Alkalization as Efficient Slurry Treatment Reduces Ammonia and Methane Emissions and Enables P-Recycling

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Introduction

The conventional fertilization of arable land with slurry is no longer practicable, as excessive amounts of nutrients are applied per unit area. The excessive addition of nutrients pollutes the soil and groundwater and releases emissions that are harmful to the climate and the environment, such as methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O) and ammonia (NH_3). Therefore, this study investigates and presents aspects of an innovative and decentralized solution strategy based on the alkalization of slurry to reduce emissions and recycle nutrients such as nitrogen and phosphorus.

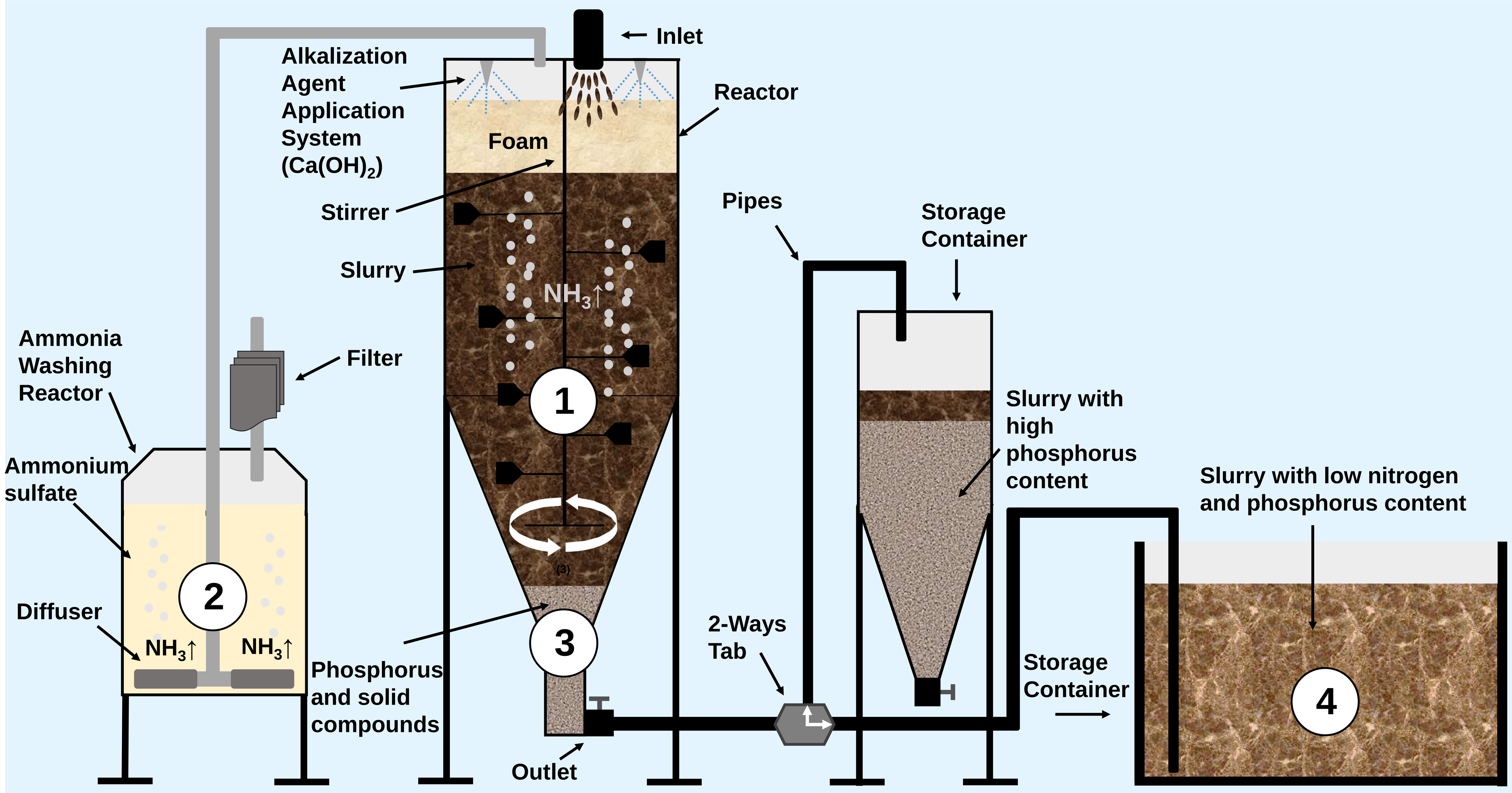
Benefits

- ✓ Reduction of CH_4, CO_2, N_2O and NH_3
- ✓ Production of P- and N-based fertilizers
- ✓ The slurry produced has a low N and P content, so it can be applied to the field in large quantities without causing a major environmental impact.

Objectives

- **Study A** was made to determine the dynamics of buffers present in slurry. Based on the results, a better prediction of the amount of base needed to adjust a certain pH can be made, so that this can be done faster, more accurately and at the optimal time during storage.
- **Study B** was performed to reveal if an increased pH-value in slurry will lower the emission rate of CH_4, CO_2 and N_2O.
- **Study C** was carried out to determine whether the application of alkalized slurry causes plant damage and if these damages led to reduced yields.

Technical Concept



Mode of Operation

1. Increasing the pH by adding calcium hydroxide leads to a shift in the equilibrium between ammonium and ammonia in favor of the non-ionized and volatile ammonia ($NH_4^+ + OH^- \rightarrow H_2O + NH_3\uparrow$). Thus, nitrogen can be removed from the slurry in the form of ammonia by outgassing.

