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Comparative analysis of production of Biogas by using Kitchen Waste, Cow Dung & Paper Waste

Amit Kumar Thakur, J.V.M Lal Jeyan, Bilji C Mathew
School of Mechanical Engineering
Lovely Professional University, Phagwara, Punjab

ABSTRACT

Energy has become very important and plays a pivotal role in the overall development of any country.The basic infrastructure for the industrial, social and economic development of country is highly dependent on energy.Household and community wastes have emerged as the food for thought for harnessing the energy in many developed countries.The need of the hour is to properly utilise the resources so that maximum energy can be extracted from these wastes which are always readily ignored. These days, a novel environmental schema is emerging, which is now forcing itself on the attention of policy-makers and the public at large. In recent years, there are various harmful effects of global warming due to nearly dependence of fossil fuels are observed. The need of developing clean, sustainable and secure energy resources is realized. The economic growth cannot be sustained until reliable energy is made available at a responsible cost.Energy can be harnessed from variety of resources available. Biomass has effectively proved as the one of the potential source of energy as it completely helps in providing the solution for the depleting resources and efficiently handles the global warming.Fossil fuels, which are used for thermal and electricity applications can be replaced by biogas because it is ecofriendly.Biogas has proved itself very reliable in terms of electrical efficiency and has readily shown its immense potential for the generation of electricity.Thus biomass gasfication has provided different alternative to conventional heat and power generation systems.The extraction of energy in gaining importance in various countries who have rich source of feedstock,and those countries were oil prices are quite high.Biomass gasification has picked up strongly in many developed countries and is considered to be a promising candidate for the suitable energy extraction.

This work introduces the comparative study of production of biogas by using different wastes such that kitchen waste, paper waste, and cow dung in a certain ratio and determination of parameters of establishing biogas plants. All these wastes were kept into 20 liter plastic prototype bio digester in different ratios. They were kept to anaerobic digester for 15 days in temp range of 25^0 c-35^0 c the physicochemical parameters of the wastes were determined in different wastes. In this study it is shown that the cow dung and paper waste gives the sustained gas flammability throughout the digester period and kitchen waste gives more production than cow dung and paper waste. In paper waste the gas production is comparatively less.

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INTRODUCTION

Energy is the basic requirement of the economic growth of any country, due to the environmental problems and possible shortage of fossil fuels, world necessitates enduring potential measures for sustainable development. It is commonly known that the world's main energy resources will be exhausted in coming years.The world is going to face the shortage of fuel available and due to the exessive usage of fossil fuels, the environment is found to be degrading day by day[1] .Energy is limited but the usage is high as the end users are more, the demand for energy is increasing beyond and the need of the hour is to find the better and efficient substitute of these fossil fuels which can hold the crises[2]. Biogas technology has created its mark over the last 60 years but not yet established fully.Biogas constitutes methane and CO_2 which is generated by the biodegradation process of organic material with the help of bacteria.The renewable energy resources are one of the most resourceful solutions. Biogas has internationally remained a renewable energy source which is a general thing for living material, plants, animals and bacteria [3]. Energy attained from biomass is known as biomass energy. It is generated due to the photosynthesis process. Biogas is a colorless flammable gas it contains mainly methane,carbon dioxide and other gases [5]. It is a mixture of Combustible gasses produced during anaerobic digestion of organic matters in an anaerobic biogas digester. Biomass are considered as a potential candidate when it comes to lessen the amount of greenhouse warmimg[6].Various bioenergy programmes can be initiated and developed with effective management and fully developed strategies.In order to develop biomass crop proper understanding and knowledge has to be developed,so that the biomass crop helps in proper extraction of biomass energy[7].As major organic matter decomposes as and soon it is exposed to oxygen and sunlight.In the case of anaerobic fermentation however ,the organic matter decomposes without the help of oxygen.Mostly these types of decomposition is seen in landfills when the waste material becomes drenched and recieves very little sunlight[8].Due to this effect lot of methane and nitrous oxide is shaped and freed into the atmosphere.Biogas is the result of this decay and is considered as the energy source which has no comparison with other source.Although the structure of the biogas is bit complex as it mainly comprises of methane and carbondioxide and it is quite confusing as how these gases help in reducing greenhouse emissions.The wonder takes place only when the gas is burnt.As biogas burns it reacts with oxygen and releases ebergy whichis considered to be clean in nature.Biogas plants are gaining importance owing to numerous benefits coupled with them.Biogas is readily being utilised for public transport,industrial

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heating and many more applications[10].Owing to its high calorific value it becomes very difficult to store ,compress or liquefy biogas.Biogas has great potential and is rightly called as ecofriendly biofuel.It has shown its potential in generating electricity and also as readily available automotive fuel.CNG (compressed natural gas) can be replaced for biogas if proper production of biogas is monitored[12].

Compositions of Biogas-

The compositions of biogas are –

Table 1 Composition of biogas

S. No.	Substance	Percentage
1	Methane (CH_4)	60-70%
2	Carbon dioxide ($C0_2$)	20-30%
3	Hydrogen (H_2)	10-15%
4	Nitrogen (N_2)	1-5%
5	Water vapor (H_2O)	0.5%

Biogas is generally 25% lighter than air and having the ignition temperature ranging from 700^0c to 800^0c. The calorific value of biogas is about 8 kwh/m^3. The net calorific value is depending on the efficiency of burning of the other applications. Various waste materials have been initialized for the production of biogas. Cow dung, Agricultural wastes and papers are reading available from offices and various institutions. Biomass is competent enough of delivering firm energy. Ministry of New and renewable energy has realized the potential of biomass energy and started various programs for its promotion.

Characteristics of Biogas:-

Composition of biogas is also depends on the feed material. Biogas is about 25% lighter than air and equation temperature is about $600\text{-}700^0$ C. Biogas is odourless and colourless and burns with blue flame like LPG. This gas is useful as fuel in substitution of LPG, cow dung, electricity & firewood etc. Biogas digester offers a residue organic waste after anaerobic digestion. Another function of biogas digester is waste disposal system for human wastes and other material.Biogas technology is predominantly priceless in agricultural residual treatment of animal and kitchen wastes.

Energy is the basic and important Infrastructure in this age. Renewable energy is the one of the best alternatives. Due to heavy potential, Govt. of India is executing one of the biggest renewable energy programs of the world. In renewable energy sources bio energy is the largest diverse portfolio including efficient biomass stones, biogas, biomass combustion and specification of fuels. Biogas digester is usually made from steel, Zink, Rubber aluminum or

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combination with two or more between of them. The digester body is generally made through casting process. Currently there are various improvements in manufacturing the body structure of biogas digester such as the change of materials of the digester, biogas digesters are used widely to produce Methane gas which can be used for generating electricity and also can be used as cooking gas.

