EFFECT OF SELENIUM ON ACCELERATION OF BIOGAS AND TRENDS OF NITROGEN AND PHOSPHOROUS

K. Swapnavahini[1], M. Sumanth Kumar[2] and G. Appala Naidu[3]

1. Assistant Professor, Department of Biotechnology, Dr B.R.Ambedkar University, Srikakulam, Andhra Pradesh, India.
2. Assistant Professor, Department of Basic Sciences, Vignan's Institute of Engineering for Women, Visakhapatnam, Andhra Pradesh, India.
3. Teaching Associate, Department of Rural Development, Dr B.R.Ambedkar University, Srikakulam, Andhra Pradesh, India.

ABSTRACT

Many heavy metals are part of the essential enzymes that drive numerous anaerobic reactions. Hence in the present paper the effect of a heavy metal Selenium (2mM) on progressive biogas production was assessed. Laboratory scale digesters of 2.5 l capacity were used and fed with Holy Basil (*Ocimum sanctum*) as the substrate with cow dung as the inoculum which was digested in a batch reactor for a retention period of 45 days at room temperature. During the course of experiment, pH, temperature and biogas production were monitored daily. Total Solids (TS), Volatile Solids (VS), Chemical Oxygen Demand (COD), Total Nitrogen (TKN) and Phosphorous were analyzed at a regular interval of 5 days using standard methods. Encouraging results were obtained as the yield of biogas generated was increased 1.38 folds from 0.453dm^3/kg to 0.613 dm^3/kg. The digester with selenium has revealed a steady state reduction in the Solids and COD concentration and an accumulation in the Phosphorous and TKN. The overall performance of the digester was also increased with the addition of Selenium.

Keywords: *Selenium, Holy Basil, batch reactor, COD, phosphorus, nitrogen*

INTRODUCTION

Anaerobic digestion involves the degradation and stabilization of organic materials under anaerobic conditions by microbial organisms and leads to the formation of biogas (Kelleher *et al*., 2000; Chen *et al*., 2008). It is a complex process requiring the presence of several different microorganisms. Many heavy metals are part of the essential enzymes that drive numerous anaerobic reactions. Whether heavy metals would be stimulatory or inhibitory to anaerobic microorganisms is determined by the total metal concentration, chemical forms of the metals, and process-related factors such as pH and redox potential (Mosey *et al*., 1971; Lin and Chen, 1999; Zayed and Winter, 2000). Few trace elements, like iron, manganese, molybdenum, zinc, copper, cobalt and nickel accelerated the process of methanogenesis while cyanide and heavy metals at elevated concentration have some toxic effect on the anaerobic process (Singh and Singh, 1996). Heavy metals can be present in significant concentrations in municipal sewage and sludge. The heavy metals identified to be of particular concern include chromium, iron, cobalt, copper, zinc, cadmium, and nickel (Jin *et al*., 1998). Hence in the present study, the effect of Selenium on

the biogas generation potential and the overall performance of the digester were investigated.

MATERIALS AND METHODS

Ocimum sanctum Linn. (Labiatae), commonly known as holy basil, is a herbaceous plant found throughout the south Asian region. The plant grows wild in India, but is also widely cultivated in homes and temple gardens (Hannah *et al.*, 2006). It is cultivated for religious, medicinal uses, as well as for its essential oil. Holy basil 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, and used as a substrate. The substrate was then blended to make a paste. In each digester bottle, 1500 ml slurry (6% TS w/v) of the substrate, and cowdung as active inoculum were added (Singh *et al*. 2007). Elemental Selenium was added to the digester at a concentration of 2mM 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 Parameters

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 experiment was carried out for a period of 45 days. The pH was maintained in the range of 6.8 to 7.2. The total solids (TS), volatile solids (VS), Chemical Oxygen Demand (COD), Nitrogen and Phosphorous were analyzed at a regular interval of 5 days using standard methods (Eaton *et al*., 2005).

Statistical Analysis:

The data was subjected to statistical analysis using regression. Statistical analyses were performed using MINITAB statistical package (Minitab Statistical Software, Version 14, State College, Pennsylvania, USA) software used for regression analysis (Giannoutsou *et al.*, 2004)

RESULTS AND DISCUSSION

The temperatures varied between 30.2^0C -35.9^0C and an average biogas of 238.88 m^3(Figure 1) with a rise in biogas by 1.38 times from 0.453dm^3/kg to 0.613 dm^3/kg when compared with control digester.

The Total Solids (TS) and Volatile Solids (VS) in the feed material decreased as the digestion period increased with a maximum degradation of 80.26% and 70.71% respectively. The reduction rates of COD after 45 days were 75.19%. Process performance and process stability can be judged by lower COD values indicating better degradation (Patel and Madamwar, 1998; Desai *et al*., 1994).

