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# Biogas Plants for Sustainable Agriculture

Dr. D. Rajkumar*, Varsha. P. Sarma, S. Gobika, R. Ganeshwari, T. Haarshiny
Department of Agricultural Engineering
RVS Technial Campus, Coimbatore – 641402

**Abstract:- The production of biogas will give rise to a great deal of organic fertilizer, i.e., biogas fertilizer, which has not only the characteristics of traditional organic fertilizer but also some more merits as a result of anaerobic fermentation. The biogas fertilizer can increase the yields of crops, improve the fertility of soil and have the potential of a wide use. Accordingly, it is considerable problem to know the properties of biogas fertilizer well in order to make a good job of its comprehensive utilization. This paper deals with the fertilizer characteristics and comprehensive utilization of biogas fertilizer in crop production and other components of integrated farming system.**

***Keywords:-*** *Biogas Plants, Biogas Fertilizer, Nutrient Value, Sustainable Farming.*

## I. INTRODUCTION

Owing to the expanding population, agriculture heavily relies on synthetic fertilizers to boost productivity and guarantee food security. High inputs of chemical fertilizers cause an adverse effect on soil structure, micro-organisms, water, fodder and it disturb the ecological balance. Despite of higher nutrient content in inorganic fertilizers, the efficiency of fertilizers are lower in comparison with organic manures. The slow-releasing nature and growth-promoting compounds in organic manures help to maintain the soil fertility. In recent years, awareness has been created to perform crop management in a sustainable manner. The sustainable agriculture rely in recycling and reuse of farm wastes, as well as the production of food grains without harming the environment or the soil. The only choice available in this case is organic manures, which include farmyard manure, biofertilizers, biogas slurry and vermicompost [8].

One of the methods of recycling the wastes is the anaerobic decomposition. Bio-slurry is an anaerobic fermented organic material generated from the biogas plant as a byproduct after production of combustible methane gas residues. Biogas slurry is a typical organic fertilizer that ensures the proper use of livestock waste for organic crop management and maintenance of an eco-friendly, pollution-free environment [4].

The digestion process in biogas plant produces materials containing high contents of N and other essential nutrients for the crop growth [7]. Raw undigested cattle slurry materials have lower pH value, higher $NH_4^+$-N as well as C:N ratio compared with digested cattle slurry. Cow dung and poultry manure that has been digested anaerobically contains more plant nutrients than aerobic digestion[10]. The decomposed farm residues can be made substitute for chemical fertilizers.

Despite the nitrogen, phosphorus and potassium content of organic manures are low in nature, the anaerobically decomposed organic manures pretended to be slightly high than aerobically decomposed manures but lesser than the synthetic fertilizers. The organic manures in addition to chemical fertilizers increased the yield.

Bio-slurry found in different forms and varies according to the digester and feeding substances. The fully-digested bio slurry can be easily identified with non odorous, black or dark brown in color. In Biogas slurry digestion, organic matter will give a large amount of organic acids, which can timely neutralize the release of ammonia and fix it in the fermentative substrate so as to stop it from escaping which enhances the crop yield .The higher N uptake (10-20%) was observed in crops applied with biodigested slurry than undigested slurry [5][16].

According to a recent estimates however, the consumption of mineral fertilizers could be reduced by 30-35% on the average through the production of biogas and subsequent use of the digested sludge as a fertilizer. Biogas technology is an appropriate approach to coping with the increasing demand for energy, food and fertilizer among the rural population. Biogas system supply both energy and fertilizer, both of which can be made accessible to the poor. This, however, would entail public funding. Any government planning to allocate public funds to the enhancement of energy supplies and agricultural production should investigate the benefits of biogas programmes as compared to other approaches.

## II. DIFFERENT TYPES OF BIOGAS PLANT

Three commonly used biogas plant designs in India are the KVIC (Fig 1), Janata (Fig 2) and Deenabandhu (Fig 3) biogas plants.

### *A. KVIC plant (Khadi and Village Industries Commission model plant (Floating)*

This design consists of an underground digester that is deep and well-shaped. It is connected to inlet and outlet pipes at the bottom, which are divided into two sections by a partition wall that makes up 3/4 of the entire height. With the accumulation and withdrawal of gas, a mild steel gas storage drum is inverted over the slurry and moves up and down along a guide pipe. Now, the gas holders made up of FRP and Ferro cements were also used instead of steel drum.

