UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE
DEPARTMENT OF PLANT AND ENVIRONMENTAL SCIENCES

Bio-acidification of livestock slurry to reduce ammonia emissions

Bradley Kennedy[1], Beatriz Gómez Muñoz, Lars Stoumann Jensen[2]

(1) bradley.c.kennedy@gmail.com (2) lsj@plen.ku.dk
Plant and Soil Science Section, Department of Plant and Environmental Sciences, Faculty of Science, University of Copenhagen
Thorvaldsensvej 40, Frederiksberg C, Copenhagen, Denmark

Why bio-acidification?

- Ammonia (NH_3) emissions from manure are harmful to people, livestock, and the environment, and are an economic loss to the farm.
- Acidification with sulfuric acid is a proven method of reducing ammonia emissions by changing the proportion of NH_4^+ relative to NH_3 (Figure 1).
- However, sulfuric acid is hazardous, and use is restricted in biogas plants and prohibited in organic farming.

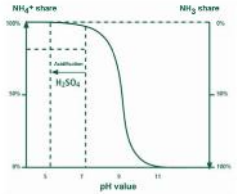

Figure 1. Effect of pH on NH_3 and NH_4^+ speciation. Source: JH Agro A/S

- Bio-acidification could potentially achieve the same results without the drawbacks of sulfuric acid.

How does it work?

- Under anaerobic conditions, adding carbohydrates to slurry stimulates the production of organic acids by naturally-occurring bacteria.
- The magnitude and duration of the pH change depends on the amount and type of carbohydrate added.
- If the pH goes below 5, further microbial activity is inhibited, preventing degradation of the organic acids and preserving the low pH.
- The carbohydrate can be a variety of waste products, including soy or sugar beet molasses, other food waste, silage, or straw.

Results: pH change

For both slurry types, mixtures of 25% soy molasses and 75% slurry were sufficient to reach the target pH of 5 (Figure 2). This corresponds to approximately 3% sugar by fresh weight, similar to results from other studies with other materials.

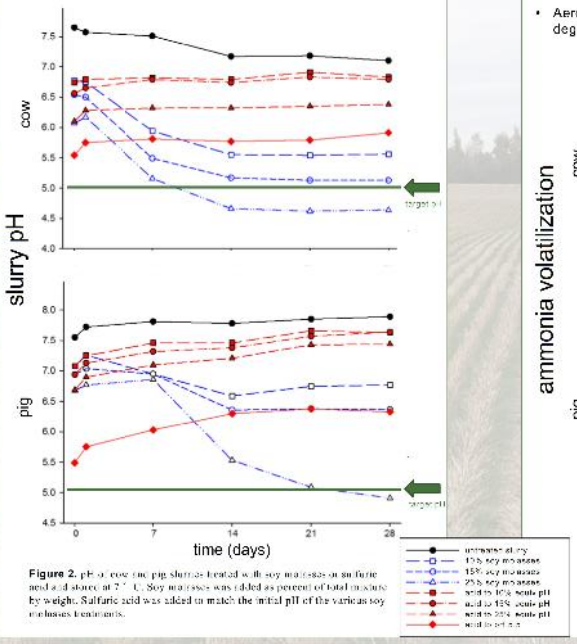

Figure 2. pH of cow (top) pig slurries treated with soy molasses or sulfuric acid and stored at 7 °C. Soy molasses was added as percent of total inclusion by weight. Sulfuric acid was added to match the initial pH of the various soy molasses treatments.

Results: Ammonia loss

- In mixtures of 25% soy molasses, potential ammonia volatilization was completely inhibited for two weeks in pig slurry, and longer in cow slurry (Figure 3). This was more effective than the standard sulfuric acid treatment.
- Aerobic conditions in the volatilization chamber eventually degrade the organic acids, raising pH and inducing volatilization.

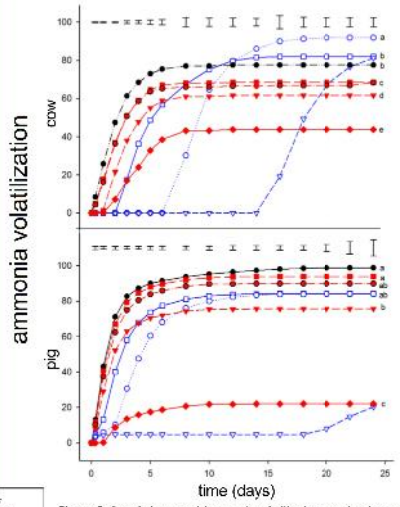

Figure 3. Cumulative potential ammonia volatilization over time in cow and pig slurries treated with soy molasses or sulfuric acid. Results are expressed as a percent of the total ammonium in the original slurry mixture. Treatments were allowed to ferment at 7 °C for 7 days prior to the start of the experiment, then a small quantity was placed in a sealed jar with CO_2 and NH_3 traps.

Results: Fertilizer value

- When added to soil, bio-acidified slurry had slightly lower N and P availability than the unacidified control, probably due to greater immobilization and a higher proportion of organic N (N: Figure 4, P: data not shown).
- However, bio-acidified slurry showed high fertilizer value when applied to maize (similar height and biomass as non-acidified control) (data not shown).
- In both experiments, the slurry was thoroughly incorporated into the soil. If it were surface applied, N availability would likely be higher in bio-acidified slurry, due to avoided ammonia losses.

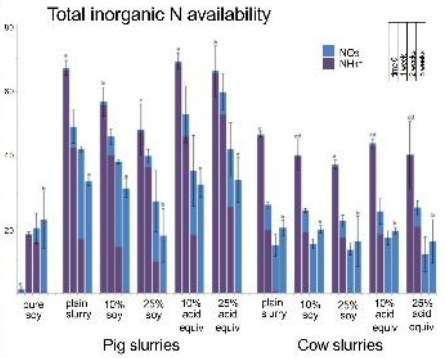

Figure 4. Nitrate and ammonium available over time in soil amended with slurry treated with soy molasses or sulfuric acid. Results are expressed as a percentage of total applied N. Bars for each treatment indicate 1–0, 1 week, 2 weeks, and 5 weeks. Incubation temperature was 15 °C.

Materials and Methods

- For a carbohydrate source, we used soy molasses, a byproduct from soy protein extraction.
- The soy molasses was mixed with two different types of slurry (pig and cow) at 10, 15, and 25% concentrations (by fresh weight).
- We also included slurry acidified with sulfuric acid to pH 5.5 (the standard in Denmark) and to pH values matching the starting values of the soy molasses treatments.
- We measured the effects of acidification on slurry pH and ammonia volatilization, then on nutrient availability (nitrate, ammonium, water-extractable phosphate, and soil pH) in a 5-week soil incubation experiment, and finally on maize growth in a 5-week greenhouse trial.

Properties of soy molasses

pH	4.6
Dry matter	25%
Easily degradable carbohydrates	13%
N and P	Similar to slurry
K and S	Higher than slurry

Conclusions & Outlook

- Bio-acidification can effectively reduce ammonia emissions from slurry without compromising fertilizer value.
- In some cases, the reduction may be even greater than standard sulfuric acid acidification.
- Bio-acidification has several advantages over sulfuric acid: it is safe to work with, can be used in biogas plants and organic farms, and does not reduce soil pH more than untreated slurry.
- Field testing is needed, particularly at fluctuating temperatures, with variable storage times, and on aerobic surface effects in storage tanks.
- In theory, methanogenesis should also be inhibited below pH 5, but this should be verified to avoid unintended emission of CH_4 (a powerful greenhouse gas) from slurry storage.