Composting of Cooking Residue from Fast Food Restaurant and Fertilizer Production

by

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Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Civil Engineering with Honours

JANUARY 2022

Universiti Teknologi PETRONAS,

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32610

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

____

Dr. Lavania Baloo

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2022

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 herein have not been undertaken or done by unspecified sources or persons.

Signature of Student

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MUHAMMAD NAJMI ZAFRAN BIN MOHAMAD RAZALI

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ABSTRACT

Cooking residues are one of the definite wastes that people will produce throughout the day. Studies has shown that cooking residues that are disposed is negatively impacting our environment. Thus, this research is to properly degrade the cooking residues through aerobic composting approach. Accordingly, aerobic composting measures happen within the air and utilize those microorganisms (also called aerobes), which use sub-atomic/free oxygen to assimilate regular pollutions for instance by transforming them into carbon dioxide, water, and biomass. In this project, the excess cooking residue is to be composted using aerobic method to reduce the contamination to the environment and waste can be transformed into useable compost that can function as fertilizer. To degrade the residue, the sample is tested in laboratory to understand its characteristics. Characterisation has also been done on the cooking residue which shows that it is high in moisture content. So, sawdust was added as the bulking agent to balance out the moisture content to allow the composting treatment properly degrade the cooking residue. The composting procedure can be carried out on the mix using this understanding to calculate the appropriate compost mix ratio for an effective composting rate. Using varied ratios of 1:1:6, 1:1:8, and 1:1:10, each compost combination was homogeneously mixed and stored in a plastic container with good aeration. Thus, the aim of this research is to produce a composted product with optimum nutrient value which further to be used as plant fertilizer as an eco-friendlier solution in dealing fryer oil residue. The compost ratios were tested for Total Nitrogen (TN), Total Organic Carbon (TOC), Total Phosphorus (TP), moisture content and pH to determine whether the compost mees the standards for plantation. The results shows that the 1:1:8 ratio has the most reliable parameters for a compost that is safe for agricultural activities.

ACKNOWLEDGEMENT

First and foremost, I would like to convey my heartfelt gratitude to Dr. Lavania Baloo, my project supervisor, for her important advice, comments, and ideas during the project. It was a wonderful honour and privilege to be assigned to her. Her experiences and knowledge are invaluable and will be quite useful in my future profession.

Thank you in particular to the lab staff in the Centralized Analytical Lab (CAL) and the Wastewater Lab for their assistance. Throughout the duration of my assignment, their unending assistance and direction have been really beneficial. My gratitude goes out to my peers for assisting me in surviving this year's stress and for not giving up.

Last but not least, I'd like to thank Universiti Teknologi PETRONAS for allowing me to pursue my dream of becoming a student here, particularly my department, Civil and Environmental Engineering, for providing me with the skills I needed not only as a Civil Engineer, but also as a versatile student

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1 CHAPTER 1: INTRODUCTION

1.1 Background Studies

Solid waste production is increasing daily and due to rapid urbanization. Food waste is one of the wastes with higher rate of waste generation in Malaysia (Hazren A. Hamid*, et al,. 2019). Most of the food waste has been landfilled with other wastes, resulting in a variety of issues such as odour, vermin attraction, hazardous gas emissions, leachate contamination of groundwater, and waste landfill capacity (Prakash, 2015). Methane (CH4) and carbon dioxide (CO2) are released into the atmosphere as a result of microbial activity at dumping sites under uncontrolled anaerobic circumstances, contributing to global warming. (Gill, Jana, & Shrivastav, 2014)

Fats, oils, and grease (FOG) from cooking and food processing industries are generally collected in grease traps and interceptors to prevent damage to sewage collection systems. As food waste mostly come from commercial kitchens, cafeterias, and restaurants (Chen et al., 2017), Gerbang Alaf Restaurants Sdn Bhd has been a point of reference for the project which operates all McDonald outlets in Malaysia. Each of the McDonald outlet produces excess oil every day which is stored at the site at the facility in a separate tank as in FIGURE 1.1.

FIGURE 1.1: Storage tank

In the process of frying french fries, patties and chicken, the oil used in the deep-frying process is recycled at the end of the day to be reused. However, the cooking residues steadily increases each second before being disposed at the end of the day. Prior to oil reuse, the cooking residues are filtered at the bottom of each deep fryer as in FIGURE 1.2, FIGURE 1.3, FIGURE 1.4, and FIGURE 1.5.

FIGURE 1.3: Bottom of the fryers

FIGURE 1.2: Fryers

FIGURE 1.5: Cooking residue

FIGURE 1.4: Cooking residue

The filtered oil was collected in the container below the filter to remove the cooking residue which may consists of flour, bits of chicken, fries, and patties.

As shown in FIGURE 1.6, Magnasol was then added into the container. This chemical is a pure white compound that removes both solid and dissolved impurities from used oil to provide extended oil life for further reuse. These fine solid and dissolved impurities from the used oil will precipitate in the container. Regularly the cooking residue formed in the container will be removed and discarded into the garbage bin together with the cooking residue. Daily wastes were observed from each McDonald’s outlet in Gunung Rapat and Seri Iskandar. It is proposed that this waste material is to be recycled into a compost material which can be reused by the facility for its garden around the outlet.

FIGURE 1.6: Magnasol added into the residue

Composting is an effective approach to reduce the amount of solid waste that is disposed of in landfills. Composting is a method of controlled decomposition that replicates the natural breakdown of organic matter. Composting is the conversion of organic waste into biologically stable humic chemicals that can be employed in a wide variety of soils and plants. (Antizar-Ladislao, 2005) Organic fertilisers are produced as a result of composting. Plants, fruits, animals, and other natural sources are used to make organic fertilisers. Organic fertilisers are crucial in agriculture since they assist the soil while causing no harm to groundwater or plants. (Asgari, 2017).

Composting is the process of turning organic waste from plants and animals into manure. Composting produces compost, which is high in humus and plant nutrients, as well as carbon dioxide, water, and heat as by-products. It requires oxygen to complete the composting process, often known as aerobic composting.

Aerobic microorganisms use organic matter as a substrate, such as food waste and agricultural waste. As the substrate progresses from complex to intermediate, the bacteria break it down into simpler components. The mixture contains both carbon and nitrogen. They are converted to more stable organic matter, which chemically and physiologically resembles humic compounds, during composting, through the actions of several bacteria. The rate and extent of the changes are determined by the substrates available and the composting control parameter (Mittal, 2013). Thereby the aim of this study is to try reducing the amount of oily food waste generated by repurposing the waste as biofertilizer through aerobic composting process

1.2 Problem Statement

Over the years, these excess cooking residues are disposed away while it can be used for other purposes. All of these unwanted cooking residues contributes to the amount of waste at the landfill ultimately. Initiatives need to be taken to reduce the amount of food waste at landfill since it is harmful for the environment and our climate such as greenhouse gas production. This project aims to provide a solution to lessen the food waste by reusing the cooking residue as bio fertilizer.

A compost is a great way to turn these unwanted cooking residues into something more purposeful and beneficial for the environment rather than simply throwing it away. Next is to find a solution to properly compost the residues since it is high in moisture content. Optimal moisture content is important in a composting process for the residue to properly breakdown. Without proper bulking agent, the pile's moisture balance will alter and attract pests. The idea is to find the suitable bulking agents to allow the cooking residue to breakdown and proper ratios to compost the cooking residue aerobically into fertilizers that is safe for agricultural use.

