International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 07, July 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

# BIOGAS PRODUCED FROM THE CODIGESTION OF KITCHEN WASTE AND CHICKEN LITTER UNDER THERMOPHYLIC CONDTION

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**ABSTRACT**

*The project was aimed at production of biogas by the co-digestion of kitchen waste and chicken litter by anaerobic dry fermentation .Due to scarcity of petroleum and coal it threatens supply of fuel throughout the world also problem of their combustion led to research in different corners to get access the new sources of energy, like renewable energy resources. Solar energy, wind energy, different thermal, hydro sources of energy, biogas are all renewable energy resources. But, biogas is distinct from other renewable energies 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 nor does it require advanced technology for producing energy, also it is very simple to use and apply. Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased. Chicken litter, saw dust, rice husk, and pig waste are some bio resources that are available abundantly. They help in production of electricity, thus solving the dual problem of waste disposal in poultry farms. They also meet the demand for energy. Co-digestion is a waste treatment method in which different wastes are mixed and treated together. Co-digestion is preferably used for improving yields of anaerobic digestion of solid organic wastes due to its numeral benefits. We need an eco friendly substitute for energy. Potential of renewable and other new energy technologies and this is a likely harbinger of the economic reality of truly competitive renewable energy systems*

***Keywords: Kitchen Waste, Chicken Litter, Co-Digestion, Energy Audit***

## I. INTRODUCTION

Deforestation is a very big problem in developing countries like India, most of the part depends on charcoal and fuel-wood for fuel supply which requires cutting of forest. Also due to deforestation It leads to decrease the fertility of land by soil erosion. Use of dung, firewood as energy is also harmful for the health of the masses due to the smoke arising from them causing air pollution. We need an eco friendly substitute for energy. Kitchen waste and chicken litter is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude as said earlier. It means higher efficiency and size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes the public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

uncontrolled dumping bears several adverse consequences: It not only leads to polluting surface and groundwater through leach ate and further promotes the breeding of flies , mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour & methane which is a major greenhouse gas contributing to global warming. Mankind can tackle this problem (threat) successfully with the help of methane, however till now we have not been benefited, because of ignorance of basic sciences, like output of work is dependent on energy available for doing that work. This fact can be seen in current practices of using low calorific inputs like cattle dung, distillery effluent, municipal solid waste (MSW) or sewage, in biogas plants, making methane generation highly inefficient. We can make this system extremely efficient by using kitchen waste/food wastes and chicken litter [1].

### 1.1 Biomass energy

Biomass includes solid biomass (organic, non-fossil material of biological origins), biogas (principally methane and carbon dioxide produced by anaerobic digestion of biomass and combusted to produce heat and/or power), liquid biofuels (bio-based liquid fuel from biomass transformation, mainly used in transportation applications), and municipal waste (wastes produced by the residential, commercial and public services sectors and incinerated in specific installations to produce heat and/or power).

India is very rich in biomass. It has a potential of 19,500 MW (3,500 MW from bagasse-based cogeneration and 16,000 MW from surplus biomass).Currently, India has 537 MW commissioned and 536 MW under construction. The facts reinforce the idea of a commitment by India to develop these resources of power production [2].

### 1.2 Problem statement

Dry Thermophilic digestion of Municipal wet waste is a process which is of greater importance, As this process helps in proper disposal of Municipal wet waste and production of biogas it has the potential of greater future. Basically the (Thermophylic Dry Fermentation) TDF plant differs from other plant in its simple construction. When compared with other biogas plants such as deenabandhu and bharc plant this anaerobic digester plant is less expensive and easier to maintain.

Advantage of anaerobic digester plant is that its feasibility in cities and towns whereas other aerobic plant is not that feasible in cities. Another problem for aerobic plants is sourcing of cow dung. The anaerobic plant or TDF plant require very little amount of cow dung in the initial start up of the plant.TDF plant can be used in hotels, municipality, markets, household's for the disposal of kitchen waste. When space is a major concern in disposing kitchen waste TDF plant is a final resort.

