is composting by introducing domestic waste to cultivate and enhance microbial degradation of this hazardous compound. Oily sludge (O) and domestic sludge (D) are incorporated into soil (S) surface and periodically turned over (tilled) to aerate the mixture. This sample scale for composting analysis of O: D: S mix of about 4: 3: 1. The mixture was composted for a period of one month. Samples were collected every week and analysed using leaching test for the level of COD and TOC. After one month the COD and TOC of the leachate reduce from 5166 mg/L and 4771 mg/L to 1033 mg/L and 738 mg/L respectively. The reductions were 80% for COD and 84% for TOC. From this research, conclusion can be deduced that domestic waste can enhance the microbial degradation of oily sludge.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| COD | Chemical Oxygen Demand |
| TOC | Total Organic carbon |
| TC | Total Carbon |
| TIC | Total Inorganic Carbon |
| O | Oily sludge |
| D | Domestic Sludge |
| S | Soil |

# CHAPTER 1
# INTRODUCTION

## 1.1 Background

The oil industry generates large quantities of oily and viscous residues, which are formed during production, transportation and refining. These residues, called oily sludge, are composed of oil, water, solids, and their characteristics, such as varied composition, make them highly recalcitrant and very difficult to reutilize.

The marked stability of the multiphase system is due to the adsorption of oil into solid particles, producing a highly protective layer (as they tend to settle to the bottom of the tanks), and also to the presence of surface-active compounds, which are responsible for the formation of emulsions.

It is estimated that approximately 1% of the total oil processed in PETRONAS Penapisan (Melaka) Sdn. Bhd. is discharged as oily sludge, usually after being accumulated in storage tanks for several years. Incineration of this sludge is not recommended due to the high energy costs involved, the potential risk of air pollution. Similarly, the inadequate disposal of such a very toxic residue in landfills encourages the search for alternatives.

Oil extraction and processing operations produce large volumes of oily sludge, which can constitute a severe pollution problem for oil industry. The oily sludge contains crude oil (10-60%), water (30-90%) and petroleum solid particles (5-40%) in various proportions depending on its origin. Nowadays, they use land farming method to treat the large volumes of oily sludge.

Composting, land farming and bio-piles are examples of bio treatment techniques which are reported to be effective in many cases. They all exploit soil biodiversity, but they have the disadvantage of requiring long treatment and there is the risk of contaminating air and aquifers by leaching. They also use up large areas and are affected by the climate.

This project is to study on oily sludge treatment using composting process as the disposal method. The treatment that method involve combining domestic waste and the sludge to cultivate and enhance microbial degradation of this hazardous compound.

## 1.2 Problem Statement

Land farming is an example of bio treatment techniques which are reported to be effective in many cases. It exploits soil biodiversity, but it has the disadvantage of requiring long treatment and there is the risk of contaminating air and aquifers by leaching. It also use up large areas and are affected by the climate.

Factors that may limit the applicability and effectiveness of the process include:

1. Large space requirements
2. It has the disadvantage of requiring long treatment and
3. there is the risk of contaminating air and aquifers by leaching
4. Inorganic contaminants are not biodegraded
5. The potential of large amounts of particulate matter released by operations
6. The presence of metal ions may be toxic to microbes and may leach from the contaminated soil into the ground.
7. Hydrocarbon compounds that have been identified as being not readily degraded by land farming include creosote, pentachlorophenol (pcp), and bunker oil.

### 1.3 Objectives and Scope of Study

Throughout this project, we choose bioremediation treatment process as the disposal. The method that we choose is composting of oily sludge by introducing domestic waste to cultivate and enhance microbial degradation of this hazardous compound.

The objective of the studies is to determine whether the domestic waste introduce can enhance the microbial degradation of oily sludge.

This project aims to examine bioremediation treatment of oily sludge by composting. Oily sludge samples in this study were taken from the PETRONAS Penapisan (Melaka) Sdn. Bhd.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Bioremediation Treatment

Bioremediation can be defined as any process that uses micro organisms, fungi, green plants or their enzymes to return the natural environment altered by contaminants to its original condition. Bioremediation may be employed to attack specific soil contaminants, such as degradation of chlorinated hydrocarbons by bacteria. An example of a more general approach is the cleanup of oil spills by the addition of nitrate and/or sulphate fertilisers to facilitate the decomposition of crude oil by indigenous or exogenous bacteria.

### 2.1.1 Land farming

Land Farming is a bioremediation treatment process that is performed in the upper soil zone or in mistreatment cells. Contaminated soil, sediments, or sludges are incorporated into the soil surface and periodically turned over (tilled) to aerate the mixture.

This technique has been successfully used for years in the management and disposal of oily sludge and other petroleum refinery wastes. In situ systems have been used to treat near surface soil contamination for hydrocarbons and pesticides. The equipment employed in land farming is typical of that used in agricultural operations. These land farming activities cultivate and enhance microbial degradation of hazardous compounds. As a rule of thumb, the higher the molecular weight (i.e., the more rings within a polycyclic aromatic hydrocarbon), the slower the degradation rate. Also, the more chlorinated or nitrated the compound, the more difficult it is to degrade.

Land farming gained popularity over incineration, land filling, and deep well injection due to its following distinct merits:

- Low energy consumption,
- low risk of pollution of the surface and groundwater due to the immobility of hydrocarbons or metals through the soil, (R.F. Hejazi, 2003)
- Minimal impact on the environment; good site appearance, absence of odours,
- Relatively low cost,
- Compliance with sound industrial practices and/or government regulations,
- Minimal residue disposal problems, and
- Compatibility of the technique with the climate, location and type of sludge treated.

### 2.1.2 Composting

Composting is the purposeful biodegradation of organic matter, such as yard and food waste. The decomposition is performed by micro-organisms, mostly bacteria, but also yeasts and fungi. In low temperature phases a number of macro-organisms, such as springtails, ants, nematodes, isopods and earthworms also contribute to the process, as well as soldier fly, fruit flies and fungus gnats. There are a wide range of organisms in the decomposer community.

- A biodegradable material is capable of being completely broken down under the action of microorganisms into carbon dioxide, water and biomass. It may take a very long time for some material to biodegrade depending on its environment such as wood in an arid area versus paper in water, but it ultimately breaks down completely. Many contaminating materials not dealt with in common composting are in fact biodegradable, and may be dealt with via bioremediation, or other special composting approaches.

- A compostable material biodegrades substantially under specific composting conditions. It is metabolized by the microorganisms, being incorporated into the organisms or converted into humus. The size of the material is a factor in determining compostability, and mechanical particle size reduction can speed the process. Large pieces of hardwood may not be compostable under a specific set of composting conditions, whereas sawdust of the same type of wood may be. Some biodegradable materials are only compostable under very specific conditions, usually with an industrial process.

Composting organisms require four equally important things to work effectively:

- Carbon ("C" or carbohydrates), for energy - the microbial oxidation of carbon produces the heat.
  - High carbon materials tend to be brown and dry.
- Nitrogen ("N" or protein), to grow and reproduce more organisms to oxidize the carbon.
  - High nitrogen materials tend to be green (or colorful, like fruits and vegetables) and wet.
- Oxygen, for oxidizing the carbon, the decomposition process.
- Water, in the right amounts to maintain activity without causing anaerobic conditions.

Certain ratios of these elements will provide beneficial bacteria with the nutrients to work at a rate that will heat up the pile. In that process much water will be released as vapor (steam), and the oxygen will be quickly depleted, explaining the need to actively manage the pile. The hotter the pile gets, the more often added air and water is necessary; the air/water balance is critical to maintaining high temperatures until the materials are broken down. At the same time, too much air or water also slows the process, as does too much C (or too little N). (Beffa, 1996)

The most efficient composting occurs with a C: N mix of about 30 to 1. All organics have both carbon and nitrogen, but amounts vary widely, with characteristics noted above (dry/wet, brown/green).Fresh grass clippings have an average ratio of about 15 to 1 and dry autumn leaves about 50 to 1 depending on species. Mixing equal parts by volume approximates the ideal C: N range. Few individual situations will provide the ideal mix of materials at any point in time - in this respect, home composting is like horseshoes, perfect is great, but close still works. Observation of amounts and consideration of different material as a pile is built over time can quickly achieve a workable technique for the individual situation.

