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Production of Biogas from Sugarcane Waste

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ABSTRACT: The present world is experiencing a lot of problems due to the increasing in population and the growth is unpredictable, due to that the demand for different resources is also increasing. Humans started exploiting different resources due to which they get extinct in future. After India achieved independence rapid industrialisation took place due to which utilisation of conventional fuels has increased and the automobile industries contribute a major portion in the consumption of fossil fuels. In India, the annual production of vehicles from the automobile industry is 23.37 million vehicles/per year as per FY (Fiscal year) 2014-15 survey, which is increased by 8.68% over the last year. Most of the vehicles run on fossil fuels which led to the energy crisis. The reformation of natural sources may take so many years, because of that the demand and supply balance will be lost which ultimately led to the price hike. The best way to reach the balance is by using alternative energy i.e renewable energy. The future worlds require some renewable energy for its running so the present world has the responsibility to save the energy for the next generations. It can be achieved by using alternative energy and the most economical way to overcome the energy demand is by using biogas. India is the second largest country as per population and it is also the largest producer of different wastes like food waste, agricultural waste etc.,. The present review paper deals with the production and utilisation of biogas from sugarcane waste.

KEYWORDS: Biogas, Anaerobic digestion, Organic wastes, Global warming.

I. RELATED WORK

Biogas has the capability of ruling the modern world. Literature survey reveals that utilisation of biogas maintains the CO₂ and Methane balance in the atmosphere thereby reducing the global warming. A lot of research is conducted on the improvement of production of biogas and it is found that using slaughterhouse waste and animal manure the percentage of Methane is found the maximum. Taking sugarcane waste into consideration more amount of methane is produced using bagasse followed by filter cake, vinnase and Straw[1]. In Sweden, most of the companies utilise their daily waste in the production of electricity and they contribute 50% of the total electricity production. Sweden stands the first place in waste followed by America, Russia etc and in India the waste management is still at the ground level.

II. INTRODUCTION

At present, the average time span of a human is 71 years but according to 2006, it was 76, one of the reasons for the decrease in the life span is global warming[2]. The air pollution and global warming are the major problems created by a human being which affects the ecosystem. Some of the greenhouse gases are carbon dioxide (CO₂), methane (CH₄), chloral fluorocarbon, nitrous oxide etc., which are mostly emitted by vehicles[3]. Increasing population has led to increasing in the utilisation of vehicles thereby increasing the pollution[4]. Global warming is caused due to the absorption of heat reflected from earth surfaces and retaining the heat in the atmosphere for a long time. This results in the increasing temperature of the earth's surface, a decrease in annual rainfall, depletion of ozone, acid rains etc.,[5]. CO₂ and methane contribute about 75% of the atmosphere. Methane and carbon dioxide have the capability to absorb the reflected heat and can retain the heat for a longer time thereby increasing the temperature of the earth's surface[6]. So by the reducing the percentage of Methane and Carbon dioxide the effect of global warming can be reduced and this can be achieved by the proper utilisation of Biogas.

The carbon dioxide emission from vehicles as follows

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Cumulative CO₂ Emissions 1850–2011 (% of World Total)

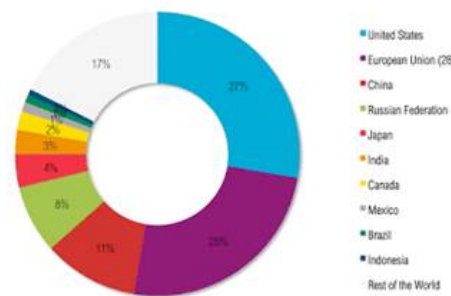


Fig 1. Percentage of CO₂ emissions emitted by different countries.[7]

Major pollution is caused by automobile sector and the industries. These result in the release of large amounts of CO₂ emissions to the atmosphere and the emissions react with ozone and result in the depletion of ozone layer. The percentage of emissions emitted by on road and off road vehicles is given in Fig 2.

