BIO-GAS PLANT ANAEROBIC DIGESTER

A GRADUATION REPORT SUBMITTED TO
THE FACULTY OF ENGINEERING
OF
NEAR EAST UNIVERSITY

By
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SUPERVISOR: FATMA ZOR

IN PARTIAL FULFILLMENT OF REQUIREMENTS
FOR A DEGREE IN BIOENGINEERING

NICOSIA 2016

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I hereby declare that all information in this document has been obtained and presented according to academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name:

Signature:

Date:

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ABSTRACT

Biogas can be produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste, green waste and energy crops. The biogas produced from a digester is comprised primarily of methane, carbon dioxide and other trace gases.

Methane (CH_4) is the second most prevalent greenhouse gas emitted from human activities. Methane is emitted by natural sources such as wetlands, as well as human activities such as leakage from natural gas systems and the raising of livestock. Natural processes in soil and chemical reactions in the atmosphere help remove CH_4 from the atmosphere. Methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO_2), but CH_4 is more efficient at trapping radiation than CO_2. Pound for pound, the comparative impact of CH_4 on climate change is over 20 times greater than CO_2 over a 100-year period. Globally, over 60% of total CH_4 emissions come from human activities.

When you build a biogas plant, methane, hydrogen, carbon monoxide and other trace gases are produced but methane is the main combustible gas. Biogas is currently used as a low cost fuel in many countries for heating and cooking, and is also extracted from waste management facilities like sewage plants and landfill sites where it refined into biomethane and used to run engines to generate electricity.

Key words: Greenhouse gas, Methane, Emitted, Waste, Fermentation, Natural resources, Renewable resources, Non-renewable resources, Biomass, Biogas, Anaerobic digestion**.**

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KEYWORDS

Acetogenic: is a process through which acetate is produced from CO_2 and an electron source (e.g., H_2, CO, formate, etc.) by anaerobic bacteria via the reductive acetyl-CoA or Wood-Ljungdahl pathway**.**

Acidogenic: producing acid, as bacteria, or causing acidity, as of the urine.

Biodegradable: capable of being decomposed by bacteria or other living organisms and thereby avoiding pollution

Carbohydrates and fats digester: The digestive tract processes a multitude of different food components each day through the use of a wide variety of enzymes and digestive juices.

Converting microbes: also known as biotransformation, is the conversion of organic materials, such as plant or animal waste, into usable products or energy sources by biological processes or agents, such as certain microorganisms

Electrical properties: is an intrinsic property that quantifies how strongly a given material opposes the flow of electric current. A low resistivity indicates a material that readily allows the flow of electric current.

Fossil fuels: a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms

Forces: is any interaction that, when unopposed, will change the motion of an object. In other words, a force can cause an object with mass to change its velocity (which includes to begin moving from a state of rest), i.e., to accelerate.

Gravitational: the force of attraction between any two masses. Compare law of gravitation.

Photosynthesis: is a process used by plants and other organisms to convert light energy, normally from the Sun, into chemical energy that can be later released to fuel the organisms' activities (energy transformation).

Humankind: human beings collectively; the human race.

Magnetic: is the magnetic effect of electric currents and magnetic materials.

Resources: a stock or supply of money, materials, staff, and other assets that can be drawn on by a person or organization in order to function effectively.

Recycle: is a key component of modern waste reduction and is the third component of the "Reduce, Reuse and Recycle" waste hierarchy.

CHAPTER 1

1.1 Introduction

The main aim of this project is to use natural resources as it free of cost and it does reproduce so there's no shortage from our gift from life. We use electricity and fuel as an everyday of life ass it makes our way of living easier.

The purpose of this project is to produce Biogas and from that we can then make things such as fire, energy, fuel, etc. We have to go through processes to obtain these things of course which may be anaerobic digesters, pyrolysis, gasification, liquefaction, etc.

To produce biogas anaerobic digestion has to take place which of cause is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen. Biogas is the ultimate waste product of the bacteria feeding off the input biodegradable feedstock the methanogens stage of anaerobic digestion is performed by archaea (a micro-organism on a distinctly different branch of the phylogenetic tree of life to bacteria) and is mostly methane and carbon dioxide.

Digestate is the solid remnants of the original input material to the digesters that the microbes cannot use. It also consists of the mineralised remains of the dead bacteria from within the digesters. Digestate can come in three forms: fibrous, liquor, or a sludge-based combination of the two fractions. In two-stage systems, different forms of digestate come from different digestion tanks. In single-stage digestion systems, the two fractions will be combined and, if desired, separated by further processing.

The most important initial issue when considering the application of anaerobic digestion systems is the feedstock to the process. Almost any organic material can be processed with anaerobic digestion however, if biogas production is the aim, the level of putrescibility is the key factor in its successful application.

