PAN AFRICAN UNIVERSITY

Institute of Water and Energy Sciences (Including Climate Change)

Enhanced biogas production by anaerobic co-digestion from food waste and agriculture byproduct

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DECLARATION

I RANA SALAHELDEEN, declare this thesis presenting form my personal work, to the best of my knowledge. I also announce that all the material, information and results from other works I approach it here; have been referenced according to the academic rules and ethics………….

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Firstly, I would to thanks my GOD for allowing me and supporting me to reaching this level of education. I would like also to gratitude the entire PAUWES staff to their efforts, support, expertise and assistance to helping me out on this work.

Then I would like to thank Dr. Kiros Hagos Abay for helping me with this very interesting topic and also his input on the topic. Special thanks to Etay Hailu and Godif Alene the lab technicians.

ABSTRACT

Several studies have been carried out on the AD process of biogas production using different substrate.

The co-digestion process was recommended to overcome the difficulties, there have been a number of published papers investigated the of AcoD system, the significant research efforts have been devoted to studying the co-digestion of different combinations of municipal, industrial, agricultural and farming waste materials.

Co-digestion can enhance biogas production from 25% to 40% over the mono-digestion of the same substrates, it is very promising technology to enhance the biogas products from AD of organic wastes since it can establish good synergisms in the digestion reactor, and it is economically feasible. However, there is a difficulty to enhance the AcoD system in one-stage digester since the metabolic properties, nutritional requirements, growth rates and optimum operational factors are significantly different.

In this study, we try to use the co-digestion system with two different type of raw substrates which are: the agricultural waste and the food waste, conferring to the last studies that done. we didn't reflect the manure or the dung of the animals. Due to know the consequence of replacing it with other ingredients. Finally, and affording to the result getting with relating with the literature; the research fit the aim reliant to the results we get, the total amount of methane was about: Methane reach 65 as literature say 50-75 in % additional the Carbon dioxide reach 35 literature say 25-45 in %.

Key words

AcoD, substrates, by-products, substrate, methane productions, sustainable development, alkaline.

RÉSUMÉ

Plusieurs études ont été menées sur le procédé AD de production de biogaz en utilisant différents substrats.

Le processus de co-digestion a été recommandé pour surmonter les difficultés. Un certain nombre d'articles ont été publiés sur le système AcoD. Des efforts de recherche importants ont été consacrés à l'étude de la co-digestion de différentes combinaisons de techniques municipales, industrielles, agricoles et d'élevage. déchets

La co-digestion peut augmenter la production de biogaz de 25% à 40% par rapport à la mono-digestion des mêmes substrats. C'est une technologie très prometteuse pour améliorer les produits de biogaz issus de la DA des déchets organiques, car elle permet d'établir de bonnes synergies dans le réacteur de digestion. c'est économiquement faisable. Cependant, il est difficile d'améliorer le système AcoD dans un digesteur à un étage, car les propriétés métaboliques, les besoins nutritionnels, les taux de croissance et les facteurs opérationnels optimaux sont très différents.

Dans cette étude, nous essayons d'utiliser le système de co-digestion avec deux types de substrats bruts différents, à savoir les déchets agricoles et les déchets alimentaires, ce qui confère aux dernières études réalisées. nous n'avons pas reflété le fumier ni les excréments des animaux. En raison de connaître la conséquence de le remplacer par d'autres ingrédients. Enfin, et en permettant au résultat d’être en rapport avec la littérature; la recherche correspond bien à l'objectif qui dépend des résultats que nous obtenons, la quantité totale de méthane était d'environ: Le méthane atteint 65 ans, selon la littérature, 50-75 pour cent en plus du dioxyde de carbone atteignant 35, selon la littérature, entre 25 et 45%.

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CHAPTER 1.

INTRODUCTION

1.1 Background to the study

U.S. has over 2200 sites producing biogas 191 anaerobic digesters on farms, approximately 1500 anaerobic digesters at wastewater treatment plants (only 250 currently use the biogas they produce) Europe has over 10,000 operating digesters; some communities are essentially fossil fuel free because of them.

The Netherlands Development Organization domestic biogas sectors in which local companies' market, install and service biogas plants for house-holds in developing countries.

The Netherlands Development Organization domestic biogas sectors in which local companies' market, install and service biogas plants for house-holds in developing countries. For Europe in order to reach the EU member state targets for renewable energies for 2020 and to fulfill European waste management directive requirements; anaerobic digestion is seen to be one of the key technologies. (http://www.snv.org/public/cms/sites/default/files/explore/download/, 2009)

Germany: Industrial scale Germany is Europe's biggest biogas producer and the market leader in biogas technology. It's already provides more than 3% of the whole of Germany's electricity consumption, as well as weighty amounts of industrial heat, transport fuels, and volume injected into the natural gas grid.

Sweden is a world leader in promotion of use of bio methane for transport vehicles including: private cars, buses and even a biogas train and a biogas powered touring car team. (http://www.snv.org/public/cms/sites/default/files/explore/download/, 2009)

In 2011 China and India produced 2.8 million and 150,000 biogas plants respectively, arriving at impressive cumulative numbers of 42.8 million and 4.5 million units installed of all sizes. Leading the household biogas plants In China the renewable energy policy is driving the steady development and application of biogas.

For the African case, in Ethiopia, Addis Ababa in experimental laboratory scale of anaerobic co-digestion using the kitchen waste and sanitary water as a feedstock established with blend of 25% of the sanitary water 75% from the organic kitchen waste; the result was shown that it shaped a maximum quantity of biogas. Apart from that, result in that experiment stayed tow possible difficulties of using those kind of feeding a high ratio of cellulose and the content of protein, as an effect of changing the substrates using brewers wastes 90% spent grains with 10% sewage sludge at ratio of 25:75 it causes increase in the production amount retch to 93% comparing with the previous result.

From a reviewed we can say that a high amount is required from the kitchen waste to produce extreme amount of biogas relating with the other different kind of feedstock wherever the co-digestion process is worthy partaking. Process is important to: save time and increase resources utilization efficiency transform from lab scale to industrial scale and design the system including appropriate operational factors. however, the main problem is the required data for system classification.

The important point which must be noticed here is that; missing of any parameter can severely affect the performance of the system. Thus, it is recommended to integrate BMP experimental data with ADM1 model for optimization of biogas productions and no reported paper was found on using BMP tests for ADM1 modeling for AcoD technologies. The following figure show current 2016 versus expected 2030 installed influence generation capacity in sub-Saharan Africa by fuel. We can realize the declining in using the fossil fuels resources and modify it with the renewable once.

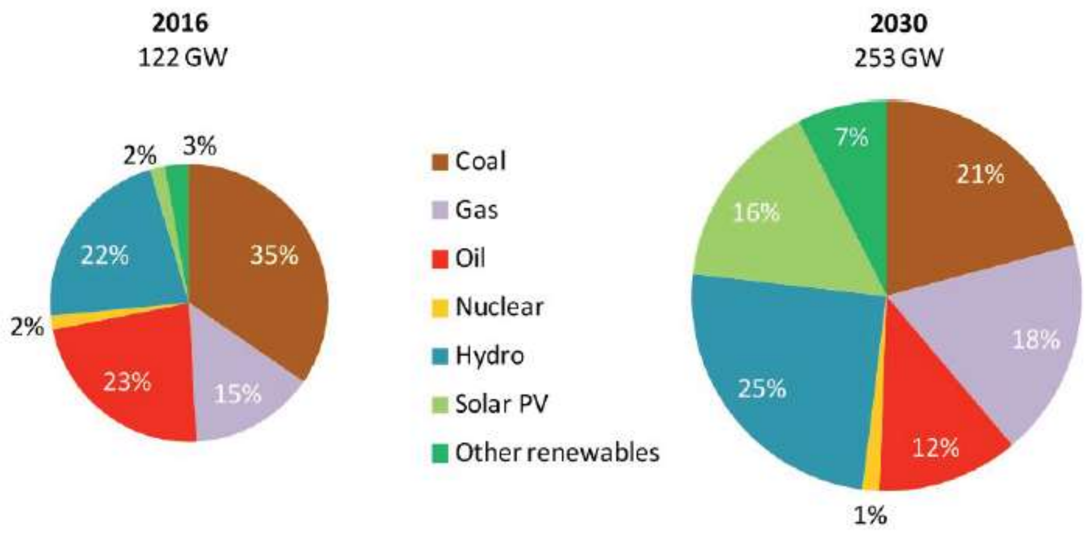

Figure (1.1): Current (2016) versus projected (2030) Installed power generation capacity in sub-Saharan Africa by fuel.

