Biogas as a Source of Energy and its Production from Kitchen Waste

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Abstract
This research was conducted to determine the efficiency of biogas generation from kitchen garbage and to present the various biogas production processes. The anaerobic digestion of kitchen waste produces a valuable energy resource, and the activity-based laboratory approach was applied for this purpose. The anaerobic breakdown is a microbiological process that produces biogas, mainly composed of methane and carbon dioxide. Biogas can be utilized as a source of energy and for a variety of other purposes. On the other hand, any potential applications require knowledge and information on the composition and quantity of components in the biogas produced. Sodium hydroxide must be added to maintain alkalinity and pH in the digester. The cow dung slurry, as well as kitchen garbage, were added to this reactor. This mixed Inoculum was combined to produce biogas in a small-scale activity. The production of biogas and methane from starch-rich and sugary material is determined on a small scale using simple digesters.

Keywords: Kitchen waste, biogas, reactor, Inoculum, anaerobic digestion, energy source

Introduction
The global supply of fuel is threatened by the scarcity of petroleum and coal and the difficulty of their burning, which has led to study in several areas to gain access to new sources of energy, such as renewable energy resources. Renewable energy resources include solar energy, wind energy, various thermal and hydro sources of energy, and biogas. On the other hand, biogas differs from other renewable fuels in that it uses, controls, and collects organic wastes while also producing fertilizer and water for use in farming irrigation. Biogas has no topographical borders and does not require advanced talent to produce energy; it is also easy to use and implement (Karve, 2007). Deforestation is a major issue in developing nations like Nepal, where most people rely on coal and firewood as a source of energy, which necessitates forest clearing. There are also signs of reducing land fertility due to deforestation and soil erosion. The usage of dung and firewood as energy sources is also hazardous to the public's health since the smoke produced by these sources pollutes the air. We require an environmentally sustainable energy source.

Kitchen trash is an organic resource with a high fattening and nutritional value for bacteria, which is why, as previously said, methane production efficiency can be boosted by several orders of magnitude. It entails increased reactor capability and capacity and lower biogas construction costs. Kitchen garbage is also disposed of in landfills or thrown in most cities and places, posing public health risks and diseases such as malaria, cholera, and typhoid. Inadequate waste management, such as unregulated dumping, has several negative repercussions (Kale, & Mehele, n.d.). It pollutes surface and groundwater through leachate and encourages the reproduction of disease-carrying vectors such as flies, mosquitoes, rats, and other pests. It also emits a foul stench and methane, a powerful greenhouse gas that contributes to global warming. Humankind can successfully handle this problem with the help of methane. Still, we have yet to reap the benefits due to a lack of basic scientific understanding, such as the fact that work output depends on the energy available to complete that activity. This truth may be demonstrated in current biogas plant techniques that use low calorific efforts like cow dung, distillery waste, municipal solid waste, or manure, resulting in highly inefficient methane generation. We can make this system incredibly efficient using kitchen garbage and food waste.

The utilization of starchy or sweet feedstock material for biogas demonstrates that this innovative technology is 800 times more efficient than conventional biogas plants, according to Kumar et al. (2003). Kitchen waste will be appropriately disposed of in a recyclable and cost-effective manner. When considering the cost-effectiveness of garbage removal, we must consider more than monitory scenarios. Food waste in public places, which degrades the environment, can be addressed to increase the value of biogas plants. The pulp can be used by using natural processes such as microorganisms' kitchen waste and biodegradable waste such as paper (Shalini, Sushil, Jain, & Dinesh 2000). The utilization of starchy or sweet feedstock material for biogas demonstrates that this innovative technology is 800 times more efficient than conventional biogas plants, according to Kumar et al. (2003). Kitchen waste will be properly disposed of in a recyclable and cost-effective manner. When considering the cost-effectiveness of garbage removal, we must consider more than monitory scenarios. Food waste in public places, which degrades the environment, can be addressed to increase the value of biogas plants. The pulp can be used using natural processes such as microorganisms' kitchen waste and biodegradable waste such as paper (Shalini, Sushil, Jain, & Dinesh 2000). The treatment of kitchen waste with anaerobic digestion is a viable option. While anaerobic digestion for animal manure management is prevalent in rural areas of emerging countries, knowledge on technological and practical options for treating organic solid waste is scarce. Several factors influence the design and performance of anaerobic digestion. Some are related to feedstock properties, reactor design, and real-time operating conditions. Because physical and chemical features affect biogas generation and process stability during anaerobic digestion, they are crucial to consider when constructing and operating digesters. Some of them are moisture content, volatile solids, nutrition 10 content, particle size, and biodegradability. Biogas output or methane yield and the proportion of solids eliminated in anaerobic digestion are indicators of a feed's biodegradability. The amount of biogas produced per unit of volatile solids contained in the feedstock after subjecting it to anaerobic digestion for a sufficient amount of time at a temperature that is assumed to be required in our case is measured by the amount of biogas. It can be produced per unit of volatile solids contained in the feedstock after subjecting it to anaerobic digestion for a sufficient amount of time at a temperature that is assumed to be required in our case.

