ISSN 2229-5518

Utilization of a Noble Renewable Energy efficaciously and Essentiality Considering the Third World Country

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Abstract: Electricity availability for agrarian society, so long, has been a disparity in context of third world countries as Bangladesh. Realizing this, many organizations along with Bangladesh government are trying to bring renewable energy in a competitive package to meet deficiency. In respect of Bangladesh there is huge possibility to use lot of wastage as renewable energy. The wastage of kitchen, sewage, dead plants and crops, cow dung etc. all these are good sources of Biogas and are available near the grasp of hands a lot. Different types of biogas purification method have been tested with good results. Some are easier to operate, but less effective in purifying biogas. Others require more attention and expense to operate, but produce significantly more purified biogas. As Bangladesh is having a big population the production of wastes are huge, it will be a great asset if this wastes can be utilized to produce biogas. These wastes not only pollute the environment these are the cause of lots of disease and endemics. Also the placements of these wastages are problems. So the process and utilization of these wastes will make the scope of biogas production as renewable energy which can be a cheap source of power generation, moreover it will help to preserve our healthy and beautiful environment situation. This paper based on discussion and analysis of various methods of production and purification to produce refining biogas. This paper also gives a short overview of raw materials available in Bangladesh which is having the highest efficiency to produce biogas.

Keywords: Biogas, Biogas raw materials, Bangladesh, Purification process, Purification analysis, Production method, Production analysis.

1. Introduction: Biogas is a gaseous bio fuel originates from biological breakdown of organic waste and biogenic components such as dead plant, animal feces, kitchen waste, human excreta, water hyacinth etc. Biogas is formed by the anaerobic digestion or fermentation or a state of agitation of bio degradable materials such as biomass, manure, sewage, municipal waste, green waste, plant material, and crops. Biogas incorporates primarily Methane (CH_4) 50-75 %, Carbon dioxide (CO_2) 25-50 %, Nitrogen N_2 0-10 % and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes. It is a renewable source of energy, can be used as fuel for cooking, lighting directly but producing electricity from biogas is still relatively rare in most developing countries. In Germany and other industrialized countries, power generation is the main purpose of biogas plants; conversion of biogas to electricity has become a standard technology. The main barrier of using biogas as the fuel of generator is its corrosive nature at unpurified state. If biogas is purified we can get biofuel containing methane (CH_4) 90-97%, methane is also the main component of natural gas, by compressing this natural gas we can get CNG which is mainly used in Bangladesh as vehicle fuel and also it can be used for the generation of electricity. So with the purification process of Biogas (involving removal of CO_2 and H_2S) we can use the Biogas as the Natural gas later this can be converted to CBG (compressed Bio-gas) which is having similarity with CNG.

Information: Evidence suggests biogas was used to heat bath water as long ago as 10BC in Assyria.

Population of Bangladesh is highly dense. The large portion of people of urban and rural areas still use fire wood, animal excreta and agricultural residues for domestic cooking which causes high deforestation rate. Vegetation covers only 9-10 % of total land, which is lowest as world average. To meet the required energy demands in rural and urban areas the dependency on fire woods increasing day by day, this leads to higher deforestation rate than the forestation so resulting in environmental degradation. Uses of fire wood increases at rate of 2% annually. The high cost of petroleum, below required coverage of electricity grid and increasing scarcity of fire woods due to deforestation may occur to energy deficit situation. Environmental experts predicted massive deforestation if crisis is not being met from alternative sources. The energy sector requires a gradual shifting towards renewable energy sources to avoid this kind of crisis situation. According to economic situation of Bangladesh biogas technology and its utilization could be a cheap option of renewable energy source. In Bangladesh neither the decision-makers nor the experts pay due importance on proper extraction and use of natural resources. With the present rate of consumption, natural energy resources like gas will be exhausted shortly and this is high time to derive policy and practice for exploration and use of alternative renewable sources if we want to meet energy crisis in near future.