Source:(Ugokwe, 2018)

1.2 About the biogas:

Firstly when talking about the biogas manufacture and biogas plants We will starting with the components of the standers plant and the function from each one, in Figure 1.2 it shown those elements are; the digester: The anaerobic digester process of the digesting and the fermentation of the row material , gas piping system: to storage, the biogas .expansion chamber: components of regulation of the biogas production: and they like pressure gauge biogas stove lamp and slurry handling structures mixing tank inlet pipe: first step to inter the row substantial in the vessel.

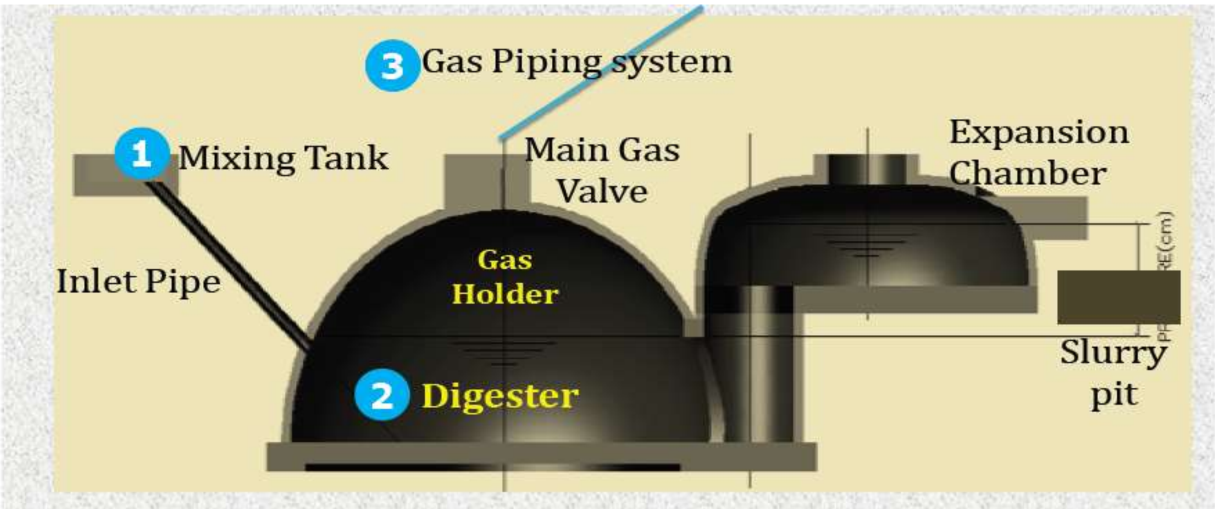

Figure (1.2): Modified Biogas plant

Source: (lavinina Warnars, 2014)

1.2.1 The advantage of the biogas:

First: the biogas technology:

The knowledge used to produce biogas is fairly cheap. it is easy to set up and needs little investment when on a small scale. Small biodigesters can be used right at home applying kitchen waste and animal manure. A household system pays for itself after a while and the materials used for generation are undeniably free. The gas can be used directly for cooking and generation of electricity. This is what allows the cost of biogas to be relatively low.

(https://www.homebiogas.com/Blog/141/Advantages_and_Disadvantages_of_Biogas, 2019)

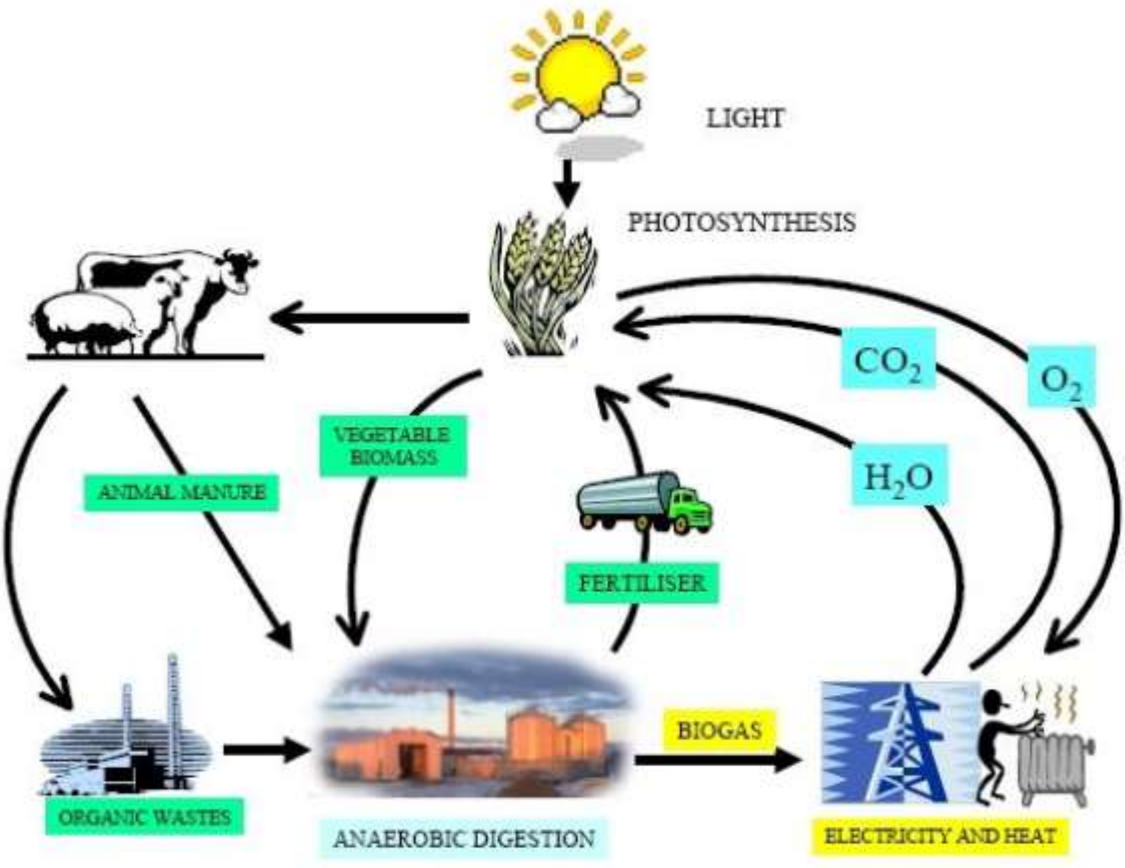

Figure (1.3): Biogas production circle

Source: (https://www.homebiogas.com/Blog/141/Advantages_and_Disadvantages_of_Biogas, 2019)

Biogas plants provide multiple benefits at the household local general and international level. These benefits are appreciated differently in different countries and can be classified according to their impact on energy security employment environment and poverty. Farms can make use of biogas plants and waste products produced by their livestock every day. The waste products of one cow can provide enough energy to power a lightbulb for an entire day. In large plants biogas can also be compressed to achieve the quality of natural gas and utilized to power automobiles. B uilding such plants requires relatively low capital investment and creates green jobs. For instance, in India 10 million jobs were created mostly in rural areas in plants and in organic waste collection. the figure below shown the circle of the biogas production

Environmental benefits: anaerobic digestion of wastes results in reduced pollution of groundwater shallow water and other resources. Anaerobic digestion electively destroys such harmful pathogens. Effluent from biogas digesters can serve as high quality biological compost displacing import or production of artificial nitrogenous fertilizers. Anaerobic digestion serves to reduce the volume of wastes and associated problem of their disposal. The influence on the greenhouse effect.

