SUSTAINABLE SOLID WASTE MANAGEMENT UTILIZING GREEN TECHNOLOGY: BIOGAS GENERATION

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Abstract-In India, Large amount of kitchen waste, vegetable waste, bagasse, garden waste are obtained which is given in municipal solid waste which adds to management of waste. If it can be utilized for better purposes it can reduce load to municipal solid waste management. This waste being organic in nature can be used for biogas production. This research is utilized organic waste like KW, Bagasse and GW for anaerobic digestion. Any matter which can be decomposable by the action of microorganisms in a short period of time is called biodegradable. Mostly food waste; Kitchen waste, vegetable waste, bagasse, Garden waste are biodegradable. These wastes are generally dumped in dumping sites which when degraded release carbon dioxide, methane, ammonia and hydrogen sulphide into the environment thereby contributes to air pollution and odors pollution. This paper even opens new avenue of waste to energy method of disposal of municipal waste. These waste if treated in proper method can be utilize for integrated solid waste management. Efficiency of production of biogas increases by mixing cow dung to any of these wastes. Cow dung is also easily available in rural part of India and even at urban India.

Experiment work is carried out in air tight digester of six set used for digestion of kitchen waste, bagasse and garden waste with cow dung at different proportion. The result showed set 3(70:30)of Kitchen waste, set 4(80:20) of Garden waste and set 2(60:20) of bagasse was produced maximum biogas yield that gave 6 minute, 20 minute and 23 minute light.

***IndexTerms* –Anaerobic Digestion, Biogas Generation, organic waste, solid waste management.**

I. INTRODUCTION

Fuel requirement is increasing due to population growth, changing lifestyle, urbanization etc. this gives a quantum jump to requirement of fuel. Fossil fuel are major source of fuel in world around which is in reduction stage now. Thus universe has moved toward renewable source of fuel and energy. Fossil fuel on burning emits out green gases and other air dispersible pollutants. Different wildly used sources of renewable energy are Solar energy, wind energy, different thermal and hydro sources of energy, biogas etc. An anaerobic digestion process(Biogas generation) is an alternative renewable energy which is utilize because of its characteristics of using, controlling and collecting organic wastes and at the same time producing fertilizer and water for use in agricultural irrigation. Biogas does not have any geographical limitations. Biogas is very simple to use and apply. Biogas is produced from organic wastes by concerned action of various groups of anaerobic bacteria through decomposition. (S.C. Rabelo. Et al.,2011)

Anaerobic digestion is a four step process involving different microbial population for each step. The first step starts with hydrolysis. In hydrolysis, the complex organic waste converts into simpler component and formation of organic waste takes place. The second and third step is acid phase involving Acitogenesis and Acidogenesis. The fourth step is called Methanogenesis. The detention time depends on biodegradability of waste. If waste is more biodegradable then reduce retention time. Biogas formation from organic matter like kitchen waste, Bagasse and Garden waste are very complex and necessary of interaction of microorganisms. (SnehaEshore. Et al, 2017)

Biogas technology is a fast growing technology whose transform organic matter like kitchen waste, bagasse and Garden waste into biogas through biological fermentation. Biogas refers to a gas made from anaerobic digestion of different organic waste such as kitchen waste, vegetable waste, bagasse, garden waste. Reduce the wastes as a form of energy can be recovered from anaerobic digestion of solid wastes. This process is very eco-friendly. Researchers have studied that for 2.5 million populations in Asia, most traditional energy source was wood and in most developing countries the rural communities are bound to depend on dung, paraffin, firewood and crop residues etc. Disadvantages is sometimes they can be time consuming and expensive. 90% consumption of energy is required in developing countries and also electricity is used as energy source in rural areas. In rural areas likely firewood and dung are used as a source and Biogas has potential to sub statute these energy source. Energy source such as liquefied petroleum gas (LPG) and natural gas (NG) can be replaced by biogas. (A. Apte. Et al, 2013)

Above study indicate increase in fuel demand is leading to reduction in fuel quantity at large. India regularly generated municipal solid waste. If solid waste is not managed properly it occurred deterioration of public health, air water and land and quality of life in our city. So we require renewable energy for management of solid waste and also its give energy to use for our purpose like cooking, light etc.

II. SOLID WASTE MANAGEMENBT BY BIOGAS

Energy is the prime factor of economic growth and development. In India about 70% of our population lives in villages. The effective utilization of energy is very low in rural areas. Increased demand of fuel wood for cooking and timber due to significant increase in population is resulting into rapid depletion of forest resources. The rural energy problem is multidimensional and needs to be tackled through a multidimensional integrated approach which would include augmentation of energy supply resources for the rural peoples. On account of availability of local resources, community biogas plant is best suited for rural sector. (OjikutuAbimbola. Et al, 2014)

Biogas can be used to implement sustainable waste management programme suitable for urban and rural area as biodegradable waste are transferred into biogas used as a fuel and slurry used as a fertilizer. Biogas technology worked as a waste disposal technology and helps to solve garbage and organic solid waste environmental problems. Biogas technology is extreme ecologically and economically good for the future as it can provide pollution free environment, efficient energy for cooking lighting and improve health condition of the people. (Dhanalakshmi Sridev. Et al, 2012)

Disposal and treatment of organic waste including Kitchen waste, Bagasse and Garden waste represent a major challenge for the waste industry. Organic waste from agriculture, foodstuff of feed industries. Anaerobic digestion is an alternative to composting. Biogas is a mixture of methane and carbon dioxide. Biogas is improve waste management while maximizing the use of an economical energy supply. (Dan Brown.et al, 2013)

The above study indicating that more population occurred day by day. Lots of waste produced so required proper handling of organic solid. So biogas can be best source for sustainable waste management programme for rural and urban area. Disposal and treatment of organic waste is major issues so biogas uses organic waste so disposal and treatment is not more issue.

