

An Overview of Biogas and Associated Opportunities

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ABSTRACT: *Biogas is a renewable energy resource that provides energy in green manner that leads to the reduction in emission of greenhouse gases and offers various opportunities that makes technology based on biogas is an emerging field. Energy generation based on fossil fuels and coal is a commercial technology that produces harmful gases at large scale resulting in damaging of ecosystem. In contrast, biogas is a best alternative that reduces these effects significantly. Biogas produces from the waste organic products from various sectors such as industries and agricultural sector. Since the organic wastes are existed in limited quantity for the production of the biogas that is why it is necessary to focus on new technologies for biogas production worldwide. This review paper aimed to discuss about the biogas and its associated opportunities. The recent advancement in the techniques in molecular biology can help to optimize as well as control the biogas production process in more efficient and effective way in the near future.*

KEYWORDS: *Anaerobic Digestion, Biogas, Digester, Renewable Energy, Organic Waste.*

INTRODUCTION

Commercial technologies for the production of electricity and heat based on non-renewable energy resources such as fossil fuel and coal has been utilized from many decades. These technologies fulfill our energy needs efficiently and effectively. But the most common issue associated with the non-renewable energy resources is emission of various harmful gases that has huge negative impact on our ecosystem as well as environment that leads to the climate change and global warming[1]. Currently, climate change and global warming is the major issue in from of the world. Every nation put extra effort in order to minimize its effect. Renewable energy resources are the best alternative to the non-renewable energy resources because it offers various advantages over it including its availability, capacity and it doesn't produce greenhouse gases.

Rapid growth in the greenhouse gases heavily damages our ecosystem resulting in the adverse effect on the wildlife and human health etc. The utilization of the renewable energy resources can reduce these impact significantly that will help to conserve our ecosystems. There are five main renewable energy resources such as wave energy, wind energy, solar energy, biogas and geothermal energy. Every energy resource has its own advantages according to their applications[2]. Among the all renewable energy resource, biogas has amazing future in terms electricity and heat generation. Various industries, agricultural sector and Municipal Corporation produce organic wastes at large scale. These wastes are full of nutrients and consist of other healthy substances. Biogas is a promising and emerging technology that fulfills the energy needs all across the world with various environmental benefits The major source of the biogas are agricultural waste, sewage as well as industries waste water, forestry waste and solid municipal waste etc. Multiple European countries as well as American countries focus on the electricity generation based on the biogas[3]. Biogas has huge potential in terms of socio-economic importance because it minimizes the costs for treating the waste and reduces the consumption of the raw materials. This review paper provides an overview of biogas and its various aspects including production techniques, merits and demerits, applications and future perspective.

RENEWABLE ENERGY RESOURCES

Renewable energy resources are well known energy resources and considered as a best alternative of non-renewable energy resources such as fossil fuels and coal for the production of the electricity and heat. Renewable energy resources are also known as clean energy resources that available in the environment in endless quantity[4]. The availability of the renewable energy resources depends on the time, geographical location and weather conditions. Major renewable energy resources are shown in the Figure 1.

