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DEVELOPMENT OF MICROBIAL CONSORTIA FOR ENHANCEMENT OF BIOGAS PRODUCTION USING DIFFERENT WASTES AND ITS EFFECT ON DEHYDROGENASE AND CELLULASE ACTIVITY

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Abstract

Paddy soil, compost, kitchen waste and landfill waste were used to develop the microbial inoculum for the enhancement of biogas production from cattle dung. Fourteen digesters were set up and digestion was carried out in batch type manner for eight weeks. The samples were analyzed for dehydrogenase activity and cellulase activity. Biogas production was measured for a period of eight weeks. The maximum biogas production (32.1 litres) was observed at the end of 4th week on supplementation of cattle dung with kitchen waste @ 5%, compost @ 5%, landfill waste @ 5% and paddy soil @ 5% on dry weight basis in batch anaerobic digestion. The dehydrogenase activity (1772.0 µg TPF/g sample/24 h) and cellulase activity (178.7 µg glucose/g sample/24 h) was observed at 4th week in digester 14.

Keywords: Microbial inoculum; Dehydrogenase; Cellulase.

INTRODUCTION

Biogas is an alternative and renewable energy source produced by the anaerobic degradation of organic matter whereby the organic matter is converted into a combustible biogas rich in methane. Biogas consists of methane (CH_4) and carbon dioxide (CO_2) and small amounts of hydrogen sulfide (Pasha *et al*., 2015). Anaerobic digestion is an eco-friendly technique which involves microbial decomposition of organic matter in oxygen depleted environment to produce energy in the form of biogas and residue left behind can be used as soil conditioner. This process is also called bio-methanogenesis (Gashaw, 2016). Waste is one of the most promising options for the production of biofuels which act as an alternative source of energy as it would also help in the treatment of wastes which is becoming a nuisance to the community (Singhal *et al*., 2012). The potential feedstocks for the production of biogas include municipal solid waste, industrial organic waste, garden waste, agricultural waste (manure and crop residue), energy crops and cellulose rich biomass (Lantz *et al.*, 2007; Börjesson and Mattiasson, 2007; Demetriades, 2008). The organic fraction of almost any form of biomass, including sewage, sludge, food wastes, animal wastes and industrial effluents can be digested to produce useful energy for the world (Alemayehu and Abile, 2014).

A wide variety of microbial communities have been reported to be involved in the anaerobic decomposition process. According to Ike *et al.* (2010), a group of microorganisms such as actinomyces, *Thermomonospora*, *Ralstonia* and *Shewanella* are involved in the degradation of food waste into volatile fatty acids, but *Methanosarcina* and *Methanobrevibacter/ Methanobacterium* mainly contribute in methane production. Organic waste materials such as vegetables contain adequate quantity of nutrients essential for the growth and metabolism of anaerobic bacteria in biogas production (Dhanalakshmi and Ramanujam, 2012). So it is better to co-digest organic wastes with cattle dung for developing the microbial inoculum to increase biogas production and obtain excellent soil conditioner.

MATERIALS AND METHODS

For development/adaptation of microflora, cattle dung was enriched with paddy soil, compost, kitchen waste and landfill waste and then fed into aspirator bottles of 5 litre capacity.
Following fourteen digesters were set up for determining the effect of these wastes on biogas production:
(D1). Cattle dung (CD) + biogas slurry @ 10%
(D2). CD + biogas slurry @ 20%
(D3). CD + compost @10%
(D4). CD + landfill waste @ 10%
(D5). CD + paddy soil @ 10%
(D6). CD + compost @ 5% + landfill waste @ 5%
(D7). CD + compost @ 5% + paddy soil @ 5%
(D8). CD + landfill waste @ 5% + paddy soil @ 5%
(D9). CD + compost @ 5% + landfill waste @ 5% + paddy soil @ 5%
(D10). CD + kitchen waste @ 10%
(D11). CD + kitchen waste @ 5% + landfill waste @ 5%
(D12). CD + kitchen waste @ 5% + paddy soil @ 5%
(D13). CD + kitchen waste @ 5% + compost @ 5%
(D14). CD + kitchen waste @ 5% + compost @ 5% + landfill waste @ 5%, + paddy soil @ 5%

The experiment was conducted in batch conditions for 8 weeks. The samples were analyzed for dehydrogenase and cellulase activity using the procedures of Casida *et al.*, 1964 and Deng and Tabatabai, 1994 respectively. The rate of biogas production was estimated by water displacement method.