1.1 A short brief discussion about Biogas:

Chemical reactions involved in Biogas production

1) $C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$
2) $CO_2+4H_2 > CH_4+2H_2O$
3) $CH_3COOH > CH_4+ CO_2$

Biogas production process (Anaerobic digestion) is a multiple-stage process in which some main stages are:

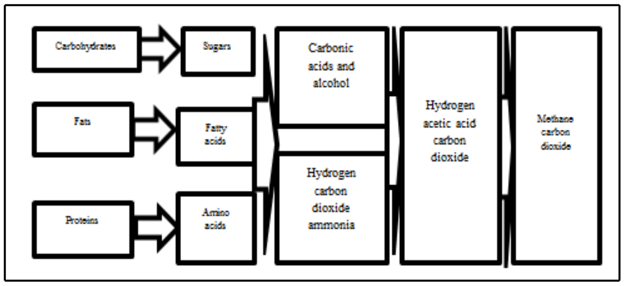

Figure: Biogas production process. [Reference:]

2. Raw materials availability in Bangladesh:

2.1 Energy Crops: An energy crop is a plant grown as a low-cost and low-maintenance harvest used to make biofuels, or combusted for its energy content to generate electricity or heat. Energy crops are generally categorized as woody or herbaceous plants; many of the latter are grasses.Woody crops such as willow or poplar are widely utilized, as well as temperate grasses such as Miscanthus and Pennisetum purpureum (both known as elephant grass). If carbohydrate content is desired for the production of biogas, whole-crops such as maize, Sudan grass, millet, white sweet clover and many others can be made into silage and then converted into biogas.

Elephant grass is native to tropical and sub-tropical regions of Bangladesh. It has shallow roots which mean it does not penetrate waste within soil that is contaminated on brownfield sites. The elephant grass plants absorb carbon dioxide and it provides a local environmentally friendly energy source. Maize is a versatile crop and is more nutritious than rice in terms of protein, phosphorus, fat content and also in trace elements like magnesium, potassium and sulphur. It has an insignificant coverage of only 0.2 per cent of rice and three per cent of wheat acreage. With the introduction of high yielding seeds, its area and production have been expanding fast and it reached the level of 65,000 tons in 1997/98 from cultivation of 15,000 hectares of land. Among different districts of the country, Dinajpur, Rangpur, Bogra, Kushtia, Chuadanga and Dhaka are observed to be more progressive in maize cultivation. This can be really used to produce high quality of Biogas.

The millets are a group of small-seeded species of cereal crops or grains, widely grown around the world for food and fodder. They do not form a taxonomic group, but rather a functional or agronomic one. Their essential similarities are that they are small-seeded grasses grown in difficult production environments such as those at risk of drought. They have been in cultivation in East Asia for the last 10,000 years.

So, we can understand that it is possible to grow high quality of energy crops in Bangladesh, which we can use to produce high quality of Biogas. This could open a new business source and it can create new occupations. Government should take necessary steps to encourage the production of high quality energy crops mainly dedicated to production of high quality of biogas.

Information: The production of biogas from dedicated crops yields more energy per hectare than any other biofuel production path these crops are called energy crops.

2.2 Cow dung: Bangladesh has a great potential for development of biogas technology. The cattle population including buffaloes is about 24.19 million (1996), which yield about 242 million kg of cattle wastes per day. This waste has a potential of production of 3.19109 cu m of gas. If even 50% of the cattle wastes could be used for biogas Production, about 1.36 million biogas digesters of the capacity of 3 cu m could be set up. A biogas digester of 3 cum capacity could provide the energy requirements for cooking and lighting of a family consisting of 7-8 members. Such a digester would require 60-70 kg cow dung which could be obtained from 5-6 cattle or 3-4 buffaloes. Apart from the benefits of energy, the treated slurry could be used as fertilizer, since it is a bonus from biogas production.[Ref: Banglapedia]

