

FEASIBILITY STUDY OF ANAEROBIC DIGESTION OF *OCIMUM SANCTUM* LEAF WASTE GENERATED FROM *SANCTUM SANCTORUM*

Korla Swapnavahini,^{a*} Tanuku Srinivas,^b Pinapathruni Lokesh Kumar,^a Manjeti Shanthi Kumari,^a and Tholapi Lakshmi^a

The waste originated in temples is presently piled up at one place and then disposed off in water bodies or dumped on land to decay, leading to water and soil pollution. The present work aims to determine the biogas yield and nutrient reduction potential of *Ocimum sanctum* (basil) leaf waste obtained from temples. Laboratory scale digesters of 2.5 L capacity were used and fed with basil leaf waste, which was digested in a batch reactor for a retention period of 30 days at room temperature. Preliminary results indicate that the process is effective in reducing the pollution potential of the basil waste. The process removed up to 73% and 42% of total solids and BOD, respectively, along with biogas production.

Keywords: *Ocimum sanctum*; Batch reactor; BOD; Biogas

Contact Information: a: Dept of Environmental Studies, GIS, GITAM University, Visakhapatnam, Andhra Pradesh, India-530 045; b: Dept of Biotechnology, GIT, GITAM University, Visakhapatnam, Andhra Pradesh, India-530 045; * Corresponding Author: ksv_jr08@yahoo.com

INTRODUCTION

In view of the increasing population, the demand for energy has increased enormously. At the same time, the reserve for fossil fuels is steadily dwindling. Among the different non-conventional energy options, conversion of biomass resources into biogas appears to be best for India (Chakraborty et al. 2002; Lahiri 1999). Biogas is currently produced by anaerobic degradation of millions of tons of organic waste arising from municipal, industrial, and agricultural sources (Gunaseelan 1997; Parawira et al. 2008). Methane derived via anaerobic digestion has proved to be competitive with heat (via burning), steam, and ethanol production in efficiency, cost, and environmental impact of the conversion of waste streams to energy forms (Parawira et al. 2008).

The improper disposal of waste causes a serious threat of organic pollution to the environment and also several infectious diseases are likely to occur in epidemic proportion due to contamination of drinking water resources (Dhaked et al. 2003). Several researchers have labored on waste-to-energy generation by biomethanation as a good alternative to dispose of diverse waste materials (Wilkie et al. 1986; Nipanay and Panholzer 1987; Ranade et al. 1987; Abbasi et al. 1991; Shyam and Sharma 1994; Kalia and Joshi 1995; Singh et al. 2007; Cuetos et al. 2008; Parawira et al. 2008; Urman et al. 2009; Dhanya et al. 2009) as solitary wastes or as mixtures. However, a literature review clearly indicates the nonavailability of work carried out on basil (*Ocimum sanctum*).

In India, religion is a path of life. It is an intrinsic element of the entire Indian tradition. Hindus worship a host of Gods and are accustomed to go to the temples offering flowers, fruits, coconut, and sweets, etc., as offerings. The bulk of the flowers, leaves of different plants, coconut shells, milk, and curd are piled up and then disposed of exclusively in water bodies. In a temple nearly 900 kgs of flowers, leaves, and coconut wastes are accumulated daily, and the quantity expands to 1200 kg/ day during festivals (Singh et al. 2007).

The goal of the present study is to assess the feasibility of a biomethanation process for biogas production from waste comprised of mainly basil leaves, which is one of the main offerings to God in the Vaishnavite tradition of Hinduism. The work was carried out taking basil leaf waste from the famous temple of Simhachalam situated in Visakhapatnam, Andhra Pradesh. The analysis was set up to determine the biogas production and nutrient reduction potential of *Ocimum sanctum* leaf waste coming from *Sanctum sanctorum*.

EXPERIMENTAL

Study Area

Simhachalam temple is situated 16 km from the city of Visakhapatnam in Andhra Pradesh, among thickly wooded hills. The site is known for its rich cultural heritage and scenic beauty. Its geographical coordinates are 17° 45' 0" North, 83° 10' 0" East. It is one of the most exquisitely sculpted shrines of Andhra Pradesh.