Biogas produced on a sustainable basis can significantly reduce greenhouse gas emissions. of the worldwide 30 million tons of methane emissions per year generated from the different animal waste management systems like solid storage anaerobic lagoon liquid/slurry storage pasture etc. About half could be avoided through anaerobic treatment. It is estimated that through anaerobic treatment of animal waste and energy use of the methane produced about 1324 million tons of CH_4 emission can be avoided worldwide per year. Economic and social benefits: increased employment promoting biogas production from organic wastes and sustainably in society. Sustainable energy resource: the development of biogas represents a strategically important step away from dependence on fossil fuels whilst contributing to the development of a sustain able energy supply and enhanced energy security in the long-term.

Decentralized energy generation: one of the advantages of biogas technology is that it can established locally without the need for long distance transportation or import of raw materials. Small or medium-sized companies and local authorities can establish biogas plants anywhere i.e. they need not be sited in any particular location; for example, close to large cities sustainable waste management: utilizing organic wastes reduces the amount that must be taken care of in some other way for example by combustion or transport to landfills. Clean fuel for industry: methane is a fuel in demand by industry partly because it is a gas that gives a high-quality combustion that can be precisely controlled. Methane burns with a clean and pure flame which means that boiler sand other equipment is not clogged by soot and cinders. This leads to a cleaner workplace environment and possibly a reduced maintenance costs for the plant.

Secondly: Biogas Application:

The biogas produced can now be combusted in a combined heat and power plant converts the energy stored in the biogas to rotational energy. A connected generator converts rotational energy into electric power. Electrical energy a combined heat and power plant also produces heat which can be used to heat the reactor or buildings apart from that the waste management that the biogas provided with using the waste to produce energy. Biogas covers a variety of markets including electricity heat and transportation fuels. Direct combustion in household stoves and gas lamps is common in some countries producing electricity from biogas is still relatively rare in most developing countries. In industrialized countries power generation is the main purpose of biogas plants; conversion of biogas to electricity has become a standard technology. To improve overall efficiency of biogas utilization combined heat and power plants are often. After fermentation the biogas is normally cooled dried of water vapor and cleaned of hydrogen sulphide to produce a good combustion gas for gas engines

1.2.2 Disadvantages of Biogas:

Even if the biogas seems as alternative solution although it has some disadvantages such as:

1. Impurities: the reason why that bio gas is suitable for water boilers lamps and kitchen stoves more than using it with the automobiles power. in many cases it cases corrode he metal parts of the engines and that will lead to more cost of maintenance.

2. The weather effects on biogas production: the optimal temperature that the bacteria needed to digest the waste is around 37c°. that consider in cold climate condition it need a source of heat to continue the production

3. Not suitable for the civilized areas: well known that the biogas production plant industrial scale needs the supply of the raw material such as animal manure waste food etc. those materials are available in rural and suburban areas.

4. Lake of technological upgrade: means that the process and technology that used to produce the bio gas is not efficient although there are no new technologies yet to simplify to make it plenty and low cost. That leads to scarcely of the large scale of biogas plants additional to that the governments are not willing to invest in thesector. (https://www.homebiogas.com/Blog/141/Advantages_and_Disadvantages_of_Biogas, 2019).

1.3 Problem Statement:

Energy is a vital manor and condition for the developing process it's a catalyst for economy of the country. As well known the lack of energy; and when we said energy, we mean affordable efficient sources of it makes major numbers of nation suffering from misery in the developing word. More than two billion people can't access to renewable safe and clean sources of power. The shortage of energy is the main bones to expansion. all most the majority of the unindustrialized nation state have deficient

Generation capacity high energy tariff and nil energy substructure and off course unreliable stream. as a result of all that the community start using LPG firewood for cooking and kerosene for lighting diesel for electrical engines. These dynamisms have a huge negative impact on the environment. For instance, two million die yearly from using the firewood in cooking its clearly because the smoke and soot. Plush eye diseases and the rick of gets burns.

However, using the wood as a daily rate bring deforestation in many areas especially when the gathering of the wood being exhaustive. In our point of view for replace the firewood by the biogas which is shaped from the animal and food waste will dropping the amount of the biomass and accessibility of the nutrient which according to that will decline the soil fertility and the crops yields so finally the result should be the sparkling energy which can be wind solar hydro and biogas those kind of resources are affordable reliable and environmentally friends (lavinina Warnars, 2014) and through using them we can reduces the greenhouse gases emission as much as we can as figure 1 show depending to the analysis on this manor the biodigesters can mitigate these effects.

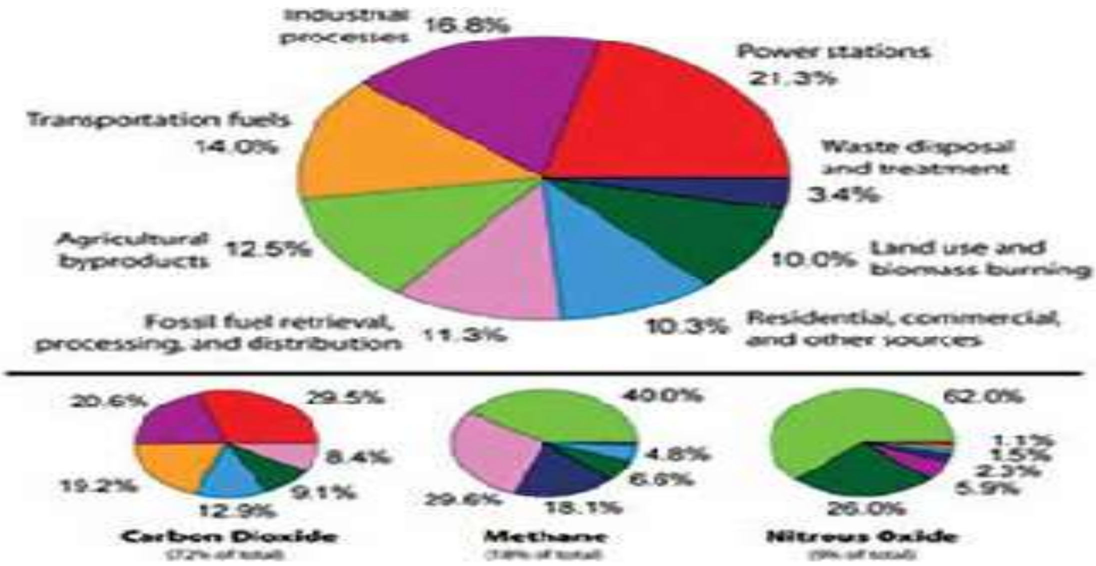

Figure (1.4): Annual Greenhouse Gas Emissions by Sector

Globally energy security is a key factor to achieve the maintainable development goal line. Due to the rapid populace growth increasing growth and unstructured domestication in developing countries there is a large number of disorganized and disseminated by- products. With a high energy demand and the need for waste management within a safe environment have become a main challenge for today's world and tomorrow's world.

