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Enhancement of Biogas Production from 2.5m^3 Puxin Digester

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ABSTRACT
The world moved away from the concept that waste is something to be disposed of to recognizing it as a feedstock for energy. Therefore, the research was carried out by 2.5m^3 pilot-scale Puxin digester from China to evaluate the anaerobic biodegradation of lignocellulose waste comprising cow dung, wheat straw and rice straw as feedstock is feasible at thermophilic condition (45 ^{0}C) for production biogas as a renewable energy. The addition of cow dung inoculum to fixed amount of feedstock was observed to improve biogas production. However, biogas yield was observed to decrease with use cow dung only. The ultimate biogas yield which can be determined from very long periods of anaerobic batch reaction was alternatively estimated through curve fitting. The maximum biogas yield for digester was estimated to be 233 L/Kg VS fed, while the ultimate biogas and methane yield attainable from these mixtures were estimated to be 340 L/Kg VS fed. This biogas can be burnt to produce heat and power. The results show that there are number of operating parameters affect the performance of the anaerobic digestion including the amount and type of inoculum, digestion duration, pH adjustments, temperature, C: N ratio and total solids (TS).

Introduction

Global Renewable energy replaces fossil and nuclear fuels in four distinct markets: power generation, heating and cooling, transport fuels, and rural/off-grid energy services.

In 2009, renewable energy supplied was estimated to be 16% of global final energy consumption – counting traditional and modern biomass, hydropower, wind, solar, geothermal, and biofuels [1]. From all renewables accounted for growing very rapidly in many developed countries as well as in some developing countries, biomass is becoming increasingly important globally as a clean alternative source of energy to fossil fuel as a result of rising energy demand, high cost of fossil fuels, dwindling fossil fuel reserves and contribution of fossil fuel usage to greenhouse effect.

"Waste-to-energy" is the use of modern combustion and biological technologies to recover energy from urban wastes. The conversion of waste material to energy can proceed along three main pathways – thermochemical, physicochemical and biochemical [2]. Biochemical technologies are more suitable for organic non-woody feedstocks and converted to a gas by the action of micro-organisms in the absence of oxygen. It is highly suited to processing wet wastes such as sewage sludge, food wastes and agricultural wastes – like manure and slurry. The process produces digestate – which can be used as a fertilizer – and a gas made of about 60% combustible methane and 40% non-combustible carbon dioxide. This biogas can be burnt to produce heat and power or upgraded to pure biomethane.

AD is suitable for a very wide range of feedstocks which are summarized in (Figure 1) [3].The expansion of viable organic streams to include lignocellulosic biomass will enable an even broader adoption of AD. Lignocellulosic biomass present problems for liquid phase AD. Agricultural waste materials like straw and part of the manure are lignocellulosic materials. These materials are strong, flexible and protected against decay. The anaerobic digestion is thus a complex process which is slow compared to chemical processes.

Wu et al. in (2010) reported the result on the co-digestion of swine manure with three agricultural residues, corn stalk, oat straw and wheat straw. They reported significant gain in daily biogas volume: around 11.4 times in corn stalk, 8.45 times in oat straw and around 6.12 times in wheat straw as compared to simple digestion at C/N ratio 20 [4].

The pretreatment of lignocellulosic biomass offers higher biodegradation rate and overall main product yield in any biological energy conversion processes. Pretreatment of lignocellulosic biomass has been found to cause swelling, leading to increase in internal surface area, decrease in degree of polymerization and crystallinity, separation of structural linkages between lignin and carbohydrates (cellulose and hemicellulose), and disruption of lignin structure.