Reference: 2009 Naskeo Environment from http://www.biogas-renewable-energy.info/anaerobic_digestion_definition.html

1.1.1 Hypothesis

The microscopic organisms that produce biogas, known as Archaea, are among the oldest life forms on Earth. They predate the planet's oxygen atmosphere — much less oxygen-breathing and CO2-absorbing plant life — by a cool 3.5 billion years. That's billion with a "B." Archaea are not bacteria, they are genetically closer to humans and other animals (eukaryotes), and form their own animal kingdom. As the Earth's atmosphere became predominantly oxygen about 500 million years ago, archaea became isolated in the few remaining airless places, such as stagnant swamps, deep oceans, caves and hot springs, and of course the stomachs of vertebrates. To create biogas, we must recreate the conditions in which Archaea thrive in nature.

1.2 Converting Biomass into Bioenergy

Biomass with a low moisture content is often used a feedstock for combustion. This "refers to the rapid oxidation of the feedstock as it is exposed to high heat" in a boiler where steam, under high pressure, is passed through a turbine which powers a generator. The main types of combustion processes are; "fixed-bed combustion, fluidised-bed combustion and dust combustion".

2. **Prolysis** - "Heat is used to chemically convert biomass into fuel. It occurs when biomass is heated in the absence of oxygen". A by-product of pyrolysis is "pyrolysis oil that can be burned.

The pyrolysis of wood is a thermal decomposition carried out in a closed furnace with very limited air input (less than 10% stoichiometric)". To start the process, a heat source is required, but when the temperature in the furnace "reaches more than 250°C, the reactions that take place are exothermic and the process is self-maintained up to 600°C".

3. Gasification - The process of heating wood in a chamber until all volatile gases such as CO, H2 and O2 are released from the wood and combusted. The emitted wood gasses are then superheated and mixed with air or pure oxygen for complete combustion.

Gasification has the great advantage of having extremely high combustion efficiency and thereby generating minimal emissions.

Gasification is a quicker process than pyrolysis and differs by "the presence of a limited quantity of air (20-80% stoichiometric)". The main product (of gasification) is syngas, composed of CO and H_2, which can be of high quality if oxygen is used instead of air.

The general raw materials used for gasification (creation of syngas) are coal, petroleum based materials, or other materials that would be rejected as waste. From these materials, a feedstock is prepared. This is inserted to the gasifier in dry or slurry form. In the gasifier, this feedstock reacts in an oxygen starved environment with steam at elevated pressure and temperature. The resultant syngas is composed of 85% carbon monoxide and hydrogen and small amounts of methane and carbon dioxide.

4. Liquefaction - is a conversion process resulting in liquid products (methanol) from biomass by direct or indirect processes. Indirect, through gas phase; direct, without gas phase, for example by rapid pyrolysis. This is a fast process where pressurized water is used to convert a liquid slurry of organic material into hydrocarbon oils and products. Direct liquefaction, or thermal depolymerization, has been successful in producing a liquid oil while the newer indirect liquefactionhas.

1.3 Why do we want to replace fossil fuels?

Burning fossil fuels creates carbon dioxide, the number one greenhouse gas contributing to global warming. Combustion of these fossil fuels is considered to be the largest contributing factor to the release of greenhouse gases into the atmosphere. In the 20th century, the average temperature of Earth rose 1 degree Fahrenheit (1°F). This period saw the most prolific population growth and industrial development, which was and remains totally dependent on the use of energy.

1.4 Natural resources

Natural resources are all that exists without the actions of humankind. This includes all natural characteristics such as magnetic, gravitational, and electrical properties and forces. On earth we include sunlight, atmosphere, water, land (includes all minerals).

1.5 Renewable resources

Renewable resources can be replenished naturally. Some of these resources, like sunlight, air, wind, etc., are continuously available and their quantity is not noticeably affected by human consumption. Though many renewable resources do not have such a rapid recovery rate, these resources are susceptible to depletion by over-use. Resources from a human use perspective are classified as renewable only so long as the rate of recovery exceeds that of the rate of consumption.

Reference: 2009 Naskeo Environment from http://www.biogas-renewable-energy.info/anaerobic_digestion_definition.html

1.6 Non-renewable resources

Non-renewable resources either form slowly or do not naturally form in the environment. Minerals are the most common resource included in this category. By the human perspective, resources are non-renewable when their rate of consumption exceeds the rate of replenishment, a good example of this are fossil fuels, which are in this category because their rate of formation is extremely slow (potentially millions of years), meaning they are considered non-renewable. Some resources actually naturally deplete in amount without human interference, the most notable of these being radio-active elements such as uranium, which naturally decay into heavy metals. Of these, the metallic minerals can be re-used by recycling them, but coal and petroleum cannot be recycled.

1.7 Benefits of manure derived biogas

High levels of methane are produced when manure is stored under anaerobic conditions. During storage and when manure has been applied to the land, nitrous oxide is also produced as a byproduct. Nitrous oxide (N_2O) is 320 times more aggressive as a greenhouse gas than carbon dioxide and methane 25 times more than carbon dioxide.

By converting cow manure into methane biogas via anaerobic digestion, the millions of cattle would be able to produce 100 billion kilowatt hours of electricity, enough to power millions of homes. In fact, one cow can produce enough manure in one day to generate 3 kilowatt hours of electricity; only 2.4 kilowatt hours of electricity are needed to power a single 100-watt light bulb for one day. Furthermore, by converting cattle manure into methane biogas instead of letting it decompose, global warming gases could be reduced by 99 million metric tons or 4%.

