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**EVALUATION OF SOLID WASTES FOR UTILISATION IN BIOGAS PLANT IN
LIBYA- A CASE STUDY**

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ABSTRACT

Biogas is a combustible gas consisting of methane, carbon dioxide and small amounts of other gases and trace elements. Production of biogas through anaerobic digestion of animal manure and slurries as well as of a wide range of digestible organic wastes and agricultural residues, converts these substrates into electricity and heat and offers a natural fertiliser for agriculture. In this paper, solid waste management status in the city of Misurata has been investigated through an extensive survey carried out and generation of organic waste in the city of Misurata was calculated to establish a database for build up a biogas plant in the city. The average solid waste generation rate was found to be 1.48 kg/person/day. Only 3% of the solid waste was recycled and open dumping is currently the most popular form of waste disposal for 360 tons of waste daily. The waste composition was mainly comprised of 56 % organic, 26.5 % plastics, and 8% paper. The waste was evaluated, the moisture content and the calorific heating values were calculated. The results of this study along with key findings are discussed and summarized. In addition, several effective recommendations and improvements of solid waste management (SWM) are suggested.

KEYWORDS: solid waste, heating value, biogas plant

INTRODUCTION

Two of the main environmental problems of today's society are the continuously increasing production of organic wastes as well as the increase of carbon dioxide in the atmosphere and the related green house effect. A way to solve these problems is the production of biogas. Biogas is a combustible gas consisting of methane, carbon dioxide and small amounts of other gases and trace elements. Production of biogas through anaerobic digestion of animal manure and slurries as well as of a wide range of digestible organic wastes and agricultural residues, converts these substrates into electricity and heat, and offers a natural fertiliser for agriculture. The microbiological process of decomposition of organic matter, in the absence of oxygen takes place in reactors, called digesters. Biogas can be used as a fuel in a gas turbine or burner and can be used in a hybrid solar tower system offering a solution for waste treatment of agricultural and animal residues [1].

In the last few years, the Environmental General Authority in Libya works to create regulations and instructions for waste management, but up to now they are still under development. This belongs to the fact that there is only little information available regarding generation (quantities and compositions), handling and disposal of waste. Therefore an appraisal of the current situation regarding solid waste management in Libya is required [2].

Rapid expansion of industry, urbanization and increasing population, especially in large cities like Misurata, has dramatically increased the amount of solid waste generated in Libya. However, issues related to sound municipal solid waste management – including waste reduction, and disposal – have not been addressed adequately and the collection and separate treatment of solid waste is still neglected.

Solid waste management and the associated pollution problems have attracted significant attention, and great deal of research has been conducted on these topics in countries such as India [3], Ethiopia [4], Jamaica [5] and Bangladesh [6].

Very few studies on solid waste have been conducted in Libya indicating that no proper management is existing [7].

Thus, work is required to establish a database, information and statistics on solid waste generation, collection, transportation, treatment and disposal. This will form the basis of planning, designing, technology development and implementation of waste management facilities. In this paper quantities of solid waste generation was investigated and its composition was analysed.

AIM OF THE STUDY

The aim of this study is, to come up with real description of the actual situation of solid waste management as the basis for an adequate waste management strategy. The specific objectives of this study are directed towards conducting a survey of organic waste generation which is the basic requirement for building up a biogas plant in Misurata and the evaluation of this data will help to correlate and interpret possible treatment processes.

MATERIAL AND METHODS

- **Study area**

The study was conducted in the city of Misurata, which situated in the western north part of Libya as a case study. This city is the third largest city in Libya, it is serve a community of about 350 000 people.

In this paper, solid waste management status in the city of Misurata has been investigated through an extensive survey carried out on selected public and private companies. The survey contained information regarding the generation of waste and main aspects of segregation, collection, internal transport, treatment, and final disposal.

- **Sample collection and analysis**

The city of Misurata was divided to ten zones, Table (1). In each zone plastic bags were distributed to random ten families houses with different economic conditions (monthly income) for waste collection. On the next day, in the early morning, these plastic bags were weighed before disposal to calculate the waste production. Determination of waste material composition was done by way of physical segregation (manual sorting) and observation of collected wastes components. Each bag of waste was weighed and then its contents emptied, sorted and weighed again. The percentage (%) composition was categorized into major categories.