1.4 Aim and Objectives:

Objectives:

The main objective of this thesis is to optimize biogas production system from co-digestion of different proportions of by-products.

Specific Objectives:

1. To characterize available biomass feedstock (i.e. cattle manure and food waste).
2. To identify mixing ratios that produce highest biogas volume and methane yield
3. To investigate the effect of temperature and retention time on biogas volume and methane yield.
4. To improve biogas production system from co-digestion of different proportions of by-products.

1.5 scope and limitation:

Produces biogas mainly comprised of methane (60%) and carbon dioxide (35%).

And to consider the Biogas as an energy source, it has the Composition of:

Methane CH_4 (50 – 75) %

Carbon dioxide CO_2 (25 – 45) %

Water vapor, H_2O (2-7) %

Nitrogen, ($N_2 < 2$) %

Oxygen, ($O_2 < 2$) %

As the case maybe require enables the ambient conditions to be adjusted more specifically to the respective bacteria to do the digesting job the main parameters that we need to take it in consideration are PH value it must be at the range between 5.2- 6.3 as minimum and 6.7-7.5 for the supreme value for the other indicators are the temperature value which had better not exceed 25- 60 °C.

As it shown all most all the investigation that had done -up to my knowledge get the data from studies which done on a laboratory experimental scale and we cannot transfer the result on a full scale operation even though the number of the pilot studies on this topic are literally few another thing is the capacity in the current copies very little that is why the transfer of technological to the full scale are really hurdle as well known the role of the bioenergy to replacement the fossil fuel which used to produce the gasoline diesel and the natural gas in the while mean the debate was competing for land and water that should be used for producing food and fiber on the other hand one of the disadvantage of the co- digestion is related to the economic barriers such as collection cost pretreatment and preparing for the subtracts and transportation. to over all those limitation in this study we are going to use the farming byproducts such as straw and hay as good suggestion to avoided the usage of the energy crops then they are available in a plenty amount specially in the rural area and again according to their high living elements .but we need to mention that the pretreatment for the agriculture waste is necessary to break the lignocellulosic construction and to convey the sugar polymers to archives the biogas yields in this study using pretreated agricultural byproducts specific the three types of strew: wheat tuff and derived from Mekelle city cattle market were tested to find out the amount that can obtain from the biogas production using the reactor.

In another view to be able to figure out for the waste food arrangement which is reliant in many elements such as regions culture and habits and the period of the years. etc. To design a facility efficient for the ad and to know the bio-methanization potential of the waste main mechanisms :proteins lipids carbohydrates and cellulose this due to the bio-chemical characteristics of each components (Arsova, 2010) comparing those four once we can say that the highest methane yields have systems with lipids but with the longest rotational time

for the faster type in systems with protein and then after the protein comes the cellulose then consecutively comes the carbohydrates. so according to all that classification of the components we decide to choose a specific type of the food waste and that to void the complexity due to the using such as the cellulose among the mixture.

The question will be: why the food waste instead the manure or the dunk the answer should be: recovering the potential of food waste as a renewable energy source is one of the great challenges of waste management now days and in the coming future days. The statistics showing that every year nearly 1.3 billion tons of food products including fresh vegetables fruits meat bakery and dairy products are lost due to inefficiencies along the food supply chain and the amount will likely increase in the next25 years due to economic and population growths (Konrad Koch, 2015)

CHAPTER 2:

Literature review

Due to the medical progress and increasing the agriculture productivity ;the population of the world is growing exponentially .The global population will reach up to 9 billion due to 2050 it means more than 50%increase since 2007 these people needs to be feeding. As well as the efficiency agricultural lands currently occupy 40% of land surface worldwide and the sector contributes 4%to the global GDP and that already providing around 1.3 billion person as employment the performance of the developing biodigester should take inconsideration the size and to be supported with external source of heat like the reflecting parabolic solar concentration (N, 2016) solar cells or a diesel engine etc.

The search for the suitable co-substrates to achieve the maximum amount of the biogas production the biochemical methane potential bmp has been examined (Marie M. Syndergaard, Iohannis , Adam, & Irini, 2015) one of the renewable sustainable and clean source of energy is the biogas and producing that kind of clean energy can be done by degradation of wastes by naturally microorganism under anaerobic condition (Hanghome, 2014) .

Apart from that the biogas has more advantage in terms of environmental social and economic. The systems are low cost due to the digester can be constructed from available local materials additional benefits is the maintenance cost of the plant are insignificant. the carbon dioxide emission also will be decrease compared with burning the biogas of wood and paraffin that commonly used in rural and informal areas.

Biogas production has resulted in spending time for women to collect the biomass and reduce the amount of smoke from burning. The effect in the biggest cities the result of producing biogas has decrease the landfill and the waste disposal issues sadly 4.3 million people a year die prematurely from illness attributable to the household air pollution caused by the inefficient use of solid fuels for cooking. figure 7 show that the world map of the lap deaths /1000 population

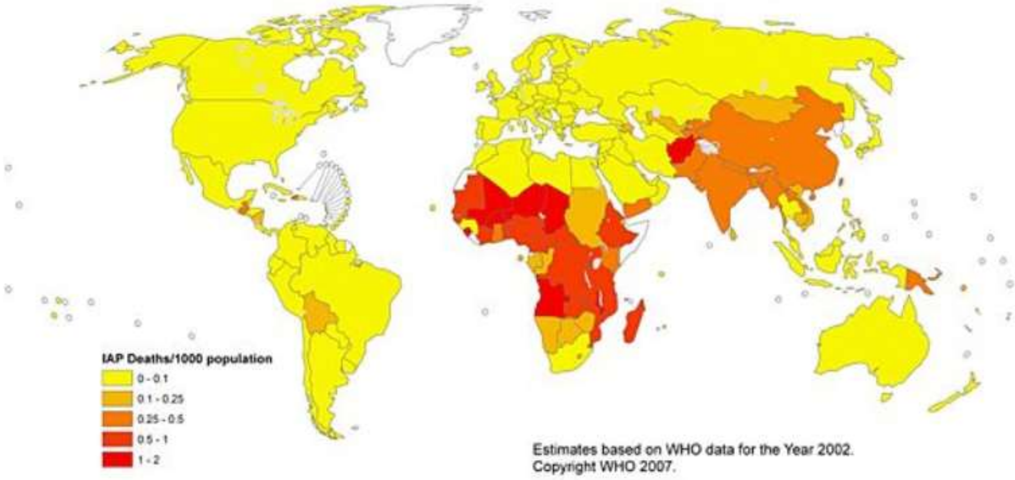

Figure (2.1): the world map of the LAP deaths /1000 population,

What is the anaerobic digestion process?

The co- digestion as short form in AcoD is a way of manage the organic wastes and to generate renewable energy sources concurrently the process is more instability because it is operate under a high organic loading rate (OLR) hydraulic retention time (HRT) sludge retention time (SRT) the temperature and the configuration for the (HRT) note that a risk ratio that may obtain if the over loaded of the organic studies show that the co- digestion of rice husk with the food waste when increasing the ORLS observed alkalinity ratio is increase up to 0.94 from the normal ratio which is equal to 0.15 and that will causes the failure of the process can cause instability and significant decrease the methane production amount. (Sihuang Xie, et al., 2016)

is a process which using the absence of oxygen with presence of anaerobic bacteria in enclosed container while the main substrates could be one of it the organic wastes such as: kitchen waste agricultural waste as in our case Ethiopia animal wastes poultry waste human excreta urban wastes industrial wastes and forest waste.

