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Biogass Production Potential of Wastewater

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Abstract: *The water we refer to as wastewater (run off after rainfall, sewage etc) is actually a useful waster as 1% of it in any quantity is a sludge which when subjected to anaerobic digestion will produce biogas. For every liter of sludge produced from wastewater, 127.21m^3 of biogas is produced from it. Immerging that all the wastewater produced annually in a city is channel into a treatment plant where the water is recovered and sludge produced from it, the sludge has the potential to produce biogas that can generate electricity for the city. This means that wastewater has a high potential of biogas producing raw material that must be harness rather than allowed to constitute additional environmental problem. The treatment of wastewater produces sludge as a byproduct which undergo sequential breakdown by microorganism and enzymes at a mesophilic temperature of 35^{o}C-39^{o}C to produce biogas. The process is an anaerobic (absence of oxygen) one which takes place in a biogas digester tank.*

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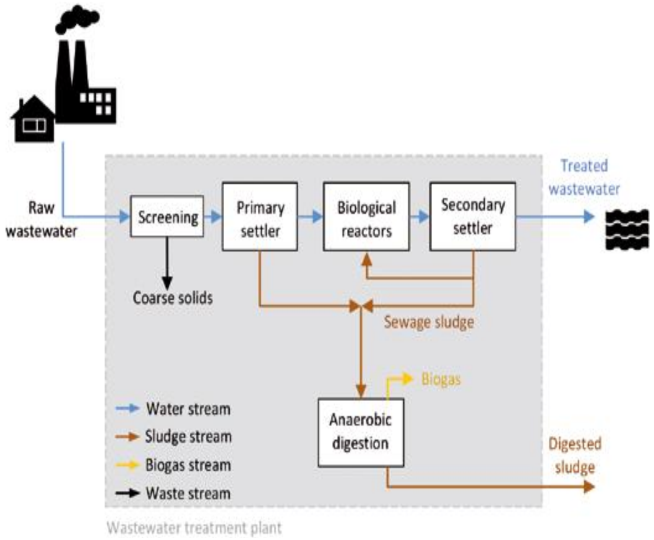
I. Introduction

Wastewater is the effluent from household, commercial establishments and institutions, hospitals, industries and so on. It also includes storm water and urban runoff, agricultural, horticultural and aquaculture effluent while the word Sewage refers to wastewater from toilets and bathroom fixtures, bathing, laundry, kitchen sinks, cleaners, and similar dirty water that is produced in households and public places. (1) Basically, the component of wastewater depends on its source however, all wastewater irrespective of its source contains large amount of organic material especially the sewage which can be efficiently recovered in as sludge which and when subjected to anaerobic digestion, the sludge produces methane gas (biogas). (2)

Biogas is a mixture of gases containing 50-75% Methane, and 25-50%Carbon dioxide while 0-10% Nitrogen, 0-3% Hydrogen disulphide and 0-2% Hydrogen may be present as impurities which is produced by anaerobic digestion of organic material i.e. a sequential enzymatic breakdown of biodegradable organic material (Biomass) in the absence of oxygen. The process is usually carried out in a digester tank known as biodigester. Biogas is an important energy source used as cooking gas, to generate electricity, etc. thus producing biogas from wastewater is an efficient and sustainable waste management and renewable energy technique.(4) One of the major environmental problems of the world today is waste management and wastewater constitutes a huge environmental problem to the society thus the need for wastewater treatment to recover and also recycle the recovered water for usage (2). This article highlights an efficient way of managing wastewater in the environment, generating biogas from wastewater to meet up the energy demand of the nation and the potential in wastewater to produce biogas.