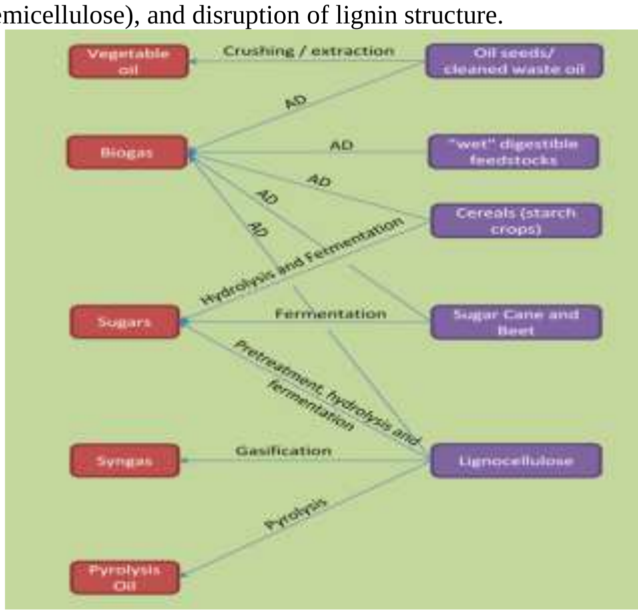

Figure 1: Feedstock conversion from which the biofuels are manufactured [3]

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Zhu et al. in (2010) observed at alkali pretreatment of corn stover using 1% NaOH did not result in a significant improvement of biogas production yield, whereas 5% NaOH pretreated corn stover resulted into 37.0% higher biogas production than that of the untreated corn stover [5].

In this work, an approach was used for determining biogas yield and the maximum biogas yield attainable for cow manure with co-digested substrates (like wheat and rice straw) at 45 ^{0}C in batch Puxin Pilot-scale Digester (2.5m^3). We find that some specific feature of the batch process such as its simple design and process control and lower investment cost can make it particularly attractive for rural areas in developing countries.

Biodegradable Solid Waste:

The major constituents of lignocellulose are cellulose, hemicellulose, and lignin, polymers that are closely associated with each other constituting the cellular complex of the vegetal biomass. Basically, cellulose forms a skeleton which is surrounded by hemicellulose and lignin (Fig. 2). However, cellulose is usually the dominant structural polysaccharide of plant cell walls (35–50%), followed by hemicellulose (20–35%) and lignin (10–25%) [6].

Cellulose is a high molecular weight linear homopolymer of repeated units of cellobiose (two anhydrous glucose rings joined via a β-1,4 glycosidic linkage). The long-chain cellulose polymers are linked together by hydrogen and van der Walls bonds, which cause the cellulose to be packed into microfibrils. Therefore, cellulose microfibrils have both highly crystalline regions and less-ordered amorphous regions. *More ordered or crystalline cellulose is less soluble and less degradable.*

Hemicellulose is a linear and branched heterogeneous polymer typically made up of five different sugars as well as other. The backbone of the chains of hemicelluloses can be a homopolymer (generally consisting of single sugar repeat unit) or a heteropolymer (mixture of different sugars). When compared to cellulose, hemicelluloses differ thus by composition of sugar units, by presence of shorter chains, by a branching of main chain molecules, and to be amorphous, which made *its structure easier to hydrolyze than cellulose*.

Lignin is a very complex molecule constructed of phenylpropane units linked in a large three-dimensional structure. Lignin is closely bound to cellulose and hemicellulose and its function is to provide rigidity and cohesion to the material cell wall, to confer water impermeability to xylem vessels, and to form a physic–chemical barrier against microbial attack. Due to its molecular configuration, *lignins are extremely resistant to chemical and enzymatic degradation.*

The amounts of carbohydrate polymers and lignin vary from one plant species to another. In addition, the ratios between various constituents in a single plant may also vary with age, stage of growth, and other conditions and Table 1 shows the typical compositions of the three components in various lignocellulosic materials [7].

However, the wide availability of lignocellulosic biomass make them a viable substrate for AD. Each feedstock widely differs in composition and texture making studies necessary to determine AD process parameters to best suit each feedstock for methane production. Table 2 summarized methane yield from these biomass tested with AD by varying particles sizes, most used digestion times from 30-75 days, and used mesophillic conditions. Substrate loadings were reported in varying fashions [8].

Finally, Izumi et al. reported in 2010 that the feedstock composition, harvesting season, particle size, and pretreatment methods substantially affect methane production from lignocellulose biomass [9]. A number of operating parameters also affect the performance of the AD including the amount and type of inoculum, digestion duration, pH adjustments, nutrient supplementation, temperature, C:N ratio, total solids (TS) content, substrate loading rate, and reactor system configuration according to Li et al. work in 2011 [10,11].