1.8 Methane

A chemical compound with the chemical formula CH_4 (one atom of carbon and four atoms of hydrogen). It is a group 14 hydride and the simplest alkane, and is the main constituent of natural gas. The relative abundance of methane on Earth makes it an attractive fuel, though capturing and storing it poses challenges due to its gaseous state under normal conditions for temperature and pressure.

Natural methane is found both below ground and under the sea floor. When it reaches the surface and the atmosphere, it is known as atmospheric methane. The Earth's atmospheric methane concentration has increased by about 150% since 1750, and it accounts for 20% of the total radiative forcing from all of the long-lived and globally mixed greenhouse gases (these gases don't include water vapor which is by far the largest component of the greenhouse effect).

Methane (CH_4) is the second most prevalent greenhouse gas emitted from human activities.

Methane is emitted by natural sources such as wetlands, as well as human activities such as leakage from natural gas systems and the raising of livestock. Natural processes in soil and chemical reactions in the atmosphere help remove CH_4 from the atmosphere. Methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO_2), but CH_4 is more efficient at trapping radiation than CO_2. Pound for pound, the comparative impact of CH_4 on climate change is over 20 times greater than CO_2 over a 100-year period. Globally, over 60% of total CH_4 emissions come from human activities.

1.9 Biomass

Biomass is the material derived from plants that use sunlight to grow which include plant and animal material such as wood from forests, material left over from agricultural and forestry processes, and organic industrial, human and animal wastes. Biomass comes from a variety of sources which include:

- Wood from natural forests and woodlands
- Forestry plantations
- Forestry residues
- Agricultural residues such as straw, stove, cane trash and green agricultural wastes
- Agro-industrial wastes, such as sugarcane bagasse and rice husk
- Animal wastes
- Industrial wastes, such as black liquor from paper manufacturing
- Sewage
- Municipal solid wastes (MSW)
- Food processing wastes

Reference: Online Trade Magazine Alternative Energy from Solar, Wind, Biomass, Fuel Cells and more… from http://www.altenergymag.com/content.php?post_type=1359

1.10 How it works

The energy contained in biomass originally came from the sun. Through photosynthesis carbon dioxide in the air is transformed into other carbon containing molecules (e.g. sugars, starches and cellulose) in plants. The chemical energy that is stored in plants and animals (animals eat plants or other animals) or in their waste is called bio-energy.

When biomass is burned it releases its energy, generally in the form of heat. The biomass carbon reacts with oxygen in the air to form carbon dioxide. If fully combusted the amount of carbon dioxide produced is equal to the amount which was absorbed from the air while the plant was growing.

In nature, if biomass is left lying around on the ground it will break down over a long period of time, releasing carbon dioxide and its store of energy slowly. By burning biomass its store of energy is released quickly and often in a useful way. So converting biomass into useful energy imitates the natural processes but at a faster rate.

CHAPTER 2

2.1 Bio-gas Plant anaerobic digester

Nature is our gift from life, so why not take advantage of that and so I came about into ways one can make efficient and cheaper ways to feed of our necessities. We use electricity, fuel daily so the purpose of this project is to discover ways to produce Biogas with alternate sources by using our local resources making of Biogas Plant can help us in basics of Anaerobic digestion and production of biogas by different organic kitchen wastage, basic task is to design, fabricate, and test a simple waste digester and gas collection system. With this Anaerobic Digester system you can examine various facets of the anaerobic digestion process.

The end products of this system are:

1) Methane: Can be used as a fuel

2) Slurry: The spent slurry is excellent manure

The main components of this system are:

1) Inlet pipe

2) Digester tank

3) Gas holder tank

4) Slurry outlet pipe

5) Gas outlet pipe

2.2 List of Materials

Digester seed material

Digester feed stock

20 liter water can

1/4" plastic tubing - possible use in gas collection system

Medium size Tyre tube for gas storage

Tub for mixing water feed stock

PVC Pipe 3/4" 2.5 ft

T-valve

Valve

Super glue

Fine Sand

Soldering Iron

Black Color Paint

2.3 Procedures

Bio gas plant is a digester and it involves the production of highly combustible methane gas, while constructing a prototype, following prescriptions must be followed.