RESULTS AND DISCUSSION

Biogas production from developed microbial inoculum

It was observed that biogas production increased upto fourth week of batch digestion and after that the biogas production declined. The temperature ranged from 35.7 to 42.6°C during eight weeks of the experiment under investigation. The maximum weekly biogas production was observed in digester, D14 with the range of 3.9 to 32.1 litre/week followed by digester, D2 (29.9 litres) and digester, D7 (27.5 litres) (Table 1). Dehydrogenase activity was found to decrease after eight weeks of batch digestion. The initial dehydrogenase activity in different treatments varied from 1025 to 1620 (µg TPF/g sample/24 h) and it decreased to 924 to 1406 (µg TPF/g sample/24 h) after 8 weeks of solid state fermentation under batch condition (Fig 1).

The cellulase activity was found to increase from 147.9 to 169.4, 156.0 to 171.3, 150.2 to 161.0, 134.3to 145.9, 129.5 to 136.5, 134.8 to 145.7, 148.3 to 153.1, 166.2 to 172.6, 157.3 to 165.2, 142.9 to 153.3, 147.6 to 158.9, 143.1 to 151.8, 158.5 to 167.1 and 172.4 to 178.7 µg glucose/g sample/24 h up to 4th week of digestion in digesters D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13 and D14 respectively (Fig 2).

The dehydrogenase activity (1772.0 µg TPF/g sample/24 h) and cellulase activity (178.7 µg glucose/g sample/24 h) was observed at the end of 4th week of batch digestion in digester, D14 (cattle dung (3kg) + kitchen waste @ 5%+ compost @ 5% + landfill waste @ 5%+ paddy soil @ 5%) and found to decrease afterwards.

Table 1: Weekly biogas production from cattle dung supplemented with combination of different inocula during batch digestion

Time						Biogas production (litres)									Temp
(week)	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	(°C)
1	5.3	8.3	2.6	2.3	2.1	1.1	2.9	1.8	3.7	1.6	2.8	4.3	2.5	3.9	38.2
2	9.0	16.2	3.5	2.4	1.5	4.2	8.5	9.4	6.1	6.9	3.3	5.4	3.9	8.2	39.2
3	21.9	19.7	11.4	3.9	2.3	16.5	24.3	23.5	24.7	19.8	19.5	11.9	16.3	22.8	40.5
4	22.3	29.9	18.4	15.8	10.9	18.6	27.5	24.3	26.4	21.1	20.8	20.4	25.4	32.1	42.6
5	11.3	7.8	14.9	14.3	8.6	14.9	12.2	15.4	14.5	14.7	15.6	15.3	15.9	15.9	40.3
6	8.4	5.8	8.8	13.3	8.5	10.1	9.8	11.6	12.9	12.9	11.5	12.5	11.9	13.8	37.8
7	4.6	3.3	6.1	7.9	7.4	8.9	6.0	9.0	8.4	8.4	5.8	6.5	8.2	8.5	37.5
8	6.1	3.4	5.8	9.2	4.5	5.4	8.1	5.2	5.3	8.0	7.6	4.4	9.0	9.0	35.7

