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EFFECT OF MICROBIAL GROWTH ON BIOGAS GENERATION USING CARRIER MATERIAL IN THE SELF CIRCULATING BIOGAS PLANT

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ABSTRACT
A modified three stage methane fermentation system was developed to digest animal manure effectively. The digester having an effective volume of 200 liter is constructed with central tube filled with burnt bricks. The burnt brick in the central portion of the digester increase the microbial concentration by immobilizing the bacteria on the surface of the burnt brick. The size of brick materials is not more than 3 to 5 mm size. The carrier materials used in the digester are 5%, 10%, 15%, and 20% of the total volume of the digester and also for each percentage 3.5kg of cow dung and 3.5kg of water (1:1) is well mixed and added daily. The readings were taken between biogas generations versus time for each percentage continuously up to 90 days. It was observed that 10 to 15 percentage of carrier material from the total volume for microbial growth gave more gas generation. Operational temperature was from 30°C to 50°C. In this study we examined the effect of microbe growth, temperature on biogas generation and hydraulic retention time.

Keywords: biogas, plant, generation, brick, microbe, immobilization, temperature.

INTRODUCTION
Approximately 78 million tons of organic waste such as food waste, livestock manure, vegetable waste and wastewater sludge is produced in India each year. This organic waste is generally treated in sanitary landfills. However, this method of disposal causes secondary pollution of groundwater and soil. In particular, Indian food waste putrefies because of its high water content, which makes its transport and storage difficult.

Anaerobic digestion has been suggested as an alternative method of removing the high-concentration organic waste. Several research groups have developed anaerobic digestion processes using different substrates Angelidaki, I. and Ahring, B. K.: Thermophilic (1993). The advantages of such processes over conventional aerobic processes are a low energy requirement for operation, a low initial investment anaerobic digestion process produces biogas, which can be used as a clean renewable energy source Bouallagui, H., Haouari, O., Touhami, Y., Ben Cheikh, R.,Marouani, L., and Hamdi, M (2004).In India, increasing numbers of biogas plants (BGPs) employing anaerobic digestion use food waste and manure as energy sources. Currently, there are 129 BGPs in Thanjavur, 11 in Trichy, and 110 in South district of Tamil Nadu with additional plants under construction Chen,Y., Varel,V. H. and Hashimoto, A. G(1980).

Anaerobic digestion can be developed for different temperature ranges including, mesophilic temperatures of approximately 35°C and thermophilic temperatures ranging from 55°C to 60°C Sahlstrom, L. (2003). Conventional anaerobic digestion is carried out at mesophilic temperatures, that is, 35-37°C.However, the thermophilic temperature range is worth considering because it will lead to give faster reaction rates, higher gas production, and higher rates of the destruction of pathogens and weed seeds than the mesophilic temperature range. However, the thermophilic process is more sensitive to environmental changes than the mesophilic process Kim, J.K., Cho, H.C., Lee, J. S., Hahm, K. S., Park, D. H., and Kim, S.W (2002).

A modified three-stage methane fermentation system that can produce methane from easily biodegradable Animal waste was developed in our laboratory Milan, Z., Sanchez, E., Weiland, P., Borja, R., Martin, A.,and Ilangovan, K (2001). This system uses a process that entails three stages: semi anaerobic hydrolysis/acidogenesis, strictly anaerobic acidogenesis, and strictly anaerobic methanogenesis. This separate-reactor system efficiently decreases hydraulic retention time (HRT) by increasing the rates of Microbe growth with in the digester by adding carrier material as the burnt brick, hydrolysis, acidogenesis and methanogenesis without affecting pH, and shows a high methane yield. In this study, we determined the biogas generation for various percentage of immobilization, optimum reaction temperature and HRT of the methanogenesis, which is directly related to methane production, with the aim of increasing animal waste digestion efficiency using the three stage methane fermentation system.

MATERIALS AND METHODS
The lab-scale methanogenic digester used was a cylindrical-type reactor having the effective volume of 200 litre capacity equipped with sampling ports, a gas valve connected with gas flow meter to measure the gas outlet and an outlet path. Initially, the species are mixed in the reactor, which gives perfect mixing. Then the plug flow pattern is applied to the system. Mixed flow reactor has longer residence time, whereas plug flow has lesser residence time. Hence when this combination is adopted, the reactor can be achieved with lesser residence time and

improved efficiency than that of mixed or plug flow. The shaded area gives the residence time of the reactor. This is the best setup, which can be adopted for getting maximum efficiency with residence time (Figure-1).