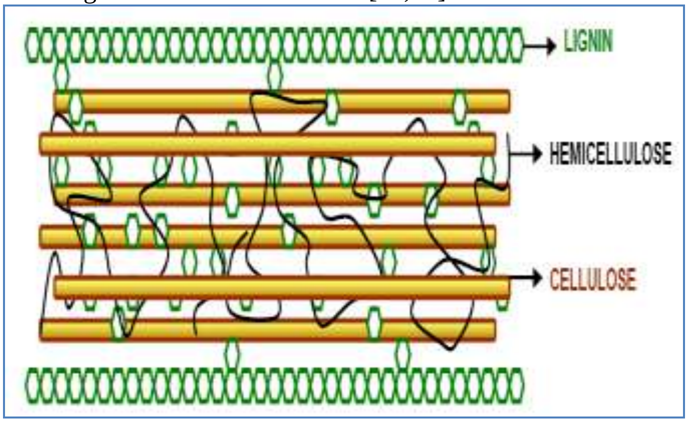

Figure 2: Representation of lignocellulose structure showing cellulose, hemicellulose and lignin fractions [6]

The biogas process

The AD process can be divided into four phases: hydrolysis, acidogenesis, acetogenesis and methanogenesis, in each individual phase, different groups of facultative or obligatory anaerobic microorganisms work together. The microorganisms use their substrate for a source of energy as well as a carbon source for growth [12]. All reactions happen simultaneously and are interdependent. Nevertheless, the overall chemical reaction can be simplified to:

[Organic matter → $CH_4 + CO_2 + H_2 + NH_3 + H_2S$]

Hydrolysis is the first step in the anaerobic digestion. During this phase, dissolved compounds, such as polysaccharides, proteins, and fats get degraded into their monomers, such as sugars, amino acids, and fatty acids.

The hydrolysis of complicated structures, like lignocelluloses, can require weeks, and the degradation is often not complete. As such, the hydrolysis is the rate-limiting step, while the methanogenesis is considered the rate-limiting step for readily available substrates [13]. The rate of the hydrolysis step depends on substrate characteristics, bacteria concentration, and also environmental factors such as pH and temperature [14].

[Protein→ Amino acids]   [Carbohydrate →Sugars]

[Fat → Long chain fatty acids]

In the second phase, the monomers produced in the hydrolysis phase are further degraded by fermentative bacteria into short-chain organic acids, with one to five carbons. Some of the degradation products from the acidogenesis phase can be directly used by the methanogens. Typical reactions occurring in this stage are presented below:

- Conversion of glucose into ethanol:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + Heat$$

- Conversion of glucose into propionate :

$$C_6H_{12}O_6 + 2H_2 \rightarrow 2CH_3CH_2COOH + 2H_2O$$

However, the fatty acids longer than two carbon atoms, alcohols longer than one carbon atom, and branched chained and aromatic fatty acids are degraded further into acetic acid, hydrogen, and carbon dioxide in the third acetogenic phase. In parallel with the formation of acetic acid from short chain organic acids, homoacetogenic microorganisms reduce hydrogen and carbon dioxide into acetic acid. The concentration of hydrogen is very crucial because the reactions can only proceed when the hydrogen concentration is very low, therefore, acetogenic bacteria live in symbiosis with hydrogen consuming methanogens. In addition, the acetogenic bacteria are very sensitive to fluctuations of temperature

The last step in the anaerobic digestion is the methanogenesis. The methanogenic microorganisms, work under strictly anaerobic conditions. The methanogens, which belongs to the group archaea, differ from the other organisms in the anaerobic reactor, which are bacteria. Archaea are more sensitive compared with the bacteria, regarding environmental stresses in the reactor, such as pH, or toxic compounds such as heavy metals or different toxic organic materials [15]. The methanogens mainly use acetate, carbon dioxide, and hydrogen, but also methylamines, alcohols, and formate for the production of methane. About 70% of the methane production arises from the acetate, and about 30% of the methane arises from hydrogen and carbon dioxide. The methanogens have the longest generation times (2-25 days) of the microorganisms in the reactor, which makes this step the most time-limiting step for easily hydrolyzed materials. The reactions which occur in methanogenesis step are the following:

- Conversion of ethanol to acetic acid:

$$2CH_3CH_2OH + CO_2 \rightarrow 2CH_3COOH + CH_4$$

Followed by

$$CH_3COOH \rightarrow CH_4 + CO_2$$

- Conversion of methanol:

$$CH_3OH + H_2 \rightarrow CH_4 + H_2O$$

- Reduction of carbon dioxide by hydrogen:

$$CO_2 + 4H_2 \rightarrow CH_4 + H_2O$$

Materials and Method

As mentioned before, various kinds operational criteria selection to be operated is depends upon the feedstock characteristics, financial aspects etc. Anyhow, each mode of operation always has its own advantages and limitations. However, this research is dealing with pilot-scale batch mode of digester using horizontal reactor. Solid waste characteristics, nutrient content, biogas and leachate characteristics were analyzed on daily basis. The results obtained both from laboratory and pilot scale experiments were used to compare in terms of biogas production and digestate waste properties. This work is followed the methodology according to the Chea Eliyan Laboratory Analytical Procedure [16].

Laboratory Scale work:

Analysis of solid waste characteristics:

Homogenous samples were taken to determine the dry matter content of the original sample. To calculate the mass reduction of solid waste after anaerobic digestion, the waste characteristics needed to be analyzed. (Figure 3) represents the detailed procedure of the solid waste analysis. The general information on solid waste analysis is depicted in (Table 3). The solid waste analyses were based on ASTM (1993). The moisture content and total solid was calculated based on Eq. (1 and 2). Finally, the average value was obtained.

$$\%MC = \frac{1000-wo}{1000} x100\% \qquad \text{Eq.1}$$

Where

w_o: Weight of sample after drying

Thus, the total solid is calculated by subtracting the percentage of MC from 100 as shown below:

$$\%TS = 100\% - \%MC \qquad \text{Eq.2}$$

Volatile solid determination:

The same sample was used for moisture content analysis was again used for volatile solid analysis. Several samples each of size 2 g were put in evaporating dishes which had been ignited at 550 °C for at least one hour in a muffle furnace. The empty dishes were immediately weight after cooling to room temperature. Initially, the solid samples were evaporated to dryness in an oven at 103-105 °C for at least one hour.

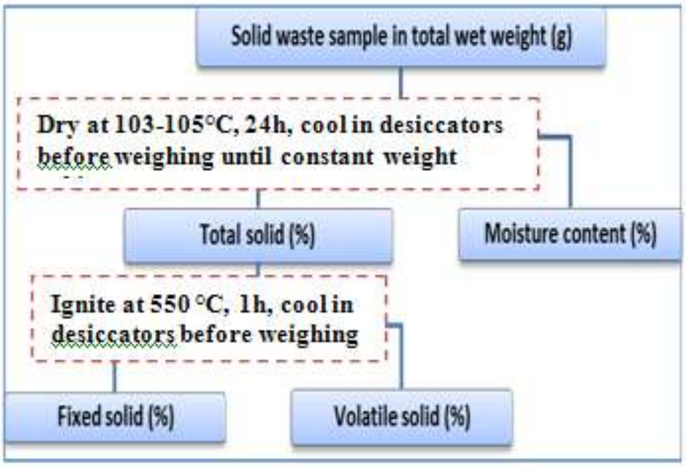

Figure 3. Solid waste analysis procedures

Then the samples were cooled to room temperature in desiccator and weight on an analytical balance. The cycle of drying, cooling, desiccating and weighing was repeated until a constant weight was obtained. Then, the samples were ignited in a muffle furnace at 550°C for one hour. After that, they were kept in a desiccator and weights were obtained. The cycle of igniting, cooling, desiccating and weighing was repeated until a constant weight was obtained. The volatile solid of each dish was calculated using Eq. 3. Finally, the average value was obtained.

$$\%VS = \frac{wo-wf}{wo-we} x100\% \qquad \text{Eq.3}$$

Where

wo: Weight of the sample and evaporated dish after drying at 103- 105°C

wf: Weight of the sample and evaporated dish after igniting at 550°C

we: Weight of the empty evaporated dish

Equation 4 was applied to obtain the total carbon in both fresh and digestate waste sample.

$$\%\,Total\ carbon = \frac{\%VS}{1.8} \qquad \text{Eq.4}$$

Total solid and volatile solid loss determination

The material balance analysis is shown in (Figure 4). The loading substrate has total a weight of TW_0 and a dry weight of M_0. After entering the reactor and being digested, the reduction of solid and volatile solids were occurred. Therefore, the residual had a total weight of TW_1 and a dry weight of M_1 which were less than that of TW_0 and M_0 , respectively.

