Review on Environmental effect of Biogas production: Solution to Greenhouse gas problem

ABSTRACT: In the study of environmental effect of biogas production, it is essential to identify the main constituents the biogas consist of with a special equilibrium system of whatever their qualities, quantities and properties, to become more suitable to environment and human activities, furthermore questions related to the final disposal and management of wastes leads to a serious environmental concerns, a smaller amount of the wastes are effectively handled in areas of recycling, treatment and disposal, most wastes generated are mainly dumped openly in the environment causing greenhouse gas release into the environment and this is not environmentally friendly. Although these wastes offer abundant resources, large proportions of the wastes are biodegradable materials and can be efficiently used in producing biogas, which can serve as ananswer to greenhouse gas problem but also inappropriatecontrolling of the wastes will lead to rise of greenhouse gas in the environment.

Keywords*:Biogas; Environment; Waste; Greenhouse gas*

1. Introduction

1.1. Origin and formation of Biogas

Biogas production from organic waste dates back to 3000 years ago [1]. Facts has been developed, which shows the usage of biogas in both Assyria in 10th century and Persia in 16th century. Although, acceptance of organic waste as basis of renewable energy was achieved in 1808 by Davy, who recorded themethane production during the breakdown of live stocks manure. The first physicaluse of biogas for energy creation occur in 1896 in England when biogas formed from digestion of sewage sludge was used to fuel street lights. Same as most other renewable energy, interests in anaerobic digestion suffered with the rise in reliance on petroleum. Nevertheless some developing countries, mostly Asia, embraced the technology for the small scale generation of energy and sanitation services [2]. Since that time, there has been considerable interest in anaerobic digestion to achieve its waste removal and energy generatingabilities[3].

Biogas is formed in three main stages; hydrolysis, acidification and methanogenesis. The first stage of biogas formation is called hydrolysis which is known as the polymer breakdown stage. The second stage is known as the process of acidification where the acid producing bacteria change the monomers formed in the first stage to different fermentation products, mostly acids. In the second step of this stage, called acetogenesis, the fermentation products will be changed to acetic acid, which is one of the substrate for the formation methane. In third stage, methane-producing bacteria utilize acetate, carbon dioxide and hydrogen to form methane and carbon dioxide. Biogas is becoming a gradually general product generated from the recycling, treatment and management of agriculture, domestic and municipal waste. The process involve in biogas production is anaerobic digestion and it allows organic waste including sewage sludge, manure, and landfill

organics to be converted into usable products such as biogas, fertilizer e.t.c. Howeverin utilizing these resources, there must be an understanding of the environmental concernsrelated with several anaerobic digestion technologies.

Anaerobic digestion refer to the degradation of organic matter in the absence of oxygen into a methane rich gas through the complex and synergistic relations of various micro-organisms including hydrolysis, fermentation, acidogenesis, and methanogenesis bacteria [3, 4]. The first set of microorganism produces enzymes, which hydrolyses polysaccharides and proteins in the organic matter to monomers such as glucose and amino acids. The fermentative bacteria change the monomers produced during hydrolysis to organic acids, mostly acetic acid. The acidogenic bacteria change the acids to hydrogen, carbon dioxide, and acetate, which the methanogens utilize to produce methane and carbon dioxide [3, 5].