III. EXPERIMENTAL WASTES

3.1. Kitchen waste: Kitchen waste (KW) is organic matter which discarded from restaurants, hotels and house. Generally KW is not segregated from other solid waste from the source. KW is disposed along with Municipal Solid Waste (MSW) which is generally dumped. Dumping of such waste can cause fire hazard in landfill site due to generation of methane and other inflammable gases. KW along with other MSW causes public health hazard and other issues like flies, air pollution etc. Kitchen waste can be best utilized for waste to energy process as it is having high calorific volume. Many researchers have worked in different types of kitchen waste from residence, vegetable market etc. The vegetable waste is also organic matter which leftover from vegetable markets, restaurant, house, hotel. Vegetables are source of proteins, vitamins, minerals, dietary fibers, micronutrients, antioxidants, carbohydrates. The vegetable waste is a very serious issue. The vw disposal methods include dumping in municipal landfills, spreading on land and by feeding to animals. These methods results in many issue like dieses (cholera, malaria, and typhoid), insect, hazards, water pollution, air pollution and land pollution. (S.C. Rabelo. Et al., 2011)

3.2. Bagasse: Bagasse is the fibrous material that remain after sugarcane crushed to make juice. It is a dry pulpy residue left after the extraction of juice from sugarcane. Bagasse is lignocellulose in nature. Hence digestion of bagasse waste takes more time to biogas production and increase detention time. Bagasse is used as a bio-fuel and raw material for pulp and paper production, boards, animal feed, product based on fermentation. Bagasse is burnt by sugar industry as fuel for boiler. Mechanical pre-treatment, alkaline pre-treatment and acid pre-treatment are used for enhancement of biogas production. (OjikutuAbimbola. Et al, 2014)

3.3. Garden waste: Green waste is organic waste includes foliage, plant residues, fallen flowers, garden refuse, leaf litter, cut grass, residues of pruning, weeds and other organic matter discarded from gardens and greeneries. These green wastes disposal method include dumping in municipal landfills, or will be burned, if not collected and processed contributing to the pollution of land, air, water. (Priyanka Gupta et al., 2012)

The above study indicating that kitchen waste, bagasse and garden waste have best characteristics. So this is the best waste for producing biogas and no issue for waste treatment and disposal. Advantages are that biogas use as a energy source and outlet are used as a fertilizer for irrigation purpose.

IV. ANALYTICAL METHOD

4.1 pH: The pH Value is determined electrochemically with an pH electrodes.

The pH Value is determined electrochemically with an pH electrodes. As the check reference, pH paper was also used to determine the pH value. The 20gm of Kitchen Waste is weighted on weighing balance and thoroughly mixed into 5 times (100mL) tap or distilled water. The mixture is stirred with the pH electrode. The pH electrode is inserted into this mixture and reading is noted dow (SUYOG VIJ.et al, 2011)

4.2. Temperature: pH meter also measure Temperature.
The 20 gm kitchen waste is weighted on weighing balance and thoroughly mixed into 100 ml tap or distilled water(SUYOG VIJ.et al, 2011)

4.3. Total solid: It is the amount of solid present in the sample after the water present in it is evaporated. The sample, approximately 10 g is taken and poured in silica plate and dried to a constant weight at about 105 ^{0}C in furnace.

TS % = (Final weight/Initial weight) * 100

4.4. Volatile solid: Dried residue from Total Solid analysis weighed and heated in crucible for 2 hrs at 500±50 ^{0}C in furnace. After cooling crucible residue weighed.

VS % = [100-(V3-V1/V2-V1)] * 100

Where,
V1= Weight of crucible.
V2= Weight of dry residue & crucible.
V3= Weight of ash & crucible (after cooling)

4.5. Moisture content: Determine the water content of a sample by drying a sample to constant weight at a 105^{o}c

Moisture Content = 100 – Total solid

4.6. Organic content: Organic dry matter weighs the sample and weighs remaining ashes.

$$\text{Organic content} = \frac{(\text{Mass of total solid} - \text{Mass of ashes})}{(\text{Mass of Total solid})}$$

V. MATERIAL AND METHOD

5.1. Material

Kitchen waste like cooked rice, cooked dhal, Vegetables, Discarded floor Etc. are collected in bag from Govinda restaurant near ISCON temple. Kitchen Waste will be crushed by mixer grinder then use as a substrate.
Bagasse collected in polythene bag from Saurastra juice centre. Bagasse dried for a week then milled and sieved in small particle size.
Garden Waste collected from Nagarpalika garden near ISCON temple. Garden waste dried for a week then milled and sieved in small particle size.

4.2. Procedure

Six set of five liter digester are required. Substrate and inoculums with water required for different proportion will be mixed. Now close these six bottles by rubber gasket and this bottle attached with six Displacement bottle simultaneously. KOH solution require for absorb co2 into biogas. Three day set up monitored manually. Check pH, temperature of KOH solution in daily. Check Before or also after digestion of waste like parameter like pH, Temperature, total solid, volatile solid, moisture content, and organic content. Content measured.
Above study indicating that kitchen waste, bagasse waste and garden waste was used as substrate and cow dung used as an inoculums. Six set require with different proportion. Parameter like total solid, volatile solid, pH, temperature, organic content, moisture Content was measured before and after digestion.