## II.LITERATURE REVIEW

Solid Waste is the discarded or the unwanted material in the form of garbage or refuse resulting from industrial, commercial, mining and agricultural operations, and from community activities. This solid waste is categorized as Municipal Solid Waste, Construction and Demolition Waste, Hazardous Waste, abandoned vehicles, etc. Municipal Solid Waste generation is at ever-increasing rate with the increase in economic prosperity and urban population. Reduction in the volume and mass of solid waste is a crucial issue and simultaneously, the country has a growing need for electrical power, particularly in the more industrial regions where the standard of living is increasing. Therefore, to reduce the amount of solid waste and producing energy at the same time can be contracted by a municipal waste to energy plant.Municipal solid waste (MSW) in India MSW, commonly known as trash or garbage, is a waste consisting of everyday items that are discarded by the public. Typically the major components of MSW in India includes food and kitchen waste, green waste, paper, glass, bottles, cans, metals, certain plastics, fabrics, batteries, inert waste, dirt, rocks, debris, etc. MSW is generated from several sources like residential, commercial, institutional, etc. The composition of municipal waste varies greatly from country to country and region to region and changes significantly with time. In India the biodegradable portion which mainly includes food and yard waste dominates the bulk of MSW by making up approximately 50% of the total MSW. Some facts about Indian MSW:- Solid waste generation in India is about 115,000 tons per day with a yearly increase of about 5% (according CPCB, India) Research studies reveal that the per capita generation rate increases with the size of the city and varies between 0.3 to 0.6 kg/day in the metropolitan areas. The estimated annual increase in per capita waste quantity is about 1.33% per year. The 11th Five Year Plan of India has envisaged an investment of approximately Rs. 2,000 crores for Solid Waste Management (SWM).

Technical Aspects: Waste To Energy (WTE) requires high cost and sophisticated technology which is not presently available in India and is imported from US and Europe. Also, WTE projects require highly skilled technical expertise for both operation and maintenance.

Socio- Economic Facts: WTE requires high investment, operation and maintenance costs and results in significant revenue generation from electricity sale which in turn can reduce the flow of fuel import to a considerable extent benefiting the country's economy.

WTE technologies Methane capture: Land filling is still the primary method of disposal of municipal solid waste. If left undisturbed, landfill waste produces significant amounts of carbon dioxide ($CO_2$) and methane ($CH_4$) by the anaerobic digestion of organic matter. Landfill gas can be captured via a collection system, which usually consists of a series of wells drilled into the landfill and connected by a plastic piping system. The gas can then be burned directly in a boiler as a heat-energy source, or, if the biogas is cleaned by removing water vapour and sulphur dioxide, it can be used directly in internal-combustion engines, or for electricity generation via gas turbines or fuel cells.

Biogas plants: Feedstock in Biogas plants could include food-processing waste or other agricultural waste such as manure. The process begins with the placement of waste and various types of bacteria into an airtight container called a digester. Then anaerobic digestion to produce biogas is done in a controlled environment. Advanced digester systems can now produce biogas with pure methane content higher than 95%. Biogas plants can transfer electrical energy to the main utility grid, or they can generate power for use on-site in applications like lighting, processing plants, etc. Biogas plants have been deployed in India, Israel, Australia, and elsewhere.

Fermentation: Fermentation uses yeast to generate liquid ethanol from biomass waste [3].

Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude as said earlier. It means higher efficiency and size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes the public health hazards and

IJARSE
ISSN (O) 2319 - 8354
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diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences. It not only leads to polluting surface and groundwater through leach ate and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. a major greenhouse gas contributing to global warming[4]

Around the world particularly in urban areas, pollution of air and water from kitchen solid wastes continues to grow. It has become great threat to environmental and public health. Anaerobic digestion not only provides pollution prevention, but also allows for energy, compost and nutrient recovery. In life cycle assessment using eco-indicator method, AD also showed a compared to other treatment technology such as composting, incineration [5].