2.3 Rice husk: Bangladesh produces more than 46 million tons of paddies each year. About 70% of this paddy is processed in local rice mills to produce food grain rice. Husk is produced as waste biomass during the rice processing. Annual rice husk production is about 9.0 million tons in Bangladesh. 200 number of rice mills were surveyed from four major rice processing zones viz. Pulhat (Dinajpur), Naogaon, Bogra, and Ishawrdi (Pabna) clusters to explore available husk and to estimate potential of electricity generation from rice husk. Total paddy processed in these clusters was 3.62 million tons. Amount of surplus husk for selected rice processing zones is estimated to be 455356 tons per year. The potential power capacity is estimated to be 41450 MW based on the estimated available rice husk considering the steam turbine technology used for electricity generation.[ref: needed]

2.4 Sewage: Sewage sludge compositions vary from city to city as well as day to day. In Dhaka city itself produces 54750 tons (approximately) sewage sludge containing about 1000 to 1400 tons of nitrogen and 350 to 500 tons phosphorus are produced per year. (BARC 1997)

Information: The largest single facility for producing biogas is the Liaoing Huishan Cow farm project in China, which produces 38,000 MWH of electricity each year.

3. Production of Biogas:

A biogas plant is the name often given to anaerobic digester. Organic materials like cow dung and other organic matters fermented under an anaerobic condition produce a combustible gas where a chamber is required to complete the anaerobic digestion process. This usually occurs a dome shape chamber with inlet and outlet chamber. These plants can be fed with biodegradable wastes including sewage sludge and food waste. During the process, as an air-tight tank transforms biomass waste into methane producing renewable energy in the presence of water. The two types of bio gas plants are:

1. Floating gas-holder type 2. Fixed dome type

3.1 Floating gas holder type of plant: A well is made out of concrete. This is called the digester tank. It is divided into two parts. One side has the inlet, from where slurry is fed to the tank. Generally slurry is made from cattle dung and water, which forms the starting material for these plants. The tank has a cylindrical dome made of stainless steel that floats on the slurry and collects the gas generated. Hence the name given to this type of plant is floating gas holder type of bio gas plant. The slurry is made to ferment for about 50 days. As more gas is made by the bacterial fermentation, the pressure inside increases. The gas can be taken out through outlet pipe. The decomposed matter expands and overflows into the next chamber in tank. This is then removed by the outlet pipe to the overflow tank and is used as manure for cultivation purposes. In the floating gas holder type of plant, the floating chamber is made of stainless steel. This is expensive and needs continuous maintenance and supervision for non-rust. This does not arise in the fixed – holder type of bio gas plant as everything here is made of concrete.

3.2 Fixed dome type of plant: A well and a dome are made out of concrete. This is called the digester tank. The dome is fixed and hence the name given to this type of plant is fixed dome type of bio gas plant. The function of the plant is similar to the floating holder type bio gas plant. The used slurry expands and overflows into the overflow tank. Fixed dome type of bio gas suffers from a disadvantage that its volume is fixed. So if the gas pressure increases inside, it may cause damage to the concrete dome. This does not happen in the floating holder type of bio gas plant.

3.3 Portable type biogas plant: Portable type biogas type is also available. In India various places portable type biogas plant are used to meet daily cooking energy. This could be also very profitable in Bangladesh if it is properly utilized. If the price of these plants is cheap these can be used in rural and urban areas to meet daily cooking. Also big type portable biogas plant can be installed in the CNG and fuel station along with the purification process to produce purified methane gas 90-97 % which can be alternative of Natural gas and if it is compressed it can be substitute of CNG.

Information: Compressed biogas (CBG) is the most climate friendly of more than 70 different fuels and is considered to be CO_2 neutral.

Below table shows Compositional analysis of Biogas produced from each substrate (cm3):

Substrate	Total biogas (cm^3)	CH_4 (cm^3)	CH_4 (%)	CO_2 (cm^3)	CO_2(%)	H_2S (cm^3)	H_2S (%)
Cow dung	8545	5639.85	66.00	2830.50	33.00	74.65	1.00
Millet husk.	6525	3790.00	58.08	2657.20	40.72	52.26	1.00
Rice husk.	1386	900.50	64.97	462.12	33.00	22.40	2.00
Saw dust	974	670.00	68.79	288.83	29.65	14.93	1.53
Paper waste	476	345.54	72.59	115.53	24.27	14.93	3.14