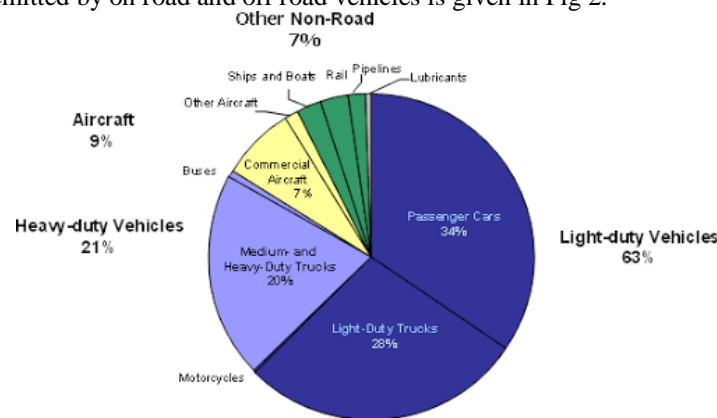


Fig 2. Emissions from different on road and off road vehicles.[7]

There are a large variety of alternative fuels available but among them, biogas serves as the best alternative to the present fossil fuels[2]. Different countries have already set up different biogas plants and Italy doubled the biogas plants in 2013 and they are increased further. Biogas is an eco-friendly fuel which is produced by the anaerobic digestion of different organic and inorganic wastes. Upon considering different positive as well as negative results Biogas has been considered as major renewable energy which has the capability to replace the conventional fuels [3]. Energy is the fuel that has the capability to run the world so it is produced from different sources among them some cause a great damage and disturb the balance of the ecosystem. To overcome these problems alternate fuels (Biogas) are required. Biogas is produced from wastes which are of no use and can be converted into useful energy[4]. The different types of wastes which we come across in our day to day life is a municipal solid waste, food waste, industrial waste, sewage sludge, animal manure and agricultural residue can be converted to biogas.

The utilisation of biogas not only preserve non-renewable energy, it also decreases greenhouse emissions and maintains the balance. Production of Biogas from different types of waste not only reduce global warming but also protect the soil and the surroundings from different harmful germs because the waste of animal dung contains concentrating nitrogen (N) and phosphorus (P) and heavy metals[7]. These increases the fertility of the soil but if it is combined with different germs causes harm to humans and the inorganic wastes cause soil pollution and diseases in humans. The

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microorganisms in dung along with other organic and inorganic wastes pollute the environment and causes various diseases to humans. Industrial wastes contain toxic and contaminated things which are released into the water and left outside which severely harms the ecosystem. With this, it is clear that waste, when left outside, can pollute the soil, air, water etc.,[6].

The basic principle used in the production of biogas is Anaerobic Digestion (AD) i.e the decomposition occurs in the absence of oxygen. The decomposition of wastes is done by the microorganisms present in the dung. The percentage of the gas produced from anaerobic process depends upon various factors like pH, temperature, mixing etc.,

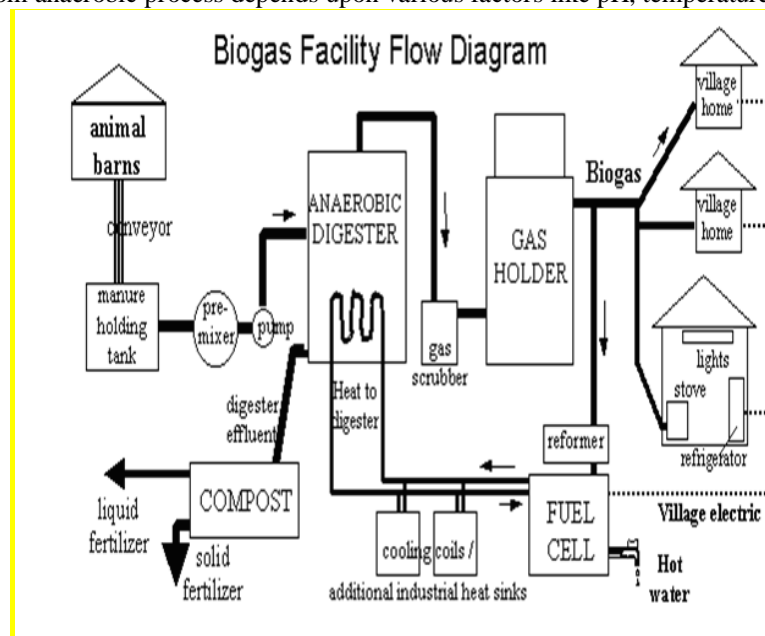


Fig 3. Stages of biogas production[8].

