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DETERMINATION OF INOCULUM DOSE FOR METHANE PRODUCTION FROM FOOD INDUSTRY EFFLUENT

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ABSTRACT

This study investigates to find out optimum inoculum percentage for anaerobic treatment of Food industry wastewater in ambient environmental conditions. The effluent of Britannia food industry was selected for this study. Source of inoculum was the digested slurry from the active cow dung biogas plant. The inoculum concentrations were varied from 10-40% in effluent. It was found that 30% inoculum concentration was most suitable for anaerobic treatment of this effluent. Results reveals that biogas production was higher with 30% inoculum concentration as compared to 10, 20 and 40% inoculum concentration in ambient environmental conditions.

INTRODUCTION

The amount of waste materials discharge into water bodies around the world are raising steadily. Water is very precious resource because only 0.03% of Earth's total volume of water is accessible to humans (Mathews, 1986). But increase in population, the dependence of agriculture on massive amounts of fertilizers and pesticides, expansion of food industry and growth of other industrial processes, all contribute to the volume of sewage and wastewater and their content of undesirable substances to water bodies.

Several physical, chemical and biological processes are available for the treatment of enormous volume of high strength wastewater of food industry. Aerobic and anaerobic wastewater treatments are micro-biological treatment

which is mainly depending on degradation of organic substances by bacteria.

Anaerobic treatment is used for high strength pollutants concentration and have many advantages over aerobic treatment process like 1) stabilization and reduction of organic solids to more favorable and acceptable form 2) energy generation in form of biogas 3) almost complete nutrients conservation. Biochemical reactions involved in anaerobic process can be divided into three groups (Benefield and Randall, 1980).

1. Hydrolysis- extracellular enzymes degrade complex compounds into simpler one like amino acids, hexoses, fatty acids etc.
2. Oxidation/Fermentation- intermediary products acetate and H_2.
3. Methanogenesis – conversion of H_2 and CO_2 into methane.

The combined and co-coordinated metabolic activity of an anaerobic reactor population is required for the complete degradation of complex organic matter to CO_2 and CH_4. Intermediates necessary for certain micro-organisms are frequently involved in these conversions (Van assche, 1982).

Microorganisms exist in various ranges of shape, size, and growth phases in anaerobic process since form of biomass is likely to have a nutrient, transfer, efficiency of over all digestion process. Adhesion, biofilm, flocks, pellet formation are various forms of biomass in anaerobic degradation, is done by heterogenous micro flora which provide not only the microbial substrates for subsequent phases of breakdown process but also contribute anaerobiosis (Bungay *et al*. 1983).

Prevailing conditions of anaerobic process sustain facultative and obligate anaerobic bacteria. Methanogens are obligate anaerobes, archaebacteria, can use only a limited range of substrates for growth and energy production. These derive their energy by reduction of several compounds by H_2 with fermentation of methane.

In anaerobic treatment inoculum plays an important role. It contains microorganisms which starts the anaerobic fermentation process, in case it is not added the process of fermentation does not start. As far as seeding material is concerned, out of the three different inoculates viz. slurry from cow dung biogas plant, sewage plant and rumen fluid, the slurry from biogas plant is best source of inoculum which can enhance microbial activities, substrate utilization and gas yield (Chawla, 1986). Boopathy (1987) also reported that sludge from a biogas plant is best source of inculum as compared to their other sources.

Keeping these points in consideration present study was undertaken for quantification of inoculum percentage for anaerobic treatment of food industry effluent.

MATERIALS AND METHODS

To fulfill the objective of above study the wastewater samples were collected from Britannia Food Industry, SIDCUL, Pantnagar. This place is around 12 Km from main university campus of Pantnagar in southwest direction.

Samples were collected from main drain that is going to effluent treatment plant. The industry discharges its effluent through two drains, first one from production site and second from communal waste. Both of these meets at equalization tank. The wastewater samples were collected from production

drain before it reaches to equalization tank. Moreover, this wastewater sample is not diluted with communal wastewater. After grab sampling from main effluent drain, the effluent samples were brought to laboratory for design of experimental setup and for reduction of pollutants.

Source of inoculum

Digested slurry from biogas plant was collected from Livestock Research Center of University at Nagla, Pantnagar. This slurry was filtered with muslin cloth and active bacterial suspension was brought to laboratory and used as seeding material.

