

Production of biogas from willow dust

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Willow dust is a textile mill waste and is rich in cellulose, hemicellulose and lignin. Cellulosic substances with a carbon-nitrogen (C:N) ratio of 25:1 are reported to be optimum for biogas production. As the C:N ratio of willow dust (28-30 : 1) is close to this optimum level, it has been found suitable for biogas production. The proximate analysis is given here.

On the basis of the experiments carried out at laboratory scale, an experimental plant for batch type fermentation was designed and fabricated. This plant had the capacity to handle 100 kg of willow dust. The plant consists of an anaerobic batch fermenter and a separate gas holder constructed from galvanized iron sheets. The anaerobic fermentation tank was totally closed except for one opening of 180 mm diameter at the top to feed the material and a similar size outlet to take out the digested slurry. The biogas, generated was led to the gas holder through a flexible rubber hose. The gas holder was of the floating types designed to store 500 liters of gas over water.

The process involves mixing of willow-dust in water (1:1.5) containing sodium hydroxide (1%) and aerobic digestion for 72 hr. The aerobically digested material was charged in the anaerobic digester with cattle waste (10%) as inoculum. The total solid in the fermenting slurry was maintained at 16% in the beginning.

The studies carried out on this plant indicated that during the first six days after charging the digester with willow dust, biogas rich in carbon dioxide was generated. In the subsequent period, the gas produced was combustible and the methane percentage increased to 55-60%. As much as 17 m³ biogas was obtained from 100 kg material in 30 days. About 50 kg of their material remained in the slurry was found to be of a good quality manure.

This digested slurry was tested for its manurial value. It was found that the digested slurry had better NPK content than the slurry obtained from cattle waste.

BIOMANURE

The biomanure obtained after fermentation can be directly used for plants, unlike the spent slurry from cattle waste based biogas plants which requires dewatering or sun-drying for immediate use.

Analysis of willow-dust along with that of biomanure obtained from willow dust and that of cattle waste is given in Table 1. It is observed that willow dust manure is having better NPK content than cattle waste.

To assess the manurial value of the biomanure obtained from willow dust, pot culture trials were undertaken on a crop of Laxmi variety cotton using red sandy loam soil. Three sets of pots were taken. One set received 500 g of biomanure obtained from willow dust. Another set received a basal dose of 1.5 g ammonium sulphate, 4.0 g super phosphate and 1.5 g potassium sulphate. This set again received the same does of fertilizers after one month of

sowing as top-dressing. The third set served as control and did not receive either fertilizer or willow dust manure. The stand of crop on the biomanure of willow dust was found to be comparable to that of fertilized crop.

Further experiments in the field conditions on cotton crop under irrigated conditions indicated that the application of the biomanure prepared from willow dust @ 5 tonnes/ha is equivalent to 10 tonnes of FYM or 80:40:40 of N,P and K/ha.

Attempts were made to reduce the amount of water in the fermenting mass. It was possible to produce biogas as effectively as before with a substrate to liquid ratio of 1:1.5. In this process, the alkali treatment and aerobic digestion remained unaltered. However, with the substrate to liquid ratio of 1:1.5, biogas production started after 10 days, as compared to 7 days when substrate to liquid ratio was kept at 1:5. By following this technology, it is now possible to charge the same 100 kg experimental biogas plant with 200 kg material, thereby getting twice the gas yield from the same unit space.

PILOT PLANT STUDY

A pilot plant to process willow dust for biogas production was commissioned at Apollo Textile Mills, a unit of the National Textile Corporation, with financial assistance from the Ministry of Non-conventional Energy Sources (MNES), Government of India under an operation research programme.

The plant was constructed on 104 m² land. There were six batch digesters each of 2.40 m x 2.40 m x 2.50 m in size, with a capacity to handle 2 tonnes of willow dust when the substrate to liquid ratio is 1:6. The digesters were constructed by reinforced concrete and are partially underground. For the initial digestion, an open tank of 8.0 m x 2.4 m x 2.5 m, and for collection of slurry, a tank of 4.8 m x 2.4 m x 2.5 m have been provided. The digesters could handle 4 tonnes of willow dust each when the substrate to liquid ratio was reduced to 1:1.5. The digesters were separately connected through gas flow meters, which, in turn, were connected to a common gas holder through a header. Each digester had a separate bypass for the carbon dioxide generated during the initial stages of biogas production. The gas holder was of floating type and constructed from mild steel sheets. The weight of the drum was adjusted to exert a constant pressure of 25cm water column pressure. The gas holder had a capacity to store about 70 m³ of biogas.

A number of trials were taken on this plant and data were collected. Based on the trials, modification and improvements were made subsequently.

Installation of a biogas plant: M/s Century Yarn located at a distance of about 90 km from Indore, Maharashtra generates about 400 kg of cyclone dust every day. A semi-continuous plant to process about 150 kg waste was installed in the mill in 1998.

Design: The plant was constructed by using brick masonry structure. The water seal portion, which was built using RCC work, is positioned at the top of the digester. The plant is of hexagonal shape to facilitate easy flow of the substrate from inlet to outlet. A slope at bottom of inlet portion gives extra momentum to this flow. The digester cover and gas holder are combined into a single unit. This cover-cum-gas holder moves up and down in the water seal. Suitable guiding arrangement is made for the easy movement of the gas holder. The gas holder is fabricated from mild steel sheets, angles and flats. The FRP coating is given on

inner and outer surface of gas holder. The volume of the digester is about 40 m³. The weight of gas holder was adjusted to exert a constant pressure of 5 cm water column when it is floating.

Installation of biogas plant based on cyclone dust at Century Textiles and Industries Ltd., Mumbai was completed in 2003. The plant has two batches fed digesters to accommodate 10 tonnes of cyclone dust in each digester with a common gas holder. The gas produced is being used in their canteen and the plant has been working satisfactorily to date.

CIRCOT has developed methods to produce biogas from these materials both by a semi-continuous and a batch fermentation process. Both the advantages and disadvantages of these methods are given below

Semi-continuous process

Advantages: Only one digester, Low capital cost

Disadvantages: Charging everyday, High water requirement, Slurry handling difficult, Low solid loading

Batch fermentation process: Charging every month, High capital cost, Water requirement less, Two or more digesters required, Slurry handling easy, High solid loading

Over the years, after rigorous analysis CIRCOT has now come out with a new approach for disposing small quantities of waste generated in ginneries which has the potential for easy acceptance by the ginners.

Salient Features of the Process	
• Primary digester	One
• Semi-continuous plant	One
• Raw material requirement	100 kg/day
• Capital investment	Rs. 1,00,000
• Biogas production	450 m ³ /month (15 cyl. of 14.5 kg)
• Biomanure production	1.5 tonnes/month
• Running cost	Rs. 1,000/month
• Net income	Rs. 8,000/month
• Pay back period	One year

The organic acids produced during digestion in the primary digester are taken out by adding appropriate quantities of water and the leachates are fed to the anaerobic digester. The gas generated can be utilized by the families in and around the ginnery atleast by 10-15 of them depending on the size of each family.