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Biogas production potential of Poultry waste and Jatropha de-oiled cake

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***Abstract*— India is on path of developed country as well as the second nation on this planet regarding population, consequently increasing the number of industries and urbanization to fulfill the demands which are being created by same. Mean while a big challenge has been faced by the solid waste management authority like municipality, especially poultry waste and jatropha de-oiled cake generated millions kg per day. This work has two aspects one is the management of such huge generation and another is the production of energy in terms of Biogas. There were four different composition of batch reactor were constructed, D1, D2, D3 and D4 are for cow dung slurry, poultry waste slurry, jatropha de-oiled cake slurry and mixture of poultry waste and jatropha de-oiled cake slurry respectively. Physio-chemical parameters of these influent (on the starting day of digestion) and effluent slurries (after 60th day from starting) in terms of total solid, volatile solid, organic content, moisture content, pH and C:N ratios . A comparative studies between influent and effluent slurries found gradually declined during 60 days periods of the Biogas production, like total solid (%) of D1, D2, D3 and D4 was decreased from 10.88, 14.76, 16.05 and 17.67 to 3.07, 5.82, 7.02 and 7.11 respectively, volatile solid (%) of D1, D2, D3 and D4 was decreased from 62.65, 61.98, 56.87 and 51.66 to 28.34, 30.72, 29.01 and 28.02 respectively, organic content (%) of D1, D2, D3 and D4 was decreased from 48.78, 57.78, 58.34 and 58.23 to 22.32, 23.42, 23.02 and 22.02 respectively, moisture content (%) of D1, D2, D3 and D4 was decreased from 32.07, 18.53, 6.1 and 9.1 to 25.02, 10.02, 4.1 and 4.3 respectively, influence these above data on different D for the production of Biogas.*

A produced biogas from different batch reactors were analyzed on the day of 10th, 20th, 30th, 40th, 50th and 60th during 60 days period in terms of temperature, pH, amount of biogas production and CH4:CO2 ratios. Temperature parameters varies from 27 to 33 0C during this period which reveals the methanogenic steps of the Biogas production happened above 30 0C. and pH value is near to 7.1 for the proper climate for methanogenic bacteria and CH4:CO2 ratios of Biogas produced during the period were analyzed which is different for different batch reactor, amount of biogas production on the same day during the 60 days period for D1, D2, D3 and D4, is from 6.2, 5.8, 5.7 and 6.8 ml to 71.13, 91.21, 79.34 and 115. 87 ml respectively. Overall study reveals that the digester 1 was started production of biogas fastly but fourth batch reactor produced more amount of biogas i.e. 115.87 ml with high methane ratio i.e. 70:44, which had the composition of poultry waste, jatropha de-oiled cake and cow dung. This work can solve the problems of poultry waste and jatropha de-oiled cake management as well as bring the fulfillment of energy requirement in terms of Biogas.

***Index Terms*—D-Digester, OC-Organic Content, TS-Total Solid, VS- Volatile Solid.**

I. INTRODUCTION

India is the second largest nation in the world, with a population of 1.21 billion, accounting for nearly 18% of world's human population, but it does not have enough resources or adequate systems to full fill the requirement of energy in terms of kitchen fuel and electricity etc [1]. The primary energy demand in India is expected to increase from 537 MTOE (Metric tons of oil equivalent) in 2005 to 770 MTOE in 2015 and to 1,299 MTOE by 2030 [2] and other side they also unable to manage Solid Waste generated 68.8 million tons per year (TPY) in urban areas only [1]. Bioremediation i.e. anaerobic digestion is the solution for both of the problems to enhance the energy production as well as to reduce the volume and weight of Solid Waste which makes easy for Solid Waste Management.

Biogas

A gas produced by the breakdown of organic matter through Anaerobic Digestion (AD). It is one of the renewable energy sources, like solar and wind energy [7]. There are many characteristics that makes different from another sources of renewal energy such as this is 20% lighter than air, ignition temperature is in range of 650 to 750 ^{0}C, odorless & color less gas with blue falme, having 20 mega joules (MJ) / m^3 caloric value, 60% efficient to burn in conventional biogas stove [8]. AD is a decomposition of biodegradable material to the one carbon compound level like methane and Carbon dioxide in absence of oxygen. There are four steps to accomplished methanogenesi i.e. completion of AD, Hydrolysis, Acidogenesis, Acetogensis and Methanogenesis [4]. There are some factors which affects the production of biogas like as quantity & quality of organic matter, temperature, pH value and dilution of material [9]-[10].

