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Characterization of Malaysian Sewage Sludge Dried Using Thermal Dryer

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Abstract – *The production of sewage sludge in Malaysia keeps increasing and the available solution for their disposal cannot cope the huge amount of sludge produced. Most of the treated sewage sludge from the sludge treatment plant in Malaysia were disposed by landfill. However, this disposal technique cannot sustain and harmful to the environment as well as to the human health. Thus, there is needed a new disposal method for treating sewage sludge that can sustain and environmentally friendly. Converting this waste into energy can resolve the disposal problem of sewage sludge and generate the new sources of energy to human kind. However, the moisture content is sewage sludge is high which is more than 85% of moisture content. In order to convert into energy, the small scale disc dryer was developed in order to reduce the moisture content of the sewage sludge which into acceptable level is less than 20% of moisture content for conversion into solid fuel. In this paper, the basic characteristic of the dried sewage sludge for conversion into energy was studied. Besides that, the initial moisture content of sewage sludge, the effect of inlet temperature and mass flow rate also recorded and analyzed. The result obtains for this dryer showed a positive result which produces 17.8% of moisture content of sewage sludge with a heating value of 16,036.21 kJ/kg which is acceptable for conversion into energy.*

Keywords: Thermal dryer, energy, moisture content, sewage sludge, heating value

1.0 INTRODUCTION

Prior to independence, there is no proper sewerage system in Malaysia since there are still low population and very slow urbanization development. Most of the waste effluent at that time will discharge into rivers and seas. A few years later, the country needs proper sludge management and treatment for the development starting to rise due to changing in the base economy from agriculture to industry. Nowadays, the production of sewage sludge increases drastically with annual production of 4.9 million tons [1]. This value expected to be double in the next 6 years [2]. Rapid development as well as increase in population has led the increasing of sewage sludge produced. Recently, most of the treated sewage sludge from the sewage sludge treatment plant (STP) disposes by landfill. However, the available solution required space as well as higher operating cost causes this solution not relevant anymore [3]. Converting this waste into useful energy is one of the solution to solve the sludge disposal problem as well as produced the useful energy for the mankind.

Presently, sewage treatment plants have to deal with large volume of sewage sludge that accumulated over the years due to years of neglecting the sludge management issue. Sewage

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sludge need to be given special consideration in handling and treatment as it contains toxic element, such as harmful pathogens which is can seriously affect the human health [4]. Malaysian sewage sludge has been proven its potential to convert into solid fuel as it has a high heating value. Based on previous work done by local researcher, the heating value of Malaysian sewage sludge predicted between 14-18 MJ/kg [1]. However, the drying method that used to dry the sludge is uneffectively since using microwave oven.

The conventional drying method such oven dryer as used by Mokhtar et. al. [5] required a long time to dry the sludge and only applicable for research purpose only, but not in practice for application since required high energy, required larger space and takes time to dry the sludge. Mechanical dewatering of sewage sludge usually not sufficient to remove the moisture content of the sewage sludge into acceptable level, hence required thermal drying for further process [6] . Thermal dryer often used to dry the sewage sludge as it isn't just removing the moisture content, but also able to stabilize the sludge, removes the harmful pathogen and eliminate the odors of the sludge. Thermal processing of wastewater sludge includes thermal conditioning, thermal drying, and incineration. Municipal sewage sludge is the final product from the waste water treatment plant. This product has high moisture content which is more than 85%, hence required most of the thermal process [7–9].

2.0 METHODOLOGY

The sample of treated sewage sludge was collected from the sewage treatment plant at Bunus. The small sample of sewage sludge was taken and subjected fully drying in order to determine the initial moisture content of the wet sewage sludge that taken from the treatment plant. After that, the wet sewage sludge will dried using proposed thermal dryer for dewatering process. The production rate, temperature profile and fuel consumption were recorded for analyzing process.

The schematic of thermal dryer as presented in Figure 1 . This dryer was equipped with 240kW burner in order to supply heat to evaporate the moisture in sludge. The temperature profile of the dryer was investigated by attaching the K-type thermocouples along the dryer and the location of the thermocouple as presented in Figure 2.