The AcoD it has a various advantage for example as achieve the balance between C/N ratio and the nutrients. on the other hand a bright aspect of the AcoD resent models which is the capacity of the optimal ratio and the loading organic materials and co-substrates for the superior energy and the economic effectivity (Sihuang Xie, et al., 2016) the future prospective of anaerobic co-digestion technologychallenges productionare input characterization emerging microbialproc esses the availability and biodegradability of feedstock wastes. Using principal analysis.

The co-digestion processes?

It refers to using two or more from the organic materials through digestion the composition of the substrates that are the guide to dominate the successful of the digestion for instance most of the food waste are disintegrate able to biodegrade while other material it take much more time to degradation such as crops and slaughterhouse manure.

The important parameters that we should put in our consideration to select the e kind of co- substrate are higher biodegradable organic fraction to raise the pragmatic of biogas to avoid the PH level the substrate must have a high lightening capacity the other thing that to assure is the balance between the ratio of carbon and nitrogen c:n to keep the activity of producing the gas that ratio should not goes beyond 35% if its exceed the nitrogen will consumed rapidly and the reaction rate will decrease other

what if the ratio be very low ;the nitrogen will be liberated and accumulated in ammonia form and its toxic under some condition so the optimum for the C/N ratio is 30 (lavinina Warnars, 2014)

As mention before substrates which have an optimum C/N ratio only can fulfill the probable nutritional necessity of the microorganisms. thus, while selecting substrates for co-digestion however it is difficult to say precisely what ratio is optimal because the optimum value of C/N ratio.

When the C/N ratio becomes higher or lower from the optimum value it causes the instability failure of the system and reduction of biogas production progresses and challenges of anaerobic co-digestion process: ad technology is the biochemical process of biogas production which can change the complex organic materials into a clean and renewable source of energy. As the applicability demand of the AcoD technology enlargement the complexity of the system becomes increased and the characterization of organic materials becomes volatile which requires advanced methods for investigation.

2.1 Application of The Anaerobic Digestion Around the World:

the anaerobic digestion application has been put into operational worldwide both chain and India having a large scale of Appling the idea on the producing energy from the farms waste manure dunk and agricultural waste the biogas is used for heating cooking and lighting that for the facilities are farm or village-scale

the situation is bit different in Europe for instance they create a commercial plant for treating and separated the organic solid waste from the municipal. in another part from the world in north America the AD plant was spreading in both wastewater treatment plant large farm for manure treatment

lately the sustainable solution for treatment of the organic fraction of the municipal solid waste using the AD plant process the installed ad capacity has increased substantially since 1995. (Arsova, 2010) the total capacity has increased five-fold worldwide from about 2 million metric tons in 1995 to over 11 million by 2008 as we can see in figure 5

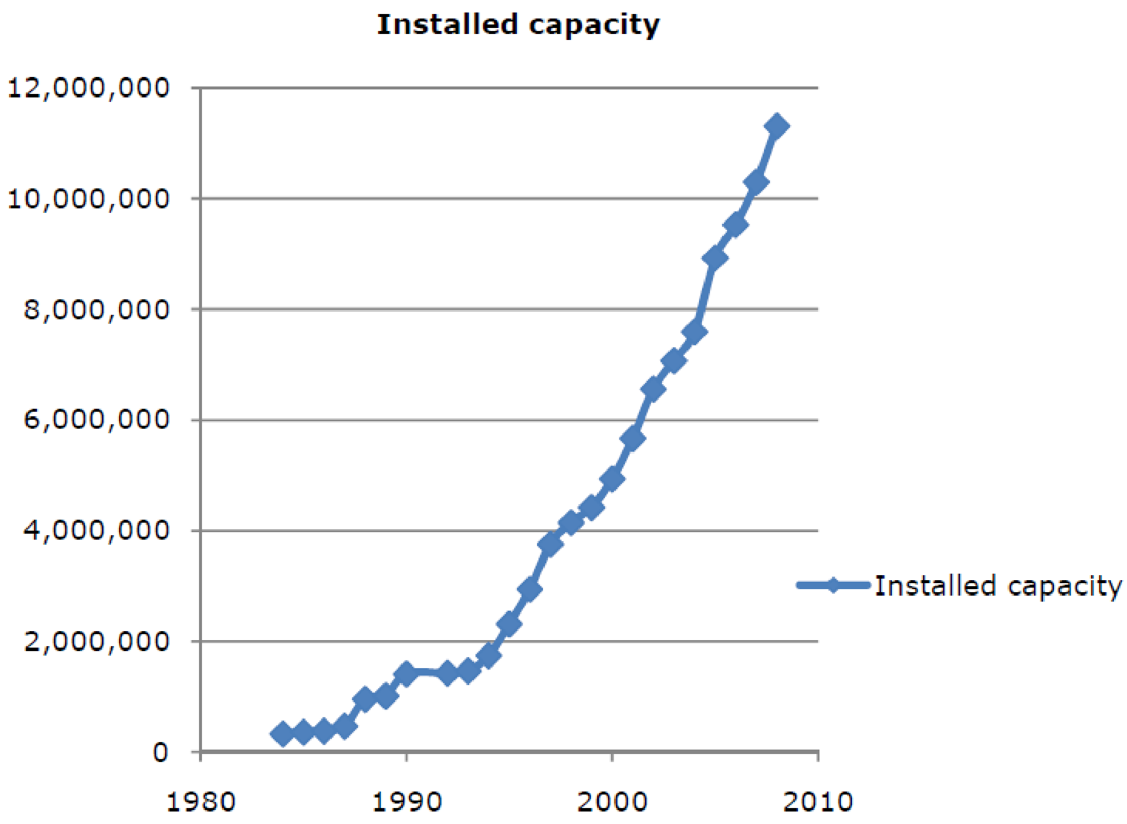

Figure (2.2): Increase of installed global AD capacity.

In this study the reason why we are going to use the AcoD process was because to the overcome the difficulties which are some of them : The direct utilization of substrates is difficult because of their nutritional imbalance, lack on this study the reason why we are going to use the AcoD process was because to the overcome the difficulties which are some of them the direct utilization of substrates is difficult because of their nutritional imbalance lack of diversified microorganisms and the effect of operational factors4. f diversified microorganisms and the effect of operational factors4.

The fact of considering the biogas produced from the waste as a source of energy, date backs to 3000 BC. Alessandro Volta analyzed data on gas from the Como lake in 1776 and the result indicated that, gas explodes if it mixes with air. The deep research after that started in France on the second half of the 19 the century, the main purpose of that studies was to explain the anaerobic fermentation process. The fact of considering the biogas produced from the waste as a source of energy date back to 3000 BC. Alessandro Volta analyzed data on gas from the Como lake in 1776 and the result indicated that gas explodes if it mixes with air. the deep research after that started in France on the second half of the 19 the century the main purpose of that studies was to explain the anaerobic fermentation process.
It wasn't Until1868 that researcher figured out that to convert from ethanol into methane there should be a mixture of microorganisms throw fermentation process, and that process contingent on the substrate. it wasn't until1868 that researcher figured out that to convert from ethanol into methane there should be a mixture of microorganisms throw fermentation process and that process contingent on the substrate (Deublein & steinhauser, 2008)

In the following decade many research studies had been done in terms of biogas production through the digestion process using the by- products as a feed stock. the researchers forecasted the limit of the fossil fuel resources simultaneity with the population expansion. this was done using an advanced simulation approaches and characterization methods of organic wastes which will improve biogas production.