1.3 Objective

The objectives of this research study are as follows:

1. To find the optimum ratio of bulking agent, sludge and cooking residue for an aerobic composting
2. To determine the feasibility of producing compost from cooking residue.
3. To find the suitable bulking agent to degrade the cooking residue

1.4 Scope

This research focuses on breaking down cooking residue as a compost product. The objective is to use laboratory scale aeration composting method to degrade the fryer residues to have optimum nutrients values as a compost. Characterisation of the fryer residue need to be done to understand its properties. The characteristics that need to be tested are Total Nitrogen, Total Organic carbon, moisture content, pH etc. Additionally, a bulking agent and dry sludge are added to enhance the composting process' efficiency.

By the end of this study, the sample may be capable of serving as a soil enhancer or fertiliser while adhering to all applicable standards. This would help reducing the food waste dispose in landfills.

2 CHAPTER 2: LITERATURE REVIEW

2.1 Cooking Residue

Cooking residues or oily food waste (OFW) is one of the world's most serious issues, and its production has risen in lockstep with the world's population. Untreated OFW have impacted negatively on the environment, contaminating water, emitting offensive odours, and attracting vermin. As a result of the substantial focus on environmental conservation and energy recovery, OFW management is a subject of extensive research (HKEPD, 2015).

Food waste (FW) was divided into two categories: pre-consumption food wastes (PrCFWs) and post-consumption food wastes (PCFWs). Fruit, vegetable, and other peeling wastes make up the majority of PrCFWs. As a result, PrCFWs were discovered to be the simplest to breakdown. (Awasthi, Selvam , Chan, & Wong, 2017). PCFWs, on the other hand, are heterogeneous in composition, with 40–60% starchy waste (meats and meat trimmings, cheese whey, and coffee filters), 5–10% protein (fish processing wastes and eggshells), and 10–40% different additional fatty or oily components (Demichelis, et al., 2017). Landfilling, composting, burning, and anaerobic digestion are just a few of the traditional ways for treating and disposing of FW (Pleissner, et al., 2017). For this research, the composting process is the most relevant method to degrade the fryer residues into a compost. The degradation process which are thermophilic and mesophilic phases mostly comprises of microorganisms. Ultimately, sludge is used to co-compost with the fryer residue since it contains microbes for the composting process.

2.2 Sludge

sludge can be for the most part known as used water. It incorporates substances like human waste, food scraps, oils, cleansers, and synthetic compounds. In homes, this incorporates water from sinks, showers, baths, latrines, clothes washers, and dishwashers. (Perlman, 2013). sludge should be treated through assortment of measures and systems. The reason of treating sludge is to eliminate suspended solids, biodegradable organics, and nutrients (nitrogen, phosphorus, or both nitrogen and phosphorus) (Metcaf & Eddy, 2004). Sludge is also consisting of aerobic and anaerobic microbes such as fungi, archea, bacteria, and protstis that are capable to breakdown organic matter (Seviour R., 2016).

2.3 Aerobic

As stated by (Metcaf & Eddy, 2004), aerobic means include air (oxygen), accordingly aerobic treatment measures occur within the air and use those microorganisms (additionally called aerobes), which utilize sub-atomic/free oxygen to absorb natural contaminations for example by changing them into carbon dioxide, water, and biomass. FIGURE 2.1 shows the treatment principles that happen during aerobic composting.

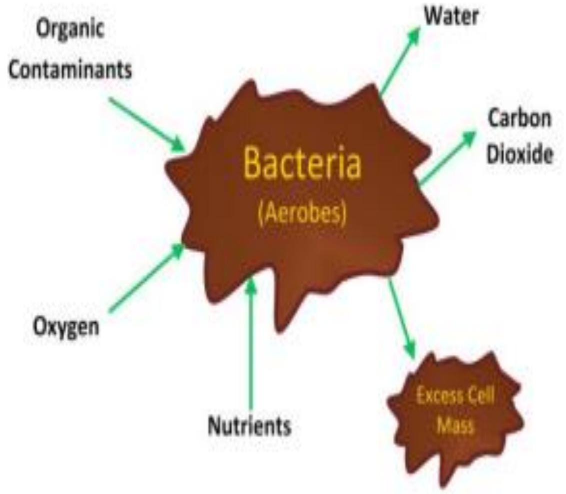

FIGURE 2.1: Aerobic treatment principles.

Under aerobic conditions, microbes quickly burn-through natural matter and convert it into carbon dioxide. Once there is an absence of organic matter, microbes die and are utilized as food by different microorganisms. This phase of the interaction is known as endogenous respiration (Mittal, 2011). Solids decreases in this stage as the microorganisms need to eat each other to endure. In view, aerobic digestion happens a lot quicker than the anaerobic digestion.

The following is the reaction that occurs during aerobic treatment. Due to the shortfall of microorganisms, the biomass needs to eat each other to endure and there will be an increase in ammonia during the interaction.

Biomass + O_2 = Less Biomass + CO_2 + H_2O + NH_3 (Gallert, 2005).

2.4 Compost

Composting is regarded as one of the most cost-effective methods for disposing of solid waste and increasing the amount of natural materials available for climate restoration and preservation. (Sher, et al., 2014). Aerobic composting includes a course of natural decomposition and adjustment of natural substrates under conditions that encourages duplication and activity of thermophilic microorganisms because of organically created heat, to deliver a result that is steady, liberated from microbes, pests, and plant seeds, helpful in agriculture as manure (Sher, et al., 2014). Nonetheless, the variety of compost quality is noticeable due to contrasts of raw materials, activity conditions, micro flora, and composting techniques (Aoshima *et al.*, 2001).

As of late, composting has drawn in much consideration and has come to be viewed as an environmentally friendly and maintainable option for managing and reusing natural wastes. Composting process creates stable, soil-enriching humus and concentrates the Nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), and Magnesium (Mg) contents (Eneji, et al., 2001).

Composting is divided into two phases which are microbial activity and natural material transformation. During the primary stage, the microbiome begins fertilising the soil cycle by increasing temperature through natural material oxidation, breaking down a larger portion of biodegradable material, and increasing the stability of the natural residue. Fungi, bacteria, and protozoa make up the soil microbiome, which fluctuates depending on temperature, moisture content, C/N proportion, and the composition of organic components. (Azim, K, et al., 2018).

Composting can be done in a variety of methods depending on the mode of operation, including batch, continuous, and semi-continuous operations. The key advantage of is composting is waste stability. Microorganisms that degrade xenobiotics can be found in abundance in composting matrices and composts (Prakash et al., 2015). Laboratory scale composting was used for this study because it is easy to monitor and can determine the composting product in a short amount of time (Antizar-Ladislao, Lopez-Real, & Beck, 2005). TABLE 2.1 and TABLE 2.2 below shows the summary of composting methods.

TABLE 2.1: summary of composting methods

No.	Method	Descriptions	Remarks	Referrences
1	Aerated static composting	• Any of a variety of systems for biodegrading organic matter that do not require physical manipulation during primary composting.	• Allows for quick biodegradation by providing process control. • Large amounts of feedstocks can be handled. • Composting can be either open or closed.	(K., et al., 2020)
2	Aerated windrow composting	• Organic waste is arranged in the form of long heaps known as "windrows" and aerated by turning the piles manually or mechanically on a regular basis.	• The liquid that is released during the composting process is known as leachate.	
3	In-vessel composting	• In vessel composting is composting in a vessel or container where the temperature, moisture, and other variables can be controlled.		(Asgari et al., 2017; Hu et al., 2013)

TABLE 2.2: summary of composting methods

No.	Method	Descriptions	Remarks	Referrences
1	Vermicomposting	• Earthworms have a lot of potential for speeding up the decomposition process.	• Biotechnological process which cost effective and faster. • In natural settings, it is difficult to decompose.	(Hu et al., 2013; Prakash et al., 2015)
2	On-site composting	• On-site composting methods include bio piles and landfarming. • Turning waste materials into piles or windrows, usually to a height of 2–4 m, for degradation by indigenous or foreign microorganisms. • Aeration piping used, and the piles will either be static or turned and mixed by special devices.	• It takes a big area of land. • Temperature has a significant impact on the biodegradation efficiency of contaminants. • Low initial investment, simple operation, and the ability to treat a large volume of compost	(Ball et al., 2012; Hu et al., 2013)

Composting with enough aeration generates biogenic CO_2 instead of CH_4 from the degradation of organic materials (Sher, et al., 2014). Bio-fertilizer are normally containing living microorganisms and their interactions will promote the soil ecosystem and produce beneficial substances for the plants (Parr et al., 2002). The microorganisms and the nutrients exist in the crude materials which are useful in improving soil health. There are various sorts of bio-fertilizers available that their variations are primarily the raw materials utilized, types of use, and the sources of microorganisms (Svensson et al., 2004).