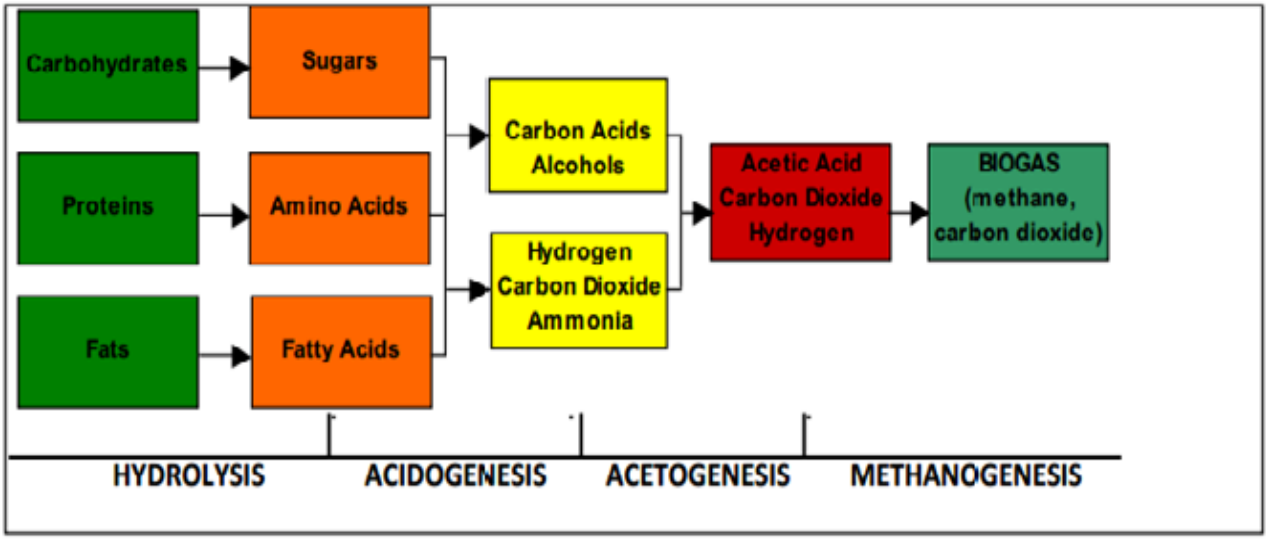

Figure 1.A typical Anaerobic Digestion Process [6].

1.2 The role of renewable energy: Biogas technology (Anaerobic Digestion)

Improvement of renewable energy technologies, particularly biogas technology can help lessen reliance on non-renewable resources and curtail the social and environmental degradation problems related with fossil fuel [7].

Renewable energy makes available the much desired sustainable rural regeneration in many countries that are still developing. It is a perfect substitute due to its less expensive option for low income communities. An ideal renewable energy is one which is locally accessible, cheap and can be easily managed by local communities. Anaerobic digestion offers the practical option of producing modern energy resources utilizing readily available materials such as cow dung, domestic, municipal and agricultural wastes. Anaerobic digestion of huge amounts of municipal and agricultural waste in Africa can produces biogas that can be used for electricity generation and the

digestate can be recycled as organic fertilizer. Anaerobic digestion systems are moderately simple and cost effective[8].

1.3 Composition and application of biogas

Biogas consists of a mix of methane (40-70 vol %), carbon dioxide (30-60 vol %) and trace components (1-5 vol %) like hydrogen (0-1 vol %) and hydrogen sulphide (0-3 vol %). The pressure, temperature, moisture content and the composition of raw materials are determinants of the characteristic properties of biogas [9].

1.3.1. Methane

Methane (CH_4) gas contains one carbon and four hydrogen atoms and is the essentialcomponent of biogas. Methane is an odourless and colourlessgas that is generated over a period of thousands or millions years ago. Putrefied plant and animal matter trapped deep underneath bedrock is changed into petroleum products by extreme pressure and heat. Without the presence of oxygen, methanogenic bacteria are accountable for converting organic materials into methane, the similarto the process that occur in anaerobic digestion. Anaerobic digestion process yields between 50-60% CH_4 for dairy manure wastes [10]. The higher the content of methane in biogas, the higher the heat content.

1.3.2. Carbon Dioxide

Carbon dioxide is a gas comprising of one carbon and two oxygen atoms. Like methane, it is both odorless and colorless. Carbon dioxide is produced by the combustion of organic matter in the presence of oxygen or by microbial fermentation and plant respiration. In biogas, Carbon dioxide is produced when methanogenic bacteria degrade simple organic compounds through the fermentation process. The two main components of biogas are methane and Carbon dioxide. High amounts of Carbon dioxide suggest poor methane content and therefore a lower energy value.

1.3.3. Trace Components

The trace components make up about 2% or less of the biogas. The common trace components of anaerobically digested biogas include hydrogen, hydrogen sulfide (H_2S), and water vapour. Based on biogas use, it is important to ensure the removal of most trace components from the biogas. Presence of water vapor in biogas most is hazardous because it is highly corrosive when combined with acidic components such as hydrogen sulfide (H_2S) and to a lesser extent, when reacted with carbon dioxide (CO_2). The major contaminant in biogas is H_2S, which is poisonous, corrosive and can cause damage such as corrosion to piping and equipment. In combustion, H_2S in the gas is also released as sulphur dioxide, causing pollution to the atmosphere. During anaerobic digestion, biogas containing more than 6% H_2S can limitmethanogenesis [11]. A wide range of application is common forbiogas, like other fuel gas for use in the household and industry. Some common applications include gas cookers, engines, incubators, and biogas lamps [9].

2. Green-house Gas and Effects

Green-house Gases refers to some particular gases present in the atmospheric layer which trap the heat that is attempting to escape back into space [12].The four main green-house gases, which cause adverse

concern, are carbon dioxide, Methane, nitrous oxide and chlorofluorocarbons. Among these, carbon dioxide is the most vital green-house gas, ozone and sulphur dioxide alsocauses global warming. Hence, if there is increase in the amount of these gases in the atmospheric layer, it is expected that large quantities of heat emitted by the surface of the earth will get trapped within the atmospheric layer. The green-house effect can therefore be defined as the progressive warming up of the earth's surface due to blanketing effect of some gases[13].