1.1 **Wastewater treatment**;- Wastewater treatment is a process used to convert wastewater into an effluent that can be either returned to the water cycle with minimal environmental issues or reused. The major aim of wastewater treatment is to remove as much of the suspended solids as possible before the remaining water known as effluent is discharged back to the environment. Treatment means removing impurities from water being treated and the physical infrastructure used for wastewater treatment is called a wastewater treatment plant (WWTP).(2)

1.1.1 Processes of municipal water treatment;-

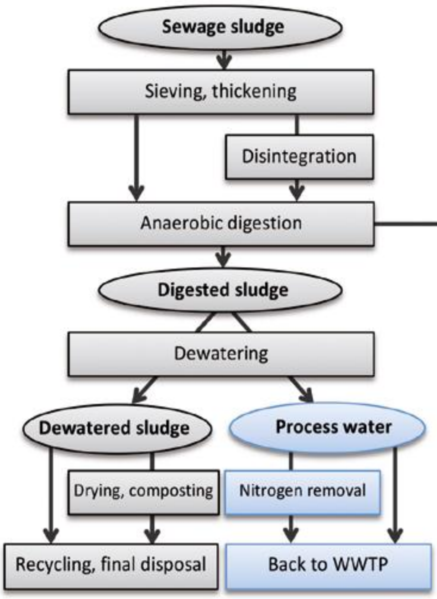


The municipal wastewater treatment is basically divided into two processes (a) the physical process and (b) the biological process. **The physical process**;- this is the mechanical treatment of the water that involves removal of debris from the raw wastewater right from the point it enters the plant. I,e, The screening and primary settling of debris. Wastewater enters the treatment plant through the **inlet chamber** from where it is channeled to the **coarse screen** that removes solid waste above 5cm and sends it to the crew pump. **The screw pump** then homogenizes the water by mixing it vigorously and pumps it into the fine screen. The **fine screen** removes debris and waste above 4mm for compaction and extraction after which the sewage then enters the **Grit chambers** which consist of two compartments that removes the grease, grit, scum and colloidal particles from the wastewater and sends it to the **grit pumping station** which pumps the grits to the classifiers that separates the grits from sewage. The sewage from the classifier is distributed to the bioreactors through the **distribution wells** while the grease, grits, scum and colloidal particles are send to the anaerobic digester as feedstock.

T**he biological process**;- this involve the biotreatment of the sewage in the **bioreactors**. It is the heart of the treatment plant where a biological process takes place. The bioreactors of a treatment plant are usually large tanks consisting of several mammoth rotors and submersible mixers. While the rotor introduces atmospheric oxygen into the sewage, the submersible mixers keep the biomass in suspension thus several reactions takes place in the bioreactors; usually, a treatment plant has more than 3 bioreactor tanks connected one to another e.g. the bioreactor at wupa treatment plant in Abuja has 6 biorectors with an hydraulic retention time of 30.4 hours for each bioreactor. From the bioreactor, the sewage enters the **sedimentation tank**. Here the biological process ends and sludge is separated from water such that the clean water is passed to the disinfection tank for disinfection and onward discharge for use while the sludge is removed by the returned activation sludge (RAS) pump that removes and sends part to the anaerobic digestion chamber while some are return to the anaerobic bioreactor for reactivation.

