COMPARISON OF THE SCUM WITH TRADITIONAL BIOMASS FUELS: A SOURCE OF RENEWABLE ENERGY

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ABSTRACT

This study investigated the gross heat value (MJ/kg) of the scum from 14 Wastewater Pumping Stations (WWPS) situated in the residential and industrial area in the eThekwini Municipality, Durban, South Africa. A manual sampling procedure was carried out to collect the scum formed from these WWPS. The gross calorific value of the scum samples was analysed on the Parr 6200 Oxygen Bomb Calorimeter. Results showed a significant difference of 10.00 MJ/kg between the average calorific value of the scum samples from the 14 WWPS is 30.61TS MJ/kg higher than the traditional biomass fuels like coffee husks is 19.3MJ/kg and rice husks 15.8 MJ/kg. Gross heat values ranged from 21.31 MJ/kg to 39.81 MJ/kg. This energy in future could be used as renewable energy resource.

ABSTRACT

Thermal property, Gross Heat, Calorific value, Renewable energy.

1. INTRODUCTION

Wastewater Pumping Stations (WWPS) are required in municipalities where the topography does not support gravitational flow of sewage. This is true of the city of Durban in the eThekwini Municipality where the eThekwini Water and Sanitation department (EWS) has a total of 283 WWPS, the second highest number in South Africa after Cape Town [1]. Of these 283 pump stations, 232 are operational in residential and industrial areas. The 51 are decommissioned due to various technical problems. EWS operates on automatic electric WWPS including the largest ones.

From past one decade the EWS staff operating WWPS experienced problems in the pumping of wastewater due to excessive scum formation, a problem that is reported from various municipalities around the world. This is due to urbanization and people moving towards western diet contains higher amount of Fat, Oil and Grease (FOG) and the leftover food and dish washing drains down the sink[2] .

The most commonly reported problems in sewers and pump stations are blockages caused by the presence of FOG [3], followed by increased demand for line flushing, with the most severe problems being experienced in the city centres [4]. An example of this was observed in the Hillcrest area, west of Durban where blockages in sewer lines were found to be caused by scum accumulation due to high number of food establishments [5]. A further example is the removal of a 10-tonne blockage of scum made of FOGs from the West London sewer by Thames Water (known as fatberg as in the newspapers), which caused 200,000 blockages from 2009 to 2014, with 18,000 homes flooded with sewage [6].

The problems caused by the formation of scum at WWPS have attracted the attention of people working in wastewater engineering and research where investigations are underway into the feasibility of converting scum into renewable energy resource. A study on the thermal processing of bio-fuels from sewage sludge indicate the potential for this application, particularly when considered consuming of sludge as other fuels in existing plants and co-processing with biomass [7]. In support of this, an investigation into the thermal properties of VIP latrine sludge showed that the 90% of the faecal sludge samples analysed have a calorific value ranging from 9.5 KJ/g ash to 91 kJ/g ash, with a median calorific value of 31 kJ/g ash [8]. This calorific value in the faecal sludge is indication towards converting it into the bio-energy.

An investigation into the fuel potential of faecal sludge was also performed in Uganda, Ghana and Senegal where the average calorific value of raw faecal sludge was found to be 19.1 MJ/kg TS, 16.6 MJ/kg TS and 16.2 MJ/kg TS respectively [9]. In this project, the gross calorific value (MJ/kg) of the scum sampled from the 14 WWPS in the city of Durban was investigated as a first step towards scum management and its possible use as a bio charcoal in renewable energy resource.

2. METHODOLOGY

The sampling points in this study were WWPS, located on the coastal area or nearby beach front of Durban. Regardless of the amount of scum present in individual pump stations, samples were collected from the 14 operational WWPS. The sampling points were chosen such that they are situated in heterogeneous population in terms of income level and diet, and number of food establishments Records of any previous scum formation and accumulation in the tanks could not be obtained as the scum in sewer lines are normally flushed out during precipitation or cleaned manually when required.Fig1 shows the sampling points in the city is made by using Arc GIS 10.2.