The organic components were thoroughly mixed, shredded and sieved to a quality size of < 2 mm which can be handled in the laboratory for further analysis.

Table 1. Population in the city of Misurata 2014 [8]

No	Zone	population
1	Tomina	24148
2	Eldafnia	16370
3	Gaser Ahmed	19208
4	Elzaroug	32288
5	Elgiran	32924
6	9 yolyo	41179
7	Ras Touba	29500
8	Elmahgoub	30027
9	That Elremal	37531
10	Shuhada Rmila	52326
	Total	343502

- **Evaluation of waste**

The chemical composition of the solid waste samples was done in accordance with Bank [10] who conducted proximate analysis by looking at moisture, volatile matter and ash. Dulong's formula as adopted by Nithikul [11] was used to determine the heating values

a) **Moisture content determination**

The various component of waste was weighed and placed in the oven and heated to 105°C for 1 hour. Samples were cooled in desiccators and then reweighed. The percentage moisture was determined using the formula below:

$$M = \frac{(w_0 - w) \times 100}{w_0} \dots \dots \dots (1)$$

Where: M - wet mass moisture content, %

W₀ – initial mass of sample as delivered, kg

W - mass of sample after drying , kg

b) **Determination of volatile matter and ash**

The dried sample and crucible was placed into a muffle furnace and ignited at 950°C for 30 minutes, till the ash was charred to a clear white color. The crucible plus ash was removed from the muffle furnace, cooled

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for at least 30 minutes and carefully weighed on an analytical balance. The weight of volatile matter (on a dry basis) was computed as the difference between the dry weight of solid waste and the weight of the residue after ignition.

$$\% \text{ volatile matter (dry basis)} = \frac{\text{weight of dry solid waste} - \text{weight of residue after ignition}}{\text{weight of dry solid waste}} \times 100 \dots\dots\dots(2)$$

Ash content is the amount of residue obtained after ignition of solid waste .

$$\% \text{ ash (dry basis)} = \frac{\text{weight of residue after ignition}}{\text{weight of dry solid waste}} \times 100 \dots\dots\dots(3)$$

c) **Determination of calorific value**

The calorific values (higher heating values) were determined using the modified Dulong equation [9] which is :

$$\text{HHV(KJ/ kg)} = 337^\circ\text{C} + 1428 (\text{H}_2 - \text{O}_2/8) + 9\text{S} \dots\dots\dots(4)$$

The calorific values were again calculated by using the Dulong equation , considering Nitrogen in the formula below:

$$\text{HHV(KJ/ kg)} = 337^\circ\text{C} + 1419 (\text{H}_2 - 0.125 \text{O}_2) + 93 \text{S} + 23 \text{N} \dots\dots\dots(5)$$

Where , C= carbon (%), H= Hydrogen(%), O= Oxygen (%), S= Sulphur (%),
N = Nitrogen (%)

Lower Heat Value (KJ/kg) (LHV) is the net energy released on combustion

$$\text{LHV (KJ/kg)} = \text{HHV} - (2.766 \times \text{M}) \dots\dots\dots(6)$$

Where , M= moisture content , 2.766 kg/g = coefficient of heat requirement for evaporation (Enthalpy of vaporization) [9]

RESULTS AND DISCUSSION

Generation and classification of waste

Solid wastes generated from each house were weighed, and the average generated quantity of solid waste was determined. A summary of the generation rates from different zones is presented in Table (2) and figure (1). The highest generation rate of 1.48 kg/patient/day was found in zone No 9 , followed by 1.43 kg/patient/day in zone 10. The lowest rates were found in zone No 1. The determined average generation rate of solid waste is 1.2 kg/person/day.

