Effects of Ammonia Nitrogen on H_2 and CH_4 Production During Anaerobic Digestion of Dairy Cattle Manure

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Introduction

- Anaerobic digesters are difficult to control – complex micro interactions.
- Reasons for digester imbalance
  - Excessive temperature changes
  - Sudden changes in organic loading
  - Presence of toxic material
  - Change in feed characteristics.

Introduction

- Purpose: to convert waste organic matter into CO_2 and CH_4.
- Three groups involved:
  - Hydrolytic bacteria
  - Acid-forming bacteria
  - Methanogenic bacteria.
- Monitoring state of digester via H_2 or .

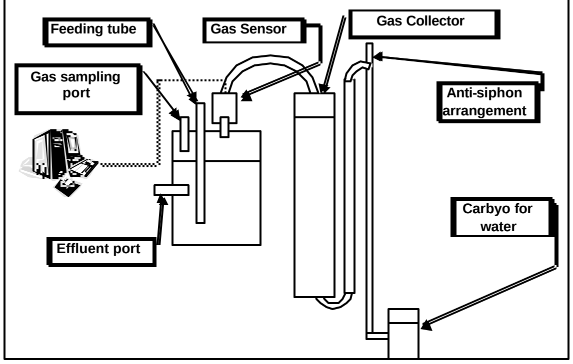
Objective

To determine the feasibility of monitoring H_2 as an indicator of digester upset resulting from ammonia overloading.

Materials and Methods

- 9 digesters maintained at 35 C.
- Initially inoculated with rumen fluid.
- Removed 500 ml effluent / day.
- Urea used as N source.

Experimental Apparatus



Experimental Treatments

Reactor Group	Urea concentration
Control	Manure slurry only
Group A	Manure slurry + 600 mg N / L
Group B	Manure slurry + 1500 mg N / L
Group C	Manure slurry + 3000 mg N / L

Materials and Methods

- 9 digesters maintained at 35 C.
- Initially inoculated with rumen fluid.
- Removed 500 ml effluent / day.
- Urea used as N source.
- 125 ml samples collected and 500 ml feed slurry added at 3, 6, 9, 12, 24, 48, 72, 96 h.

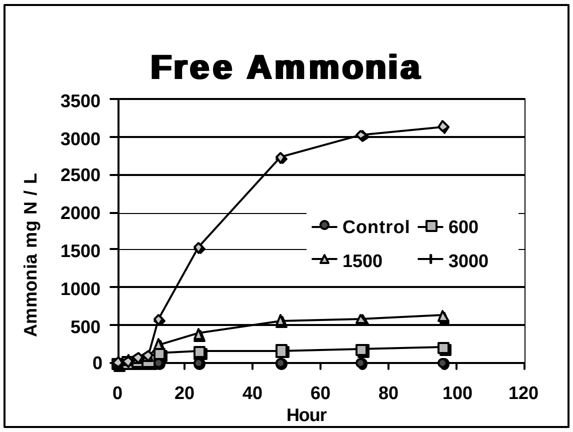
Collections

- Feed and effluent – total solids, volatile solids, alkalinity.
- Biosolids - cellulose, hemicellulose, lignin, permanganate lignin.
- Other – chemical oxygen demand, Kjeldhal N, total ammonia N.

Statistics

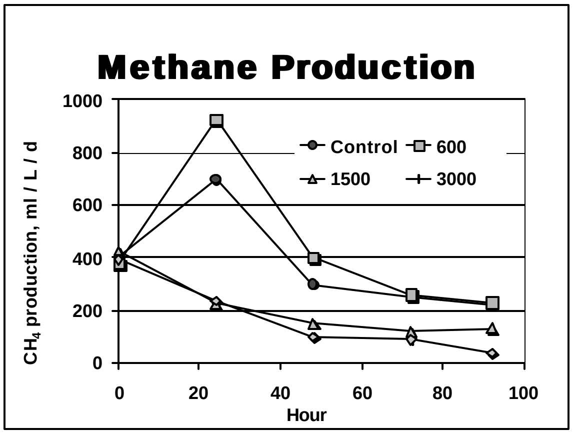
- ANOVA via SAS – biogas production, CH_4 production, pH, alkalinity, volatile solids, chemical oxygen demand, fiber content.
- Significance reported at an alpha of 0.05.