A compact biogas plant was developed by appropriate rural technology of India, Pune (2003) in which waste food is used in place of cow dung used as feedstock to supply biogas for cooking. 3 Kg of such feedstock produces 700 gm. of methane in 24 hrs. In the conventional biogas systems cow dung is used which produces the same amount of meat 40-50 kg of feedstock. Hence this plant is very efficient in comparison of biogas system. Shalini Singh et al [4] analysed the elevated biogas production utlizing microbial stimulant aquasan and teresan on biogas yield especially from cattle dung.Later a mixture of cattle dung and kitchen waste was used to study the overall production of biogas.The results revealed that mixing of cattle dung to aquasan boosted the gas production upto 55% and the mixed residue of cattle dung and kitchen waste in equal proportion enhanced the gas production by 15%.Kumar et al [9] in his reasearch work examined the reactivity of methane .It was observed that the reactivity of methane proved to give 20 times more global warming as compared to carbon dioxide and the concentration kept on raising in the standard atmosphere . Thomsen et.al [11] displayed his work on biogas degradation using microorganism.The biogas thus produced was considered to be environmentally sustainable energy source.Challenge was to effectively use the subtracts of kitchen waste and crop residues for the production of biogas. Suyog vij et.al [13] investigated the production of biogas from kitchen waste and created an organic processing facility to enhance the production of biogas from kitchen waste.They this concluded that biogas is more cost effective and considered to be more cost effective.Sagagi et al [14] in his experimental investigation generated the production of biogas from fruits and vegetable waste .The production of the biogas was found to be more with the low dung and proved to be beneficial when it came to the production of biogas as that depends on the nature of the substrate used. In this present work study about the production of biogas by using cow dung, kitchen waste, and paper waste has been carried out. The biogas production is compared among these materials. In the above papers different studies were found for the biogas production by using different materials but there is not a comparison between the two or three or more materials which produces biogas.

METHODOLOGY

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This chapter deals with the experimental methodology, processes for the production of biogas, different types of digestion systems used. By using Biogas digester, methane gas can be produced thought the fermentation process generally the waste products (Cow dung, Kitchen wastes, human waste paper wastes) are used to produce methane gas from the digester the methane gas will presently flow out from outlet the biogas digester must be build to be long lasting, has characteristic of corrosive resistance high tensile strength and has technical stability in this thesis an attempt in made to consider the potential of bio energy to meet the rural energy needs :-

(1) The combustion of biomass.

(2) Gasification of electricity.

(3) Biomethanation for cooking gas and electricity.

This thesis focuses on the analysis of the effectiveness of bioenergy in creating this rural energy access and its sustainability. The demand of for bio energy and potential that could be created. Bioenergy technologies are presented as potential carbon abatement opportunities substitutly fossil fuel biomass energy system. Proximate analysis has been carried out in this study to access the potential use of the biomass.

EXPERIMENTAL WORK

Objectives and materials used:-

The objectives of the present thesis work are -

1. Selection of biomass wastes.
2. Characterization of these biomass components for their energy values.
3. Estimation of power generation potentials for small plants.
4. Comparative study of biogas production from cow dung, agricultural wastes, and paper wastes.

In present thesis work various types of waste materials are used, they are as follows:-

(i) Cow dung.

(ii) Paper Waste.

(iii) Agricultural/Kitchen waste.

For the production of Biogas the setup is prepared. The Experiment is performed in different ways. The Steps involved in this experiment are discussed as follows:-

Experiment No-1

Procedure

(1) A 1 liter bottle is used.

(2) 200 gm. cow dung

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(3) 400 gm. water

Result: Gas production was seen but not calculated.

Confirmation: Gas burned with blue flame.

Experiment No-2

Procedure

(1) A 1 liter bottle is used.

(2) 200 gm. Kitchen waste (Blended)

(3) 400 gm. water

Result: Gas production was seen but not measured.

Confirmation: Gas burned with blue flame.

Experiment No-3

Procedure

(1) A 1 liter bottle is used.

(2) 200 gm. blended paper(Blended)

(3) 400 gm. water

Result: Gas production was seen but not calculated.
Confirmation: Gas burned with blue flame.
In all the experiment PH value of the solutions decreases.

Experimental works -

The experiment is performed in 3 different Jars of capacity of 20 L. All the jars are filled by the waste materials (cow dung, kitchen/Agricultural waste, and paper waste) in different concentration & combination. Different parameters of inputs like total solid, volatile solid, volatile fatly acid, PH value, Temperature are measured, then the gas production is 20 liter Jar is analyzed. The objectives of the thesis/experiment work are –

(i) Optimization of gas production

(ii) Comparison with each other and conventional plants also.

(iii) Different effective parameters such as temperature, C: N ratio, PH value, etc.

First of all the length of PVC pipe is marked equal to the length of Jar and to be cut, the PVC pipe is inserted in the jar. A hole is made in Jar equal to the diameter of pipe. The pipe is kept 2-4 inch above the jar surface this is the inlet pipe. Now another outlet pipe is also fitted. Now the holes are made airtight, the air pipe is connected in jar and T-value is connected in the pipe and further it is connected to the tyre tube. The end of the T-valve is connected to the nozzle. All the connections are made air tight. Now the digesters are made to use, the wastes

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are collected in the digester and left for 2 weeks. After two weeks bacteria are generated in the digester and left for 2 weeks. After two weeks bacteria are generated in the digester due to anaerobic reaction methane gas is produced the digester should be avoided from high so that algae formation because they produced oxygen which can interrupt the methane formation for this problem the jars are painted by black paint. The wastes are collected separately in all jars the weight of tyre tube is measured before attacking them after 2 weeks their weight of tyre tube is measured before attaching them after 2 weeks their weight is measured again the gas generated in the Jars can be used

Preparation of digester plants -
Required Materials-

Digester plants are prepared in 20 L Jar of drinking water, the following materials are required to make a digester plant –

Table 2 List of materials

Sr.no.	Name of material	Quantity
01	20 L Jar	03
02	Pipe	09 m.
03	$\frac{3''}{4}$ PVC pipe	05 m.
04	T – Valve	03
05	Tyre tube	03
06	Valve	03
07	Solid tape	01
08	M-seal	5 tube
09	Funnel(for input)	01
10	Cape(to seal the pipes)	06
11	Bottles	03

Description:-

First of all the length of PVC pipe is marked equal to the length of Jar and onto be cut, the PVC pipe is insisted in the jar. A hole is made in Jar equal to the diameter of pipe. The pipe is kept 2-4 inch above the jar surface this is the inlet pipe. Now another outlet pipe is also fitted.