Of the bio resources that are available, animal waste and agro waste hold promise and can meet the requirement significantly. Chicken litter, saw dust, rice husk, and pig waste are some bio resources that are available abundantly. They help in production of electricity, thus solving the dual problem of waste disposal in poultry farms. They also meet the demand for energy. In the poultry industry, chicken litter is available in mixture form mixed with saw dust or rice husk.

The chicken population has registered an annual growth rate of 7.3 percent in the last decade. The organized sector accounts for nearly70 percent the total poultry output in the country. The current strength of layers and broilers in India is estimated at 230 million and 2,300 million, respectively. The increase in the population of chicken has gone up by 20 percent [6] .The annual production is reported to be 33,000 million eggs, which ranks third in the world after china and United States. The total poultry population of India is estimated at 2,530 million and states like Andhra Pradesh, Maharashtra, Tamilnadu, Haryana, Punjab and Delhi are the major producers [7].

India is a developing country with a large gap between energy production and energy utilization. The poultry industry is largely located in rural areas where they are facing huge power shortage. 425 MJ of energy per year is required for breeding 10000 birds in the poultry industry for heating the chickens, breeding them, for lighting purposes, etc[8]. The supply of power to such remote areas is not an easy task and will also lead to large amount of power distribution loss. The increase in the population of the country has increased the demand for chicken meat, which in turn has led to proliferation of poultry farms. Chicken litter is found to have certain energy property: by converting the chicken litter into an energy source in an energy source in an efficient manner, we can reduce power scarcity in the poultry industry. The production of chicken litter varies according to the season, the type of feed, the type of the bird, etc.It is estimated that 10,000 birds can produce around136.7 tons of dried litter per year, amounting to 100million tons/year. Chicken litter is found to have calorific value of 10,000 to 11,000 kJ/kg with a moisture content of nearly 15 to 20 percent. It has been found that 10,000 birds can produce nearly 137 tons of litter, with an average calorific value of 10,000kJ/kg.It has a capacity of 137MJ of energy, hence ,the problem of chicken litter disposal can also be resolved[9].

Anaerobic digestion is a well established process for treating many types of organic waste, both solid and liquid. Poultry manure has a higher fraction of biodegradable organic matter than other livestock wastes. As such, the digestion of cattle slurries and of a range of agricultural wastes has been evaluated and has been successful. Chicken manure is also an important waste for anaerobic digestion due to its biogas potential. Yet this substrate, rich in organic nitrogen, can reduce the process performance due to high ammonia accumulation

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

when anaerobically digested without dilution or removal of ammonia [10]. Nitrogen, especially ammonium is one of the most commonly encountered problems in anaerobic or aerobic biological processing of chicken manure (biogas production or composting). Nitrogen was produced due to anaerobic degradation of protein and amino acids present in the poultry manure [11]. Chicken manure contains two main forms of nitrogen: uric acid and undigested proteins, which represent 70% and 30% of the total nitrogen in chicken manure, respectively[12] demonstrated that almost all nitrogen was converted to ammonia during anaerobic digestion of poultry litter. The results also showed that methane production was stable between ammonium levels of 2–10 g/L [13]. But higher ammonium levels resulted in 769 significant reduction of both biogas and methane [14]. reported that ammonia inhibition occur above pH 7.4 in the range of 1.5–3 g L-1 total ammonia nitrogen, whereas at concentrations in excess of 3 g L-1, ammonia is claimed to be toxic irrespective of pH. Also reported that 100% inhibition occurs in the range of 8–13 g L-1 depending on the condition of acclimatization and the pH of the system. The digestion of chicken manure alone is generally very problematic due to the ammonia toxicity. Therefore, the most common application method is either the dilution of raw material or co-digestion with other available organic substrates.

