Development of Alternative Fuel Briquettes from Poultry Processing Waste (Energy Content and Chemical Characteristic)

by

Mohammad Sollehuddin Bin Sabtu

A Project Dissertation Submitted in Partial Fulfillment of

The Requirements for the

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(Mechanical Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Mechanical Engineering Programme
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Approved by,

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(Ir. Dr. Mohd Shiraz Aris)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

DECEMBER 2010

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.

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MOHAMMAD SOLLEHUDDIN BIN SABTU

ABSTRACT

Attempts were made to utilize the water treatment sludge as an alternative fuel to decrease the usage of fossil fuels. This research explored the Dinding Poultry Processing Plant (DPPP) water treatment sludge from a water treatment plant to develop of an alternative fuel briquette. The main objectives are to increase the value of the water treatment sludge and to offer an alternative route towards a sustainable and profitable disposal alternative for the water treatment sludge. DPPP Sludge was converted into a compressed form of briquette through experimental tests. This study presented the results of these studies on proximate analysis and ultimate analysis of the water treatment sludge for beneficial uses.There is also an experiment on determination of calorific value of the sludge. The results in this study showed that the water treatment sludge have high potential to be used as solid biofuel since it has comparable calorific value to the coal and higher than other conventional biomass like bagasse, rice husks and corn cobs. The moisture content in DPPP sludge, however, required further drying. By reducing moisture content to about 10 percent, the calorific value obtained reached 35000 kJ/kg. Fuel briquettes from poultry processing waste as one of the an alternative fuel is one of the profitable disposal alternative in the future.

ACKNOWLEDGEMENT

Bissmillahirrahmanirrahim,

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

World community is largely dependent on fossil fuels, which makes future sustainable development very difficult. There are drastic changes in the composition and behavior of our atmosphere due to the rapid release of polluting combustion products from fossil fuels. A significant amount of the NO_x and SO_x emissions from the energy sector is related to the use of fossil fuels for electricity generation. As the demand for electricity grows rapidly, the emissions of these pollutants can be expected to increase unless alternatives are made available. Among the energy sources that can substitute fossil fuels, biomass wastes appear as one of the potential option [1]. Therefore, this study was conducted to investigate the feasibility and possibilities of using the water treatment sludge from Dinding Poultry Processing Plant, Perak (DPPP) to produce an alternative fuel. After a series of visit to Dinding Poultry Processing plant in Setiawan, Perak, it was found the types of industrial waste disposed are sludge and chicken feather. Instead of wasting this poultry waste, it can offer many environmental benefits and the most appealing part is the savings that poultry processing waste can be used as an alternative fuel.

1.2 PROBLEM STATEMENT

The present investigation identifies few problems:

1. Two main poultry industrial waste, sludge and feather being thrown on open dumps through Department of Environment, Ministry of Natural Resources and Environment.
2. The world dependence on oil, natural gas or non renewable resources have been increasing and its involve greenhouse gas emissions.

1.3 OBJECTIVE

The present investigation constitutes an attempt;

1. To produce a durable briquetted biomass fuel from Dinding Poultry Processing Plant (DPPP) sludge and feather.
2. To characterize Dinding Poultry Processing Plant (DPPP) sludge in terms of proximate analysis, ultimate analysis and the calorific value especially with reference to the presence of other farming and agriculture waste.
3. To study the cost effectiveness of sludge recovery and its utilization as an alternative fuel.

1.4 SCOPE OF STUDY

The scope of this project would involve exploring the characteristics in poultry processing waste (Dinding Poultry Processing Sdn Bhd) such as energy content, chemical composition, and mechanical characteristic. The characterization is achieved through the following experiments:

1 Proximate analysis experiment

Thermo gravimetric analyzer (TGA) being used and based on the ASTM E1131-98 Standard Test Method for Compositional Analysis by Thermogravimetry. This type of analysis of samples allows prediction to be made as to how the samples will behave in a furnace.

2 Ultimate analysis experiment

LECO CHNS is the equipment used and specially to detect and quantifies carbon, hydrogen, sulfur and oxygen by means of individual.

3 Calorific value determination

Sample being put in Bomb Calorimeter. It is used to determine the enthalpy of combustion.

1.5 THE RELEVANCE OF THE PROJECT

DPPP sludge fuel briquettes are good to begin with for several reasons.

- Raw materials are readily available.
- Fuel briquetting can help reduce the greenhouse effect by avoiding the excess use of fossil fuel in our country.
- This poultry processing waste utilization can conserve our country natural resources.
- Fuel briquette making supports poultry production and directly saving the usage of electricity.
- Fuel briquette manufacturing can produce product for in country use as well as for export.
- Export markets for fuel briquettes have unlimited potential for profit.

CHAPTER 2

LITERATURE REVIEW

2.1 DINDING POULTRY PROCESSING PLANT (DPPP)

Dindings Poultry Processing SdnBhd (DPPP) incorporated on the 14th of September 1985 produces processed chicken and further processed poultry products. DPPP is a 95% owned subsidiary of Malayan Flour Mills Berhad (MFM). On the 27th August 1990, its plant, situated at Kampung Acheh, Sitiawan, Perak was officially opened by the former Prime Minister of Malaysia, Tun Dr Mahathir bin Mohamad in the presence of an entourage of Ministers and other dignitaries. The plant, which is one of the largest poultry processing plants in Malaysia, was designed according to United States Department of Agriculture (USDA) Standards. In addition, its proximity to the Ipoh-Lumut federal road system offers a ready means for shipment of its poultry products.

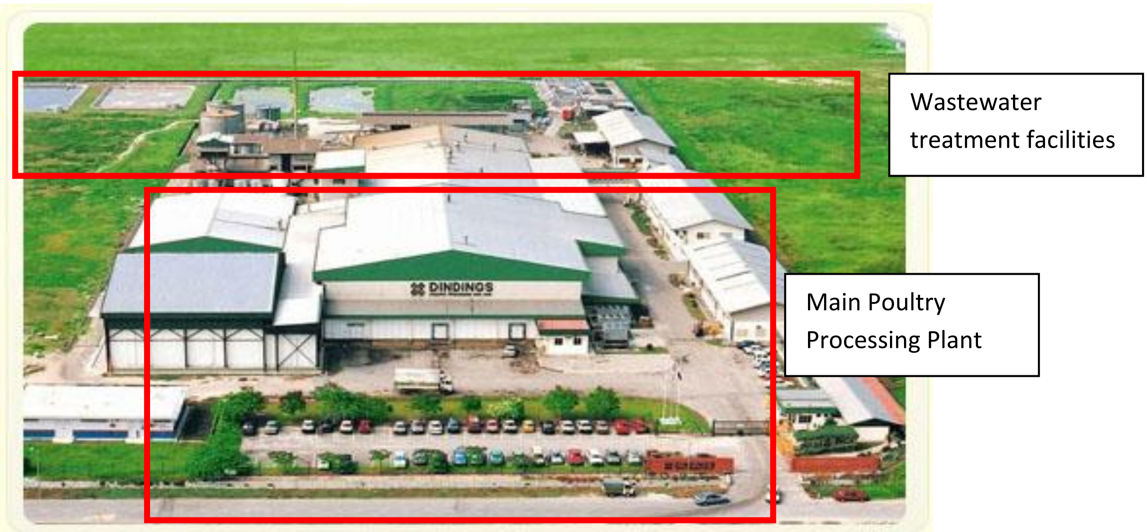


Figure 1- Dinding Poultry Processing Plant (DPPP) Sdn Bhd.