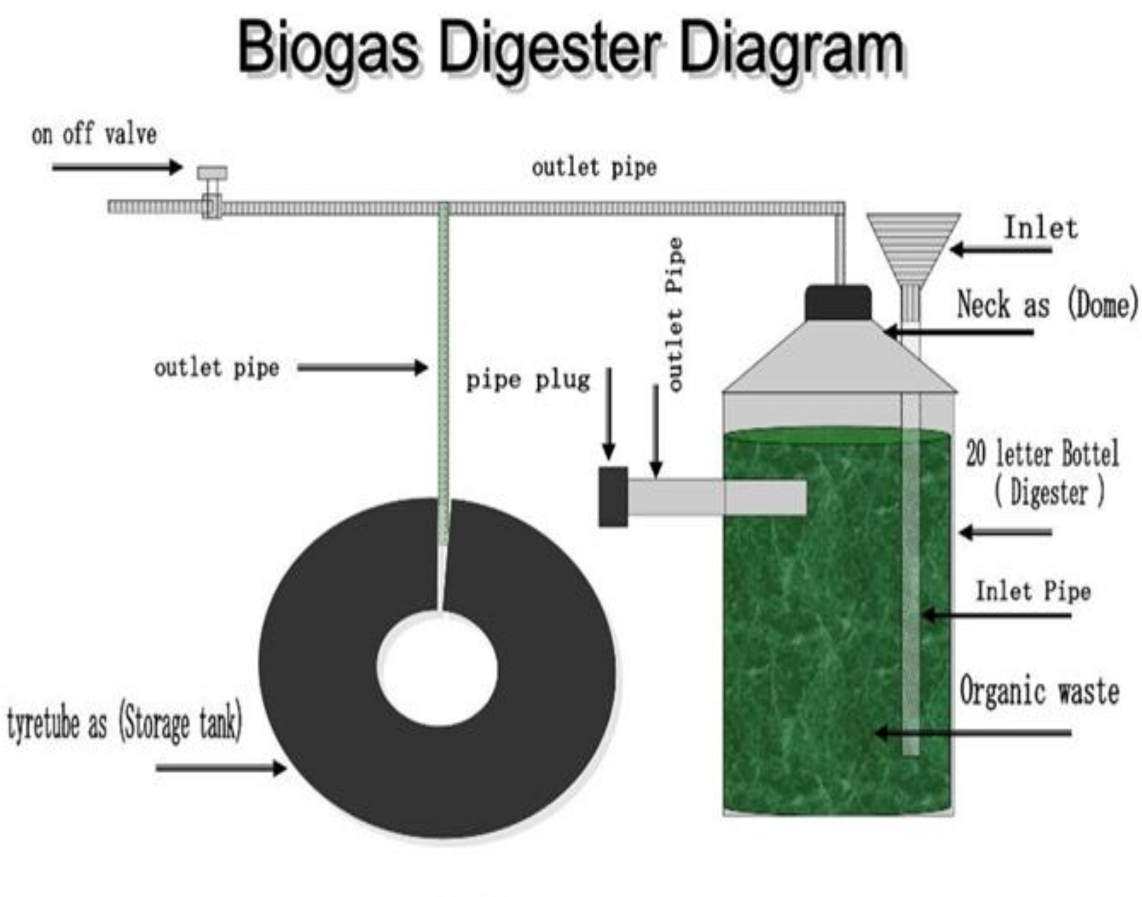
The container that we are using must be air tight, as we know that it’s a digester, that digests the biological waste an aerobically (strictly in the absence of air).

Transparent or translucent containers are not to be used for this purpose;if it is transparent it must be painted black because it keeps the temperature steady, if sunlight passes through the container it shall encourage the growth of algae. That is quiet lethal for the production of biogas.

Keeping in view that its highly inflammable gas, standard gas fittings must be used in this project. (i.e gas pipes, gas nasals)

Animal manure must be used as per containers dimensions, (i.e. in case of 20 l container 18 or 17 l of mixture in ratios of 50% dung and 50%water is prescribed)

For the first time. Animal dung must be used later on any biological waste that may include plants waste; dried dung, dried leaves or even paper can be used. But keeping in view that must be mixed in ratio of 50% with water and shaken well.



2.4 Purpose

The purpose of this project is to discover ways to produce Biogas with alternate sources by using our local resources this project can help students to basics of anaerobic digestion and production of bio-gas by different organic wastage, basic task is to design, fabricate, and test a simple waste digester and gas collection system. With this system you can examine various facets of the anaerobic digestion process.

Biogas, known as a source of renewable energy, is made mostly of methane. (60-70%) Biogas, as known by many scientific associations and universities, is made from a mixture of CH_4 (methane), CO_2 (carbon dioxide), H_2S (hydrogen sulfide), NH_3 (ammonia), and SO_2 (sulfur dioxide). This gas is formed when biological matter (usually cow manure), is decomposed in an environment with no oxygen present by bacteria.

Biogas has been popular as a source of energy for over 200 years In order to create In order to produce biogas, the individual has to first build an anaerobic (no oxygen present) digester, or an enclosed tank (usually made of steel), where specific types of organic wastes are placed in order for bacteria to decompose them. In the environment, biogas is produced naturally in deep soils, lake bottoms, and wetlands.

2.5 Precautions

- Avoid the biogas digester from getting in direct contact with sunlight.
- Avoid it from high temperature variations (Neither too hot, nor too cold)
- It must not go out of 30C – 40C temperature variations.
- All safety precautions must be used while testing the biogas, the valve must be faced away while testing the biogas.
- If results are not found after one week of feeding in biogas digester. Check the pipes for dung or water blockage.
- Dung from the animals who are being or were injected antibiotics recently for any reasons are highly discourages.