Experimental set-up for optimization of inoculum level

600 mL plastic bottles were used as anaerobic chamber. Slurry (active bacterial suspension), which was added to the effluent in different ratio (10, 20, 30 and 40%). The total volume of effluent and inoculum was kept in 300 mL in plastic bottle (digester), which has an outlet for gas. After filling the plastic bottles with effluent and inoculum of different ratio, the mouth of each plastic bottle was sealed by synthetic adhesive to make it air tight.

Rubber tubing was connected to this digester at one end and another end of this tubing was connected to water filled bottle. In this water filled bottle an outlet for water discharge is provided. Gas produced from digester goes in water filled bottle through rubber tubing where water displacement takes place because of gas production. The water displaced is use for the measurement of biogas production from the digester. This setup of experiment is shown in Fig.1

This setup was kept in ambient environmental conditions to find out anaerobic digestion in terms of biogas production. The biogas produced in bottles was measured by water displacement method and quantified by Gas chromatography.

Experimental analysis

Methane gas was estimated by Nucon Make 5700 series Gas liquid chroma-

Fig 1. Experimental setup for optimization of inoculum percentage

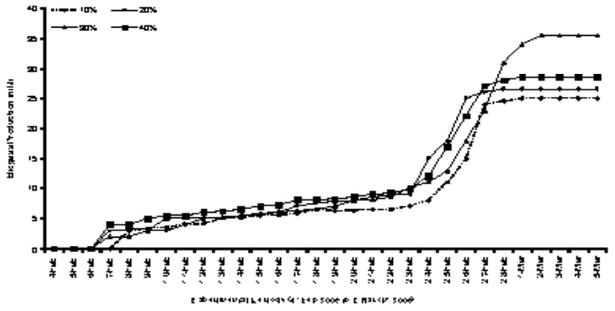

Fig 2. Average biogas production with different concentration of inoculum in ambient environmental condition during experimental period.

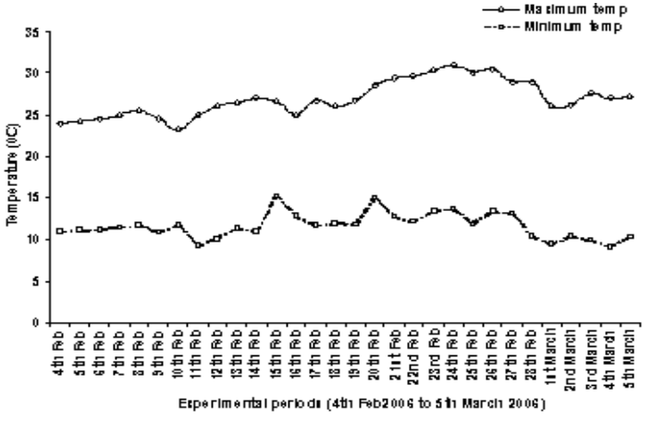

Fig 3. Minimum and maximum temperature during study period

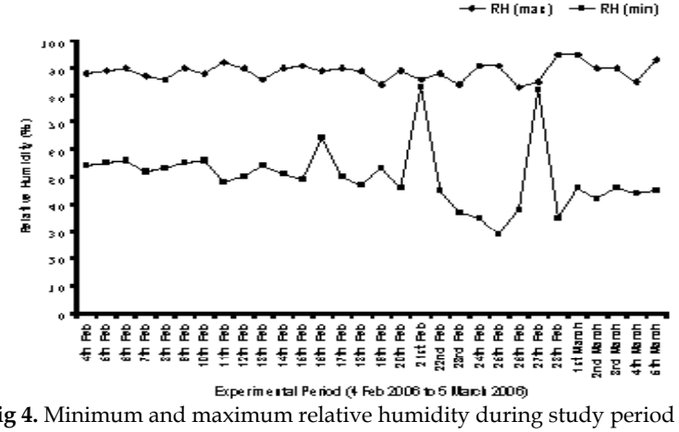

Fig 4. Minimum and maximum relative humidity during study period

tography. It is filled with porapak Q.S.S. column with, TCD detector (Thermal Conductivity detector). Oven, detector and injection port were at the