To optimize the moisture content and carbon to nitrogen ratio in compost, bulking agents such as wood chips, wheat straw, sawdust, hacked roughage, wood shavings, and rice grain must be added (Chang, J.l., et al., 2010). Bulking agents contain a high carbon to nitrogen (C/N) ratio and is then fit for engrossing abundance moisture in the food burn through and simultaneously adding structure with the existing mix particularly when managing waste materials with high moisture and low C/N ratios like sewage sludge or manure (Risse., et al., 2009). In this study, In vessel composting was selected as the composting method. The optimal ratio for this method is 1:1:6 which is for food waste, bulking agent and sludge respectively (Azim, 2018).

2.5 Bulking Agents

Bulking agents are compounds that allow for the most amount of free air space and manage the water content of compostable waste (Iqbal et al., 2010). The high moisture content of the cooking residue necessitates the use of a bulking agent for efficient composting. As a bulking agent, any fibrous carbon-containing materials with a low moisture content can be used. Table 2.3 shows various bulking agents that can be used to improve the compost quality

TABLE 2.3: Properties of Bulking Agents

No	**Bulking Agent**	**Advantages**	**References**
1	Wheat straw	• Increase the heat of the mixture to speed up the process.	(Uçaroğlu, 2016)
2	Plane leaf	• It just takes 14 days to complete • Easy to handle	
3	Sawdust	• It's cheap and simple to get. • Can control the moisture • allow aeration in pile	
4	Sunflower stalk	• allow oxygen in pile	
5	Wood pallets	• keep the moisture in pile	

2.6 Factors for A Healthy Compost

The basic requirements to know the stability of a compost to use as a fertilizer is to know the amount of nutrients in the compost itself. Some of the important nutrients for plant growth are Nitrogen (N), Phosphorus (P) and Potassium (K). According to WHO compost requirements, nitrogen (N) should be between 0.4 and 3.5 percent, phosphorus (P) should be between 0.3 and 3.5 percent, and potassium (K) should be between 0.5 and 1.8 percent. The optimal Nitrogen NPK fertiliser ratio 3:1:2 (Sadeghi, S., et al., 2015).

The pH value and moisture content are important for a good compost (Khater., et al., 2015 Using a pH metre or a potentiometer, you may manage the pH of the natural waste compost. The potentiometer is set at a ratio of 1-part dry matter to 10 parts water in the aqueous suspension of natural waste compost. The pH of natural waste compost is usually between 7 and 8. (Dominguez., et al., 2019). A developed compost doesn't smell of ammonia, rather it has a pleasant scent, has a consistent and low temperature, is recognizable when contrasted with crude material, and seems dark in colour (Jain, S., et al., 2018). The C/N proportion during composting can influence the pace of deterioration. The microbiome engaged with composting the soil interaction utilizes carbon as an energy source and nitrogen to construct proteins. The lower the C/N ratio, the more the deficiency of nitrogen from the compost. Then again, the higher the C/N proportion, the slower the pace of decay, and nitrogen would be immobilized during the process also (Risse., et al., 2009). TABLE 2.4 shows the parameters of recommended composting range.

TABLE 2.4: Parameters for composting

Parameter	Acceptable range	Preferred range
Carbon to nitrogen (C/N) ratio	20:1 or 40:1	25:1 or 30:1
Moisture Content (%)	40 to 65	50 to 60
Oxygen concentrations (%)	> 5%	> 5%
Particle size (inches)	1/8 to ½	Varies
pH value	5.5 to 9.0	6.5 to 8.0
Temperature (°C)	43 to .65	54 to 60

2.7 Stages in Composting

The composting system is divided into three significant stages to be specific the mesophilic stage followed by the thermophilic stage and finally cooling or maturation stage, in which assorted microflora, for example, mesophilic and thermophilic bacteria fungi, and actinomycetes are available to change over and settle the natural waste to humus (Moreno, J., et al., 2013).

The mesophilic temperature and accessibility of carbon-rich substrate at the beginning phase of composting measure favour the development of mesophiles with a combination of bacteria, actinomycetes, and fungi whereby they develop at the temperature between 15 °C to 45 °C and accomplish ideal development at the range of 30 °C to 39 °C. At this stage, mesophilic fungi, for example, yeasts and acid-producing bacteria are the predominant species to deteriorate natural waste materials. At the mesophilic stage, microbial activity during the degradation interaction will bring about an increase in temperature due to the energy of the natural mix (Partanen, P., et al., 2010).

The thermophilic stage is when the majority of the breakdown takes place. The decomposition of natural matter (cellulose, lipids, hemicelluloses, and lignin) by thermophilic microorganisms such as fungus and bacteria is observed at this stage. During this stage of composting, mesophiles are replaced by thermophiles, which prefer actinomycetes and thermophilic bacteria and thrive at temperatures between 40 and 80 degrees Celsius. (Santos, H., et al., 2006).

The final phase (cooling) is marked by a temperature of less than 25 °C. Fungi will return to the compost and are ready to degrade the surplus natural materials now that the temperature has dropped to a mesophilic range. Because phytotoxic chemicals are digested by the microorganisms during this stage, it plays a critical role in compost maturation and plant pathogens suppression. (Mehta, C.M., et al., 2004). FIGURE 2.2 summarize the changes of composting temperature throughout the composting process.

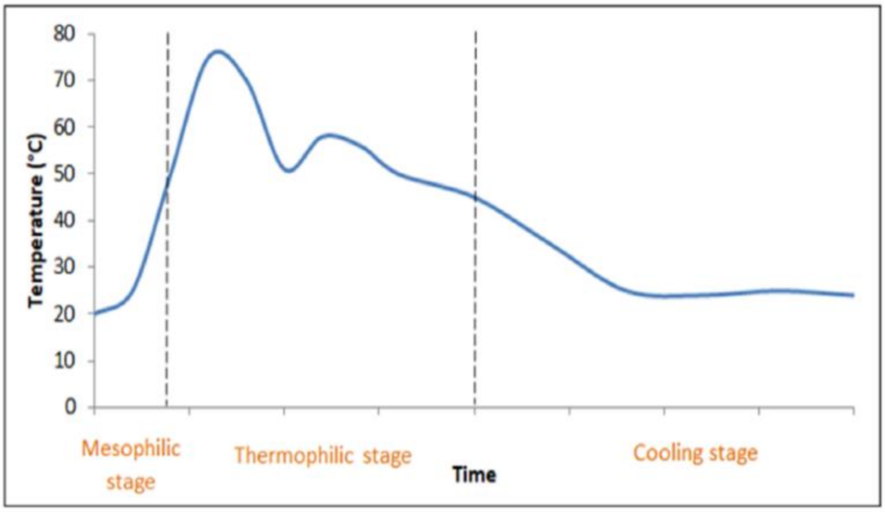

FIGURE 2.2: Shows the temperature during composting at each microbial stages

3 CHAPTER 3: METHODOLOGY

3.1 Introduction

Before beginning the composting process, characterization of the cooking waste was required to determine the sample's qualities. The next step is to determine the ideal mix of bulking agent (sawdust), cooking residue, and dry sludge to create a high-quality compost. The composting method utilised in this study is in-vessel composting, which is a closed system that allows for the setting and control of ideal operating parameters for optimum microbial activity and pollutant breakdown, such as temperature, moisture content, and mixing ratios.