AD technology is the biochemical process of biogas production which can change the complex organic materials into a clean and renewable source of energy. As the applicability demand of the AcoD technology enlarges, the complexity of the system becomes increased, and the characterization of organic materials becomes volatile which requires advanced methods for investigation. oil the wheels still seek further investigations to figure out the solutions and the alternative ad technology is the biochemical process of biogas production which can change the complex organic materials into a clean and renewable source of energy. As the applicability demand of the AcoD technology enlarges the complexity of the system becomes increased and the characterization of organic materials becomes volatile which requires advanced methods for investigation. Oil the wheels still seek further investigations to figure out the solutions and the alternative.(Kiros Hagos, 2017)

The 50-megawatt mw converting waste to energy facility which Ethiopia claims to be the first of its kind in Africa will be commissioned in December. The facility in the Ethiopian capital Addis Ababa is 94.3-percent complete as of July. The project is being built on Ethiopia's largest landfill commonly called kosha meaning dirty in Ethiopia's official working language Amharic lying on 5.3hectares of land. the landfill in recent years has struggled to dispose of the city's increasing waste. opened five decades ago when Addis Ababa was a small city it is currently the main landfill for the city of 4 million plus population. (JIT, 2017).

The project capacity process around 350 000 tons of solid waste annually Ethiopia plans to increase energy production capacity from the current 4 200 mw to about 17 300 mw by 2020 from hydro wind geothermal solar and biomass sources. Ethiopia hopes the series of energy projects it is currently undertaking will meet the demands of its fast-growing economy and a rising population estimated to stand around 100 million currently.

Additional to that the climate change has a huge and clear effect on the agriculture versa the studies shown that direct effects of agriculture about 14% with a direct impact about 17% from biomass burning .indeed climate change and agriculture are interrelated when the global climate change the demand for more food nutrients and meat for the population growth the solution could be in compiling the energy efficient and the agricultural productivity with improving the technology that used.

CHAPTER 3.

METHODES AND MATERIAL

A quick look the lifetime of plate for the biogas production range between 2-20 years and that depend on the materials that used in constriction and indeed the maintenance which should be periodically and the cost of the equipment that used for instance the cost of a biogas plant in Asia been between 350-800 us$ while in Africa the cost will raise to 600-1000 us because of the higher price of laborers and material of building https://www.inc.com/encyclopedia/costs.html

. (lavinina Warnars, 2014)

3.1 Methodology:

previously mention the two type of row material going to use agricultural waste and the food waste the methodology that we will consider it is using the two different volume from the row material putting in the reactor to reach the 100%. the round will be 60% from the strew vs 40% from the food waste then the second round will be 60% food waste from the vs 40% from the strew this ratio up of the both rounds will consider the slurry and the KOH that will be added. and making the experiment according to this and compare the both result which rounds give more gas and the advantage and dis advantage of each. The first step of preparing the row material agriculture waste strew is drying bring the strew and putting in the oven as figure 2 shown the construction on the oven.

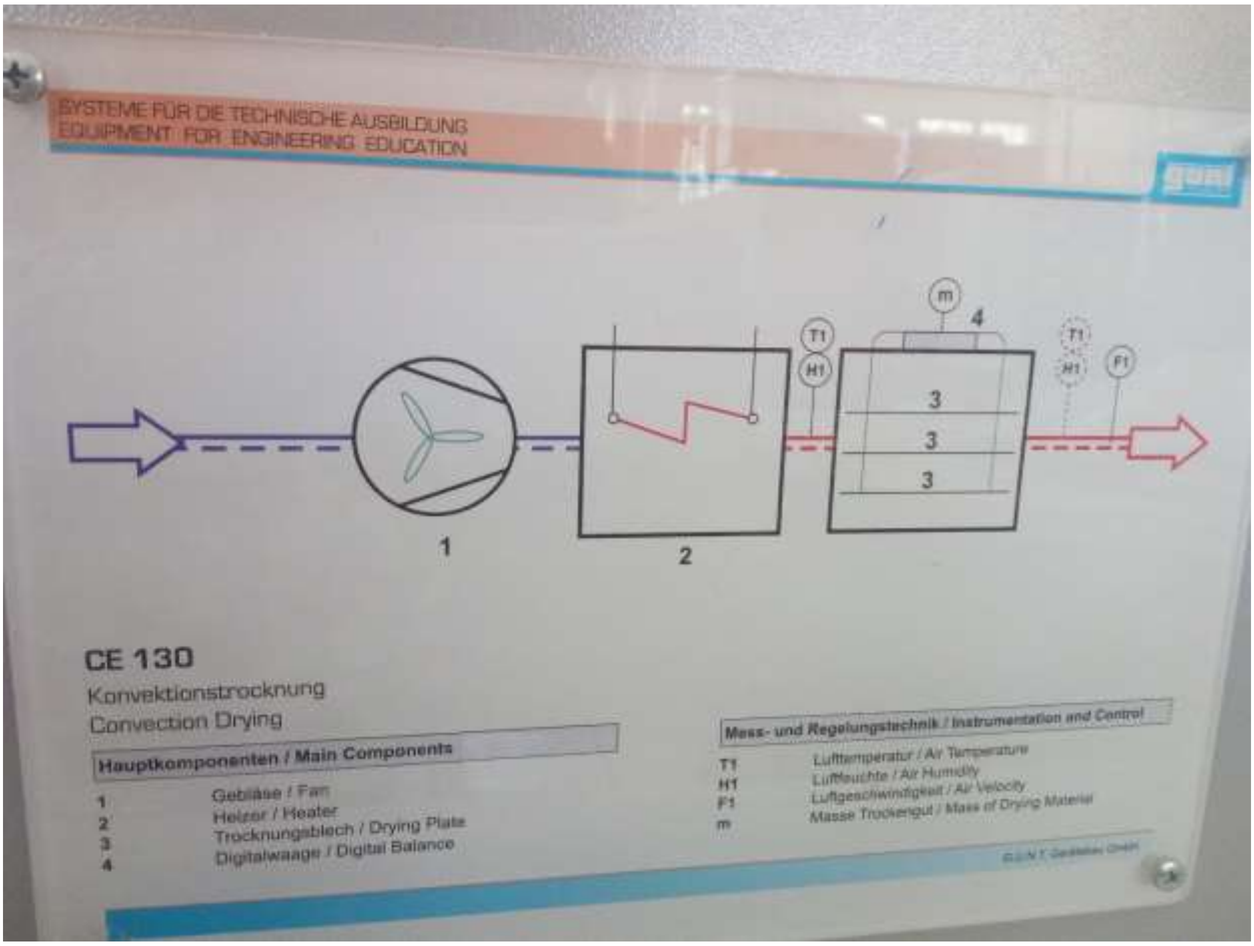

Figure (3.1): the constriction of the drying oven.

Figure (3.2): the strew in oven to dry.

At the end of that stage, now had a dry strew and could be crashed and smashes, and it will affect the reactor process and make it faster. The next step for the time being of preparing the other row material which are the food waste – in specific -the chicken and fish waste.

The Figure (3.3) below shown all the raw materials after preparation them, which are: food waste, strew and the slurry, After ingredients arrangement, our materials become ready to use and been putting in the reactor to start the biogas experiment.

Figure (3.3): the ingredient after get ready

3.2 Gathering the Raw Materials / Waste and Preparation Process:

Feed Stock: The mixture of the dung and maze to produce biogas can produced from most biomass and waste materials, nevertheless it depending on their configuration and a large range of moisture contents, although very high moisture content material of under 5 dry matter reduces biogas yield with limited feedstock preparation.