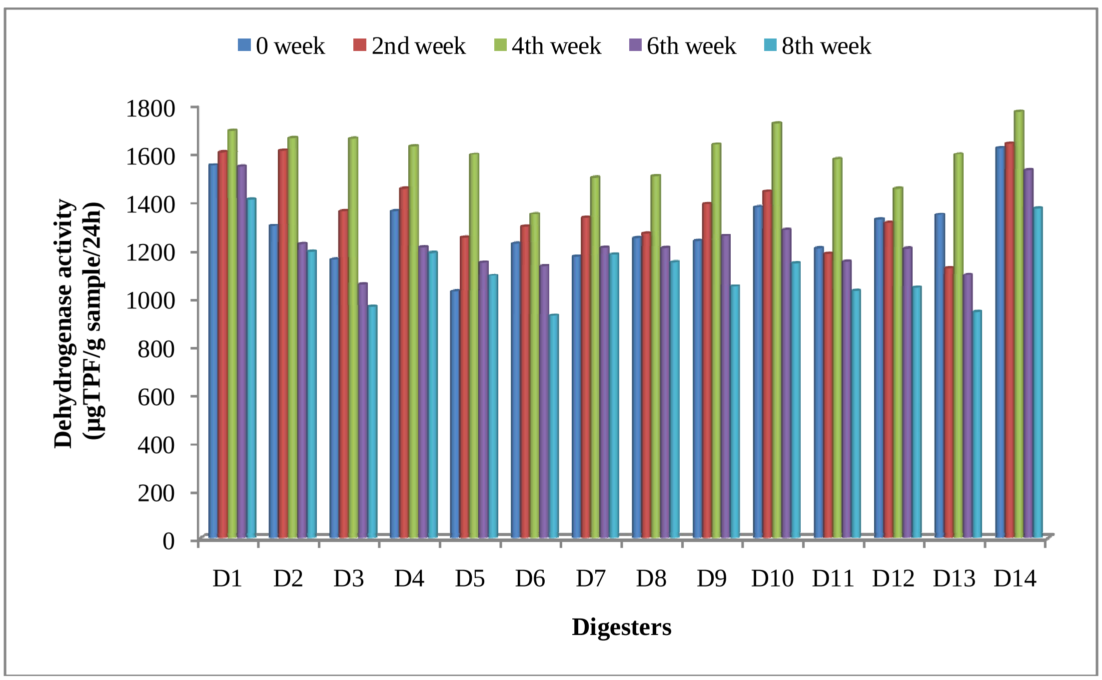

Fig 1: Dehydrogenase activity in digesters having combination of different inocula during batch digestion

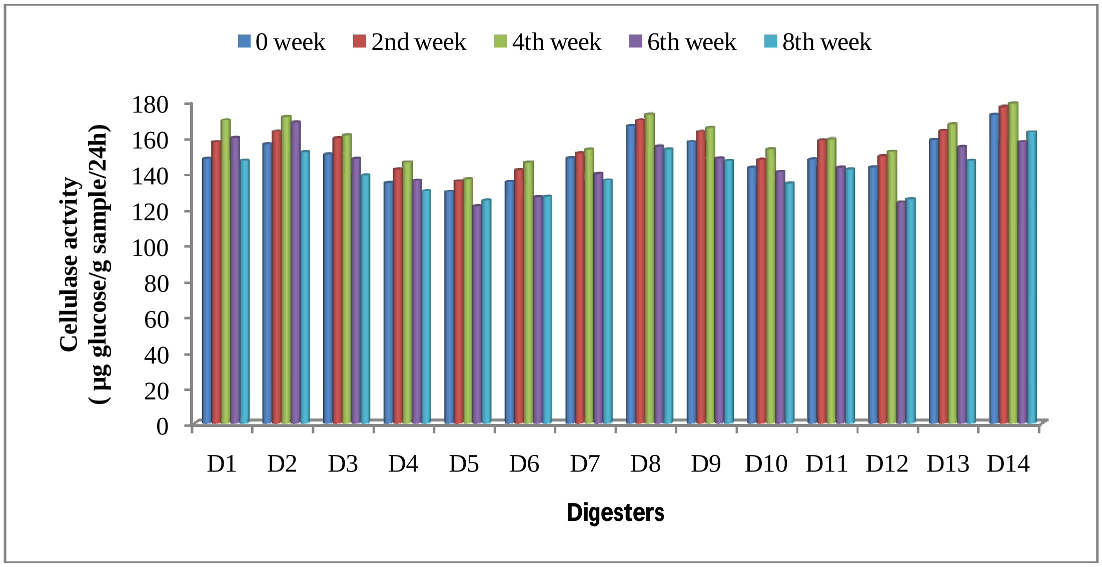

Fig 2: Cellulase activity in digesters having combination of different inocula during batch digestion

CONCLUSION

The different inoculum amended to cattle dung in different digesters stimulated cellulase activity and dehydrogenase activity of samples. The dehydrogenase activity and cellulase activity was maximum in the digester, D14 where different amendments such as kitchen waste, compost, landfill waste and paddy soil were made.

The microbial biomass in terms of dehydrogenase activity increased on supplementation of enriched biogas slurry containing kitchen waste, compost, landfill waste and paddy soil and this activity was maintained probably due to the adaption of microflora resulting in the increase of biogas production.

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