The initial decline in the Nitrogen and Phosphorous was monitored up to 10 days. The raise in the initial Phosphorous and Nitrogen was observed to be 49.40% and 65.03%. There was a decrease in the Nitrogen and Phosphorus content in the feed initially and later on the concentration increased (Figure 2). The initial reduction in Nitrogen content in the digester could be explained by the loss in the form of gaseous Nitrogen and its conversion into biomass as was proposed by Beux (2007). Later, as the retention time increased, there was an increase in Nitrogen and phosphorus content in the feed which can be attributed to mineralization of organic compounds containing organic Nitrogen and phosphorus (Coombs, 1994).

In the present study, Selenium at the concentrations of 2mM had a positive effect on the biogas generation. Lenz and his co workers (2008) proved that the 50% inhibitory concentration (IC_{50}) of both Selenium oxyanions was below 6.1×10^{-5} M in

hydrogenotrophic assays. But the concentration added was in micro molars. The tolerance of the high concentration in the present study might be due to the addition of elemental Selenium. Elemental Selenium is insoluble and it rapidly gets precipitated. Astratinei and his colleagues (2006) found that the granular structure protects the microorganisms when exposed to high selenate concentrations (0.1 to 1 mM). Both microbial metabolic processes (e.g dissimilatory reduction) as well as microbial mediated physicochemical mechanisms (adsorption and precipitation) might have contributed to the removal of Selenium from the medium and thus inhibitory effect of the metal was absent even at higher concentrations on the performance of the digester. According to Shamberger (1985), Selenium (Se) is an essential trace element at low concentration having beneficial effects. Hence the addition of Selenium has enhanced the overall performance of digester when compared with the control. The statistical outcome corroborated with the experimental results with the effect of

Selenium on the digester performance (Figure 3).

CONCLUSION

- Selenium addition appears to have accelerated the production of biogas based on the consistently stronger production from reactor fed with low concentration of heavy metals over the unfed reactors.
- Selenium at 2mM acted as a good initiator in the process of microbial degradation.

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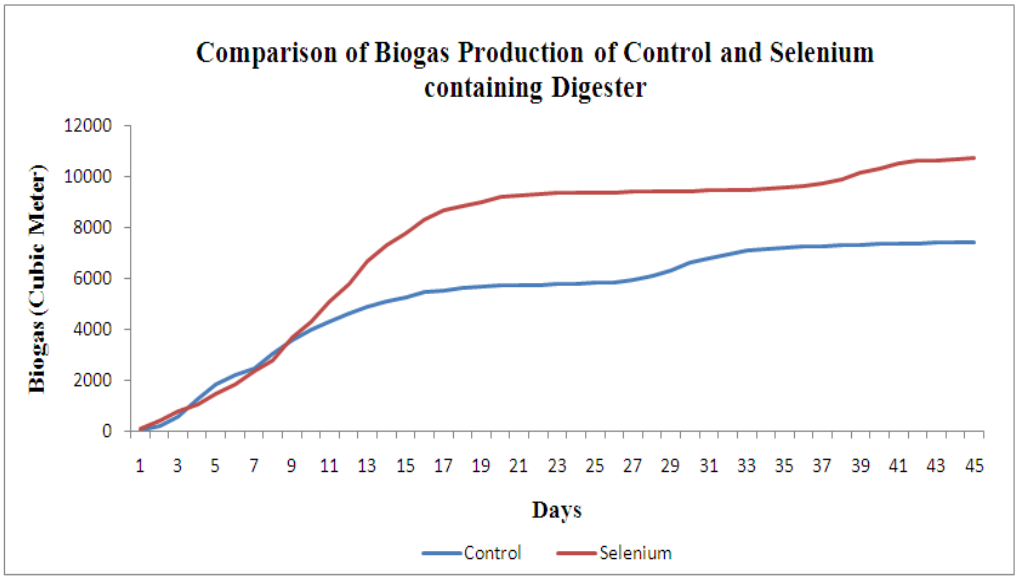

Figure 1: Comparison of Biogas generation potential of Control and Selenium containing digester