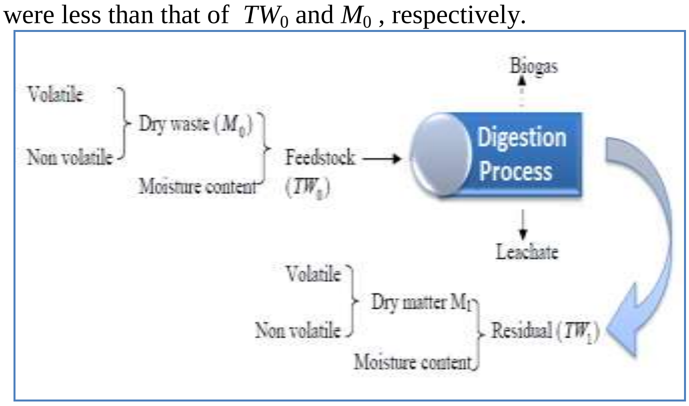

Figure 4. Material balance analysis in anaerobic digestion process

The equation below was used to estimate the percentage of total solid loss (%TS loss) and percentage of volatile solid loss (%VS).

$$\%TSloss = \frac{Mo-M1}{Mo} x100\% \qquad \text{Eq. 5}$$

Table 1. Lignocellulose contents of common agricultural residues and wastes.[7]

Lignocellulosic materials	Cellulose (%)	Hemicellulose (%)	Lignin (%)
Hardwood stems	40-55	24-40	18-25
Softwood stems	45-50	25-35	25-35
Corn cobs	45	35	15
Paper	85-99	0	0-15
Wheat straw	30	50	15
Rice straw	32.1	24	18
Sorted refuse	60	20	20
Leaves	15-20	80-85	0
Newspaper	40-55	25-40	18-30
Waste paper from chemical pulps	60-70	10-20	5-10
Fresh bagasse	33.4	30	18.9
Solid cattle manure	1.6-4.7	1.4-3.3	2.7-5.7
Grasses (average values for grasses)	25-40	25-50	10-30

Table 2. Methane yield from various crop residues tested with anaerobic digestion [8]

Feed stock	AD System	Particle Size(mm)	Temp. (°C)	Total Solids	Digestion Time(days)	Substrate Loading	Methane production
Wheat straw	Batch	10	35	<20%	150	0.1-4.0 *	299-333 L/kg VS
Wheat straw	Batch	1-30	=	=	60	1.4*	145-161 L/kg VS
Cattle dung & wheat straw	CSTR			10%	40	Not reported	107-113 L/kg TS / day
Cattle dung& Rice straw	Batch	1-6	37	<20%	56	8%(w/v) feedstock	241-367 L/kg TS

Solid to inoculum ratio

Where $M0$: Dry weight of feedstock going in the reactor (g)

$$M_0 = TW_0 \times TS_0 \qquad \text{Eq.6}$$

TW_0 : Wet weight of solid waste going in the reactor (g)

$TS0$: % total solid of feedstock (%TW)

M_1 : Dry weight residual going out reactor (g)

$$M1 = TW1 \times TS1 \qquad \text{Eq. 7}$$

$TW1$: Wet weight of residual going out of the reactor (g)

$TS1$: % total solid residual (%TW)

$$\%VSloss = \frac{No - N1}{No}\, x100\% \qquad \text{Eq. 8}$$

Where $N0$: Weight of volatile fraction going in the reactor (g)

$$N0 = M0 \times VS0 \qquad \text{Eq.9}$$

$VS0$: % volatile solid of feedstock (%TS)

$N1$: Weight of volatile fraction of residual going in the reactor (g)

$$N1 = M1 \times VS1 \qquad \text{Eq.10}$$

$VS0$: % volatile solid of residual (%TS)