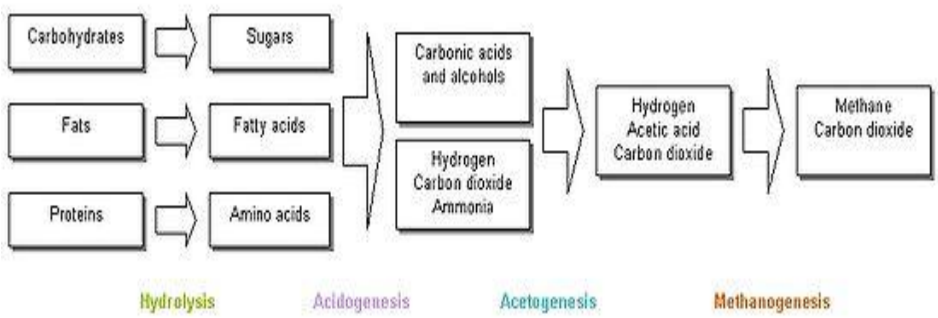

Wastewater inlet chamber and bioreactor at Wupa water treatment plant Abuja

Biogas production from sludge;-



Production of biogas is an anaerobic digestion whereby microorganisms break down biodegradable material in the absence of oxygen to produce methane/carbon dioxide used to generate electricity and heat. Sludge from the treatment plant (primary and activated sludge) is the main feedstock (biodegradable organic matter) in the biogas production plant of a wastewater treatment plant and the biogas production process involves series of steps. The combine sludge resulting from primary and secondary water treatment is gathered, sieved and thickened to a dry solids content of up to 7% before entering the digesters. Optionally, the sludge can be pretreated by disintegration technologies with the aim to improve the gas yield. In the anaerobic digestion process, the sludge is pumped into the anaerobic continuously stirred tank reactors where digestion takes place, usually at mesophilic temperature (35 – 39 °C) and a retention time of about 20 days. In the process, microorganisms break down part of the organic matter that is contained in the sludge and produce biogas, which is composed of methane, carbon dioxide and trace gases. (3)

The breakdown of sludge (organic matter) to biogas involves four sequential steps i.e. hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis as illustrates in the schematic diagramme below.



The raw biogas produced is dried and hydrogen sulphide and other trace substances removed and after cleaning, the biogas is upgraded to biomethane or combusted in a combined heat and power (CHP) plant to generate electricity and heat simultaneously. The digested sludge is dewatered and the water reintroduce into the treatment plant while the remaining undigested matter used for organic fertilizer. (4)

II. Biogas Potential In Waste Water

The biogas potential of a wastewater is proportional to the quantity, type and composition of the total sludge obtained after treating the wastewater. Sewage sludge refers to the residual, semi-solid material that is produced as a by-product during sewage treatment of industrial or municipal wastewater. The amount of sewage sludge produced can be expressed as kg dry solids per cubic meter of the wastewater treated. The total sludge production from a wastewater treatment process is the sum of sludge from primary settling tanks (if they are part of the process configuration) plus excess sludge from the biological treatment step. For example, primary sedimentation produces about 110–170 kg/ML of so-called primary sludge, with a value of 150 kg/ML regarded as being typical for municipal wastewater in the U.S. or Europe(3). The sludge production is expressed as kg of dry solids produced per ML of wastewater treated; one mega litre (ML) is 10^3 m^3 (10000). In the biological treatment processes, the activated sludge process produces about 70–100 kg/ML of waste activated sludge, and a trickling filter process produces slightly less sludge from the biological part of the process: about 60–100 kg/ML. This means that the total sludge production of an activated sludge process that uses primary sedimentation tanks is in the range of 180–270 kg/ML, being the sum of primary sludge and waste activated sludge.(5)

In general, it is estimated that the volume of sludge produced in a wastewater treatment plant is about 1% of the volume of influent wastewater to be treated. If this is the case worldwide, then for instance, the wupa treatment plant in Abuja which receives an average dry weather flow of 131,250m^3/ but was design to treat sewage flow of 700,000 population equivalent (P.E) with an expandable capacity of 1million (P.E), when calculation, the treatment plant will produces 1% of 131250m^3 sewage sludge out of the dry weather inflow of wastewater into the treatment plant per day. That is 1312.5 liter of sludge per day.

The work by D S Malik and U Bharti, gave the value of biogas produce from sludge of sewage treated water as tabulated below;

Production of biogas seasonally	Amount of biogas produced (m^3)	Quantity of sludge used liters	Temperature range (°C)
Winter	76252.8	$96x10^5$L	25-35
Summer	84952.34	$96x10^5$L	25-45

From the table above, it means If 9600000 liters of sewage sludge produce 76252.81m^3 of biogas; 1 liter will produce 127.21m^3. Thus wupa treatment plant for instance that produces 1312.5liter of sludge in a day has the potential to produce 127.21x1312.5= 166963.13m^3 of biogas daily.

166963 $m^3/10^3$= 1.7ML of gas produced daily. (3)

III. Conclusion

A very large quantity of wastewater especially during the raining season has been left to constitute a nuisance in the environment making environmental management very difficult. This wastewater has a potential to mitigate the energy crises in the word especially in the developing nations like Nigeria when harness and used efficiently in generating biogas. The water we consider as waste is actually a useful water with high potential of biogas such that rather than the problem it poses to the environment, it can help to provide a clean energy source which is not only renewable but provide a substitute to the use of fossil fuel that has been a major cause of environmental pollution the whole world is facing today.

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