Ingredients that are primarily carbon include:

- Dry, straw-type material, such as cereal straws and corn stalks
- Dry leaves (best shredded, as with a rotary mower, to prevent matting)
- Wood, as coarse or fine (may compact) sawdust, or ground wood waste

Paper and card board, both unprinted and printed are not recommended as both the inks and paper contain materials such as pigments, clays, binders, etc that are not biodegradable. While these insoluble ingredients are not toxic, they will not readily break down as other biodegradable materials. In addition, paper will decompose very slowly interfering with the composting process.

Ingredients with relatively high nitrogen content include:

- Green plant material, like crop residues, hay (especially alfalfa), grass clippings and weeds.
- Manure from poultry, and herbivorous animals such as horses, cows and llamas.
- Kitchen waste - fruit and vegetable cooked waste and trimmings, juicing-pulp residue, tea and coffee grounds.

In composting, there are two approaches which are:

- Active (aerobic)
- Passive (anaerobic)

**2.1.2.1 Active (aerobic)**

Hot thermophilic composting is essential with some materials, such as meat and other animal products, dairy products, eggs, grease, cooking oil, manure of non-herbivores, and residuals from the treatment of wastewater, in order to kill pathogens; but these materials are not generally recommended in home composting because of the likelihood of creating odors and attracting rodents. Human waste can be composted by industrial methods as well as composting toilets. When high temperatures are reached, the resulting compost can be safely used for agricultural or horticultural purposes, providing local health regulations are met. Humanure fertilizer (as opposed to night soil) is used throughout the developing world and is becoming more accepted as a garden amendment in the developed world.

Hot, aerobic composting is conducted at close to the ideal conditions noted above, allowing thermophilic bacteria to thrive. These aerobic bacteria break down material faster, producing less odor, fewer pathogens, and less greenhouse gas than cool, uncontrolled, or accidental anaerobic methods. Commercial scale composting operations actively control the composting conditions (C:N ratio, moisture level and air), usually in a closed environment (in-vessel composting, tunnel composting or aerated static pile composting), where air is fan forced through the mass, and moisture added with sprayers, or conserved via the enclosure, with computer monitored probes detecting conditions. (Xuesong Li , 2008)

High temperatures destroy insects, larvae, and weed seeds, but no compost will be totally sterilized by high temperatures alone. In hot compost where the temperature exceeds 55 °C (131 °F) for several days, the ability of most organisms to survive is compromised, and there are temperature standards set by various regulating authorities for commercial products Nevertheless, many organisms in nature can survive extreme temperatures, including extremophiles such as Thermus thermophilus which play an important role in thermogenic composting, as well as pathogens such as Clostridium. The necessary second stage of hot composting is maturation, a period allowing the dissipation of any phyto-toxins remaining from the process or contaminating ingredients (eg: chemical residues), and achieving a state of nutrient stability (low C:N ratio) that will not have an impact on Nitrogen availability in the receiving soil. (Beffa, T, 1996)

#### 2.1.2.2 Passive (anaerobic)

Cool or ambient temperature composting, when the level of physical intervention is minimal, usually results in temperatures never reaching above 30°C (86°F). It is slower but effective, and is the more common type of composting in domestic gardening. Such composting systems may be in open or closed containers of wood or plastic, or in open exposed piles. Kitchen scraps are put in the garden compost bin and left untended. This scrap bin can have a very high water content which reduces aeration, and may become odorous. To improve drainage and airflow, and reduce odor, carbon-rich materials, or 'browns', such as wood chips, shredded bark, leaves, or twigs may be added to mix and cover each wet addition, or holes made occasionally in the pile. The amount of attention may vary from none through occasional to regular. (Oppelt, 1968)

## 2.2 Parameter Test

Parameter is a quantity that defines certain characteristics of systems or functions. This parameter test is to determine whether the domestic waste introduce can enhance the microbial degradation of oily sludge. Three parameters that is chosen to be use is Chemical Oxygen Demand (COD) Test, Paper Chromatography Test and pH measurement.

### 2.2.1 Chemical Oxygen Demand (COD) Test

COD or Chemical Oxygen Demand is the total measurement of all chemicals in the water that can be oxidized. A COD test measures all organic carbon with the exception of certain aromatics (benzene, toluene, phenol, etc.) which are not completely oxidized in the reaction. COD is a chemically chelated/thermal oxidation reaction, and therefore, other reduced substances such as sulfides, sulfites, and ferrous iron will also be oxidized and reported as COD. NH3-N (ammonia) will NOT be oxidized as COD.

COD uses strong chemicals to oxidize organic matter. Generally, COD is preferred to BOD for process control measurements because results are more reproducible and are available in just two hours rather than five days. By the time you have the results from a five day test, the plant conditions are no longer the same, so real time monitor and control can not be relied upon by the use of BOD. COD is a quick and easy measurement to get a snap in time picture of what is going on in the system and with trending, long term predictions can be made and monitor and control of the process at the wastewater treatment plant can be optimized and controlled.

### 2.4.2 pH Test

pH is a measure of the acidity or basicity of a solution. It is defined as the co logarithm of the activity of dissolved hydrogen ions ($H^+$). Hydrogen ion activity coefficients cannot be measured experimentally, so they are based on theoretical calculations. The pH scale is not an absolute scale; it is relative to a set of standard solutions whose pH is established by international agreement.

The concept of pH was first introduced by Danish chemist Søren Peder Lauritz Sørensen at the Carlsberg Laboratory in 1909. It is unknown what the exact definition of p is. Some references suggest the p stands for "Power", others refer to the German word "Potenz" (meaning power in German), still others refer to "potential". Jens Norby published a paper in 2000 arguing that p is a constant and stands for "negative logarithm"; which has also been used in other works. H stands for Hydrogen. Sørensen suggested the notation "PH" for convenience, standing for "power of hydrogen", using the cologarithm of the concentration of hydrogen ions in solution, p[H] Although this definition has been superseded p[H] can be measured if an electrode is calibrated with solution of known hydrogen ion concentration.

Pure water is said to be neutral. The pH for pure water at 25 °C (77 °F) is close to 7.0. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are said to be basic or alkaline. pH measurements are important in medicine, biology, chemistry, food science, environmental science, oceanography and many other applications.

### 2.2.4 Total Organic Carbon (TOC)

Inorganic carbon forms are derived from geologic or soil parent material sources. Inorganic carbon forms are present in soils and sediments typically as carbonates. The two most common carbonate minerals found in soils and sediments are calcite (CaCO3) and dolomite [$CaMg(CO_3)_2$] although other forms may be present (e.g., siderite, $FeCO_3$) depending on where the soils were formed or where the sediment source was located. It should be noted that calcite and to some extent, dolomite, may also be present in soils and sediments due to agricultural input.

The naturally-occurring organic carbon sources are sources that are derived as a result of contamination through anthropogenic activities. The spills or releases of contaminants into the environment increase the total carbon content present in the soil or sediment. In general, though, the total carbon contribution from contaminants (typically measured in the g/kg to mg/kg concentration range) to the total organic carbon content (measured in the % range) of the soil or sediment is relatively small to negligible unless a fresh spill has occurred, pure product is present, or a hot spot is sampled.

In contrast to spilled contaminants, various sites may contain discrete organic carbon bearing particles such as wood fibers from pulp mill wastes or leather scraps from tannery wastes. At these locations, the total carbon content contribution of these wastes may be a significant to dominant fraction of the TOC determined for the sample. It should be noted that the methods for determining total organic carbon and total carbon contents generally do not distinguish between the sources of the organic carbon forms. Nonetheless, there are two methods noted below that are capable of qualitatively identifying carbon forms in the soil/sediment, and two methods that analyze specific fractions of the TOC.