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Jatropha corp in India

200 districts in 19 potential states have been identified on the basis of availability of wasteland, rural poverty ratio, below poverty line (BPL) census and agro-climatic conditions suitable for Jatropha cultivation. Each district will be treated as a block and under each block 15000 ha Jatropha plantation will be undertaken through farmers (BPL) [4]. Proposed to provide green coverage to about 3 Million ha of wasteland through plantation of Jatropha in 200 identified districts over a period of 3 years. Jatropha World India 2013 will showcase agricultural advancement to grow the Jatropha and other nonfood oil crops effectively with proper resources i.e. balancing resources to end up with a sustainable long-term solution without harming the environment [3]. As on today the total diesel fuel demand in India is 66.9 Million Metric Ton (MMT). If engine is to be operated with 20% mixing with Jatropha oil with diesel, which is most suitable replacement of diesel fuel without losing engine efficiency, the biodiesel requirement would be 13.38 MMT. For the required production, requirement of waste land would be 11.19 M ha [3]-[4]. Table 1 is describing the potential of Jatropha non-edible seeds.

Table 1: Potential of Jatropha non-edible seeds in India [4]

Sl. No.	Name		Million Metric Tonnes / Year			Oil Content, %
	Common Name	Botanical Name	Seed	Oil	Cake	
1	Jatropha	Jatropha curcus	0.05	0.015	0.035	30-40

Poultry Industries in India

Domestic poultry meat production (broiler - carcass weight) is estimated to have increased from less than 1.0 million tons in 2000 to 3.4 million tons in 2012 with per capita consumption increasing from 0.8 kg to 2.8 kg p.a during same period. Table egg production is estimated to have increased from 30 billion eggs in 2000 to 66 billion eggs in 2012 with per capita egg consumption increasing from 28 to 55 eggs during that period [5].

India is emerging as the world's 2nd largest poultry market with an annual growth of more than 14%, producing 61 million tonnes or 3.6 percent of global egg production. The annual growth rate of egg production is 5-8%. Apart from this, India ranks 6th in broiler production (125 billion Rupees) with an annual output of 2.39 million tonnes of broiler meat, as per the estimates of the Ministry of Agriculture, Govt. of India. The total poultry industry is valued at about 350 billion rupees [6].

Biogas potential of poultry waste

The anaerobic digestion of poultry waste yields biogas, a combustible gas composed of approximately 60% methane, 38% carbon dioxide, and mixture of water vapour, ammonia and hydrogen sulphide[9]-[10]. Biogas (also known as 'producer' gas) may be used as an energy source for burning as heat or as fuel for internal combustion engines to generate electricity. Both the burnt ash material and the post-anerobic digested solids may be used as fertiliser and animal feed supplement [8].

II MATERIALS AND METHODS

Poultry waste was collected from "Firoz Meat Shop", Dadi ka phatak, Jaipur, who generates 70-250 kg per day poultry waste according to day and season, where Jatropha de-oiled cake was colleted from "Bharat Traders", RIICO, Bassi, Jaipur, who generated 25-350 kg per week Sample collections are shown in figure 1 and 2 below.

Fig 1: poultry waste collection

Fig 2: Jatropha de-oiled cake collection

Work Plan

Four batch digesters were constructed with different composition of feed slurries as given below in table 2.