Table 2: Average waste production in different zones in Misurata

Zone Number	Average generation rate (Kg/day /	Total amount of waste
1	0.906	21878
2	0.942	15420
3	0.994	19092
4	1.15	37131
5	1.13	37204
6	1.418	58391
7	1.348	39766
8	1.368	41076
9	1.478	55470
10	1.432	74930
	Average 1.2	Total 400358

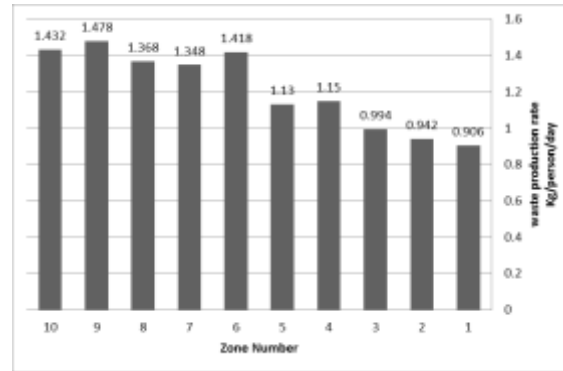


Figure 1. The average generation rate of solid waste for each zone in Misurata

The qualitative analysis of solid waste (Fig 2) identified organics as the major component (56%), followed by plastics (26.5%). The high plastic content is due to the widespread use of disposables rather than reusable for different purposes (e.g. bottles, packing materials and bags used for food). Paper had the third highest percentage (8%).

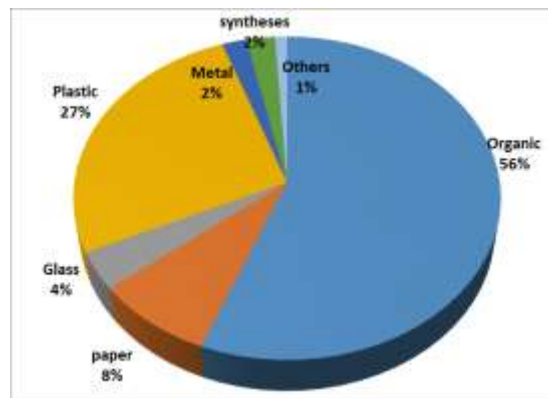


Figure 2: The qualitative analysis of solid waste in Misurata

Waste collection, transportation and final disposal

Solid wastes generated at all zones are collected by municipal companies, and then transported to collecting-site in each zone.

The municipality has the responsibility for off-site transportation of the waste to the final disposal site. From daily to three times a week, the municipality workers collect the solid wastes from the on-site storage containers and transport them along with general domestic waste to open dumping sites outside the cities. Generally, simple trucks and in some cases an uncovered tractors are used for waste transportation (Fig. 3). These open tractors are passing within residential areas which increase the potential risk to the public and environment.

All domestic waste dispose, in an open dumping sites outside of the city. In these open dumping sites the waste is buried and sometimes combusted, Figure (4).



Figure 3: Waste transportation in Zone No. 8 in Misurata



Figure 4: One of an open dumping sites in Misurata

Evaluation of waste

- **Moisture content**

Moisture content of the waste ranged between 52.2 to 64.3% with the highest recorded from zone No 8 while the least was recorded from zone No 4. (Table 3).

Table 3. Percentages of the various components of solid waste generated in different zones

Zone #	Moisture %	Volatile matter%	Ash %	HHV (KJ/Kg)	LHV (KJ/Kg)
1	54.7	72.3	2.03	19312.75	19161.45
2	55.6	74.2	2.6	17692.26	17581.06
3	60.8	68.4	3.14	21833.40	21711.80
4	52.2	77.1	2.4	20772.91	20668.51
5	63.1	80.3	4.8	18255.47	18129.27
6	58.5	82.4	3.7	15632.81	15515.81
7	53.3	79.6	6.2	17993.63	17887.03
8	64.3	74.1	5.05	22305.45	22176.85
9	59.7	83.7	2.34	20621.12	20501.72
10	52.8	70.1	4.52	23872.25	23766.65

The percentage ash content of the waste ranged between 2.03 to 6.2 % with the highest recorded from zone No 7 while the least was recorded in zone No 1.

The calorific value is very important parameter in establishing a conversion technology to power generation. Some studies reported that calorific value for incinerated waste should not fall lower than 6500 kJ/kg [12] . The heating values (calorific values) of the solid waste generated from the study areas are greater than the standard values.

CONCLUSION

Waste in Libya is still being dumped .Environmental measures or recycling programs are not available. The great need for establishing and implementing a proper waste management strategy to control and improve the current situation in Libya is pointed out .

The study revealed that the types of solid waste generated in the study area have substantial organic matter, moisture content and calorific values or energy content, making them suitable for energy generation. It is recommended that thermal plants that can convert solid waste into fuel should be provided to harness the potentials of waste.

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