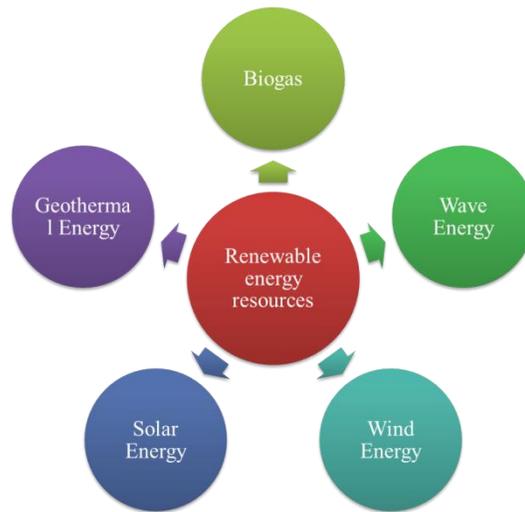


Figure 1: Schematic Illustration of the Major Renewable Energy Resources

For instance, solar energy is utilized for the production of the electricity in which heat energy comes from the sun captures through the electrical systems. Since the availability of the sun light is depends on the weather conditions that is why technology based on the solar energy needs storage systems so that the electricity produced by the solar energy can be utilized in the absence of the solar energy[5]. On the other hand, Geothermal energy is available at the specific geographical locations and wind energy is depends on the weather conditions as well as the place where these technologies are established[6]. Among all the energy resources, biogas has an extra advantage of availability and its doesn't depends on the weather conditions. It is just depend on the availability of the organic wastes that produces by the various industries at large scale. Organic waste includes kitchen waste, flowers, fruits, vegetables and leaves etc.

These wastes generally disposed into the landfills that have major adverse impact on the environment. When organic wastes fill in landfills, in the absence of oxygen, the organic waste goes under the process of anaerobic decomposition. This process produces methane gas to the atmosphere at large scale. The proper utilization of the organic waste leads to the production of the biogas that can be directly utilized for the production of heat, cooling, electricity generation and production of the steam. There are various benefits offering by the biogas gas such as it is environmental friendly, it helps in the reduction of pollution related to the soil as well as water and alternate method of healthy cooking. Recent advancement in the biogas production technologies enables biogas based technologies for the generation of the electricity and heat at large scale in order to fulfill the energy requirement of the growing population. It will help to minimize the air pollution, water pollution and soil pollution significantly that will conserve our ecosystem effectively. The status of the electricity generation based on the biogas from 2010 to the 2016 is shown in the Figure 2.

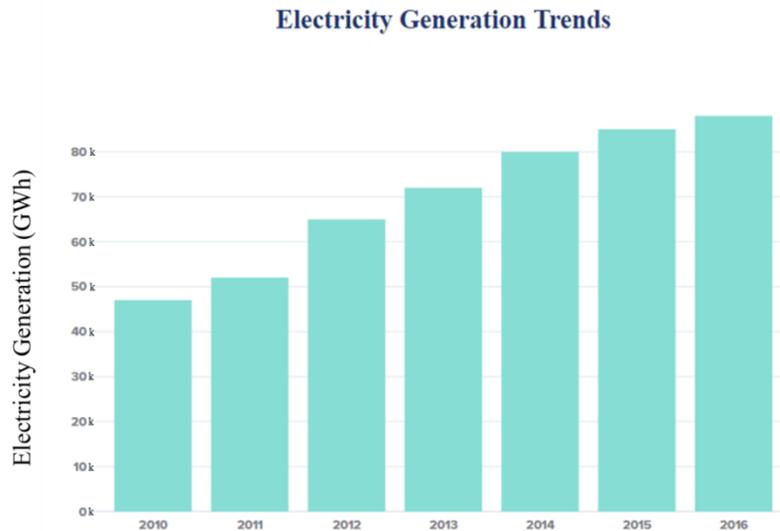


Figure 2: Bar Diagram Representation of the Electricity Generation Trends from 2010-16 based on the Biogas

BIOGAS AND ITS PRODUCTION

Biogas is a mixture of carbon dioxide and methane gas that has been produced by the decomposition of the organic waste such as vegetables, kitchen waste, food waste and livestock etc. in the absence of the oxygen. Earlier, organic waste disposed in the landfills that promote the emission of harmful gases in the atmosphere. From past few years, Researchers and scientists find a way to utilize these organic wastes for the production of the gas named biogas that can be utilize for different applications including electricity generation, heat generation as well as steam generation. There are various steps involve in the production of the biogas (shown in the Figure 3).