1. 1. Digester of waste

Table 1: proportion of waste

No. of Sets	Kitchen Waste/ Bagasse/Garden Waste (%)(substrate)	Cow-dung (%) (Inoculums)	Water(L)
1	50	50	1
2	60	40	1
3	70	30	1
4	80	20	1
5	90	10	1
6	100	0	1

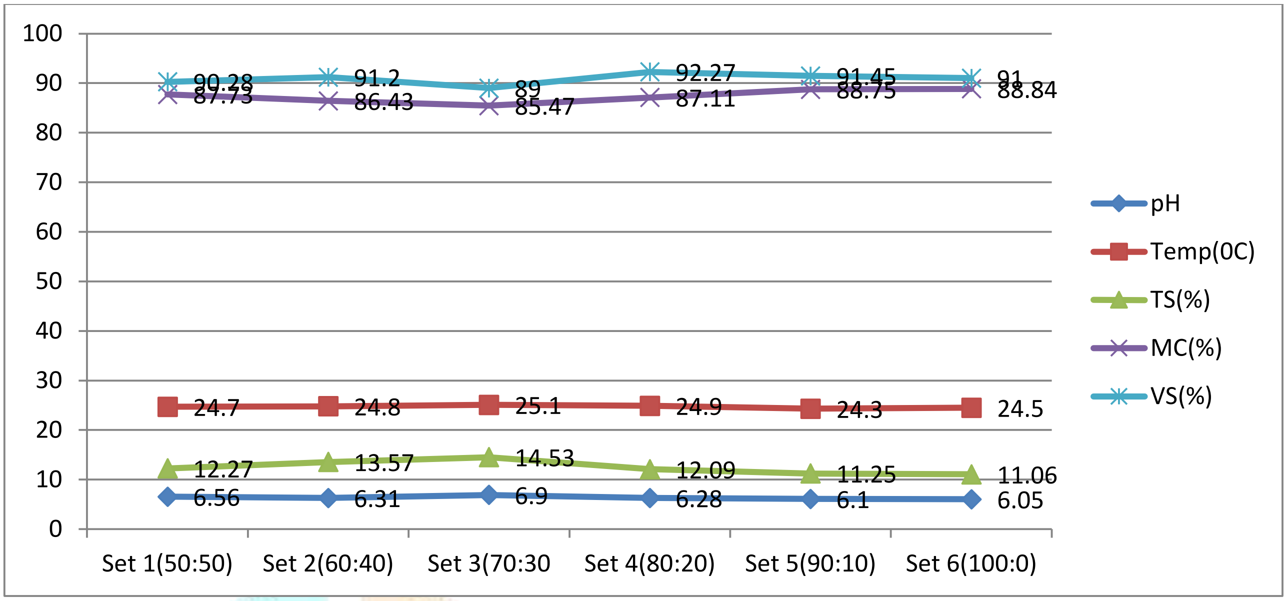
VI. RESULTS AND DISCUSSION

5.1. Parameter of Kitchen waste before Digestion

Table 2: Parameter of KW before Digestion

No. of Sets	pH	Temp(^{o}c)	Total solid (%)	Moisture content (%)	Volatile solid (%)	Organic content
1 (50:50)	6.56	24.7	12.27	87.73	90.28	0.90
2 (60:40)	6.31	24.8	13.57	86.43	91.2	0.91
3 (70:30)	6.90	25.1	14.53	85.47	89	0.89
4 (80:20)	6.28	24.1	12.09	87.11	92.27	0.92
5 (90:10)	6.10	24.3	11.25	88.75	91.45	o.91
6 (100:0)	6.05	24.5	11.06	88.84	91	0.91

The above table showed that the Set 3 of waste was maximum generation of biogas which used 70 percent substrate and 30 percent inoculums.



1. 2. Parameter of KW before digestion

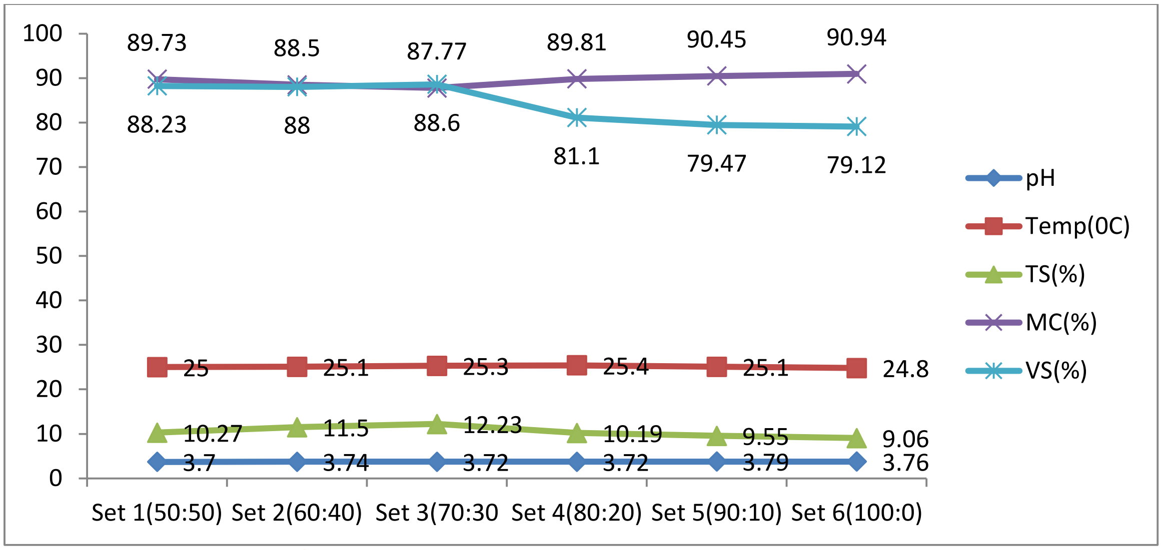
The Graph showed that number of set against pH, temperature, Total solid (%), Moisture Content (%), Volatile solid (%). The above graph show that Set 3(70 % of Kitchen waste and 30% of Cow dung) was produced maximum gas within 3 days.
The Optimum pH: 6.9 , Temp.:25.1, Total solid (%):14.53, Moisture Content (%):85.47, Volatile solid: 89.The maximum gas was more where parameter of pH, Temp, Total solid is maximum..