Total carbon is calculated as:-

$$\text{Total Carbon} = \text{Inorganic Carbon} + \text{Organic Carbon}$$

TOC content can be measured directly or can be determined by difference if the total carbon content and inorganic carbon contents are measured.

$$\text{Total Organic Carbon} = \text{Total Carbon} - \text{Inorganic Carbon}$$

# CHAPTER 3
# METHODOLOGY/PROJECT WORK

## 3.1 Methodology chart

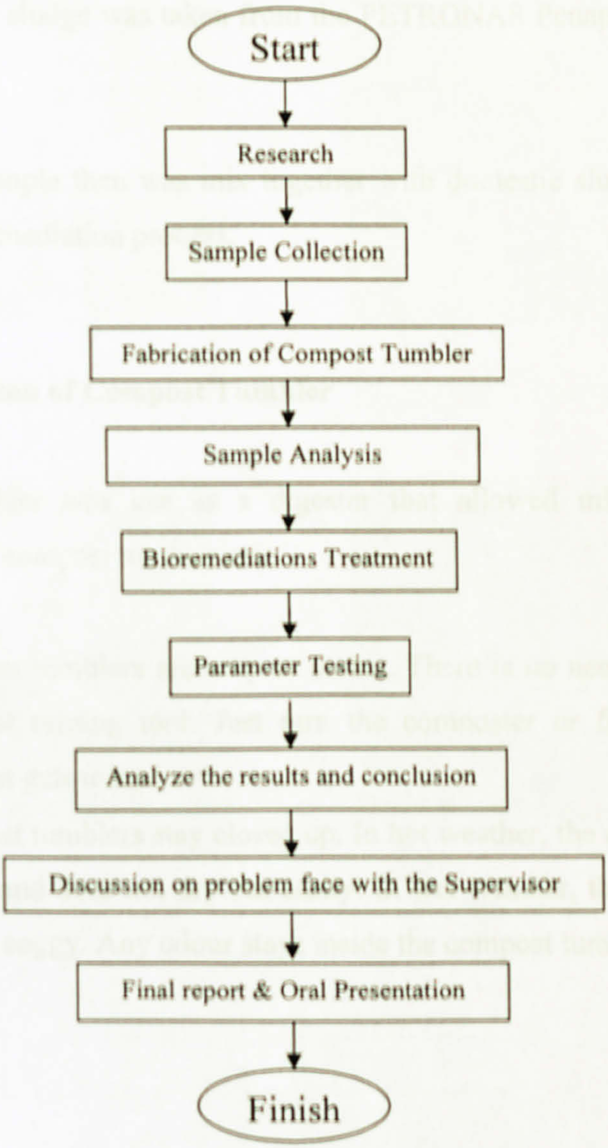


**Figure 3.1** Methodology chart

### 3.1.1 Research.

The method that was used in this project is composting of oily sludge by introducing domestic waste to cultivate and enhance microbial degradation of this hazardous compound.

### 3.1.2 Sample Collection

Sample of oily sludge was taken from the PETRONAS Penapisan (Melaka) Sdn. Bhd.

Oily sludge sample then was mix together with domestic sludge, peak soil, and water for bioremediation process.

### 3.1.3 Fabrication of Compost Tumbler

Compost tumbler was use as a digester that allowed mixing and aeration. Advantages of compost tumbler are:

- Compost tumblers are easy to aerate. There is no need to pitchfork, or a compost turning tool. Just turn the composter or flip it over and the compost gets mixed.
- Compost tumblers stay closed up. In hot weather, the compost stays damp longer and does not dry out easily. In wet weather, the compost does not get too soggy. Any odour stays inside the compost tumbler.

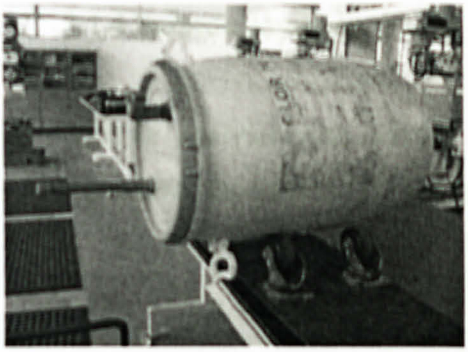

**Figure 3.2** Compost Tumbler

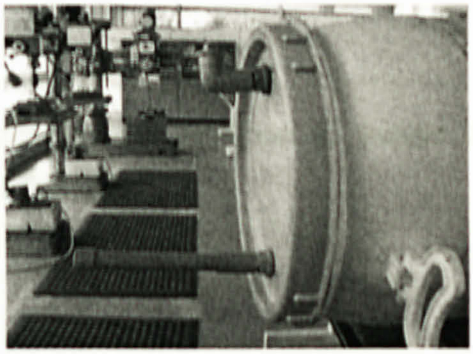

**Figure 3.3** Compost Tumbler(side view)

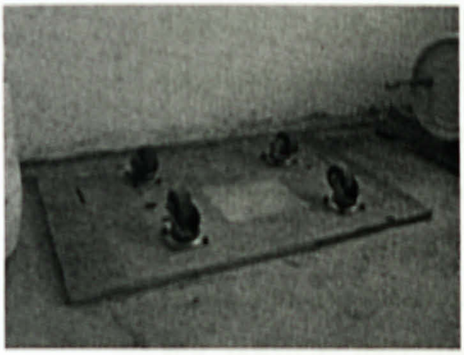

**Figure 3.4** Roller Base 1(side view)

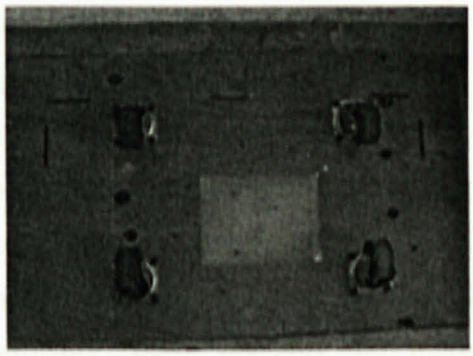

**Figure 3.5** Roller Base 1(top view)

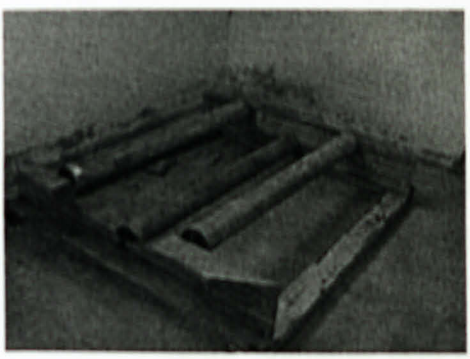

**Figure 3.6** Roller Base 2(side view)

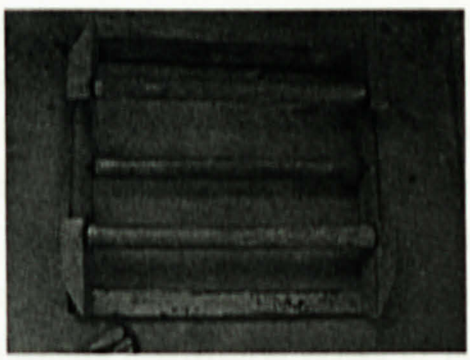

**Figure 3.7** Roller Base 2(top view)

### 3.1.4 Sample Analysis

Sample analysis was carried out to determine the condition of sample that. Parameter used was COD test, pH test and TOC test.

#### 3.1.4.1 COD Test

The Chemical Oxygen Demand (COD) test measures the oxygen equivalent consumed by organic matter in a sample during strong chemical oxidation. The strong chemical oxidation conditions are provided by the reagents used in the analysis. Potassium dichromate is used as the oxygen source with concentrated sulphuric acid added to yield a strong acid medium. Several reagents are added during the set up of the analysis to drive the oxidation reaction to completion and also to remove any possible interference. Specifically, these reagents are mercuric sulphate, silver sulphate and sulfamic acid. Mercuric sulphate is added to remove complex chloride ions present in the sample. Without the mercuric sulphate the chloride ions would form chlorine compounds in the strong acid media used in the procedure. These chlorine compounds would oxidize the organic matter in the sample, resulting in a COD value lower than the actual value. Silver sulphate is added as a catalyst for the oxidation of short, straight chain organics and alcohols. Again, without the silver sulphate the COD of the sample would be lower than the actual value. Sulfamic acid is added to remove interferences caused by nitrite ions. Without sulfamic acid the COD of the sample would measure higher than the actual value.

Even with the use of these additional reagents the oxidation of the organic matter is not always 100% complete. Volatile organics, ammonia and aromatic hydrocarbon are not oxidized to any great degree during the procedure.

The advantages of the COD test as compared to the BOD test are:

1. COD results are available much sooner.
2. The COD test requires fewer manipulations of the sample.
3. The COD test oxidizes a wider range of chemical compounds.
4. It can be standardized more easily.

The major disadvantage of the COD test is that the results are not directly applicable to the 5-day BOD results without correlation studies over a long period of time. The samples used for the COD analysis may be grab or composite. Preservation of the sample can be accomplished by adding sulphuric acid to depress the pH to 2 and the holding time with preservation is 7 days.

**3.1.4.2 pH Measurement**

Depending on the pH meter used and the electrode used procedure can look slightly different, but in most cases pH measurements procedure will be at least very similar.

First of all - remember, that the electrode should be always immersed. Thus between pH measurements it should be put into a baker with distilled water or - much better - KCl solution (0.1M to 1M).