In recent years, many technological advancements have been made to reduce the cost of biogas production. Various methods have been developed to increase fermentation speed for bacteria gas producers. The gas producers include shrinking reactors. They used starchy, sugary materials for production, modified the feeding materials for fermentation and the effluent exit for better work and compacted the equipment to produce gas in small spaces such as the backyard. With improved services in the current economic context, operating expenses per unit can be reduced to the point where extensive anaerobic breakdown services can be cost-effective, but small ones cannot. This is where economies of scale come into play. If energy prices continue to rise and demand for local waste management and fertilizers rises, this arrangement may shift. In anaerobic settings, microorganisms produce biogas by digesting biological material (Meres, Szczepaniec, Sadowska, Piejko, Oczyszczania, & Szafnicki, 2004). Methane gas is a naturally occurring gas that plays a significant role in the biogeochemical cycle. It's appropriate for both rural and urban locations.

Composition of Biogas

Component	Concentration (by volume)
Methane (CH_4)	55-60 %
Carbon dioxide (CO_2)	35-40 %
Water (H_2O)	2-7 %
Hydrogen sulphide (H_2S)	20-20,000 ppm (2%)
Ammonia (NH_3)	0-0.05 %
Nitrogen (N)	0-2 %
Oxygen (O_2)	0-2 %
Hydrogen (H_2)	0-1 %

Source: **Ziauddin, and Rajesh 2015**

Properties of Biogas

Biogas has qualities such as volume change as a function of temperature and pressure, calorific value change as a function of temperature, pressure, and water vapour content, and water vapour change as a function of temperature and pressure.

Factors Affecting Production of Biogas

The quantity and kind of organic matter, the temperature, acidity, and alkalinity (PH value) of the substrate, and the flow and dilution of the material are all elements that affect the fermentation process of organic substances under anaerobic conditions.

Benefits of Biogas Technology

The benefits of biogas technology include: energy production, the transformation of organic wastes into very high-quality fertilizer, improved hygienic conditions through pathogen reduction, environmental benefits through the soil, water, and air protection, micro-economic benefits from energy and fertilizer substitutes, macro-economic benefits through decentralized energy generation, and environmental conservation. Manure collection, anaerobic digester, effluent storage, gas handling, and gas usage are components of a typical biogas system. Biogas is a renewable energy source. Methanogens (methane-producing bacteria) are the final link in a chain of microorganisms that decompose organic matter and release the decomposition product into the environment. Organic chemicals can be found in many living and dead creatures. Organic substances, such as carbohydrates, proteins, and lipids, are made up of carbon (C) coupled with elements such as hydrogen (H), oxygen (O), nitrogen (N), and sulfur (S). Microorganisms in nature break down complicated carbon into smaller compounds during the digestive process (Karve, & Pune 2006). Anaerobic digestion and aerobic digestion are the two types of digestion processes.

Aerobic Digestion

Aerobic digestion is a type of digestion that occurs in oxygen and produces mixes of gases that contain carbon dioxide, one of the principal "greenhouse gases" that contributes to global warming. Anaerobic digestion is a type of digestion that occurs without oxygen and produces gas mixtures. When the gas, predominantly methane, is burned at room temperature, it yields 5210-5790 KJ/m3, making it a potentially environmentally beneficial energy source to replace fossil fuels.

Anaerobic Digestion

It is also known as biomethanization. It is a natural process that occurs without oxygen (Thomsen, Lissens, Baere, Verstraete, & Ahring, 2004). It entails the biochemical decomposition of complex organic material through various biochemical processes, resulting in the production of energy-rich biogas and nutritional effluents.