Table 2: Digester nomenclature with feed description

Sl. No.	Digester Name	Feed Description
1	D 1 (Digester 1)	Cattle dung 100% of 2 kg = 2 kg
2	D 2 (Digester 2)	Cattle dung 50 % of 2 kg = 1 kg, Poultry waste 50 % of 2 kg = 1 kg
3	D 3 (Digester 3)	Cattle dung 50% of 2 kg = 1 kg, Jatropha de-oiled cake 50 % of 2 kg = 1 kg
4	D 4 (Digester 4)	Cattle dung 50% of 2 kg = 1 kg, Poultry waste 25 % of 2 kg = 0.5 kg, Jatropha de-oiled cake 25 % of 2 kg = 0.5 kg

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Batch reactor or Digester setup was done as in figure 3.
Where,

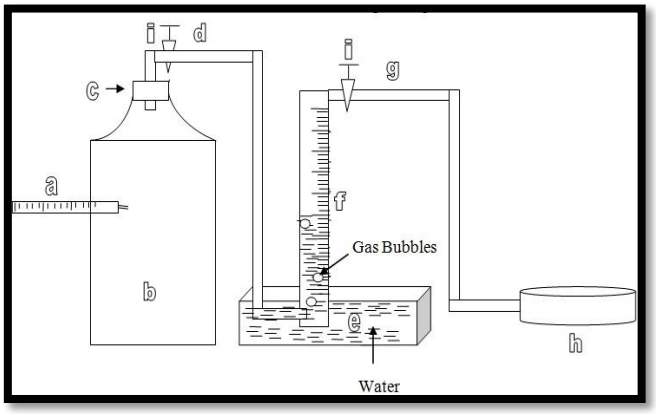

Fig 3: A Schematic Diagram of Biogas formation setup

ⓐ – This is the Thermometer to measure the temperature during the biogas formation in ^{0}C.
ⓑ – This is the Digester (5 liter volume, made up of plastic) in black painted.
ⓒ – This is a Cap with m-seal packing to check the leakage.
ⓓ – This is a PVC or rubber pipe which was acted as an outlet for forming Biogas from digester and follow to inverted measuring cylinder.
ⓔ – This is a Water bath which gave the water platform to the inverted measuring cylinder to check the gas leakage.
ⓕ – This is an Inverted measuring cylinder to measure the gas production per day.
ⓖ – This is a rubber pipe which collected the Biogas and sends it to the tube of the truck.
ⓗ – This is a Tube of the truck which collected Biogas from Plastics pipe and stored it for further analysis.
▭ - This is a knob (act as a T valve) to close the way of biogas movement and measure the biogas production per day and then it makes allow passing the biogas to the next.

There were different physio-chemical parameters analyzed for inlet and outlet slurries like total solid (%), volatile solid (%), moisture content (%), pH and biogas produced during the 60 days period were analyzed on 10th day periodically in terms of temperature, pH, amount of Biogas produced, CH4:CO2 ratios.

III. RESULT AND DISCUSSION

Following are the result analysis of physio-chemical data of influent and effluent slurries.

Total solid % of all four kind of Inlet slurry and outlet slurries

Before feeding in corresponding batch digester, slurries were analyzed in terms of total solid % and outlet slurries was analyzed the same which shown in figure 4.

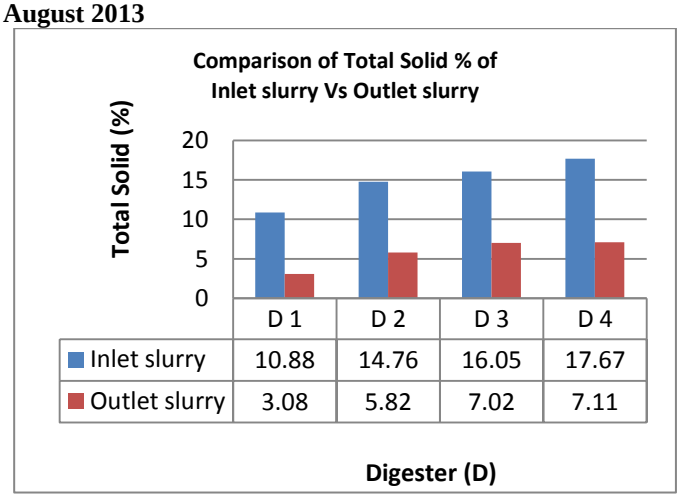

Fig 4: Comparison of total solid % of Inlet and Outlet slurry

Volatile solid % of all four kind of Inlet slurry and outlet slurries

Before feeding in corresponding batch digester, slurries were analyzed in terms of volatile solid % and the results compared with outlet slurries analyzed value of same parameters as shown in figure 5.