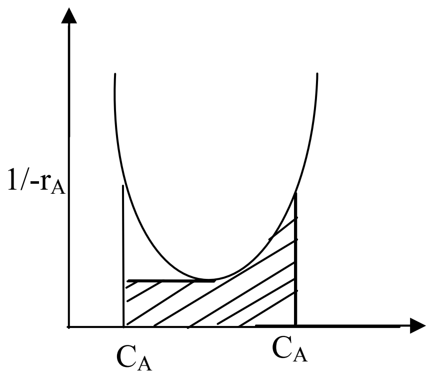

Figure-1. Typical concentration curve for mixed flow followed by plug flow.

Chemical properties of reaction mixture

The three-stage methane fermentation system developed in this laboratory used a process that entailed a primary semi anaerobic hydrolysis/acidogenic stage, a secondary anaerobic acidogenic stage, and a tertiary strictly anaerobic methanogenic stage. The system was operated to digest Animal waste rapidly. Table-1 shows the characteristics of Indian animal waste. These characteristics indicate that the animal waste is a good source for methane fermentation. In this study, the acid fluid eluted from the secondary acidogenic fermentor was used as the substrate and the methanogenic fluid eluted from the methanogenic fermentor was used as the inoculum. The microorganisms used in the acidogenic fermentation were Clostridium species and those used in the methanogenic fermentation were a mixture of methanogenic bacteria isolated from landfill soil and cow manure. The pH, soluble chemical oxygen demand (sCOD), ammonium concentration and C/N ratio of the substrate were 4.6, 18,000mg/l, 382mg/l and 17.8, whereas those of the inoculum were 8.2, 2600mg/l, 1300mg/l and 2.0, respectively.

Table-1. Elemental analysis of collected cow waste.

Solid content (%)	VS/TS (%)	COD/VS	Elemental composition (%)			
			C	H	O	N
12.38	89.3	0.71	47.8	6.1	40.9	5.2

Operational conditions

In the batch reaction, 7 liters of a mixture of the substrate and inoculum (1:1) was placed in the self circulating reactor. The reactor was operated at temperatures ranging from 30°C to 50°C at intervals of 5°C. The changes in pH, sCOD, and gas production were monitored.

Analytical methods

The following parameters were examined: pH, sCOD, and ammonium (NH3-N) concentration. sCOD was measured using the sealed tube method (sample size = 2ml) (DR/4000U spectrophotometer; Hach, Loveland, CO, USA) after filtration (Whatman GF/C). NH3-N was determined using NH3 sensitive electrodes (model 95-12; Thermo Orion, Beverly, MA, USA),connected to a pH meter (710Aplus pH/ISE Meter; Thermo Orion).The amount of gas produced from the methanogenic digester was monitored using a wet gas meter (W-NK-5; Shinagawa, Tokyo),and gas composition was analyzed by gas chromatography (GC-14B; Shimadzu, Kyoto) using a packed column (100/120 mesh,1/8″×10 ft, Haysep D; Alltech, Columbia, SC, USA). The temperatures of the column, injector, and detector (thermal conductivity) were 100°C, 50°C and 150°C, respectively.

EXPERIMENTAL SETUP

Mixed flow followed by plug flow reactor

The pilot scale methanogenic digester used was a cylindrical-type reactor having the effective volume of 200 liter capacity equipped with sampling ports, a gas valve connected with gas flow meter to measure the gas outlet and an outlet path (Figure-1A). The digester consisted of a cylindrical drum of diameter D = 57.3cm, height H = 90cm for holding 168 liters of cow dung slurry (TS = 10%).

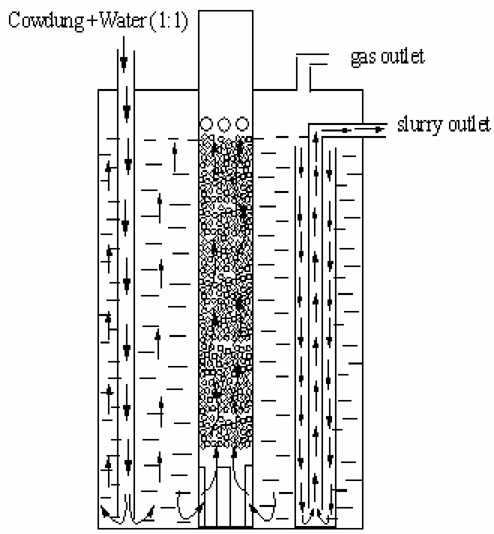

Figure-1A. Central tube filled with 10% of carrier material for microbe growth.