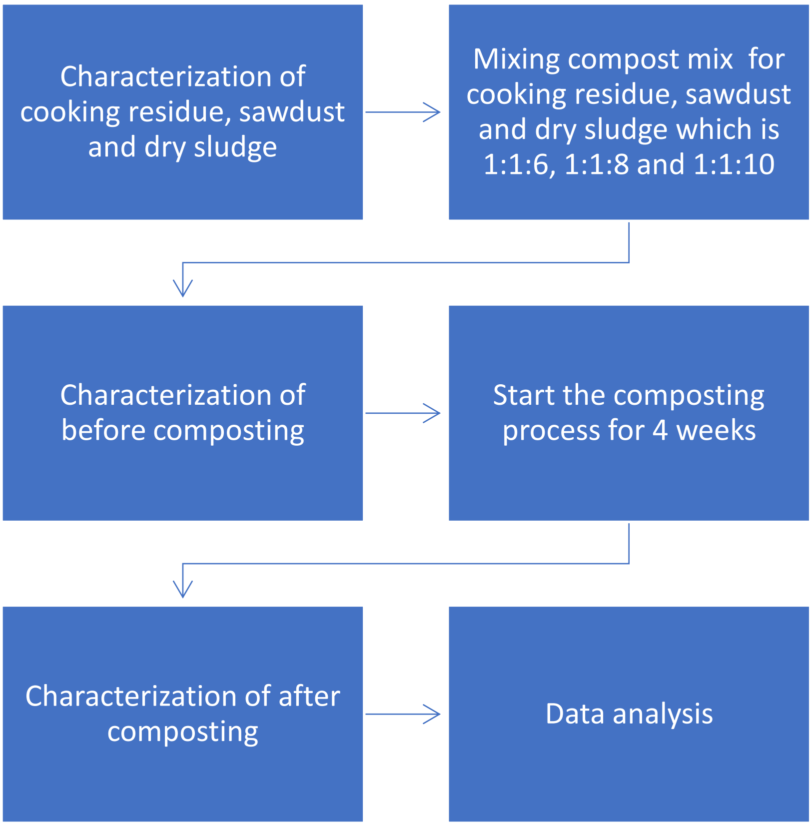

FIGURE 3.1: Flowchart for experimentation

3.1 Materials

1. **cooking residue**
   The cooking residue was obtained from Mcdonald's Seri Iskandar cooking waste.
2. **Dry Sludge**
   The sludge was obtained from Universiti Teknologi Petronas sewage treatment plants clarifier tank which was dried afterwards.
3. **Sawdust**
   Sawdust was selected in order to control the moisture content and provide aeration in the pile. The sawdust was obtained in Ipoh, Perak.
4. **Water**
   Water was used in small sprays to maintain the moisture in the pile. Water was obtained from Sewage Treatment Plant Laboratory tap water

3.2 Determination Of Moisture Content

The moisture content of the samples was determined using the oven-dry method. Before being utilised, the crucible was cleaned, dried, and weighed. The sample was poured into the container until it reached the desired volume, then the container was weighed again. The sludge-containing container is baked for 24 hours at 110°C at a steady temperature. After 24 hours in the oven, the container was removed and placed in the desiccator for 30 minutes. After 30 minutes, the crucible with dried sludge was weighed again. The moisture content of the sample was determined using the formula below:

Moisture Content = $\frac{(W_2 - W_1) - (W_3 - W_1)}{(W_3 - W_1)}$

Where,

$W_C = Weight\ of\ clean\ and\ dried\ crucible$

$WW = Weight\ of\ wet\ petroleum\ sludge$

$W_D = Weight\ of\ oven\ dried\ petroleum\ sludge$

3.3 pH Analysis

After the moisture content has been established, the oven-dried sample is used for pH analysis. Combine the desired amount of oven-dried sample and distilled water in a mixing bowl. After that, the mixture was allowed to settle for 10 minutes. Finally, the pH of the sludge was determined using a pH metre.

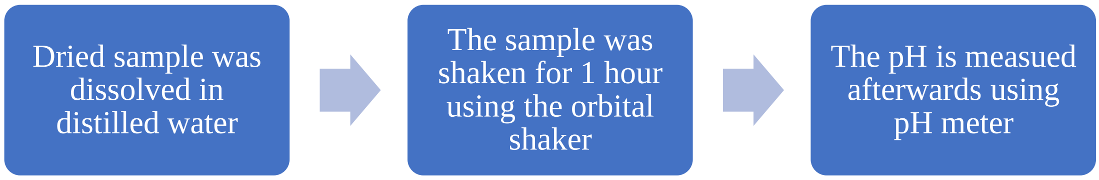

FIGURE 3.2: Flowchart for pH analysis method

3.4 Total Organic Carbon (TOC)

The quantity of carbon contained in an organic compound is known as TOC, and it is frequently employed as a non-specific indication of petroleum sludge deterioration. The TOC of the extracted material was determined using TOC analyzers after it was placed in a vial. The sample was heated to 680°C in an oxygen-rich atmosphere, inside TC combustion tubes equipped with a platinum catalyst.

The carbon dioxide is cooled and dehumidified as it is produced. An infrared gas analyser (NDIR) was used to detect carbon dioxide produced by oxidation through burning. A calibration curve formula was used to determine the concentration of TC (total carbon) in the sample. The sample was oxidised during the sparging procedure. The inorganic carbon (IC) content is determined by using the NDIR to detect the carbon dioxide produced. Finally, the TOC concentration was determined using the formula below.

$$TOC = T_c - I_c$$

3.5 Total Nitrogen (TN) Analysis

Total nitrogen is the total nitrogen content inside the tested sample. The microorganisms in the compost need enough nitrogen to properly breakdown the residues. The test starts by adding one Total Nitrogen Persulfate Reagent Powder Pillow to each HR Total Nitrogen Hydroxide Digestion Reagent vials 0.5 of each sample was added into a vial and one extra vial was added with distilled water for blank reading. The vials were shaken vigorously before putting inside a DRB200 Reactor which is set for 105 °C. the samples were left in the reactor for 30 minutes. After that, the samples were taken out from the reactor to cool down to room temperature. The contents of one Total Nitrogen (TN) Reagent A Powder Pillow were added to each vial then and shaken for 30 seconds. A 3-minute reaction time starts. One TN Reagent B Powder Pillow were added to each vial after the timer expires.

The vials were shaken again for 15 seconds, and a 2-minute reaction timer starts. The solutions will start to turn yellowish in colour. To prepare for the reading, 2 ml of each vial were transferred into a TN Reagent C vial each. The vials then were inverted 10 times and inserted into the spectrometer to read the TN values of the samples.