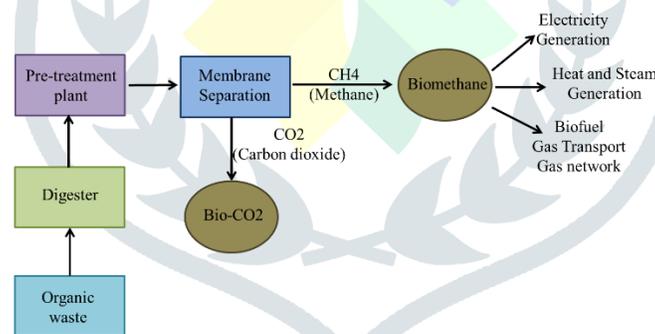


Figure 3: Schematic Illustration of the Various Steps Involves in the Production of Biogas

1. Stage 1:

In the first stage, the process of the anaerobic digestion takes places inside the digester. For that the collected organic wastes crumpled into very small pieces followed by adding a fluid to it in order to make the process of the anaerobic digestion easier to take place. The digestion process takes place in the absence of the oxygen. Since the activity of the microorganisms depends on the temperature so the digester heated at around 36°C so that digestion process takes places more effectively[7]. The optimum digestion temperature of microbes shown in the Figure 4.

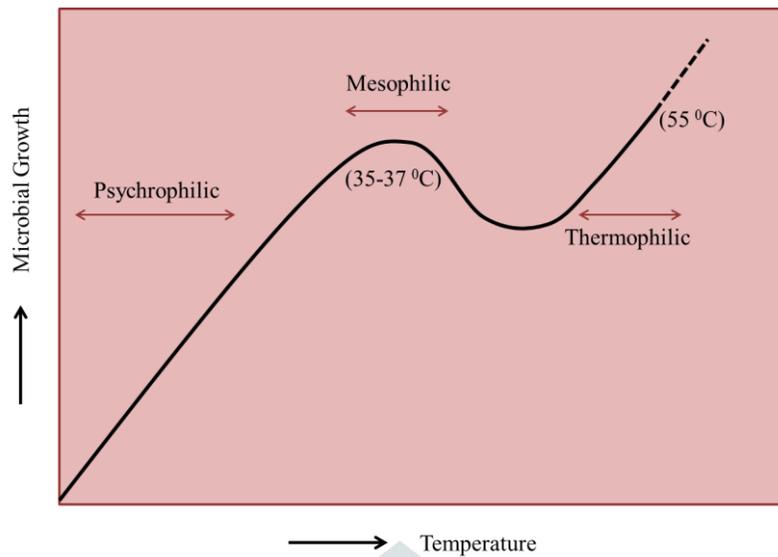


Figure 4: Graphical Representation of the Temperature Variation for the Microbial Growth

2. Stage 2:

In the second stage, actual biogas production takes place by the process of anaerobic digestion. A pre-treatment plant has been established that has multiple large tanks containing slurrified organic waste and keeps it for about four weeks. It's a long process because the decomposition takes place based on the activity of the microorganisms. After keeping the organic waste inside the large tanks for multiple weeks, combination of the methane (CH_4) and carbon dioxide (CO_2) has been produced and these generated gases undergoes subsequent stages for the further processes[8]. The anaerobic digestion process consists of two main steps that have been shown in the Figure 5. The process is mainly dominated by the activity of the microorganisms that is why it must be ensure to understand about the microbiology so that the process of the anaerobic digestion process can be enhanced for the production of the biogas. In order to maintain life of the microbes and improve the activity, the organic waste slurrified heated at a particular temperature as shown in the Figure 5.

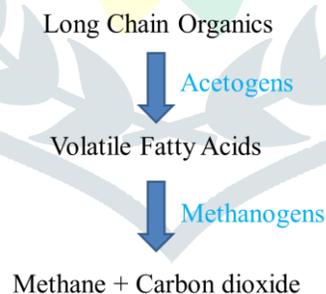


Figure 5: Schematic Illustration of the Simplified Anaerobic Digestion (AD) Process

3. Stage 3:

Since in the previous stage, methane gas is produced along with the carbon dioxide that is why in this step these two gases will be separated through the separation membrane. In this stage, the produced gas been upgraded and eliminate the impurities present in it and separate the carbon dioxide from it. This step is the final stage in the production of the biogas. Purified methane called as Biomethane that can be utilized further for the production of the electricity, heat as well as steam. And the separated carbon dioxide known as bio-carbon dioxide. Since the digestion of the organic waste depends on the microbes, the understanding of the lifespan of the microbes is must. Figure 6 shows the life and death of the microbes in the digestion process.

