



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 10, October 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569



Biogas Generation by Using Different Proportions of Solid Waste

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ABSTRACT: Anaerobic digestion is one of the eco-friendly methods to treat and dispose the bio-degradable wastes and has more advantages when compared to any other waste treatment methods. Biogas production and composting of slurry from the biogas plant is one of the methods to reduce volume of the waste and to recover maximum energy from the organic wastes. Under anaerobic digestion the organic content is reduced, poultry waste, sewage sludge along with kitchen waste was used in the bio-digester inoculums. In digester -1, poultry waste (3250gms) and chopped kitchen waste (3250gms), and water were mixed and filled in the proportion of 1:1 digester -2 was filled with poultry waste (2167gms) and sewage sludge (4334gms) in the proportion of 1:2 and also poultry waste (1182gms), sewage sludge (1773gms) and kitchen waste (3546gms) in the proportion of 1:1.5:3 and water were mixed and filled in digester -3, for a detention period of 33 days under room temperature. Parameters such as pH, total solids (TS), volatile solids (VS), and chemical oxygen demand (COD) were analysed for the slurry. Finally the biogas generated in digester -1 was 4.86 kg, digester -2, was 6.82 kg and digester -3 was 8.02 kg respectively. The flame test was positive for the digester-2 and digester -3, while it was absent for digester -1.

KEYWORDS: Anaerobic digestion, poultry waste, Kitchen waste, Sewage sludge, Total solids, Volatile solids, Chemical oxygen demand, Biogas generation, Detention period.

I. INTRODUCTION

Solid waste generation has become a growing environmental and public health concern across the world, especially in developing nations because of fast urbanization and population increase [1]. Solid waste management is one of the major challenges faced by many countries around the world. In Indian cities, per capita solid waste output ranges from 0.2 to 0.87 kilograms per day, with an annual increase of 1.3 percent. The Integrated Solid Waste Management System is a comprehensive waste prevention, recycling, composting and disposal program [2]. Biogas is produced by bacteria through the bio-degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle [3]. The biogas production from anaerobic digestion from digestible poultry waste, Kitchen waste and Sewage Sludge converts the substrates into renewable energy and also provides natural fertilizer for agriculture. Biogas is defined as gas mainly composed of methane (CH₄) and Carbon dioxide (CO₂) produced by the biological process of anaerobic digestion, which can be converted into transport fuels and renewable natural gas [4]. Anaerobic digestion technology has immense use in future for sustainability, for agriculture and environmental, as it represents efficient and feasible waste stabilization method for converting diluted solid waste into sustainable energy with organic fertilizers [5]. Objective of this study was to compare quantity of biogas generated from waste by using poultry waste, kitchen waste, and sewage sludge as inoculums in different proportions, and to analyse for Total solids (TS), pH, Volatile solids (VS), and COD. Analysis of mention parameters will be useful for establishing a biogas system with the use of various types of available kitchen waste and substrates for production of biogas [6].



II. RELATED WORK

Anaswara (2015) studied on co-digestion of the smell nuisance producing, poultry waste and pig manure and evaluated the optimum biogas production by comparing these two substrates in different mixing ratios at different atmospheric temperatures in three mini biogas plants for 26 days, and the results analysed showed that the best mixing ratio of poultry waste to pig manure to water is 1:3:6 [7]. Mustafa et al., (2016) presents a case study to investigate the potential for upgrade of a bio-waste treatment plant, and also discusses development potentials in order to optimize the plant for maximum energy and environmental benefits. Data gathered over two consecutive years about the production of biogas, energy and bio-rest were considered and mass balance analysis of inputs and outputs of the plant were carried out [8]. Ramakrishna et al., (2018) studied on recovery of biogas and compost from solid waste, five samples with different ratios (1:2, 2:1, 1:1, 5:3 and 3:1) of organic waste and cow dung are prepared, made into slurry using water and subjected to 30 days of anaerobic digestion. Parameters such as pH, temperature, volatile solids, gas yield are determined from the biogas digester samples. Flame test is used to determine the effectiveness of biogas generated [9]. A plant was installed and operated by Mandavgade et al., (2019) to evaluate its performance when fed with used Tea Powder, the performance of the digester considering the gas production was found to be good. The plant has proved to be effective in terms of reduction of waste volume and organic load, thus it proves to be an alternative to cooking gas as well as it can be used in generation of electricity [10].