3.6 Total Phosphorus (TP)

Phosphorus is important in a compost since it provides nutrients for the plants to grow. To prepare the sample, 5.0 mL of samples were added to the Total Phosphorus Test Vial. One Potassium Persulfate Powder Pillow for Phosphonate were added into the vials. The vials were then shaken and inserted into a DRB200 Reactor that was preheat to 150 °C. After 30 minutes, the samples were cooled down to room temperature and 2 mL of 1.54 N Sodium Hydroxide Standard Solution were added. The vials were mixed and zeroed using the spectrometer. The contents of one PhosVer 3 Powder Pillow were added to each vial. After a 2-minute reaction time, the phosphorus values were determined again using the spectrometer.

3.7 Carbon To Nitrogen Ratio (C/N) Analysis

In composting, the carbon-to-nitrogen ratio is critical. It will not heat up if the compost mix has too little nitrogen. If the nitrogen level in the compost is too high, the compost may grow excessively hot, killing the compost microorganisms. The following formula can be used to calculate the carbon to nitrogen ratio:

$$\text{Carbon – Nitrogen Ratio} = \frac{Wx\%C}{Wx\%N}$$

3.8 Laboratory composting (In vessel)

In this study, the optimal sludge to bulking agent to microbe ratio for composting cooking debris would be determined using this method. The rate of decomposition and the outcome of the composting process were monitored for this study. The ratios of cooking residue, sawdust, and dry sludge used in this method were 1:1:6, 1:1:8, and 1:1:10, respectively. The required quantity of each mixture is taken for examination at the start of the composting process (0 week). For four weeks, the samples were checked, and the compost was rotated every day. This will guarantee that the procedure goes as smoothly as possible. The mixes are sprayed with tap water to keep the moisture content consistent. FIGURE 3.3, FIGURE 3.4 and FIGURE 3.5 shows the respective ratios in separate containers.

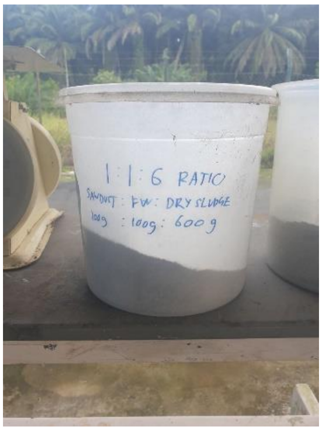

FIGURE 3.5: 1:1:6 compost mix

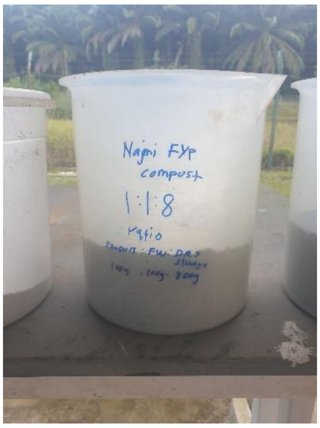

FIGURE 3.4: 1:1:8 compost mix

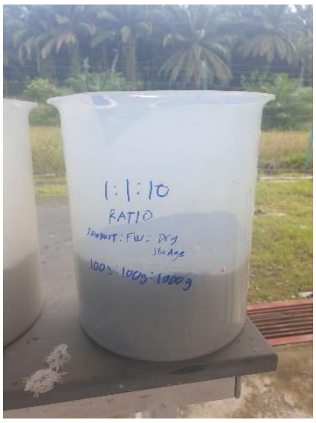

FIGURE 3.3: 1:1:10 compost mix

4 CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

In this research, a variety of tests and experiments were conducted. TOC, TN, Ph, and moisture content are some of the values obtained from compost. The compost ratios were determined after knowing the carbon and nitrogen values from TN and TOC tests.

4.2 Material Characterisations

From the analysis, TABLE 4.1 summarize the general properties of the materials used for the experiment.

TABLE 4.1: General Properties of samples

No	**Parameters**	**Units**	**Materials**		
			Cooking residue	**Sawdust**	**Dry sludge**
1	TN	mg/L	5.6	4.7	19.3
2	TOC	%	93.4	30.5	46.5
3	MOISTURE CONTENT	%	80.65	1.24	5.23
4	PH	-	6.92	6.4	7.5

From the table, it is said that the cooking residue has low amount of nitrogen in its composition. Dry sludge is added into the mix in order to increase the nitrogen content in the compost. This to ensure there is enough nutrients for the aerobes to breakdown the compost. Since there high moisture content in the cooking residue, sawdust was added to balance the moisture content

4.3 Moisture Content

FIGURE 4.1: Moisture content analysis by oven-dry method

TABLE 4.2: Moisture Content of Compost Ratio

No.	Compost Mix	Moisture Content (%)	
		Before Composting	After Composting
1.	1.1.6	82.5	54.44
2.	1.1.8	82.2	56.75
3.	1.1.10	83.1	60.18

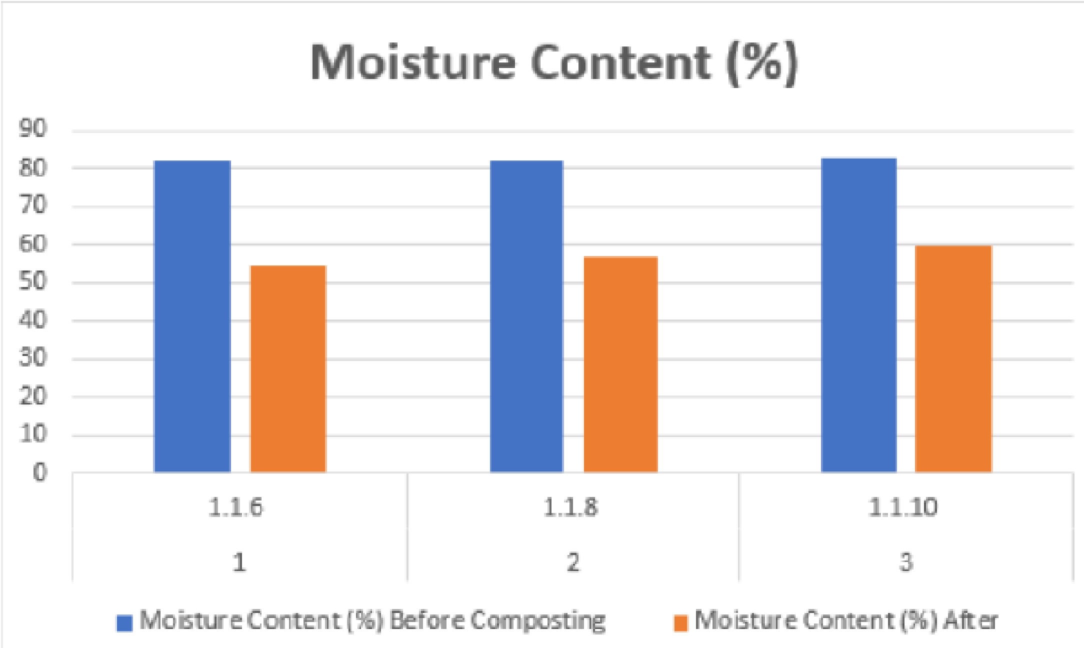

FIGURE 4.2: Moisture Content of Compost Ratio

FIGURE 4.1 shows the moisture data analysing using the oven dry method. The ideal moisture content is thought to be between 50 and 60 percent, whereas less than 50 percent of water content slows down microbial decomposition (Rihani, 2010). Based on TABLE 4.2 and FIGURE 4.2, the moisture content the mix reduces after composting. The 1:1:6 ratio has the lowest final moisture content. This proves that sawdust is an effective agent to control the moisture content in the mix. All three of the mix ratio's final moisture content is within 50% to 60% which is ideal for composting.