Second, equally important thing is - the electrode is very fragile. Bubble at the end is made of very thin glass - the thinner the glass, the lower the internal electrode resistance, which is good for measurements. At the same time thin glass is very delicate, thus you should treat your electrode with care.

Ensure that pH meter is on. If you want high precision of measurements it is better to let the pH meter to warm up for some time (like 30 minutes) to ensure it will not drift later.

Before every single pH measurement, or before any series of uses, you must calibrate pH electrode.

After calibration you are ready to measure pH. Rinse electrode and submerge it in the tested solution. Read the result and write it down in your lab notebook. Rinse the electrode and move it to the storage baker.

### 3.1.4.3 TOC

Total organic carbon (TOC) provides a speedy and convenient way of determining the degree of organic contamination. A carbon analyzer using an infrared detection system is used to measure total organic carbon. Organic carbon is oxidized to carbon dioxide.

The CO2 produced is carried by a "carrier gas" into an infrared analyzer that measures the absorption wavelength of CO2. The instrument utilizes a microprocessor that will calculate the concentration of carbon based on the absorption of light in the CO2. The amount of carbon will be expressed in mg/L. Two other test methods that offer organic contamination information are biochemical oxygen demand (BOD) and chemical oxygen demand (COD). However, TOC provides a more direct expression of the organic chemical content of water than BOD or COD.

By using TOC measurements, the number of carbon-containing compounds in a source can be determined. This is important because knowing the amount of carbon in a freshwater stream is an indicator of the organic character of the stream. The larger the carbon or organic content, the more oxygen is consumed. A high organic content means an increase in the growth of microorganisms which contribute to the depletion of oxygen supplies. The source of this organic material could be a wastewater treatment plant releasing treated sewage into the stream. Both the plant effluent and the stream must be monitored for organic levels. Industrial waste effluent may contain carbon-containing compounds with various toxicity levels. Both of these situations can create unfavorable conditions for aquatic life, such as the depletion of oxygen and the presence of toxic substances.

Total carbon is calculated as:-

Total Carbon = Inorganic Carbon + Organic Carbon

TOC content can be measured directly or can be determined by difference if the total carbon content and inorganic carbon contents are measured.

Total Organic Carbon = Total Carbon - Inorganic Carbon

**3.1.5 Bioremediation Treatment**

Oily sludge, domestic sludge are incorporated into soil surface and periodically turned over (tilled) to aerate the mixture. Water will be added to keep the moisture content in the mixture. Figure below shows bioremediation treatment.

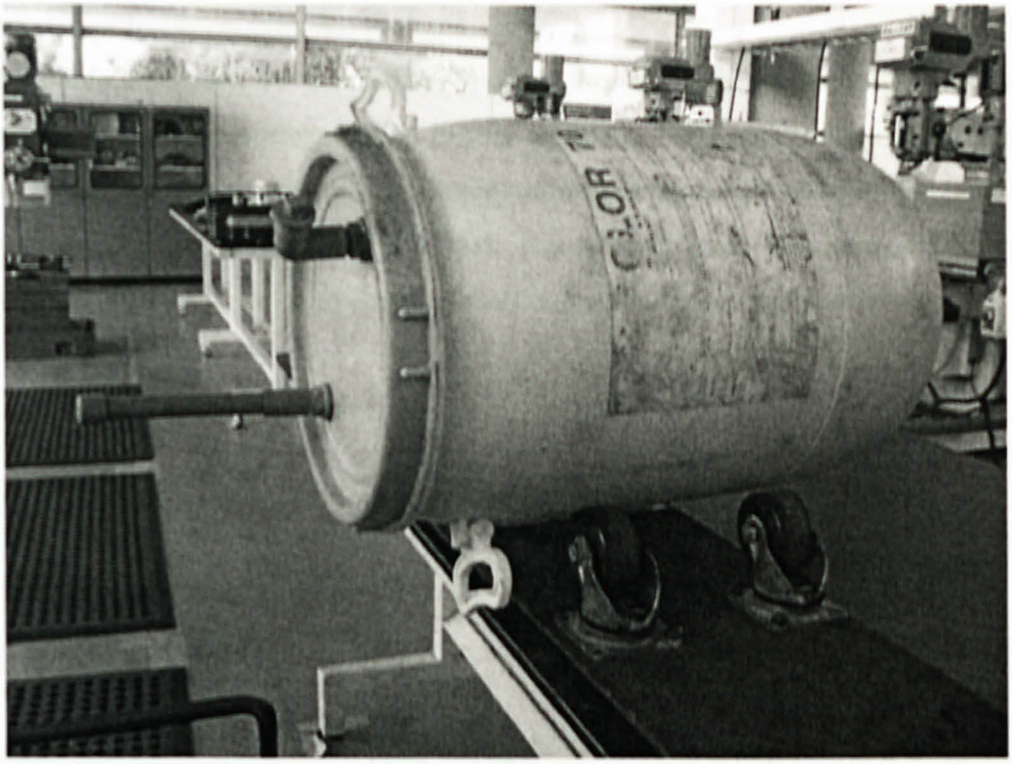

**Figure 3.8** Compost Tumbler

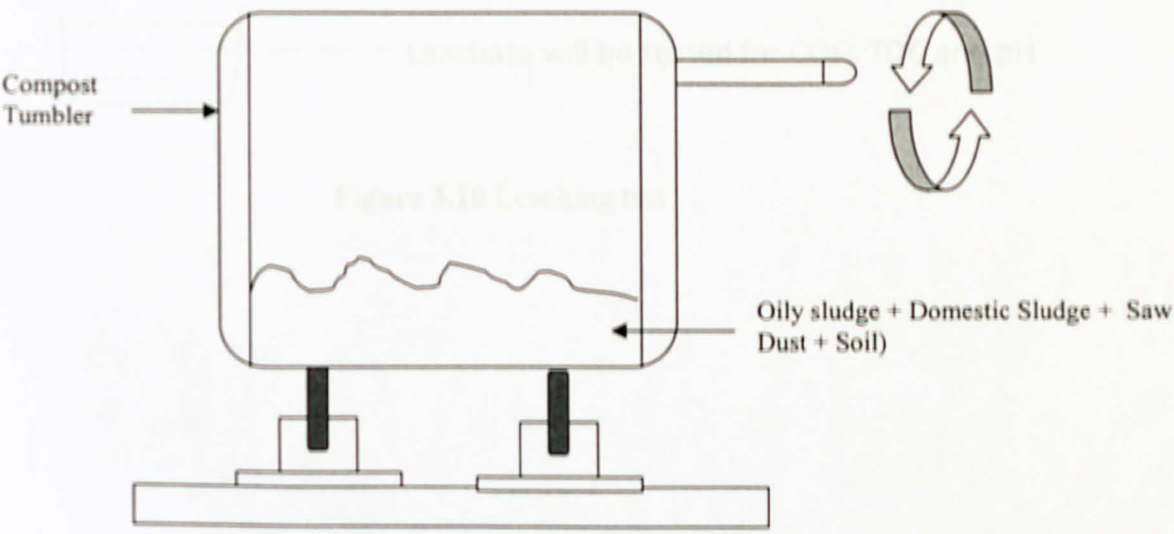


**Figure 3.9** Compost Tumbler (cross section)

The parameter used to determine whether the domestic waste introduce can enhance the microbial degradation of oily sludge is COD and TOC. The test was conducted before and after the bioremediation treatment. A portion of the sample was taken out to conduct leaching test. The leachate then was analysed for its COD and TOC. Figure below shows how the leaching test was conducted.