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Plan of Bio digester

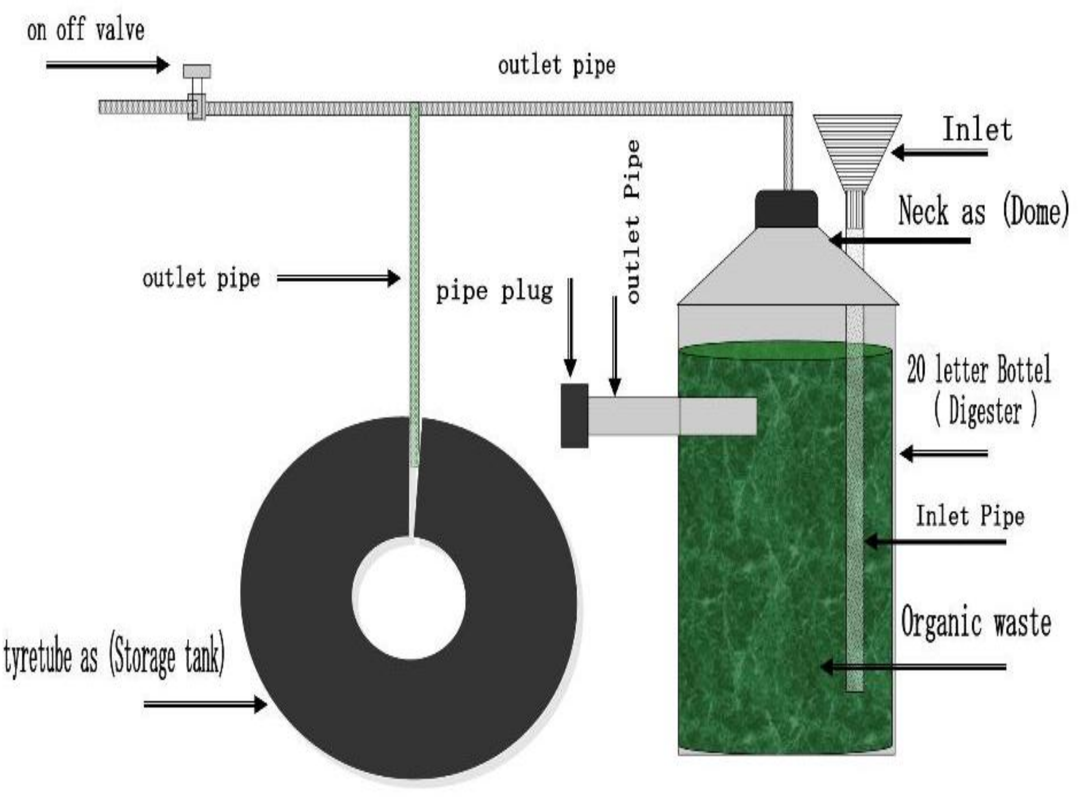

Fig 1. Plan of bio digester

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Fig 2 Model of the digester

RESULT AND DISCUSSION

Calculation:-

Total Solids (TS %) - It is defined as the quantity of solid present in the sample after the water in attendance has vaporized.

$$TS\% = \frac{Final\ \ weight}{Initial\ \ weight} x100$$

Composition of the Kitchen waste used:

In this experiment various types of kitchen wastes are used in different compositions. Such wastes were cooked and such were uncooked.

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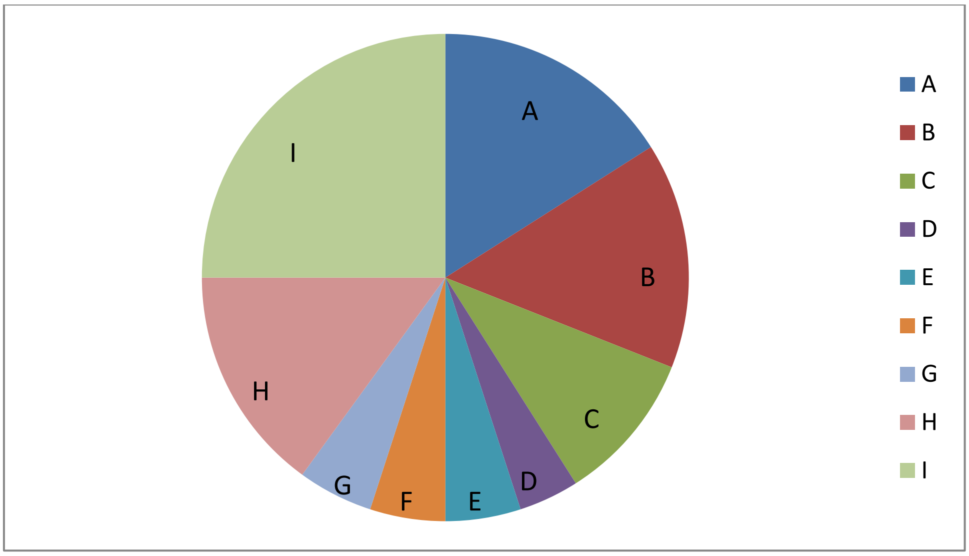