4.4 pH Value

TABLE 4.3: pH values for mix compost

No.	Compost Mix	Final pH values
1.	1.1.6	.5.84
2.	1.1.8	6.34
3.	1.1.10	6.13

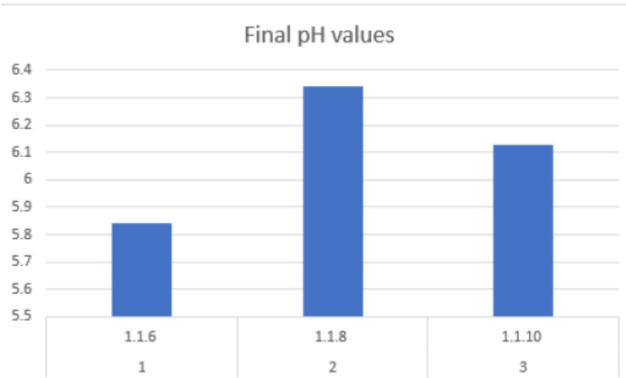

FIGURE 4.3: pH values for mix compost

FIGURE 4.4: pH meter reader

FIGURE 4.4 shows the pH meter apparatus used for reading the pH values of the compost. The pH value, which should be between 5.5 and 9.0, can be used to analyse the decomposition of organic waste. For aerobic composting, the pH should be in the neutral range.

TABLE 4.3 shows the finalized compost mix pH value for 1:1:6, 1:1:8 and 1:1:10 which are 5.84, 6.34 and 6.13 respectively. All three of the ratios achieved the optimum pH value that is suitable for biodegradation process. In this case, 1:1:8 has the favourable pH value since it is the median value between 5.5 and 9.0.

4.5 Total Organic Carbon (TOC)

TABLE 4.4: Total Organic Carbon of Compost Mix

No.	Compost Mix	Total Organic Carbon (mg/L)	
		Before Composting	**After Composting**
1.	1.1.6	84.1	79.4
2.	1.1.8	83.4	73.98
3.	1.1.10	83.2	61.5

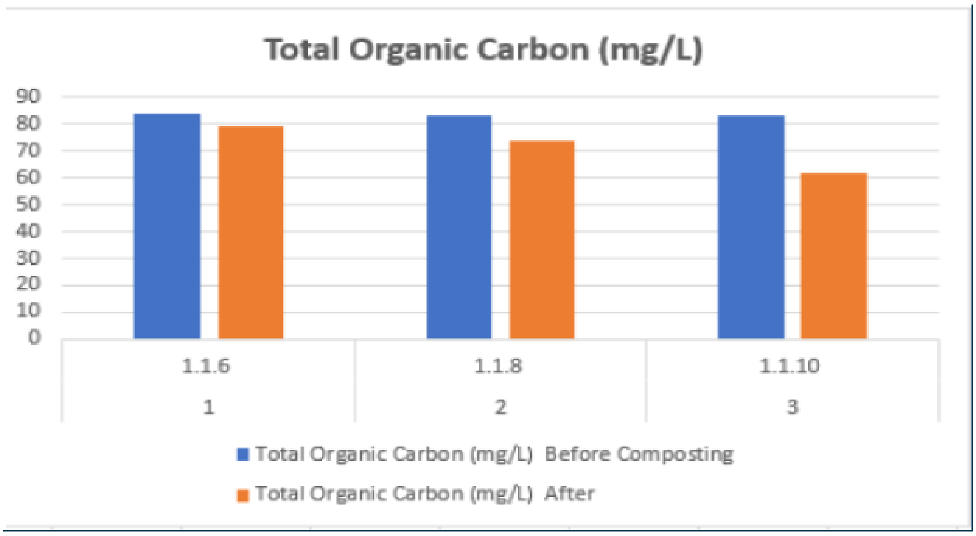

FIGURE 4.5: Total Organic Carbon of Compost Mix

TABLE 4.4 and FIGURE 4.5 shows the summarized TOC data of before and after composting. After composting, it is found that the TOC values of the mix decrease after composting ends. This is because organic matter decomposes and is turned into carbon dioxide, resulting in a drop in total organic carbon. The 1:1:10 ratio has the lowest TOC values compared to the rest.

4.6 Total Nitrogen (TN)

FIGURE 4.6: SPECTROMETER with the TN value setting

TABLE 4.5: Total Nitrogen of Compost Mix

No.	Compost Mix	Total Nitrogen (mg/L)	
		Before Composting	After Composting
1.	1.1.6	2.54	2.60
2.	1.1.8	2.56	2.74
3.	1.1.10	2.55	2.90

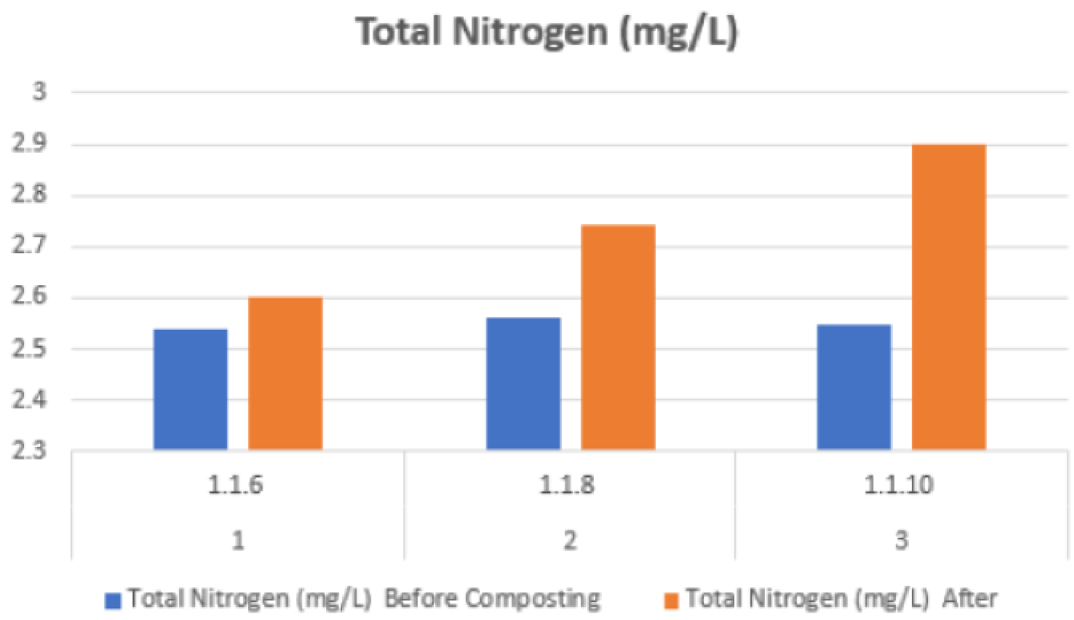

FIGURE 4.7: Total Nitrogen of Compost Mix

FIGURE 4.6 shows the spectrometer which is used to calculate TOC, TN, and TP values. TABLE 4.5 and FIGURE 4.7 shows the summarized TN data of before and after composting. The data shows that the TN value increases after the composting proses. The 1:1:10 ratio has the highest TN value because it has the highest amount of dry sludge. This shows that the more dry sludge is added, the higher the nitrogen value.