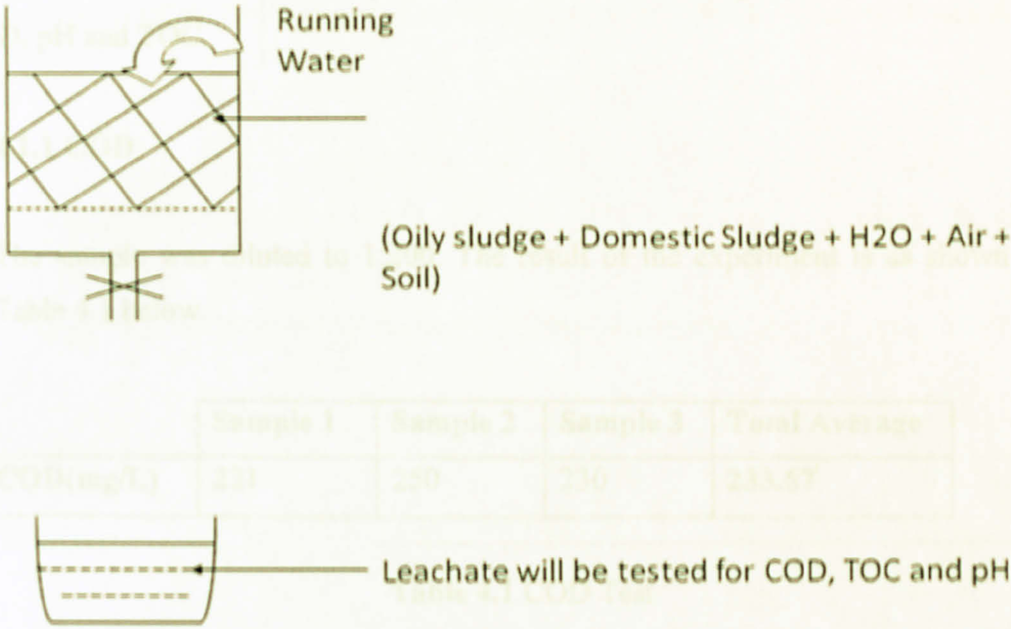


**Figure 3.10** Leaching test

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 Sample Analysis of Oily Sludge

Sampling was carried out for quality determination of the sludge. The parameter used was COD, pH and TOC.

### 4.1.1 COD

The sample was diluted to 1:200. The result of the experiment is as shown in Table 4.1 below.

| | **Sample 1** | **Sample 2** | **Sample 3** | **Total Average** |
|---|---|---|---|---|
| **COD(mg/L)** | 221 | 250 | 230 | **233.67** |

**Table 4.1** COD Test

COD = (Total Average)*Dilution

= (233.67)*200

= 40,134 mg/L COD

### 4.1.2 pH

The result of the experiment is ad shown in Table 4.2 below.

| | Reading 1 | Reading 2 | Reading 3 | Average pH |
|---|---|---|---|---|
| **pH** | 6.97 | 6.90 | 6.89 | **6.92** |

**Table 4.2** pH Test

Pure water is said to be neutral. The pH for pure water at 25 °C (77 °F) is close to 7.0. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are said to be basic or alkaline. pH measurements are important in medicine, biology, chemistry, food science, environmental science, oceanography and many other applications. Our sample is more likely close to 7 which is neutral.

### 4.1.3 TOC

The Result of the experiment is shown in Table 4.3 below.

| | Reading 1 | Reading 2 | Reading 3 | Reading 4 | Average |
|---|---|---|---|---|---|
| **TC** (ppm) | 726.867 | 735.617 | 734.770 | 732.418 | 732.418 |
| **TIC** (ppm) | 143.775 | 143.854 | 147.663 | 145.098 | 145.098 |
| | | | | **TOC** | **587.32** |

**Table 4.3** TOC Test

$$\begin{aligned} TOC &= \text{Average TC} - \text{Average TIC} \\ &= 732.418 - 145.098 \\ &= 587.32 \text{ ppm} \end{aligned}$$

TOC test is carried out to determining the degree of organic contamination. A carbon analyzer using an infrared detection system is used to measure total organic carbon. Organic carbon is oxidized to carbon dioxide.

Total carbon is calculated as:-

$$\text{Total Carbon} = \text{Inorganic Carbon} + \text{Organic Carbon}$$

TOC content can be measured directly or can be determined by difference if the total carbon content and inorganic carbon contents are measured.

$$\text{Total Organic Carbon} = \text{Total Carbon} - \text{Inorganic Carbon}$$

**4.2 Bioremediation Treatment**

Oily sludge (O) and domestic sludge (D) are incorporated into soil (S) surface and periodically turned over (tilled) to aerate the mixture. Water will be added to give moisture to the mixture. Saw dust is added to balance the moisture content and to make sure that the mixture has the suitable medium for the micro-organisms to decompose.

In this research, three tests were run, sample 1, sample 2, and sample 3. Sample 1 and sample 2 were conducted simultaneously with different portion of mixture for one week. Sample 3 was run for the extended version of test 2 to see the reduction of COD and TOC after four weeks.

All samples were evaluated using COD test and TOC test. The pH, moisture content and temperature were also been closely monitor. Below are the test results of the entire sample:-

Sample 1

This sample scale for composting analysis of O: D: S mix of about 1: 1: 1. Sample is evaluated before treatment and after treatment (one week).

1) COD

The result of COD of sample 1 is as shown in Table 4.4 below.

| | Reading 1 | Reading 2 | Reading 3 | Average COD (mg/L) |
|---|---|---|---|---|
| **Before** | 4200 | 6200 | 5600 | **5333.33** |
| **After** | 8000 | 9000 | 8300 | **8433.33** |

**Table 4.4** COD Test for sample 1

From Table 4.4, the values of chemical content that can be oxidize increased from 5333 mg/L to 8433 mg/L after 7 days. This shows that the microorganisms action in degrading biodegradable material into smaller chain and producing leachate which can lead to higher COD.

2) pH

The result of the experiment is ad shown in Table 4.5 below.

| | Reading 1 | Reading 2 | Reading 3 | Average pH |
|---|---|---|---|---|
| **Before** | 7.93 | 7.97 | 8.01 | **7.97** |
| **After** | 7.92 | 8.1 | 8.1 | **8.04** |

**Table 4.5** pH Test for sample 1

pH of the sample is the measure of acidity or alkalinity in the composting system, which determines the various chemical and biological interactions occurring within. The composting samples were found to be alkaline throughout the study period with pH ranging from 7.9 to 8.0, which could be attributed to the dissolved alkaline substances.

3) TOC

The Result of the experiment is shown in Table 4.3 below.

| | TC (ppm) | TIC (ppm) | TOC (ppm) |
|---|---|---|---|
| **Before** | 2933 | 2202 | **1068.00** |
| | 2030 | 746 | |
| | 1913 | 724 | |
| | 2292 | 1224 | |
| **After** | 2312 | 832 | **1344.50** |
| | 2199 | 837 | |
| | 2127 | 936 | |
| | 2213 | 868 | |

**Table 4.6** TOC Test for sample 1

Table 4.6 shows that total organic carbon also reduced after 7 days but only in small amount form 1068ppm to 1344ppm. This shows that the degree of organic contamination is reduced.

4) Moisture Content

The Result of the moisture content of sample 1 is shown below.

moisture before : 51.08%
Time (min) : 57.6
weight (g): 10

moisture after : 47.09%
Time (min) : 14.6
weight (g): 1

Moisture content of the sample is determined using moisture analyser. Moisture analyser is used as a quick and reliable means of determining the moisture content in powders and liquids by the thermo graphic process. The term moisture does not just relate to water, it also encompasses all substances which evaporate when they are heated. Along side water, they include fats, oil, alcohol and solvents.

5) Temperature

| Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Temperature (0C) | 28 | 28 | 29 | 29 | 30 | 30 | 30 |