5.2. Parameter of Kitchen waste after digestion

Table 3: Parameter of KW after digestion

No. of Sets	pH	Temp(°c)	Total solid (%)	Moisture content (%)	Volatile solid	Organic content
1 (50:50)	3.70	25	10.27	89.73	88.23	0.88
2 (60:40)	3.74	25.1	11.5	88.50	88	0.88
3 (70:30)	3.72	25.3	12.23	87.77	85.6	0.88
4 (80:20)	3.72	25.4	10.19	89.81	81.1	0.81
5 (90:10)	3.79	25.1	9.55	90.45	79.47	0.79
6 (100:0)	3.76	24.8	9.06	90.94	79.12	0.79

The table showed that after digestion within 3 days. 15% total solid reduction and. 4% reduction in volatile solid was indicate that the gas production are maximum with reduction of total solid and volatile solid.



1. 3. Parameter of KW after digestion

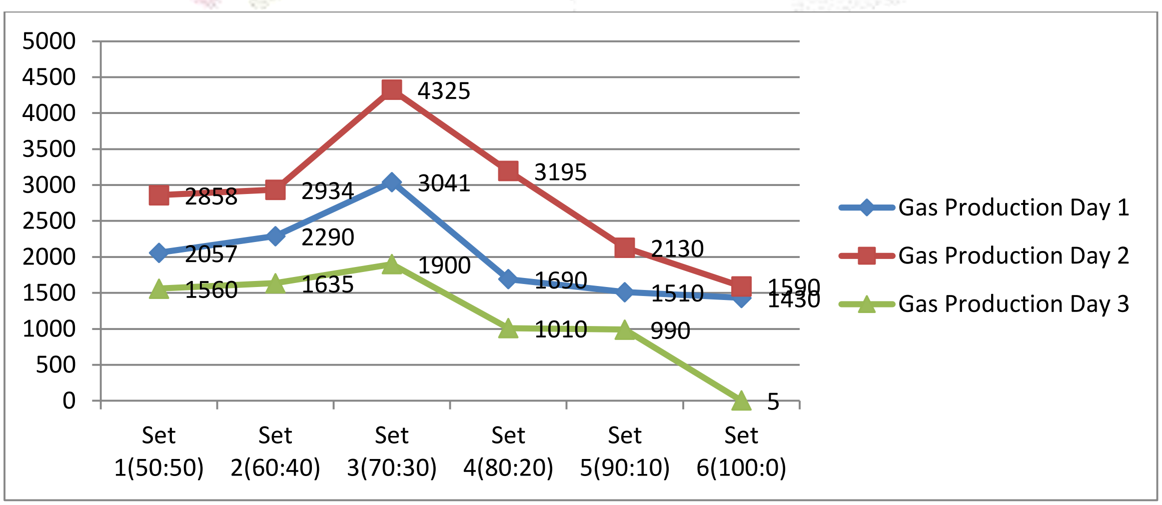
The above graph showed that the ph value, total solid and Volatile solid were decreased after Digestion.

5.3. Gas production of Kitchen Waste in ml

Table 4: Gas production of KW in ml

No. of Sets	Gas Production in Day 1(ml)	Gas Production in Day 2(ml)	Gas Production in Day 3(ml)	Total Gas Production in ml
Set 1(50:50)	2057	2858	1560	6475
Set 2(60:40)	2290	2934	1635	6859
Set 3(70:30)	3041	4325	1900	9266
Set 4(80:20)	1690	3195	1010	5895
Set 5(90:10)	1510	2130	990	4630
Set 6(100:0)	1430	1590	945	3965

The above table showed that set 3 was produced maximum gas at set 3 which 70% Bagasse and 30% cow dung was produced 9266 ml gas. If (0.0092m3) 9.266 of gas was used 6 minute give light.



