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REVIEW ON PRODUCTION OF ENERGY USING DIFFERENT TYPES OF WASTE MATERIALS

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ABSTRACT

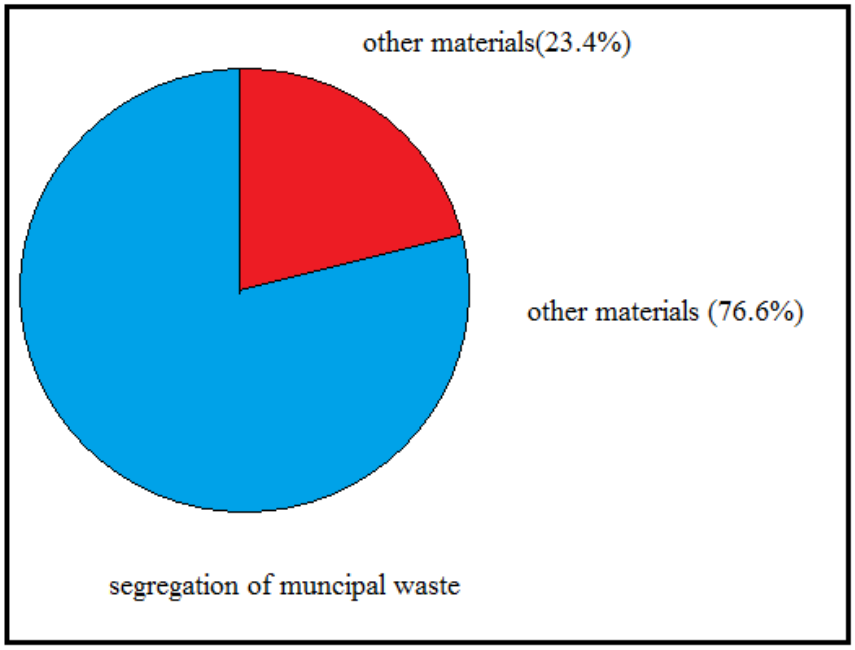
Energy is a complex system. Energy demand must be satisfied with lowest possible stress on environment. At the current rate of growing of industries, their complexity in the demand of energy cannot be satisfied. The stooping petrol reserve sand the increasing cost of imports has led to the emphasis on development of non-conventional sources of energy. Out of the various sources of production of clean energy, biogas has many applications such as internal combustion gas engines,LPG,CNG,turbinesetc.biogas can beproduced from wastematerials suchasseaweed,cattle organs, paper, alcohol,agricultureandmunicipalwaste. In India, 55million tones of waste Is generated annually by urban areas. Use of this waste as biomass would solve the problem of safe disposal of waste and also suffice the growing need of energy. This can be achieved by using proper mixtures in anaerobic digesters. The main part of abiogassystemisa large tank, or digester. Inside bio digesters, methan ogenic bacteria convert organic waste into methane gas through the process of anaerobic digestion. Use of bio gasasan alternative source of energy would help in sustainable development.

***Keywords:** energy, biogas, anaerobic digesters, nonconventional energy*

I. INTRODUCTION

Energy is the backbone of human development and improves the lifecycle. Primarily it is the gift of nature to mankind in various forms. With the growing population and the improvement in living standards the consumption of energy is exacerbating. Progress is directly proportional to consumption of energy. India being a developing country, observes more exploitation of the senatural sources. Thus there is a need of emphasis on production of energy from renewable resources such as wind energy, solar energy, geothermal energy, biomassetc. From the end of 2004, there is an increase in us a geofre newable sources of energy. Owing to globalization and advancements in technology, their efficiency has increased and cost of production has reduced. Today the major source of generation of electricity is solar energy. The senatorial resources have found their application in various walks of life. With the increase in population, there is an increase in waste generation. It is estimated that by 2025, world urban population will increase by 4.3 billion and the waste generated will be around 2.2 billion ton nesa day . This waste is referred to as municipal waste.

This waste consists of various organic products. Using this waste as a source of production of energy is an advancement towards clean and green energy. The waste products are collected in an aerobic digester where methane gas is obtained with the help of living micro organisms. This can be converted to useful heatoras bio fuel.