2.6 Developments

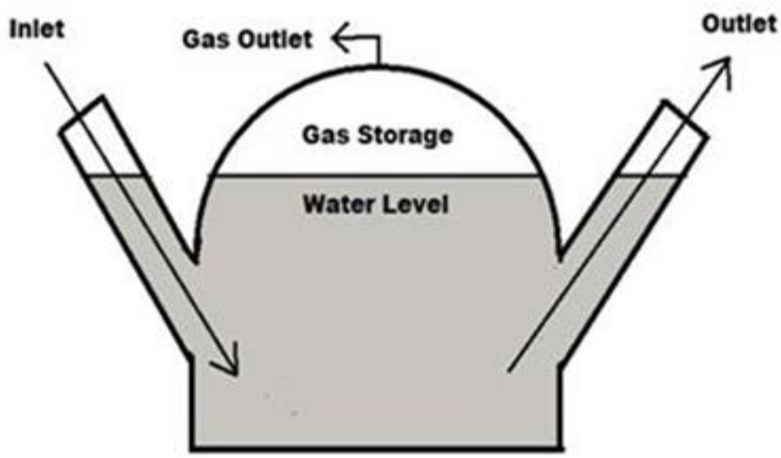
2.6.1 FEEDING IN THE DIGESTER

While feeding in the digester, outlet must stayed open so that slurry (digested mixture of dung and water) comes out of outlet.

The first production of biogas bring up slowly, so be patient, it may take as long as one complete week to produce gas.

Daily one liter of fresh properly mixed biological waste and water in 50% ratio shall be fed in the digester to keep the digester in good working condition.

The cheaper, affective and the safer method to store biogas is old tire tube. Bicycle tire tube or car tire tube as per the dimension of digester.



2.6.2 FERTILIZER

50 grams of fertilizer 15+ (15_{SO3}) was used in order to feed the bacteria and speed up the reaction. A Bunsen burner was used as a nozzle for the outlet of the methane gas.

Fertilizers may be made from organic materials or from chemicals. Some inorganic materials are manufactured, while others are obtained directly from the earth. Various minerals are considered inorganic fertilizers.

Organic Fertilizers: Organic fertilizers are made from plant material. Many consider them superior to inorganic fertilizers to condition the soil and improve the health of plants. Common organic fertilizers include:

Compost: Compost is made from decomposed plants. Grass clippings, leaves raked from the lawn, apple peels, and any discard uncooked fruit or vegetable peels or cores can be added to a compost pile. Some people add shredded newspaper, tea bags and coffee grounds. Meat scraps should never be added to compost piles since they will smell bad and attract vermin to the pile. Compost piles are easy to make and most home gardeners can create a simple compost pile. As time goes by, the materials added to the compost pile begin to decompose thanks to the action of various microbes. The result is a rich, crumbly material often dubbed 'black gold' by gardeners.

Peat moss: Gardeners often add peat moss to the soil to improve soil texture and add nutrients. Peat moss is harvested from peat bogs, where decomposing moss creates thick mats. It's then dried and sold by the bag or container for home use.

Seaweed: Seaweed or kelp fertilizer utilizes harvested plants that grow in the ocean. These plants are nutrient-rich and decompose rapidly. You can buy seaweed fertilizers at many garden centers.

Manures: Animal manure, such as cow and horse manure, can be added to the garden for natural organic fertilizers. Care must be taken to allow manures to age or they can burn the roots of plants.

Inorganic Fertilizers

Inorganic fertilizers are composed of ground up rocks, such as limestone and rock phosphate or manufactured chemical fertilizers. When they were invented in the 18th century, they were hailed as a boon for farmers and ushered in a golden age of agriculture. Chemical fertilizers may be grouped into two types: fertilizers suitable for home garden use and mass produced agricultural fertilizers. Fertilizers produced for home gardens are typically granular or pellet kinds of fertilizers to sprinkle around the roots of plants. Lawn fertilizers are placed in the hopper of a lawn spreader and gently spread on the grass. Most inorganic fertilizers for the home garden contain a balanced ratio of nitrogen, phosphorus and potash (potassium) expressed as a ratio of 10-10-10 or 20-20-20. Others may have slightly more phosphorus to encourage blooming, such as a 5-10-5 fertilizer. Read the package labels to select a fertilizer appropriate for your particular plants and garden.

Reference: C- 189 sec 35/A Zaman town Korangi 4 Karach from http://paksc.org/pk/diy-projects/764-biogas-plant-experiment/

2.7 Things to avoid

- Anything that floats
- Wood or sawdust
- Fresh chicken manure
- Fruit or juice or peels
- Coffee grounds
- Vinegar
- Meat, fish or bones
- Soap or cleaners

2.8 BIO GAS READINGS

1. Five Steps to Make Biogas:

5 Steps to Make Biogas		
Step	**Condition**	**Controlled by**
1	Airtight environment	Digester Design
2	Water content	
3	Heat	
4	Neutral pH	Digester Loading
5	Carbon-to-nitrogen	

2. Temperature readings:

Operating Temperature	**Temperature (F)**	**Time to break down waste**	**Pros and Cons**
Common	50-85	30 days	Can withstand day/night temperature changes, very robust.
Medium	85-100	15 days	Very cautious when changing temperature or loading.
High (Not Recommended)	122-131	3 days	Extremely fragile, cannot withstand +/-5.