Generally human beings are accountable for what is happening to the earth. Green-house Gases production is basically due to fossil fuel burning such as petroleum, coal e.t.c and this has speed up the Green-house Effect process which occurs naturally and therefore is known as Man-Made Green-house Effect.Also, fossil fuels burning elevate the level of carbon dioxide, causing about 76% of all the green-house gases in the atmosphere. Methane gas is present in about 13% of the green-house gases in the atmosphere, ton of about 500 tons of methane annually is added to the air through mining of coal, oil drilling and landfill emissions. Most green-house gases stay in the atmosphere for a very long time, howevermethane stays for only 10 years and it traps heat 20 times more than carbon dioxide, methane is both a likely alternate energy source and a strong green-house gas.

Nitrous oxide concentration in the atmosphere is at the increase of 0.2 to 0.3% annually, causes of this increase include land use conversion, biomass burning, combustion of fossil fuel, and soil fertilization, likewise the using nitrates and ammonium fertilizers to enrich plant growth is another cause of nitrous oxide. Nitrous oxide makes up approximately 6% of the green-house gases in the atmosphere[13].According to Thomas *et al.*,[14] the increase of the greenhouse gases causes a rise in temperature of the earth.

2.1. Types of Green House Gases

The most abundant greenhouse gas in earth's atmosphere includes: Methane (CH_4), Carbon dioxide (CO_2), Nitrous oxide (N_20), Chlorofluorocarbons (CFCs) and Ozone (O_3).

2.2. Emission of Green House Gases

2.2.1. CH_4 emissions

Methane emission arises from the degradation of organic wastes in agriculture, municipal solid waste, landfills and the raising of livestock. Methane emissions from livestock keeping were evaluated with respect to animal type, performance and feeding.

2.2.2. N_2O emission

N_2O emissions are assessed during agriculture and industrial activities, as well as during waste and fossil fuels burning. It was expected, although very simplified, that 1.25% nitrogen supplied to the soils by organic and mineral fertilization, N_2 fixation and N deposition is emitted in N_20–N form. Otherwise, a N_20–N emission factor of 2.53% of the overall N input as obtained in several measurements at the experimental farm was applied.

2.2.3. CO_2 emission

Carbon dioxide arises in the atmosphere through the burning of fossil fuels, solid waste, trees and wood products, and also as a result of some chemical

reactions, for example manufacture of cement. Removing carbon dioxide from the atmosphere is achieved when plants absorbed it as part of biological carbon cycle.

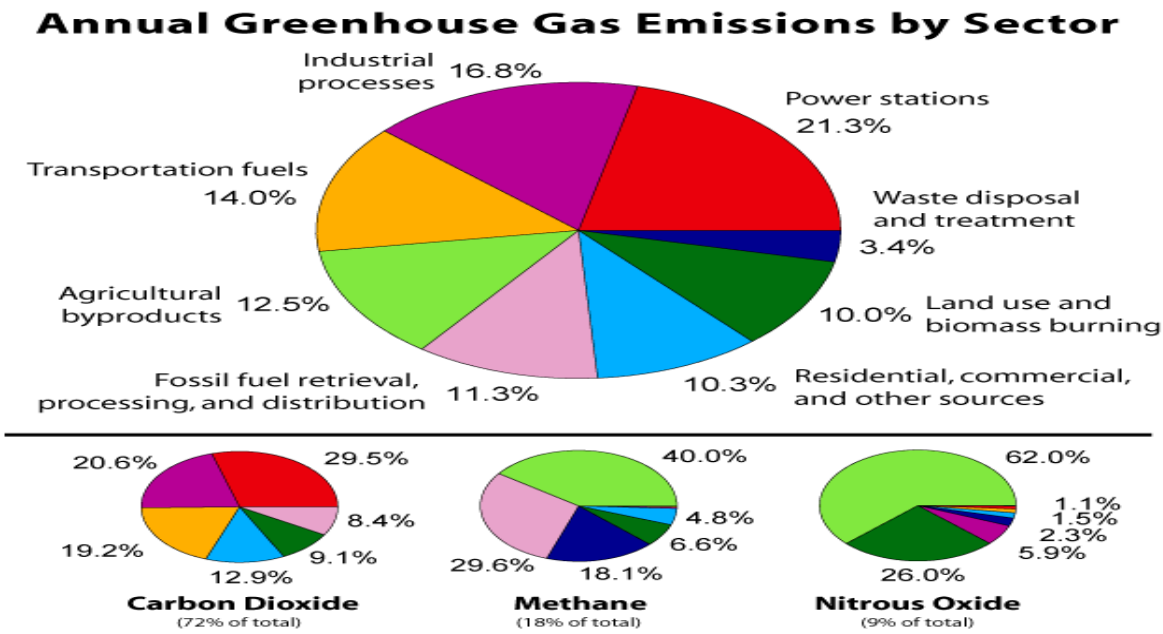

Figure 2. Emission of greenhouse gases [15].