III. METHODOLOGY

A. Sample Collection

The samples were poultry waste, kitchen waste, and sewage sludge. These are collected from different places. The poultry manure was collected from S K Group (poultry farm) Bathi, Avaragolla Davanagere, the kitchen waste was collected from UBDT Ladies Hostel Davanagere, and Sewage sludge was collected from Sewage Treatment Plant (STP) Kalpanahalli Davanagere, Karnataka.

B. Fabrication of Digester

Present experimentation was carried out using digesters (acrylic bottle) having each bottle capacity 20L. Since the digester digests the wastes anaerobically, the container was kept air tight. A gas pipe is connected to the bottle cap using m-seal and is provided for the flow of generated gas. In order to transport the digesters gas, lengthy delivery tubes were linked to the output valves stored in the tire tube.

C. Preparation of feedstock

Fresh organic solid waste has been used as feed for biological digester. Organic solid waste includes poultry waste, kitchen waste and sewage sludge. Wastes were sorted shredded and mixed number of times in laboratory. All the digesters were filled with raw materials supply and seeded in proportionally with poultry waste, kitchen waste and sewage sludge.

D. Inoculums

The experiment used three different inoculums sources: poultry waste, kitchen waste and sewage sludge.

- Digester -1 contains poultry waste, kitchen waste in the ratio of 1:1 and water.
- Digester -2 contains poultry waste, sewage sludge in the ratio of 1:2 and water.
- Digester -3 contains poultry waste, sewage sludge, kitchen waste in the ratio of 1:1.5:3 and water.

IV. EXPERIMENTAL RESULTS

Three digesters of volume 20 litres and effective volume of 15 litres were operated under effective state with solid waste and tap water as shown in fig.1. Experimentation was carried out for 33 days at room temperature. Through weighing method, biogas generations from the digesters were monitored every three days.



Fig.1 Biogas digester

The pH value of the slurry was found between 6.15 – 7.5 (digester-2 and digester-3) except in digester-1 during the study period, which is satisfactory range for biogas production, the higher value of pH in digester-1 may be due to formation of ammonia along with continuous of digestion process. The methane formation is also followed by slightly increase in pH of slurry; hence this is the reason for low biogas generation compare to digester-2 and digester-3.

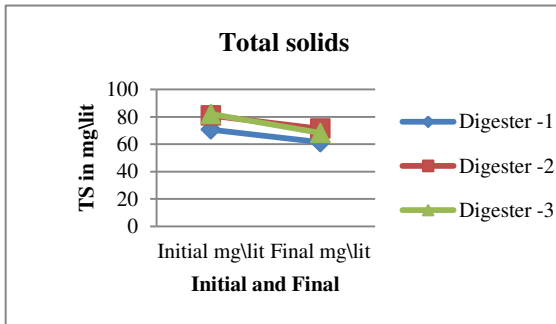


Fig.2 Variation of Total solids (TS)

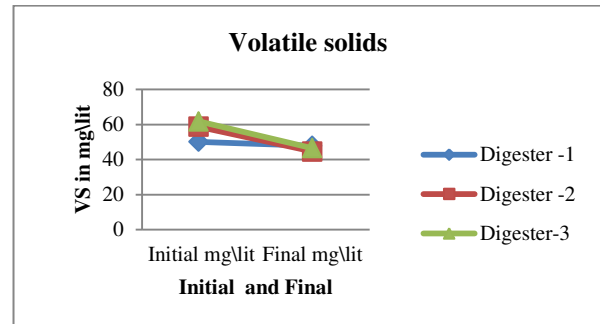


Fig. 3 Variation of Volatile solids (VS)

Fig.2 and fig.3 shows that before and after digestion of total solids and volatile solids in all three digesters respectively, the reduction in TS and VS concentration is computed by subtracting the value obtained on that day from the initial TS and VS content. A decrease in the TS and VS content is noticed indicating decomposition in biogas digester. A reduction of total solids and volatile solids indicates increased biogas generation.