Table: Compositional analysis of Biogas produced from each substrate (cm3) [Ref:]

Graphical representation of biogas production potential from different wastes:

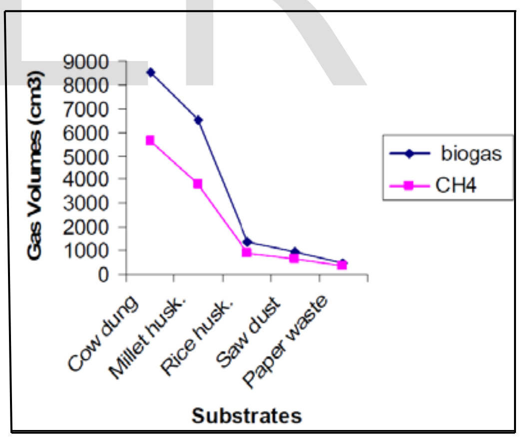

Figure: Relative proportions of methane in biogas samples from various Substrates. [Reference:]

4. Purification methods of biogas:

4.1 Water Scrubbing: Water Scrubbing: Water scrubbing is used to remove CO_2 and H_2S from biogas since these gases are more soluble in water than methane. The absorption process is purely physical. Usually the biogas is pressurized and fed to the bottom of a packed column while water is fed on the top and so the absorption process is

ISSN 2229-5518

operated counter-currently. Raw biogas is compressed up to 1.0Pa pressure to enhance solubility of CO_2 in water. Water scrubbing can also be used for selective removal of H_2S since H_2S is more soluble than carbon dioxide in water. The water which exits the column with absorbed CO_2 and H_2S can be drained; later on it can be regenerated and re-circulated back to the absorption column.

Polyethylene Glycol Scrubbing: Polyethylene glycol scrubbing relies on the same underlying mechanism as water scrubbing, with a physical absorption process that works because both CO_2 and H_2S are more soluble than methane in the solvent. Selexol is the trade name for one of the common solvents used for this process. The big difference between water and solvents is that CO_2 and H_2S are more soluble in Selexol which results in a lower solvent demand and reduced pumping. In addition, water and halogenated hydrocarbons (contaminants in biogas from landfills) are removed when scrubbing biogas with Selexol. Selexol scrubbing is always designed with recirculation. Due to formation of elementary sulfur stripping the Selexol solvent is normally done with steam or inert gas rather than with air. Removing H_2S beforehand is an alternative.

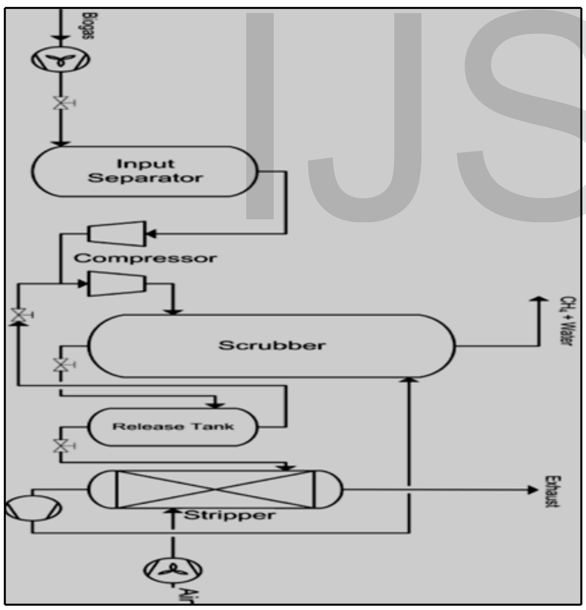

Figure: Flow chart of Water scrubbing method. [Reference:]