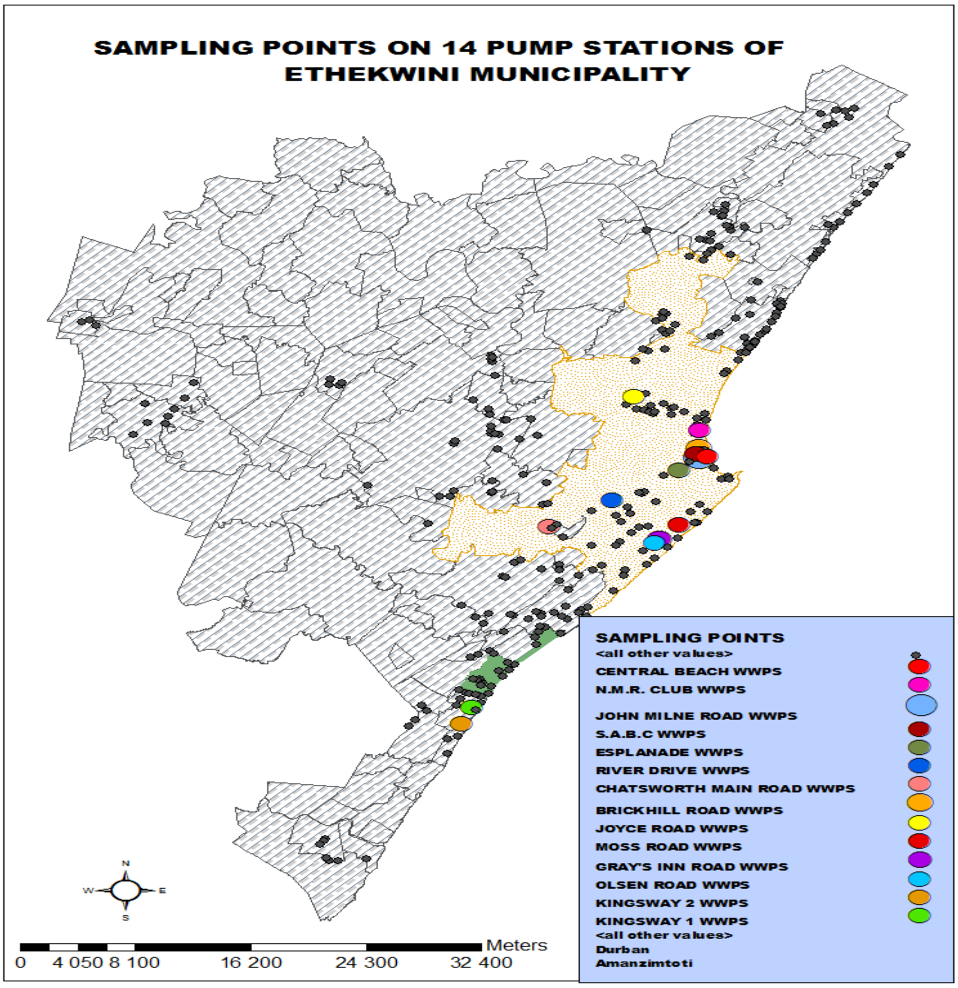

Fig. 1. Location of the wastewater pumping stations and the 14 scum sampling points in Durban

The map in Figure1 shows two types of dots: the large coloured markers represent the sampling points, while the small markers indicate the remaining WWPS. Table 1 provides an overview of each sampling point in terms of its location.

The sampling programme entailed manually collecting scum from the 28 September 2015 to 7 October 2015 from the 14 WWPS. The samples were taken from the tank at depths of between 10ft. to 30ft. below the ground. The sampling was carried out by EWS staff employed by the eThekwini municipality in Durban. The scum was removed manually from the surface of the wastewater in the tank of the pump station using long-handled spades and safety transferred into 1 kilogram of plastic container. The same procedure was followed for all the 14 sampling points. All the samples after collection is immediately placed into cooler box and transferred into laboratory cold room maintained at 4℃ to avoid any further changes in chemical composition and bacterial action.

3. LABORATORY ANALYSIS

In order to calculate the gross calorific value of the scum samples, the calorific value was measured on a Parr calorimeter using the Standard Methods for Examination of Water and Wastewater [10]. All the samples were prepared by weighing a representative mass of 2.0 gram of wet scum. This analysis required that all moisture was removed from the samples, and therefore they were dried for 48 hours in oven at 105° C in crucibles. The samples were analyzed on a Parr 6200 Oxygen Bomb Calorimeter, 1180P Oxygen Combustion Bomb using 1 gram of Benzoic acid tablets for standardization. Each sample analyzed on the machine with a mass of 0.75 gram. The energy equivalent (EE) value is 2345.48 for all the samples is determined by standardizing the calorimeter. The EE value is computed by substituting the following equation:

$$EE = \frac{H_m + e_1 + e_2 + e_3}{T}$$

Where EE is Energy Equivalent of the calorimeter in calories per℃. H = Heat of combustion of the standard benzoic acid sample in calories per gram,

m = Mass of the sample,

T = Temperature rise in℃,

e_1= Correction for heat of formation of nitric acid in calories.

e_2 = Correction for Sulfur which is usually 0.

e_3= Correction of heating wire and combustion of cotton thread.