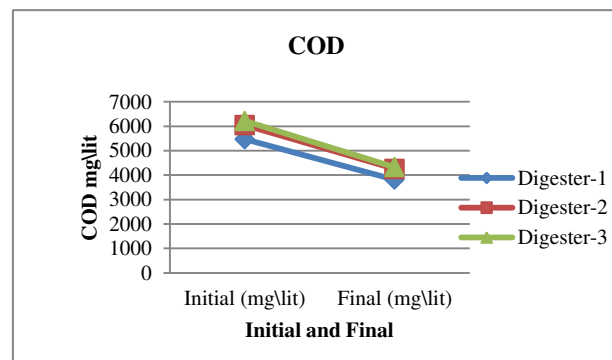


Fig. 4 Variation of COD

The above fig.4 represents the variation of COD in the biogas production, during the first stages of the biogas generation process, the COD decreased significantly due to the strong mineralization of the reactants. Finally, when there was no longer any activity from the bacteria and the process was terminated, the COD percentages began to decline.

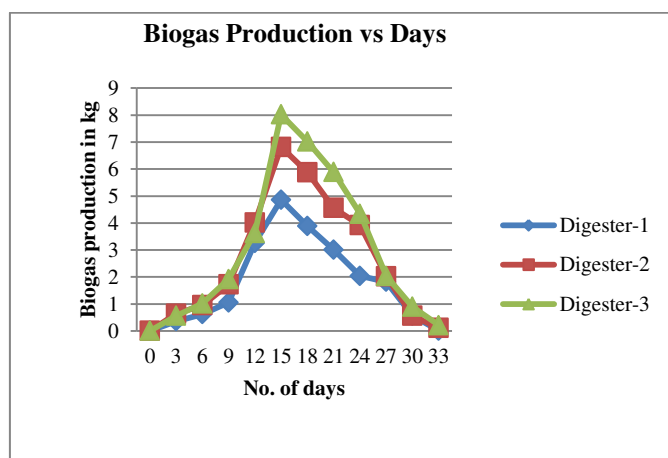


Fig. 5 Comparisons of biogas production in all three digesters

Fig.5 shows the comparisons of biogas production in all three digesters for 33 days of biogas generation, it was observed that biogas output increased significantly between 6 and 12 days. The peak biogas production rate was recorded at intervals of 12 to 18 days for all the combinations and reduced thereafter, when it comes to the digester-1 showed the maximum quantity of biogas was generated was 4.86 kg, when it comes to digester 2, it was 6.82 kg and digester 3 was 8.02 kg.



Fig.6 Flame test on three digesters

The blue colour in the biogas flame indicates that the biogas quality is good. The flame test was done in the dark room, flame test was positive in digester -2 and digester -3, while it was absent for digester-1, as shown in the fig.6. The table: 1 shows the comparisons of results of experimentation.

Table -1: Comparisons of parameters for all the samples are used in biogas generation

Parameters	Digester-1	Digester-2	Digester-3
Ratio of organic waste	1:1	1:2	1:1.5:3
Initial pH	6.56	6.15	6.2
Highest pH	7.9	7.3	7.4
Initial TS mg/lit	70.68	81	82
Final TS mg/lit	61.38	71.39	68.2
Initial VS mg/lit	56.15	58.78	61.78
Final VS mg/lit	47.87	44.62	46.52
Initial COD mg/lit	5470	6048	6218
Final COD mg/lit	3809	4250	4320
Flame Test	Negative	Positive	Positive



V. CONCLUSION

The digester -3 containing poultry waste, sewage sludge and kitchen waste showed maximum quantity of gas production compare to digester -1 (poultry waste and kitchen waste) and digester-2 (poultry waste and sewage sludge). The maximum level of biogas can be attained by the maximum reduction of COD in the digesters. As the reduction of total solids and volatile solids, the production of biogas increases. The pH was maintained between 6.15 to 7.9 which were good for biogas generation. The gas generated from digester- 2 and digester-3 are flammable but the gas generated from digester -1 is not flammable; this might be owing to the presence of contaminants in the gas, such as moisture.

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