Basil (*Ocimum sanctum*)

Ocimum sanctum (also known as *Ocimum tenuiflorum*, tulsi) is an aromatic plant that belongs to the family Lamiaceae (Warrier 1995). It is cultivated for religious, medicinal uses, as well as for its essential oil. It has an important role within the Vaishnavite tradition of Hinduism, in which devotees perform worship involving Tulsi plants or leaves.

Collection and Preparation of Material

The leaf waste was collected from *Sanctum sanctorum* (garbha gudi) of the famous Simhachalam temple, Visakhapatnam. The leaves were washed with distilled water, air dried in shade, and used as a substrate. The substrate was then blended to make a paste. In each digester bottle, 1500 ml was slurry (6% TS w/v) of the substrate, and 10% (v/v) of the active inoculum (cow dung) was added.

Experimental Setup

The setup was comprised of three graduated glass bottles of 2.5 L capacity and 1.5 L working volume, fitted with rubber caps holding thermometers and pH electrodes. The whole reactor was made airtight. The bottles were connected with pipes for taking away gas from the digester. The gas was collected in a gas collector and collection bottle. Biogas produced in the digester was measured once a day by reading the level of saline water displaced by gas pressure (Singh et al. 2007). The contents of the digester were

mixed once a day by shaking them manually for 5 minutes. The experiment was carried out for a period of 30 days, and the various parameters were analyzed at a regular intervals of 5 days.

Statistical Analysis

Data were subjected to statistical analysis using Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

The reactor was operated in a batch condition, and the setup was studied for 30 days. The pH, temperature, and biogas production were monitored continuously, and the total solids (TS), volatile solids (VS), alkalinity, chlorides, biological oxygen demand (BOD), chemical oxygen demand (COD), and total nitrogen were analyzed at an interval of 5 days (Fig. 2). All of the parameters were determined according to the standard methods (APHA 1992).

The composition of basil waste (Table 1) comprised mainly an organic fraction, i.e. volatile solids (VS). As the fraction was mainly lignocellulosic (Bhattacharya 2008), the degradation was very slow.

Table 1. Analysis of Leaf Waste of *Ocimum sanctum*

S.No	Parameter	Concentration
1	pH	5.19
2	Temperature (°C)	28
3	Alkalinity (mg/L)	6900
4	Chlorides (mg/L)	798.7
5	Total Solids (mg/L)	32000
6	Volatile Solids (mg/L)	28176
7	Biochemical Oxygen Demand (mg/L)	1733.3
8	Chemical Oxygen Demand (mg/L)	5200
9	Total Kjeldal Nitrogen (mg/L)	799.84

Temperature

Temperature is the most important variable in controlling the rate of microbial metabolism in anaerobic environments (Westermann et al. 1989). The range of temperature was between 27 °C to 30 °C for the basil leaf waste (Fig. 1). As the temperature was below the optimum temperature (30° to 60° C), the biogas potential was lower. The lower potential may be attributed to unstable fermentation rather than

decreased substrate availability at that temperature, as was reported by Angelidaki and Sanders (2004).

pH

The pH plays a major part in anaerobic biodegradation. pH influences the activity of the hydrolytic enzymes and the microorganisms that are active within certain, usually narrow pH ranges. The anaerobic digestion process occurs in the pH interval of 6.0-8.3. Most methanogens have a pH optimum between 7 and 8, while the acid-forming bacteria often have a lower optimum (Angelidaki and Ahring 1994; Angelidaki and Sanders 2004). The pH ranged between 2.15 and 5.74 (Fig. 1). The pH tested was outside the optimal range, and as enough buffering capacity was not present, the anaerobic process was inhibited. This led to the low biogas potential.

Biogas

The biogas was determined by the liquid displacement method (Raju and Ramalingaiah 1997). As seen in the figure, the gas production was reduced within seven days from the digester (Fig. 1), which may be due to pickling of the digester (Singh et al. 2007). The low yield of biogas produced can be traced back to the presence of more cellulose material (Ojolo et al. 2007) and nonavailability of the pH buffering.