2.2 (DPPP) WASTEWATER TREATMENT FACILITIES

From the overall Dinding Poultry Processing Plant (DPPP), our focus goes to wastewater treatment plant. This is the where to get the sample of sludge and feather for the project development was obtained.

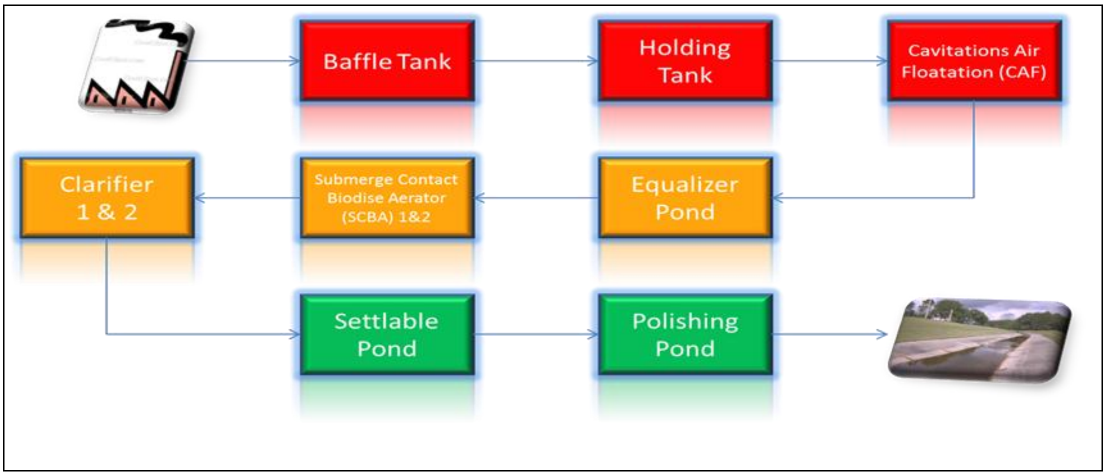


Figure 2: Process Flow of Wastewater Treatment Facilities

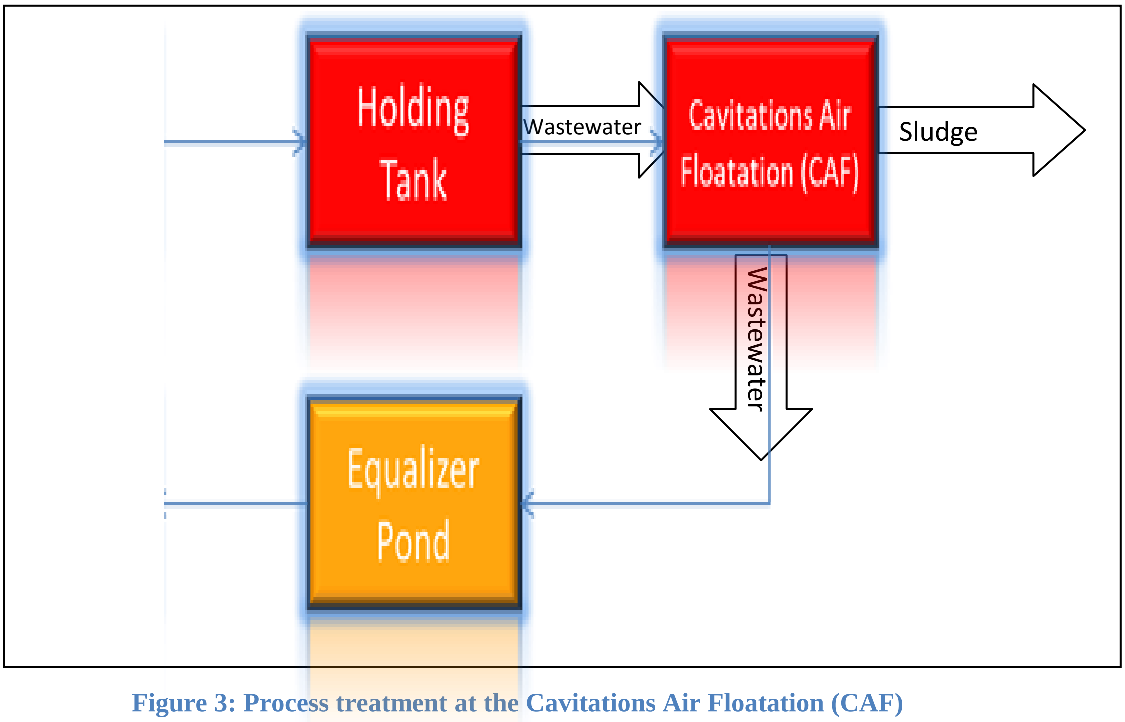


Figure 3: Process treatment at the Cavitations Air Floatation (CAF)

In DPPP, the by-product of the poultry processing plant is treated before the wastewater is discharged out of the plant. At the Baffle Tank, a rotostrainer is used to segregate water and feathers. The Feathers and the processed chicken will be accumulated in baskets and then moved out for disposal. The water flows to a holding tank where it stores water for the next treatment at the Cavitation Air Floatation (CAF) equipment. Figure shows that, the sludge consists of chicken manure and residue which have been removed from the wastewater. Then, the wastewater is passed through an equalization pond to a Submerge Contact Biodise Aerator (SCBA) (1&2) and Clarifier (1&2).

2.3 (DPPP) RAW SLUDGE

The raw sludge, coming from wastewater treatment processes that have been discussed before, is highly hydrated (up to 99%) [14][15]. The utilization of wet, raw sludge is possible only after dewatering and drying. Thermal drying is the last stage of removing water from sludge, after thickening and dewatering. It requires the highest energy supply, but provides the best results (Figure 4). Thermal drying of sludge significantly enhances the number of possibilities of its further usage; not only as a fuel but also for environmental purposes.

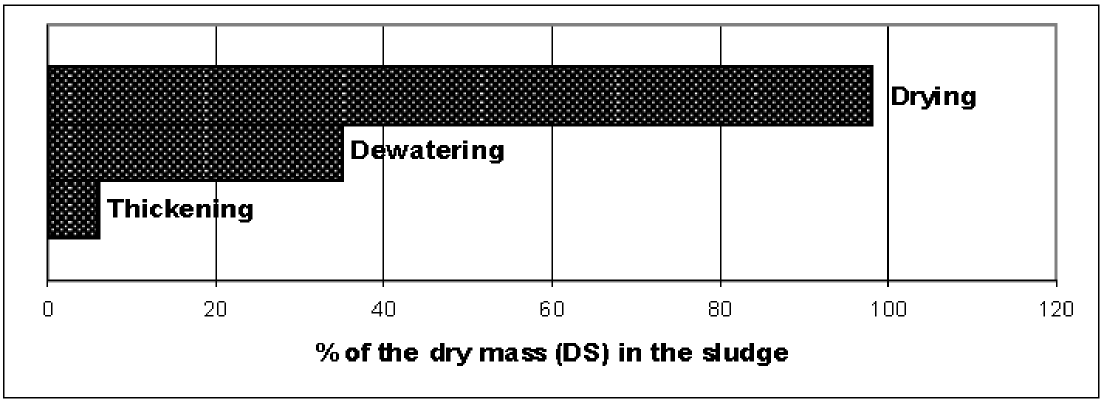


Figure 4: Concentration of dry mass (DS) in the sludge after processes of thickening, dewatering

Consequently, the drying process requires a lot of energy and therefore is very expensive with high environmental impact. Not always is the sludge drying process necessary, but in this case, it is the only solution.