II. BIO ENERGY

Biogas refers toa mixture of different gases which are produced with the help of living micro organisms in the absence of oxygen. Biogas is produced from materials such as animal waste, manure, kitchen waste, plant material, sewage, green waste. It is a clean source of energy which does not pollute the environment and also has alow carbon footprint. It is produced in metal bio digesters. Raw materials are converted to methane and carbon dioxide and small amounts of hydrogen sulfide, moisture and siloxanes. The gases can further be oxidized using oxygen. This energy released can be used as a fuel. It can be used for heat and electricity generation and also for chores such as cooking. It can also be used in a gas engine, and for production of electricity. Bio gas can be compressed as the same way natural gas is compressed to CNG and used to power motor vehicles. In developed countries such as UK, bio gas is capable and has the potential to replace around 17% of vehicle fuel. Biogas can be treated cleaned and improvised to natural gas standards, when converted to

Sr. No	COMPOUND	%
1	METHANE	50-75
2	CARBONDIOXIDE	25-50
3	OXYGEN	0-0.5
4	NITROGEN	0-10
5	HYDROGEN	0-1
6	HYDROGENSULFIDE	0-3

bio methane.

III. BENEFITS AND APPLICATION

- **Renewable Source of Energy:** Biogas is considered to be a renewable source of energy. It often is composed from materials that form organic waste products. The production of biogas will get affected only when there is no waste to be fermented
- **Non-Polluting:** It a clean source of energy as it does not use oxygen for its production, in anaerobic digesters and hence it does not pollute the environment
- **Cheaper Technology:** Due to globalization, there is advancement in technology. It can be used for cooking, developing electricity, and fuel in vehicles. Production depends on the quantity of raw material and accordingly the number of tanks in the plant.
- **Large number of Jobs:** As rural areas are targeted for establishment of biogas plants, this paves way for work opportunities for the people around. It not only supplies power but solves the problem of rural unemployment.
- **Little Capital Investment:** Biogas are convenient to setup and require less monetary funds if established on a small scale. This way, many farms can become a self dependent biogas plant by using manure and animal waste as a source of biogas. These waste materials are available in excess at any farm.
- **Reduces Greenhouse Effect:** Being a clean source, it reduces global warming effect by using landfills as a source of biogas and this has led to more research and advancement in its production. It uses most forms of biodegradable wasteto convert them to useful energy.
- **A clean fuel:** Biogas is a non polluting source of energy which can also be used as vehicular fuel. The emissions by using biogas are negligible and do not strain the environment. It is observed that biogas emissions such as hydrocarbons and nitrogen oxides are 80% and 60% less as that compared to diesel.

- **Biogas never runs out:** Organic compounds are a useful source for biogas supply. All animal and human waste can be converted to useful energy and the rest products of the anaerobic digestion are used as fertilizers thus proving complete utilization of organic waste. As long as humans and animals exist on the planet, biogas will go on being produced, thus supply is unlimited.

Sr. No.	AIR POLLUTANT	BIOGAS	COAL	OIL
1	CARBON DIOXIDE	120,000	210,000	160,000
2	CARBON MONOXIDE	40	210	33
3	SULPHUR DIOXIDE	1	2600	1100
4	MERCURY	0	0.016	0.007
5	PARTICULATES	7	2700	84
6	NITROGEN OXIDES	92	460	450

3.1 Factors Affecting Biogas Production

3.1.1 C/N ratio

The ratio of carbon to nitrogen in the raw material mixture is called C: N ratio. It is an important factor in maintaining proper environment for digestion. Nitrogen is used for building cell structure and carbon for energy. Required condition for anaerobic digestion ranges from 20-30:1. With too much carbon in the raw wastes, nitrogen will be used up first and carbon will be left over, which will make the digestion slow down and gradually stop. With excess nitrogen, the carbon gets exhausted and fermentation stops. The left over nitrogen will combine with hydrogen to form ammonia. This affects or inhibits the growth of bacteria

3.1.2 Temperature

Temperature has an effect on the rate of chemical processes happening inside the digester. Rise in the temperature increases the rate of reaction, increasing the biogas production as well. Ideal temperature for methane bacteria is around 350 – 380 C. The decrease in rate of gas production starts at 200C and stops at a temperature of 100 C.