Co-digestion is a waste treatment method in which different wastes are mixed and treated together [15]. It is also termed as ‘‘co-fermentation’’. Co-digestion is preferably used for improving yields of anaerobic digestion of solid organic wastes due to its numeral benefits. For example, dilution of toxic compounds, increased load of biodegradable organic matter, improved balance of nutrients, synergistic effect of microorganisms and better biogas yield are the potential benefits that are achieved in a co-digestion process. Co-digestion of an organic waste also provides nutrients in excess [16], which accelerates biodegradation of solid organic waste through bio stimulation. Additionally, digestion rate and stabilization are increased [17]. described the following multiple benefits of co-digestion: the facilitation of a stable and reliable digestion performance and production of a digested product of good quality, and an increase in biogas yield[18].It has been observed that co-digestion of mixtures stabilizes the feed to the bioreactor, thereby improving the C/N ratio and decreasing the concentration of nitrogen [19]The use of a co-substrate with a low nitrogen and lipid content waste increases the production of biogas due to complementary characteristics of both types of waste, thus reducing problems associated with the accumulation of intermediate volatile compounds and high ammonia concentrations. Several studies have shown that mixtures of agricultural, municipal and industrial wastes can be digested successfully and efficiently together. A stimulatory effect on synthesis of methane gas has been observed when industrial sludge was co-digested with municipal solid waste. The co-digestion of municipal solid waste with an industrial sludge ratio of 1:2 yielded the highest amount methane gas, compared to municipal solid waste alone. Similarly, in a two-phase anaerobic digestion system[20]recorded the highest methane productivity when a mixture of olive mill wastewater and olive mill solid waste was co-digested. The process has also been useful in obtaining a valuable sludge which can eventually be used as a soil amendment after minor treatments [21].

Numerous investigations show advantages and disadvantages of thermophilic ver-sus mesophilic methane fermentations [ 22 ]. In most studies a specific temperature optimum was defined, either in the mesophilic range between 35 and $40^0$C or in the thermophilic range between 50 and $65^0$C [23]. For this reason most practical biogas fermentations operate either at about 35 or $55^0$C. In contrast, there are not many data available on the process temperatures between 40 and $50^0$C. However, deviation from the meso-philic temperature range proved

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

to be problematic in several cases of full-scale energy crop fermentation plants[24]. The exothermic carbohydrate degradation and the high energy density in the substrates, together with high loading rates, can cause a sudden temperature increase. Such self-heating effects led to an increase in process temperatures from 35–39$^0$C to 42–49$^0$C. This effect was accompanied by a gradual cease in methane formation. This phenomenon was observed in 20 of 41 full-scale biogas plants investigated, which subsequently had to be operated at increased temperatures between 40 and 50$^0$C [25].The self-induced temperature increase in mesophilic digesters to sub-thermo-philic levels (40–50$^0$C) was shown to cause severe disorders of the microbial population. In laboratory-scale experiments, complete failure in methane production for several days occurred after a sudden temperature increase [26]. The only way to prevent a sudden temperature increase is to change the feedstock, to reduce the organic loading rate or to install a fermented cooling system. However, in the early planning phase of an energy crop digestion plant a thorough investigation of the optimum fermentation temperature is highly recommended.

## III. METHODOLOGY

- Collection of municipal solid waste
- Standardization of parameters for anaerobic digestion of collected waste
- Analysis of difficulties faced and their solution
- Installation of biogas digester
- Estimation of Bio gas yield
- Energy audit and analysis of biogas produced
- Conducting workshop for further dissemination of technology

## IV. PROCEDURE INVOLVED IN ADDITION OF FRESH WASTE

[1] Initially a certain amount of cooked food waste, chicken litter and is collected in a bin.
[2] 5kg of digested waste is withdrawn from the digester through the outlet provided at the bottom and discarded.
[3] Same amount of fresh waste is shredded to a paste (like noodle) form in a commercial shredder.
[4] The shredded waste is then input to the hopper into which some amount of digested waste was collected earlier.
[5] The mixture is well stirred manually before the circulation for proper mixing.
[6] After mixing send that mixture in to digester tank with the help of progressive pump.
[7] Measure the gas flow rate with the help of gas flow meter and collect the gas through a balloon.
[8] Switch of the progressive pump.