**Table 4.7** Temperature of sample 1

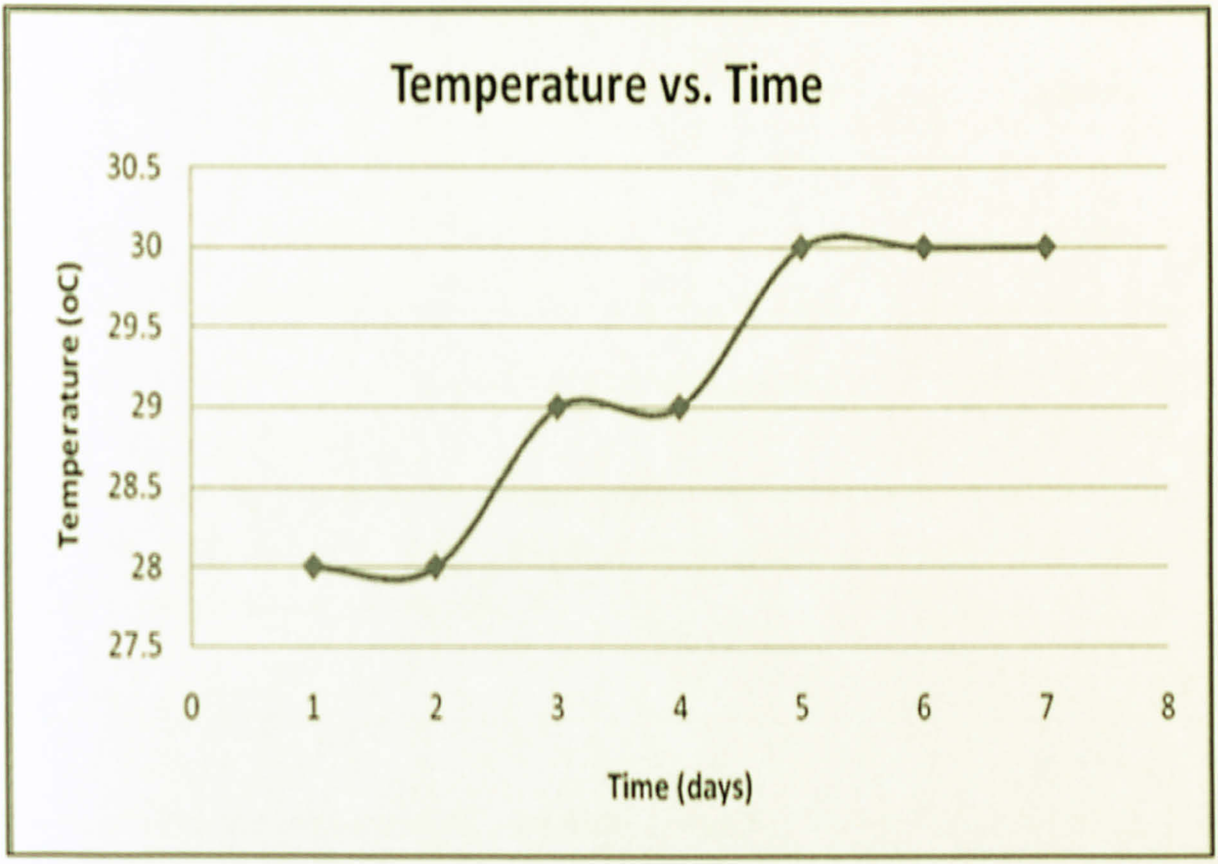


**Figure 4.1** Temperature versus Time for sample 1

The slightly increase in temperature shows that there is microbial degradation. Cool or ambient temperature composting, when the level of physical intervention is minimal, usually results in temperatures slightly reaching above 30°C (86°F). It is slower but effective, and is the more common type of composting in domestic gardening. Such composting system is in closed containers of plastic.

1) COD

The result of COD of sample 2 is as shown in Table 4.8 below.

| | Reading 1 | Reading 2 | Reading 3 | Average COD (mg/L) |
|---|---|---|---|---|
| Before | 3000 | 3000 | 3000 | 3000.00 |
| After | 1000 | 1000 | 500 | 833.33 |

Table 4.8 COD Test for sample 2

From Table 4.8, the reduction of chemical content that can be oxidized reduce from 3000 mg/L to 833 mg/L after 7 days. This shows a large number of reduction of chemical content in sample that can be oxidized.

2) pH

The result of the experiment is as shown in Table 4.9 below.

Sample 2

This sample scale for composting analysis of O: D: S mix of about 4: 3: 1. Sample is evaluated before treatment and after treatment (one week).

1) COD

The result of COD of sample 2 is as shown in Table 4.8 below.

| | Reading 1 | Reading 2 | Reading 3 | Average COD (mg/L) |
|---|---|---|---|---|
| **Before** | 3000 | 3000 | 3000 | **3000.00** |
| **After** | 1000 | 1000 | 500 | **833.33** |

**Table 4.8** COD Test for sample 2

From Table 4.8, the reductions of chemical content that can be oxidized reduce from 3000 mg/L to 833 mg/L after 7 days. This shows a huge number of reduction of chemical content in sample that can be oxidized.

2) pH

The result of the experiment is ad shown in Table 4.9 below.

| | Reading 1 | Reading 2 | Reading 3 | Average pH |
|---|---|---|---|---|
| **Before** | 6.89 | 6.86 | 6.54 | **6.86** |
| **After** | 7.62 | 7.21 | 7.01 | **7.28** |

**Table 4.9** pH Test for sample 2

pH of the sample is the measure of acidity or alkalinity in the composting system, which determines the various chemical and biological interactions occurring within. The composting samples were found to be neutral throughout the study period with pH ranging from 6.8 to 7.2.

3) TOC

The Result of the experiment is shown in Table 4.10 below.

| | TC (ppm) | TIC (ppm) | TOC (ppm) |
|---|---|---|---|
| **Before** | 3594 | 286 | **3269.00** |
| | 3694 | 281 | |
| | 3342 | 256 | |
| | 3543 | 274 | |
| **After** | 3335 | 277 | **2940.75** |
| | 3238 | 274 | |
| | 3089 | 287 | |
| | 3221 | 280 | |

**Table 4.10** TOC Test for sample 2

Table 4.10 shows that total organic carbon also reduced after 7 days but only in small amount form 3269ppm to 2940ppm. This shows that the degree of organic contamination is reduced.

4) Moisture Content

The Result of the moisture content of sample 2 is shown below.

| | |
|---|---|
| moisture before : | 28.98% |
| Time (min) : | 24.6 |
| weight (g): | 2 |
| | |
| moisture after : | 32.67% |
| Time (min) : | 14.6 |
| weight (g): | 1 |

Moisture content of the sample is determined using moisture analyser. Moisture analyser is used as a quick and reliable means of determining the moisture content in powders and liquids by the thermo graphic process. The term moisture does not just relate to water, it also encompasses all substances which evaporate when they are heated. Along side water, they include fats, oil, alcohol and solvents.

5) Temperature

| Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Temperature (0C) | 29 | 30 | 30 | 31 | 32 | 32 | 31 |

**Table 4.11** Temperature of sample 2

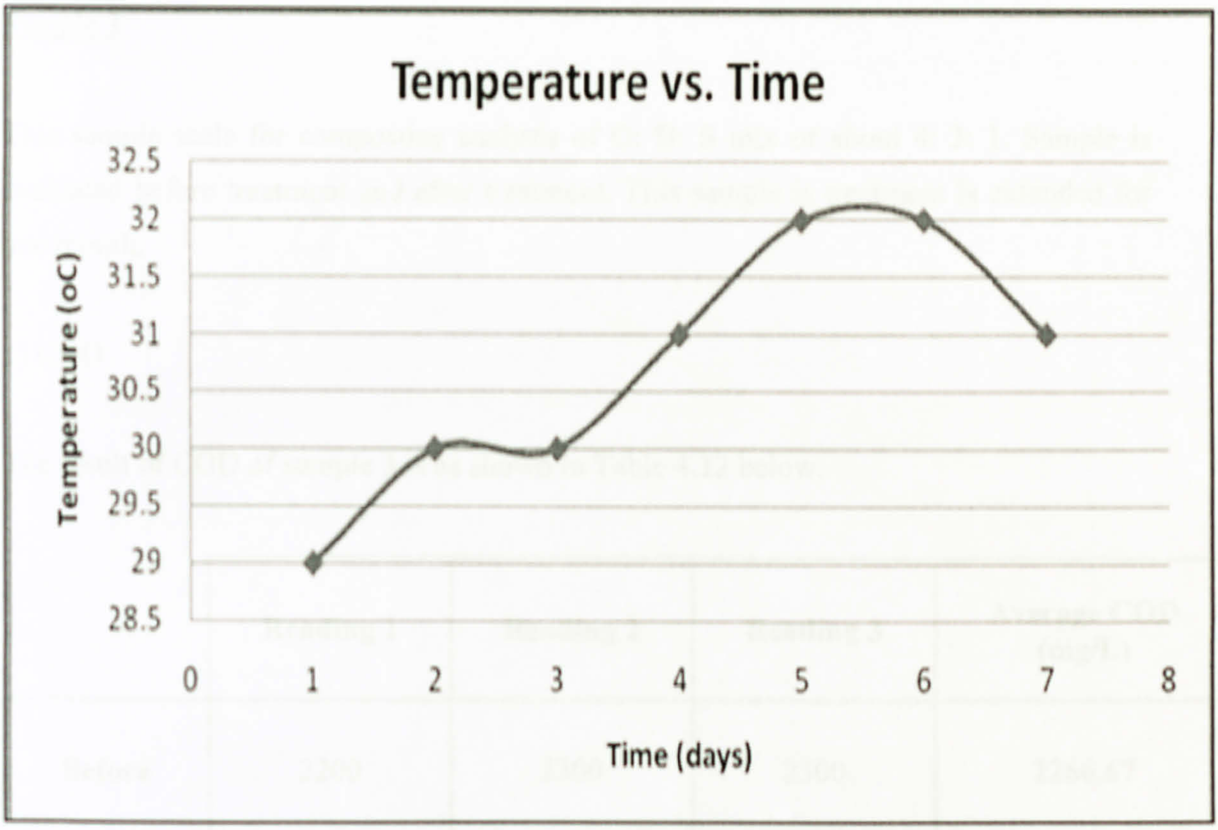


**Figure 4.2** Temperature versus Time for sample 2

From figure 4.2, the temperature slightly reach above 30°C .The slightly increase in temperature shows that there is microbial degradation. Cool or ambient temperature composting, when the level of physical intervention is minimal, usually results in temperatures slightly reaching above 30°C (86°F). It is slower but effective, and is the more common type of composting in domestic gardening. Such composting system is in closed containers of plastic.