1.4. Generation of Gas in ml

The below graph Observed that Gas Production is maximum on 2nd day FOR the practical because of

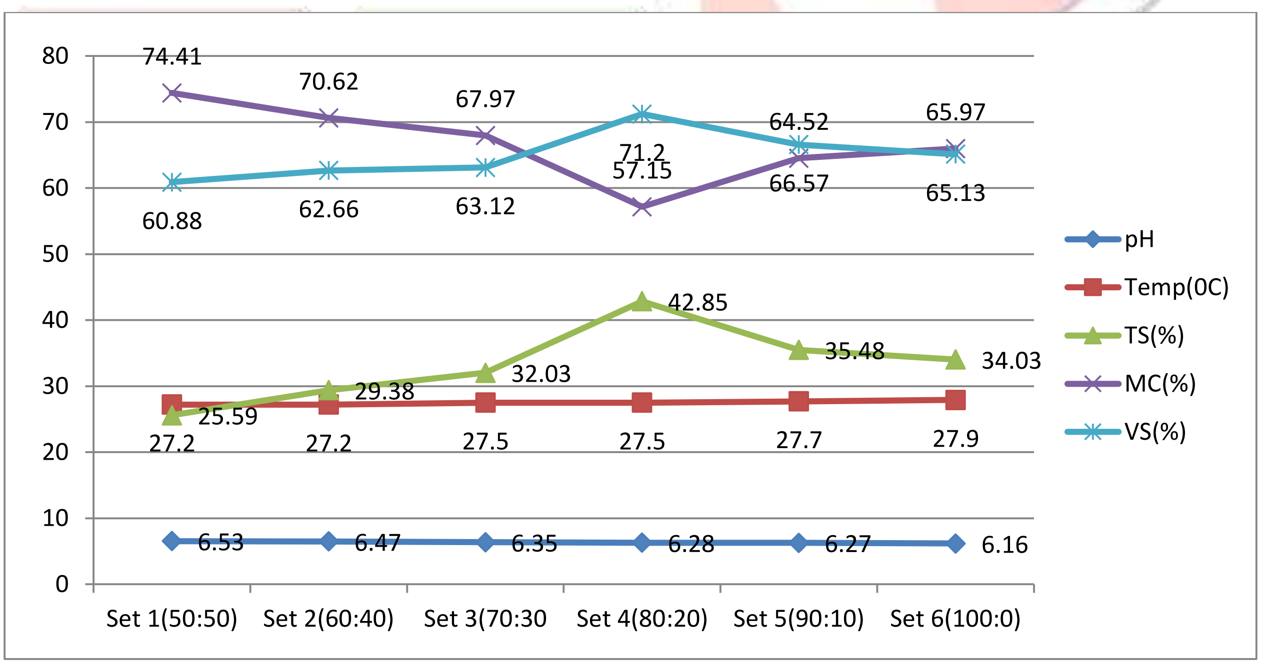
1. The slurry get mixed up and anaerobic condition developed.
2. On 2nd day proper anaerobic condition form and Gas Production goes maximum.
3. As a utilization of waste take place Gas Production reduced

5.4. Parameter of Garden waste before Digestion

Table 5: Parameter of Garden Waste before Digestion

No. of Sets	pH	Temp(^{o}c)	Total solid (%)	Moisture content (%)	Volatile solid (%)	Organic content
1 (50:50)	6.53	27.2	25.59	74.41	60.88	0.60
2 (60:40)	6.47	27.2	29.38	70.62	62.66	0.62
3 (70:30)	6.35	27.5	32.03	67.97	63.12	0.63
4 (80:20)	6.28	27.5	42.85	57.15	71.20	0.71
5 (90:10)	6.27	27.7	35.48	64.52	66.57	0.66
6 (100:0)	6.36	27.9	34.03	65.97	65.13	0.65

The table showed that set 4 of waste which 80% Garden Waste and 20% Cow dung was maximum at maximum total solid and volatile solid and minimum moisture content.



1. 5. Parameter of GW before Digestion

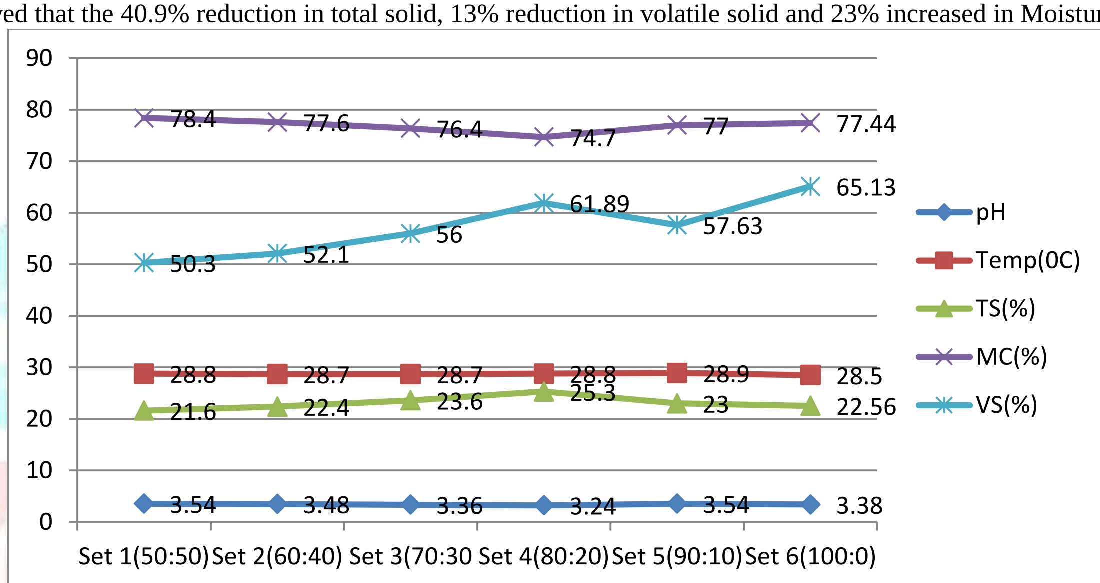
Garden waste was used as substrate and cow-dung was used as an inocumams are required different proportion of six set. The below graph show that Set 4(80 % of Garden waste and 20% of Cow dung) was produced maximum gas within 3 days.
The Optimum pH: 6.28, Temp.:27.5, Total solid (%):42.85, Moisture Content (%):57.15, Volatile solid: 71.2.The maximum gas was more where parameter Total solid are maximum and moisture content and volatile solid minimum.