The gas produced from the anaerobic digestion can be used directly or it can be converted into electricity. This reduces the cost of gas and electricity. The residue which is left after decomposition can be used as fertiliser because it is highly nutritious.

After the anaerobic digestion, the residue is sent to the compost where the separation of solid and liquid residue takes place which can use as solid fertiliser and liquid fertiliser based on requirement. The main output is a gas which has the properties similar to LPG and can be used for cooking purpose or it can be converted into electricity. It can also be used in automobiles by running the engine in dual fuel mode using biogas as pilot fuel and petrol and diesel as secondary. The biogas can be converted into electricity by using gensets. Gensets convert gas into electricity and it can be supplied accordingly.

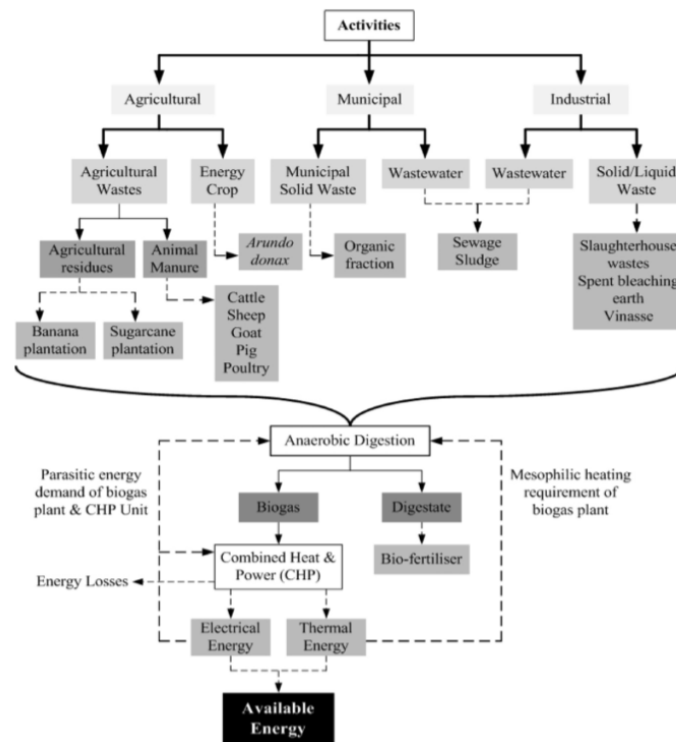


Fig 4. A flow chart representing the different types of waste from which the biogas is produced.[9]

III.AGRICULTURAL WASTES

As we all know, agriculture is the main occupation of people living in India. Taking these factors into consideration a huge amount of agriculture residue can produce from agriculture. It is further divided into two types[10].

- i. agricultural residues
- ii. animal manures

IV. AGRICULTURAL RESIDUES

Agricultural residue means the by-product formed by harvesting or processing different crops, and accordingly these are classified as “Field-based (or) Process-based”. Field based residue are obtained by the cultivation of crops on fields and Process-based residues are produced from industrial crop processing[11]. Agricultural residues in India include wastes from the cultivation of food crops and industrial crops. In 2016, food crops production amounted to 253.16 m.t which increased by 1.14 m.t as compared to that previous year while the production of the major industrial crop (sugarcane) was 346.39m.t[11].

The residue which is left out after harvesting is divided into two categories.

- i. primary residue
- ii. secondary residue.

primary residue means the residue which is left at the field while yielding. examples are primary residue is rice straw, sugarcane tops etc.,[9]. The things which are attached to the main output during the harvesting process is called secondary residue. Examples are rice husk, bagasse etc., The primary residue can be used as fertilisers or feed for

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animals and these contribute the major waste[8]. As it is used as feed and fertilisers only secondary residue is preferred for the production of biogas. Among agriculture residues, banana and sugarcane are mostly used.