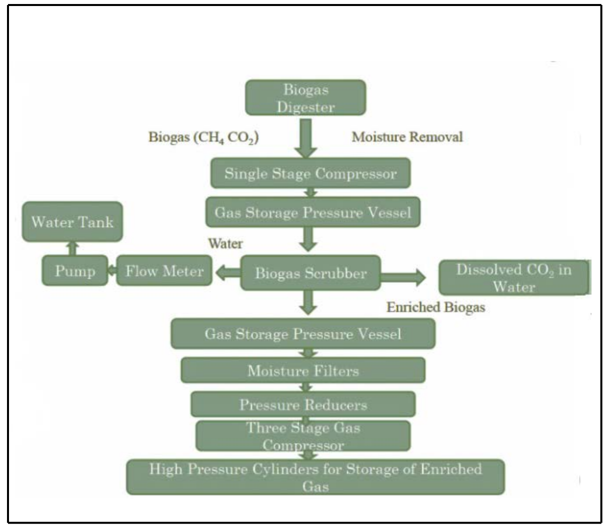

Figure: Algorithm of Water scrubbing method.(Reference:)

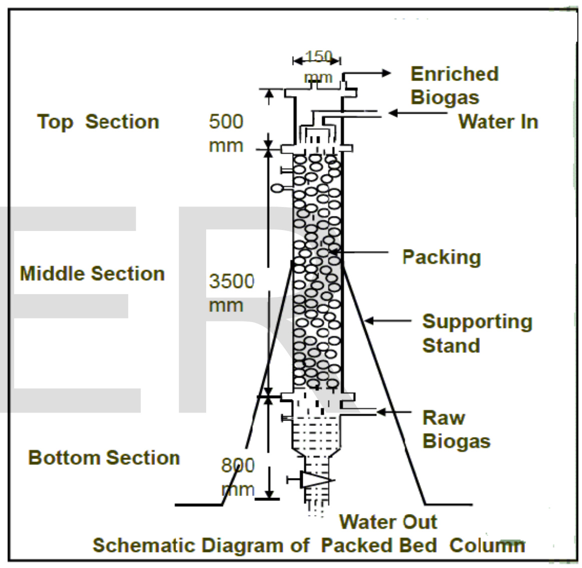

Figure: The setup measurement of scrubbing technology. [Ref- BIOGAS PURIFICATION USING WATER SCRUBBING SYSTEMS by Dr. Virendra K. Vijay; Indian Institute of Technology, Delhi]

4.1.1 Advantages:

*No special chemicals required (except relatively inexpensive PEG) and removal of both $CO_2$and H_2S.

4.1.2 Disadvantages:

* Requires a lot of water.

* Limitations on H_2S removal, because the CO_2decreases pH of the solution

* Corrosion to the equipment caused by H_2S.

Cost: 13.02 BDT/Nm^3biogas (De Hulluet al., 2008).

4.2 Chemical Absorption:

Chemical absorption process depends on reversible chemical bonds between the solute and the solvent. Regeneration of the solvent, therefore, involves breaking of these bonds and correspondingly, a relatively high energy input. Chemical solvents generally employ either aqueous solutions of amines (i.e. mono-, di- or tri-ethanolamine) or aqueous solution of alkaline salts (i.e. sodium, potassium and calcium hydroxides). MEA solution can be completely regenerated by boiling for 5 min and is then ready for re-use. The experimental study and research of M.S. Horikawa, F. Rossi, M.L. Gimenes, C.M.M. Costa and M.G.C. da Silva on “CHEMICAL ABSORPTION OF H_2S FOR BIOGAS PURIFICATION” showed that with their chemical absorption process it is possible to achieve the complete removal of H_2S from biogas using an iron-chelated process that operates at ambient temperature. Also there process included the conversion of Sulfur from H_2S.

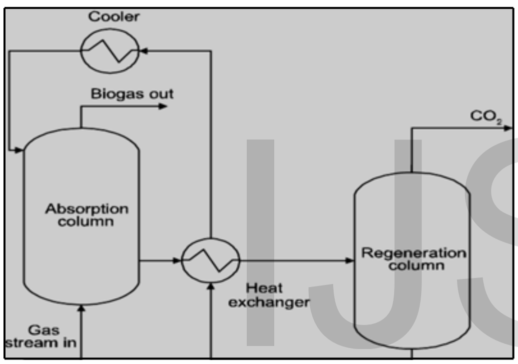

Figure: Flow chart of Chemical absorption process [Reference:]

4.2.1 Advantages:

* Complete H_2S removal.