**Fig1-Typical picture of the fresh waste collected from the canteen**

**Fig 2-The shredding output of the fresh waste from the shredder is depicted below**

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 07, July 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
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**Fig 3- Picture of Biogas plant**

## V. ORIGIN OF KITCHEN WASTE AND CHICKEN LITTER, ENERGY AUDIT AND ECONOMIC ANALYSIS AND GAS COMPOSITION TEST

**Table1-Details of Kitchen waste and Chicken Litter**

| Origin of Kitchen Waste | Origin of Chicken Litter |
|---|---|
| Centralize kitchen (Hostel mess + College canteen)<br>Total members= 500<br>For cooking<br>Rice =50kg/day<br>Vegetable= 50kg/day<br>Seeds and other cooking item =25kg/day<br>Waste collected from centralize kitchen(Morning and afternoon)<br>25kg+25kg= 50kg (2 buckets) | Aishwarya Poultry farm, Harohalli<br>No of layer chicken= 120000<br>No of Eggs produced= 100000<br>Waste per chicken= 50 grams<br>Total waste= 6000kg/day |

### 5.1Energy audit

**Table 2- Capacity details of the power consumed by the biogas plant**

| Sl No | Components | Capacity in KW | Work time in hrs/Day | Power usageKWH/day |
|---|---|---|---|---|
| 1 | Compressor | 1.38 | 0.5 | 0.69 |
| 2 | Shredder | 0.375 | 0.5 | 0.1875 |
| 3 | Geyser | 2 | 0.5 | 1 |
| 4 | 1HP induction motor | 0.75 | 0.5 | 0.375 |
| | | | | **Total=2.2525KWH/day Totalpower charge=16.55Rs/day** |

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 07, July 2017
www.ijarse.com
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ISSN (P) 2319 - 8346

### 5.2 Economic and cost analysis

Plant is designed for production of $0.8m^3$ of gas per day

- If we add 5kg of waste we will get $0.16m^3$ of gas per day. Actual gas production rate After stop the gas production from beginning, when added the fresh waste
- From 10-05-2015 to 18-05-2015 (5 kg of waste is added)
  (94+103+126+153+164+193+203+214)/8
  = 156.25 ltr/day
- If we add 50kg waste approximately we get 156.25*10=1562.5 ltr/day=$1.5623m^3$/day
  Density of biogas=0.743kg/$m^3$
  1.5625*0.743=1.16kg/day
- Commercial gas cost 1kg=67Rs
  For 19kg cylinder= 1267Rs
  1.16*67=77.7Rs/day
- Power charge/day=16.55Rs
- Saving amount per day=(77.7-16.55)=61.2Rs
- Saving amount per month=61.2*30=1836Rs
  1836/1267=1.5 cylinder is possible to replace per month
- Saving amount per year=1836*12=22043.8Rs
  22043.8Rs/1267=17.39 cylinder is possible to replace per year
- Investment cost of plant =28050Rs
  Payback period is two years
  Plant life approximately 20 years
- Profit=22043*20-28050 =412810Rs

### 5.3 Gas Composition Test

The test was conducted at **Shiva Analyticals**, Hosakote. The following were the observations of the gas composition

**Table 3- Constituents of gas composition test**

| Constituents | Composition (%) |
|---|---|
| Methane | 55 |
| Nitrogen | 2 |
| water vapors | 6 |
| Carbon dioxide | 30.5 |
| Calorific value | 18.5MJ/$m^3$ |

International Journal of Advance Research in Science and Engineering
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www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
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## VI. RESULTS AND DISCUSSIONS

### 6.1 Reactor start-up

The reactor was initiated with the fresh waste of 120L which was 75% of the reactor volume. From the measurement the density of the waste was around 1000kg/m3. The total volume of the reactor was 160 L.The reactor was operated in batch mode for 8 weeks for start-up process. The inoculum was comprised of cow dung, and digestate. The ratio of these inoculums was 2:1. Homogenization of fresh wastes with inoculums was done properly before feeding into the system. The composition of waste was 12.5kg chicken litter ,7.5kg kitchen waste and 10 kg cow dung, To avoid the risk of thermal shock inside the reactor, the reactor was started with mesophilic temperature 37°C and the temperature was gradually increased to a thermophilic temperature 55°C. The main feature of this system was to avoid the use of leachate for the mixing. To enhance the biodegradability of the substrates, the mixing was performed by circulating the waste inside the reactor.