Tab 1. Amount of residue obtained from different crops in (Kt/yr)

Crop	Residues	Biomass potential (kt/yr)	Crop	Residues	Biomass potential (kt/yr)
Arecanut	Fronds, husk	1,000.8	Meshta	Stalks, leaves	1,645.5
Arhar	Stalks, husk	5,734.6	Moong	Stalks, husk	762.5
Bajra	Stalks, cobs, husk	15,831.8	Moth	Stalks	17.8
Banana	Residue	11,936.5	Mustard	Stalks, husk	8,657.1
Barley	Stalks	563.2	Niger seed	Stalks	94
Barseem	Stalks	71.6	Oilseeds	Stalks	1,143.1
Black pepper	Stalks	29.1	Onion	Stalks	66.5
Cardamom	Stalks	43.6	Others	Others	0.34
Cashew nut	Stalks, shell	189.4	Paddy	Straw, husk, Stalks	169,965.1
Castor seed	Stalks, husk	1,698.6	Peas and beans	Stalks	27.4
Casuarina	Wood	211.8	Potato	Leaves, stalks	887.3
Coconut	Fronds, husk, pith, shell	10,463.6	Pulses	Stalks	1,390.4
Coffee	Husk, pruning and wastes	1,591	Ragi	Straw	2,630.2
Coriander	Stalks	188.3	Rubber	Primary and secondary wood	2,492.2
Cotton	Stalk, husk, bollshell	52,936.5	Safflower	Stalks	539.3
Cow gram	Stalks	48.5	Sunnhemp	Stalks	14.1
Cumin seed	Stalks	182.6	Sawan	Stalks	0.22
Dry chilly	Stalks	268.6	Small millets	Stalks	600.1
Dry ginger	Residue	5.3	Soyabean	Stalks	9,940.2
Eucalyptus	Stalks	162.8	Sugarcane	Tops and leaves	12,143.9
Gram	Stalks	5,440.6	Sunflower	Stalks	1,407.6
Groundnut	Shell, stalks	15,120.4	Sweet potato	Stalks	12.8
Guar	Stalks	233.3	Tapioca	Stalks	3,959
Horse gram	Stalks	191.3	Tea	Sticks	909.8
Jowar	Cobs, stalks, husk	24,207.8	Til	Stalks	1,207.7
Kesar	Stalks	9.4	Tobacco	Stalks	204.8
Kodo millets	Stalks	3.13	Turmeric	Stalks	32.3
Linseed	Stalks	86.3	Urad	Stalks, husk	924.9
Maize	Stalks, cobs	26,957.7	Wheat	Stalks, panicle	112,034
Masoor	Stalks	600.3	Total		511,041.39

V. BANANA PRODUCTION

The yield of banana is so good that the cultivation of banana is increasing every year. Every year nearly 265 lakh tonnes of annual production in India is banana [11]. Tamilnadu stands first in the production of banana among India. It usually grows at a temperature range of 80-85 °F and usually requires a lot of water. The banana plant consists of rhizome, suckers, pseudostem, leaves and banana fruits. Usually, bananas are used to produce in tiers which constitute a bunch. Each pseudostem can produce one bunch of fruits and dies to leave the suckers to grow[9]. After harvesting, the pseudostem needs to be cut off to reborn from a sucker. Thus the pseudostem becomes a primary residue and rotten bananas, banana peels, leaves act as secondary residue.

VI. SUGAR CANE WASTE

The largest production of residue in India is through sugar cane waste which contributes 346.39 million tonnes of sugar cane production as per survey of 2015-16 in India[11]. Therefore the residue produced from sugar cane is also more. Due to that reason sugarcane is mostly used for biogas production. Even the German biggest biogas company which will set up in India will produce biogas from sugarcane waste.

Production of biogas from sugarcane waste is usually done by the process of sugarcane press mud mixture[9]. Using press mud methane along with different other gases is produced which is most essential gas in the production of biogas. The disadvantage from press mud is, its form's wax with soil causes clogging and decreases the efficiency. We can use a substrate(catalyst) in press mud to increase its efficiency. The process of making biogas from sugarcane is

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VII.PRESS MUD

It is a solid residue which is formed after the extraction of sugarcane juice. It is usually used as a manure but can be used as raw material for the production of biogas. It generally consists of 60 to 85% moisture. The chemical composition depends on the sugarcane waste and type of press mud. The press mud formed from sugarcane factory usually consists of 71 % of moisture, 9% of ash and 20 % of volatile solids along with 74-75% of organic matter on solids.