Biological Process

Hydrolysis: Extracellular enzymes of microorganisms, such as cellulose, amylase, protease, and lipase, enzymolysis organic materials in the first phase. Bacteria break down long chains of complex carbohydrates, proteins, and lipids into smaller chains. Polysaccharides, for example, are transformed into monosaccharides. Peptides and amino acids are two types of proteins.

Acidification: Acid-producing bacteria are involved in this stage, which consists in converting the intermediates of fermenting bacteria into acetic acid, hydrogen, and carbon dioxide. These anaerobic bacteria can thrive in acidic environments. They require oxygen and carbon to produce acetic acid. They do this by using dissolved or bound oxygen. The acid-producing bacteria thus generate an anaerobic environment, which is necessary for the methane-producing microorganisms to thrive. They also break down low-molecular-weight molecules into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulfide, and methane traces. Because bacteria alone cannot support that type of reaction, this process is partially endergonic and only viable with energy input.

Methanogenesis: Low-molecular-weight chemicals are decomposed by methane-producing bacteria, which were involved in the third phase. They use hydrogen, carbon dioxide, and acetic acid to make methane and carbon dioxide. Methane-producing bacteria can be found in natural settings when anaerobic conditions are available, such as underwater in marine sediments and marshes (Shekdar, Kshirsagar, & Singh, 2004). They are anaerobic and extremely vulnerable to environmental changes. Methanogenic bacteria are members of the archaebacteria genus. It is a group of bacteria with a diverse morphology and many biochemical and molecular-biological characteristics that set them apart from other bacteria. The fundamental distinction is seen in the composition of the bacteria's cell walls.

The symbiosis of bacteria: Methane and acid-producing bacteria work together in a symbiotic relationship. In anaerobic conditions and low molecular weight substances, acid-producing bacteria generate an environment with excellent parameters for methane-producing bacteria (Igoni, Ayotamuno, & Eze, 2008). On the other hand, methane-producing microorganisms employ the acid-producing bacteria's intermediates. Toxic conditions for the acid-producing microbes would emerge if they were not consumed. The metabolic activity of numerous bacteria acts in a design in real-time fermentation systems. No single bacteria can make fermentation products on its own; they need the help of others.

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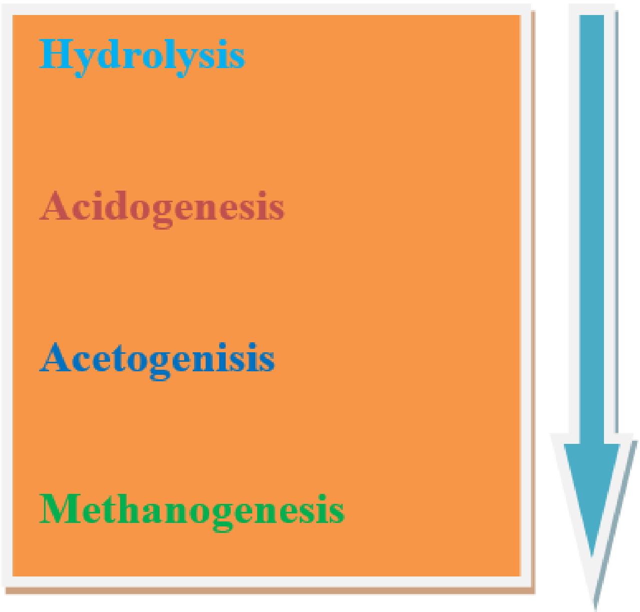

Materials and Methods

This research is based on an activity-based method. The garbage was collected from Kirtipur's house kitchen. Cooked rice, veggies, and vegetable waste are among the waste. A mixer grinder was used to smash the garbage, and the slurry was prepared to combine with water. This experiment was carried out in a 1-litre bottle and a digester on an activity scale. Different concentrations and mixes of wastes are utilized in this experiment. Total solid, volatile solid, volatile fatty acid, pH, Temperature, Nitrogen, Carbon, and Phosphorous were all measured in the input and effluent. Coconut shells, eggshells, peels, chicken, mutton, and bones should all be kept in their container. Mixer grinders will crush each of these independently. Different 5-litre containers collected wet garbage, stale cooked meals, and waste milk products. Vegetable waste such as peels, rotting potatoes, and coriander leaves are gathered in bags. It happens when thick biological waste does not reach the microbes in time to be digested. Solid wastes can be converted into liquid slurry using slurry mixers, which is a simple solution to this problem.