Table 1. An overview of the location of each sampling point

Pump Stations	Named	Area	Locality
Central Beach	PS-1	North Coast	High class apartments, hotels and restaurants
NMR	PS-2	CBD	Small scale industry , Restaurants, Lodge
John Milne	PS-3	CBD	Middle scale industry and offices
SABC	PS-4	CBD	Restaurants , shops and offices
Esplanade	PS-5	Victoria Embankment	Small scale industry , residences and restaurants
River Drive	PS-6	Umbilo	School and residences
Chatsworth	PS-7	Chatsworth	Residences and small scale industries
Brick hill	PS-8	North Beach	Car service shops and school
Joyce Road	PS-9	Newlands	Small scale industry
Moss Road	PS-10	Bluff	Residential area of whites and coloured
Grays Inn	PS-11	Bluff	Small scale industry and informal settlement
Olsen Road	PS-12	Bluff	Residences of higher income
Kingsway-1	PS-13	Amanzimtoti	Large industries
Kingsway-2	PS-14	Amanzimtoti	Residences and Residences of middle income

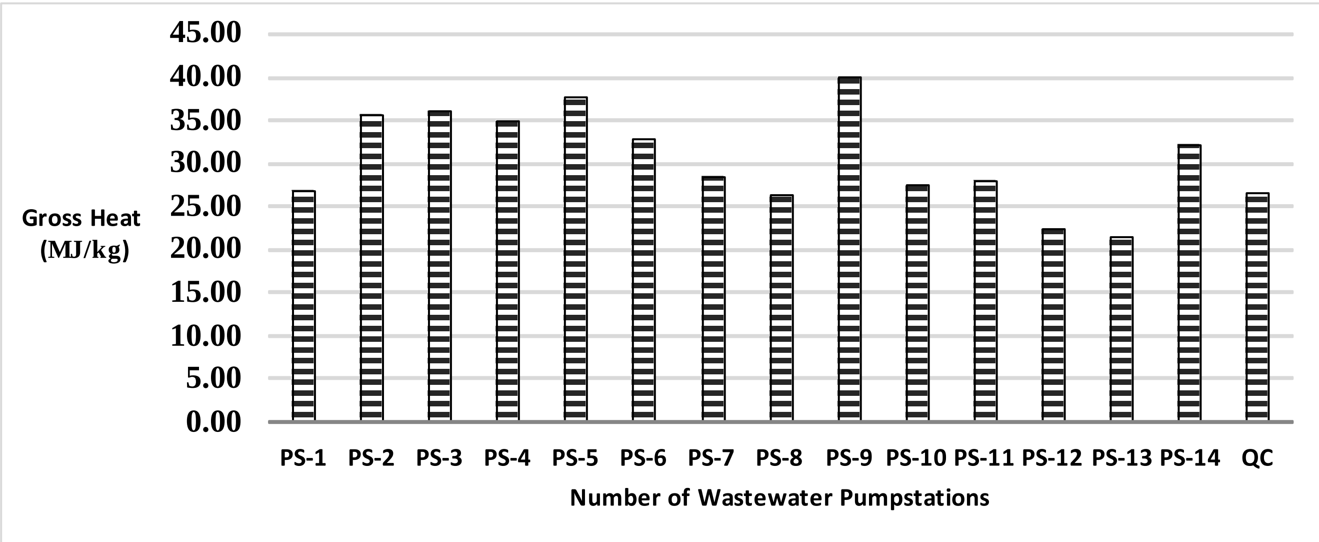

Fig. 2 - Graph showing gross calorific value in MJ/kg TS of the 14 scum samples

4. RESULT AND ANALYSIS

Figure 2 shows the results of the gross heat value in MJ/kg in total solids (TS) for the 14 samples.
From these results, the following conclusions can be drawn on the gross calorific value (MJ/kg) of the scum from the WWPS:

- PS-9 has highest gross heat value of 39.81MJ/kg. This pump station is situated in the vicinity of food establishments on Joyce Road in the Newlands area north of Durban. PS-5, situated on the Victoria Embankment near the Durban harbour has second highest value of 37.65 MJ/kg.
- PS-12 is situated nearby a slaughter house in the Bluff area on Olsen Road, and PS-13 on Kingsway Road in Amanzimtoti (south of Durban) have gross calorific values of 22.29 MJ/kg, and 21.31 MJ/kg respectively, which are the lowest of the 14 scum samples.
- PS-1 and PS-8 have gross calorific values of 26.75 MJ/kg and 26.08MJ/kg respectively which shows a nominal difference. Both pump stations are situated on the North Coast of the city with high rise apartments, hotels and restaurants.

