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Nutrient Reduction and Biogas Production of Rose Residue by Anaerobic Digestion in a Batch Reactor

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A B S T R A C T

Rose (*Rosa Damascena*) is a species being used to produce attar of rose by distilling volatile oils from flowers. One unit of rose flower milled gives about two units of residue in wet weight basis. The present work aims to determine the biogas yield and nutrient reduction potential of rose residue by using a laboratory scale completely mixed batch reactor. Laboratory scale digesters of 2.5 L capacity were used and fed with rose residue, which was digested in a batch reactor for a retention period of 30 days at room temperature. The parameters like total solids (TS), volatile solids (VS), chlorides, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Kjeldhal Nitrogen (TKN) were analyzed at 5 day interval. The process removed up to 73%, 45%, 82%, 42%, 58% of TS, VS, chlorides, BOD, TKN respectively, along with biogas production.

Introduction:

The generation and disposal of large quantities of biodegradable waste without adequate treatment results in significant environmental pollution. Besides health related problems for the population near the sites where waste is dumped, further degradation of waste in the environment can lead to the release of green house gases (GHGs) such as methane and carbon dioxide. In the absence of any waste treatment, as is the normal case, the environmental damage costs to the society works out to be more than the financial costs to the industry (Arun Kansali, 1998)

With increasing demand for energy and cost effective environmental protection, anaerobic digestion biotechnology has become focus of worldwide attention (Patel and Madamwar, 1998). Anaerobic degradation or digestion can be defined as a biological conversion process without external electron acceptor such as oxygen as in aerobic process or nitrate/sulphate as in anoxic processes. In the anaerobic process organic carbon is converted by subsequent oxidations and reductions to its most oxidized state (CO_2), and to its most reduced state (CH_4). A wide range of microorganisms catalyze the process in the absence of oxygen (McInerney et al., 1980).

The major advantages of anaerobic digestion are low sludge production, low cost, high energy efficiency and process simplicity, compared with other waste treatment methods. Moreover it offers a positive environmental impact since it combines waste stabilization with net fuel production and allows the use of the effluent as fertilizer (Patel and Madamwar, 2001).

Several investigators have worked on waste to energy generation by biomethanation as a good option to dispose of different waste materials (Wilkie etal., 1986; Nipaney and Panholzer, 1987; Ranade et al., 1987; Abbasi et al., 1991; Shyam and Sharma, 1994; Kalia and Joshi, 1995; Singh et al., 2007; Maria JC, 2008; Urman et al, 2009) as individual or in combination. However literature survey clearly indicates the little availability of work done on flower waste.

Rose, the beautiful and admired flower has a number of uses that raise the flower to a great height. Presently the flower is cultivated primarily as part of commercial floriculture. Rose is used in making perfumes, essential oils, rose water and other cosmetics. Apart from these roses are used to make medicines and have soothing effects in mind and body. Hence the roses are used in different cosmetic and pharmaceutical industries were the oil is extracted by distillation and petals are discarded.

The study was, therefore, undertaken to assess the feasibility of biomethanation process for biogas production from waste consisting of rose especially the petals.

Materials and Methods:

Collection and Preparation of Material:

The flower waste was collected from the local market of the famous Simhachalam temple, Visakhapatnam. The flowers were washed to remove the dirt. It was first dried in shade. The substrates were then blended to make a paste of the substrate. In each digester bottle, 1500 ml of the slurry (6% TS w/v) of the substrate, with 10% (v/v) of the active innoculum (cow dung) was added.

Experimental Set Up:

The set up comprises of three graduated glass bottles of 2.5 L capacity, fitted with rubber caps with thermometers and pH electrodes. The bottles were connected with pipes for taking away gas from the digester to a gas collector to a collection bottle. Biogas produced in the digester was measured once a day by reading the level of saline water displaced by gas pressure. The contents of the digester were mixed once a day by shaking them manually for 5 minutes (Singh et al., 2007).

Analysis of the Parameter:

pH was measured by pH meter, temperature by thermometer regularly. The reactor effluent samples were routinely analyzed at 5 day interval for total solids (TS), Volalitile Solids (VS), Chlorides, Alkalinity, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Volatile Fatty Acids (VFA) and Total Kjeldhal Nitrogen (TN) according to the standard procedures described below.

The reactor was operated in batch condition and the set up was studied for 30 days. The pH, Temperature and biogas production were monitored continuously and the BOD, COD and the nutrients were analyzed at an interval of 5 days. All the parameters were determined according to the standard methods (APHA, 1992)

Results and Discussion:

Composition of Flower Waste:

The composition of flower (rose) waste contained mainly organic fraction ie., VS. As the fraction was mainly lignocellulose (Bhattacharya, 2008), the degradation was very slow.