### 6.2 Biogas generation and quality

Digestion during start-up ran for a total of 48 days, during that period start-up reached methanogenesis, Daily and cumulative biogas production where the biogas production was high in the beginning which is due to the entrapped air inside the reactor and the waste itself because the methane composition during that period was almost zero. High biogas production and methane yield was obtained during circulation of the wastes inside the reactor It is clear that the biogas production and methane composition was lower between 12 and 22 days because there was no circulation of the waste and these components were increased on initiating the circulation of the waste. The gas production chart for the startup phase is shown below

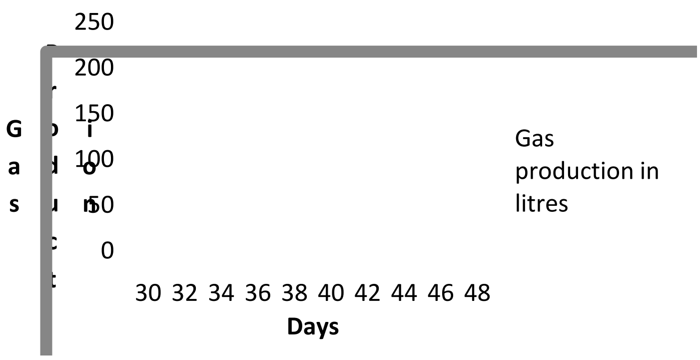


**Fig4- Daily gas production**

Daily biogas production Cumulative biogas production Mixing affected the time taken to establish methanogenesis in the start-up, as methanogenesis started gradually on mixing and reached maximum between days 46 (as can be seen in the graph above) and The longer start-up period was attributed to the heterogeneity of the inoculum. The waste was started being added from day 41. Following this, the highest volume of biogas produced (214 L/d) was achieved at day 46 (as shown below in the graph) and the methane composition was reached to a maximum value of 66.68% at the same day. The biogas production rate fell after day 47 indicating exhausting of readily accessible substrate for biogas production. The reactor system was run until the gas production rate peaked and then dropped below 214 L of gas per day. Then, the feeding and withdrawing mode of operation was started.

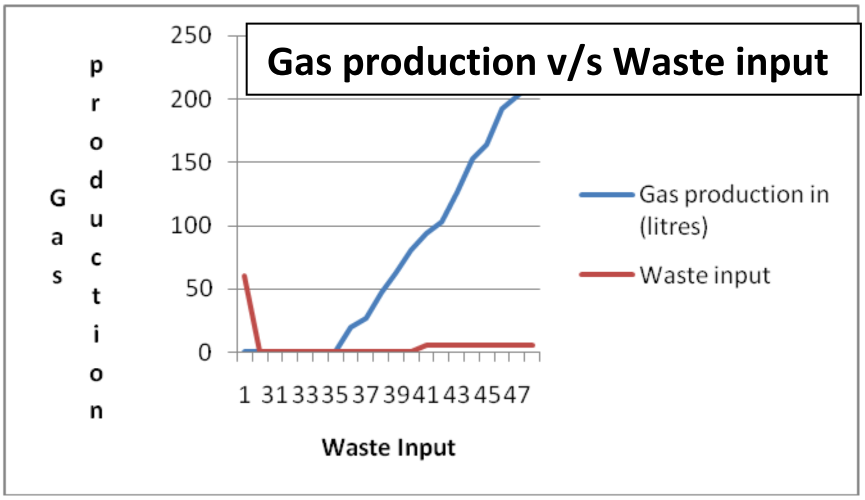


**Fig 5- Comparison of Gas production and Waste input**

### 6.3 pH variation of the gas mixture

The pH variation are shown in Figure in which the pH was at a lower value below 7 during first 10 days. This was due to the formation of organic acids e.g. volatile fatty acid.. Due to lower alkalinity and pH, the methanogenic activity was not initialized and the composition of methane was below 50%. The pH of the input was monitored and an attempt was made to keep it above 6.5 by the addition of commercial NaOH. From then on, NaOH was consistently added and the pH almost found steady. The variation of pH with NaOH is shown below.