Results and Discussion

The amount of methane and carbon dioxide produced in gas production was measured using the syringe method. Because sodium hydroxide absorbs carbon dioxide but not methane, a syringe with a flexible tube and a dilute sodium hydroxide solution was employed to estimate carbon dioxide percentages. Dissolve sodium hydroxide granules in roughly 100 ml of water to get a 100 ml dilute sodium hydroxide solution. Fill the syringe with a 20-30 ml sample of biogas created during an experiment, dip the end of the tube into the sodium hydroxide solution, and then squeeze out the excess gas to get a 10 ml gas sample. Now read the volume of liquid, which should be 3-4 ml, indicating that around 30% of the gas has been absorbed, implying that the remaining 60% is methane. We must have nitrogen or other gas presents if the flame does not burn properly. As shown below, two separate sets with various compositions have been installed. Two hundred gram cow dung was combined with water and placed into a 1-litre container to make a 1-liter slurry. A 1lit solution was made by mixing 50gm ground kitchen with 150gm cow dung and adding water to form a 1-litre solution placed into a 1-litre bottle.

Figure. Bottel contains kitchen waste materials (Source; Ziauddin, and Rajesh 2015).

Gas is produced in both sets, and the gas is burned with a blue flame. As the process continues, volatile fatty acids are generated, causing the PH of the solution to drop. Compared to the other sets, it has been discovered that set 1 (which comprises kitchen garbage) produces more gas. Waste produces a large scale of gas in set 1, with the kitchen. It means that it produces more gas because kitchen waste has more nutrients than cow manure. Similarly, karve (2007) express that biogas is also very easy to use and implement. Shalini, Sushil, Jain, & Dinesh (2000) point out that the pulp can be used by using natural processes such as microorganisms' kitchen waste and biodegradable waste such as paper to enhance biogas production. As a result, using kitchen garbage for biogas production is more efficient.

Conclusion

According to the preceding findings, biogas can be created on a large scale by utilizing a big reactor holding kitchen garbage. More gas is produced by kitchen trash than by cow manure. As a result, kitchen trash has a higher nutritional[1] content than dung. Using kitchen garbage for biogas production is more efficient. Alternative energy development policies should be made for the use of kitchen waste, which is effective for biogas production.

References

Igoni, M. F. N., Ayotamuno, M. J. and Eze, C. L. (2008). E*ffect of total solids concentration of municipal solid waste on the biogas produced in an anaerobic continuous digester.* Tanzania traditional energy development and environment organization, biogas technology: Construction, utilization and operation manual.

Kale, S.P and Mehele, S.T. (n.d.). *Kitchen waste-based biogas plant:* PDF, Nuclear agriculture and biotechnology division. http://www.arti-india.org.

Karve, .A. D. (2007). *Compact biogas plant,* a low cost digester for biogas from waste starch: http://www.arti-india.org.

Karve, and Pune A.D. (2006). *Compact biogas plant compact,* low-cost digester from waste starch: www.bioenergylists.org.

Kumar D. and V.K. Jain and Shanker G. and Srivastava A. (2003). The utilization of fruits waste for citric acid production by solid-state fermentation. *Journal of Process Biochemistry*.38 (12) doi.https://doi.org/10.1016/S0032-9592(02)00253-4 https://www.sciencedirect.com/science/article/pii/S0032959202002534.

Meres, M., Szczepaniec, E., Sadowska, A., Piejko, K., Oczyszczania, M. P. Szafnicki, K. (2004). Operational and meteorological influence on the utilized biogas composition at the Barycz landfill site in Cracow, Poland: *Waste Management Resource.* 22: 195–201.

Shalini S., Sushil k, Jain, M.C. and Dinesh k. (2000). The increased biogas production through microbial stimulants. The University of Southampton and greenfinch Ltd. *Biodigestion of kitchen waste.*

Shekdar, A.K., Kshirsagar, P.K., Singh, R.N. (2004). *Estimation method for national methane emission from solid waste.* Landfills Atmospheric Environment.

Thomsen, A.B., Lissens, G., Baere, L., Verstraete, W., Ahring, B. (2004). Thermal wet oxidation improves the anaerobic biodegradability of raw and digested biowaste. *Environmental science and technology*.38: 3418-3424.

Ziauddin, Z. and Rajesh P. (2015). Production and Analysis of Biogas from Kitchen Waste. *International Research Journal of Engineering and Technology (IRJET)* e-ISSN: 2395 -0056 Volume: 02 Issue: 04 | July-2015 www.irjet.net p-ISSN: 2395-0072.