



# Analysis of the biogas productivity from dry anaerobic digestion of organic fraction of municipal solid waste



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## ABSTRACT

In this study, it was observed that in experimental work under laboratory scale using conventional biomethane potential (BMP) analyser under the *mesophilic* optimum temperature of 37 °C and pH of 7. Organic fraction municipality solid waste (OFMSW) inoculated with cow manure had higher biodegradability rate leading to high methane production under shorter hydraulic retention rate. The co-digestion of OFMSW and cow manure stabilises conditions in digestion process such as carbon to nitrogen (C: N) ratio in the substrate mixtures as well as macro and micronutrients, pH, inhibitors or toxic compounds, dry matter and thus increasing methane production. It was concluded that the organic waste generated in the municipality co-digested with manures to produce methane can be used as a source of sustainable renewable energy.

## 1. Introduction

Many African nations have been motivated to look for sustainable renewable energy sources such as; hydropower, wind energy, solar power, biomass energy, geothermal power, tidal power as well as wave power, to solve the problem of the extinction of fossil fuels and the need for green and clean energy [1]. Biomass energy is one of the renewable energy sources that has gained momentum because of its environmentally friendly aspect [2]. In addition to the carbon dioxide pollution from fossil fuels, the world is also faced with a waste pollution in the form of leftover food, which is proven also to be one of the contributing factors to global warming [3]. As research develops the solutions to handle all waste management issues have been addressed as some of them include pyrolysis, gasification and incineration of solid waste [4]. The difference between pyrolysis and gasification is the degree of air/oxygen present for combustion. While incineration can be done in the presences of oxygen. The heated waste material will create gas, liquid and solid deposits [4]. Though these technologies offer a practical approach to managing waste, they have been found to require a great deal of energy to operate, and some consume more energy to operate than the energy that can be produced from them [4]. The use of biogas has proven to be an effective way to use renewable energy sources and reduce these greenhouse gases [5,6].

The main objective of this study was the analysis of the production of methane from dry fermentation of organic fraction of municipal solid waste (OFMSW) on the bio – methane potential (BMP). To analysis biogas production of this substrate, the focus was given at optimum temperature and pH level.

### 1.1. Biogas

Biogas is the by-product from the anaerobic digestion (AD) process of biomass and is used as a clean fuel. Biogas products play a major role in the biogeochemical carbon cycle. Biogas is a mixture of approximately 60% methane, 39% carbon dioxide and a small fraction of 1% as the water vapour, hydrogen sulphide and some other gases by volume. When it is purified to over 99% methane it becomes identical to a natural gas known to be bio-methane [7]. Bio-methane like biogas is used to generate heat using boilers, for lighting households, cooking and as fuel for vehicles. The compositions of biogas are outlined in Table 1 [7].

Biomethane potential tests (BMP) are done to determine the amount of biogas or biomethane per gram of volatile solids (VS) contained in the substrate used in the AD process. The tests are used for many other properties such as the process operational conditions that have to be monitored to avoid process malfunctions, environmental considerations, the time it will take for a substrate to degrade and the average bio-methanation for each substrate examined and integrated into the biogas production process [7].

### 1.2. Anaerobic digestion

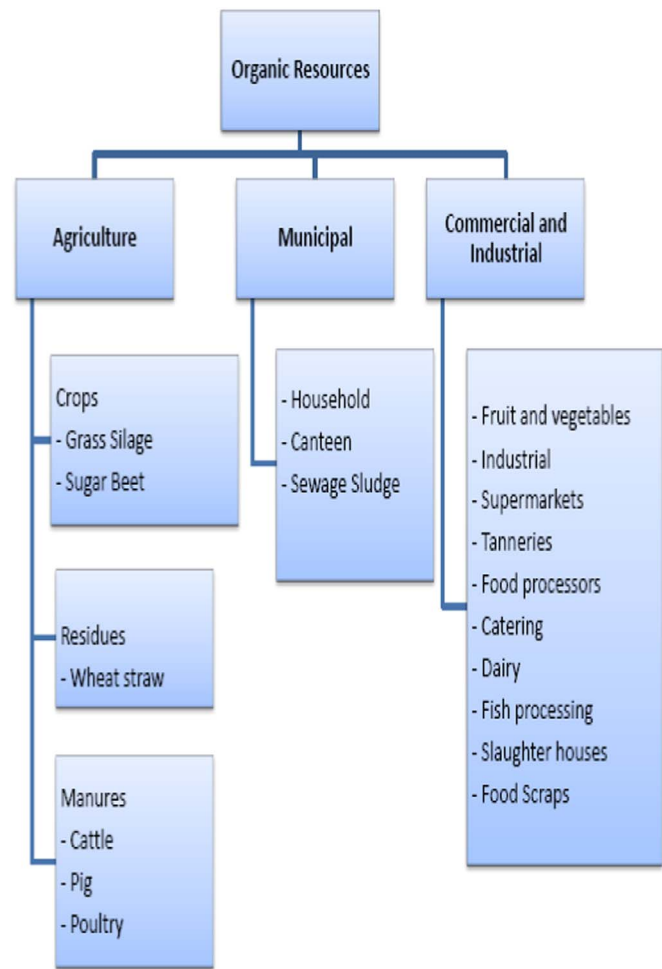
AD is one of the alternative renewable energy technologies which has proven to be the acceptable option among most of these waste management's technologies. AD is a biochemical process where organic matter is decomposed in the absence of oxygen by various types of

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**Table 1**  
Percentage of gases by volume present in biogas.