2.3. Causes of Green-House Effect:

2.3.1. Deforestation

Deforestation is one of the man-made sources of the Greenhouse effect, It increases the extent of carbon dioxide in the atmosphere. Likewise, as a result of cutting down of trees, photosynthesis cannot occur. Deforestation is widespread today due to increase in human population. There has been rise in the levels of deforestation by about nine 9% in recent years. Similarly, wood burning causes it to decay,and this allow for the release of carbon dioxide into the atmosphere.

2.3.2. Industrial Emission

Burning of fossil fuels, coal and gas to run the factories has led to the hazardous rise of carbon dioxide and methane which has a radical impact on greenhouse effect and also contributes to global warming. With this, industries can act as a main cause of the Green-house Effect. Manufacturing of goods also leads to rise in the amount of green-house gases.

2.3.3. Electrical Emission

Emission of gases from electrical appliances is another man-made cause of Green-house effect. Refrigerator in the house releases greenhouse gas.

This gas is known as chlorofluorocarbons (CFCs) and it contribute to the green-house effect.

2.3.4. Fuel Burning

Furtherman made processes that contribute to Greenhouse effect are burning of gasoline, oil and coal. Apart from these, some farming practices are also cause of Greenhouse effect. Likewise, Emissions from automobiles increase the amount of carbon dioxide in the environment,similarlyareother gases like carbon monoxide and sulphur dioxide emitted from vehicle exhaust pipes. These gases contribute

towards pollution of air, which causes addition of green-house gases in the atmosphere.

2.3.5. Population

Population growth is an indirect contributor of the Greenhouse effect. As the population increases, the needs and wants of the people increases. Hence, this increases the manufacturing processes together with industrial processes, this result in the increase of the release of industrial gases which catalyzed the greenhouse effect. Also rise in agricultural practices is due to increased population.