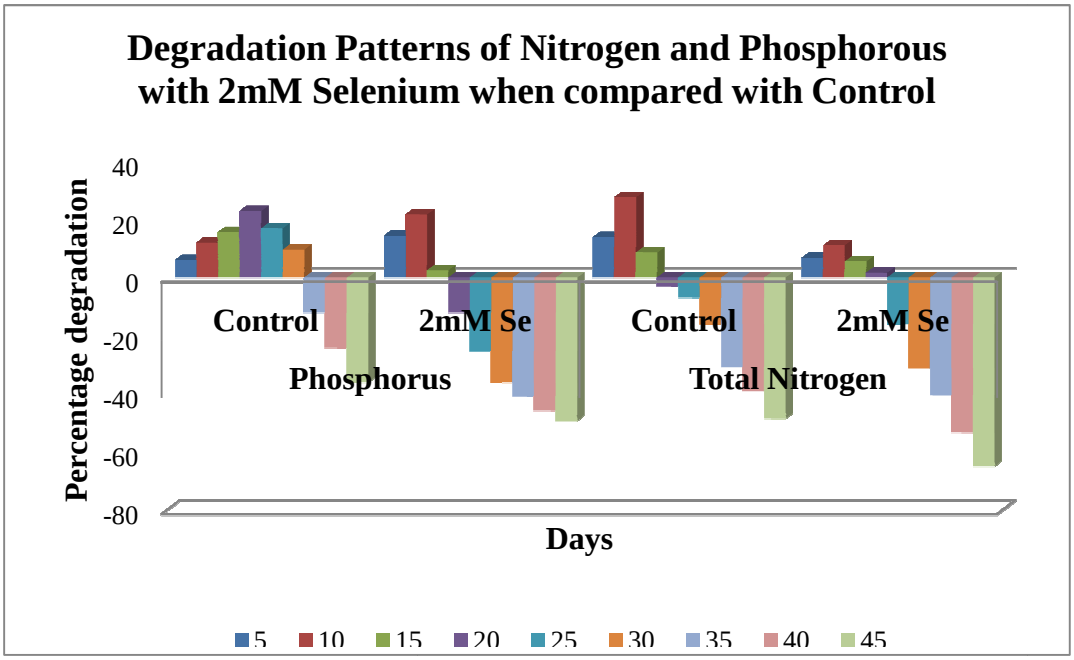

Figure 2: Degradation patterns of Nitrogen and Phosphorous with 2mM Selenium when compared with Control

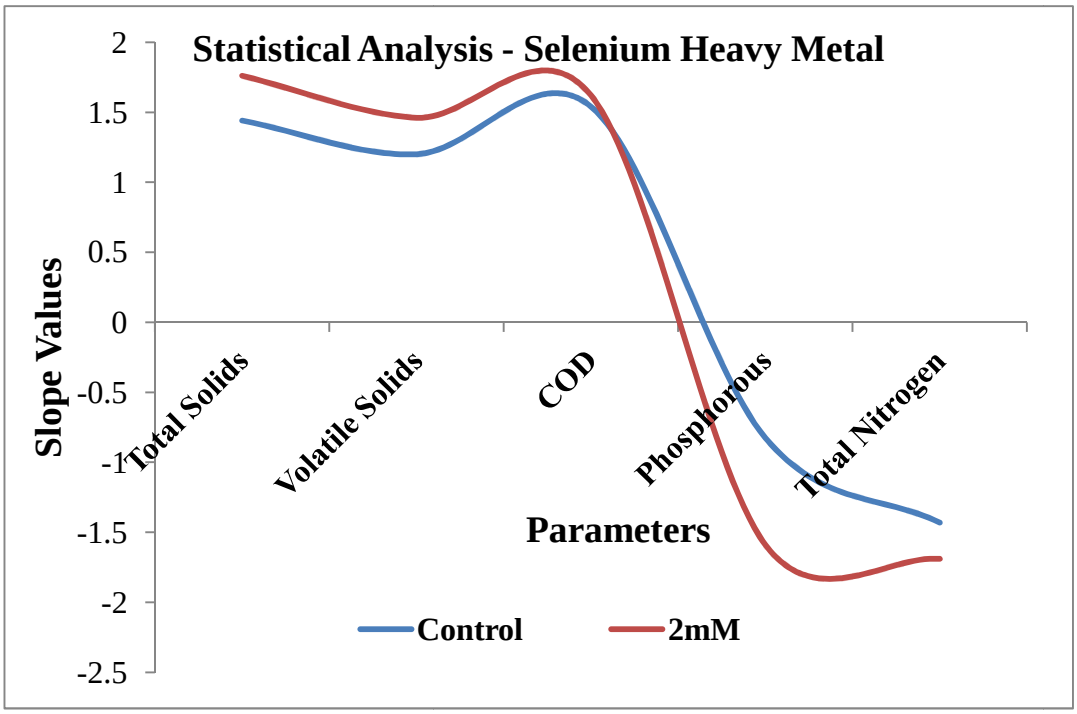

Figure 3: Statistical Analysis showing the effect of Selenium on the performance of the digester when compared with control digester