* High efficiency and reaction rates compared to water scrubbing.

* Ability to operate at low pressure, the process is commonly used in industrial applications, including natural gas purification (Kim et al., 2004; Palmeri et al., 2008).

4.2.2 Disadvantages:

*Additional chemical inputs needed

* Need to treat waste chemicals from the process

Cost: 17.03 BDT/Nm3biogas (De Hulluet al., 2008)

4.3 Pressure Swing Adsorption:

Pressure Swing Adsorption (PSA) is a technology used to separate some gas species from a mixture of gases under pressure according to the species' molecular characteristics and affinity for an adsorbent material It operates at near-ambient temperatures and so differs from cryogenic distillation techniques of gas separation. Special adsorptive materials (e.g., zeolites and active carbon) are used as a molecular sieve, preferentially adsorbing the target gas species at high pressure. The process then swings to low pressure to desorb the adsorbent material (Cavenati et al., 2005).The PSA process relies on the fact that under pressure, gases tend to be attracted to solid surfaces, or "adsorbed". The higher the pressure, the more gas is adsorbed; when the pressure is reduced, the gas is released, or desorbed. PSA processes can separate gases in a mixture because different gases tend to be attracted to different solid surfaces more or less strongly. During biogas purification, the adsorption material adsorbs H_2S irreversibly and thus is poisoned by H_2S. For this reason a preliminary H_2S removing step is often included in the PSA process’s using zeolites or activated carbon at different pressure levels is an effective method for the separation of CO_2 from methane (Grande and Rodrigues, 2007; Pinto et al., 2008).

4.3.1 Advantages:

*More than 97% CH_4 enrichment.

*Low power demand.

* Removal of nitrogen and oxygen.

4.3.2 Disadvantages:

* AdditionalH_2S removal step is needed before PSA.

* Tail gas from PSA still needs to be treated.

* Relatively expansive.

Cost: 40.07 BDT/Nm^3 biogas (De Hulluet al., 2008)

4.4 Membrane Process:

The principle of membrane separation is that some components of the raw gas are transported through a thin membrane while others are retained. The permeability is a direct function of the chemical solubility of the target component in the membrane. Solid membranes can be constructed as hollow fiber modules or other structures which give a large membrane surface per volume and thus very compact units. Typical operating pressures are in the range of 25-40 bars. The underlying principle of membrane separation creates a tradeoff between high methane purity in the upgraded gas and high methane yield. The purity of the upgraded gas can be improved by increasing the size or number of the membrane modules, but more of the methane will permeate through the membranes and be lost. There are two membrane separation techniques: high pressure gas separation and gas-liquid adsorption. The high pressure separation process selectively separates H_2S and CO_2 from CH_4. Usually, this separation is performed in three stages and produces 96% pure CH_4. Gas liquid adsorption is a newly developed process that uses micro-porous hydrophobic membranes as an interface between gas and liquids. The CO_2 and H_2S dissolve into the liquid while the methane (which remains a gas) is collected for use (Chatterjee et al., 1997; Harasimowicz et al., 2007).

4.4.1 Advantages:

* Compact and light in weight

* Low energy and maintenance requirements

* Easy processing.

4.4.2 Disadvantages:

* Relatively low CH_4 yield and high membrane cost

Cost: 12.02 BDT/Nm3biogas (Difficulties with yield and purity and potential for fouling membranes raises operating costs)

4.5 Cryogenic Separation:

Cryogenic separation of biogas is based on the fact that CO_2, H_2S and all other biogas contaminants can be separated from CH_4 based on the fact that each contaminant liquefies at a different temperature-pressure domain. This separation process operates at low temperatures, near -100oC, and at high pressures, almost 40 bars. These operating requirements are maintained by using a linear series of compressors and heat changers. Crude biogas streams through the first heat exchanger which cools the gas down to 70oC. This heat exchanger makes use of the product stream as cooling medium, which is energy efficient and has the advantage of preheating the upgraded biogas before leaving the plant. The first cooling step is followed by a cascade of compressors and heat exchangers which cool the inlet gas down to -100oC and compress it to 40 bars before it enters the distillation column. Finally, the distillation column separates CH_4 from the other contaminants, mainly H_2S and CO_2.