2.4 DEVELOPMENT OF FUEL BRIQUETTES

Fuel briquette is a type of solid fuel in a compacted form. Pressure will be in place to compress the raw material to overcome the natural springiness of the material [6]. It is one of the methods to compress loose materials into a compact solid form. Then, the briquetted fuel will be test for its chemical characteristic and calorific value determination. Common types of briquettes are charcoal briquettes and biomass briquettes. There is several ways to produce fuel briquettes. Each one requires differing amount of equipment and supplies.

The process of sludge thermal drying is not a cheap solution mainly because of its high-energy demand. The economical feasibility of developing fuel briquette depends on the availability of waste energy. In DPPP plant, there is source of waste heat from its flue gas that can utilize for drying the sludge purpose.

2.5 CHEMICAL PROPERTIES TEST

The chemical properties tests consist of three main tests:

- Proximate analysis

  A technique that separates and identifies categories of compounds in a mixture; It is reported are moisture and ash content, the extracts of the mixture made with alcohol, petroleum ether, water, hydrochloric acid and resins, starches, reducing sugars, proteins, fats, esters, free acids, and so on; this type of analysis of solid fuels allows a prediction to be made as to how the fuel will behave in a furnace.

For proximate analysis, thermo gravimetric analyzer (TGA) will be used. Proper procedure and standard for proximate analysis was based on the ASTM E1131-98 Standard Test Method for Compositional Analysis by Thermogravimetry and the steps for coal were adopted [4].

Thermo gravimetric analysis or thermal gravimetric analysis (TGA) is a type of testing that is performed on samples to determine changes in weight in relation to change in temperature. Such analysis relies on a high degree of precision in three measurements: weight, temperature, and temperature change. As many weight loss curves look similar, the weight loss curve may require transformation before results may be interpreted. A derivative weight loss curve can be used to tell the point at which weight loss is most apparent. Again, interpretation is limited without further modifications and deconvolution of the overlapping peaks may be required.

Simultaneous TGA-DTA/DSC measures both heat flow and weight changes (TGA) in a material as a function of temperature or time in a controlled atmosphere. Simultaneous measurement of these two material properties not only improves productivity but also simplifies interpretation of the results. The complementary information obtained allows differentiation between endothermic and exothermic events which have no associated weight loss (e.g., melting and crystallization) and those which involve a weight loss (e.g., degradation).

The analyzer usually consists of a high-precision balance with a pan (generally platinum) loaded with the sample. The pan is placed in a small electrically heated oven with a thermocouple to accurately measure the temperature. The atmosphere may be purged with an inert gas to prevent oxidation or other undesired reactions. A computer is used to control the instrument. Analysis is carried out by raising the temperature gradually and plotting weight (percentage) against temperature. The temperature in many testing methods routinely reaches 1000°C or greater, but the oven is so greatly insulated that an operator would not be aware of any change in temperature even if standing directly in front of the device. After the data are obtained, curve smoothing and other operations may be done such as to find the exact points of inflection.

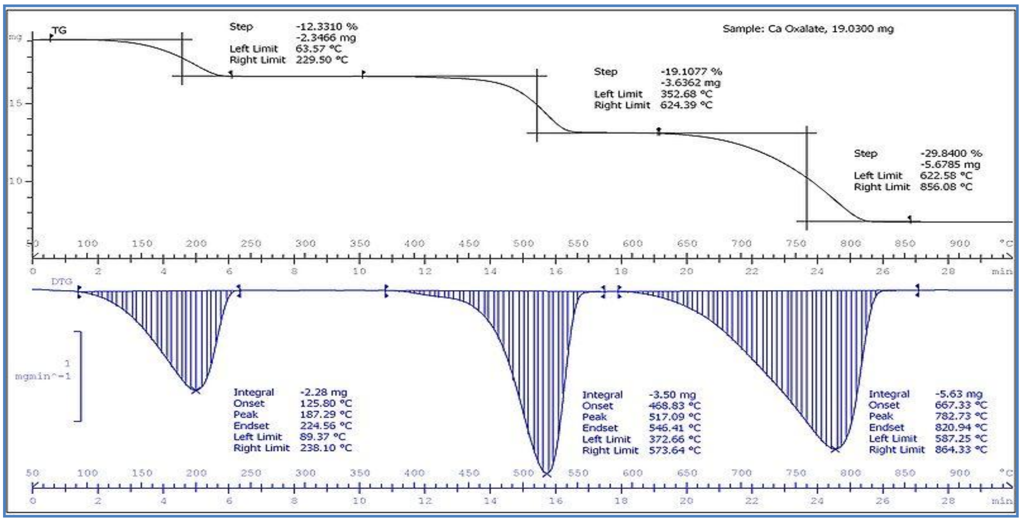


Figure 5: Thermo gravimetric analysis of Ca Oxalate

- Ultimate analysis

A process to determine the percentage of elements contained in a chemical substance. Simultaneous Elemental Analysis for Micro samples. Labs facilities need to use are the CHNS-932. This equipment specially detects carbon, hydrogen, sulfur, and oxygen by means of individual, highly selective, infrared detection systems. Nitrogen is measured as N in a highly sensitized thermal conductivity detection system. Since CHNS is determined simultaneously, analysis times are dramatically reduced compared to any sequential system. The LECO CHN-900 simultaneously determines carbon, hydrogen, and nitrogen in three minutes [5].

Basic CHNS principles [17], in the combustion process (furnace at ca. 1000^{o}C), carbon is converted to carbon dioxide; hydrogen to water; nitrogen to nitrogen gas/ oxides of nitrogen and sulphur to sulphur dioxide. If other element such as chlorine is present, they will also be converted to combustion products, such as hydrogen chloride. A variety of absorbents are used to remove these additional combustion products as well as some of the principal elements, sulphur for example, if no determination of these additional elements is required [18].

The combustion products are swept out of the combustion chamber by inert carrier gas such as helium and passed over heated (about 600^{o}C) high purity copper. This copper can be situated at the base of the combustion chamber or in a separate furnace. The function of this copper is to remove any oxygen not consumed in the initial combustion and to convert any oxides of nitrogen to nitrogen gas. The gases are then passed through the absorbent traps in order to leave only carbon dioxide, water, nitrogen and sulphur dioxide.

Detection of the gases can be carried out in a variety of ways including (i) a GC separation followed by quantification using thermal conductivity detection (ii) a partial separation by GC (‘frontal chromatography’) followed by thermal conductivity detection (CHN but not S) (iii) a series of separate infra-red and thermal conductivity cells for detection of individual compounds. Quantification of the elements requires calibration for each element by using high purity ‘micro-analytical standard’ compounds such as acetanilide and benzoic acid.