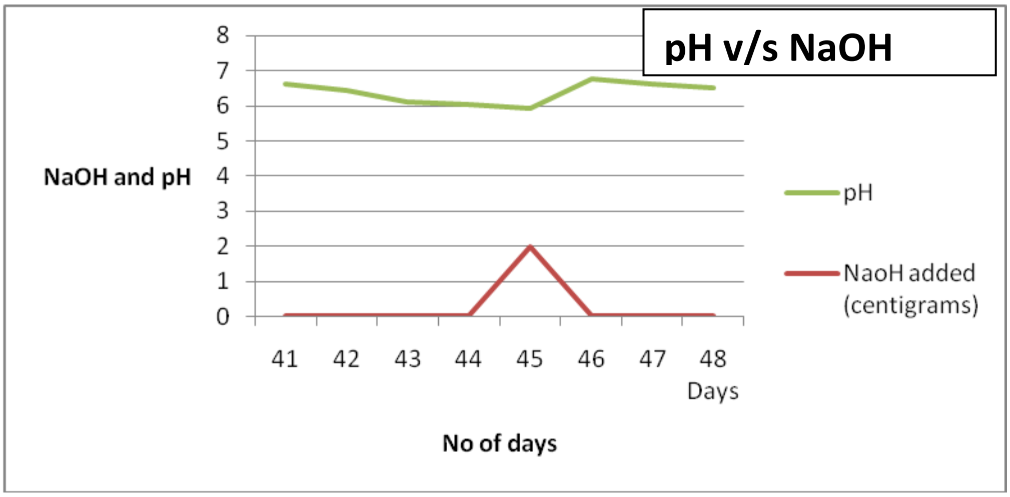


**Fig 6- Variation of pH according to NaOH content**

Despite of steady pH and alkalinity, the biogas gas i.e. methane production was low during that period due to lack of mixing. So the mixing by circulation of waste inside the reactor was performed and both pH and alkalinity was found increased. The pH reached above 6.5 but not exceeded 7 which are inhibiting condition for methanogenesis. During that period, the biogas production as well as methane composition was reached the maximum value of <X> L/d and 66.68% respectively. Also, as can be seen from the graph below, the gas production started once the pH stabilized to around neutral.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