Provisions were made to admit fresh slurry at the top and to discharge the spent slurry at the other side end of the digester. The central tube in the digester was filled with 20 liters of bio filters (10%) prepared as mentioned earlier. The tube has triangular slots at the bottom (Height

H = 7.62cm) to provide slow mixing of the cow dung slurry in the digester. The discharge tube is kept at one side that has rectangular slot bottom (Height H = 3.81cm). The gas which is discharging collected in the tubes and the collected gas is measured daily using wet gas meter. The digester was charged with 7 liters of cow dung slurry daily (TS = 10%) at the feed inlet. At the discharge end, the spent slurry of 7 liters was discharged daily. The collected gas was measured daily using wet gas meter. The reading was taken continuously for 90 days gas production versus for 5%, 10%, 15%, and 20% of bio filters or carrier materials.

RESULTS AND DISCUSSION

The process adopted in this equipment is autocatalytic the immobilized bacterial column provided in the central column increases the microbial content. The increased gas production in the central column creates a difference in density and the density and the density difference helps in better mixing. The mixing process adopted here eliminates the requirement of power. There is an increase of 60 percent gas production is achieved in 10% to 15% of carrier materials used in the self-circulating plant (Figure-2) than the conventional model and the hydraulic retention time is only 40 days where In 5% or 20% model HRT is 60 days. Temperature is usually maintained in between 35ºC to 50ºC.Hence a constant temperature is essential for high yield.

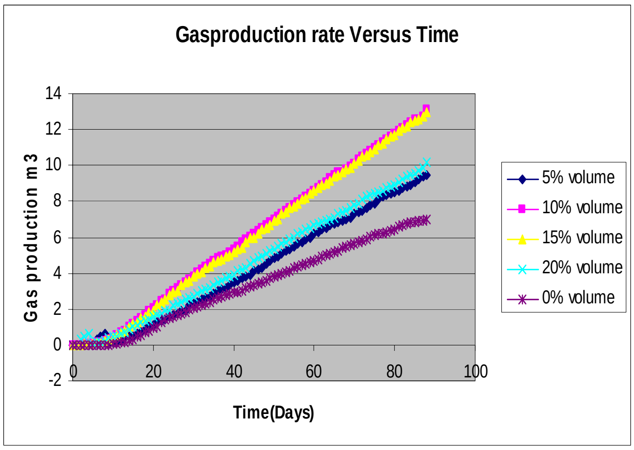

Figure-2. Gas production rate for 5%, 10%, 15%, 20% of carrier material for microbial growth.

Figure-2A shows sCOD as a function of temperature for the batch reaction (So = 9800 mg-COD/l). sCOD decreased with increasing digestion time. The maximum sCOD removal efficiency (83%) was obtained from the digester operated at 50°C. The removal rate at 45°C was almost the same as that at 50°C. However, the rate at 55°C decreased to 77%. Removal rates also gradually decreased at temperatures lower than 40°C.

The above pilot design is very much useful for continuous generation of biogas for industrial type model. The immobilized bacteria increase the microbe concentration in the brick and the biogas production is increased in the central column. Self-mixing is done in the digester by density difference in the solid and gas generation leads to more bubbles formation within the digester. In future these type of plants will increase the overall conversion efficiency by adopting the same immobilization technique.

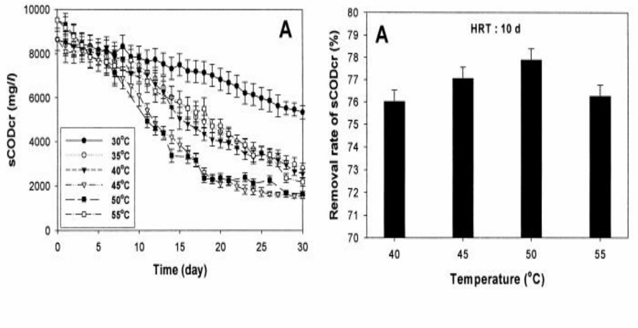

Figure.2A.Temperature-dependent changes in sCOD in anaerobic methane digesters in batch reaction.

This model tested only by a family type biogas plant having a capacity of 200 litres. We have tested using the same technique for $2m^3$, $15m^3$ capacity biogas plants and achieved more gas generation than existing model. In future the same technology is useful for industry related waste recycling processes and dairy wastes.

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