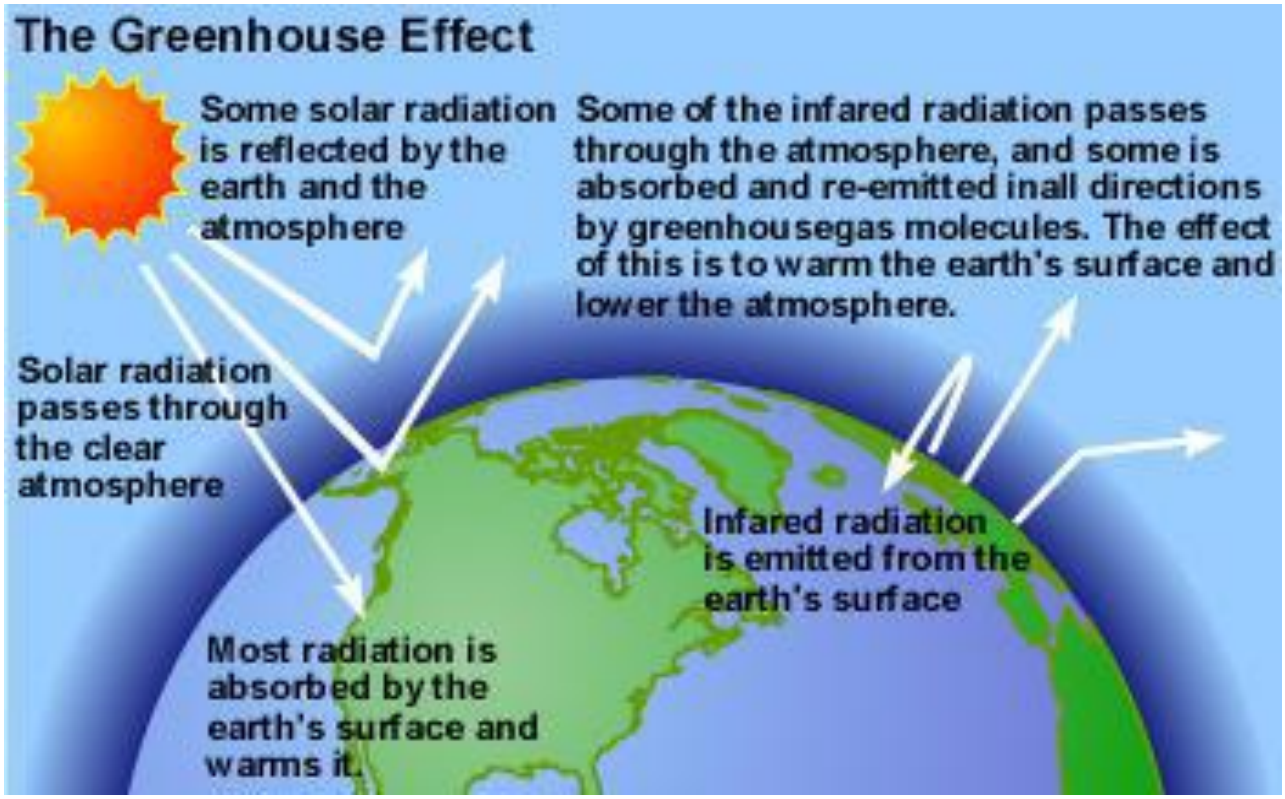

Figure 3.The Greenhouse Effect [15].

3. ENVIRONMENTAL IMPACTS ASSESSMENT OF BIOGAS

3.1. Review on environmental impact of biogas

The demand of energy must be managed to cope with both energy and environmental problems as well. The energy production from renewable sources is one of the main issues to reduce environmental damage and greenhouse gases emissions [16].The use of biogas as source of fuel is eco-friendly because it contributes to a reduction of fossil fuel use and mitigates the greenhouse effect. In particular, the emissions of CH_4, one of the two greenhouse gases emitted, which is almost 21 times more dangerous than carbon dioxide for the greenhouse effect [17].

With the use of biogas instead of fossil fuel, emissions of CO_2 and other green-house gases is declined, as a result, the green-house gases emission decreases 75% with the using of biogas in houses and cars. Methaneis an important component of biogas and reducing loss of methane from biogas system will decreases green-house gas emission.

Eryasar, [18] reported that if organic matters are not used in the production of biogas, they become pathogenic and harmful to humans and the environment, biogas system provides considerable reduction of environmental pollution that arises due to those waste.

Biogas systems have two important impacts in terms of green-house gas effect. First of all, biogas reduces methane emissions that occur during storage of animal waste, Secondly, conversion of biogas reduces carbon dioxide emissions that will be caused by fossil fuels.

Yilmaz, [19] analysis shows that if biogas is used for the purpose of heating as a substitute of fossil fuel, emissions of green-house gas decrease around 75-90%, if it is used instead of combined heat and power, emissions of green-house gas decrease around 60-90%. If it is used as an alternative of gasoline and diesel for vehicles, emissions of green-house gas decrease around 50-85%.

3.2. Potential impacts of biogas on the environment

According to Eryasar, [18] potential impacts of biogas can be grouped under four categories as follows;

3.2.1. Fertilizer related impacts

Digestate of anaerobic digestion can be used as organic fertilizer. Nitrogen which is found in the digestate is mainly in ammonium form. And ammonium form is more appropriate for the development of plants, thus use of commercial fertilizers is reduced.

3.2.2. Health related impacts

People who live in the rural areas use woods and plant waste for burning and these causes variety of respiratory diseases, use of biogas eradicates these problems. In addition, flies which live on waste, and diseases threaten the health of people living in this area. Using anaerobic digestion, waste is disposed of most of the pathogens and parasites, with this, pathogen removal is around 90%, thus reduction occurs in health care expenses.

Stefan *et al.,* [20] investigated that since biogas technology does not attract flies or other insects, the vectors for contagious diseases, for humans and animals are reduced. Likewise, eye infections and respiratory problems, attributed to soot and smoke from the burning of dried cow dung and firewood are mitigated.

3.2.3. Development related impact

Biogas system provides the improvement of rural living standards, as a result rural to urban migration is reduced. Biogas for lighting can lead to changes in the way families integrate in the cultural and educational sectors. The use of biogas for lighting makes it possible to engage in activities at night such as reading or attending evening courses [14].

3.2.4. Economic and Nutrition related impacts

Biogas technology helps in increase of savings and income, it reduces dependence on energy and expensive fertilizer. The accessibility of a well functioning biogas plant in the household can have positive effects on nutritious pattern. With easy access to energy, food like grain and beans can be cooked for long period, which aid digestion especially in children. Water may be boiled more regularly, thus reducing waterborne diseases [20].