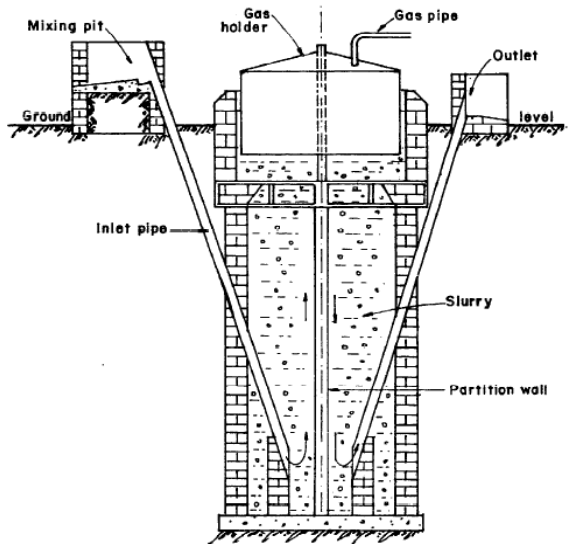


**Fig 1. KVIC model**

*B. Janata model biogas plant (Fixed dome type)*

This model also operates on a semi-continuous flow. The digester and gas holder are integrated into a composite unit composed of bricks and cement masonry, which is the primary characteristic of the Janata design. It features a cylindrical digester with two-sided large inlet and output tanks and a dome-shaped roof. To create the dome-shaped ceiling, shuttering is needed, and a master mason with the necessary skills and training is required to build the Janata biogas plant. The cost of this plant is approximately 20–30% cheaper than that of the KVIC floating drum type plant.

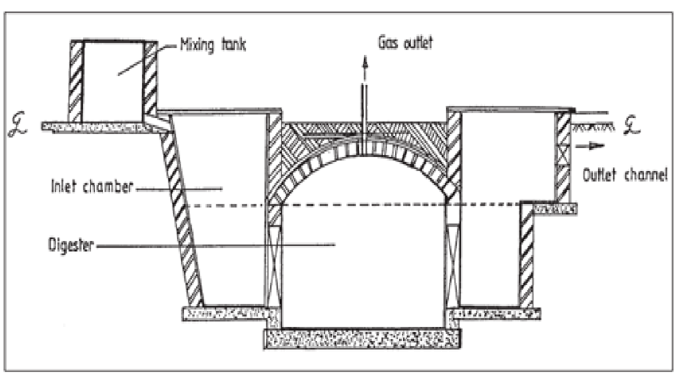


**Fig 2. Janata model**

*C. Deenabandhu model biogas plant (Fixed dome type)*

Deenabandhu Biogas Plant (DBP) is a low cost fixed roof type biogas plant designed by AFPRO. The biogas plant's efficiency has not been impacted by the decrease in costs. All readily available building materials such as brick, cement and sand are used to construct Deenbandhu biogas plants. No shuttering is required in this model which significantly reduces the labour cost.

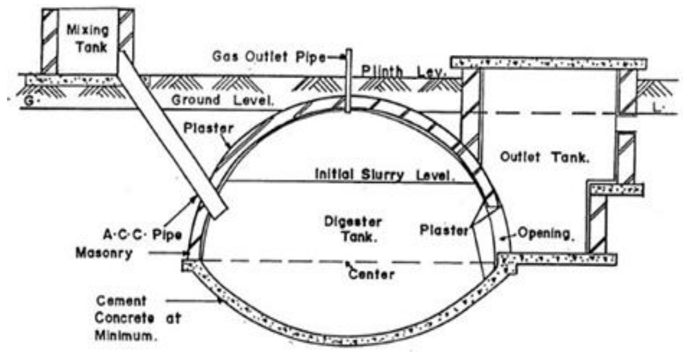


**Fig 3. Deenabandhu model**

## III. CHARACTERISTICS OF BIOGAS FERTILIZER

Biogas fertilizer comes from the anaerobic fermentation of organic matter in an airtight biogas digester, hence having the following characteristics:

*A. A good effect of conserving nutrient elements*

In the course of biogas fermentation, organic matter will give a large amount of organic acids, which can timely neutralize the ammonia released from organic matter and fix it in the fermentative substrate so as to stop it from escaping. Some researchers were conducted on rural biogas digesters in 16 counties (or municipalities) of Sichuan Province. The same quantity and quantity of human and animal excreta were respectively put into open manure pits and biogas digesters and then sampled after 30 days of fermentation. The results showed that the contents of the total N and the ammonia N in slurry higher in the biogas digester than in the open manure pits respectively. In addition, biogas fertilizer has a good effect on the conservation of P, K and other trace elements. Accordingly, biogas fertilizer is likely to have some difference in its nutrient contents because the kinds and the mixing ratios of its feedstock are different, but in general the content of its various nutrients is higher than that of compost's and open manure pits[13].