Table 3.General information on solid waste analysis parameters

Parameters	Method/instrument
Moisture content (%)	Gravimetric analysis
Total solid (%)	Gravimetric analysis
Volatile solid (%)	Muffle furnace
Biogas analysis [(CH_4, CO_2, H_2S,O_2)]	**Gas detector**

B. Pilot-Scale work:

Inputs and Their Characteristics:

One of the main attractions of biogas technology is its ability to generate biogas out of organic wastes that are abundant and freely available or any biodegradable organic material can be used as substrate for processing inside the biodigester. However, for economic and technical reasons, some materials are more preferable as input than others. For example potential gas production per kg cattle (cows and buffaloes) dung is (0.023 - 0.040) m^3 of biogas. In addition, plant materials can also be used to produce biogas and biomanure. For example, one kg of pre-treated crop waste has the potential of producing 0.037 m3 of biogas.

So, when we used different organic materials have different bio-chemical characteristics, their potential for gas production also varies. Two or more of such materials can be used together provided that some basic requirements for gas production or for normal growth of methanogens are met .Some characteristics of these inputs which have significant impact on the level of gas production are described in below (Tables 4 and 5) as Co-anaerobic digestion or co-digestion (is anaerobic digestion performed on a mixture of at least two different substrates).

Pretreatment:

The pre-treatment of feedstock involves; removing the non-biodegradable materials, which are not affected by digestion and take up unnecessary space. Providing a uniform small particle size feedstock for efficient digestion. Protecting the plant from components that may cause physical damage and removing the materials which may decrease the quality of the digestate. Therefore, in order to obtain homogeneous feedstock, the pretreatment processing involves separation of non-digestible materials such as sand and gravel, which may accumulate in the bottom of the digester. The organic material must be chopped or shredded before it is fed into the digester. The organic matter is also diluted with a liquid, ranging from sewage slurry, to recycled water from the process. In contrast, pretreated sludge achieves 75 % destruction rate of volatile organics, resulting in a greater production of CH_4 gas [17].

Dilution and Consistency of Inputs:

Before feeding the digester, especially fresh cattle dung, has to be mixed with water at the ratio of 1:1 on a unit volume basis (i.e. same volume of water for a given volume of dung) as in Tables 4 and 5. However, if the dung is in dry form, the quantity of water has to be increased accordingly to arrive at the desired consistency of the substrate (e.g. ratio could vary from 1:1.25 to even 1:2). The dilution should be made to maintain a total solid content from 7 to 10 %. If the dung is too diluted, the solid particles will settle down into the digester and if it is too thick, the particles impede the flow of gas formed at the lower part of digester. There is also higher risk of scum formation at the top of the slurry layer. In both cases, gas production will be less than optimal. Furthermore, most biogas plants are designed for a total solids content of about 8%. A change of this ratio will have an impact on the HRT (hydraulic retention time) and the hydraulic functioning of the plant.

The feedstock was diluted with water to a concentration of 8 percent. The amount of water required to adjust the total solid fraction in the digester was calculated by using the following equation [18] :

$$\mathbf{Y = x\,[(TS_{man} - TS_{dig}) / TS_{dig}]} \qquad \text{Eq. 11}$$

Where Y = Dilution water required, kg

X = Amount of raw material, kg

TS_{man} = Total solids fraction of raw material, %

TS_{dig} = Total solids of slurry (influent), %

Finally, the important parameters affecting the performance of anaerobic digestion in the batch pilot- scale to produce biogas was kept as mentioned in Table 6 throughout the processes.

Batch pilot-scale digestion:

The 2.5m^3 Puxin digester tank is loaded with raw feedstock and inoculated with digestate as shown in Figure 6 and 7. It is then sealed and left until thorough degradation has occurred. The digester is then emptied and a new batch of organic mixture is added [16].

The 2.5 m^3 digester was made of fiberglass reinforced plastic to protect it from rust and corrosion. The gas was pump to PVC storage bag with (thickness 0.6mm), size (2 m^3) and dimension (2.8 x 2.8 meters). It is Easy and quick to install and can be installed by the users themselves within two hours. It is convenient to transport, because its total weight is only 80 kg to the places where are wastes available, especially in rural areas. In addition, ease of cleaning and maintenance process. This system can be used above ground to prevent contamination of ground water especially in areas with the high level of water. Wide range of fermentation material: It is suitable to use food waste, grass, leaves and straw as fermentation material.