The characteristics and composition of press mud are shown below:

Tab 2.Composition of press-mud[9]

Compound	Percentage
Cellulose	11.4
Hemicellulose	10.0
Lignin	9.3
Protein	15.5
Wax	8.4
Sugar	5.7
Na	0.22

The different compositions and characteristics are represented in table 3 and 4 and considering composition the percentage of protein is more followed by Cellulose,Hemicellulose etc.The moisture percentage is also more so it reacts with the gas which results in the decrease in the percentage of methane.

Tab 3. Characteristics of press-mud[9]

Parameter	Average value(%)
Moisture	76.3
Volatile Matter	76.6
Sugars	6.4
Wax	7.2
C/N ratio	14

The present method of press mud is not good for the environment because in this process non-biodegradable gases are released, but by this process, we can generate a good amount of biogas.The non-biodegradable gases react with the atmosphere and forms a strong bond with some harmful gases and acts as a corrosive agent to ozone.

VIII.FORMATION OF BIOGAS

Biogas is formed by anaerobic digestion using bacteria formed due to biodegradation of organic waste material. It consists of methane, carbon dioxide and small amounts of H₂S,N,CO,O. Methane is the most important thing in the aspect of the formation of biogas fuel.

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Tab 4.Percentage of chemical components[8]

Compound	Percentage
Methane(CH ₄)	50-75
Carbondioxide(CO ₂)	25-50
Hydrogen Sulphide(H ₂ S)	0-3
Hydrogen	0-1
Nitrogen	0-10

After the process of decomposition (fermentation) the main products are:



Using Hydrolysis, the organic materials are broken into simpler elements and the solid waste is liquefied and hydrolysed into small solid molecules like cellulose and it is transformed into soluble sugar.

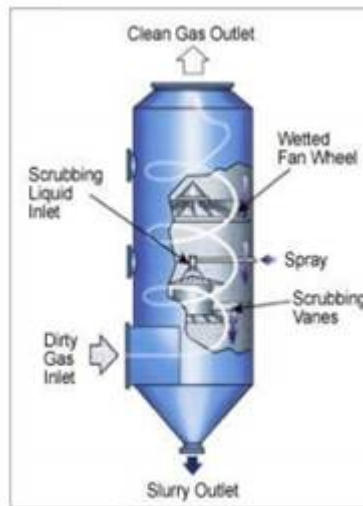


Fig 5. Biogas plant

Using Acidogenesis, the products of hydrolysis are converted into methanogenic substrates, sugars and amino acids by acetogenic(fermentative) bacteria and fatty acids are degraded into acetate, carbon dioxide, hydrogen, VFA(Volatile Fatty Acids), alcohols[5-8].

Acetogenesis: The products formed in Acidogenesis requires an additional transformation to form methane. In this process, bacteria is removed and hydrogen sulphide is formed.

Methanogenesis: The last process where two types of methanogenic bacteria are formed. First one reduces methane acetate to methane and carbon dioxide, the second one reduces methane and Carbon dioxide to Methane and water.[12]



Scrubbing: It is used to eliminate the hydrogen sulphide which is formed along raw gas. This process is necessary because hydrogen sulphide causes the spoiling of internal machinery because it is corrosive in nature. During this process, the raw gas is absorbed then filtered and the methane per volume of gas is increased which is required for biogas. The process behind it is the carbon dioxide and other trace elements are scrubbed by cascading water running counter-flow to the gas. In this process, there will be 2% of methane loss[4].

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Tab 5.Percentage of Gas yield using various substrates [11]

Substrate	Gas yield(L/g)
Press-Mud	0.241
Press-Mud : Cow dung(2:1)	0.202
Press-Mud : Cow dung(1:1)	0.167
Press-Mud : Cane Pith(2:1)	0.290
Press-Mud: Cane Pith (1:1)	0.381
Press-Mud : baggasse(1:1)	0.273

IX.CONCLUSION

The future is green sustainable renewable energy. In order to be a green future, everyone should adapt for the new non-conventional fuels which don't harm our environment. Research in production and application of biogas has been conducted by many universities around the globe. Then why aren't we implementing this technology? The answer is "Lack of awareness". A huge potential market for production of biogas is available. With proper investment and planning, this untapped potential can be harnessed. Every day more and more number of people is exposed to the benefits of the biogas, thus inspiring investments and innovation in this emerging technology.

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