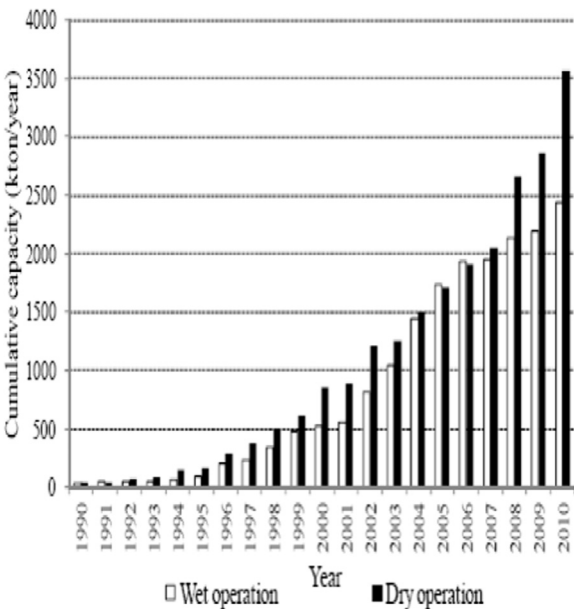
Biogas Composition	Percentage (%)
Methane (CH <sub>4</sub> )	50–70
Carbon dioxide (CO <sub>2</sub> )	30–45
Hydrogen sulphide (H <sub>2</sub> S)	1–2
Hydrogen (H <sub>2</sub> )	1–2
Ammonia (NH <sub>3</sub> )	1–2
Carbon monoxide (CO)	trace
Nitrogen (N <sub>2</sub> )	trace
Oxygen (O <sub>2</sub> )	trace



**Fig. 1.** Type of feedstock for anaerobic digestion [7,9].

anaerobic micro-organisms [7]. The rate at which this process take place in the production of biogas depends on a number of parameters that include, pH, temperature, nature of the substrate used, nutrients, digester construction and size [7,8]. AD uses a wide range of biomass as feedstock/substrates for the production of biogas. The type of feedstock or substrate that is mostly used can be animal manure, agriculture waste, garden waste, market vegetable waste, slaughter houses or abattoir waste, sewage sludge, a mixed organic fraction of municipal solid waste (OFMSW) and other commercial and industrial organic waste. Fig. 1 shows the classification of feedstock used for the AD from different sources. Feedstock for AD varies according to its composition, homogeneity, fluid dynamics, dry matter content, methane yield and biodegradability [7].

The pathways for anaerobic digestion are either wet or dry digestion depending on the need for the fluidity of the substrate. The definition of both wet and dry anaerobic digestion are defined as followed:



**Fig. 2.** Trend of low and high solid anaerobic digestion plants in Europe [12].

**1.2.1. Wet anaerobic digestion (WAD)**

Wet digestion requires water greater or equal to the biomass being processed while in the dry digestion process, the biomass or feedstock is digested as received [10]. Wet anaerobic digestion (WDA) process is an effective process yet it has a water wasting problem which should be avoided since water is one of the scarce resources that can run out. Also, the percentage of water in the digested feedstock will need to be dried. This requires a lot of energy and nutrients are also lost in the process [11]. Contrarily, dry anaerobic digestion has proven to be better for wet digestion due to its versatility, robustness and better water management strategies as shown in Fig. 2 [12]. In this current study, the focus is on dry anaerobic digestion.

**1.2.2. Dry anaerobic digestion (DAD)**

The dry anaerobic digestion process is an energy and water saving process. It does not require an addition of a lot of water to the substrate, meaning that it does not require dewatering and energy used to dry the digestate [13]. The dry anaerobic digestion process takes place within bioreactors, which are batch processes operating independently, hence the malfunctioning of a reactor do not affect the functionality of the others. Unlike wet digestion process, the substrate in dry fermentation does not need stirring or being pumped through pipes which sometimes experiences blockage [13].

DAD process is been given much attention in the energy sector and research based environments for laboratory scale studies because of its low operation cost and potential by-products. However, despite all its advantages, the process may show inhabitation problems which are due to the requirement of large inoculums, long retention time, accumulation of VFA and the type of water material used [14]. Therefore, for a development of a suitable DAD process various aspects of the process, operational parameters, environmental impacts of the process, economic analysis, mass balance and energy flow needs to be monitored carefully [15]. Fig. 3 shows the mains steps that are undertaken in a DAD process for the production of biogas.

Biogas production undergoes four distinct chemical and biological processes. These processes do not differ in either wet or a dry digestion process and they include hydrolysis, acidogenesis, acetogenesis and methanogenesis. The major functional groups of bacteria according to their metabolic (activity) reactions are [17,18]: Fermentative, hydrogen-producing acetogenic, hydrogen-consuming acetogenic, carbon dioxide reducing methanogens and aceticlastic methanogens bacteria

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