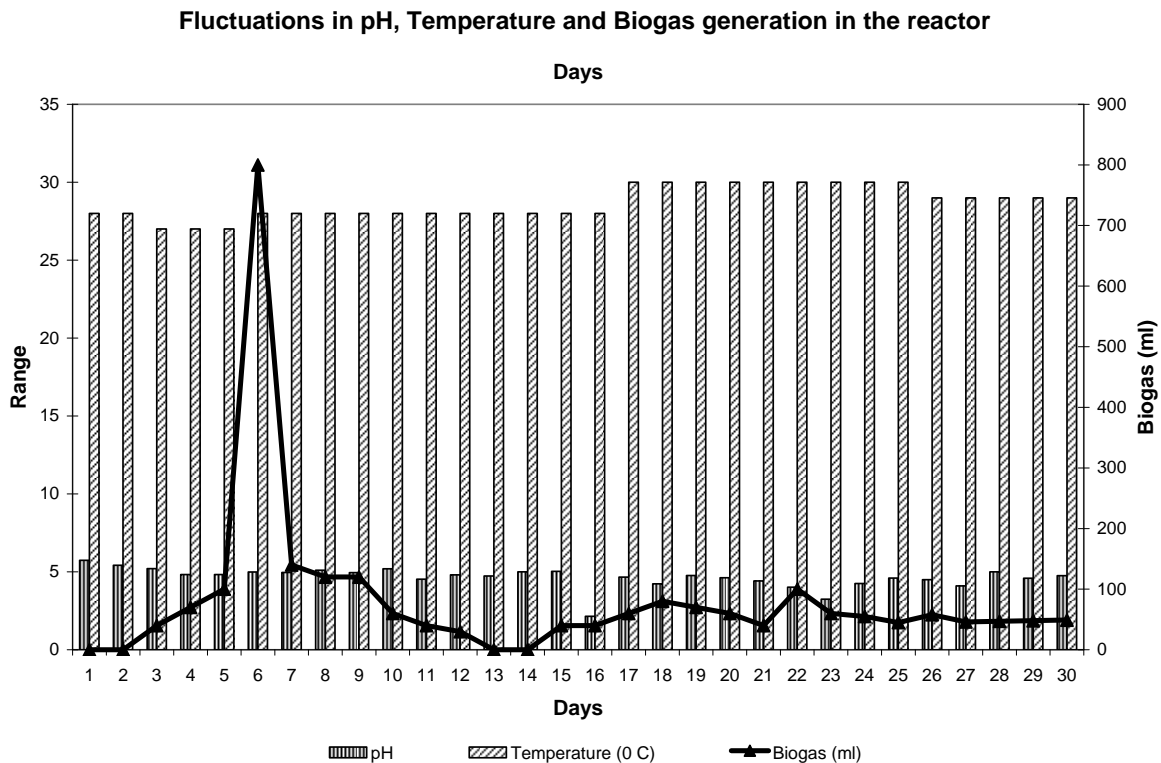


Figure 1. Fluctuations in pH, Temperature and biogas generation in the reactor

Solids

The range of total solids was between 32000 mg/l and 8000 mg/l. A maximum reduction of TS up to 73% was observed after 25 days of retention time. The VS content gives a good first impression of the strength of the waste. A maximum of 45% of reduction in volatile solids was seen after 25 days of retention time (Fig. 2). The increase in alkalinity was mainly caused by the mineralization of protein into ammonia. The later combines with carbonic acid in solution to form an ammonium bicarbonate buffer (Masse and Masse 2000). There were fluctuations in alkalinity according to the conditions of the pH. The chloride content of the waste has also reduced, and it showed a maximum reduction of 82% after 30 days of retention time.

BOD and COD

The biological oxygen demand (BOD) decreased continuously and attained a maximum reduction (42%) on the 30th day of retention time in the reactor. The most common single parameter used to describe the concentration of waste or wastewater is the chemical oxygen demand (Angelidaki and Sanders 2004). It was observed that in all cases the COD initially increased and later decreased, which has been corroborated by Ceechi et al. (1986). The decrease of COD may be due to product inhibition (Bhattacharya et al. 2008).

Total Nitrogen

The nitrogen content from the reactor showed significant variations. For the biological removal of nitrogen, an adequate combination of anaerobic, anoxic, and aerobic process is necessary (Del Pozo and Diez 2005). However, the reactor showed nitrogen removal of up to 58%. This reduction could be explained by the loss in the form of gaseous nitrogen and its conversion into biomass (Beux 2007).

