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Potential of Biogas Production from Different Waste

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Abstract: Biogas generation is one of the most promising renewable energy sources. Anaerobic digestion is one of the effective ways of generating biogas. The effect of various wastes of Cow Dung(CD), Rumen(RU), Agar Waste(AW) and Sewage Sludge(SS) were collected in different sources on biogas production at mesophilic condition. A laboratory experiments was carried out using in 5 litre of glass bottles working volume on a batch reactor for over 40days. The preparation of slurry in different ratio of mixture of wastes the control of CD,RU,AW and SS, 1:1 ratio of RU:AW, AW:SS, SS:RU and 1:1:1 ratio of RU:AW:SS. There was designated in $T_{0,}$ $T_{1,}$ $T_{2,}$ $T_{3,}$ $T_{4,}$ $T_{5,}$ $T_{6,}$ and T_7 respectively. All the treatments were prepared in triplicates. Biogas production was measured indirectly water displacement method. The results indicated that the mixture of 1:1:1 ratio (T_7) slurry provide the higher biogas yield of 3886.30ml and then followed by $T_{2,}$ T_3 and T_6 treatments gave average yield of 3190.35, 2068.65 and 1804.51ml. The result showed fastest onset gas flammability from T_7 and T_6 treatments after 4th days. The results obtained shows that the pH of the mixture(T_4 & T_7) before and after the biogas provided a reading 3.4&4.2 and 6.9&7.0. This both treatments maximum increased of pH in after digestion 3.5&2.8. The biogas production could eliminate its disposal problems and create another abundant source of sustainable energy. The result of study also indicates that the biogas production process is economically feasible.

Keywords: Cow Dung, Rumen waste, Agar waste, Sewage Sludge, Flammable, Biogas, etc.,

I. INTRODUCTION

There is increase in world-wide awareness and concern about the environmental impacts of fossil fuels coupled with steep increases in oil prices and this lent enormous weight to the argument for countries switching to renewable energy sources [1]. The alternative sources which are of interest are the ones that are less expensive, environmentally friendly, renewable, clean and readily available. Each year some 590-880 million tons of methane are released worldwide into the atmosphere through microbial activities [2]. Biogas technology is the transformation of solid waste through anaerobic digestion process to obtain biogas such as methane. In today's energy demanding life style need for exploring and exploiting new resources of energy which are renewable as well as bio-friendly. In rural areas of developing countries various cellulosic biomass (cattle dung, agricultural residues, and algal biomass) are available in plenty which are potential to cater to the energy demand especially in the domestic sector [3]. Biogas is a mixture of colorless, flammable gases produced by anaerobic fermentation of organic waste materials such as animal, human, agricultural and industrial wastes. These include animal faeces, municipal sludge and garbage, abattoir waste, paper waste and water weeds. Biogas, known as a source of renewable energy and it has been popular as a source of energy for over 200 years. BIOGAS produced by bacteria through the bio-degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas. Biogas is useful as fuel to substitute firewood, cow-dung, petrol, LPG, diesel, & electricity; depending on the nature of the task, and local supply conditions and constraints [4]. Anaerobic digestion (AD) is a process responsible for the degradation of most of the carbonaceous matter in natural environments where organic accumulation results in oxygen depletion [5]. In particular, AD of energy crops and organic wastes benefits society by promoting a cleaner fuel (biogas) than fossil fuels and a bio-fertilizer (digested matter) from renewable raw materials [6]. The production of biogas through anaerobic digestion offers significant advantages over other forms of bioenergy production. It has been evaluated as one of the most energy-efficient and environmentally beneficial technologies for bioenergy production [7]. Seaweed from the genus of Gracilaria has been used as a raw material for jelly powder production [8]. During the process of jelly powder making, both solid and liquid wastes are generated. The solid waste represented the biomass of the seaweed. One of big companies, PT Agarindo Bogatama, that is located at Pasar Kemis, Tangerang, produces jelly powder from the seaweed. The amount of solid wastes generated is 60 tones per day with the water content of 70%. Examination on a field, which is devoted for purging the solid wastes revealed that several farmers have attempted to utilize them as media for growing vegetables and demonstrated good results.