4.7 Total Phosphorus (TP)

TABLE 4.6: Total Phosphorus of Compost Mix

No.	Compost Mix	Total Phosphorus (mg/L)	
		Before Composting	After Composting
1.	1.1.6	1.35	1.75
2.	1.1.8	1.76	1.97
3.	1.1.10	1.21	1.83

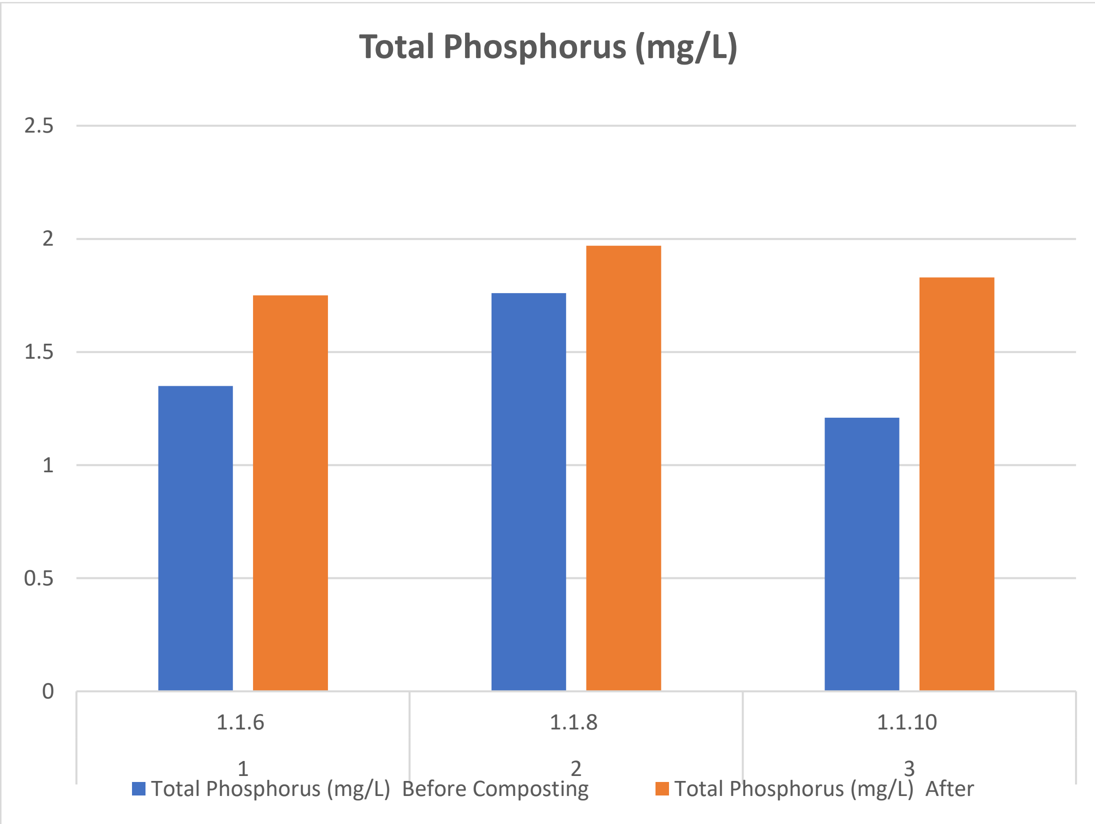

FIGURE 4.8: Total Phosphorus of Compost Mix

TABLE 4.6 and FIGURE 4.8 shows the summarized TP data of before and after composting. The TP values of each ratio increases after composting. This increases the nutrient value in the compost which can improve the overall soil quality.

4.8 NPK Values

TABLE 4.7: NPK value from each mix ratio

No.	**Compost Mix**	**NPK concentration (%)**		
		Nitrogen (N)	Phosphorus (P)	Potassium (K)
1.	1.1.6	2.5	1.8	0.5
2.	1.1.8	2.7	1.9	0.7
3.	1.1.10	2.9	1.8	0.8

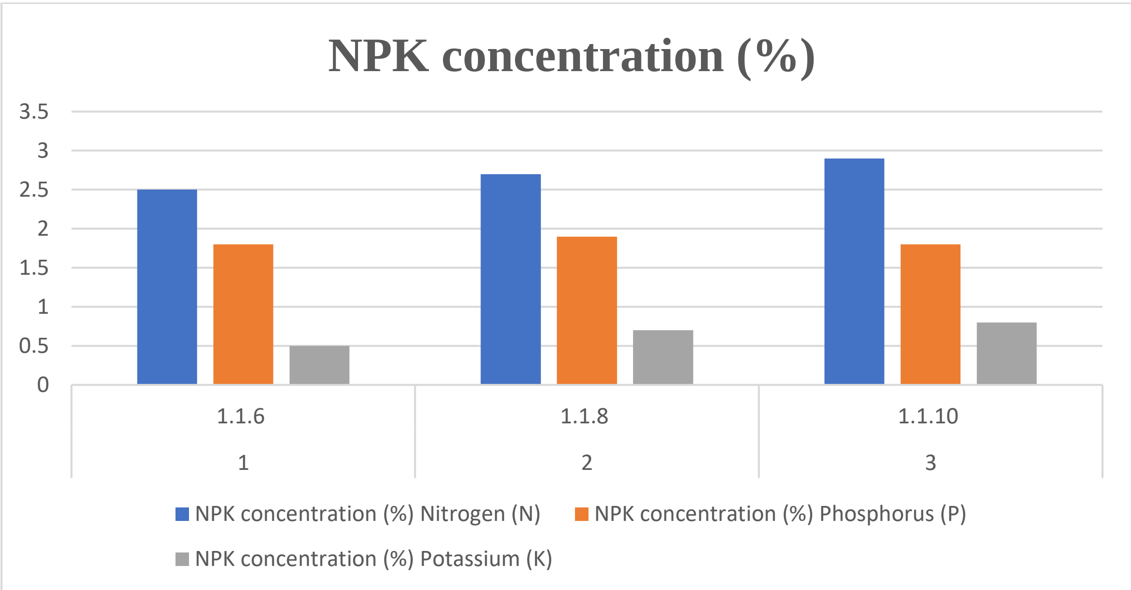

FIGURE 4.9: NPK value from each mix ratio

TABLE 4.7 and FIGURE 4.9 shows the NPK value after composting. NPK value is important in the compost since it determines the quality of the compost itself. The permitted range for nitrogen (N) is between 0.4 and 3.5 percent, for phosphorus (P) is between 0.3 and 3.5 percent, and for potassium (K) is between 0.5

and 1.8 percent, according to WHO regulations. All of the ratios are within the permissible range based on these requirements, indicating that the compost is not hazardous and can be used as a soil amendment.