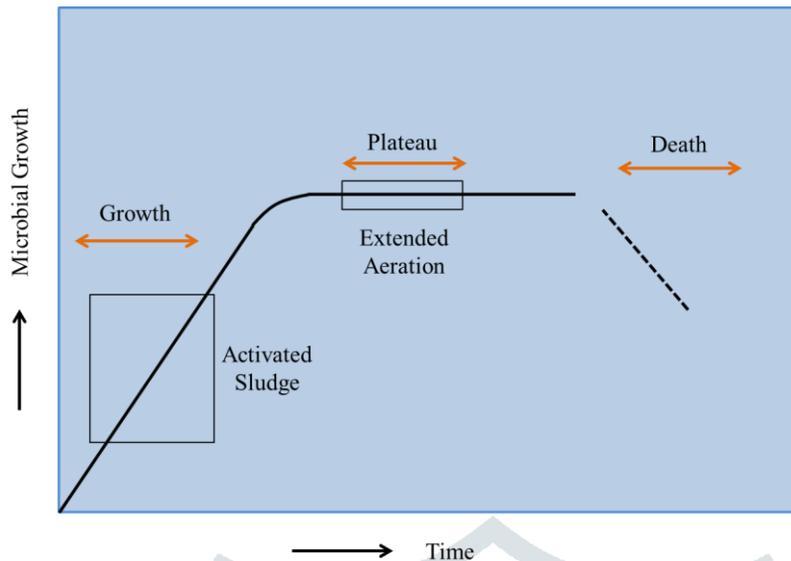


Figure 6: Graphical Illustration of the Life and Death of a Microbe

ADVANTAGES AND DISADVANTAGES OF DIGESTER

Technology based on different digester offers various advantages including some associated drawbacks based on the type of the digester. The advantages and disadvantages linked with the digester are listed in the Table 1.

Table 1: List of Advantages and Disadvantages Associated with the Type of the Digester

Type of Digester	Advantages	Disadvantages
Digester based on fixed Dome	<ul style="list-style-type: none"> • less establishment cost • can be used for longer time • simple and compact design • No mechanical parts involve • Less maintenance required • Small land area required because it can construct in underground 	<ul style="list-style-type: none"> • For the construction, it requires skilled workforce • Repairing of the leakage is very difficult • Need raw material at large scale for the construction • The quantity of the produced gas visible immediately
Digester based on Floating drum	<ul style="list-style-type: none"> • The operation is very simple and can be understand very easily • The amount of the stored gas can be visible easily • It provides the provision of constant pressure of gas • The construction is relatively easier 	<ul style="list-style-type: none"> • The cost is high because it requires extra steel material for drum • Since, corrosion is the major issue associated with the steel drum that is why the life of the digester is small • In order to make drum corrosion free, regular painting is required

		that leading to the high maintenance
Digester based on plug flow or bag	<ul style="list-style-type: none"> • Inexpensive • Transportation is easy • Less and easy maintenance • Easy to construct because of simple as less sophisticated design 	<ul style="list-style-type: none"> • Relatively less pressure of gas • High chances of damage • Small life time • Less number of local job creation

ADVANTAGES AND DISADVANTAGES OF BIOGAS

There are various benefits offering by biogas among all the renewable energy resources that makes this technology more effective and efficient for the production of the energy in order to fulfill the demand of the energy by growing population[9]. Apart from advantages, there are some disadvantages are also linked with the biogas (shown in Figure 7).