The biomass with a woody based are not suitable intended for anaerobic biogas production owing to its high lignin content. However, wood container converted for methane by the thermal gasification process. Products from that process is usually referred to as synthetic natural gas or sync.

Organic fraction in landfills by extracting then dealing out the land-fill gas by removal water also possibly hydrogen sulphide, so it can be used for energy purposes usually as fuel engine driven generators, landfill gas utilization reduces the greenhouse gas released, the agricultural and forestry creation are based from the biomass residues and adversary.

Many types from the biomass are available; such as:

- The trees part that remained after removing the round wood and wood fuel as industrial part.
- After collecting the crops, the remain parts in the felid of the maize Stover, wheat strew and cassava stalk etc.
- The manure and the mixture of bedding resources from the animal’s farms residues.
- After agriculture course and the agri-food process plants; the reminds parts it includes bark sawmill dust, cuttings and also includes rice husk sugarcane bagasse etc.
- Carbon-based fraction of municipal waste which is coming as of biodegradable left-over.

As we know Africa has been situated with varieties properties of wood, for instance: the northern Africa section consumes 40% of the wood residue and waste reserve, while the central region has the lowest wood residue potential.(LAHOUCINE, 2017)

In nearly studies, they use manures lush, so it's about the outstanding semi-solid substantial left after wastewater handling, it can be a secondhand as a feedstock meant for biogas plants. the residues from assimilation can be used as soil conditioner.

For the dung which been used wildly, it shaped by intensively housed cattle in some countries is stored on farms for several months in liquid or solid form and then used as fertilizer. Through storing process, the anaerobic digestion can take place in the bottom layers from manure producing methane. That might be released to the atmosphere if it were not used for energy or flared. In developing countries manure is often used in small family-scale anaerobic digesters and the gas is mostly used for cooking with other applications being domestic lighting or running spark ignition engines.

Dynamism gathers in the context of biogas manufacture are agricultural vegetations grown specifically for feedstock in biogas plants, blending manure with liveliness crops or other waste streams for anaerobic digestion is an attractive option to rise biogas production. Typical energy crops in Europe and north America are maize. Sweet sorghum; sugar beet is also gaining importance in northern Europe, the mix of manure by maize breaks a common feedstock meant to arranged biogas plants on farms. There also agricultural waste that can be castoff as a feed stocks, for biogas can be catch crops that are planted after the harvest of the main crop they allow a second harvest on the same piece of land within one year. Another option can be the ley crops planted on land resting between commercial crop cycles also have some potential and are already used in some places.

Also, green cuttings and other fresh leafy materials coming from the conservation of the countryside such as beginning trimming of tree as bushes and grass can be used for biogas plants feed as well. For our case study we are trying to use the food waste from kitchen like chicken and fish mixed with the cultivation waste such as straw or hay. We will consider the straw and for the process of collecting out

of collecting out feed stock from the pretreatment is usually big part of the ad plant and is necessary in order to clean up the feedstock to the required level as well as to separate as much as possible recyclable materials.

3.3 experimentation procedures:

The 4 phases of the degradation take place in one reactor regarding the PH value and temperature needs to be found. In this study for biogas yield two-stage process in two separate reactors is practical as this enables the ambient conditions to be adjusted more specifically to the respective bacteria. Intended for the chemical compositions, the substrates determent from sources that this row materials come from: if its agricultural farming based or food and industrial wastes or animal manure. The main composition for the organic materials and its effect our gas construction is; lipid carbohydrates also proteins They can remined easily within process stages: the hydrolysis stage, acidogenesis stage, acetogenesis stage and methanogenesis stage. The key for the gas and methane manufacturing are the different organic material that ingredient will convert into gas.

- phase 1: hydrolysis:

The substrate used in biogas plants is available as dissolved high-molecular mixes such as proteins adipose tissue and carbohydrates. Therefore, these compounds first have to be cracked down into their individual components by enzymes cellulase amylase protease and lipase that are excreted by bacteria found in substrata to break down long chains. for examples polysaccharides are smashed into monosaccharide proteins changes to peptides and amino acids; fats into fatty acids. (Ejigu, 2010)hydrolysis products are amino acids sugars and fatty acids. In co-digestion process it is important to consider separate hydrolysis rates for each particulate component from each substrate because the hydrolysis rates are varying significantly. Mixing the carbon-rich substrates with nitrogen rich by-products like animal manure and kitchen wastes can improve the process stability, the nutrient required for microbial to achieve the balance of nutrient contents especially the low carbon to nitrogen ratio which decreases the microorganism activity. (Steinhauser, biogas from waste and - renewable resources).

https://www.msdmanuals.com/home/disorders-of-nutrition/overview-of-nutrition/carbohydrates,-proteins,-and-fats

- phase 2: acidification:

The hydrolysis products are biochemically decomposed further primarily into propionic acid butyric acid, acetic acid CH_3COOH alcohols hydrogenH2 and carbon dioxide CO_2.Involving due to the second step these microbes are facultative anaerobes that can grow under acid conditions.They use the oxygen which melted in in the wet mixing of the feed stock and the water,

those bacteria reduce the complex with low weight into: alcohols organic acids, amino acids, carbon dioxide, hydrogen-sulphide and small amount of methane.

- phase 3: formation of acetic acid:

The products designed from the previous phase now converted addicted to: acetic acid, hydrogen and carbon dioxide we are going to use caustic soda32g of NAOH, and hydrochloric acid 10g.

- phase 4: formation of methane:

methanogens can either use acetic acid CH_3COOH or carbon dioxide with hydrogen for their metabolism. Methane CH4 can be produced in the following two reactions:

CH_3COOH -----------$CH_4 + CO_2$

$4H_2 + CO_2$----------- $CH_4 + 2H_2O$ Use of biogas

Methane and acids production bacteria act in symbiotic way. in one hand; acids assembly bacteria make the ideal surrounding for methane production. On the other hands the micro- organisms use intermediate compounds produced by the bacteria. The bio gas can now be burning in a collective heat and power plant for many purpose such as cuisine, lighting and even electrical generators by way of a clean source As it's a mixture of many gasses which they can be helpful in terms of energy; here Table(3.1) shown the quantity of different gases that may found in bio gas:

Table (3.1): different percentage of gases in biogas

Gas	**Chemical formula**	**Volume (%)**
Methane	CH_4	40-70
Carbon dioxide	CO_2	30-60
Hydrogen	H_2	5-10
Nitrogen	N_2	1-2
Hydrogen sulphide	H_2S	0-3
Water	H_2O	0.3

source:(Ejigu, 2010)

During the course of absorption around of 30-40 %from the dry material inside reactor tern to bio fume, and for the remind 70-60 from the solid content comes out in the effluent as a bio slurry.

The first tank reactor is the substrate tank, which someplace the feed stock must be stolen after preparation; this tank has pump with a controlled rate. By adding caustic and acid to control PH level of the biomass in the upper section of reactor.

Water jacket: corroborate the temperature level inside the reactor and it still around the reactor. Pump at the bottom of the first reactor to transfer the materials from the first stage reactor to the second stage reactor.

Water tank: separate tank to provide heated water and there is thrust install to brings the hot water to the water jackets for the experiment we need about 20 litter water supply second stage reactor: Bio gas processed by the first stage is delivered to the second reactor with the help of pump as the same steps and process that apply in stage one it will be repeated with the same equipment. To transmit the biomass; pump is connected at the bottom of the reactor 2 which delivers the biomass from second stage reactor to digestate tank.

