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Effect of Selenium on Acceleration of Biogas Production and Digestibility of Lignocellulosic Biomass

KEYWORDS: Selenium, Holy Basil, lignin

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ABSTRACT *The main objective of the present paper is to find the effect of elemental Selenium on progressive biogas production. Laboratory scale digesters of 2.5 l capacity were used and fed with Holy Basil (Ocimum sanctum) as the substrate, cow dung as the inoculum and digested in a batch reactor for a retention period of 45 days at mesophilic temperature. During the course of experiment, pH, temperature and biogas production were monitored daily. Solids, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Lignin and Cellulose were analyzed at a regular interval of 5 days using standard methods. The yield of biogas generated was increased 1.38 folds from 0.453dm3/kg to 0.613 dm3/kg in digester with Selenium concentration of 2mM when compared with control digester. The overall performance of the digester was increased with the addition of Selenium.*

INTRODUCTION

Anaerobic digestion of organic wastes with some additives to improve biogas yield has been given due importance for the last many years (Mandal and Mandal, 1998). Several reports (Lawrence and Mccarty, 1975; Madamwar et al., 1991) have been published on the stimulative effects of some surfactants, metal ions etc on biogas production from organic residues when added in low concentrations. Few trace elements, like iron, manganese, molybdenum, zinc, copper, cobalt and nickel accelerated the process of methanogenesis (Singh and Singh, 1996). Iron are normally essential for anaerobic digestion, while very high concentrations of nickel have shown to be more inhibitory for methanogenesis (Schonheit and Thewer, 1979). Singh and Singh (1995) reported that high concentration of iron gives a favourable response during methanogenesis.

The above findings prompted us to search out some other chemical additives with a view to enhance the production of biogas. This paper presents the results of experiments performed to study the effects of Selenium on the biogas yields of Holy basil.

MATERIALS AND METHODS

Collection and Preparation of Material

Ocimum sanctum Linn. (Labiatae), commonly known as Holy basil, is a herbaceous plant found throughout the south Asian region. It is cultivated for religious and medicinal uses (Hannan et al., 2006). It was collected from the famous Simhachalam temple, Visakhapatnam, where it is otherwise discarded as waste. The leaves were washed with distilled water, air dried in shade, blended to make a paste and used as a substrate.

Experimental Set Up

To each digester bottle, 1500 ml slurry (6% TS w/v) of the substrate, and heterogenous cowdung (10% TS v/v) was added as active inoculum. The experiment was designed as reported by Singh et al., (2007). Selenium in the form of elemental Selenium, was added to the digester at a concentration of 2mM, 4mM and 8mM and the overall performance of the digester was evaluated by comparing with a digester wherein heavy metal was not added externally that acted as a control.

Analysis of the Parameter

The experiment was carried out for a period of 45 days in a batch reactor at room temperature. 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 total solids (TS), volatile solids (VS), BOD, COD were analyzed at a regular interval of 5 days using standard methods (Eaton et al., 2005). Lignin and Cellulose were also analyzed at an interval of 5 days (Zainol and Rahman, 2008)

Statistical Analysis

Statistical analysis was performed using MINITAB statistical package (Minitab Statistical Software, Version 14, State College, Pennsylvania, USA) for regression analysis (Giannoutsou, 2004).

RESULTS AND DISCUSSION

Throughout the study period the pH of the feed was maintained within the acceptable range of 6.8 to 7.2 (Banu et al., 2007).

The feed temperature during the study was in the range of 30.3 0C to 35.6 0C, which is recommended for efficient mesophilic anaerobic digestion (Bhatti et al., 1996; Banu et al., 2007). Selenium concentration of 2mM gave a maximum biogas production. 4mM Selenium showed an enhanced biogas generation when compared to the control while biogas production declined with 8mM Selenium concentration. The cumulative biogas of 0.453dm3/kg, 0.613 dm3/kg, 0.471 dm3/kg and 0.353 dm3/kg was observed with control, 2mM, 4mM and 8mM Selenium concentration respectively (Figure 1: Comparing cumulative biogas at 2mM, 4mM and 8mM Selenium).

There was an escalated increase in the reduction of Total and Volatile Solids in the digesters with 2mM (80.26%, 70.71%) and 4mM (73.21%, 61.43%) Selenium concentrations when compared with control (67.95%, 53.57%). The solids reduction has declined with 8mM Selenium concentration (52.56%, 45.71%).