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Seaweed is the most widely distributed organisms in the ocean. It is a lower cryptogam growing in the ocean, rich in protein, amino acid, inorganic salt, vitamin, alginate, a small amount of enzyme, plant hormones, polyphenols and polysaccharides [9]. At present, there are abundant seaweed resources in China, but the industrial utilization of seaweed is low. Usually, the seaweed waste is treated as chemical solid waste after extraction of alginate, iodine and mannitol. There are many problems in existing disposal ways, such as the small utilization scale and the high utilization cost. Thus, it has caused environmental pollution and waste of resources. Results show that seaweed waste respectively contains about 20% crude protein, 50% crude fiber and 3% ash content [10]. Only parts of seaweed waste are used for organic fertilizer, most of them are discharged as waste, eventually leading to environmental pollution and waste of resources. Seaweed waste contains iodine, vitamins, minerals, dietary fiber and active ingredient. These nutrient elements are mostly organic form, which are not prone to oxidation in the natural environment and can be preserved in seaweed waste as animal feed. In addition, the seaweed waste has high practical value, non-toxic and harmless to animals. At the same time, it has some medicinal value, such as; reduces the animal morbidity, increases growth rate and improves the quality [11]. Seaweeds are considered to be an excellent source of energy for biogas production. Production of algae as a second generation biofuel feedstock has been the subject of research in the last decade. Moreover, the recent report of the Food and Agriculture Organization [12] underlines the need to focus on 'non-food' energy crops for the production of 2nd generation biofuels and to develop cost-efficient solutions which directs even more attention to the importance of biofuel production. Global warming can be counteracted by substituting fossil fuel with biogas from digesting sewage sludge, thus reducing climate impact from carbon dioxide emissions. Biogas is more easily produced from primary sludge than from excess sludge from activated sludge process with biological nutrient removal. Primary sludge is easily bio-degradable since it consist of more easily digestible carbohydrates and fats, compared to excess sludge which consists of complex carbohydrates, proteins and long chain hydrocarbons [13]. Organic waste exist both as sewage sludge from wastewater treatment and as municipal organic waste from for instance households. Sustainable handling of municipal organic waste and sewage sludge has as an important goal to recycle resources without supply of harmful substances to humans or the environment [14]. Rumen is one of slaughterhouse wastes that frequently disposed into drainage system. This waste disposal system may cause environmental nuisance particularly pose health hazard to human due its content of millions microorganisms. However, rumen may be useful to be used as an activator in producing biogas through anaerobic fermentation. Since some of rumen microorganisms are cellulolitic and methanogenic bacteria. Rumen is part of digestion system in ruminant where the microbial fermentation occurs. This fermentation process is similar to that in biogas digester [15]. So that, microorganism in rumen will have significant role in producing biogas by accelerating degradation process of organic matter in fermentation substrate to produce methane. However, sometimes this degradation process results in too low ph that may kill most microorganisms in the digester. Therefore, this process needs more acidophilic microorganisms. One of the microorganisms that can be used for this purpose is Saccharomyces cerevisiae. The addition of this yeast may increase degradation rate of cellulose and stimulate the growth of cellulolitic bacteria and fungi [16]. The increase of the two microorganism's population is important. Both of them will cooperate in increasing cellulose degradation. Besides, S.cerevisiae will decrease propionate acid and increase acetic acid proportions in Volatile Fatty Acid (VFA) [17] and increase acetogenesis after VFA formation, and the resulted acetic acid will be increased accordingly [18]. Acetic acid is a main precursor of methane. Therefore, the more acetic acid produced the highest the methane generated. In 2010, world's ruminant population was about 3.6 billion, of which 5.38%, 39.59%, 25.19%, and 29.84% were for buffaloes, cattle, goats and sheep, respectively**.**

The relative distribution of the number of ruminant animals in different parts of the world according to [19].
1) Hydrolysis, in which enzymes secreted by hydrolytic bacteria break down organic polymers (proteins, carbohydrates) into their monomer components (amino acids, sugars)
2) Acidogenesis, in which acidogenic bacteria break down the amino acids and sugars into volatile fatty acids (VFAs) and alcohols
3) Acetogenesis, in which acetogenic bacteria convert the VFAs into acetic (and propionic) acid and some CO_2 is liberated and
4) Methanogenesis, in which the acetic acids are converted to methane and CO_2 by methanogenic bacteria.

II. SOLID WASTE MANAGEMENT THROUGH ANAEROBIC DIGESTION

In this present investigation solid wastes like sewage sludge, slaughter house waste like rumen waste and agar waste were treated anaerobically for biogas production from them.