A study was conducted by Department of Agricultural Engineering, RVS Technical Campus Coimbatore to access the macro nutrient content of various organic manures used for crop production and the results are given in the Table I.

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**Table 1. Macro Nutrient Content of Various Manures.**

| S. No | Manure | % content, $N_2$ | % content , $P_2O_5$ | % content , $K_2O$ |
|---|---|---|---|---|
| 1. | Fresh cattle dung | 0.4 | 0.2 | 0.3 |
| 2. | Farmyard manure | 0.7 | 0.4 | 0.8 |
| 3. | Compost | 0.8 | 0.3 | 0.9 |
| 4. | Biodigested slurry | 2.1 | 1.8 | 0.9 |
| 5. | Poultry manure | 1.9 | 1.8 | 0.8 |
| 6. | Cattle urine | 1.2 | trace | 0.6 |
| 7. | Paddy straw | 0.4 | 0.8 | 0.8 |
| 8. | Wheat straw | 0.6 | 0.2 | 1.2 |

The results are on par with the results of Tunney, 1980. The result clearly indicated that among various manures evaluated, all the three macro nutrients *viz.,* nitrogen, phosphorus and potassium content were higher in the biodigested slurry which may be due to anaerobic digestion [13].

*B. A high quick-acting nutrient content and holding slow-and-quick acting manurial effect concurrently*

Biogas fertilizer consists of digested slurry and residue. The digested slurry is a quick-acting fertilizer containing many kinds of water-soluble nutrient content and crops are easy to assimilate its nutrient content after it is applied to soil. The digested residue not only contains all-round nutrient elements and organic matter but also adsorbs more effective nutrient contents, hence holding slow-and-quick acting effect concurrently. As a result, it can be said that biogas fertilizer is a fine quality organic fertilizer, which has not only an obvious effect on increase in the yield of current crops but also a noticeable manorial effect on following crops.

*C. Serving the function in amelioration of soil*

The digested residue of biogas fertilizer holds plenty of organic matter. Long-term application of biogas fertilizer is both beneficial to the activity of soil microbes and capable of accelerating the formation of organic and inorganic complexes in soil, thus improving the structure and physicochemical properties of soil. The facts have shown that, as compared with the soil which digested residue was not applied to, the soil which digested residue has been applied to have smaller volume weight, bigger porosity, lower compressive strength and larger coefficients of structure and settlement, and is spongy, easy to break and beneficial to cultivation. Accordingly, the application of biogas fertilizer can be used as an important measure to increase the fertility of soil, improve soil, improve soil, protect the ecological environment of soil, and realize the combination of land use and maintenance.

*D. The mixed fermentation of different kinds of feedstock can improve the quality of the gas fertilizer*

According to the experiments by Hubei Provincial Academy of Agriculture, when one among eight kinds of feedstock such as pig dung, straws, stalks, etc. was separately fermented in anaerobic gas digester, average consumption of 1 kg dry matter produced 293.3 litres of biogas. Among these materials, pig dung and cattle dung, on the average, lost 50.4% of carbon, 5.6% of nitrogen, 9.3% of phosphorus and 7.2% of potassium. If pig dung and cattle dung were fermented with straws and stalks of crops, the consumption of each kg dry matter generated 409 litres of biogas and on the average, carbon and nitrogen lost 36.9% and 3.8% respectively, but potassium and phosphorus were basically the same. This indicates that the mixed fermentation of different types of feedstock can not only increase the yield of biogas, but also decrease the loss of nutrients in biogas fertilizer and enhance the quality of fertilizer.