- PS-7 situated in Chatsworth, has a calorific value of 28.38 MJ/kg, and is situated in a predominantly Indian community. Similar results were obtained for PS-10 and PS-11 (both located in the Bluff area) with gross calorific values of 27.32 MJ/kg, and 27.86 MJ/kg respectively.
- While PS-6 and PS-14 are located far apart from one another, they are situated in similar types of communities and have calorific values of 32.75MJ/kg and 32.07MJ/kg respectively
- Results from PS-2, PS-3 and PS-4 differed from one another by of 1.00 MJ/kg, with calorific values of 35.45MJ/kg, 36.05MJ/kg and 34.84MJ/kg. All three WWPS are located in the central business district (CBD) of the city where there are several food establishments, offices and apartments.
- The sampling points situated near a high density of food establishments the gross calorific value of the scum is higher.
- The average gross calorific value of all 14 scum samples is 30.61MJ/kg.

Figure 3 compares the, average gross calorific value of the 14 scum samples (30.61 MJ/kg) to that of biomass fuels which are used in sub-Saharan Africa such as coal, coffee husks, and rice husks and sawdust [8].

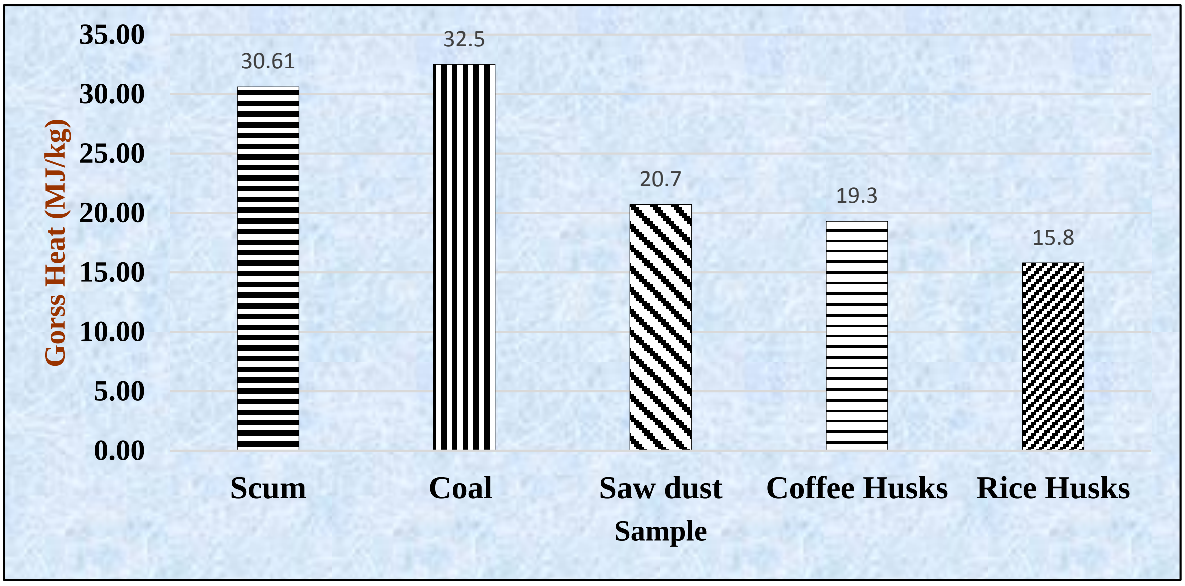

Fig. 3 - Average gross heat value in MJ/kg TS of the 14 scum samples compared to traditional biomass fuels

From Figure 3 it is evident that the average gross calorific value of the scum as determined in this investigation is approximately 10.0 MJ/kg higher than that of coffee husks, rice husks and sawdust. Surprisingly the average gross heat value of the scum (30.61 MJ/kg TS) is close to that of coal (32.5 MJ/kg TS).

5. CONCLUSION

Based on the results from this study, it is evident that scum formed at WWPS has a high gross calorific value and therefore shows the potential as a fuel source. However, further sampling and analysis is required before any suggestions for using scum as a renewable energy source can be made.

In addition, scum formation in wastewater depends on the consumer's water consumption and cooking process, as well as seasonal variation. Rain water increases the moisture content in the samples and dilutes the chemical properties. Information on the socio-economic data of the locality, income of the population, eating habits and rate of water consumption is also required for more accurate estimation of the rate of scum formation at WWPS.

In addition to the above a study in US indicates profits of the scum to biodiesel is 29% and 104% higher than profits from scum combustion and digestion correspondingly [11].Results of biogas from the FOG/Scum through thermochemical pre-treatment process is also found economic viability interrelated to the cost of energy input [12].Studies also indicate that enormous amount of methane gas emission from WWPS in future can be used as biogas source [13].

The sustainable management of wastewater resources is an essential precaution for improvement in wastewater installations. Furthermore investigations should be done in implementing scum as renewable energy resource towards scum management strategies .In order to promote the sustainable ecological growth of South Africa and the world.

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