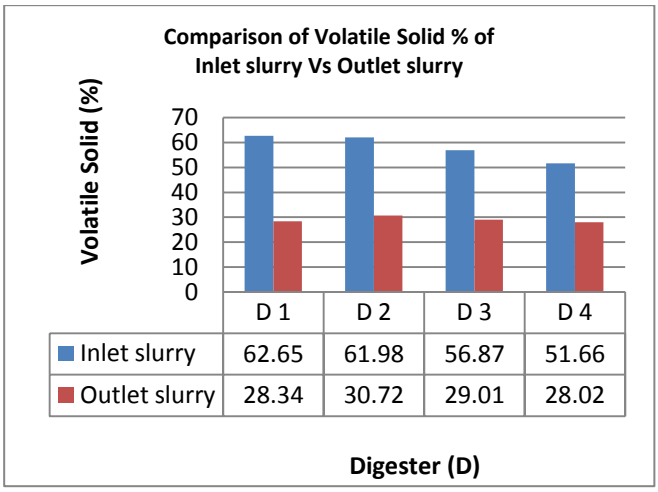

Fig 5: Comparison of volatile solid % of Inlet and Outlet slurries

Organic content % of all four kind of Inlet slurry and outlet slurries

Before feeding in corresponding batch digester, slurries were analyzed in terms of organic content % and the results are compared with outlet slurries values in same parameters as shown in figure 6.

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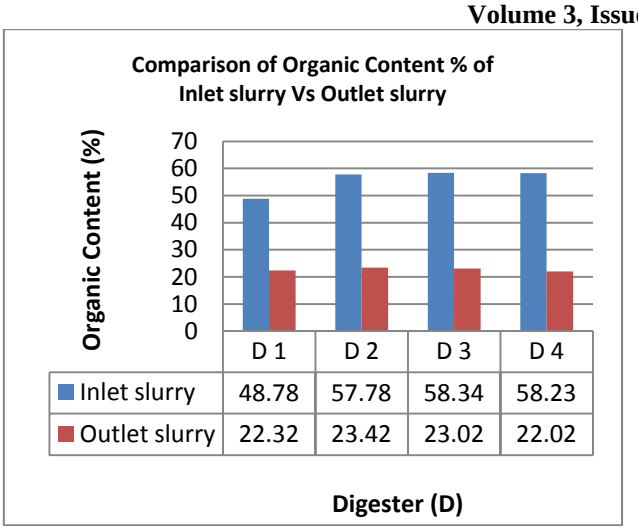

Fig 6: Comparison of organic content % of Inlet and Outlet slurries

Moisture content % of all four kind of Inlet slurry and outlet slurry

Before feeding in corresponding batch digester, slurries were analyzed in terms of moisture content % and the results are compared with outlet slurries value in same as shown in figure 7

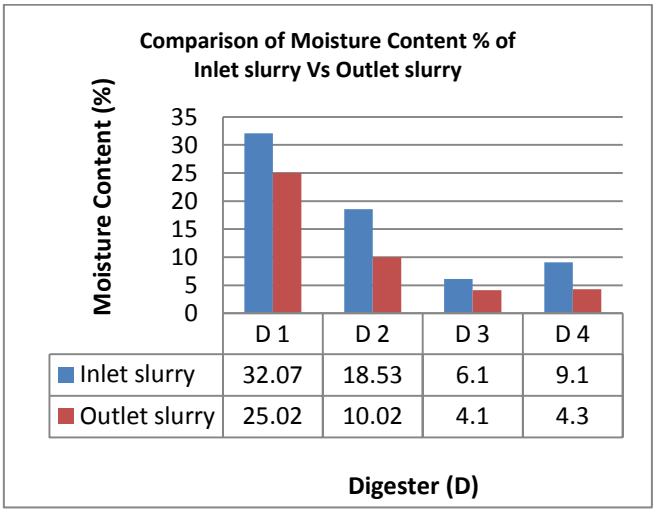

Fig 7: Comparison of moisture content % of Inlet and Outlet slurries

pH of all four kind of Inlet slurry and outlet slurry

Before feeding in corresponding batch digester, slurries were analyzed in terms of pH and the results are comparative studied with outlet slurries value in same as shown in figure 8.