Fig 3 Pie chart of the kitchen waste used

(A) Cooked food – 16%

(B) Uncooked fruits & Vegetable - 15%

(C) Green Vegetable leaves - 10%

(D) Bread – 4%

(E) Teabags – 5%

(F) Eggs-5%

(G) Cheeses-5%

(H) Ready Floor – 15%

(I) Chips of Vegetable, Fruits, Onions, etc-25%

Composition of the paper waste used:-

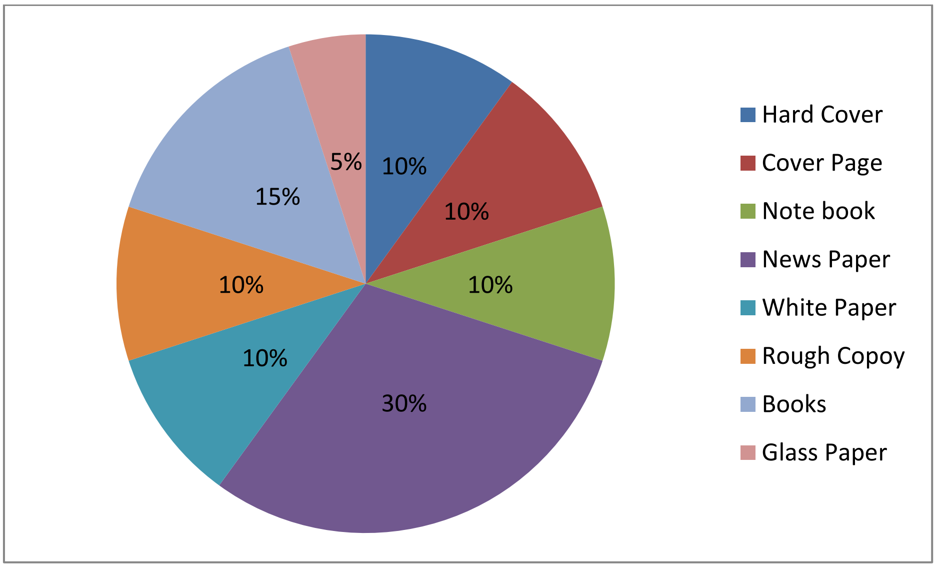

Fig 4 Pie chart of paper waste used

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(A) Hard Cover-10%
(B) Cover Page-10%
(C) Note Book-10%
(D) News Paper-30%
(E) White Paper-10%
(F) Rough Copy-10%
(G) Books-15%
(H) Glass paper-5%

Discussions:-

From the results of the above experiments it was observed that the jar in which Kitchen waste contains, more gas is produced in comparison of the other two jars. It produces average 350 % approx. more gas than paper waste and 55 % approx. more than cow dung. Thus it was revealed that as kitchen waste contains higher nutrient content ,the biogas released using kitchen waste is much more as compared to the cow dung,ultimately reaching to the conclusion that biogas can be produced more effectively and efficiently using kitchen waste.

Table 3 Day wise biogas production in gm.

Waste	2nd day	4th day	6th day	8th day	10th day	12th day	13th day	15th day	Average
Paper waste	40	43	41	37	35	38	36	28	37.25
Cow dung	55	61	86	89	87	99	101	107	85.625
Kitchen waste	110	124	131	138	147	136	143	139	133.375

Results indicated that PH value reduced as the process was carried out as the bacteria kept on producing the fatty acids.In the jar the value of PH decreased to touch low as it contained kitchen waste and the reaction was considered to be very fast.Fast reactions is due to the rapid growth of organism as it utlizes kitchen waste more faster as compared to cow dung.Total solid content was also found to be low in the jar which contained kitchen waste.

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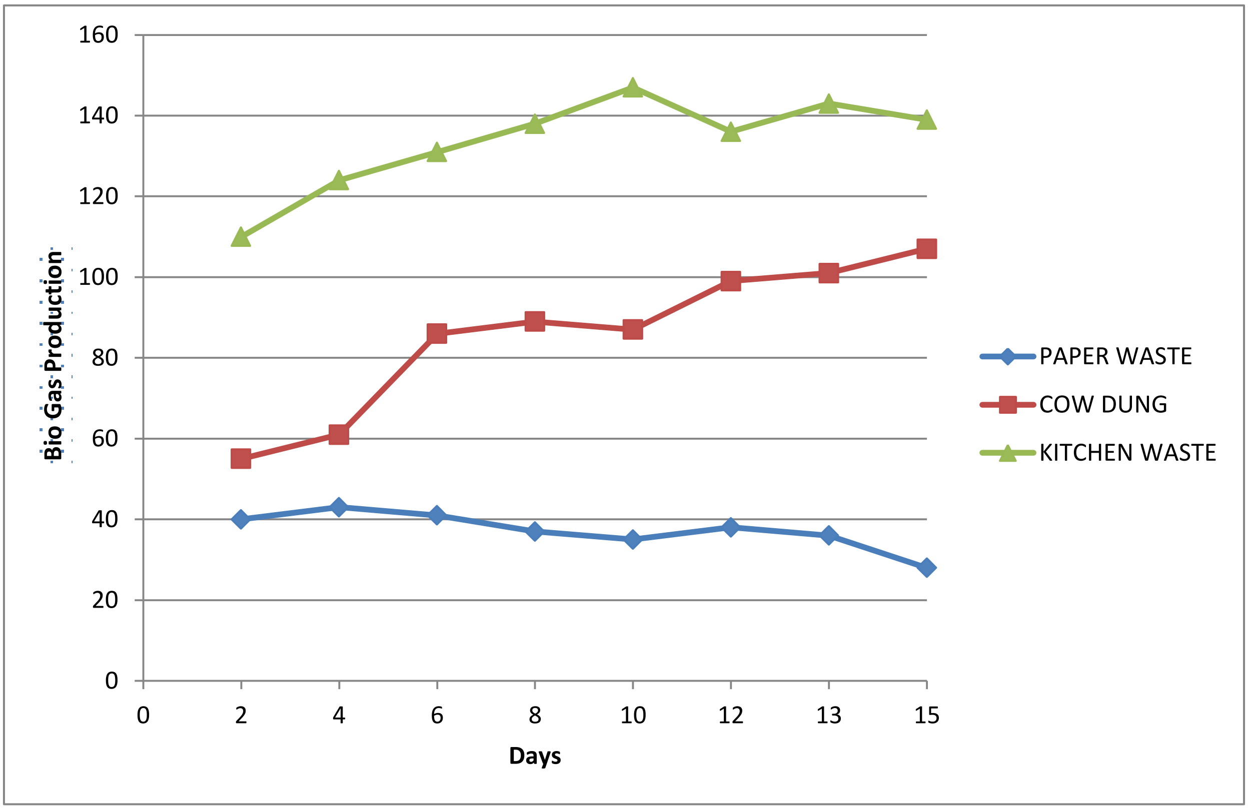

Fig 5 Gas production versus days

PHChange of the Wastes

Table 4 PH change versus days

Waste	2nd day	4th day	6th day	8th day	10th day	12th day	13th day	15th day
Paper waste	7.10	6.70	5.50	5.45	5.85	6.25	6.00	4.32
Cow dung	7.00	6.90	6.76	6.50	6.45	6.15	6.12	6.10
Kitchen waste	7.25	6.93	6.60	6.30	6.40	6.80	6.50	6.10