Sample 3

This sample scale for composting analysis of O: D: S mix of about 4: 3: 1. Sample is evaluated before treatment and after treatment. This sample is treatment is extended for one month.

1) COD

The result of COD of sample 3 is as shown in Table 4.12 below.

| | Reading 1 | Reading 2 | Reading 3 | Average COD (mg/L) |
|---|---|---|---|---|
| **Before** | 2200 | 2300 | 2300 | **2266.67** |
| **Week 1** | 5000 | 5200 | 5300 | **5166.67** |
| **Week 2** | 3900 | 3800 | 3400 | **3700.00** |
| **Week 3** | 2600 | 2500 | 2400 | **2500.00** |
| **Week 4** | 1200 | 1000 | 900 | **1033.33** |

**Table 4.12** COD Test for sample 3

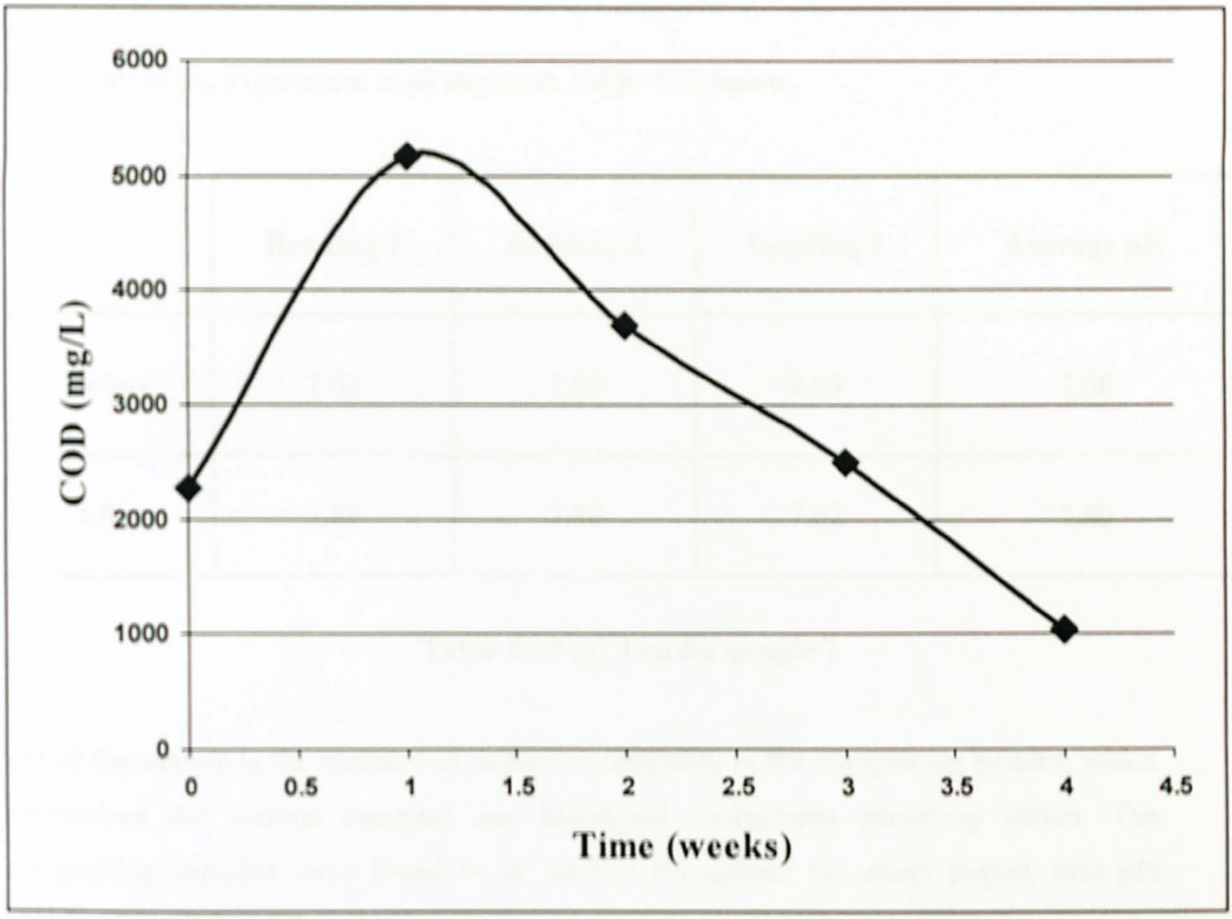


**Figure 4.3** COD versus Time for sample 3

From figure 4.3, the COD values slightly increase for the first week then reduce after 3 weeks. The COD values form initial stage to the last shows huge number of reduction of chemical content in sample that can be oxidized.

2) pH

The result of the experiment is ad shown in Table 4.13 below.

| | Reading 1 | Reading 2 | Reading 3 | Average pH |
|---|---|---|---|---|
| **Before** | 7.63 | 7.56 | 7.55 | **7.58** |
| **After** | 7.88 | 7.89 | 7.62 | **7.80** |

**Table 4.13** pH Test for sample 3

pH of the sample is the measure of acidity or alkalinity in the composting system, which determines the various chemical and biological interactions occurring within. The composting samples were found to be neutral throughout the study period with pH ranging from 7.5 to 7.8.

3) TOC

The result of the experiment is shown in Table 4.14 below.

| | TC (ppm) | TIC (ppm) | TOC (ppm) |
|---|---|---|---|
| **Before** | 5428 | 564 | **4771** |
| | 5317 | 564 | |
| | 5258 | 564 | |
| | 5334 | 561 | |
| **Week 1** | 3235 | 832 | **2402** |
| | 3238 | 837 | |
| | 3259 | 836 | |
| | 3221 | 868 | |
| **Week 2** | 2312 | 378 | **1967** |
| | 2399 | 328 | |
| | 2327 | 332 | |
| | 2213 | 346 | |
| **Week 3** | 1312 | 277 | **1010** |
| | 1298 | 276 | |
| | 1237 | 287 | |
| | 1213 | 280 | |
| **Week 4** | 832 | 66 | **783** |
| | 837 | 60 | |
| | 836 | 55 | |
| | 868 | 60 | |