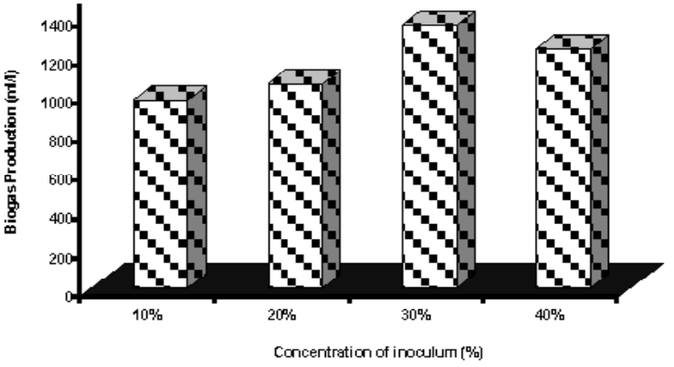

Fig 5. Total biogas production (ml/L) with different inoculum concentration over a period of 30 days

temperature of 60°C. H_2 gas used as carrier gas.

RESULTS AND DISCUSSION

This experiment was done for quantification of inoculum required for anaerobic treatment of food industry effluent. For all given inoculum concentrations of 10, 20, 30 and 40%, the amount of biogas production was measured after it's acclimatization over a period of 30 days in ambient environmental conditions in which maximum and minimum temperature were recorded 31°C and 9.2°C respectively. This experiment was conducted from 4th February, 2006 to 5th March, 2006. Three replicates of each concentrations along with control (without inoculum) samples were taken for this study. The biogas production in ambient environmental conditions on each day of 30 days experiment, are given in terms of ml of biogas produced from 1 L of seeded effluent of different inoculum concentrations (10, 20, 30 and 40%) as shown in Fig 2. Fig 3 & 4 is showing the maximum and minimum ambient temperature (°C) and relative humidity (%) respectively during the period of experiment.

These figures reveals that temperature varies between 9.2°C to 31°C and it is in cryophilic and mesophilic temperature range. The relative humidity varies between 29% and 95% during study period. Temperature is a key variable in biological process. Most bacteria have optimum temperature at which they proliferate and operate best. Temperature range of 10-15°C is for cryophilic or psychrophilic bacteria, 30-40°C for mesophilic bacteria and 40-60°C for thermophilic bacteria (Mohanrao *et al.* 1963). Higher temperature increases the activity of methane producing bacteria thus reducing the digestion time and liquefies fats and greases to fasten their decomposition (Ross *et al.* 1992).

It was observed from Fig 2 that on an average the total biogas production for effluent containing 10% inoculum concentration was 290 mL with 300 mL seeded effluent in a total time period of 30 days (from 4th February to 5th March, 2006) in ambient environmental conditions. In other words, biogas production was 960 mL from 1 L seeded effluent. The total quantity of biogas production in mL/L during this experimental period is shown in Fig 5. This figure reveals that maximum biogas was obtained from 30% inoculum concentration and it was calculated 1.3 L/L of seeded effluent. For effluent having 20% inoculum

concentration, on an average the total biogas production was 315 mL with 300 mL of seeded effluent in same time period and environmental conditions as mentioned above. However it can be calculated that total biogas production was approximately 1 L/L seeded effluent as shown in Fig 5.

In the digester having 30% inoculum concentrations, the average biogas production was 406 mL from 300 mL seeded effluent in a time period of 30 days in ambient environmental conditions which comes out to be 1.3 L from 1 L seeded effluent as shown in Fig 5. The observations with 40% inoculum level were also made in similar environmental conditions and time period. On an average total biogas production of 370 mL was obtained from 300 mL of seeded effluent (1.2 mL/L) during study period as shown in Fig 5.

Control containing effluent without seeding, was also run along with the above concentrations of seeded effluent in similar ambient environmental conditions. Almost negligible amount of gas production was found with 0% inoculum (control). Biogas obtained from digester was quantified through gas chromatography for methane gas. It was found that the maximum methane percentage was 53% with 30% of inoculum concentration in comparison to other concentrations, as shown in Table 1.

CONCLUSION

This study reveals that in existing ambient environmental conditions 30% inoculum concentration give maximum biogas production as compared to other concentration of inoculum i.e. 10, 20 and 40 %.

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