CHNS instrumentation[17][18], Combustion elemental analyzers are manufactured in a variety of configurations to suit specific applications, and the choice will depend on the elements of interest, the sample type and size, and the concentration of the sample. All instruments require two gas supplies: (i) an inert carrier gas (helium recommended); and (ii) high purity oxygen (minimum 99.9995%). The strict specification for oxygen is associated with the need to reduce the nitrogen 'blank' contribution to an inconsequential level. Additionally, GC-type gas filters are also usually fitted to prevent trace organic species and water entering the combustion system.

- Calorific value determination

The calories or thermal units contained in one unit of a substance and released when the substance is burned. Sample will be put into IkaWerke Bomb Calorimeter. Bomb calorimeter is used to determine the enthalpy of combustion, $D_{comb}H$, for hydrocarbons:

$$C_xH_YO_{Z\,(s)} + (2X+Y/2-Z)/2\ O_{2\,(g)} \rightarrow X\ CO_{2\,(g)} + Y\ H_2O_{(l)}$$

- A vessel filled with water (inner vessel) surrounds the Decomposition vessel.
- The heat generated by the combustion process is transferred into the surrounding water.
- To ensure that the heat created during the combustion does not get out of the system or heat gets into the system from the environment (room temperature changes), another water filled vessel (outer vessel) is used as isolation.

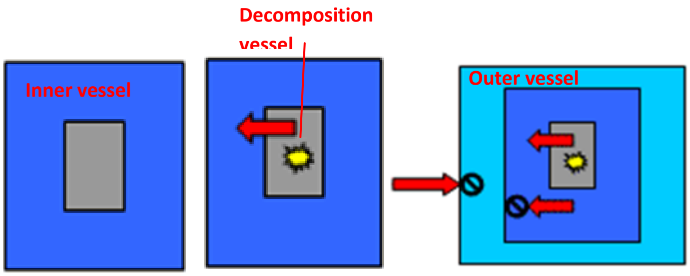


Figure 6: Concept of Bomb Calorimeter

Since combustion reactions are usually exothermic (give off heat), D_{combH} is typically negative. (However, be aware that older literature defines the "heat of combustion" as $-D_{combH}$, so as to avoid compiling tables of negative numbers!). The heat created during the burning process can be determined in different.

A Bomb-Calorimeter is used to measure the heat created by a sample burned under an oxygen atmosphere in a closed vessel, which is surrounded by water, under controlled conditions. The measurement result is called the Combustion-, Calorific- or BTU-value. The result allows the user to make certain important quality, physiological, physical and chemical as well as financial conclusions and/or decisions on the product, for the company.

About 1g of solid or liquid matter is weighed into a crucible, and placed inside a stainless steel container (the “Decomposition vessel”) filled with 30 bar (435 PSI) of oxygen (Quality: technical oxygen 99.98%). Than the sample is ignited through a cotton thread connected to an ignition wire inside the decomposition vessel and burned (combusted) [7]. During the combustion the core temperature in the crucible can go up to 1000 ^{0}C (1800 ^{0}F), and the pressure rises for milliseconds to approximately 200 bar (2900 PSI). All organic matter is burned under these conditions, and oxidized. Even inorganic matter will be oxidized to some extent [7].

CHAPTER 3
METHODOLOGY

3.1 PROJECT METHODOLOGY

Dinding Poultry Processing Sdn Bhd has been chosen as this project partner industry. Besides that, a few others biomass waste from farming sector like cow dung, goat litter, and chicken litter will also be analyzed as a reference and comparative matter towards the development of final product. For the first stage of the project, it will involve collecting and researching the necessary information regarding a few types of farming wastes. After that, a few several test specifically categorized under chemical test like proximate analysis, ultimate analysis and energy content will be done.

Both proximate and ultimate analyses were determined using Thermal Gravimetric Analyzer (TGA by Perkin Elmer) and CHNS-900 (by LECO) respectively. A known amount of sample was placed in a TGA. The thermograms produced were analyzed to determine the moisture, volatile matter, fixed carbon and ash. The elementary analysis was carried out using CHNS Analyzer and last but not least, the calorific values were determined using the Oxygen Bomb Calorimeter (by IKA).

The procedures for the entire test were obtained from various published source. The procedure for proximate analysis is based on the ASTM E1131-98 Standard Test Method for Compositional Analysis by thermo gravimetric analyzer (TGA) [4], while for ultimate analysis is based on the ASTM D 3176. While conduct the experiment, safety issue is one of the main aspects need to be taken care of. Basically, it requires the use of personal protective equipment (PPE) to reduce exposure to hazards in reducing these exposures to acceptable levels. Furthermore, all lab facilities also enforce regarding this matter to conduct experiment wisely and safely.

3.2 PERSONAL PROTECTIVE EQUIPMENT

DPPP sludge may pose a sanitary threat to human health and life or to the environment. Stabilized sludge is inhabited by microfauna and microflora, forming a specific biocenose. In its composition can de distinguished: bacteria, viruses, parasitic worms, fungi, protozoa and many many other microorganisms. Some of them are dangerous (pathogenic) and some are neutral (saprophytic) from a sanitary point of view. During thermal drying process sludge undergoes pasteurization (approx. 30 minutes in the temperature min. 85^{o}C). After drying in contact dryers, where sludge is wormed up to 100 -140^{o}C, sludge is even partially sterilized. [5] Accordingly, thermally dried sludge is considered as sanitary safe.

So, it is crucial for the user to have proper personal protective equipment. Personal protective equipment (PPE) refers to protective clothing, helmets, goggles, or other garment designed to protect the wearer's body from any chemicals, and infection, for job-related occupational safety and health purposes. OSHA's general personal protective equipment requirements mandate that employers conduct a hazard assessment of their workplaces to determine what hazards are present that require the use of protective equipment, provide workers with appropriate protective equipment, and require them to use and maintain it in sanitary and reliable condition.