5.5. Parameter of Garden waste after Digestion

Table 6: Parameter of GW after Digestion

No. of sets	pH	Temp. (^{0}c)	Total Solid (%)	Moisture content (%)	Volatile solid (%)	Organic content
1	3.54	28.8	21.6	78.4	50.3	0.50
2	3.48	28.7	22.4	77.6	52.1	0.52
3	3.36	28.7	23.6	76.4	56	0.56
4	3.24	28.8	25.3	74.7	61.89	0.62
5	3.54	28.9	23	77	57.63	0.58
6	3.38	28.5	22.56	77.44	56.7	o.57

The table showed that the 40.9% reduction in total solid, 13% reduction in volatile solid and 23% increased in Moisture content.



1. 6. Parameter of GW after Digestion

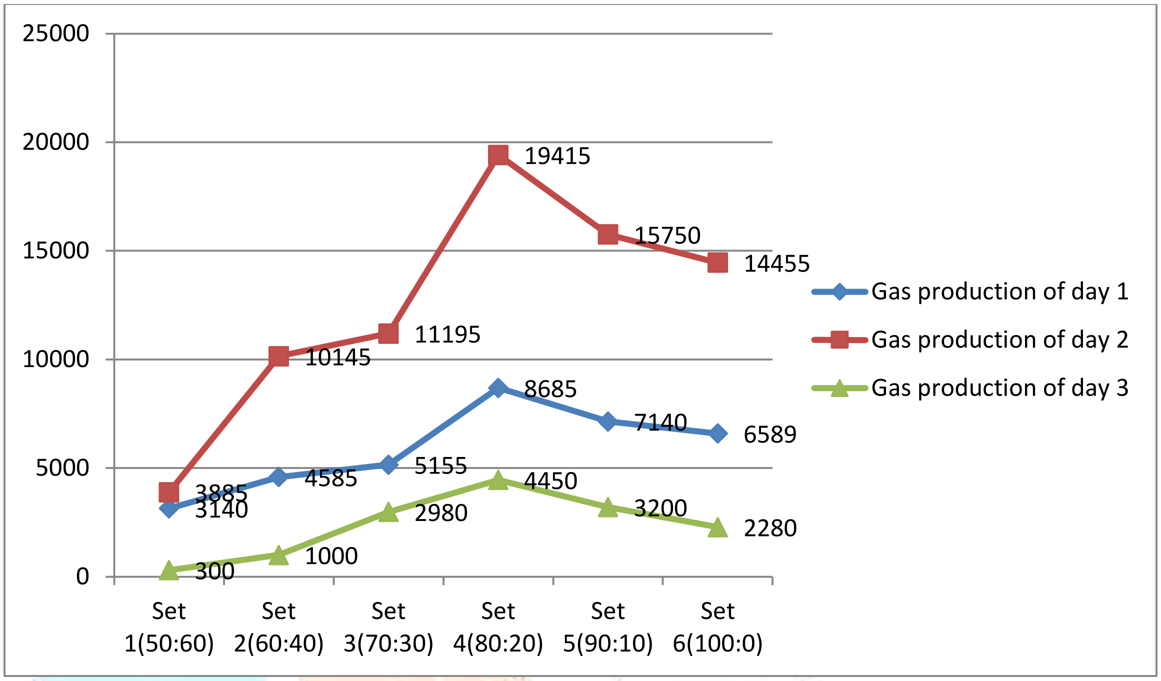
The waste after digestion pH, total solid, volatile solid was decreased day by day and increased moisture content after Digestion

5.6. Gas Production of Kitchen waste in ml within 3 days

Table 7: Gas Production of GW in ml

No. of Sets	Gas Production of Day 1 in ml	Gas Production of Day 2 in ml	Gas Production of Day 3 in ml	Total Gas production in ml
1	3140	3885	300	7325
2	4585	10145	1000	15730
3	5155	11195	2980	19330
4	8685	19415	4450	32550
5	7140	15750	3200	26090
6	6589	14455	2280	23324

The table Showed that the maximum production rate at set 4 in which 80 % Garden Waste used as a substrate and 20% cow dung used as an inoculums. The set 4 was produce 32.55 L gas which gave 20 minute light.



1. 7. Gas Production of GW in ml

It is observed that Gas Production is maximum on 2nd day FOR the practical because of