Anaerobic digestion for biogas generation

Anaerobic digestion experiments were carried out with laboratory scale batch digesters of 2.5 litre working capacity. To produce slurry each sample was mixed separately with tap water, as per the table given below. Totally eight types of slurries were prepared and were designated as T_0,T_1,T_2,T_3,T_4,T_5,T_6 and T_7 respectively. One litre of each such slurry was taken separately in different sets of digesters for anaerobic digestion (A set consists three digesters). After loading the slurry, the digesters were perfectly sealed and kept at room temperature for 40 days. The digesters

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were shaken well periodically. The gas produced in the digesters were measured once in a day by water displacement method. The measured gas was subjected to burning test. The dry weight of the slurry was measured before and after digestion. Total amount of dry weight reduced during the digestion was calculated and correlated with the amount of biogas produced.

Table:1 Biogas Slurry Preparation

Sl.No.	Slurry type	Cow dung (g)	Rumen (g)	Agar waste (g)	Sewage sludge (g)	Water (lit)	Amount of slurry in digester (lit)
1	T_0	600	-	-	-	1	1
2	T_1	-	600	-	-	1	1
3	T_2	-	-	600	-	1	1
4	T_3	-	-	-	600	1	1
5	T_4	-	300	300	-	1	1
6	T_5	-	300	-	300	1	1
7	T_6	-	-	300	300	1	1
8	T_7	-	200	200	200	1	1

Digester setup:

A 2.5 litre narrow mouthed reagent bottle was used to setup laboratory scale digester. The bottles were cleaned and dried. The mouth of the bottle was closed with one hole rubber cork (No.3); then a known length of saline tube was taken and its one end was inserted through the hole of rubber cork. The other end of the saline tube was closed with a metal pinch cork.

Measurement of gas by water displacement method:

In order to measure the quantity of gas produced in the digester, a measuring cylinder was filled with water. Then a glass plate was placed over the mouth of the cylinder ; then the cylinder filled with water was inverted carefully and placed in a rectangular tray with some water. The other free end of the saline tube of the digester was inserted in such a way into the inverted measuring cylinder. The pinch cock of the tube was loosened to allow the biogas produced inside the digester to pass through and was collected at the top of the cylinder by displacing water. The amount of water displaced from the cylinder was equal to the amount of gas collected. The level of water displaced in cylinder was noted by observing the graduation marked on the cylinder. Biogas formed was measured by using 'liquid displacement method' as described previously by [20].

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Burning Test:

After collection, the measuring cylinder filled with gas was carefully turned up and lighted match sticks were placed near the mouth of cylinder. If blue flame appeared the gas produced in the digester is the burnable gas (contain more amount of methane) if no flame is formed the gas produced in the digester containing is non-burnable gas which containing more amount of CO_2 or H_2S then it is methane.

Measurement of dry weight and pH:

50ml of slurries was taken before and after digestion in different china dishes. It was kept at 100^oC overnight in a hot air oven. Then the dry weight of the slurry was measured. The differences between the initial and final weight of the slurry can also be recorded as moisture content [21]. pH of the slurry was measured before and after digestion by standard method.

III. RESULTS AND DISCUSSION

Table:2 shows that the details dry matter reduction and pH shift of fermented slurry during anaerobic treatments of cow dung, rumen, agar waste and sewage sludge. It was noted that slurry prepared with rumen fluid either alone and in combination with other waste material have acidic pH. The other waste substrate of sewage sludge and Agar waste were slurry prepared either alone and in combination have alkalis. A range of pH values suitable for anaerobic digestion has been reported by various researchers. [22] showed that the most favourable range of pH to attain maximal biogas yield in anaerobic digestion is 6.5-7.5.

Raw sewage consists of organic and inorganic solids in dissolved and suspended form with 90-99.9% of water. physical characteristics of digester sludge were recorded at sewage treatment plant, as pH was observed highest 7.06 during summer and lowest 6.89 during winter, total solids % was observed highest in summer 3.42% and lowest in winter 3.04%. The pH of the mixture slurry before and after the biogas production experiments provided a reading in table:2. The rate of pH measured the after digestion in maximum increase in pH 3.5 of T_4 treatments than followed 2.8, 1.8, 1.7, -0.5, -0.6 and -0.7 in respectively T_7, T_5, T_0, T_3, T_1 and T_2.