Results



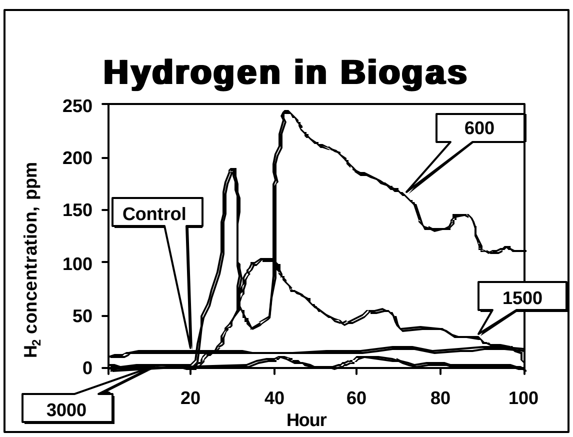
Total N and Ammonia

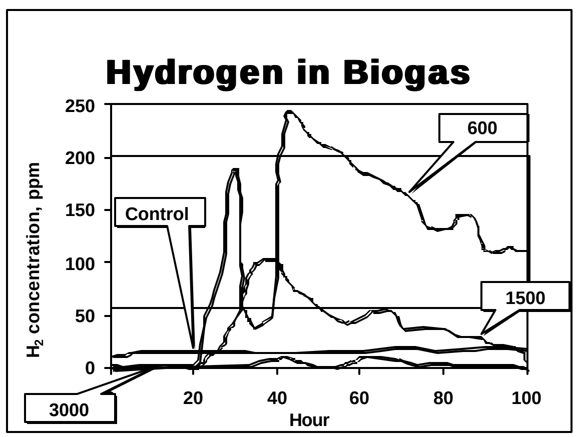
- Urea caused an increase in N and ammonia.
- Total Ammonia was slower than total N.
- Concentration of ammonia was related to digester pH.



Methane Production

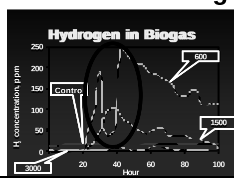
- Higher levels of urea resulted in methanogen inhibition.





Hydrogen Production

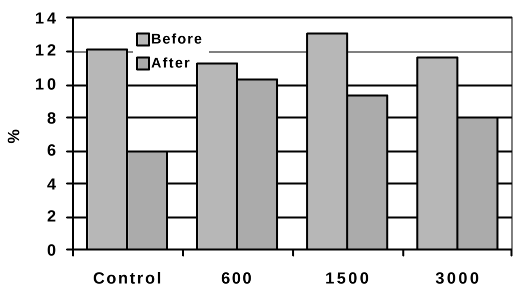
- Decrease in H_2 partially resulted from increased pH.
- Methanogen inhibition more so than hydrolytic and acid-forming bacteria.



pH and Alkalinity

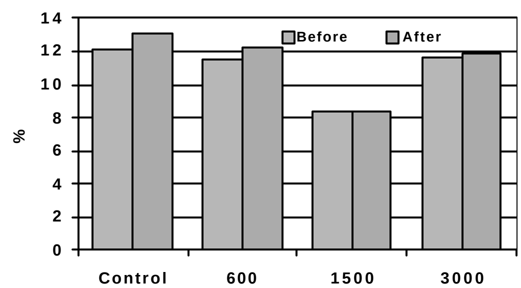
- Urea addition increased pH and alkalinity.
- Two causes
  - Increased bicarbonate
    $NH_4^+ + OH^- + H^+ + HCO_3^- \rightleftarrows (NH_4^+ + HCO_3^-)_{salt} + H_20$
  - Inhibition of hydrolytic and acetogenic bacteria.

Cellulose Content



SEM = 2

Hemicellulose Content



SEM = 2

Lignin + Ash Content

SEM = 3.5

Fiber Composition

- Cellulose was significantly decreased ($P < 0.05$).
- No effect on hemicellulose and lignin concentrations.

Conclusions

- Ammonia N impacted H_2 and CH_4 production.
  - Small increases in ammonia N increased H_2 and CH_4.
  - Larger increases inhibited their production.
- Urea immediately increased pH and alkalinity.
- Changes in H_2 could be useful for monitoring changes due to NH_3 in dairy cattle digesters.