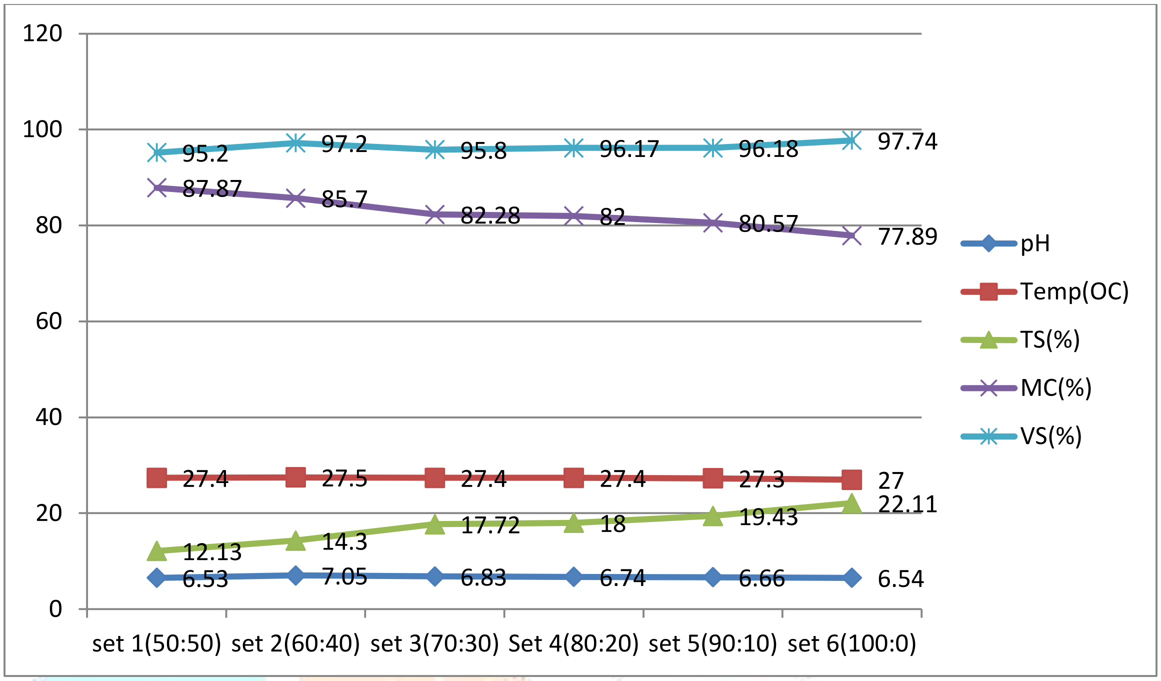
1. The slurry get mixed up and anaerobic condition developed.
2. On 2nd day proper anaerobic condition form and Gas Production goes maximum.
3. As a utilization of waste take place Gas Production reduced.

5.7. Parameter of Bagasse waste before digestion

Table 8: Parameter of Bagasse before Digestion

No. of Sets	pH	Temp.(0C)	Total Solid (%)	Moisture Content (%)	Volatile Solid (%)	Organic Content
1	6.53	27.4	12.13	87.87	95.2	0.95
2	7.05	27.5	14.3	85.7	97.20	0.97
3	6.83	27.4	17.72	82.28	95.8	0.95
4	6.74	27.4	18	82	96.17	0.96
5	6.66	27.3	19.43	80.57	96.18	0.96
6	6.54	27	22.11	77.89	97.74	0.97

The above table showed that total solid increased with number of set and moisture content decreased with number of sets.



1.8. Parameter of Bagasse before Digestion

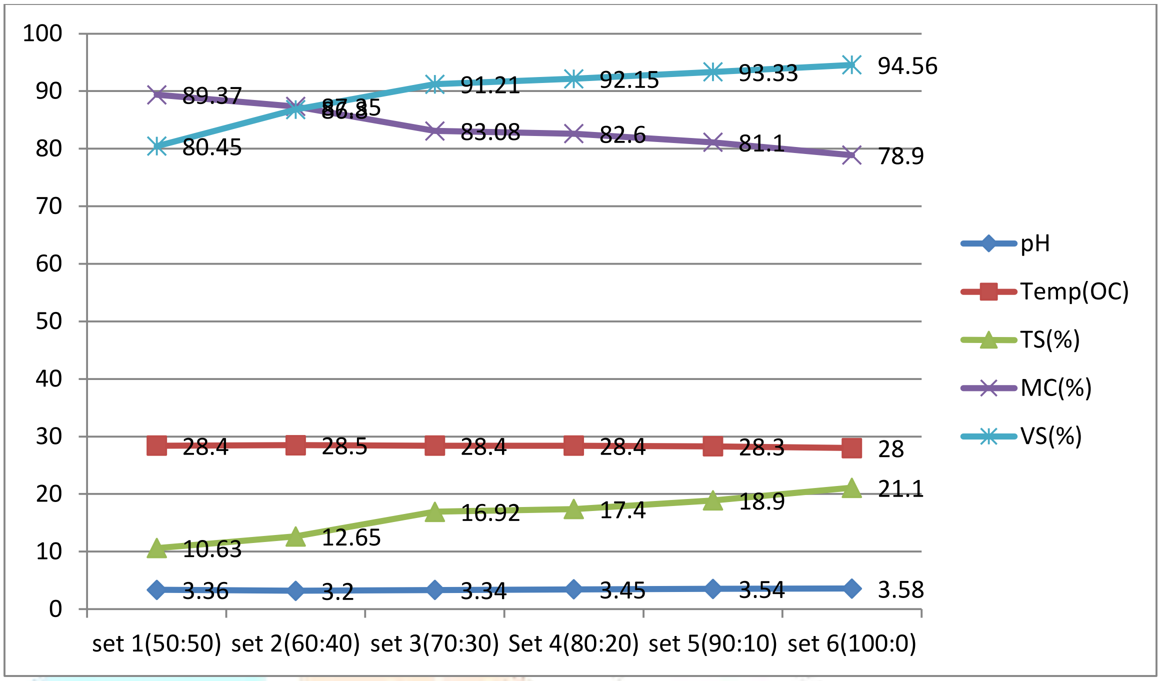
The above graph show that total solid incresed with nomber of set but gas production was not incresed with incresed total solid. One limit of gas prodution was incresed with incresed of total solid at set 2. Then not more gas production was ocuured with incresed Total solid.