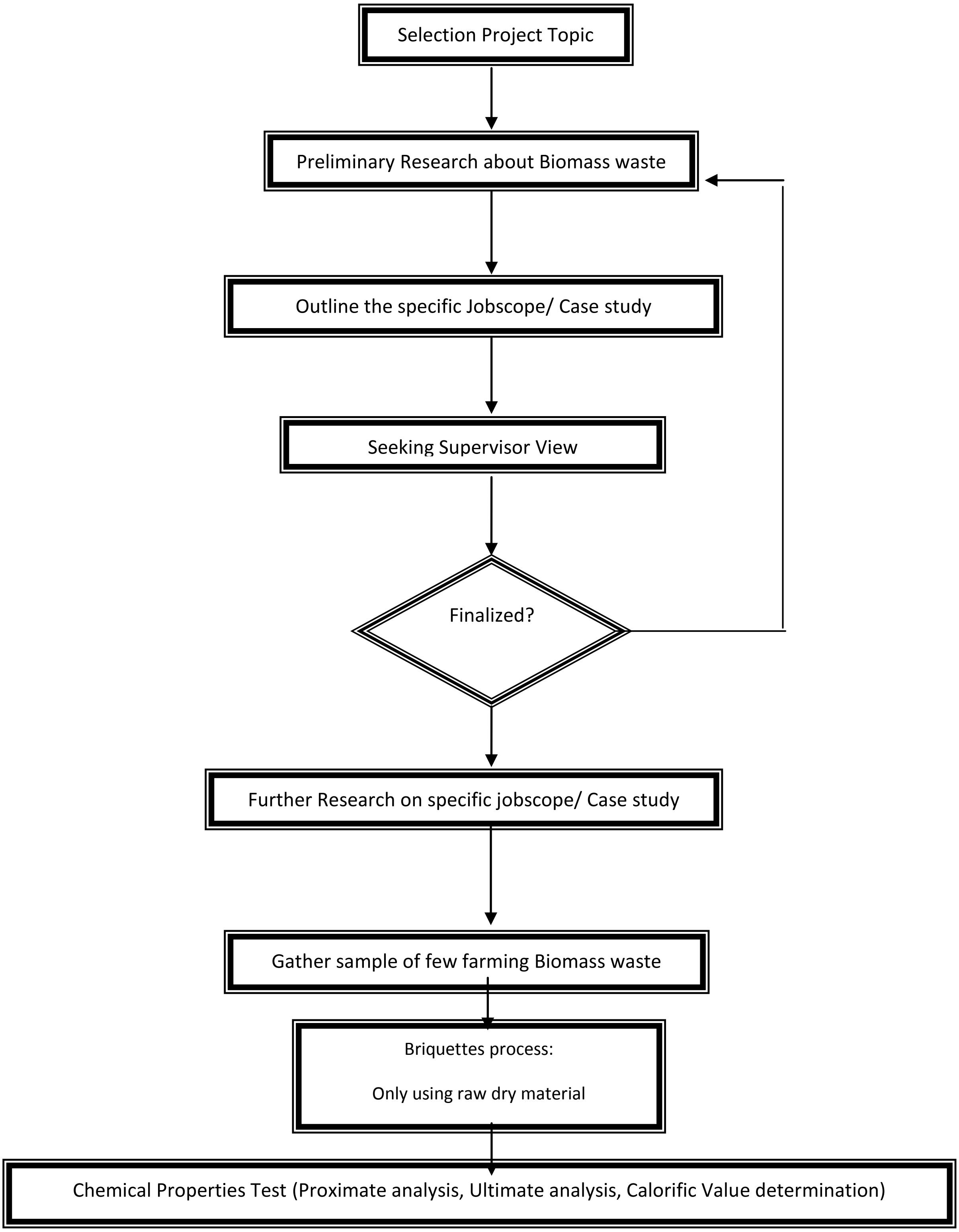
Using personal protective equipment is often essential, but it is generally the last line of defense after engineering controls, work practices, and administrative controls. Engineering controls involve physically changing a machine or work environment. Administrative controls involve changing how or when workers do their jobs, such as scheduling work and rotating workers to reduce exposures. Work practices involve training workers how to perform tasks in ways that reduce their exposure to workplace hazards.

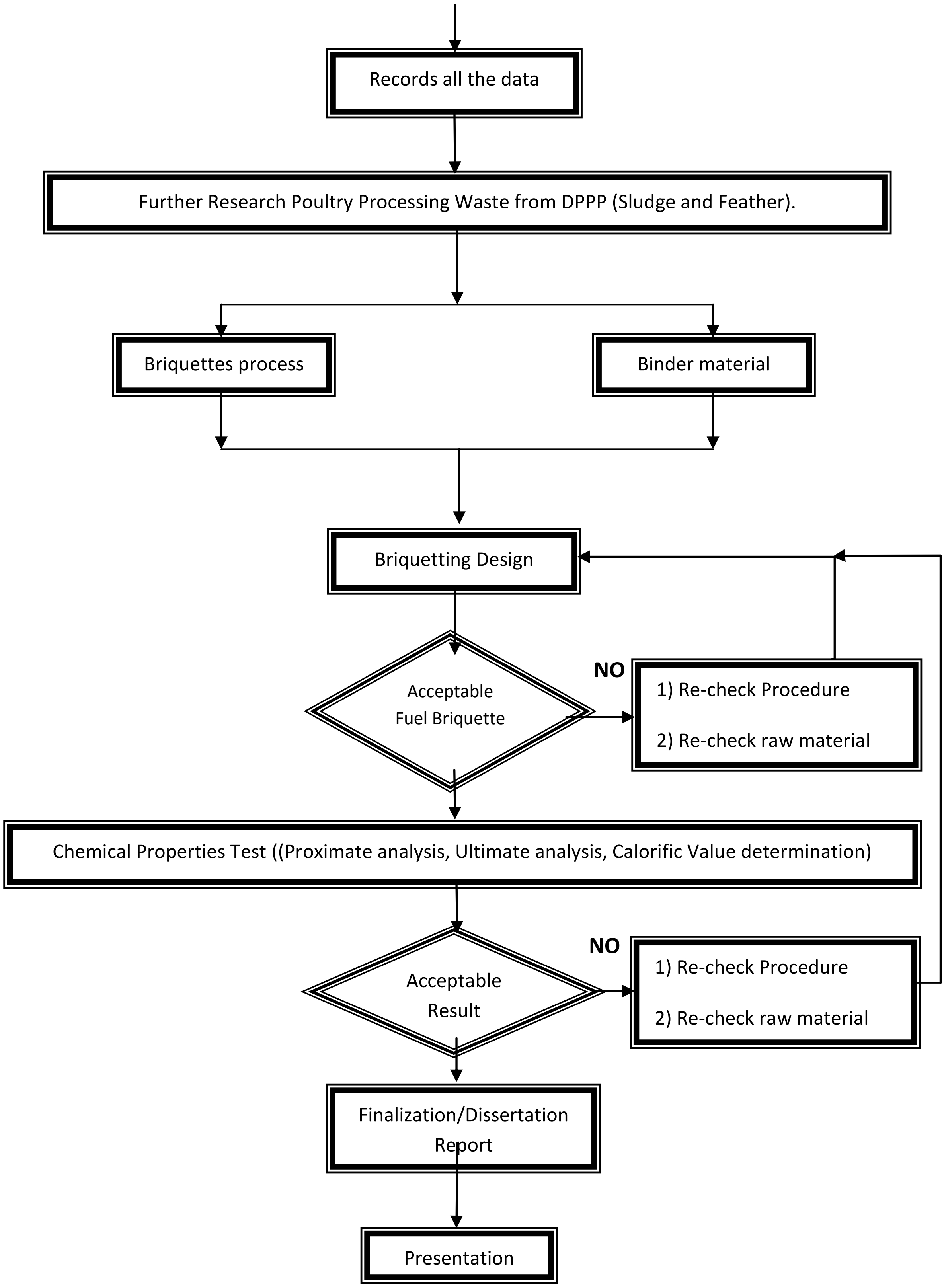
And last but not least, proper training needed to wear personal protective equipment will effect:

- Use protective equipment properly,
- Be aware of when personal protective equipment is necessary
- Know what kind of protective equipment is necessary,
- Understand the limitations of personal protective equipment in protecting workers from injury
- Put on, adjust, wear, and take off personal protective equipment, and
- Maintain protective equipment properly.