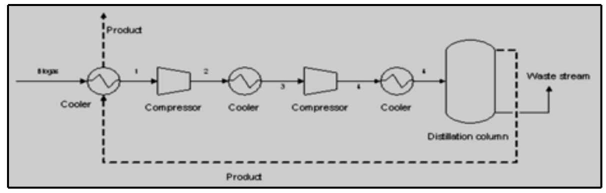

Figure: Flowchart of Cryogenic process. [Reference:]

4.5.1 Advantages:

* High purity of the upgraded biogas (99% CH_4).

* Large quantities can be efficiently processed.

4.5.2 Disadvantages:

* Use of considerable process equipment, mainly compressors, turbines and heat exchangers.

* Higher capital and operating costs relative to others.

Cost: 44.08 BDT/Nm3 biogas (De Hulluet al., 2008)

4.6 Bio-filter Process:

Biological processes are widely employed for H_2S removal, especially in biogas applications. Because chemical use is limited, they are often economical and environmentally friendly (Duan et al., 2006; van der Zee et al., 2007). The use of chemotropic bacterial species (Thiobacillus genus) to condition biogas is well established. Microalgae cultures have also been examined but the available literature is short and cannot help in appropriately evaluating this option. Another methodology deploys anaerobic phototrophic bacteria (Cholorobium limicola) capable of oxidizing H_2S in the presence of light and CO_2. No known commercial applications at this time use phototrophic bacteria. The following text therefore focuses on chemotrophic bacteria.

Chemotrophic thiobacteria can purify H_2S in both aerobic and anaerobic pathways. Most thiobacteria are autotrophic, consuming CO_2 and generating chemical energy from the oxidation of reduced inorganic compounds such as H_2S. These processes commonly produce $SO_4 2-$ and S^0 as waste products.

4.6.1 Advantages:

* Low energy requirement, mild conditions and the elemental sulfur byproduct.

* Sulfur can be re-used for the production of sulfuric acid, hydrogen sulfide or agricultural applications.

4.6.2 Disadvantages:

* Additional nutrients are required for bacteria.

* Small amount of O_2 and $N_2$are left in treated biogas.

* H_2S removal efficiency depends on activity of bacteria.

5. Analyzing:

After analyzing the above discussed processes we have seen that water scrubbing is the cheapest process although there are some limitations on H_2S removal, because the CO_2 decreases the pH of the solution. So, it is better to H_2S removal before the water scrubbing process. There are some useful steps we would like to suggest.

1) Maybe we can use the combination of chemical absorption process and water scrubbing together to get the best purified CH_4 gas. Although the system and setup of both the process initially maybe high. So, if we can re-design the water scrubbing setup compatible with the chemical absorption process maybe both processes can undertake in the same setup or system. By analyzing the flow chart of both the process we can see that the input separator of the water scrubbing system may be used as absorption column with the cooler system/ heat exchanger system and stripper can be designed as regeneration column. The combination of both the process may be expensive than the one process but it may give much purified CH_4 from the biogas. This will successfully eliminate all the biogas harmful effects for the engine and vehicles. Which means biogas purified output can straightly be used also in the power generation purpose. If the input separator of water scrubbing system can be re-designed like absorption column of chemical absorption process then first the Biogas will go through the absorption column which will make the biogas free from H_2S, here we don't need to use very expensive chemicals, may be Polyethylene glycol (PEG) only or PEG and water mixture may work. Then the biogas again will flow through the water scrubbing process which will purify the CO_2 from the Biogas. It should provide a high efficient, CH_4 rich output. After, this only the chemical waste can put into regeneration process (This system requires full experimental setup to check, ensure and prove its effectiveness). This combined system can be identified as biogas purification unit. Moreover, it will be more appropriate to make the whole setup in a portable / mobile mechanism. This should be also as much as possible small in size.