5.8. Parameter of bagasse waste after digestion

Table 9: Parameter of Bagasse after Digestion

No. of Sets	pH	Temp.(0C)	Total Solid (%)	Moisture Content (%)	Volatile Solid (%)	Organic Content
1	3.36	28.4	10.63	89.37	80.45	0.80
2	3.20	28.5	12.65	87.35	86.80	0.86
3	3.34	28.4	16.92	83.08	91.21	0.91
4	3.45	28.4	17.4	82.6	92.15	0.92
5	3.54	28.3	18.9	81.1	93.33	0.93
6	3.58	28	21.10	78.9	94.56	0.94

The above Graph showed that 55% reduction in pH 12 % reduction in Total solid and 11 % reduction in volatile solid and 2.11 % increased in moisture content and 4% increased in temperature at set 2 which 60 % Bagasse and 40 % cow dung was produce maximum biogas.



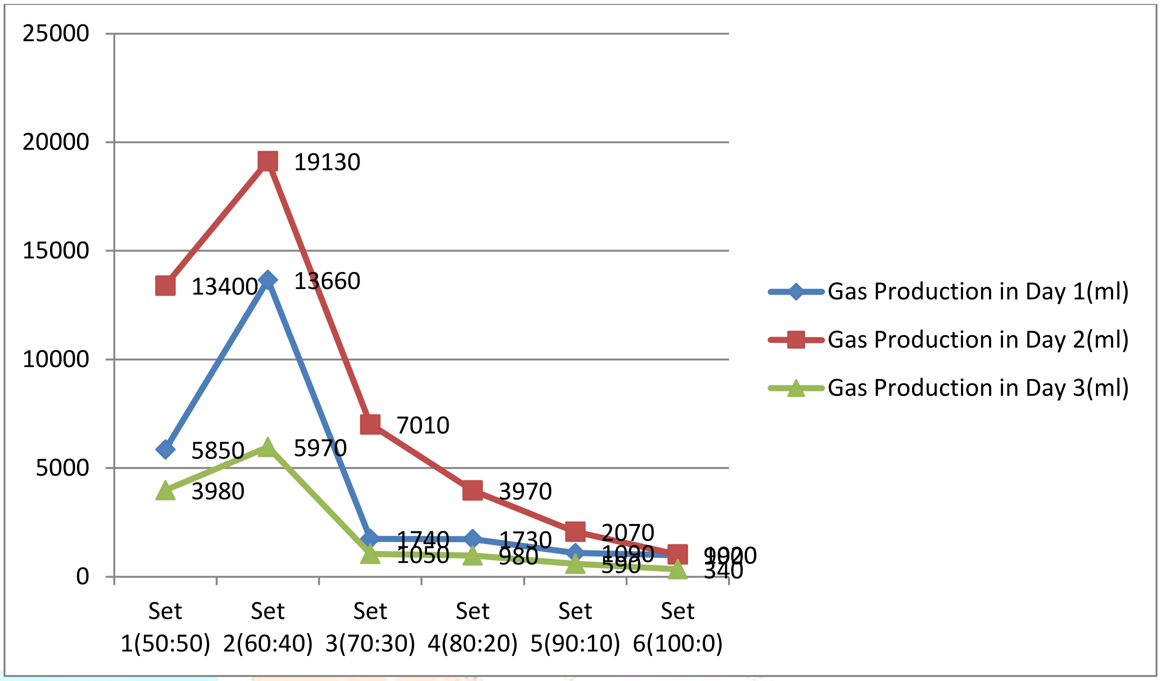
1.9. Parameter of Bagasse after Digestion

The above Graph showed that pH, Total solid and Volatile solid was decreased after digestion. Moisture content and temperature was increased after digestion.

Table 10: Gas Production of Bagasse in ml

No. of Sets	Gas Production in Day 1(ml)	Gas Production in Day 2(ml)	Gas Production in Day 3(ml)	Total Gas Production in ml
Set 1(50:50)	5850	13400	3980	23230
Set 2(60:40)	13660	19130	5970	38760
Set 3(70:30)	1740	7010	1050	9800
Set 4(80:20)	1730	3970	980	6680
Set 5(90:10)	1090	2070	590	3750
Set 6(100:0)	990	1020	340	2350

The above table showed that set 2 was produced maximum gas at set 2 which 80% Bagasse and 20% cow dung was produced 38760 ml gas. If (0.0387m3) 38.76 l of gas was used 23 minute give light.



1. 8. Gas Production of Bagasse in ml

The above graph showed that set 2 was produce maximum gas and gave 23 minute light.

VII. CONCLUSION

Gas production of Kitchen Waste, Garden waste and Bagasse was maximum on 2nd day.

Gas production of kitchen waste take place maximum with set 3 that is 70 % Kitchen waste and 30% cow dung along with water. The set 3 was produced maximum 9.266L of gas which gave 6 minute light.

Gas production of Garden waste take place maximum with set 4 that is 80% Garden waste (substrate) and 20% Cow dung (inoculums) along with water. The set 4 produced 32.55 L gas which gave 20 minute light.

Gas production of Bagasse was maximum with set 2 that is 60 % bagasse and 40% cow dung along with water. Gas production of Bagasse was produce 38.761 ml gas which give 23 minutes light.

In bagasse the total solid increased with generation of gas but one limit arrive that gas production not increased with increased total solid.

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