3.3 PROJECT WORK

For the project activity flow:-




Records all the data
Further Research Poultry Processing Waste from DPPP (Sludge and Feather).
Briquettes process
Binder material
Briquetting Design
Acceptable Fuel Briquette
NO
1) Re-check Procedure
2) Re-check raw material
Chemical Properties Test ((Proximate analysis, Ultimate analysis, Calorific Value determination)
Acceptable Result
NO
1) Re-check Procedure
2) Re-check raw material
Finalization/Dissertation Report
Presentation

CHAPTER 4

RESULTS AND DISCUSSION

Based on project activity flow in chapter three, this chapter will present all the relevant chemical characteristic data obtained using the DPPP sample and directly compared the result with other biomass waste that have been collected around Perak. Several sample of farming waste have been collected and among them are chicken litter, goat litter and cow dung. Other than farming waste, agriculture waste experimental analysis also included in this paper as to compare it with the DPPP sludge sample. Among the agricultural waste are rice husk, oil palm shell and sugarcane waste [6].

4.1 MOISTURE CONTENT

Before conducting any experiment, the samples need to go through drying process. The samples were dried in an oven at a constant temperature range of 104°C to 110 °C. The results showed that the moisture content (wet basis) of sludge was initially at 65.37 percent in the beginning of the experiment (i.e. at 0 hour). Figure 6 illustrated the moisture content for the samples were observed to decrease gradually until the end of the experiment.

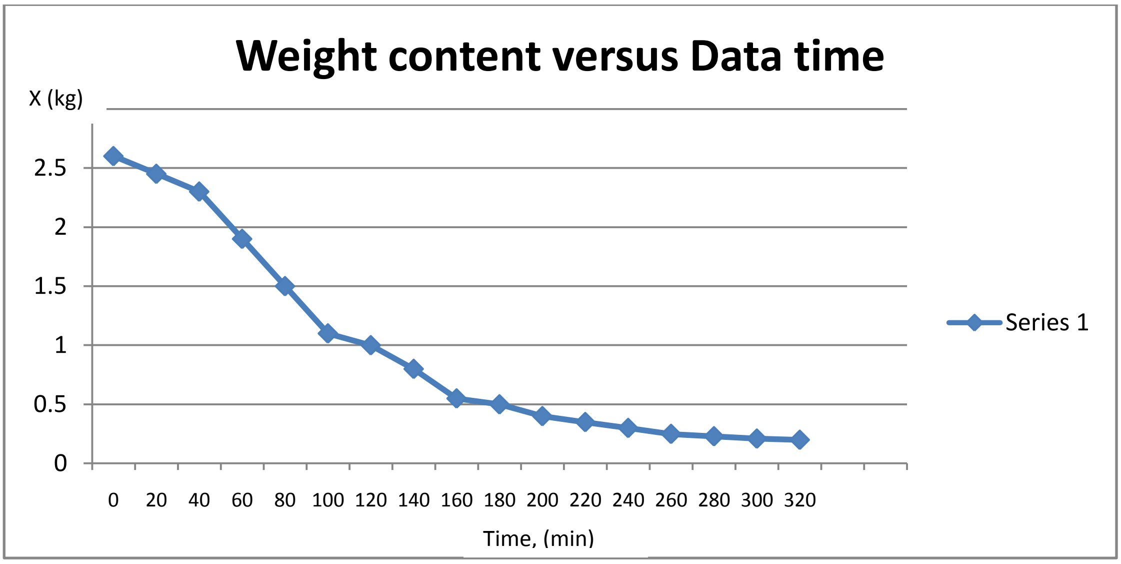


Figure 7: Moisture Content versus Data Time

A rapid moisture loss during the initial state of drying was observed for the first 7 hours, 24 hours and 48 hours for sludge, respectively. This is attributed to the evaporation of moisture from the surface area of the sludge and biomass used [9]. Assume that, fuel briquette from DPPP sludge have quite similar structure to fuel briquette made from wood. It has inner boundary and outer boundary. According to Alves and Figueiredo [22], when heat is applied to wood particles, the particles begin to dry more intensely at the outer boundary, at which the temperature is high. Whereas the bound and free water tend to move outward by convection and diffusion although some may migrate towards the inner, colder parts of the solid, where recondensation occurs. However, as the drying process continued, the penetration of heat into the deeper part of the wood particle and the moisture movement to the surface become harder due to material resistance. So, it's slower the rate of drying. This theory explains the results obtained for all drying curves of sludge.

4.2 PROXIMATE ANALYSIS

As defined by ASTM, proximate analysis separates the products into four groups: (1) moisture, (2) volatile matter, consisting of gases and vapors driven off during pyrolysis, (3) fixed carbon, the nonvolatile fraction of coal, and (4) ash, the inorganic residue remaining after combustion. Proximate analysis is the most often used analysis for characterizing in connection with their utilization.

Sample	Repeatability	% Avg Moisture	% Avg Volatile Matter	% Avg Fixed Carbon	% Avg Ash
DPPP Sludge	5 Samples	10.0 ± 1.5	66.7 ± 3.0	22.3 ± 2.8	11.0 ± 1.3
Goat Litter	5 Samples	12.0 ± 2.3	53.3 ± 3.2	20.1 ± 4.2	24.2 ± 1.8
Chicken Litter	5 Samples	11.4 ± 1.4	49.2 ± 5.0	14.8 ± 2.0	34.6 ± 3.2

Table 1: Proximate analysis of DPPP Sludge compare to farming waste in weight percentage

Sample	Repeatability	% Avg Moisture	% Avg Volatile Matter	% Avg Fixed Carbon	% Avg Ash
DPPP Sludge	5 Samples	10.0 ± 1.5	66.7 ± 3.0	22.3 ± 2.8	11.0 ± 1.3
Rice husk	5 Samples	5.75	65.01	14.98	14.26
Oil palm shell	5 Samples	7.71	68.85	20.84	2.61
Sugarcane waste	5 Samples	9.00	57.00	30.00	4.00

Table 2: Proximate analysis of DPPP Sludge compare to agriculture waste in weight percentage

Sample	Repeatability	% Avg Moisture	% Avg Volatile Matter	% Avg Fixed Carbon	% Avg Ash
DPPP Sludge	5 Samples	10.0 ± 1.5	66.7 ± 3.0	22.3 ± 2.8	11.0 ± 1.3
Coal	5 Samples	10.0	68.9	23.2	4.6
Charcoal	5 Samples	10.0 ± 1.9	68.2 ± 3.8	22.0 ± 2.5	3.0 ± 2.0

Table 3: Proximate analysis of DPPP Sludge compare to coal and charcoal in weight percentage

After drying, the moisture content of the DPPP sludge lowered to 10 to 15% by weight. DPPP sludge samples were found to consist of 22.3 percent of fixed carbon content, 66.7 percent of high volatile matter and 11.0 percent ash content on dry basis. The combustible component of a solid fuel are its volatile matter and the fixed carbon. Based on the proximate analysis result, DPPP sludge record high percentage for the volatile matter and the fixed carbon compare to other farming and agricultural waste.

Ash content is the remaining incombustible minerals of a fuel. Consequently, the calorific value decreases with increasing ash content. In general, fuels should have ash content less than 5% [9]. But DPPP Sludge in this study have been found to have high ash content compare to oil palm shells,coal or charcoal, which would then reduce the direct combustion of DPPP Sludge as biofuels.