3.1.3 Loading rate

Loading rate is the amount of raw material supplied to the digester per day per unit volume. If there is excess of raw material, acid accumulation will be more. This affects daily gas production. On the other hand, if there is under loading, there is negative impact on digester

3.1.4 pH level

For constant supply of gas, an optimum pH range has to be maintained in the digester. pH of the slurry is not constant at all stages of the digestion. At the start of fermentation process, the pH is around 6 or less and much of CO2 is given off. In the next 15-20 days time, the pH increase as the volatile acid and N2 compounds are digested and CH4 is produced. In the pH range of 6.5-7.5, the micro – organisms will be very active and digestion will be very efficient. Between a pH range of 4 and 6, it is called acidic and between 9 and 10 it is called alkaline. These temperatures are detrimental to the methanogenic (Methane production) organisms.

IV. REVIEW OF SOME RESEARCHERS

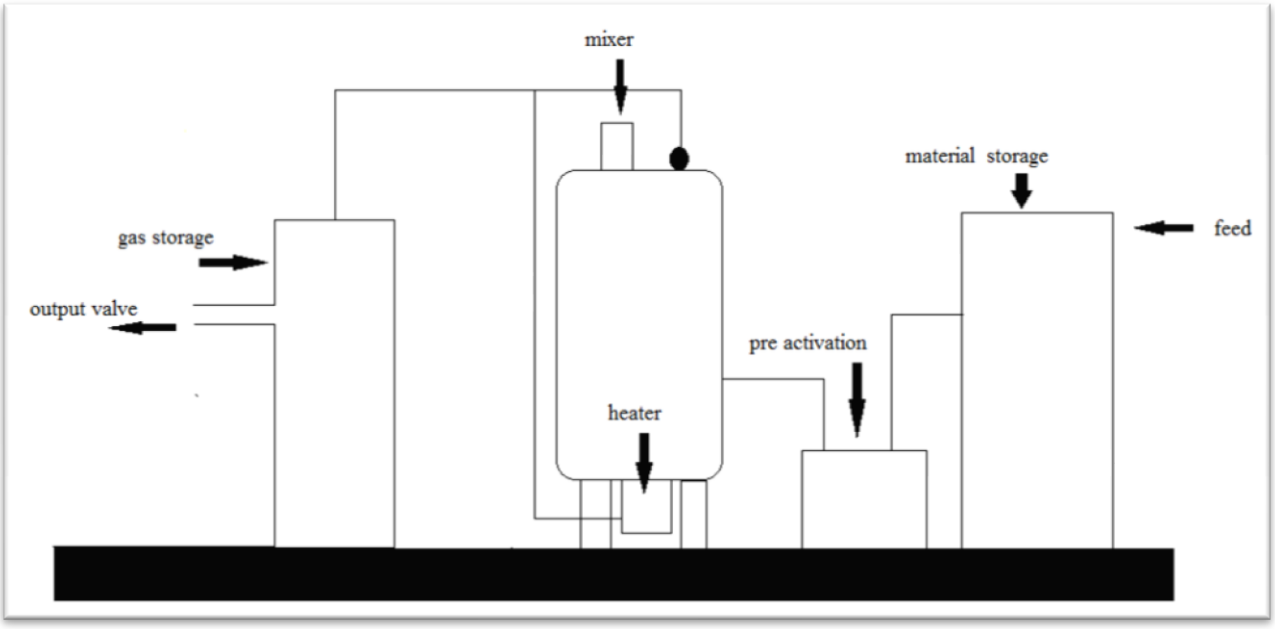
4.1 Ofoefule, Akuzuo U et al [1]:-The content of biogas varies with the materials being decomposed and the environmental conditions. Thenutrients have an effect on the rate of production and the contents of the gas produced. Many other waste products are being tested for production of biogas. In this paper, the production of biogas using a blend of paperwaste and cowdung was done. Waste paper can be collected from various sources such as schools, offices, factories and many a times it is found on streets as litter. This would prove as a very cheap source for production of biogas. The experimental setup consists of a storage tank, a mixer, a pre treatment tank and a storage tank. The slurry is provided in the storage tank from where it is passed through the pre treatment tank to the mixer and finally to the gas storage tank. This can be used as an output for various purposes. Using cow dung as an additive increases the yield by about 50% and from onset of the retention period, flammability is observed on the 6^{th} day. A full study was undertaken to check for properties such as cumulative biogas yield, onset of gas flammability and retention period. The results proved that paper waste is an excellent source of biogas. To enhance its properties, the method of co-digestion was used. The other component used was cow dung. The components were taken in a ratio of 1:1.