Temperature:

Temperature is the most important variable in controlling the rate of microbial metabolism in anaerobic environments (Westermann et al, 1989). The effect of temperature on anaerobic degradation is theoretically only influencing the degradation rates and not the biodegradability of the component. However, the biodegradation rates can be so slow that the achievable biogas potential appears to be lower than at optimal conditions. The range of temperature was between 27 ^{0}C to 30 ^{0}C in case of rose leaf waste. As the temperature is below the optimum temperature, the biogas potential was lower. The lower potential was attributed to unstable fermentation rather than decreased substrate availability at that temperature (Angelidaki and Sanders, 2004).

pH:

pH plays a major part in anaerobic biodegradation. pH influences the activity of the hydrolytic enzymes and the microorganisms which 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 optimium 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 to 5.74. The pH tested was outside the optimal range, and as enough buffering capacity is not present, the anaerobic process was inhibited. This lead to the low biogas potential.

Biogas:

The biogas was determined by liquid displacement method (Raju and Ramalinghaiah, 1997). The results of the daily gas production for a retention time of 30 days were presented in figure 4. As seen in the figure, the gas production was reduced within seven days from the digester due to pickling of 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 non availability of the pH buffering.

Total Solids:

The range of total solids was between 32000 mg/l to 8000 mg/l. A maximum reduction of TS solids upto 73% was observed after 25 days of retention time.

Volatile Solids (VS):

The VS content describes the content of organic material in the waste, and is defined as the amount of matter in a dried sample lost after I hour at a temperature of approximately 550 ^{0}C in air (APHA, 1992). 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.

Alkalinity:

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 alkalilnity according to the conditions of the pH.

Chlorides:

The chloride content of the waste has also reduced and it showed a maximum reduction of 82% on 30 days of retention time.

Biochemical Oxygen Demand (BOD):

The BOD decreased continuously and attained a maximum reduction (42%) on 30 days of retention time in the reactor.

Chemical Oxygen Demand (COD):

When considering the biogas for a specific application the characteristics of the substrate/waste is naturally of prime interest. Waste and wastewater is often a complex composition which is difficult to describe in detail. 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, 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 Kjeldhal Nitogen:

The nitrogen content from the reactor showed significant variation. For the biological removal of nitrogen, an adequate combination of anaerobic, anoxic and aerobic process is necessary (Del Pozo, Diez, 2005). However, the reactor presented nitrogen removal upto 58% (figure 1). This reduction could be explained by the loss in the form of gaseous nitrogen and its conversion into biomass (Beux, 2007).

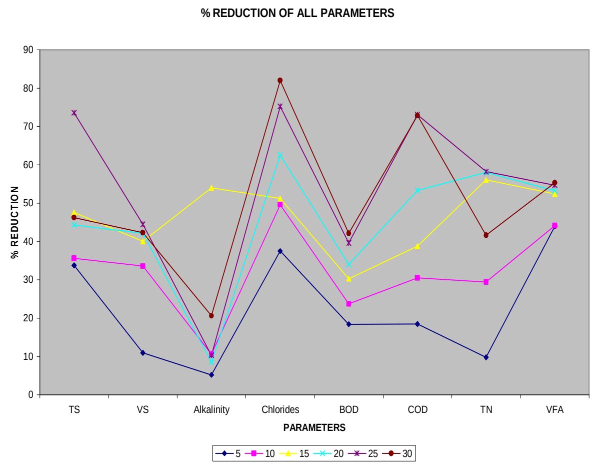

Figure 1: Reduction of Various Parameters in the batch reactors

Volatile Fatty Acids (VFA):

The assays presented maximum VFA concentrations between 5 and 10 days and reduced to a maximum of 55% on in 30 days.

- Flower waste (rose) can be used as a source for biogas production through anaerobic digestion in a batch reactor.
- Biogas was produced from the anaerobic digestion process.
- The COD, BOD and the nutrient contents of the waste were also reduced to a certain extent.
- Maximum digestion and gas production cannot be done with fresh flower waste may be due to the pickling of the reactor.
- May be further studies with physical and chemical treatment of the waste may produce good gas production and waste digestion.

Table 1: Composition of Petal Waste of *Rose*

S.No	Parameter	Concentration
1	pH	4.92
2	Alkalinity	5500
3	Chlorides	597.8
4	Total Solids	42000
5	Volatile Solids	31372
6	Biological Oxygen Demand	1733.3
7	Chemical Oxygen Demand	5200
8	Total Kjeldal Nitrogen	1364
9	Volatile Fatty Acids	340

Table 2: Variation in pH, Temperature and biogas produced from Flower Waste

Days	Temperature (^{0} C)	pH	Biogas (ml)
1	28	5.74	0
2	28	5.43	0
3	27	5.21	40
4	27	4.83	70
5	27	4.83	100
6	28	4.99	100
7	28	4.96	140
8	28	5.1	120
9	28	4.95	120
10	28	5.2	60
11	28	4.53	40
12	28	4.81	30
13	28	4.73	0
14	28	5	0
15	28	5.03	40
16	28	2.15	40
17	30	4.66	60
18	30	4.23	80
19	30	4.77	70
20	30	4.62	60
21	30	4.42	40
22	30	4.02	100
23	30	3.25	60

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