Statistical Analysis

Statistical analysis showed no significant difference among the parameters (0.09912). From the result it can be concluded that the hypothesis is accepted, as the F value was less than 2.34 as per the F table (Gurumani 2005) (Table 2).

Table 2. Anova Table

Source of Variation	Degrees of Freedom (DF)	Sum of Squares (SS)	Mean Squares (MS)	F Ratio
Between	6	6180.47098	1030.0785	0.09912
Within	35	363727.888	10392.2254	
Total	42	369908.359		

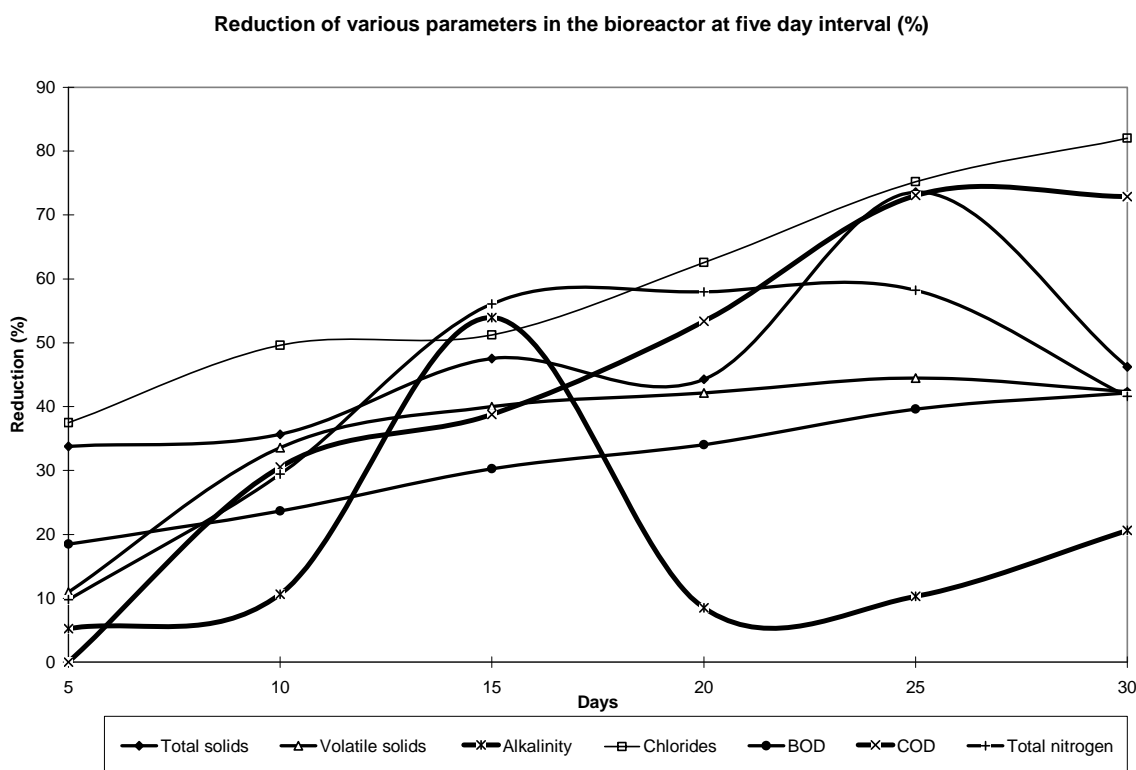


Figure 2. Percentage reduction of various parameters in the bioreactor at five day interval

CONCLUSIONS

1. Basil leaf waste can be used as a source for biogas production through anaerobic digestion in a batch reactor.
2. Biogas was produced from the anaerobic digestion process.
3. The COD, BOD, and the nutrient contents of the waste were also reduced to a certain extent.
4. Maximum digestion and gas production cannot be achieved with fresh, untreated leaf waste, an effect that was attributed to probable pickling of the reactor.
5. Further studies with physical and chemical treatment of the waste are needed to determine conditions leading to good gas production and waste digestion.

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