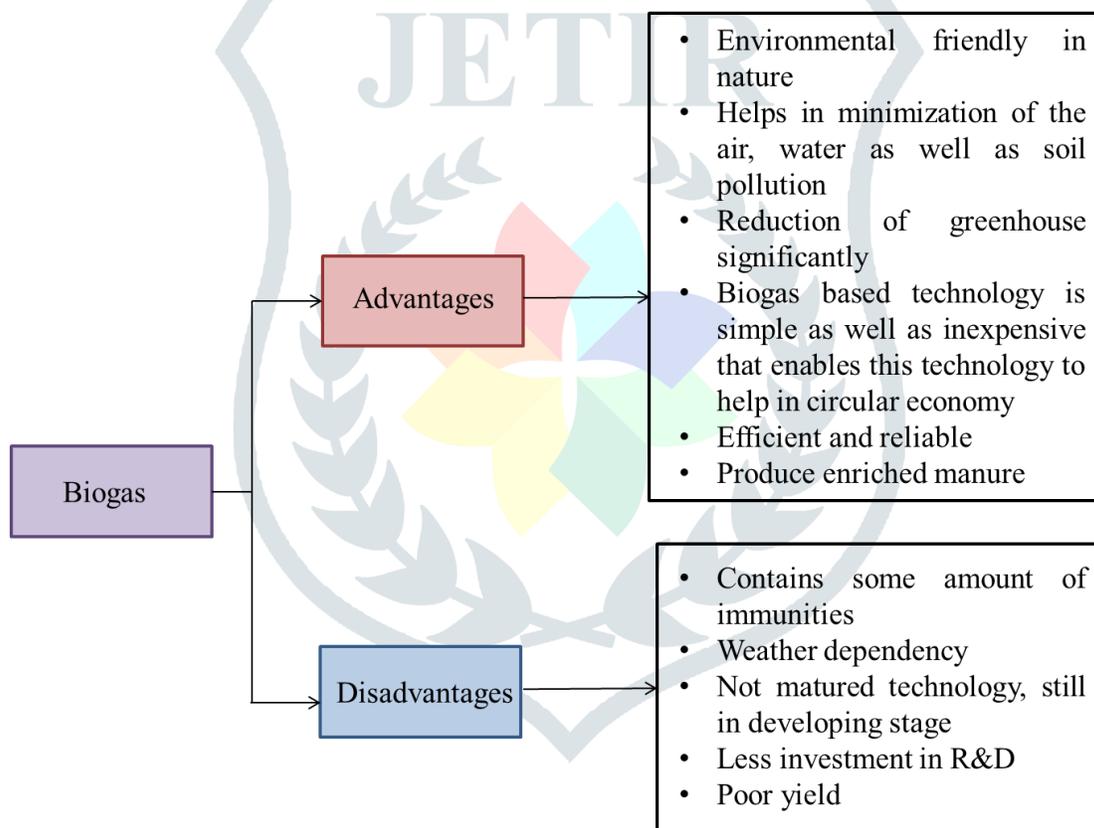


Figure 7: List of Advantages and Disadvantages Associated with the Biogas

Among the disadvantages, the less investment in the R&D is the major issue facing by the biogas technology. Every emerging technology needs proper financial investment for the advancement of the technology so that it can take up to the next level so it can be used for the commercial purpose. Like that technology based on the biogas also needs the heavy investment in R&D. R&D will find new ways to improve the efficiency and the implementation of the biogas production that will be helpful in the future.

FUTURE PERSPECTIVE OF BIOGAS

Biogas is an emerging technology that needs to be more advanced in the future through the proper investment in research and development. Since it is environmental friendly that doesn't produce carbon dioxide can be considered as a future technology for the energy generation. The proper and effective way of

separation of the carbon dioxide (CO₂) from the biogas will enhance the productivity of the Biomethane. Carbon dioxide free biogas is the primary objective of the biogas production because it reduces the climate change and global warming significantly. By considering these factors, global demand of clean/green energy rising significantly in recent years because of growing population. Biogas can play an important role in the near future for fulfilling the demand of energy. Since, the technology based on the biogas depends on the organic waste that is why the collection of the organic wastes must be extracted through the proper protocol so that it can be utilize for the production of the biogas more effectively. Since biogas technology is in developing mode that is why it is necessary to invest heavily in R&D of biogas so that it can take up to the next level.