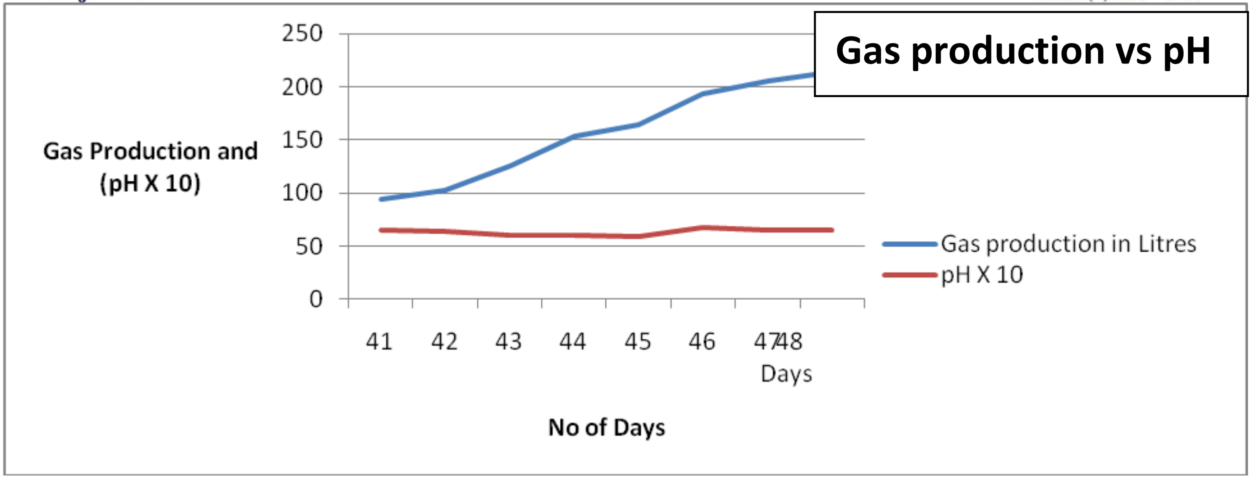


**Fig 7-Comparison of Gas production and Ph**

### 6.4 Continuous feeding

This is the final and continuous phase of operation. In this operation, the continuous feeding was applied in draw and feed mode. Experiments were conducted for constant retention time of 48 days. The experimental runs at phase 2 were carried out in a sequentially scheduled routing beginning with 2.5 kg VS/m³.d. Once the reactor was operated for the required number of days as determined from the retention time, another loading rate was started. Three such loading rates and retention time used for these experiments. The operational days were at least equal to the retention time. Retention time is a measure of the time that the substrate spends inside the digester. The working volume of the digester was maintained at approximately 60% .

### 6.5 Biogas and methane production

Biogas samples for analysis were collected and analyzed. One of the main objectives of this research was to determine the performance of the AD process when operated at different loading rates. For this reason, it was highly important to evaluate process performance in term of biogas composition and production to various loading rates. The experimental results showed the variation of the biogas production during loading rates 2 and 3 whereas it was found to some extent similar in lading rate 1.

Variation of biogas compositions during loading rates 1, 2 and 3 Methane concentration in biogas was observed around 60% in loading rate 1 and was observed 53% in loading 2 whereas it was found less than 50% in loading rate 3. The measurement of the quantity and composition of the biogas produced in terms of methane and carbon dioxide content is of fundamental important to evaluate the performance of the process. As carbon dioxide in biogas was found increasing means that the acidifying microorganisms are prevailing on the methanogens that may lead to VFA accumulation. From the fact finding of this study, carbon dioxide was produced from acidification of the system. This statement was proofed by comparing the methane concentration during the first few days of operation. For this reason, indication of unsteady state of the reactor was occurred during loading rate 3.

As the variation of the biogas production was minimum and methane concentration around 60%, the loading rate 1 can be said as the optimum loading rate for the stable operation of dry continuous anaerobic digestion process of the existing reactor configuration pH and Alkalinity during continuous feeding

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

The pH is an indicator of good process performance and should be above 7.0 at all times in which case the process operates successfully. The pH of effluent from the continuous digester remained steady state to the range of 7.5 - 8.0 during the loading rate 1 that the system was well buffered. When the loading rate was increased to 3.3 kg VS/m3.d, the pH value dropped from 7.5 and reach to lower value of 7.0 but it was still above 7 which were in the methanogenic range. The methane content in the biogas dropped and the system showed sign of overloading. As the pH was in the methanogenic range, the methane content in the biogas was above 50%.Since the pH is controlled by the volatile organic acids concentration, the alkalinity showed similar trends. This was resolved by immediately stopping the feeding and adding alkaline solution. But the condition could not be recovered during loading rate 3. In loading rate 1, these concentrations were found significantly decreased after the completion of the retention time. This can be explained that there was higher hydrolysis but less methanogenesis because hydrolytic bacteria are more robust to environmental condition. The presence of ammonia nitrogen can always be of concern in anaerobic digestion as free ammonia can be inhibitory.

## VII. CONCLUSIONS

In developing countries like India, more than 70% of the population lives in the rural areas where more than 90% of the energy being consumed comes from non-conventional sources, the major one being fuel wood. The increasing cost of conventional fuel in urban areas necessitates the exploration of other energy sources. Animal and plant wastes are abundant especially in rural areas. Biogas can be produced from food wastes and chicken as a substitute for fossil fuels. The generation of biogas from food waste and chicken litter produces an energy resource. The process also creates an excellent residue that retains the fertilizer value of the original waste products. The search for alternative source of energy such as biogas should be intensified so that ecological disasters like deforestation, desertification, and erosion can be arrested.

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