Furthermore Kossmann*et al.*, [9] also attribute the following also as potential impacts of biogas on the environment,

3.2.5. Firewood consumption and soil erosion

An exceptional feature of biogas technology is that it simultaneously reduces the need for firewood and improves soil fertilization, thus substantially reducing the hazard of soil erosion. Consumption of firewood in rural areas is one of the major factors causing deforestation.

In years past, the consumption of firewood has steadily increased and will continue to do so as the population increases unless adequate alternative sources of energy are developed. In many developing countries such as India, the gathering of firewood is a form of wasteful exploitation. Soil erosion is due to increasing wood consumption caused by deforestation. This goes hand in hand with overgrazing which can cause severe damage to soils.

3.2.6. Soil protection and reforestation

The widespread production and application of biogas is expected to make an extensive contribution to soil protection and amelioration. Firstly, biogas replaces firewood as source of energy, secondly, biogas technology yield more and improved fertilizer. As a result, more feed becomes obtainable for animals. This in turn, can minimize the danger of soil erosion attributable to overgrazing.

3.3. Effects of Green House Gas on Environment

The increased greenhouse gases have enhanced the natural greenhouse effect, contributing to global warming (Karl and Trenberth, 2003).Global warming happens to be the main effect of greenhouse gas emissions. Greenhouse gases help trap heat in the earth's atmosphere as a part of the greenhouse effect. However, human activities primarily the burning of fossil fuels and deforestation, have intensified the greenhouse effect, causing global warming [21].

3.3.1. Global Warming

Increase of greenhouse gases concentration causes a reduction in outgoing infrared radiation, thus the earth climate must change somehow to restore the balance between incoming and outgoing radiation. This climatic change will include a global warming of the earth surface and the lower atmosphere as warming up is the simplest way for the climate to get rid of the additional energy. Although, a small temperature rise will encourage many other changes, for instance, cloud cover and wind patterns. Some of these changes may act to improve the warming, others to counteract it.

3.3.2. Sea Level Rise

With the occurrence of global warming, the sea level will rise due to two different processes. Firstly, sea level to rise due to the thermal expansion of seawater caused by the warmer temperature. Secondly, sea level will rise as a result of addition of water from melting glaciers and the ice sheets of Greenland and the Antarctica.

3.3.3. Ocean Acidification

Increases in carbon dioxide levels have made the world's oceans 30% more acidic since the Industrial Revolution [22]. The ocean serves as a sink for this gas and absorbs about a quarter of human carbon dioxide emissions, which then goes on to react with seawater to form carbonic acid [23]. So rise in level of carbon dioxide in the atmosphere will increases the acidification of the oceans.

3.3.4. Changes to plant growth and nutrition levels

Subsequently carbon dioxide is needed for plants to grow, if high amounts of it is present in the air, it increases plant growth. Experiments show that where carbon dioxide concentrations were raised by around 50% increased crop growth by around 15% [24].Higher levels of carbon dioxide makes carbon more available, but plants also need other nutrients like nitrogen, phosphorus, to grow and survive, less of these nutrients as well will cause the nutritional quality of many plants to decrease. In different experiments with elevated carbon dioxide levels, protein concentrations in wheat, rice, barley, and potato tubers, decreased by 5-14% [25].

3.3.5. Smog and ozone pollution

Over the last century, global background ozone concentrations have become 2 times larger due to increases in methane and nitrogen oxides caused by human emissions [26]. At ground level, ozone is an air pollutant, which is a major component of smog that is unsafe to both humans and plants. Long-term exposure to ozone reduce life expectancy. Recent studies estimate that the global yields of staple crops, like soybean, maize, and wheat, are being reduced by 2-15% due to present day ozone exposure [27].

3.3.6. Ozone layer depletion

Nitrous oxide damages the ozone layer and is now the most important ozone depleting substance and the largest cause of ozone layer depletion[28]. This is because many other gases that are harmful for the ozone layer including CFCs were banned by the Montreal Protocol (MP) and this has reduced their atmospheric concentration. However nitrous oxide was not restricted by the MP, thus as the levels of other ozone depleting substances are decreasing, nitrous oxide levels continues to grow.

3.4. Potential effects on human life

3.4.1. Economic Effect

Almost half of the human population lives within 100 kilometers of the sea. Although most of this population lives in urban areas which serve as seaports, so therefore a measurable rise in sea level will have an economic effect on low lying coastal areas and islands. For examples, increase in the beach erosion rates along coastlines, rising sea level displacing fresh groundwater.

3.4.2. Effects on Aquatic systems

Fish population most especially shellfish reduces due to loss of coastal wetlands. Likewise the increase of salinity in estuaries can decrease the abundance of freshwater species but could increase the presence of marine species.