4.3 ULTIMATE ANALYSIS

Ultimate Analysis is defined in ASTM D 3176 as the determination of the carbon, hydrogen, sulfur and nitrogen in the material. As found in the gaseous products of its complete combustion, the determination of element in the material as a whole.

Sample	Repeatability	% Avg Carbon	% Avg Hydrogen	% Avg Nitrogen	% Avg Sulfur
DPPP Sludge	5 Samples	67.9 ± 4.0	10.1 ± 0.8	3.7 ± 0.3	0.1 ± 0.2
Goat Litter	5 Samples	27.0 ± 3.5	3.8 ± 0.7	2.1 ± 0.3	0.3 ± 0.1
Chicken Litter	5 Samples	22.4 ± 3.3	3.4 ± 0.7	2.98 ± 0.9	0.3 ± 0.2

Table 4: Ultimate analysis of DPPP Sludge compare to farming waste in weight percentage

Sample	Repeatability	% Avg Carbon	% Avg Hydrogen	% Avg Nitrogen	% Avg Sulfur
DPPP Sludge	5 Samples	67.9 ± 4.0	10.1 ± 0.8	3.7 ± 0.3	0.1 ± 0.2
Rice husk	5 Samples	36.2	5.0	1.2	0.1
Oil palm shell	5 Samples	46.5	5.9	0.9	0.1
Sugarcane waste	5 Samples	41.5	5.2	0.6	0.3

Table 5: Ultimate analysis of DPPP Sludge compare to agricultural waste in weight percentage

Sample	Repeatability	% Avg Carbon	% Avg Hydrogen	% Avg Nitrogen	% Avg Sulfur
DPPP Sludge	5 Samples	67.9 ± 4.0	10.1 ± 0.8	3.7 ± 0.3	0.1 ± 0.2
Coal	5 Samples±	65.2	3.9	3.5	0.0
Charcoal	5 Samples	70.0 ± 5.7	6.5 ± 1.9	1.5 ± 0.4	0.3 ± 0.2

Table 6: Ultimate analysis of DPPP Sludge compare to coal and charcoal waste in weight percentage

4.4 CALORIFIC VALUE DETERMINATION

From the table below, it can be seen that the calorific values of DPPP Sludge range from 33500 J/kg to 35000 J/kg. The results also show that the DPPP Sludge collected have comparable calorific values with coal and definitely higher than those of the conventional biomass fuels like rice husks and other farming waste as shown in Table 7.

Sample	Repeatability	Avg Energy Content (J/g)
DPPP Sludge	5 Samples	33517 ± 2300
Rice husk	5 Samples	18100
Oil palm shell	5 Samples	20700
Sugarcane waste	5 Samples	19200
Goat Litter	5 Samples	11710 ± 2800
Chicken Litter	5 Samples	7896 ± 1000
Coal	5 Samples	31885
Charcoal	5 Samples	29674 ± 900

Table7: Calorific Value of various biomass and conventional solid fuels

4.5 DISCUSSION ON CHEMICAL CHARACTERISTIC

Table 8 shows the results for both proximate and ultimate analysis as well as calorific values of the selected materials. Good knowledge of the heating or calorific value of a fuel lead to proper heat rate calculations, and modifying operating parameters. On the other hand, an ash composition is needed for controlling ash-related conditions such as fouling or erosion and management of environmental emissions [19] [20].

	Proximate Analysis				**Ultimate analysis**				
Sample	% Avg Moisture	% Avg Volatile Matter	% Avg Fixed Carbon	% Avg Ash	% Avg Carbon	% Avg Hydrogen	% Avg Nitrogen	% Avg Sulfur	% Avg Energy Content
DPPP Sludge	10.0 ± 1.5	66.7 ± 3.0	22.3 ± 2.8	11.0 ± 1.3	67.9 ± 4.0	10.1 ± 0.8	3.7 ± 0.3	0.1 ± 0.2	33517 ± 2300
Goat Litter	12.0 ± 2.3	53.3 ± 3.2	20.1 ± 4.2	24.2 ± 1.8	27.0 ± 3.5	3.8 ± 0.7	2.1 ± 0.3	0.3 ± 0.1	11710 ± 2800
Chicken Litter	11.4 ± 1.4	49.2 ± 5.0	14.8 ± 2.0	34.6 ± 3.2	22.4 ± 3.3	3.4 ± 0.7	2.98 ± 0.9	0.3 ± 0.2	7896 ± 1000
Rice husk	5.75	65.01	14.98	14.26	36.2	5.0	1.2	0.1	18100
Oil palm shell	7.7	64.8	20.8	2.6	46.5	5.9	0.9	0.1	20700
Sugarcane waste	9.0	57.0	30.0	4.00	41.5	5.2	0.6	0.3	19200
Coal	10.0	58.9	23.2	4.6	65.2	3.9	3.5	0.0	31885
Charcoal	10.0 ± 1.9	68.2 ± 3.8	22.0 ± 2.5	3.0 ± 2.0	70.0 ± 5.7	6.5 ± 1.9	1.5 ± 0.4	0.3 ± 0.2	29674 ±900

Table 8: The overall value of chemical characteristic and calorific value for each of the samples

The calorific value of a material is the amount of heat released by a material during combustion. It is affected by the ash and moisture contents of the biomass. The net calorific value or lower heating value is defined as the heat to be removed from the reaction products to obtain a final temperature equal to the initial temperature of the reactants, assuming that the reaction products remain in gaseous phase, i.e. that the heat of condensation of water is not available.

The 11.0 percent ash content in DPPP sludge is relatively higher compare to oil palm shell, coal and charcoal. The ash content of a fuel lowers down the calorific value and may cause major problems at high temperature combustion (melting of ash and clogging of reactors) [19] [20]. The ash-related problems, including agglomeration, corrosion, and erosion, can cause frequent unscheduled shutdowns, decreasing the availability and reliability of the energy source [20].

The calorific value decreases with increasing moisture content. The presence of moisture in fuels lower its effective heating value since a portion of the heat of combustion is utilized in evaporating the contained moisture. It is highly desirable, therefore, that the moisture content be kept as low as possible [19].

The fixed carbon also affects the heating value of the fuel in such a way that the higher the fixed carbon, the higher the thermal value of fuel. DPPP sludge contains 22.3 percent of fixed carbon and it is comparable with coal and charcoal. In general, an increase in the ash content corresponds to a decrease in the fixed carbon content and hence a decrease in heating value [21].

The fuel elements of biofuels are actually the volatile matters and the carbon content while moisture and ash contents contribute as the impurities [17]. The result obtained showed that the volatile matter of sludge and carbon content is greater than farming waste. In contrast, the moisture as well as ash content of agriculture waste is less than DPPP sludge. Furthermore, the energy content of sludge and biomass is measured by its calorific value.

DPPP sludge has 0.1 percent of the sulfur content and it is among the lowest compare to other farming and agricultural waste. The sulfur content of agriculture waste was much higher than of sludge. The nitrogen content of sludge has much higher than that of biomass. This fact constitutes an advantage from a fertilizer point of view if considering the agricultural use of sludge, could be an important drawback for combustion to be considered but other metal content in it may harmful the land and underwater stream. The NO_x emission could be expected during their combustion. Nevertheless, NO_x emission has been found decreased by combustion experiences. Albertson et al [23] reported that this could be related to the high volatile content in sludge, which accelerates the air consumed during combustion, diminishes the rate O/N in the flame and represses the thermal generation of NO_x.