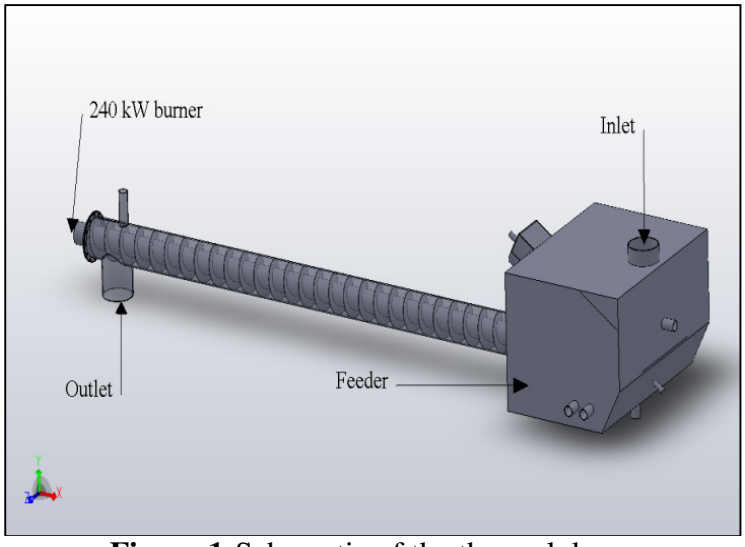

Figure 1: Schematic of the thermal dryer

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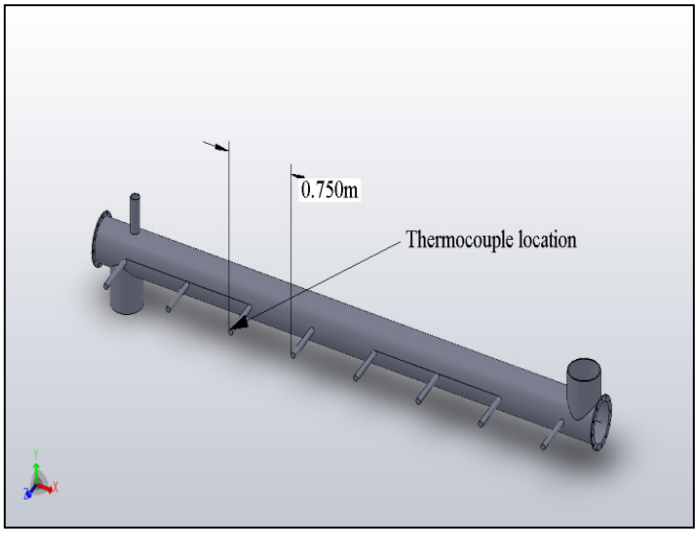

Figure 2: Thermocouple location along the dryer

After dewatering process, a few samples of dried sewage sludge will undergo fully drying process in order to determine the remaining moisture content in sewage sludge and the basic characterization for conversion into fuel. The analyze done based on the American Standard Test Methods (ASTM D346-90). After completing the drying process, the samples of dried sewage sludge were analyzed using ultimate analysis, proximate analysis and bomb calorimeter in order to find the the heating values and chemical compositions of the sewage.

Thermogravimetric analysis (TGA) method was used in proximate analysis in order to determine the Moisture Content (MC), Volatile Matter (VM), Fixed Carbon (FC) and Ash Content (AC) in weight percentage (wt %). The sample weight approximately 11-15mg were analyzed in the TGA based on the American Standard Test Methods ASTM E1131-98.

The samples were analyzed about 6 hours in order to make sure the process fully complete for determination of fixed carbon, volatile matter and ash content. In ultimate analysis, the CHNS analyzer (Leco CHNS-932, VTF-900) was used to determine the Carbon (C), Hydrogen (H), Nitrogen (N), and sulfur (S) in the samples. The equation 1 developed by Thipkhuntod et al [10] and used to predict the high heating value (HHV) of sewage sludge for sample with less than 50% of ash content in dry basis.

$$HHV = 255.75V + 283.88F - 2386.3 \quad (1)$$

V = Volatile matter
F = Fixed carbon

3.0 RESULTS AND DISCUSSION

The initial moisture content of the sewage sludge recorded was 89.45%. After an hour operating the dryer, all the relevant data and results were collected. Details result for the experiment as presented in Table 1. The pattern of the temperature profile along the dryer as presented in Figure 3. The total energy consumption by the dryer in term of electricity and diesel within an hour for both dryer were recorded as well for comparison of the total energy consumed by the dryer with the total of energy produced by the dried sewage sludge.

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3.1 Ultimate Analysis

The composition of C, H, N and S content for the sewage sludge samples are shown in Figure 5. The samples were found to contain mean percentage of 32.43% of Carbon, 3.21% Hydrogen, 4.62% Nitrogen and 0.73 % of Sulfur content. The composition of carbon obtained quite high compared to the study that reported by Fairous et al [2] . The composition of the sulfur is very low which is only 0.73 % and lower compared to the study that done by Abbas at. al [1]. With low content of sulfur and high content of carbon, the sample of sewage sludge that dried using thermal dryer has potential for converted into solid fuel.