Table:2 Anaerobic digestion of various solid waste for biogas generation

S.NO.	Treatments	Treatments	Total dry weight of slurry			pH of the slurry			Total biogas production (ml) over period 40 days
			Before Digestion (mg/l)	After Digestion (mg/l)	Reduction during the Digestion (mg/l)	Before Digestion	After Digestion	Shift during the Digestion	
1	CD	T_0	70	59.49	10.51	5.4	7.1	1.7	1377.20
2	RU	T_1	40	39.84	0.16	2.2	1.6	-0.6	615.23
3	AW	T_2	100	79.44	20.56	7.5	6.8	-0.7	1139.07
4	SS	T_3	80	65.01	14.99	7.4	6.9	-0.5	3190.45
5	RU+AW	T_4	60	45.35	14.65	3.4	6.9	3.5	2068.65
6	RU+SS	T_5	60	39.64	20.36	2.6	4.4	1.8	1221.97
7	AW+SS	T_6	80	65.40	14.60	7.4	7.0	-0.4	1804.51
8	RU+AW+SS	T_7	60	45.21	14.79	4.2	7.0	2.8	3886.30

*CD= Cow Dung; RU=Rumen; AW=Agar Waste; SS=Sewage Sludge; (-) Reduction in PH

The percentage of reduction during the dry weight of substrate in after digestion. The maximum degradation of T_5 treatments of 33.93% than followed 24.65, 24.42, 20.56, 18.75, 15.01 & 0.40 in respectively T_7,T_4,T_2,T_3,T_6,T_0&T_1 **(Fig.1).** Another factor that enhanced higher volume of gas includes; lower moisture content of the substrate (10%) compared to (20%)[23]. This is because high moisture content means low total solid.

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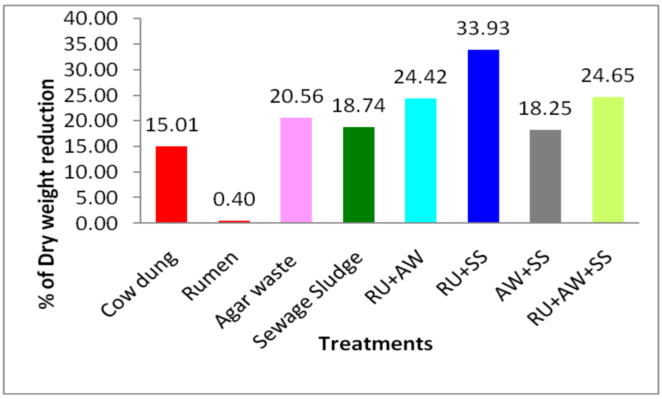

Figure:1 % of Dry weight reduction

Marine algae consist of polysaccharides (agar, alginate, carrageenan, laminaran and manitol), which zero lignin and low cellulose content, which make them an easy material to convert to methane by anaerobic digestion process [24]. High concentration of anaerobic bacteria content in liquid rumen works effectively to degrade organic substrate from manure. Rumen of the ruminant animals contains the highly anaerobic bacteria dominated by cellulolytic bacteria able to biodegrade cellulose material from manure [25].

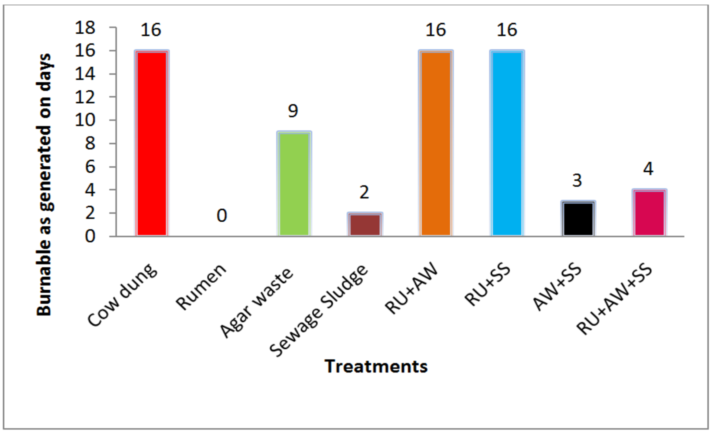

Figure:2 Burnable as generated on days

Burning test of bio gas revealed that burnable gas was record on 16th day of fermentation in T_0, T_4 &T_5 treatments, whereas it was on 2nd, 3rd, 4th and 9th day in T_3 and T_6, T_7 and T_2 respectively. No burnable gas was produced in T_1 treatments throughout study period **Fig:2** The biogas production started on the 16th day from the start of the digester in the ratio of 1:1 (50 mL food waste and 50 mL water). On 23rd day the biogas (650ml) caught flame for the first time and it burned with a blue flame which continued for about 10 seconds**.**[26].