The system contain filter to remove hydrogen sulfide gas and (12 W power) solar charger to (10 W power) biogas pump with (26 L / min) pumping rate to gas stove double burner with consumption rate about 0.45m^3/h (for one burner) and 2.5L biogas rice cooker with gas consumption(about 0.14m^3/h) . Biogas lamp with electronic fire maker which consume (0.07 m^3/ h) gas and an (600 W) electric generator has gas consumption about (0.84 m^3/ h).

The solid waste used in this study was collected from White Gold) village near Baghdad, Iraq. The dry cow manure with chopped wheat and rice straw feedstock is slurries with a large amount of water to provide a dilute feedstock of 8-10% dry solids. For the start-up operation, the prepared feedstock was loaded into the reactor after mixing well with the inoculums. The calculated amount of feeding is equal to 50% of the total digester volume. Cow dung or residue from an operation digester can be used as inoculums. Inoculums should be added into the feeding material. The more the inoculums added the easier the initial operation. In the first batch feeding for initial operation the concentration should be 4 ~ 6%. The water added into the biogas plant can be domestic wastewater, river water, reservoir water; it also can be well water or tap water, but can't be toxic wastewater. The temperature of the water should be above 20℃. In cold winter warm well water is a good choice.

Figure 6. (2.5m3) Size for Family and Farm -scale Digester

Figure 7. Pilot-scale biogas production from portable solar anaerobic digestion

After the biogas plant has been sealed with water, usually in 3-10 days the biogas plant will produce biogas. At the beginning usually the biogas produced can't be lighted up because the methane content is too low. If the biogas can't be lighted up, you should release all the biogas in the gasholder and recollect the biogas, and repeat this process until the biogas can be lighted up.

When the temperature in the biogas plant is below 10°C, the biogas plant will stop gas production. Therefore, in winter the biogas plant should be thermal insulated by covering an insulation layer or a green house on the biogas plant. In the period of normal operation you can increase the concentration of the feeding materials up to 8 ~ 10%. The liquid from the biogas plant can be recycled.

Results and discussion:

The fixed-dome digester also called "Chinese" digester is the most common model developed and used mainly in China for small family and farm -scale biogas production. The digester consists of an enclosed digester with a fixed, non-movable gas space. It is filled through the top inlet hole until the level reaches the bottom level of the expansion chamber. The produced biogas is accumulated at the upper part of the digester. The difference in the level between slurry inside of the digester and the expansion chamber creates a gas pressure. The collected gas requires space and presses a part of the substrate into a part of the substrate into an expansion chamber. The slurry flows back into the digester immediately after gas is released [19, 20].

Batch- loaded digester is operated by filling the reactor with slurry, letting the reactions that take place in the reactor proceed to completion, and then removing some or all of the contents of the reactor. This procedure is then repeated. Stirring may or may not be part of the operation of a batch reactor.

Table 4. Raw material needed to produce one cubic meter biogas from Puxin work

Raw material	Water content (%)	Dry material Gas production Rate (m^3/kg)	Raw material needed to produce m^3 biogas (kg)	
			Dry material	Fresh material
Cow Manure	83	0.19	5.26	30.96
Rice Straw	15	0.26	3.84	4.53
Wheat Straw	15	0.27	3.70	4.36

Table 5. Raw material parameters from Puxin work

Raw material	C %	N %	C:N	Methane Content of biogas produced (%)	Gas Duration (d)	Dry Material Content (%)	Dry material biogas production rate(L/kg)	Raw material biogas production rate(L/kg)
Dry wheat straw	46	0.53	87:1	59	-	82	425	348
Dry rice straw	42	0.63	67:1	61	-	83	409	340
Fresh cow manure	7.3	0.29	25:1	50-60	90	17	250	233(L/kg VS)
Cattle dung + Rice straw + wheat straw				75	60	8%(w/v) Feedstock		340 (L/kg VS)

Advantages of a batch reactor included ease of operation, absence of mechanical mixing, and high removal efficiency of an individual contaminant. Biosolids from one batch of operation may be used to seed the subsequent batch reaction with microbes [21].