3.4.3. Effects on Hydrological Cycle

Global precipitation is likely to increase. However, rainfall patterns will likely change. Some regions may experience more rainfall, while others may experience less. Furthermore, higher temperatures would probably increase evaporation.

4. Review on Greenhouse gas emissions from manure management systems

Thishighlights what have been written about greenhouse gas emissions associated with manure management systems and biogas production plants in reducing manure related emissions**.** In many countries large livestock populations serves as an important source of greenhouse gas emissions. Greenhouse gas emissions can result from livestock manure management [29]. Manure management as related to livestock is defined as the collection, storage and disposal of livestock manure in an anaerobic digester [1]. These manure management systems provide an anaerobic environment in which livestock manure decomposes and produces significant amounts of greenhouse gas, mainly methane [30].

The important factors affecting formation of methane from livestock manure is the amount of manure produced, manure composition, of which in turn depends on the composition and digestibility of the livestock intake, the manure management system [31].

5. Biogas plants in reducing manure related GHG emissions

There is a cost effective and affordable technology that can reduce emissions from manure by recovering methane and using it as an energy source. This technology is referred to as anaerobic digester, decompose manure in a controlled environment and recover methane produced from the manure [1]. Anaerobic digesters are designed to capture the methane produced from manure through anaerobic decomposition.

Reducing greenhouse gas emissions in a biogas plant system is achieved through capturing and burning of the biogas that is generated, preventing release of the gas into the atmosphere [32]. The methane burned can provide heat and other forms of energy. When the methane is burned to produce energy, the greenhouse gas emissions are reduced to only the carbon dioxide component in the biogas, which was already in the organic material at growth, and which has a global warming potential of 95% lower than that of Methane. According to U.N, [33] the measure of how much a given mass of greenhouse gas is estimated to contribute to global warming is global warming potential. The dairy-waste management system at the farm incorporated an anaerobic digestion system that produced biogas, electricity and heat through the use of a combined heat and power unit. The analysis compared the greenhouse gas emissions and global warming potential associated with the anaerobic digestion system and a reference system without anaerobic digestion.

This analysis indicates that by avoiding decomposition of the manure in open storage ponds, the anaerobic digestion system significantly reduces greenhouse gas emissions.

6. Conclusion

This study has shown that activities related to power generation and energy consumption has associated emissions with potential to influence greenhouse gas which is the main source of imminent global warming.

Undoubtedly, biogas technology has the potential to reduce greenhouse gas emissions and improve the livelihoods, particularly of the rural communities, by addressing the energy challenges of the rural communities.

References

[1] USEPA, 2008. Inventory of Greenhouse Gas Emissions and Sinks. United States Environmental Protection Agency. pp. 26.

[2] Monnet, F. 2003. An Introduction to Anaerobic Digestion of Organic Wastes.Final Report.Remade Scotland.48 pp. Electronic access at http://www.remade.org.uk/Organics/anaerobicdigestion.htm.

[3] Philip D.Lusk, 2008. A Brief History of Biogas. The University of Adelaide, Australia http://www.adelaide.edu.au/biogas/history/

[4] Parawira W. 2004. Anaerobic treatment of agricultural residues and wastewater: Application of high-rate reactors. Lund University Sweden, Department of Biotechnology, Ph.D. dissertation, ISBN: 91-89627-28-8.

[5] Verma s 2002. Anaerobic digestion of biodegradable organics in MSW.

[6] Moriarty K 2013. Feasibility Study of Anaerobic Digestion of Food Waste in St.Bernard, Louisiana. A study prepared in partnership with the environmental protection agency for the RE-Powering Americas land initiative: siting renewable energy on potentially contaminated land and mine sites. National Renewable Energy Laboratory (NREL).http://dx.doi.org/10.4172/2157-7110.1000478

[7] Amigun B., Sigamoney R., von Blottnitz H. 2008. Commercialization of biofuel industry in Africa: A review. Renewable and Sustainable Energy Reviews (12) 690-711.

[8] Von BlottnitzH.Amigun B., 2007.Investigation of scale economies for African biogas installations.Energy Conversion and Management (48) 3090-3094.

[9] Kossmann W., Pönitz U., Habermehl S., Hoerz T., Krämer P., Klingler B., Kellner C., Wittur T., Klopotek F.V., Krieg A., Euler H. 1999. Biogas digests. Information and Advisory Service on Appropriate Technology 1, 1-46.

[10] Pellerin, R.A., L.P. Walker, M.G. Heisler, and G.S. Farmer. 1987. Operation and Performance of Biogas-Fueled Cogeneration Systems. Energy in Agriculture 6, 295-310.

