Lignite improved biogas production during anaerobic digestion of swine manure

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Introduction

- Anaerobic digestion (AD) converts organic waste into biogas, a renewable fuel which is a potential solution for mitigating greenhouse gas emissions and energy crisis.
- Poor operational stability, caused by the variable (or low) quality of the manure such as high total ammoniacal nitrogen (TAN), and low C:N ratio, results in inefficient AD.
- Lignite is an intermediary product between peat and black coal and has been found to reduce ammonia emissions from animal manure.
- High cation exchange capacity of lignite can reduce TAN.
- The objective of this study was to investigate the impact of lignite on the performance of anaerobic digestion of nitrogen (N) rich swine manure.
- **Key words:** Anaerobic digestion, Ammonia, Biogas, Lignite, Methane

Materials & methods

Anaerobic digestion experiment

- Experiment was conducted in 20, 500 mL (working volume) glass bottles (batch type digesters – Figure 1).
- The inoculum and swine manure (from Berrybank farm, Windermere, Victoria) were added into the digesters at a ratio of 1:1 volatile solids (VS) basis. Characteristics of substrate are shown in Table 1.
- Ammonium chloride (4.6 g) was added to all digester to ensure sufficient ammonia to inhibit AD.
- Lignite was added at different rates. The doses of lignite were 0, 10, 40, 70, 100 g/ L of swine manure.
- The digesters flushed with nitrogen gas were kept in an incubator at 37°C (Figure 2) and manually shaken daily to mix the content.
- Gas volumes were measured daily using 1L syringe (Figure 3) and sample of biogas analysed for CH_4 concentrations with gas chromatography (Agilent 7890A).
- TAN concentrations were analysed with segmented Auto analyser (Skalar SAN^{++}).

Table 1: Characteristics of substrates used for the experiment

Parameter	Swine manure	Inoculum
Total Solids (%)	2.14 ±0.01	2.97 ±0.01
Volatile Solids (%)	72.95±0.43	71.28 ±0.23
pH (1:5 water)	7.00 ±0.10	7.47 ±0.12
Alkalinity (mg/L)	3713 ±46	8931±66
TAN (mg/L)	811±20	1118 ±77

Figure 1: A digester

Figure 2: Swine manure and Inoculum filled Digesters

Figure 3: Collecting biogas from Digesters

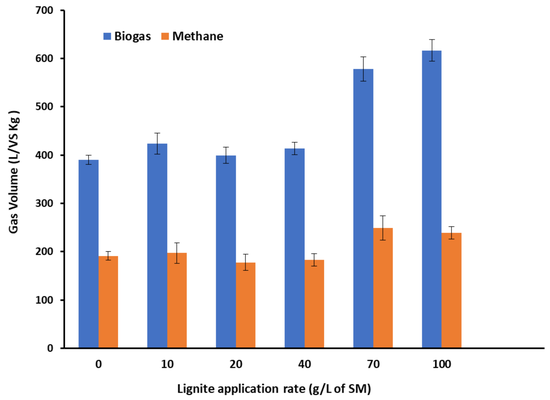

Figure 4: Biogas and CH_4 production from swine manure digesters at different lignite rates

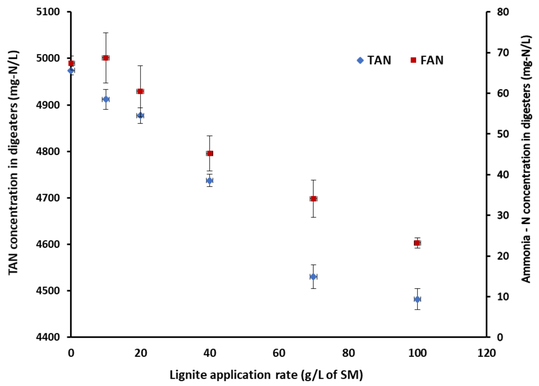

Figure 5: TAN and FAN concentrations in swine manure digesters at different lignite rates

Results & discussion

Effect of Lignite on biogas production:

- Lignite rates of 70g/L and 100g/L of swine manure have significant higher biogas (i.e. 50% and 61%) and methane (CH_4) production (34% and 29%) compare to control (Figure 4).
- Addition of lignite reduced the final TAN, Free ammonia-N (FAN) concentrations, a significant reduction observed with lignite applied at 40 mg /L or more (Figure 5) mainly because of the adsorption capacity of lignite.
- The threshold FAN which CH_4 inhibition begins ranges from a FAN concentration 45 mg-N/L (Shi et al., 2017) to 150 mg-N/L (Braun et al., 1981).
- Enhancement of CH_4 production due to lignite addition could primarily be attributed to decreasing FAN level to < 45 mg-N/L (i.e. 34.1 mg-N/L in digesters at lignite rate 70g/L of swine manure).
- Although the increase in CH_4 was observed up to the 70g/L rate of lignite, higher doses beyond that resulted in a decline in CH_4 production, which might be due to decreasing pH to 6.2 at lignite rate 100g/L. Methanogenic bacteria are extremely sensitive to pH with an optimum between 6.5 and 7.2

Conclusions

- These findings show lignite has the potential to enhance CH_4 production and increase the efficiency of energy production in AD of N rich swine manure.
- Although the higher doses of lignite continued to reduce TAN linearly, the increases in biogas yield were marginal at rates above 70g/L of swine manure.

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