As shown in Figure 10, at the bottom of a standard-rate digester, a layer of digested sludge, also known as biosolids, forms. Next, a layer of actively digesting sludge forms above the digested sludge layer. A layer of supernatant liquid stratifies above the layer of actively digesting sludge. A scum layer forms above the supernatant liquid layer.

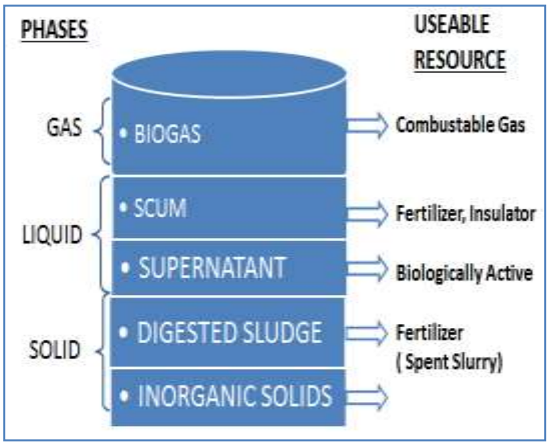

Figure 10. Layering of By-Products in the Fixed-Dome Digester

Finally, gas storage space constitutes the top space in the digester. In continuous feeding, slurry enters the digester in the actively digesting sludge layer. Liquid effluent exits the digester at the level of the supernatant liquid layer. Biosolids exit the digester from the bottom layer of digested sludge. Reactions taking place in the actively digesting sludge layer form gas, which then rises to the top of the reactor. The rising gas lifts particles, and grease, oil, and fat molecules, which eventually form the scum layer above the supernatant liquid layer. Because of the lack of mixing, not more than fifty percent of the total digester volume is used. This is important to consider in sizing a standard-rate digester [22]

A wide variety of resources are on our planet for conversion into bioproducts (as shown in Table 1). The available biomass resources can be used as biomaterials and this will require an intimate understanding of the composition of the raw material whether it is whole plant or constituents, so that the desired functional elements can be obtained for bioproduct production.

In this work the anaerobic biodegradation of biomasses comprising cow dung, wheat straw and rice straw as feedstock is feasible at 45 ^{0}C. The addition of cow dung inoculum to fixed amount of feedstock was observed to improve biogas production. However, biogas yield was observed to decrease with use cow dung only. The ultimate biogas yield which can be determined from very long periods of anaerobic batch reaction was alternatively estimated through curve fitting. The maximum biogas yield for digester was estimated to be 233 L/Kg VS fed, while the ultimate biogas and methane yield attainable from these mixtures were estimated to be 340 L/Kg VS fed.

Therefore, the biogas rate enhancement was depended on the improved fact that the C/N ratio affects gas production. C/N ratios of 20:1 to 30:1 are particularly favorable. Mixtures of nitrogen-rich feed material and carbon-rich feed material give high gas production [23]. If the C/N ratio is very high, the nitrogen will be consumed rapidly by methanogens for meeting their protein requirements and will no longer react on the left over carbon content of the material. As a result, gas production will be low .On the other hand, if the C/N ratio is very low, nitrogen will be liberated and accumulated in the form of ammonia (NH4), NH4 will increase the pH value of the content in the digester. The pH value higher than 8.5 will start showing a toxic effect on methanogen population . Animal waste, particularly cattle dung, has an average C/N ratio of about 25. Plant materials such as straw and sawdust contain a higher percentage of carbon; as a result, gas production will be more.

Conclusion:

As our demand for energy grows, it becomes increasingly urgent to find new ways of meeting it both responsibly and safely. Waste to energy technique is not new, but growing organic waste problems and increasing the proportion of carbon dioxide and rising global warming led to increased interest in this technology and their economic benefits because it is working to reduce the proportion of waste-to-quarter and convert the rest to the biogas, water and solid residues used as soil amendment or organic fertilizer with distinct specifications. More or less, every biodegradable organic waste can be treated in a biogas digester, providing energy for cooking, lighting and heating along with increased of dissolved nutrient concentration in the digestate, thus, providing farmers with an improved organic fertilizer.

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