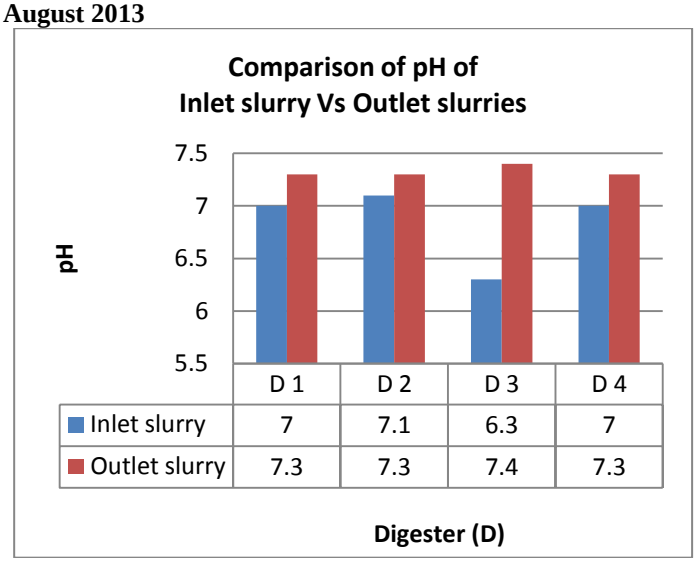

Fig 8: Comparison of pH of Inlet and Outlet slurries

Variations in Temperature with time during Biogas production

Periodically (on 10th day) the temperature was recorded to estimate the better temperature to produce the Biogas. And the result reveals that Biogas is temperature dependent, as the temperature was changed the production of Biogas also got changed as shown in figure 9.

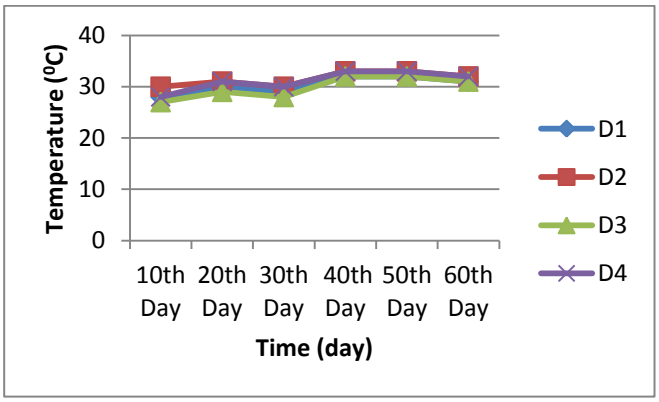

Fig 9 Temperature Vs Time

Changes in pH with time during Biogas production

Periodically (on 10th day) the pH was recorded to estimate the better pH value to produce the Biogas and the result reveals that Biogas is pH dependent also, as the pH was changed the production of Biogas also got changed. Figure 4.10 shows the graph i.e. time Vs pH.

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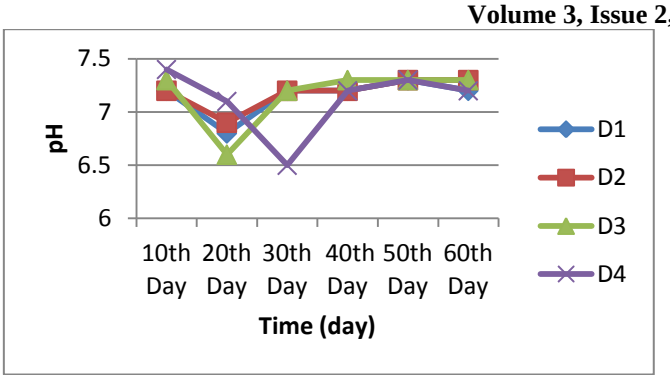

Fig 4.10 pH Vs Time

Variations of Amount of Biogas production with time

Periodically (on 10th day) the amount of Biogas was recorded to estimate the best performance of the digester and the result reveals that Biogas production on the day during 60th day's periods. Figure 4.11 shows the graph i.e. time Vs amount of Biogas production.