When the biogas starts producing from the reactor it needs to be drying, for that purpose it enters a tank fill with silica gel, from the bottom to the top. to determine the parameters: for PH level are measured by of PH meter, volumetric flow rate with the flow meter, methane concentration, carbon dioxide content, and for temperature will use temperature indicator.

Control panel as in Figure (3.1) and Figure (3.2) consists of various switches and display meters for these parameters:CO2 display meter, Methane display meter, Humidity meter, Feed pump display 1 Feed pump display 2, Feed pump display 3, Temperature controller, Temp. Indicator display with multichannel switch and Stirrer ON/OFF switches for substrate tank, Reactor 1, Reactor 2. ON/OFF switches for metering pump 1, 2, ON/OFF switches for Hot water pump and heater, Mains Indicator and ON/OFF switch CONTROL PANEL:

Figure (3.4): Control panel

Figure (3.5): Control panel

3.4 Starting Procedure:

To maintain the temperature of the mixture; we been used hot water tank to provided heater attached inside, and controller is also given to control the water temperature. the suitable temperature depends on the stage. After we check the condition of the inlet, we started the stirrer and mix up the mixture again.to control the PH level of it; start adding caustic soda sodium hydroxides in main time slurry is hydrolyzed and acidified in the first stirred tank reactor.

The anaerobic microorganisms convert the long-chain organic substances into short-chain organic substances. again, the PH level should not be exceeding the range of 5.2- 6.3 after this stage we kept the mixture in reactor for 9-10 days. the temperature of the reactor by supplying hot water in the water jacket of reactor2 which is 50C. control the PH level between 6.7- 7.5 in the reactor 2 by adding caustic soda and kept the slurry in the reactor 2 for about 14 days. In the last step of the anaerobic degradation the biogas forms in the second stirred tank. it contains mainly methane and carbon dioxide then after passed through the drying column. we checked the humidity flow rate temperature and the CO_2 content are measured. For the second reactor the waste is delivered to digestate tank with the pump.

3.5 Experimental:

After collected the raw material from around Mekelle city, those raw materials are: Food waste, strew and slurry. The amount from each are equal to3Kg, 3Kg and 3liter respectively. the following step was to get them ready for the reactor process; by crash the strew manually and sieve using Analytical sieve shaker with a diameter of 710Mm; for the purpose of the easy transport. Additionally, for the collected waste food (fish and chicken) will be dry it in conventional drying for about 12 hours with 75C° due to the easy crashing. Then crashing the meet using a mortar grinder for the purpose of easy to hydrolysis and transport by house. After prepared all the materials, add them together in the mixer, and before mixed them; the PH value for the slurry was 4.5 registered.

In order to adjust the PH value in the reactor we will going to add HCL to become more basic; inverse of that in other case we will add NAOH to become more acidic. Notes that 75% from the mixture must ne water.

The mixing process will take about 1 hours, after that we meagered the PH and it was 3.35.

The normal PH value should be in range of 6.5-7, so to adjust that ratio; from previous management it was 3.35 that means more acid, to make the environment balance for the anaerobic bacteria in the reactor; added NAOH; with amount of 0.1mole/liter. which means 4g for 1 litter.

Eventually we add 8grams from the chemical material NAOH to retch the nutrient PH, which is 7.8k

Generally, we use 32g of NAOH; which means in 8litter of water, because of the high concentration of the: slurry, strew and the waste meat.

While the reactor is working the PH value may change according to the bacteria and the chemical reaction, and that what happen in our case, the PH indicator to

switch off the equipment after shifting the slurry from one reactor to other after we finished the experiment and we get our result performed we washed the equipment then fill the substrate tank completely with water and pass this water to various reactors by the action of pump.

CHAPTER 4.

RESULTS AND DISCUSSION

This chapter will deliver the main result and the discussion that get to it though the experimental experience, which take place during 30 days, the aimed was to produce the biogas and measure the amount and the various effects on the process .the mixture of the food waste with agricultural waste avoid the problems of using animal manure due to the nutrient stability resulting in the produced gas and the yield of methane.

Table (4.1): Sample data during biogas production for only final 13 days

Experiment date	PH Meter	CO_2 display in %	CH_4 display in %	Humidity in %	Temperature Indicator in ºC	Temperature Control in ºC
July,18	5.2	85	11	62.1	25	25
July,19	5.4	90	13	60.9	26.8	27
July,20	5.6	88	20	65.2	28.3	29
July,21	6.2	89	37	70	32.8	34
July,22	7.5	88.76	40	64.5	44.9	45
July,23	7.5	77.8	45	60.4	44.8	45
July,24	7.4	65	58	60.2	44.5	45
July,25	6.5	58	60	62.2	44.8	45
July,26	7.3	46	55	63.1	44.9	45
July,27	6.96	40	48	62.1	45	45
July,28	7.23	39.8	54	63.2	44.95	45
July,29	7.26	35.9	65	67.8	44.96	45
July,30	7.5	35	65	70.6	44.98	45

Effect of stirrer and temperature on biogas production:

1. increasing temperature from lower point to higher point can decrease the production of biogas. because the bacteria can be denatured due to the effect of temperature it should increase slowly and constant to give desired product.

2. increasing the stirrer for long period of time during process will increase the hydrolysis process but the methane content reading in the cabinet board become decrease due to the gas is no floating above the reactor.

3. combined effect of temperature and stirrer must be arranged in suitable condition to get the maximum biogas. that is increasing temperature and increasing

the stirrer will become slow methane display. In addition to that increasing the stirrer for long period of time and decrease temperature the methane content will gradually increase. Finally operate the stirrer for short period of time less than 30 minute and increase temperature until 60C the methane become increase.

According to the duration of experiment that spend on it, it shown that the amount of methane is increase depending on the time that the ingredient twill spends on the digester.

There are factors affecting during biogas production those are:

- Temperature
- Substrate
- Volumetric loading (amount of mixture proportion)
- PH value

During production of methane the equipment's used are:

- ✓ Conventional dryer to dry waste food from fish meet
- ✓ Mortal grinder to crush the dried waste food
- ✓ Analytical sieve shaker to separate size of straw and the crushed waste food for easy transport in pipes.

The variation of temperature is due to stirrer, condition and capacity of heater whereas the PH value variation due to reacting the mixture and effect of stirrer.

Finally, the research fit the aim according to the literature say because:

- Methane reach 65 as literature say 50-75 in %
- Carbon dioxide reach 35 literature say 25-45 in %

The first four days represents sample for hydrolysis and acidification phases. In this phase the PH value must be in between 5.2-6.3 whereas the PH value for the next nine days for the formation of acetic acid and formation of methane phases it must be in between 6.7-7.5 with respect temperature in range 25-35 C̊ for first phases and 35-60 C̊ for second phases but for the final phases the temperature was set 45 C̊ Theoretically:

$$CH_3COOH \rightarrow CH_4 + CO_2$$
$$4H2 + CO_2 \rightarrow CH_4 + 2H_2O,$$

4.1 CONCLUSIONS AND RECOMMENDATION

The potential of the varies feed stoke that may be used in the process of manufacturing the biogas is really appreciated .to improv the creation of the biogas including the food wastes with the co-digestion mention in this study.

As recommended for the further studies to make a research within changing the PH vale at the ending point to figure out the effect of the parameters on the digestion process.

Additional to that a high treatment equipment and methodological lab tools are necessity for pretreat the feed stock such as the stew and the waste meat, due the make the process easier and avoid terminating the digester.

Finally, in the future and as additional way to the waste management, as suggestion to use the outside skin and crust from corns and fruits that people throw them in the road to investigate in the biogas creation.

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