**Table 4.14** TOC Test for sample 3

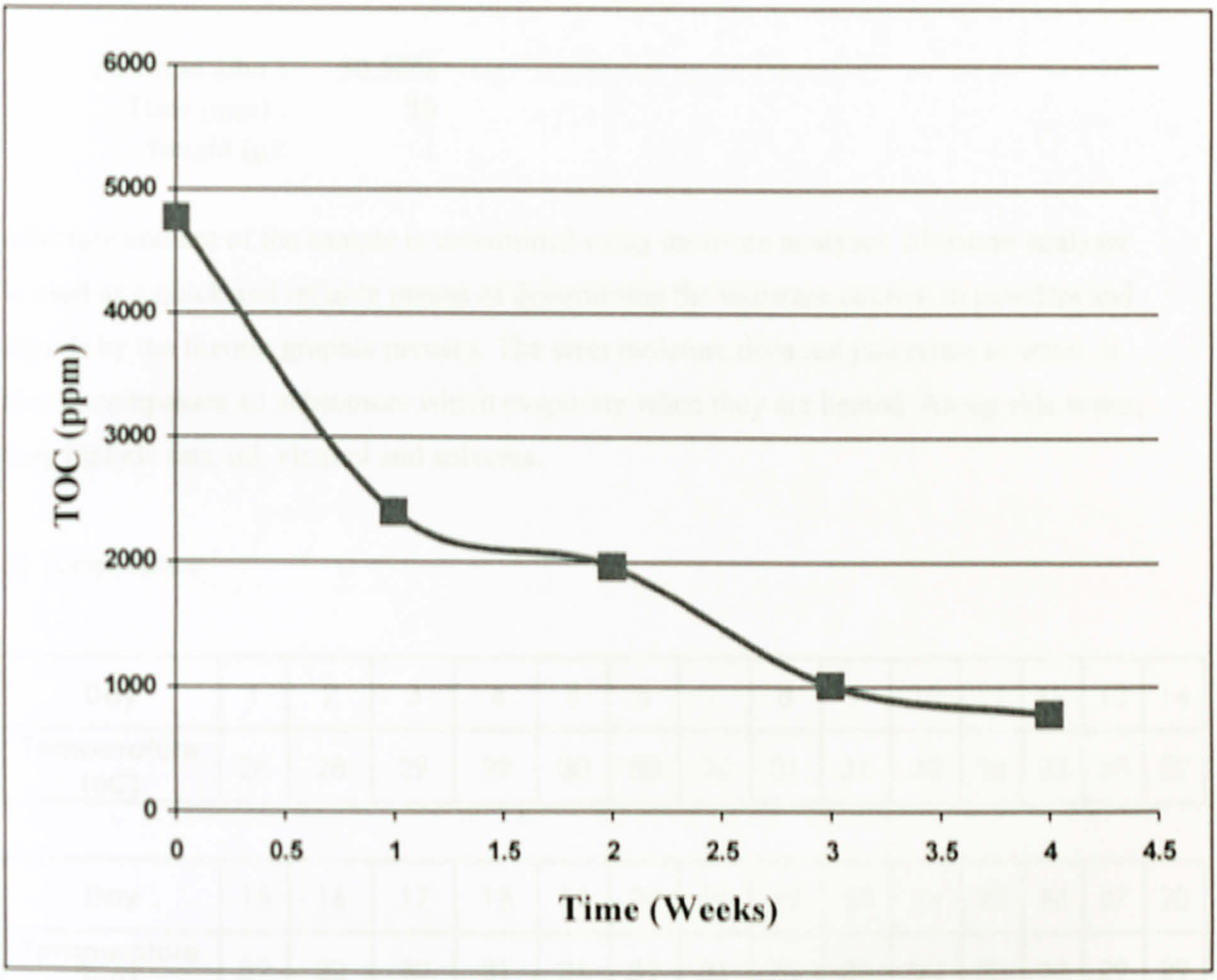


**Figure 4.4** TOC versus Time for sample 3

Figure 4.4 shows that total organic carbon reduced after 3 weeks with huge amount form 4771ppm to783ppm. This shows that the degree of organic contamination is reduced a lot after one month.

4) Moisture Content

The Result of the moisture content of sample 3 is shown below.

| | |
|---|---|
| moisture before : | 28.59% |
| Time (min) : | 26 |
| weight (g): | 1 |

moisture after : 30.58%
Time (min) : 30
weight (g): 1

Moisture content of the sample is determined using moisture analyser. Moisture analyser is used as a quick and reliable means of determining the moisture content in powders and liquids by the thermo graphic process. The term moisture does not just relate to water, it also encompasses all substances which evaporate when they are heated. Along side water, they include fats, oil, alcohol and solvents.

5) Temperature

| Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (0C) | 28 | 28 | 29 | 29 | 30 | 30 | 30 | 31 | 31 | 32 | 32 | 33 | 33 | 32 |

| Day | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (0C) | 32 | 32 | 32 | 31 | 31 | 32 | 31 | 31 | 30 | 30 | 30 | 30 | 29 | 29 |

**Table 4.15** Temperature of sample 3

Cool or ambient temperature composting, when the level of physical intervention is minimal, usually results in temperatures slightly reaching above 30°C (86°F). It is slower but effective, and is the more common type of composting in domestic gardening. Such composting system is in closed containers of plastic.

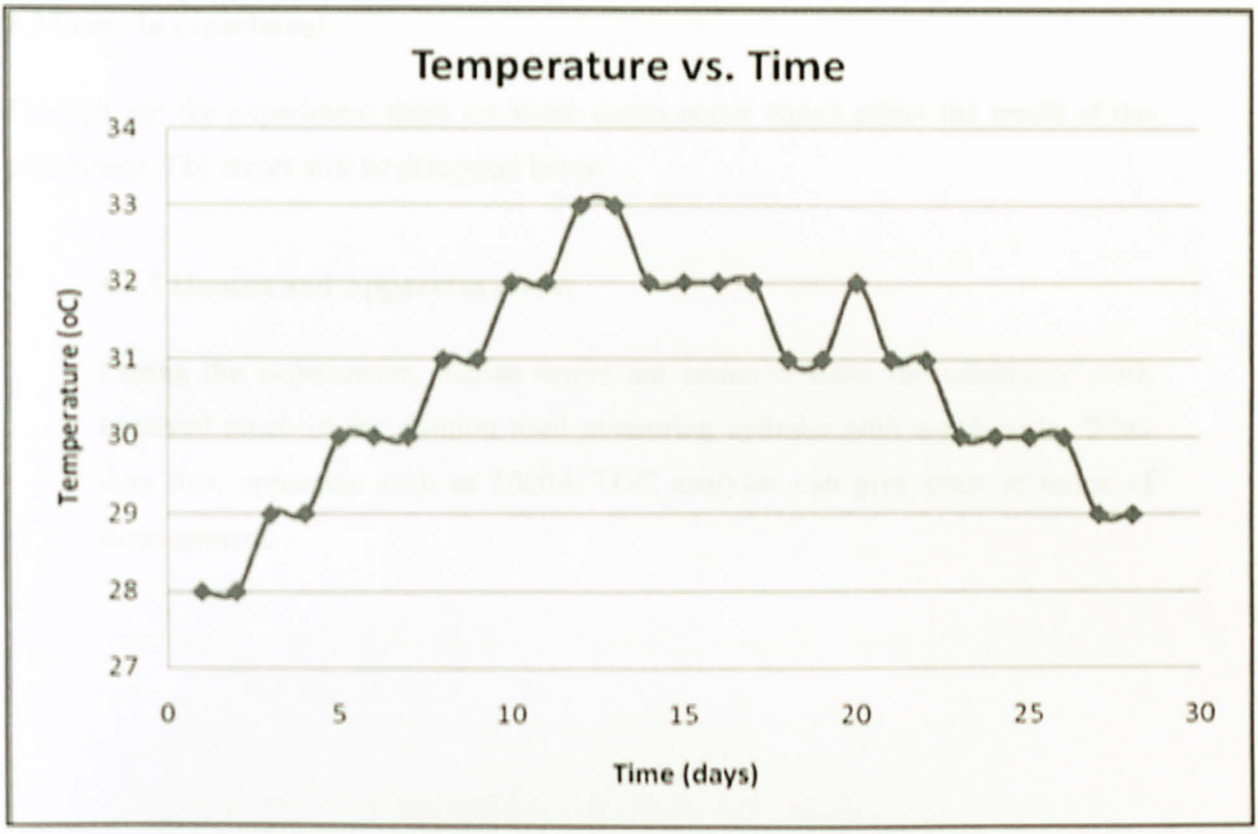


**Figure 4.5** Temperature versus Time for sample 3

From figure 4.5, the temperature slightly reach above 30°C .The slightly increase in temperature shows that there is microbial degradation. The fluctuation of the graft maybe due to the external environment.

### 4.3 Error in experiment

Through out the experiment there are some errors occur which affect the result of the experiment. The errors will be discussed below:

#### 4.3.1 Human and Apparatus error.

During the experiments, human errors are common since the laboratory work involved much of the dilution used measuring cylinder with small scale. Other than that, apparatus such as 1020A TOC analyzer can give error in terms of measurement.

# CHAPTER 5
# CONCLUSION AND RECOMMENDATION

Throughout the sample analysis, we can say that the sample is neutral but containing of chemical that can be oxidised. From figure 4.3, the COD values slightly increase for the first week then reduce after 3 weeks. The COD values form initial stage to the last shows reduction of chemical content in the sample.

The composting samples were found to be neutral throughout the study period with pH ranging from 7.5 to 7.8.

The total organic carbon reduced after 3 weeks form 4771ppm to783ppm. This shows that the organic content was reduced after one month. The composting temperature was slightly reach above 30°C .The slightly increase in temperature was due to microbial degradation. The fluctuation of the temperature may be due to the external environment.

In conclusion, it can be deduced that domestic waste introduce can enhance the microbial degradation of oily sludge.

Further studies are required to monitor the performance of this method. Several improvements can be done in order to arrive to conclusive result. There includes:

- C:N ratio and other nutrient status before and after the composting
- The aeration status inside the composting mass
- Use active approach in composting method instead of passive
- Use automated compost tumbler instead of manual

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