## IV. USE OF BIOGAS PLANT SPENT SLURRY IN CROP PRODUCTION

Field experimentation on use of biogas plant spent slurry for substitution of nitrogenous fertilizer in crop production was carried out at RVS Farm Unit IV. The results of experiments carried out have been briefly described hereunder:

Field trial was conducted in Randomized Block Design at RVS Farms (Unit IV) on rice (CO 51) using the biogas slurry in addition with nitrogenous fertilizer. The chemical nitrogenous fertilizer was applied as 75%, 100% and 125% of recommended dose of N in combination with biogas slurry at 10 t $ha^{-1}$ and biofertilizer *Azospirillum* 600 g for rice as seed treatment. The treatments were T1-Control, T2-*Azospirillum*+ biogas slurry, T3-75% RDF + *Azospirillum*, T4-100% RDF + *Azospirillum*, T5-125% RDF + *Azospirillum*, T6-75% RDF + *Azospirillum* + biogas slurry, T7-100% RDF + *Azospirillum* + biogas slurry, T8-125% RDF + *Azospirillum* + biogas slurry and replicated three times. The blanket recommendation for rice was 150:50:50 kg $ha^{-1}$. The plants were planted at 20 x 10 cm. The plant height, number of panicles $m^{-2}$, grain and straw yields were recorded Available nitrogen in the soil was estimated at tillering, panicle initiation and harvest stages. The yield of rice was influenced by the chemical N fertilizer with biofertilizer and BS (Table 2). The higher plant height and higher number of panicles $m^{-2}$, higher grain (6575 kg $ha^{-1}$) yield and straw yield (13147 kg $ha^{-1}$) yield was observed in the treatment with combination of biogas slurry (10 t $ha^{-1}$) and 125% recommended dose of nitrogen with biofertilizer (*Azospirillum*). The grain yield was increased about 72 per cent and straw yield by 71 per cent over the control plot.

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**Table 2. Effect of biogas slurry and chemical fertilizer on plant height (cm), number of panicles $m^{-2}$, grain and straw yield (kg $ha^{-1}$) of rice**

| Treatments | Plant height (cm) | Number of panicles $m^{-2}$ | Grain yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) |
|---|---|---|---|---|
| T1 | 77.93 | 199 | 8148 | 10455 |
| T2 | 83.90 | 224 | 9267 | 11766 |
| T3 | 85.40 | 291 | 10951 | 13910 |
| T4 | 84.33 | 313 | 11205 | 15442 |
| T5 | 92.80 | 379 | 12624 | 16414 |
| T6 | 88.20 | 344 | 12191 | 15021 |
| T7 | 102.33 | 430 | 14506 | 19343 |
| T8 | 100.80 | 417 | 13926 | 18754 |
| S.Ed ± | 1.13 | 9.71 | 497 | 437 |
| CD at 5 % | 2.38 | 20.38 | 1067 | 918 |

Organic manure induced nutrient-shift along with shift in the microbial communities of rice field which further affects the growth and productivity of rice. The soil available nitrogen after the harvest in rice showed the positive correlation with combination of both inorganic and organic N supplied to the crop[12]. And also the results revealed that the available N after the harvest was higher in the treatment where 125% of recommended dose of N combined with *Azospirillum* and 10 t ha $^{-1}$ of biogas slurry. Whereas, in the treatment without biogas slurry the available nitrogen in soil was drastically reduced (Fig. 4).

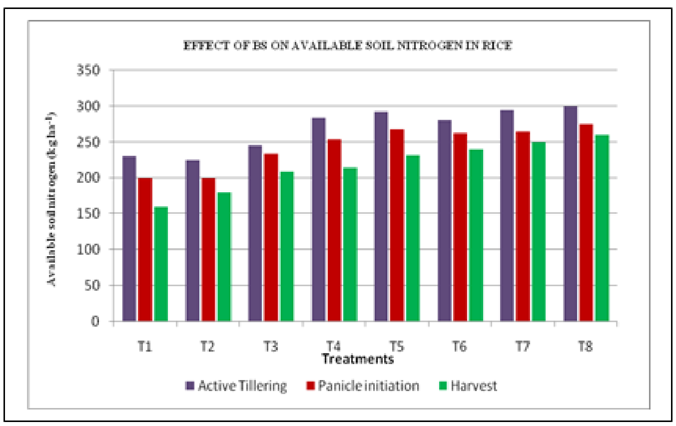


**Fig.4. Effect of biogas slurry on soil available nitrogen in rice**

## V. BIOGAS SLUDGE FOR FEED AND OTHER USES

### *A. The mixed fermentation of different kinds of feedstock can improve the quality of the biogas slurry*

The fresh manure cannot be used directly as feed for pigs and cattle. Many poultry and livestock raisers are understandably reluctant to feed it to their animals. Either they are afraid of spreading diseases among their herd, or they may find the manure too messy to handle, or the idea of feeding it to their animals may grate against their sensibilities.