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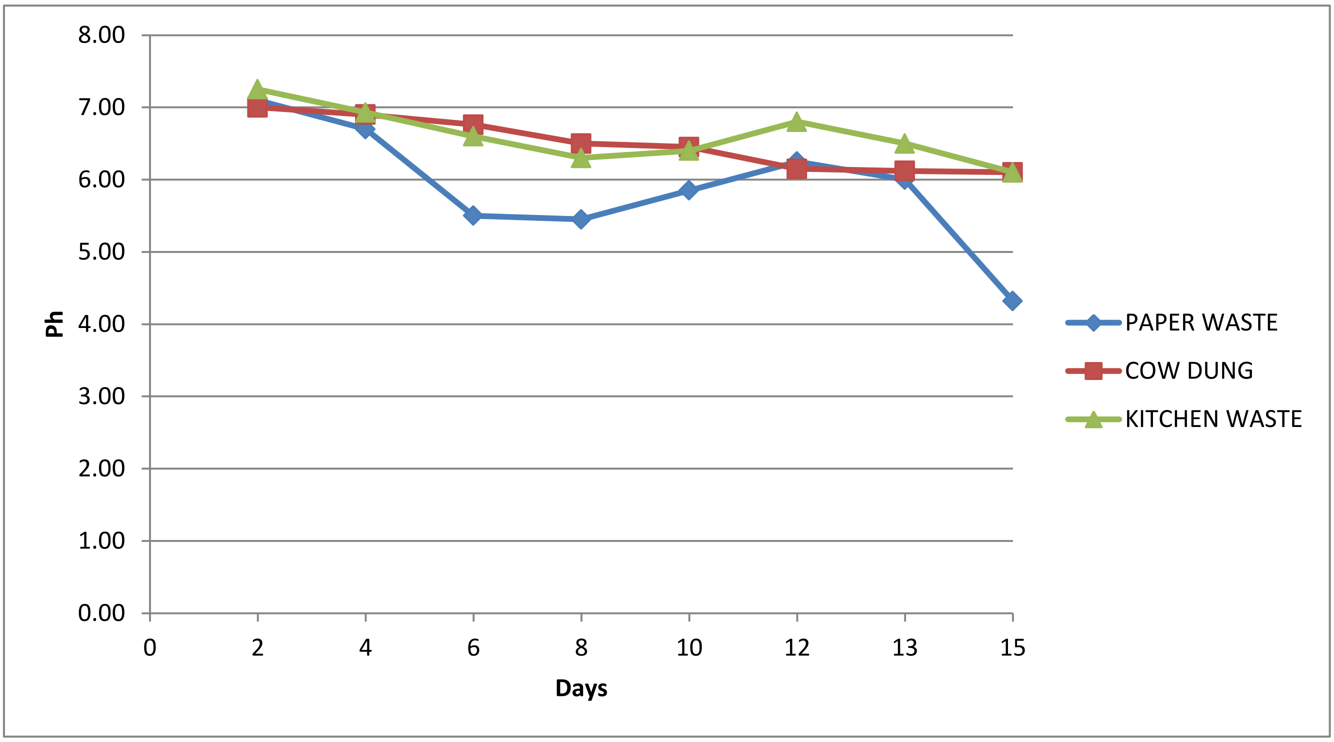

Fig 6 PH change versus days

This graph shows that firstly the P_H is high, as the reaction continues P_H starts decreasing and becomes acidic. When water is added it again increases.

RESULTS

The followings data are the result of pH and TS change of the experiment.

Table No 5 pH and total solid concentration of Setup

Day	**Cow Dung**		**Paper Waste**		**Kitchen Waste**	
	pH	TS%	pH	TS%	pH	TS%
2	7.00	9.00	7.10	5.90	7.25	8.0
3	6.92	8.96	6.92	5.86	7.00	7.91
4	6.90	8.84.	6.70	5.82	6.93	7.83
5	6.82	8.80	5.90	5.70	6.87	7.46
6	6.76	8.65	5.50	5.55	6.60	7.35
7	6.60	8.52	5.60	5.60	6.25	7.20

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8	6.50	8.00	5.45	5.52	6.30	7.18
9	4.42	7.98	5.40	5.48	6.35	7.14
10	6.45	7.15	5.85	5.45	6.40	7.10
11	6.10	7.70	6.10	5.10	6.70	6.90
12	6.15	7.60	6.25	5.20	6.80	6.45
13	6.12	7.40	6.00	4.80	6.50	6.20
14	6.13	7.10	5.01	3.90	6.35	5.97
15	6.10	7.0	4.32	3.7	6.10	6.0