3. Carbon to Nitrogen Ratios:

Carbon (C) to Nitrogen (N) Ratios (25:1 is Ideal)

Type of Waste	C:N Ratio
Human Sanitation waste	3:1
Pig waste	13:1
Food waste	15:1
Cattle Manure	25:1
Grass	27:1
Brown tree leaves	47:1
Straw	87:1
Paper	150:1
Cardboard	560:1

CHAPTER 3

3.1 Biogas

A mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. Biogas is a renewable energy source and in many cases exerts a very small carbon footprint. Biogas can be produced by anaerobic digestion with anaerobic organisms, which digest material inside a closed system, or fermentation of biodegradable materials.

Biogas is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulfide (H_2S), moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.

Biogas can be compressed, the same way natural gas is compressed to CNG, and used to power motor vehicles. In the UK, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel. It qualifies for renewable energy subsidies in some parts of the world. Biogas can be cleaned and upgraded to natural gas standards, when it becomes bio-methane. Biogas is considered to be a renewable resource because its production-and-use cycle is continuous, and it generates no net carbon dioxide. Organic material grows, is converted and used and then regrows in a continually repeating cycle. From a carbon perspective, as much carbon dioxide is absorbed from the atmosphere in the growth of the primary bio-resource as is released when the material is ultimately converted to energy.

Biogas is a gas that is formed by anaerobic microorganisms. These microbes feed off carbohydrates and fats, producing methane and carbon dioxides as metabolic waste products. This gas can be harnessed by man as a source of sustainable energy.

Biogas is considered to be a renewable fuel as it originates from organic material that has been created from atmospheric carbon by plants grown within recent growing seasons. Biogas is made in a biogas digester. We call it a digester because it is a large tank filled with bacteria that eats (or digests) organic waste and gives a flammable gas, called biogas.

Reference: *OVERCONSUMPTION? Our use of the world´s natural resources. SERI, GLOBAL 2000, Friends of the Earth Europe, September 2009.*
http://www.foe.co.uk/sites/default/files/downloads/overconsumption.pd from
http://www.eschooltoday.com/natural-resources/role-of-natural-resources.html

3.2 The dangers of biogas

The dangers of biogas are mostly similar to those of natural gas, but with an additional risk from the toxicity of its hydrogen sulfide fraction. Biogas can be explosive when mixed in the ratio of one part biogas to 8-20 parts air. Special safety precautions have to be taken for entering an empty biogas digester for maintenance work.

3.3 Health hazards

Health hazards are associated with the handling of night soil and with the use of sludge from untreated human excrete as fertilizer.

The following is a list of safety measures that should be read with great care before a biogas system is built.

1) Regularly check the whole system for leaks.

2) Provide ventilation around all gas lines.

3) Always maintain a positive pressure in the system.

4) The engine room floor must be at or above ground level to avoid the buildup of heavier- than-air gases.

5) The engine room roof must be vented at its highest point to allow lighter-than-air gases to escape. This is also true for greenhouses that have biogas digesters, engines, or burners in them.

6) The engine exhaust pipe must be extended so that the dangerous and deadly exhaust gases are released outside the building.

7) Metal digesters and gas storage tanks must have wires to lead lightning to the ground.

8) Gas lines must drain water into condensation traps.

9) No smoking or open flames should be allowed near biogas digesters and gas storage tanks, especially when checking for gas leaks.

Methane, the flammable part of biogas, is a lesser danger to life than many other fuels. However, in the making and using of an invisible fuel, dangerous situations can arise unexpectedly and swiftly--such as when a gas pipe is accidently cut. On the other hand, precaution can be exaggerated. When cars first appeared on the roads, a man waving a red flag came first.

In general, published data indicate that a digestion time of 14 days at 35 C is effective in killing (99.9 per cent die-off rate) the enteric bacterial pathogens and the enteric group of viruses. However, the die-off rate for roundworm (Ascaris lumbricoides) and hookworm (Ancylostoma) is only 90 per cent, which is still high. In this context, biogas production would provide a public health benefit beyond that of any other treatment in managing the rural health environment of developing countries.

It is important that a biogas system never has negative pressure as this could cause an explosion. Negative gas pressure can occur if too much gas is removed or leaked; Because of this biogas should not be used at pressures below one column inch of water, measured by a pressure gauge.

Frequent smell checks must be performed on a biogas system. If biogas is smelled anywhere windows and doors should be opened immediately. If there is a fire the gas should be shut off at the gate valve of the biogas system.

Reference: http://werkgroepterlinden.be/Biogas.html

3.4 Biogas systems

Biogas systems make use of a relatively simple, well-known, and mature technology. The main part of a biogas system is a large tank, or digester. Inside this tank, bacteria convert organic waste into methane gas through the process of anaerobic digestion. Each day, the operator of a biogas system feeds the digester with household by-products such as market waste, kitchen waste, and manure from livestock. Waste that has been fully digested exits the biogas system in the form of organic fertilizer.

3.5 Different types of Biogas

1. Renewable Natural Gas (Bio methane) Production

Renewable natural gas (RNG), or bio methane, is a pipeline-quality gas that is fully interchangeable with conventional natural gas and thus can be used in natural gas vehicles. RNG is essentially biogas (the gaseous product of the decomposition of organic matter) that has been processed to purity standards. Like conventional natural gas, RNG can be used as a transportation fuel in the form of compressed natural gas (CNG) or liquefied natural gas (LNG).