In general, only about half the nutrients in the feed are utilized by animals. A considerable amount of undigested organic matter is present in animal manure. Manure can be fermented in a biogas manufacturing to remove its undesirable qualities. The anaerobic process eliminates the aerobic pathogens, or disease-causing microorganisms. Humus doesn't doesn't draw flies like manure does. Furthermore, the decomposition of the biogas produces vitamin B12, one of the B-complex vitamins that are added to the sludge by the biogas process, while also preserving the minerals. By draining the liquid and letting the solids settle out in settling tanks, the solids are separated from the sludge. After that, they are dried, ideally in the sun. Artificial drying may be needed on wet days, but caution must be used to prevent the solids from being exposed to too high temperatures, which can ruin the vitamin content. After being pulverized and cleansed, the dried lumpy solids are combined with the other feed ingredients and can be fed to the poultry and pigs. It is possible to feed the settled sludge alongside the slops without drying them in small operations that use wet feeding.

### *B. Biogas slurry as source of Vitamin $B_{12}$*

Nutrient deficits occur when pigs or poultry fed off pasture on rations without an animal protein supplement. This is especially true for chicks and young because they require vitamin B12, which is absent in plants derived feeds. It is essential for the hatchability of eggs and the growth of chicks and young pigs. It is also used to treat anemia and the neurological symptoms associated with pernicious anemia.

Vitamin B12, which belongs to the B-complex family, is one of the more costly organic products that are made commercially. It has a strong physiological action and requires very few doses to be treated. Many different types of microbes, including those that make antibiotics and methane, manufacture it. The mother liquor leftover from making antibiotics is used to produce vitamin B12 on a commercial basis today. Nonetheless, the methane bacteria's production of vitamin B12 during the biogas process is so high that some experts think sludge could be a possible supply of the vitamin.

Preliminary results of research being conducted at Maya Farms in Philippines indicate concentrations over 3000 mcg. of vitamin $B_{12}$ per kg. of dry sludge. In comparison, fishmeal has only around 200 mcg. per kg, meat and bone meal has just over a hundred mcg kilo. Fishmeal and meat and bone meal are the main sources of vitamin $B_{12}$ in animal feeds[9].

### *C. Biogas waste for Chlorella cultivation*

The liquid that remains after the solids are removed from the sludge, due to its nutritional and trace mineral concentration, is an excellent growth stimulant for algae. Algae are prehistoric plants found in freshwater ponds. They include seaweeds and green scum. Chlorophyll, the green coloring material that allows green plants to produce their own sustenance, is found in the majority of algae. Algae are known to exist in over 20,000 kinds.

Chlorella is single-celled algae with high protein content of 36 to 40 per cent which is cultivated in shallow ponds. The liquid sludge can be added which encourages the chlorella growth. Concrete, metal, or plastic should be used to line the pond in order to prevent contamination and facilitate harvesting. Chlorella is harvested early in the morning before sunrise, while it is at the bottom of the pond. The water can be drained out and the chlorella is then scraped off. It is harvested 6 to 7 days after the inoculation with a chlorella feed stock. Chlorella can be used in amounts up to about 10% of animal feeds to replace soybean oil meal for protein supplementation. However, at the present cost of soybean oil meal, large-scale commercial production of chlorella is not yet economically viable. The chlorella will take its place among the important protein sources for animal feeds.

### *D. Biogas slurry as feed in Fishponds*

Plankton, the enormous variety of tiny plants and animals found at the surface of water bodies, serves as fish's primary food source. The plant population of plankton consists mainly of algae. A wide variety of unicellular organisms, crustaceans, and other animal larvae are animal kingdom of planktons. Manures from poultry and cattle are directly utilized in fishponds to increase plankton; however the smell often affects palatability of fishes. This is particularly evident in the case of bangus (milk fish). A better way is to pass the manure through a biogas plant and use the resulting sludge in the fishpond. Several advantages are;

- The sludge will not adversely affect the palatability of the fish.
- The sludge facilitates plankton growth more effectively than fresh manure
- Since the sludge has a lower BOD than the fresh manure slurry, the availability of oxygen content can be increased.
- Biogas and biofeed are produced.

## VI. CONCLUSION

According to available economic data on biogas activities, in terms of commercial energy and fertilizer equivalents, the biogas programme may be a best alternative to reduce the electricity and fertilizer costs at least in the rural areas. The widespread use of biogas systems would therefore reduce the demand on imported energy resources and fertilizer materials and as a consequence, simultaneously improve the foreign exchange resources. This approach will also help in conserving the natural resources for the future.

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