Daily PH Change Graph of Cow dung

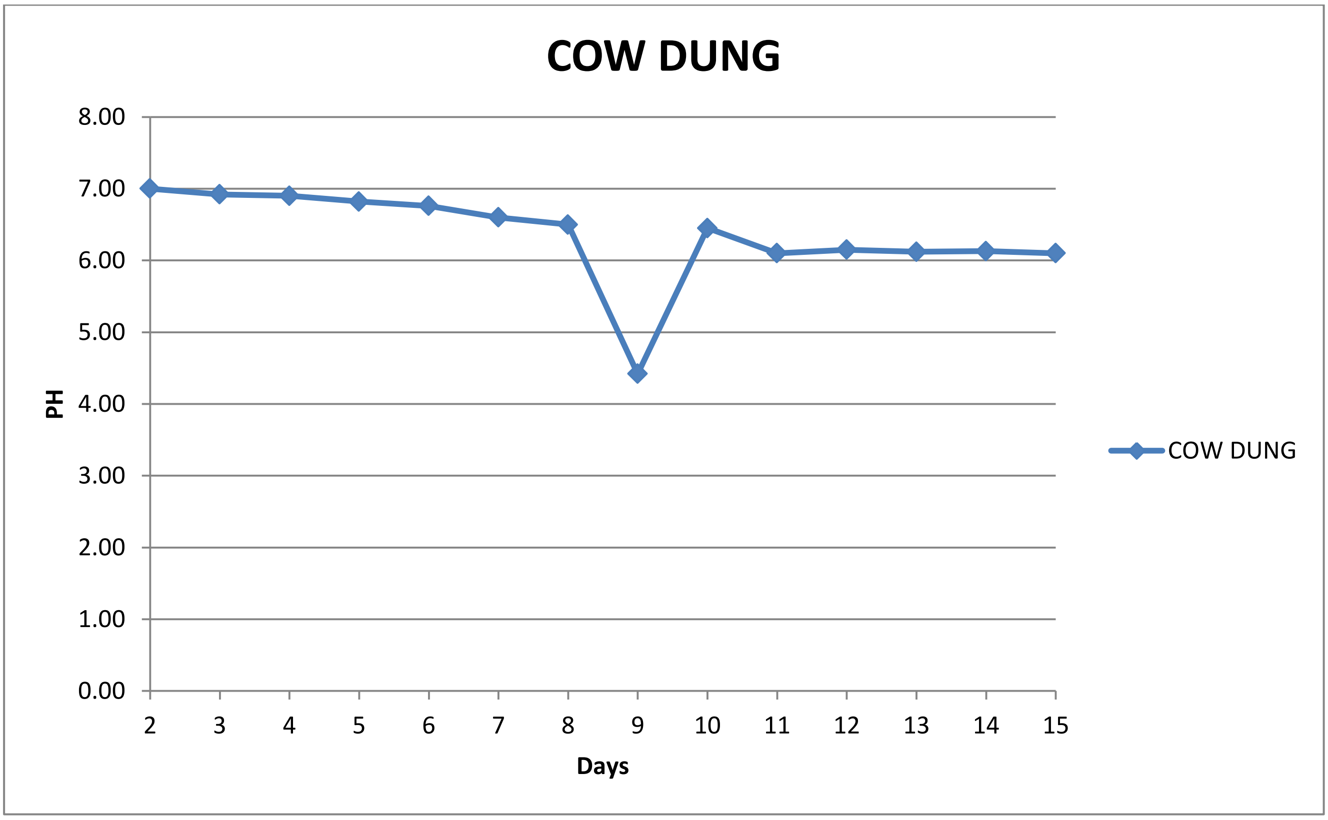

Fig 7 Daily PH change graph of cow dung

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Daily pH Change Graph of paper waste-

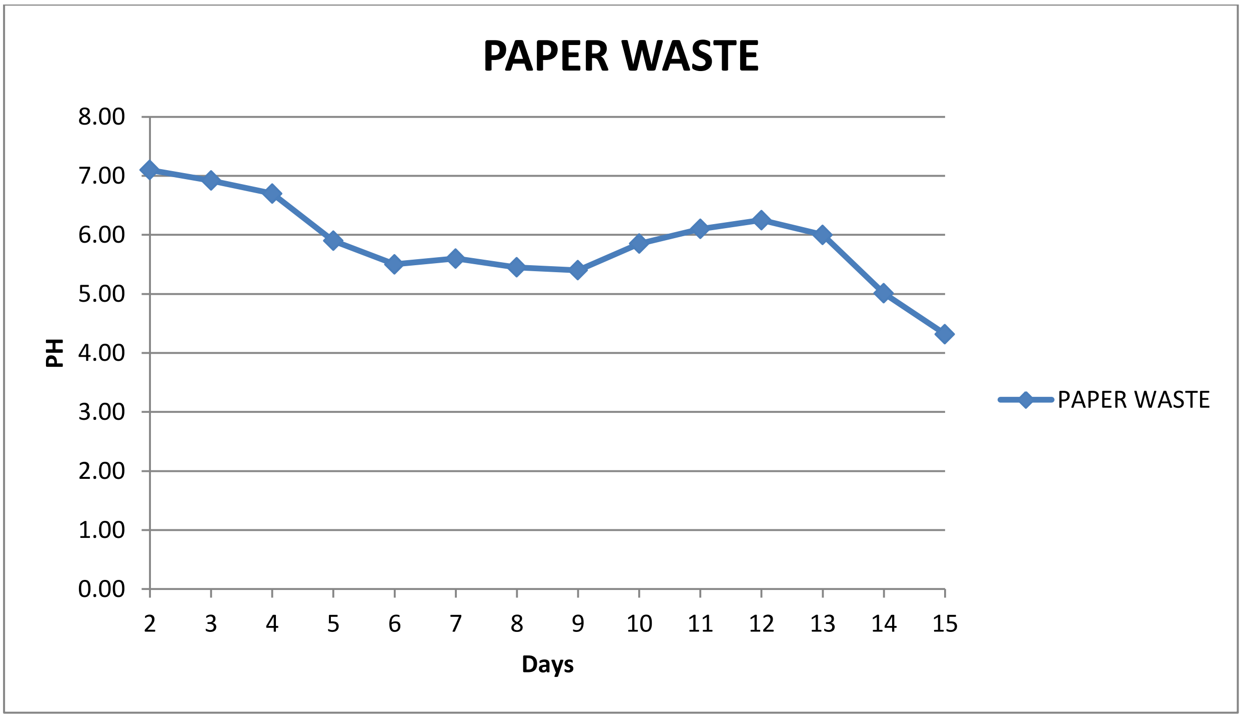

Fig 8 Daily pH change graph of paper waste

Daily P_H Change Graph of kitchen waste-

Fig 9 Daily PH change graph of kitchen waste

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Daily gas and pH production

Table 6 Daily gas and pH production

Day	PAPER WASTE		COW DUNG		Kitchen waste	
	Gas production(gm.)	pH	Gas production(gm.)	pH	Gas production(gm.)	pH
02	40	7.10	53	7.00	110	7.25
03	41	6.92	57	6.92	112	7.00
04	43	6.70	61	6.90	124	6.93
05	42	5.90	75	6.82	121	6.87
06	41	5.50	86	6.76	128	6.60
07	39	5.60	90	6.60	131	6.25
08	37	5.45	89	6.50	138	6.30
09	36	5.40	91	4.42	142	6.35
10	35	5.85	87	6.45	147	6.40
11	38	6.10	94	6.10	144	6.70
12	40	6.25	99	6.15	136	6.80
13	36	6.00	101	6.12	143	6.50
14	23	5.01	104	6.13	145	6.35
15	28	4.32	107	6.10	139	6.10

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Daily gas production of paper waste