2. Biogas from Landfills

3. Biogas from Livestock Operations

4. Biogas from Wastewater Treatment

3.6 Fundamental steps to anaerobic digestion

There are four fundamental steps of anaerobic digestion that include hydrolysis, acidogenesis, acetogenesis, and methanogenesis.

Throughout this entire process, large organic polymers that make up Biomass are broken down into smaller molecules by chemicals and microorganisms. Upon completion of the anaerobic digestion process, the Biomass is converted into Biogas, namely carbon dioxide and methane, as well as digestate and wastewater.

Hydrolysis - is a chemical reaction in which the breakdown of water occurs to form H+ cations and OH- anions. Hydrolysis is often used to break down larger polymers, often in the presence of an acidic catalyst.

Acidogenesis - acidogenic microorganisms further break down the Biomass products after hydrolysis. These fermentative bacteria produce an acidic environment in the digestive tank while creating ammonia, H2, CO2, H2S, shorter volatile fatty acids, carbonic acids, alcohols, as well as trace amounts of other byproducts.

Acetogenesis - is the creation of acetate, a derivative of acetic acid, from carbon and energy sources by acetogens.

Methanogenesis - constitutes the final stage of anaerobic digestion in which methanogens create methane from the final products of acetogenesis as well as from some of the intermediate products from hydrolysis and acidogenesis.

3.7 Anaerobic digestion

It is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen. One of the end products is biogas, which is combusted to generate electricity and heat, or can be processed into renewable natural gas and transportation fuels.

Anaerobic digestion is a biological process making it possible to degrade organic matter by producing biogas which is a renewable energy source and a sludge used as fertilizer.

The production of biogas is carried out in the environment in a natural way (e.g. gas of marshes - vegetable and animal matter decomposition where the formation of bubbles at water surface can be observed).

In the absence of oxygen (anaerobic digestion), the organic matter is degraded partially by the combined action of several types of micro-organisms. A succession of biological reactions (see diagram) led to the formation of biogas and sludge.

The bacteria which carry out these reactions exist in natural state in the liquid manure and the anaerobic ecosystems; it is not necessary to add more, they develop naturally in a medium without oxygen.

3.8 Different types of anaerobic digesters

The Biological Process

The digestion process begins with bacterial hydrolysis of the input materials in order to break down insoluble organic polymers such as carbohydrates and make them available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide.

Municipal Wastewater

Industrial Wastewater

Municipal Solid Waste (MSW)

Reference: Contacts | Web Site Policies | U.S. Department of Energy | USA.gov Content Last Updated: 05/10/2016 from http://www.afdc.energy.go/fuels/natural_gas_renewable.html

CHAPTER 4

4.1 Future aspects

I for one believe that using natural resources is an efficient way as it costs less, in actual fact it's free! Yes the years may have gone past, everyone is into technology as it makes life easy, but rich or poor one has to use the restroom at the end of the day.

It may be gross and icky but looking at the bright side we are limiting global warming and other aspects needed to survive.

Conclusion

The reason why I used fertilizer was because, Fertilizer replaces the nutrients removed when produce from the land is harvested. Fertilizer allows soils to maintain or increase plant growth and provides essential nutrients for animal health. It is a vital part of agricultural and forestry industries. These industries are a major source of income through the export of meat, wool, timber and horticultural produce to offshore markets.

Natural resources are available to sustain the very complex interaction between living things and non-living things. Humans also benefit immensely from this interaction. All over the world, people consume resources directly or indirectly. Developed countries consume resources more than under-developed countries.

The three major forms include Food and drink, Housing and infrastructure, and Mobility. These three make up more than 60% of resource use.

So be sure to Reuse, Reduce and Recycle.

References

Trade Magazine used in chapter 1.9 at the end of the sentence

SERI, GLOBAL 2000, Friends of the Earth Europe, September 2009. (Used in chapter 3 at the beginning of the sentence)

http://werkgroepterlinden.be/Biogas.html (Used in chapter 3.2 in the middle of the chapter)

A Zaman town Korangi from http://paksc.org/pk/diy-projects/764-biogas-plant-experiment/ (Used in chapter 2)

U.S. Department of Energy | USA.gov Magazine (Used in chapter 3)

2009 Naskeo Environment (Biogas Renewable Energy Information) Used in chapter 1.

American Biogas Council from https://www.americanbiogascouncil.org/biogas_what.asp (Used in chapter 3)

APPENDIX

Waste / Wood Product	Type of Conversion	Possible Processes
Timber	Thermo-chemical	Combustion, Gasification, Prolysis, Liquefaction
Organic Agricultural Waste	Thermo-chemical	Combustion, Gasification, Prolysis, Liquefaction
Solid Feacal Waste	Biological	Anaerobic Digestion

Figure 1

Converting Biomass (From chapter 1)