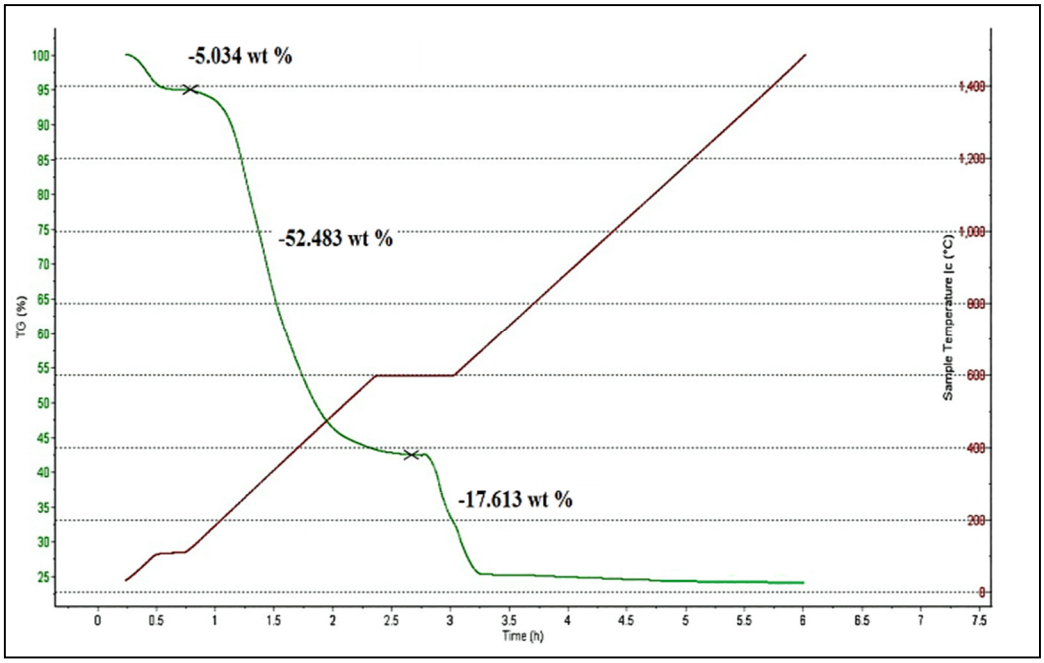

Figure 4:TGA results for sewage sludge

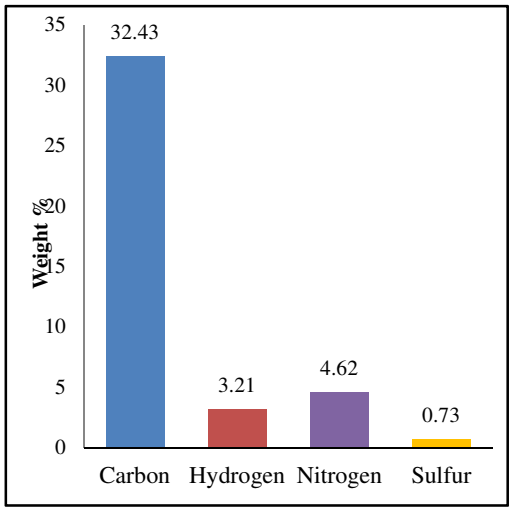

Figure 5: Percentage of C, H, N, S in sewage sludge

3.2 Proximate Analysis

Based on the Figure 4, the optimum temperature for moisture to be removed is expected to be between 30˚C-110˚C. At this temperature, all moisture assumes to be vaporized and vanish hence we can get the moisture content of the sludge. Major mass loss of mass percentage was expected during devolatilization which is between 110˚C-600˚C.

At this stage, volatile matter can be predicted since all the combustible element was burned and this leaves the char residue containing mainly fixed carbon that will be composted from 600˚C-1500˚C. The remaining mass after heating is expected to be ash. From the proximate result, the moisture, volatile matter, fixed carbon and ash content of sewage sludge was found to be 5.034, 52.483, 17.613 and 25.321 weight % respectively. The higher heating value of the sewage sludge was predicted using correlations in equation 1 as suggested by Thipkhuntod et al [10]. As the result, the predicted value of Malaysian sewage sludge using the value obtained from proximate analysis was 16,036.21kJ/kg. In order to justify the result that obtained by the proximate analysis, the sample of sewage sludge also being tested by using bomb calorimeter in order to get the calorific value by experimental analysis. This prediction was found to be within an error difference of 0.71% with experimental value that obtained by bomb calorimeter . With less than 5% of error, this result valid for the prediction of heating value of the sewage sludge.

4.0 CONCLUSSION

The preliminary result presented showed the potential of sewage sludge that dried using thermal dryer for conversion into energy. This dryer consumed less energy and capable to produce high amount of dried sewage sludge in a short time hence applicable used for sludge dewatering system. The Heating Value of Malaysian Sewage Sludge dried using disc dryer is 16036.21kJ/kg, higher than reported by previous researchers in [11], [12] which is acceptable for conversion into energy. The preliminary finding in this study showed the potential of the proposed dryer to dry the huge amount of sewage sludge in short time with low consumption of energy and the potential of the dried sewage sludge for conversion into energy.

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