Fig 10 Daily gas production of paper waste

Daily gas production of cow dung

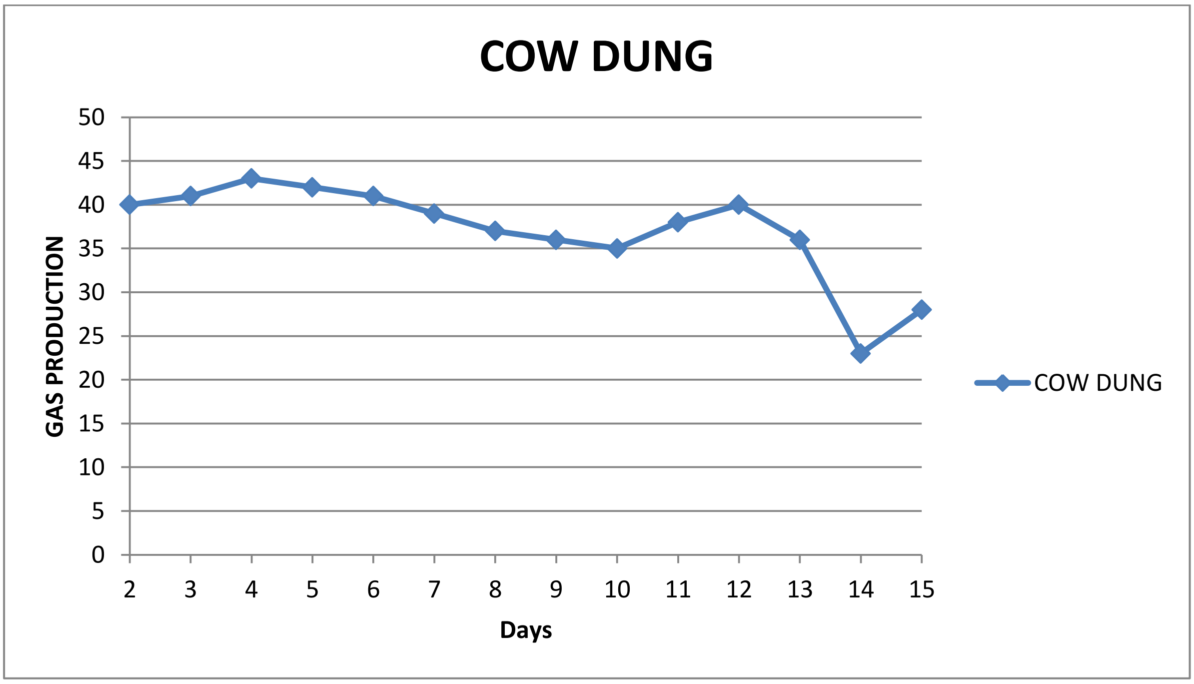

Fig 11 Daily gas production of cow dung

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Daily gas production of kitchen waste

Fig 12 Daily gas production of kitchen waste

Cumulative biogas production

Table 7 Cumulative biogas production

DAY	PAPERWASTE(in gm)	COWDUNG(in gm)	KITCHENWASTE(in gm)
1	409	409	409
2	449	462	519
3	490	519	631
4	533	580	755
5	575	655	876
6	616	741	1004
7	655	831	1135
8	692	920	1273
9	728	1011	1415
10	763	1098	1562
11	801	1192	1706

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12	841	1291	1842
13	877	1392	1985
14	900	1496	2130
15	928	1603	2269

Graph of Cumulative paper waste-

Fig.13 Graph of cumulative paper waste

Graph of Cumulative kitchen waste-

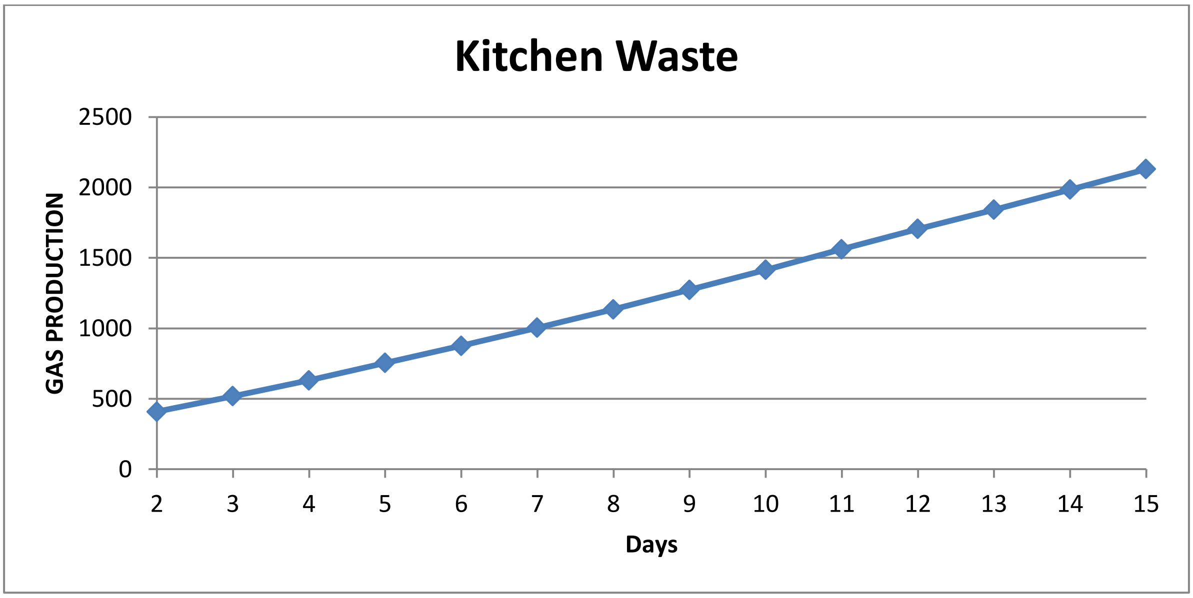

Fig 14 Graph of cumulative kitchen waste

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Graph of Cumulative kitchen waste