The lower concentration of Selenium (2mM and 4mM) has creeped up the digestion rates. The reduction rates after 45 days were 76.68%, 86.21%, 83.66%, 60.08% of BOD and 66.88%, 75.19%, 73.13%, 62.0.1% of COD respectively in digesters with control, 2mM , 4mM and 8mM Selenium concentration. Process performance and process stability can

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be judged by lower COD and BOD values indicating better degradation (Patel and Madamwar, 1998; Desai et al., 1994) which was observed in the digester with 2mM Selenium concentration.

The presence of 2mM Selenium has reduced the recalcitrance of Lignin for biodegradation and initiation of degradation was observed after 10 days of interval with maximum after 45 days for 2mM, 4mM and 8mM Selenium concentration. The less recalcitrance of Lignin (of 20 to 25 days) in the present work may be attributed to the blending of the substrate before loading the digester as was observed by Palmowski and Muller (1999); Hendricks and Zeeman (2009) and the herbaceous nature of the basil plant as reported by Zainol and Abdul-Rahman (2008).

The Cellulose content initially accumulated up to a maximum of 55.29% but the content decreased after 30 days and the degradation rate was 31.73%, with 2mM and 4mM metal concentration. The initial Cellulose content increased with time as the Lignin biodegradation help to reveal more Cellulose because Lignin and Cellulose are cross linked to each other (Zainol and Abdul-Rahman, 2008).

In the present study, Selenium at the concentrations of 2mM and 4mM had a positive effect on the biogas generation and the overall performance of the digester when compared with the control. There was a 1.38 and 1.06 fold increase in the biogas produced with 2mM and 4mM Selenium respectively when compared with the control digester. According to Shamberger (1985), Selenium is an essential trace element at low concentration having beneficial effects, however higher concentration of Selenium can be toxic and mutagenic. Lenz and his co workers (2008) proved that the 50% inhibitory concentration (IC50) of Selenium oxyanions was below 6.1 × 10−5 M in hydrogenotrophic assays. The tolerance of the high concentration (milli molars) of Selenium in the present study might be due to the addition of elemental Selenium. Hockin and Gadd (2003) reported that rapid extracellular precipitation of Selenium may constitute an effective defense mechanism in preventing the diffusion of Selenium through the biofilm. The addition of 8 mM Selenium reduced the biogas generation potential by 0.2 fold than the control which shows that the concentration is inhibitory to the digester. The increasing order of performance of the digester with Selenium is 8mM < Control < 4mM < 2mM. The statistical outcome corroborated with the experimental results with the effect of Selenium on the digester performance (Figure 6).

References and further reading may be available for this article. To view references and further reading you must purchase this article.

CONCLUSION

- Selenium has activated the process of anaerobic digestion and also improved the percentage of biogas formation at 2mM and 4mM concentration when compared with control.
- The optimum concentration of Selenium was observed to be 2mM which acted as a good initiator in the process of microbial degradation.

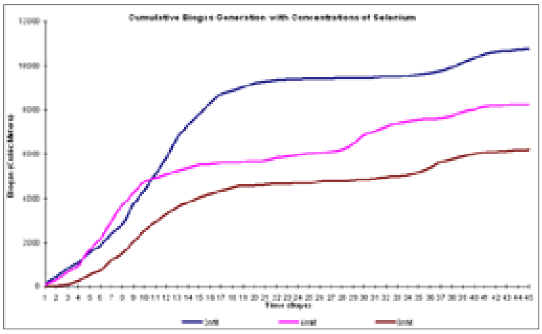

Figure 1: Comparison of cumulative biogas at 2mM, 4mM and 8mM Selenium

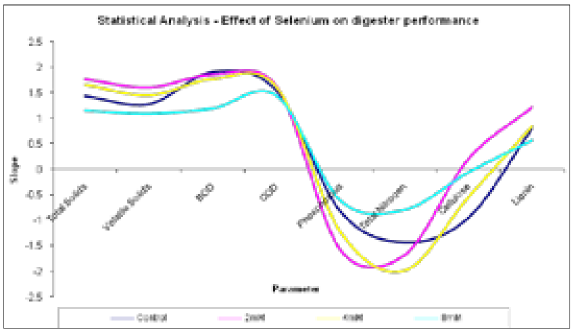

Figure 2: Statistical analysis - slope values of various parameters with 2mM, 4mM and 8mM Selenium when compared with control

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