[11] Chynoweth, D. and R. Isaacson. 1987. Anaerobic Digestion of Biomass. Elsevier Science Publishing Co., Inc., New York pp. 279.

[12] Karl, R. and Trenberth, E., 2003. Modern global climate change Science 302 (5651), 1719–1723.

[13] Supriya, k. 2005. Project report on Green-House Effect, Environmental Pollution.

[14] Thomas Hoerz, Pedro Krämer, B. Klingler, C. Kellner, Thomas Wittur, F. Klopotek, A.Krieg, H. Euler 1999. Biogas Costs, Benefits and Biogas Programme Implementation.

[15] Pooja T., P. Pawar, A. Ranveer, 2015. The Greenhouse Effect and Its Impacts on Environment"

[16] Karapidakis, E. S., Tsave, A. A., Soupios, P. M., Katsigiannis Y. A., 2010. Energy efficiency and environmental impact of biogas utilization in landfills. International Journal of Environmental

Science Technology 7(3), 599-608.

[17] Desideri, U., Di Maria, F., Leonardi, D., Proietti S., 2003. Sanitary landfill energetic potential analysis: A real case study. Energy. Conversion Management 44 (12), 1969-1981.

[18] Eryasar, A., 2007. KirsalKesimeYonelikBirBiyogazSisteminiTasarimi, Kurulumu, TestiVePerformansinaEtki Eden ParametrelerinArastirilmasi, EgeUniversitesi Fen BilimleriEnstitusu.

[19] Yilmaz, V., 2009. SurdurulebilirBirSistemdeBiyogazinYeri, V. YenilenebilirEnerjiKaynaklariSempozyumu, Diyarbakir, 203-207.

[20] Stefan H., P. Krämer, B. Klingler, C. Kellner, T. Wittur, F.Klopotek, A. Krieg, H. Euler 1999. Household Energy Appropriate Technologies. 1, 1-46

[21] Le Treut, H., R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather.2007.Historical Overview of Climate Change.The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, USA.

[22] Bernstein, Lenny, R. K. Pachauri, and Andy Reisinger, 2007. Climate change: synthesis report. Geneva, Switzerland IPCC, 2008.

[23] Le Quéré, C., A. K. Jain, M. R. Raupach, J. Schwinger, S. Sitch, B. D. Stocker, N. Viovy, S. Zaehle, C. Huntingford, P. Friedlingstein, R. J. Andres, T. Boden, C. Jourdain, T. Conway, R. A. Houghton, J. I. House, G. Marland, G. P. Peters, G. Van Der Werf, A. Ahlström, R. M. Andrew, L. Bopp, J. G. Canadell, E. Kato, P. Ciais, S. C. Doney, C. Enright, N. Zeng, R. F. Keeling, K. Klein Goldewijk, S. Levis, P. Levy, M. Lomas, and B. Poulter. 2012. The global carbon budget 1959–2011. Earth System Science 5(2), 1107-1157.

[24] Cleugh, Helen. 2011. Climate change, science and solutions for Australia. Collingwood Vic. CSIRO Publishing.

[25] Taub, D., Miller, B. 2008. Effects of elevated CO_2 on the protein concentration of food crops: a meta-analysis. Global Change Biology (14) 565-575.

[26] West, J. J. 2006. Global health benefits of mitigating ozone pollution with methane emission controls. Proceedings of the National Academy of Sciences 103(11), 3988-3993.

[27] Avnery, Shiri, Denise L. Mauzerall, and Arlene M. Fiore, 2013. Increasing global agricultural production by reducing ozone damages via methane emission controls and ozone-resistant cultivar selection. Global Change Biology 19(4), 1285-1299.

[28] Ravishankara, A. R., J. S. Daniel, and R. W. Portmann, 2009. Nitrous Oxide (N_2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century. Science 326(5949), 123-125.

[29] Jun, P., Gibbs, M. and Gaffney, K., 2011. CH4 and N2O Emissions from Livestock Manure. Good Practice Guidance and Uncertainty Management in

National Greenhouse Gas Inventoriespp. 18.

[30] Petersen, S. O., Amon, B., Gattinger, A., 2005. Methane oxidation in slurry storage crusts. Journal of Environmental Quality 34 (2), 455-46

[31] Zeeman, G. and Gerbens, S., 1999. CH4 emissions from animal manure. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories CH4 Emission from Animal Manure. Pp. 10.

[32] Bracmort, K., 2010. Anaerobic digestion: Greenhouse gas emission reduction and energy generation. Analyst in Agricultural Conservation and Natural Resources Policy.Pp. 27.

[33] U.N, 1998. United Nations.Action taken by the conference of the parties.In Conference of the parties, Kyoto. Pp. 60.