4.9 C/N Ratio

TABLE 4.8: C/N ratio after composting

No.	Compost Mix	C/N Ratio
1.	1.1.6	25:1
2.	1.1.8	27:1
3.	1.1.10	30:1

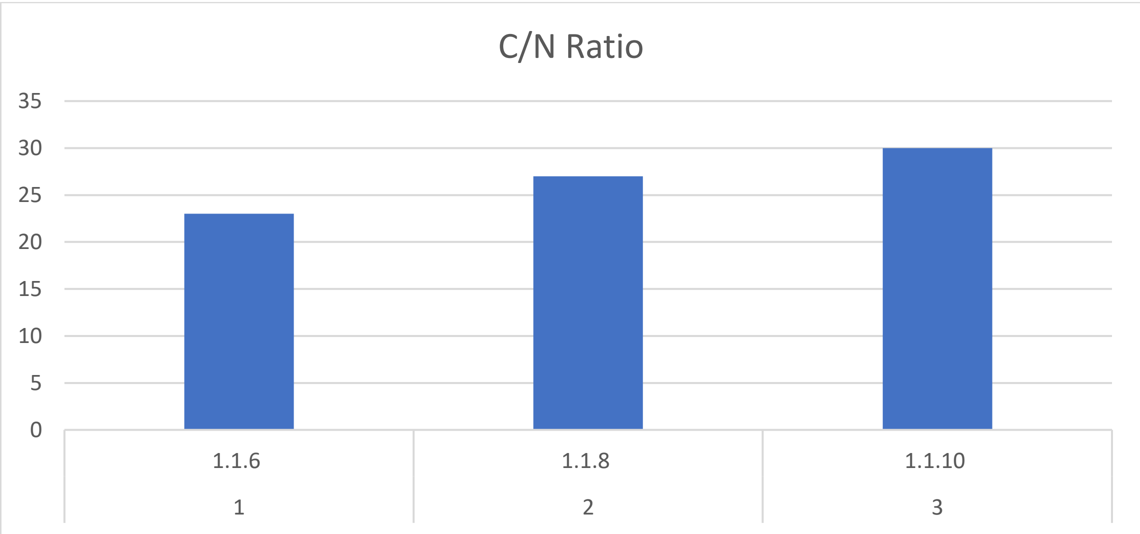

FIGURE 4.10: C/N ratio after composting

TABLE 4.8 and FIGURE 4.10 shows the C/N ratio data after composting. The carbon-to-nitrogen ratio, or C/N ratio, is a nutritional content indicator in compost. For composting, the C/N ratio should be between 25 and 30 (Kumar, 2010). The 1:1:6 ratio has a C/N value of 24 which is below from the recommended range for C/N composting ratio which means that this mix do not have optimal nutrients for the aerobes to degrade the mix. The 1:1:8 ratio is the most suitable ratio since it does not exceed the optimal C/N range.

5 CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

To conclude this study, it is known that the best performing compost mix is the 1:1:8 ratio. The 1:1:8 ratio values are within all the optimal range for a quality compost such as moisture content, pH, NPK values and C/N ratio. Sawdust is proven to be a great bulking agent to control high moisture content samples. Ultimately, composting is a reliable way to treat these excess cooking residues.

5.2 Recommendations

A composter machine will be convenient since it can compost within 24 hours which is time saving compared to in vessel laboratory composting which can take weeks to finish. To reduce the waste volume created by the fast-food companies, composting should be used more in real life rather than just on paper. Fast-food companies should care more about cooking residues degradation to further prevent damaging the environment.

REFERRENCES

Dominguez, M. N. (2019). Physicochemical and biochemical properties of an acid soil under potato culture amended with municipal solid waste compost. 8, 171–178.

Antizar-Ladislao, B. L.-R. (2005). Laboratory studies of the remediation of polycyclic aromatic hydrocarbon contaminated soil by in-vessel composting. . *Waste Management*, 25(3), 281-289.

Aoshima, M. P. (2001). Analyses of microbial community within a composter operated using household garbage with special reference to the addition of soybean oil. *Journal of Bioscience and Bioengineering*, 91, 456-461.

Asgari, A. N. (2017). iodegradation of total petroleum hydrocarbons from acidic sludge produced by re-refinery industries of waste oil using in-vessel composting. 15(1), 3.

Awasthi, M. K., Selvam , A., Chan, M. T., & Wong, J. W. (2017). Bio-degradation of oily food waste employing thermophilic bacterial. *Bioresource Technology*, 141 - 147.

Azim, K. S. (2018). Composting parameters and compost quality: A literature review. *Org. Agric.*, 8, 141–158.

Chang, J. C. (2010). Effects of bulking agents on food waste composting. *Bioresource technologies*, 101, 5917–5924.

Chen, H. J. (2014). State of the art on food waste research bibliometrics. *Journal of Cleaner Production*, 140, 840–846.

Demichelis, F. P. (2017). Investigation of food waste valorization through sequential lactic acid fermentative production and anaerobic digestion of fermentation residues. 508–516.

Eneji, A. Y. (2001). Physicochemical changes in livestock feces during composting. *Communication in Soil Science and Plant Analysis*, 32, 477- 489.

Gallert, C. a. (2005). *Bacterial Metabolism in Wastewater Treatment Systems.* Weinheim.

Gill, S. S., Jana, A. M., & Shrivastav, A. (2014). AEROBIC BACTERIAL DEGRADATION OF KITCHEN WASTE: A REVIEW. *Journal of Microbiology, Biotechnology and Food Sciences*, 477 - 483.

H, P. (2013). *Wastewater Treatment*. Retrieved from The USGS Water Science School: http://ga.water.usgs.gov/edu/wuww.html.

Hazren A. Hamid*, L. P. (2019). Development of Organic Fertilizer from Food Waste by Composting in UTHM Campus Pagoh. *Journal of Applied Chemistry and Natural Resources*, 1 - 6.

HKEPD. (24 September, 2015). *Monitoring of Solid Waste in Hong Kong - Waste Statistics for 2015.* Retrieved from wastereduction: https://www.wastereduction.gov.hk/en/materials/info/msw2011.pdf

Jain, S. N.-M. (2018). Global Food Waste Management: An Implementation Guide for Cities. 1–143.

K., P., M. A., A., N. A., N., N. M. , F., F. P., H., L. H., W., . . . S. A. , R. (2020). Food Waste Composting and Microbial Community. 30.

Khater, E. (2015). Some physical and chemical properties of composts. *Waste Resources*, 1–5.

Kumar, M. O. (2010). Co-composting of green waste and food waste at low C/N ratio. *Waste Management*, 30 , 602–609.

Mehta, C. P.-W. (2004). Compost: Its role, mechanism and impact on reducing soil-borne plant diseases. *Waste Management*, 34, 607–622.

Metcaf & Eddy, I. (2004). *Wastewater Engineering, Treatment and Reuse.* . Singapore: McGraw-Hill.

Mittal, A. (2013). *Biological Wastewater Treatment*. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC357663/?page=3.

Moreno, J. L.-G.-E. (2013). Recent advances in microbial aspects of compost production and use. *Acta Hortic.*, 1013, 443–458.

Nazaroff, a. C. (20th November, 2013). *Anaerobic Digestion of Wastewater Sludge.* . Retrieved from http://www.engineering.dartmouth.edu.

Palaniveloo, K., Amran, A., Norhashim, A., Mohamad-Fauzi, N., & Peng-Hui, F. (2020). Food Waste Composting and Microbial Community. 30.

Parr, J. H. (1992). Utilization of municipal wastes, In: Soil Microbial Ecology. *Applications in agricultural and environmental management*, 545–559.

Partanen, P. H. (2010). Bacterial diversity at different stages of the composting process. *BMC Microbiol*, 10, 94.

Pleissner, D. D. (2017). Direct production of lactic acid based on simultaneous saccharification and fermentation of mixed restaurant food waste. 615–623.

Prakash, V. S. (2015). Treatment of oil sludge contamination by composting. 6(3), 1.

Rihani, M. M. (2010). In-vessel treatment of urban primary sludge by aerobic composting. *Bioresource Technology 101*, 5988–5995.

Risse, M. F. (2009). What Is Compost? *Food waste composting: Institutional and Industrial Applications*, 1189, 1–8.

Sadeghi, S. D. (2015). Physical-Chemical Analysis and Comparison with Standards of the Compost Produced in Sanandaj, Iran. *Open Access Library Journal*.

Santos, H. L. (2006). Characterization and Quantification of Compatible Solutes in (Hyper)thermophilic Microorganisms. *Methods Microbiol*, 35, 173–199.

Seviour R., N. P. (2016). *Microbial Ecology of Activated Sludge.* London: IWA Publishing Company.

Sher Singh Gill, A. M. (2014). Aerobic bacterial degradation of kitchen waste a review. *Journal of Microbiology, Biotechnology and Food sciences*.

Svensson, K. O. (2004). *Journal of Agriculture Science*, 142, 461-467.

Uçaroğlu, S. A. (2016). Composting of wastewater treatment sludge with different bulking agents. 288-295.

Ye Chen, J. J. (2007). Inhibition of anaerobic digestion process: A review, from Department of Biological and Agricultural Engineering.