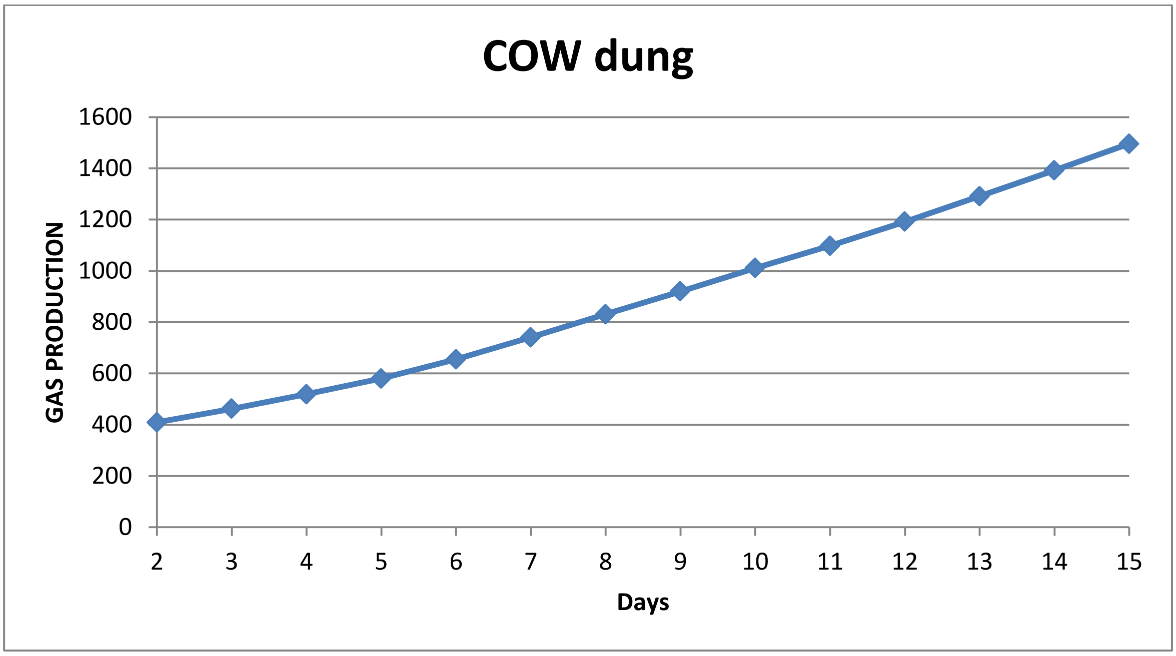

Fig 15 Graph of cumulative kitchen waste

Combined cumulative gas production graph

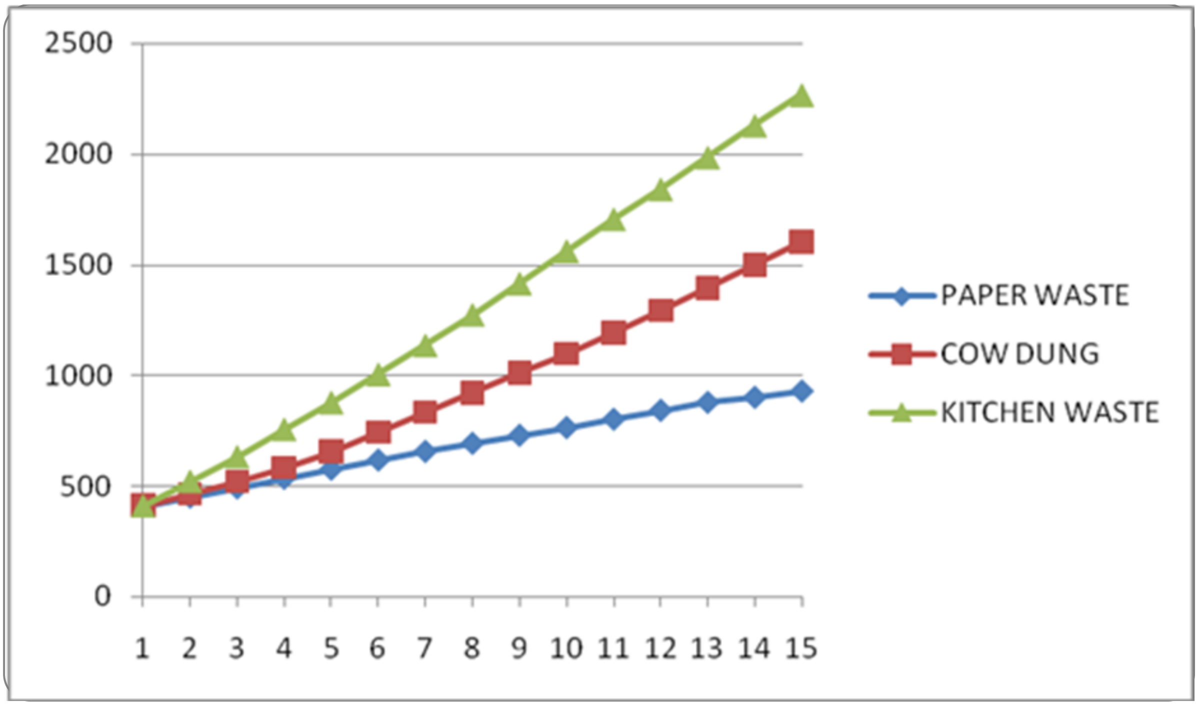

Fig 16 Graph of combined cumulative gas production graph

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CONCLUSION

Results revealed that the biogas produced by the kitchen waste is nearly 350% more than the paper waste and nearly 55% more than the cow dung for the sample size of kitchen waste, cow dung and paper waste used.It may be due to the more nutrients available in kitchen waste.It has been also observed that the chemical reaction is quite rapid in kitchen waste as compared to the cow dung sand paper waste because PH reduces at very high rate as compared to the cow dung and paper waste.Finally, it is concluded that approximately 3.72 Kg of biogas can be produced in a month from 20 litre digester by using kitchen waste.This project can be extended in near future for producing more quantity of biogas from kitchen waste. Portable Biogas plant can be designed for the installation which may be beneficial for human kind, society and environment.

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REFERENCES

[1]Kale S. P and Mehele S.T. kitchen waste based biogas plant .pdf . Nuclear agriculture and Biotechnology/ Division.

[2]Karve A.D.(2007),Compact biogas plant, at low cost digester for biogas from wastes.

[3]Karve A.D (2006).Compact biogas plant compact low-cost digester from waste starch.

[4]Shalini singh, sushil kumar, M.C.Jain, Dinesh kumar(2000),the increased biogas production using microbial stimulants.

[5]M.F.N.Abowei, M.J. Ayotamuno and C.L.Eze (2008), Effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester.

[6] TanzaniaTraditional Energy Development and Environment Organization (TaTEDO), BIOGAS TECHNOLOGY- Construction, Utilization and Operation Manual.

[7] The University of Southampton and Greenfinch Ltd.- Biodigestion of kitchen waste A comparative evaluation of mesophilic and thermophilic biodigestion for the stabilisation and sanitisation of kitchen waste.

[8] Ranjeet Singh, S.K. Mandal, V.K.Jain (2008), Development of mixed in coulums for methane enriched biogas production

[9]KumarS,GaikwadS.A,ShekdarA.K,KshirsagarP.K,Singh,R.N.(2004).Estimation method for national methane emission from solid waste landfills. Atmospheric Environment.38: 3481–3487.

[10]Jantsch T.G,Matttiason,B.(2004).Anautomated spectrophotometric system for monitoring buffer capacity in an aerobic digestion processes.WaterResearch.38:3645-3650.

[11]Thomsen,A.B.,Lissens,G.,Baere,L.,Verstraete,W.,Ahring,B.(2004).Thermal wet oxidation improves an aerobic biodegradability of raw and digested bio waste. Environmental Science and Technology.38: 3418-3424.

[12]Meres,M.,Szczepaniec,Cieciak,E.,Sadowska,A.,Piejko,K.,Oczyszczania,M.P., Szafnicki,K.(2004).Operational and meteorological influence on the utilized biogas composition at the Barycz landfills site in Cracow, Poland. Waste Management Resource.22:195–201

[13] Suyog Vij, “Biogas Production From Kitchen Waste”, a report of Bachelor degree, Department of Biotechnology and Medical Engineering, NIT, Raurkela, July, 2011

[14] Sagagi, B., B.Garba and N.Usman (2009). Studies on biogas production fromfruits and vegetable waste.Bayero Journal of Pure and Applied Sciences 2(1):115-118.