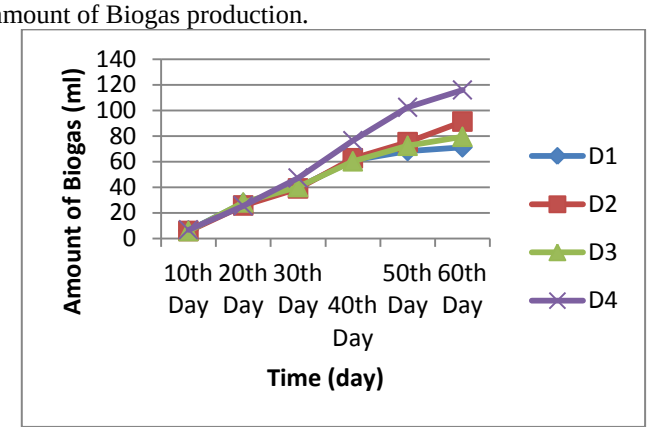

Fig 4.11 amount of Biogas produced Vs Time

Biogas analysis during gas production in terms of methane gas (CH_4) and Carbon dioxide (CO_2)

Periodically (on 10th day) the CH_4:CO_2 was recorded to estimate the best performance of the digester as given in table 3. And the result reveals that Biogas production on the day during 60th day's periods.

Sl. No.	Digester	CH_4: CO_2 ratio on 10th Day	CH_4: CO_2 ratio on 20th Day	CH_4: CO_2 ratio on 30th Day	CH_4: CO_2 ratio on 40th Day	CH_4: CO_2 ratio on 50th Day	CH_4: CO_2 ratio on 60th Day
1	D 1	3:2	15:13	22:18	33:27	38:31	39:32
2	D 2	3:2	14:10	22:16	35:26	42:32	51:36
3	D 3	3:2	16:11	26:18	34:24	41:29	45:32
4	D 4	4:3	15:10	28:18	46:29	61:39	70:44

Table 3: CH_4: CO_2 amount during Biogas production with time (in day)

As result said that the parameter of the digester were analyzed gave the clue of best production of the Biogas during the periods and on the basis of this results the conclusion given below.

IV Conclusion

The purpose of this project is to full fill the increasing need of solid waste management as well as production of energy which can be cheap as well as inexhaustible. Initially samples collection was done from the possible source with utmost precaution so that preparation of slurries can be done by mixing with cow dung with defined proportion of water. Later physio-chemical analysis of the inlet and outlet slurries was done for the samples.

Calculated data of the parameter of slurries reveals the high value of organic content which is going to decomposed by anaerobic bacteria and produced methane gas. Conversion of organic material was done from higher molecular weight to lower molecular weight by the same bacteria. Biogas produced during the digestion periods were analyzed in terms of amount of biogas production as well as CH4 and CO2, therefore data reveal that D1 has started first and fast but D4 produced more amount of Biogas in this work, D4 contains feed material of a mixture of poultry waste and jatropha de-oiled cake. As temperature increased up to 31 °C, the production of Biogas also increased and the pH reached to the 7.1, thus It can be said that Biogas production is temperature and pH dependent. Physio-chemical analysis of poultry waste and jatropha have been done and compared with the result which shows that poultry waste is more efficient in comparison with jatropha de-oiled cake, where as the results shows that the mixture of poultry waste and jatropha de-oiled cake is more efficient than all of inlet slurries.

There is still more work to be done in near future, if the temperature and pH parameters can be control it can enhance the production of the Biogas with same proportion of the feed materials and further analysis can be carried out with different proportion of the feed slurries to check the amount and quality of the Biogas produced within that digestion period. This work need to be applied at large scale so that it will bring financial benefits, as it proved to be a good quality of effluent which can be used as a fertilizer, so in village area it will be more beneficial for the crop as well as to the farmers as portable fuel. This works need to be carried out by the municipality department nearer to the poultry industry and jatropha corps area to avoid unreasonable dumping of a poultry waste and jatropha de-oiled cake and reduce environment pollution. This kind of project may help us to build a safe and clean environment where fuel source can eco-friendly.

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