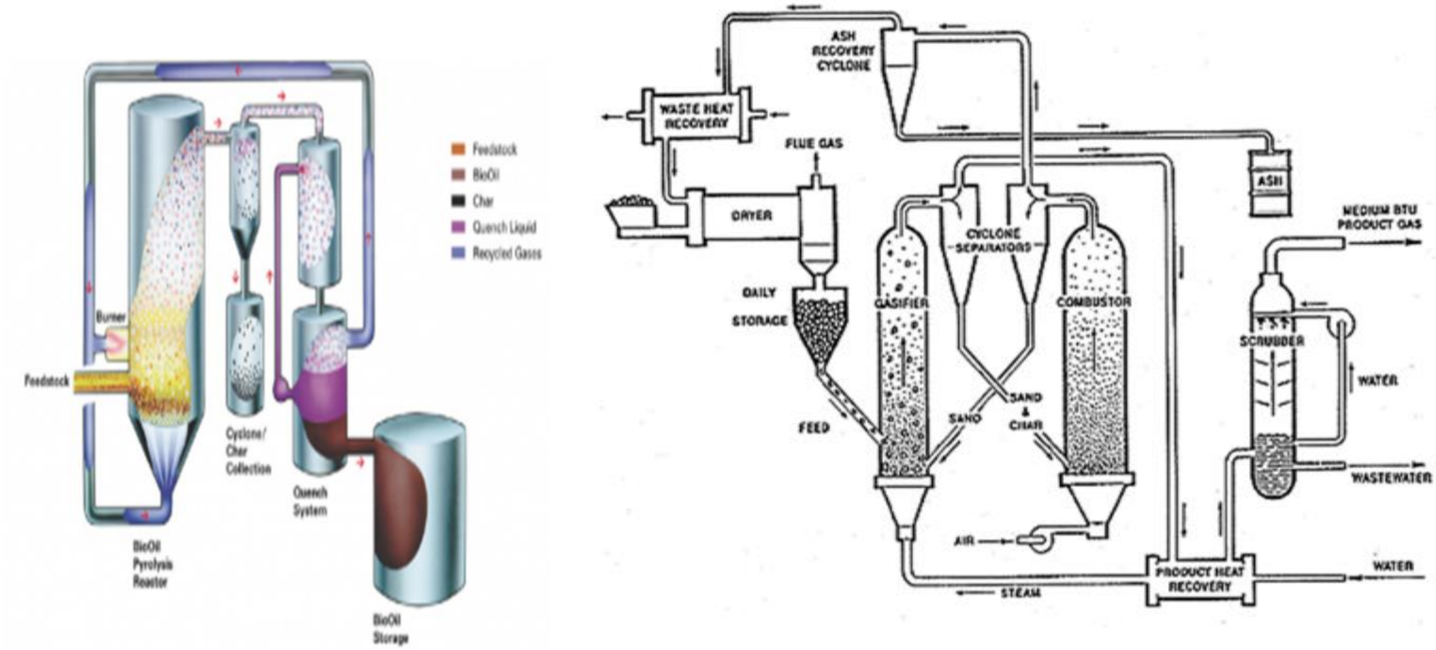


Figure 2

Pyrolysis & Gasification (From Chapter 1.3)

Figure 3

Dangers (From chapter 2.2)

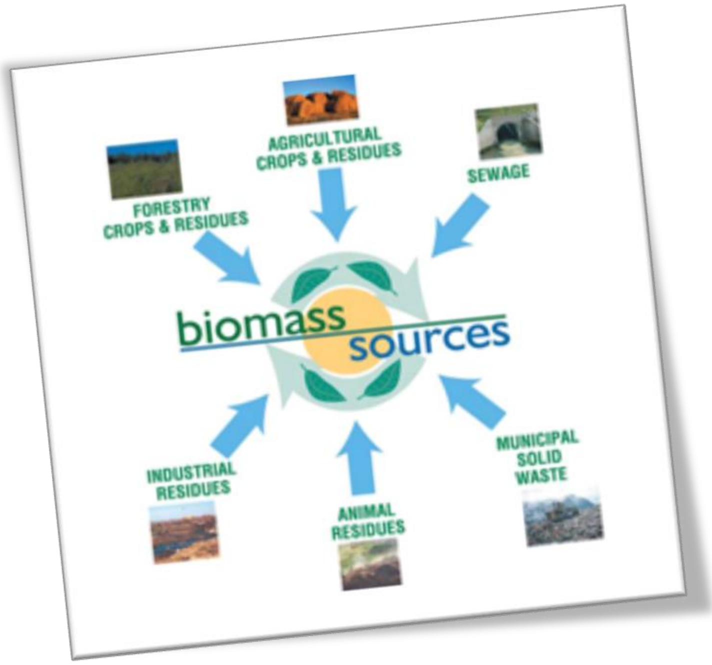


Figure 4

Biomass (From chapter 1.10

Figure 5

Natural Resources (From chapter 1.5)

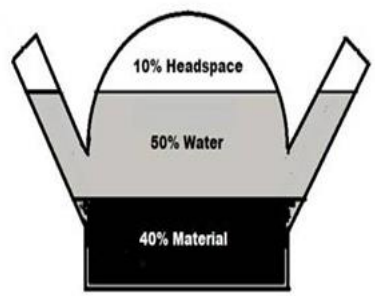


Figure 6

Anaerobic Digester (From chapter 2)

Figure 7

Biogas systems (From chapter 2.2)