4.1.1 Material Specification

- waste paper
- cow dung as part of blend

4.1.2 Result

- Biogas can be produced using a blend of paper and cowdung
- The gas produced using the blend has a sustained gas flamability



experimental setup of anaerobic digestion

4.1.3 Specification

1. Top loading balance
2. water bath for soaking the paper waste
3. water trough and transparent plastic bucket for measuring volume of gas produced
4. thermometer , digital pH meter
5. Hose pipe, biogas burner for checking gas flammability.

4.1.4 Experimentation

The paper waste was soaked in a plastic water bath overnight to allow for partial decomposition and the pH was recorded. For the PW: CD (paper waste: cowdung), 4kg each of paper waste and cow dung were blended and mixed with 27kg of water, for the required ratio of 3:1. The moisture content of the wastes determined the water to waste ratio. The paper blend was charged into the digesters as originally prepared and weighed. The wastes were filled up to head of the digester leaving a quarter of head space for collection of gas. The digester contents were stirred sufficiently to ensure proper homogenous dispersion of the constituents of the mixture. Gas production measured in dm^3/kg was collected in tanks by downward displacement of water by the gas. The supply was checked for its moisture, carbon, nitrogen and protein contents. pH levels are noted before supply and the temperatures are monitored daily during the retention period. Also, microbial analysis is done at all 4 stages. Thus after complete analysis, the supply is fed to the digesters where due to anaerobic action of

methanogenic microbes during retention period, biogas is produced. This biogas is produced is stored and tanks and provided for various purposes.

On the basis of the experiment, the following tables were prepared,

Sr. No.	Parameters	PW:CD
1.	Ash content	21.30%
2.	Carbon content	37.40%
3.	Crude fat	0.8%
4.	Crude Fiber	53.40%
5.	Crude protein	8.92%
6.	Crude nitrogen	1.43%
7.	Total solids	93.8%
8.	Moisture	6.2%
9.	Energy kcal/g	3.97
10.	Volatile solids	72.5%
11.	c/n ratio	22.89

Sr. No	Parameters	Paper blend
1.	Lag period (days)	5
2	Mean volume of gas produced	2-2.30
3	Cumulative yield (dm^3/kg)	9.38

4.1.5 Results and Discussion

Thus paper waste in a blend with cow dung is an excellent source of biogas which can be used as a fuel for cooking or in transportation. Instead of being burned as a waste and polluting the environment, it can be further researched on and developed as a source of energy production.

4.2 Per Olsson et al [2]:-Algae and sea weed form a major part of the marine biomass. Algae smells bad and is cause of an increased nutrient load. Removing the algae from the water's edge can reduce the impact of eutrophication and contribute to the maintenance of important habitats for both fish and birds. In this paper an attempt has been made to produce biogas using these Algae and sea weeds. Various samples from different places were collected and tested for the content of heavy metal in them. This content affects the rate of productivity. The supply should have enough carbon and nitrogen for production of biogas. The residue left after digestion can be used as a fertilizer but the heavy metals should be treated. Also metals like sulfur may form hydrogen sulfide instead of methane. Cadmium is one of the major metals found which inhibits the process and is also dangerous for plants if used as a fertilizer. The purification can be done by extraction or microbial metal dissolution. This is generally an acidic treatment where in the metal gets eliminated. Various other methods like floatation, coagulation and precipitation, membrane filtration etc. purify the supply. After purification, the supply is fed to the digesters for anaerobic treatment. It can be a one or multistep process.