The overall result showed that DPPP sludge is having a potential as fuel element as compared to goat litter, chicken litter, rice husk, oil palm shell, sugarcane waste in terms of higher C/O, C/H and C/N ratio. The moisture and volatile matters for DPPP sludge are comparable with the coal and the charcoal. This is proven in the result obtained where DPPP sludge record the volatile matter content range in 66 to 68 percent and moisture content range in 10 to 11 percent.

4.6 EFFICIENCY AND ECONOMIC EVALUATION.

Efficiency

We take the example of a rated output of 2.3 MW boilers. Energy conversion takes place in two stages.

- The first part of the conversion is efficiency of the boiler and combustion. For this example we take 75 % on an HHV basis that is the normal range for a well-optimized industrial plant.

- Second part is the steam turbine efficiency. Modern Rankine cycle, have efficiencies that vary from 32 % to 45 %. This depends mainly on the steam parameters. We assume a value of 42 % for DPPP plant case.

- The overall conversion efficiency then is (42% x 75%) = 31.5 %.

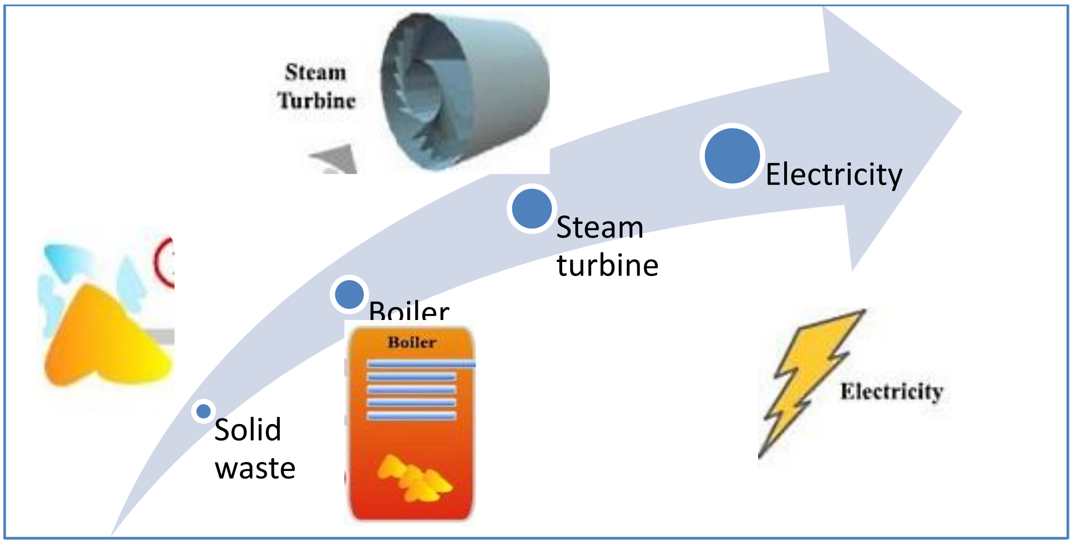


Figure 8: Conversion from solid waste to electricity

Heat Rate

Heat rate is the heat input required to produce one unit of electricity. (1 kW hr)

- One kW is 3600 kJ/hr. If the energy conversion is 100 % efficient then to produce one unit of electricity we require 3600 kJ.
- After considering the conversion efficiency in a power plant we require a heat input of (3600 / 31.5 %) 11428 kJ/ kW hr.

Sludge Quantity

- Since sludge has a heat value of 33,000 kJ/kg, for producing one kw.hr we require (11428 / 33000) 0.346 kg of sludge. This translates to (0.346 x 2.3 x 1,000) 796 kg/hr (0.796 T/hr) of sludge for an output of 2.3 MW.
- Approximately, we have 80kg to 85kg of dry sludge for each of every day. Collection of a 10 days of sludge may reach up to 800kg (0.8 T).
- 1 BTU equal to 0.293W.hrs. Output of 2.343 MW requires 8 MMBTU.
- According to tariff provide by Gas Malaysia, in a month, you can save up to RM 360. And it is 0.015 percent total savings in term of gas utilization per month.

CHAPTER 5

CONCLUSION& RECOMMENDATION

DPPP Sludge have high potential to be used as solid biofuel since it has comparable calorific values to coal and higher than conventional biomass like bagasse, rice husks and corn cobs. However, DPPP Sludge had to be dried to 10-15% moisture content in order to obtain calorific values close to the coal (30000 – 35000 kJ/kg).

A key question in this assessment is also whether it can be expected that an innovative method, which needs further research to be developed to a practical scale, will at the end be competitive with methods already applied in practice. In this respect, it also has to be taken into account that we can expect an improvement and further reduction in costs of the methods already applied in practice.

It is clear that many options exist to recover energy from the organic compounds present in wastewater sludge, sometimes also in combination with the production of valuable materials from the inorganic present in the sludge. Because the focus of a sludge treatment process is very often on a complete process that also offers a solution for the toxics present in the sludge, the fate of these toxics has to be taken into account in the evaluation of an energy recovery process. Furthermore, attention has to be given to the large amount of water in the sludge. In the case of fuel briquette production from sludge, high water content can be a problem.

Sludge drying process diminishes the volume of sludge and making its transportation and storage cost lower, increases sludge calorific value, makes it hygienic (without pathogenic organisms), stabilizes it and improves its structure. The choice of sludge drying facility should be dependent on the type of sludge and the method of sludge utilization. It should be emphasized that not all drying facilities are able to partially dry sludge (less than 85-90% of DS. The comparison of the total costs of different sludge utilization options often indicates sludge drying as the best option.

The final decision should take into consideration not only economic factors but also others like: reliability of the option, easy service, ease of storage and transportation or whether the considered solution is environmentally friendly. The energy we use comes mainly from non-renewable sources such as coal, oil and natural gas, all of which are finite resources and can be depleted. Additionally, the use of these types of fuel are damaging not just to our health but to the environment as well. On the other hand, renewable energy has the potential to produce clean energy for all, anytime and everyone. Furthermore, renewable energy systems can help reduce greenhouse gas emissions and are being recognized as a major source of energy for the 21st century and beyond.

CHAPTER 6

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CHAPTER 6

APPENDICES

6.1 Gantt chart of Final Year Project 2 (SEM 1)

Week--	1	2	3	4	5	6	7		8	9	10	11	12	13	14
Selection of Project Topic															
Preliminary Research Work															
Submission of Preliminary Report															
Session with Industry Practitioner															
Submission of Progress Report															
Seminar															
Conduct the Experiment (Properties Test)															
Submission of Interim Report Final Draft															
Oral Presentation															

6.2 GANTT CHART OF FINAL YEAR PROJECT (SEM 2)

Week--	1	2	3	4	5	6		7	8	9	10	11	12	13
Project work continues														
Submission of Progress Report 1														
Project work continues														
Submission of Progress Report 2														
Seminar														
Project work continues														
Poster Exhibition														
Submission of Dissertation Final Draft														
Oral Presentation								During Study week						
Submission of Dissertation(Hard Bound)								7 days after oral presentation						