(Table:3). Biogas production from various solid wastes at different phase of their digestion

S.NO.	Substrates	Treatments	Total biogas production (ml)over period 40 days	Gas production in various phase (ml)			
				Ist PHase	IInd PHase	IIIrd PHase	IVth PHase
1	CD	T_0	1377.20	111.83	129.87	637.00	498.50
2	RU	T_1	615.23	57.77	433.33	63.33	60.80
3	AW	T_2	1139.07	320.08	379.00	209.99	230.00
4	SS	T_3	3190.45	2276.99	603.89	187.32	122.15
5	RU+AW	T_4	2068.65	442.33	594.33	707.66	324.33
6	RU+SS	T_5	1221.97	289.99	426.66	267.99	237.33
7	AW+SS	T_6	1804.51	1088.33	423.66	162.99	129.53
8	RU+AW+SS	T_7	3886.30	1293.99	1460.32	655.33	476.66

*CD= Cow Dung; RU=Rumen; AW=Agar Waste; SS=Sewage Sludge ND=No burnable gas production

The **Table:3** shows that the highest biogas produced was recorded in 3886.30ml of T7 treatments than followed by 3190.45, 2068.65, 1804.51,1377.20, 1221.97 and 1139.07 ml in respectively T_3, T_4, T_6, T_0, T_5, and T_2. In this treatments group the least biogas produced was recorded on T_1 treatments of 615.23ml.

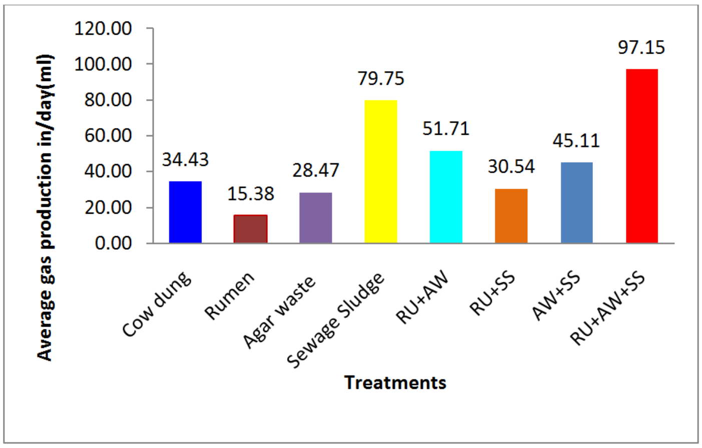

Figure:3 Average gas production in/day(ml)

The biogas from T_1, T_2 &T_5 treatments. It was 15.38 ml/day, 28.47ml/day and 30.54ml/day respectively. Which was less than the amount biogas produced from T_0 treatments and other treatments T_3,T_4,T_6 &T_7 (**Fig-3).** In this study, the biogas produced in all of the treatment groups increased as observation days increased which corroborated with the findings of [27] that observed a very slow rate of biogas being produce at the beginning of the experiment.

IV. CONCLUSION

At present, one field of intense international activity is the exploration and the development of new potential renewable and sustainable energy sources as well as of environmentally friendly processes. Currently, renewable energy resources, among which are the well-known solar, wind, hydro, wave, geothermal and biomass. The renewable energy source, refers to living and recently dead biological matter from plants and animals that can be used as fuel or for industrial production. The result of the investigation shows that the mixture of equal amount of substrate (T_7 treatment) was provide the highest biogas production. Overall results indicate that the very shortly flammable biogas production of the T_6 and T_7 treatments. The utilization of these substrates for biogas production could eliminate its disposal problems and create another abundant source of sustainable energy. Since the yield of biogas was comparatively better by the alternate biomass used with the digestion of various waste material since to improve the efficacy on anaerobic digestion and an eco- friendly manner and in economic way.

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