Multiple tanks are preferred for better digestion. Wet algae over solid algae are preferred. At a temperature of 35ºC, best results are obtained. Thus after proper purification, biogas with methane content ranging from 55%-70% can be produced.

4.2.1 Material Used

- wet or solid algae with proper proportion of water is used as a raw material with methanogenic or acetogenicmicro organisms for anaerobic digestion

4.2.2 Result

- best results are obtained at a temperature of 35ºC
- There is potential of biogas production by using seaweed and algae with methane content varying between 50%-70%
- proper purification can be done and the marine biomass can be treated of heavy metals by treating the sewage that enters the sea
- after digestion of supply material, the left over sludge can be used as a fertilizer

4.3 Samuel N. M. de Souza et al [3]:- Alcohol is one of the most consumed beverages all around the world. It is made with the help of sugarcane, wheat molasses etc. the waste products in the production of alcohol is vinasse which is also a part of fertilizer. In this paper, experiments have been performed to produce biogas using vinasse found in sugarcane and alcohol. First the properties of the fuel to be replaced were studied and the requirement of the quantity of biogas required. 10 liters of vinasse is obtained during production of 1 liter of alcohol. About 14.6 meter cube of biogas is produced using vinasse as raw material. During anaerobic treatment, frequent checks for temperature and ph level are done. The quantity of gas produced is also kept in check. Room temperature is to be maintained for proper digestion of the substrate. The substrate was checked for ratios of vinasse to water. There is about 55% of methane in the gas produced. In Brazil, vinasse could replace diesel as bus fuel. Vinasse has high potential to produce biogas and approximately about 20 million per day. This has powered 1018 buses every day i.e. in Brazil, for about 200 days the buses are powered using biogas and the rest 165 days, CNG is used. After digestion, the left over sludge is used as a fertilizer. This vinasse which polluted water and soil, after treatment is used as a bio fertilizer. However, this biogas requires suitable internal combustion engines with proper pressure and temperature.

4.3.1 Material Specification

- A waste material found in production of alcohol and sugar known as vinasse is used for production of biogas.
- vinasse is collected from ethanol and alcohol industries
- it is taken in the ratio of 1:3 since it gives the highest cumulative gas production

4.3.2 Results and Discussion

- using vinasse as a raw material for production of biogas helps in solving the problem of safe disposal of this waste material as it pollutes the environment
- it is unavailable for about 165 days a year
- it requires specific temperatures and pressure for working if it has to be used as a fuel and requires specific internal combustion engines

- the cost of the vehicles increases
- With more development and advancement in technology, it could replace as vehicular fuel and thus help in sustainable progress.

4.4 Adnan Jamil et al [4]:- different sources of raw materials are being tried and tested for production of biogas. Another unusual source of biogas is cattle organs. Method and technology are being developed to produce methane from dead animal organs such as cow organs. The Swedes were able to find the breakthrough for production of methane. They were able to produce energy sufficient to run a train for about 4 kms and that too from the organs of a single cow. The method for production of biogas is same which involves using of anaerobic bacteria to produce energy. The slurry consists of unused organs such as intestines. It is heated to a temperature of 70 degree Celsius for about 60 minutes and then is packed into the digesters. The retention period is about a month. It is continuously stirred at a constant temperature of 37 degree Celsius. This continuous stirring leads to separation of methane from the slurry. Since there is enough consumption of meat all around the world, acquisition of raw material is not a challenge. The developed countries are advancing in producing biogas but the under developed countries lack funds and technology. The rural areas are deprived of all the conveniences of energy. This problem can be solved by using this cheap source of energy. This will help in a sustainable development of the country. This research emphasizes on the use of family sized digesters so that people in developing countries are independent and their need of energy is sufficed. Using cow organs is cheaper than using any other source such as crops, manure etc. Thus energy is produced without much of investments

4.4.1 Material Specification

- unused cattle organs are like guts, intestines, stomach etc. which are easily available are used
- family sized digesters are used, keeping in mind the rural population