2) In the water scrubbing method we are using water spray to wash out the H_2S and CO_2 as they are more soluble to the water. The H_2S limitations occur as CO_2decreases the pH of the solution. So, we can use base (Such NaOH) water mixture to control and increase the pH of the solution, thus the water scrubbing process itself may provide much purified biogas. Also adding buffer to the solution could be effective to pH increment.

3) In the water scrubbing method we are using water/Polyethylene glycol to purify the biogas. But our idea is to use alternative spray system to purify the biogas. Maybe first the water spray will flow through the solution and it will do up to its limit purification, then only due to CO_2 decreasing the pH and problem occurs to H_2S removal. So, after the first flow fully exhaust the second flow of spray will follow a buffer solution or base solution to the system which will restore the pH status of the whole solution. Then the water will again flow thus the process flow will alternatively rotating.

* 1 m^3 CNG=1.23 lit. of petrol/octane.

If we combine also both the water scrubbing and chemical absorption method according to cost structure it will be same as CNG price. (Because 1 m^3 CNG= 30 BDT/-).

But if it is possible to combine both the system there should be cost reduction per unit and we will get purified biogas with high rate of CH_4.

Information: The first digestion plant to produce biogas from wastes was built in Bombay, India in 1859.

6. Results: After analyzing the purification methods it is ascertained that producing renewable energy from biogas will be one of the cheapest source and also eco-friendly. As per the analysis, the suggestion we made could be used to get highly refined biogas which can be source of renewable energy.

Future research and developments scope:

1) Increasing the effectiveness of the raw materials, waste, slurry etc. will increase the production of Biogas in drastic rate. Addition of chemical components, solutions, reagents, etc. in a small amount to the production chamber of Biogas may increase the production rate. Further research should be conducted to find the best chemical components, solutions, reagents which will increase the effectiveness of raw materials up to the maximum level. The research should conduct by analyzing the waste components and their chemical bonds, also the choice of the chemicals should be cost effective. The reagents or solution

should boost up the CH_4 production in the biogas production chamber.

2) The biogas production and purification unit should be more cheap and portable. Both the unit should combine in a single unit, with the all the features of portability. This could increase the use of the biogas unit for the private users in rural areas in the 3rd world countries and stop the use of firewood. Further research should be carried out to make the single biogas production and purification unit in a portable design with high efficiency. If this portable unit can achieve 90% of purification of biogas with the features of very easy portability this will provide great advantage for the house hold uses, urgent power supplies, generator feeds, etc.

3) To increase the CH_4 percentage from biogas, a filter with chemical reagents can be developed which will only allow to pass Methane gas but it will restrict the all the harmful gas to pass. This filter chemical should not have reaction with Methane but it should repulse the flow of H_2S and CO_2.

4) Water scrubbing method can be made more effective by controlling the pH. Research should be conducted to find the best buffer solution or base to control pH (decrease) of water scrubbing system when they will be used with water as mixture without increasing the cost. This research should analyze the suitable buffer solution according to water scrubbing system setup.

5) Instead of using normal waste and raw materials for biogas production, we may use combination of different wastes or raw materials. In this case different wastes and raw materials should be chemically analyzed to find the best combination to produce biogas. In result this could increase the biogas production a lot. Also, researches to find the combination of wastes or raw materials to get highest rate of methane within the biogas should be carried out.

6) Furthermore increased Biogas production can be achieved by controlling the bacteria involved in the fermentation process of biogas production. Different kind of Bacteria can be used to test for the better result in Biogas production. Otherwise, the existing Bacteria can be genetically engineered to produce High rate of CH_4. This need advance research and development project.

7. Conclusion:

The need of energy is increasing day-to-day. The solution for alternative cheap energy source becomes very important according to current situation. Thus biogas as a alternative energy source is not only cheap but also ecofriendly and abundantly available. If this biogas can be purified for direct feed for the generators, the electricity production cost will minimize as well as we will also get solutions for waste management and environmental pollution control.

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