DISCUSSION

The commercial technologies for the generation of the electricity and other form of energy are mainly depending on the non-renewable energy resources such as fossil fuels and coal. The utilization of the non-renewable energy resources heavily takes place in the field of electricity generation. The common issue associated with the non-renewable energy resources is generation of the harmful gases and wastes that has huge adverse effect on the environment. It damages our ecosystem so badly that affects our wildlife, forestry and human health. In contrast, renewable energy resources such as wind energy, solar energy, wave energy and biogas offer various benefits but the most common advantage is reduction in emission of harmful gases. Among all biogas is one of best energy resource that depends on the organic waste. Since, from different industries and sectors, organic wastes are generated at large scale and the production of the biogas from these wastes is the major advantages because it doesn't require any other extra raw material for the production of the biogas. Recent advancement in the technology based on the biogas develops different types of digester system in order to improve the efficiency of the production of the biogas. Purification and upgradation technologies for the separation and make methane gas impurity free enables this technology more efficient for the generation of the electricity at large scale in order to fulfill the demand of the growing population.

CONCLUSION

The demand of the renewable energy resources for the generation of the energy such as electricity and heat increasing with the growing population. Researchers and scientists trying to find new ways for the utilization of the renewable energy resources. Biogas is one of the most important renewable energy resources that gained significant amount of attention in recent years. Various raw materials and digester system for the anaerobic digestion process has been explored in order to produce energy. Currently, organic wastes has been utilize for the production of the biogas that enables waste reduction on one side and energy production on the other side. There are various advantages offers by the biogas such as reduction in air, water and soil pollution significantly, ecofriendly in nature as well as simple and low cost technology that helps to the circular economy. Apart from many benefits offering by the biogas, there are some drawbacks are also associated with the biogas such as weather dependency, less R &D and generate little amount of the impurities. Since this technology still in the developing stage that is why it is recommended that proper financial investment necessary for the R&D for making this technology to produce energy at commercial level and proper as effective implementation framework is also required so that biogas plants can be establish in minimal time and require encourage the production of the biogas at large scale.

REFERENCES

- [1] I. S. Horváth, M. Tabatabaei, K. Karimi, and R. Kumar, "Recent updates on biogas production-a review," *Biofuel Res. J.*, vol. 3, no. 2, p. 394, 2016.
- [2] C. Mao, Y. Feng, X. Wang, and G. Ren, "Review on research achievements of biogas from anaerobic digestion," *Renew. Sustain. energy Rev.*, vol. 45, pp. 540–555, 2015.
- [3] A. Roopnarain and R. Adeleke, "Current status, hurdles and future prospects of biogas digestion technology in Africa," *Renew. Sustain. Energy Rev.*, vol. 67, pp. 1162–1179, 2017.
- [4] J. Twidell and T. Weir, *Renewable energy resources*. Routledge, 2015.
- [5] S. P. Sukhatme and J. K. Nayak, *Solar energy*. McGraw-Hill Education, 2017.

- [6] J. W. Tester *et al.*, “The future of geothermal energy,” *Massachusetts Inst. Technol.*, vol. 358, 2006.
- [7] Y. Chen, J. J. Cheng, and K. S. Creamer, “Inhibition of anaerobic digestion process: a review,” *Bioresour. Technol.*, vol. 99, no. 10, pp. 4044–4064, 2008.
- [8] P. Weiland, “Biogas production: current state and perspectives,” *Appl. Microbiol. Biotechnol.*, vol. 85, no. 4, pp. 849–860, 2010.
- [9] M. G. Mengistu, B. Simane, G. Eshete, and T. S. Workneh, “The environmental benefits of domestic biogas technology in rural Ethiopia,” *Biomass and Bioenergy*, vol. 90, pp. 131–138, 2016.