4.4.2 Results and Discussion

- Use of dead cattle organs as a source is cheap and can be adopted by rural villages in developing countries
- instead of using firewood and coal which are non renewable sources of energy and are polluting, dead cattle organs do not pollute
- usage of organs of dead animals is cheaper and produces enough energy to suffice their needs of energy

4.5 A.Apte et al [5]:-with growing technology, there is more demand of luxuries. With growing luxuries, more and more resources are being exploited. The growing population generates a lot of waste. As per the surveys, there are 3 billion residents living in cities who generate about 1.2 kgs of waste per day. According to rate of growing population there will be about 4 billion residing in cities and the waste generated will be about 1.4 kgs per day. This paper investigates the potential of production of biogas using kitchen waste. Biogas is produced in anaerobic digestors. The main composition of the biogas consists 40-60% of ash, papers about 3-6% and plastics. Also the C/N ratio is about 20-30. Using this as a fuel would replace the generalized method of disposing kitchen waste. When this waste is dumped on roads or used as land fills it attracts a lot of diseases. Bad odour and mosquito breeding are the common problems faced by residents around. Also the waste collected was checked for its calorific value and also for its volatile content. The moisture and ash content found in

municipal waste are as per the required quantity. Kitchen waste can surely be used as biogas. The methane produced can be aptly used for replacing the commercial fuel.

4.5.1 Material Specification

- municipal waste was collected from various sources this waste for checked for properties such as ash, moisture content, volatile solids and its calorific value
- this waste is provided in the slurry and then it is digested in aerobic digesters which produce methane in sufficient quantity

4.5.2 Results and Discussion

- The samples collected were suitable for anaerobic digester as they had about 70% moisture and about 85% volatile matter which improves the biogas yield.
- This will solve the problem of the disposal of the enormous amount of waste generated
- This waste is sufficient to suffice the growing needs of energy

4.6 Attila Meggyes, Valéria Nagy et al [6]:-biogas is a clean source of energy that is finding its way in various walks of life. The technological advancement has led to research in various sources of raw material used as supply. This paper investigates the use of animal excretion from animals like pig, cow, sheepetc which are found on farmlands. The various samples were checked for their properties and also in a way to solve the problem of environment pollution. Also to increase the yields and the quality of gas, various plant additives were added to the slurry. Testing the utilization of this gas as fuel in different engines and checking the emissions for any harmful pollutant was the primary objective. With the production of biogas, the purpose of waste disposal and production of environment friendly fuel is realized. This again proved the relation between energy and agricultural waste. Initially the results after fermentation were not upto the mark and thus tests with other additives were conducted. Of the total manure, only 4% of the total waste consisted of solid particles. The retention period was about 1.5-2 months. With proper temperatures and stirring, methane was produced. Quantity of methane depends on the variant added. It ranged between 53%-70%. Additives such as fruit marc and maize marc were added. They had their own pH level which influenced the rate and quality of gas produced. Additives increased the quantity of volatile matter in the slurry which increased the methane content. This gas was tested for gas engines and it proved apt with certain variants

4.6.1 Material Specification

- slurry consisted of pig manure and water in appropriate levels with sufficient moisture, volatile compounds and c/n ratio
- the additives were waste materials like fruit marc and wheat marc

4.6.2 Results and Conclusion

- The utilization of agricultural waste as a source of biogas supply has sufficient potential if proper experimentation is done
- with additives, the quality of biogas improves and the methane content rises
- this gas is tested for IC engines and it suffices the requirements
- proper management of waste disposal and energy production is achieved
- an alternative fuel is prepared and it can be further upgraded by appropriate additives

V. CONCLUSION

With growing population the need of energy is increasing. The scarcity of the natural resources is adding to the problem. Biogas has come out as an alternative source of energy. With more research, biogas will completely replace the conventional fuel. Using biogas solves the problem of safe disposal of waste and also it is pollution free and environment friendly fuel. This will also encourage the use of more renewable and green energy-using machinery which will lessen the load on conventional fuels and will reduce impact of greenhouse gases on the environment.

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