2. The ammonia that gases out as a result of the pH increase is fed into a washing reactor filled with sulfuric acid. In this reactor, the ammonia reacts with sulfuric acid to form the N-based plant fertilizer ammonium sulfate ($2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$).

3. When Ca additives are added to increase the pH, Ca phosphates precipitate, which sink to the bottom of the reactor. These can be easily separated by gravitation from the rest of the slurry.

4. After the nutrients have been removed from the slurry, it is transferred to a storage tank. This nutrient-poor slurry can now be applied to the field in large quantities without causing any major environmental pollution.

Study A – Buffer Systems

IDEA: Weekly titration of cold (a) and warm (b) stored fattening pig slurry were made over a period of 12 weeks to determine the buffer dynamics in slurry as a function of storage time and temperature.

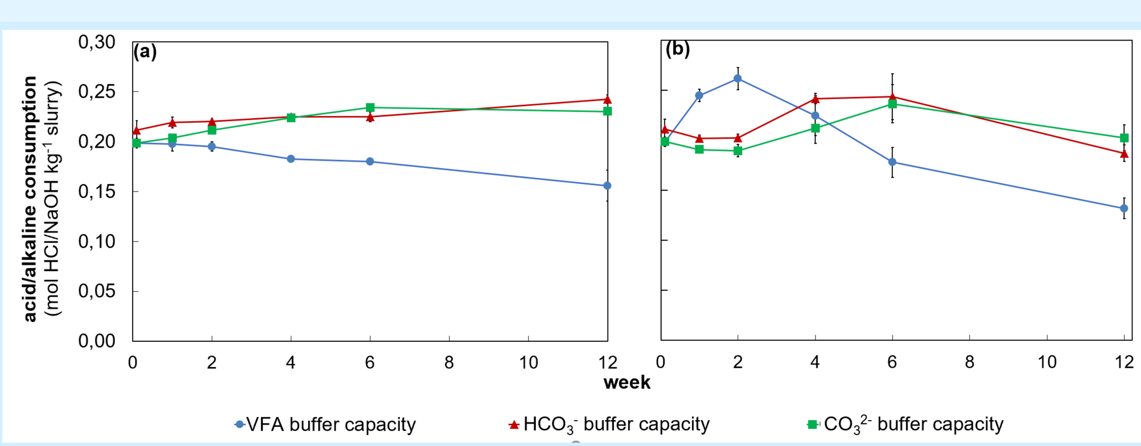
RESULTS:

Volatile fatty acids (VFA) are buffers functioning in the acidic milieu

They undergo microbial decomposition processes

This degradation process enhanced the buffer capacity (CO_3^{-2}) in the alkaline environment

Higher quantities of the additives are needed to adjust the pH-value. Therefore, the alkalization process should be carried out with fresh slurry that has not been stored for a long time.

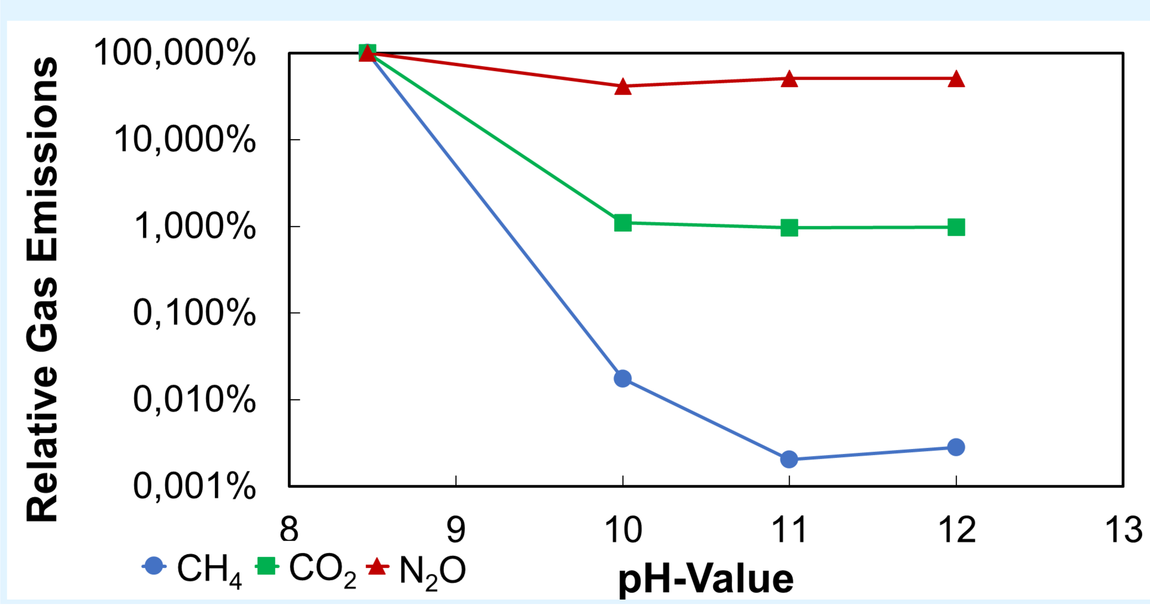


Study B – Emission Reduction

IDEA: We filled 500 ml of separated fattening pig slurry into 1 L glass bottles and alkalized them to pH 10, 11 and 12 with $Ca(OH)_2$ to determine whether an increased pH reduces CH_4, CO_2 and N_2O emissions. The gas was collected with gas bags for 8 weeks and was then analyzed for its concentration.

RESULTS:

- Reduction of CH_4 and CO_2 emissions by 99 % after a storage period of 8 weeks
- N_2O emission reduction by about 60 % after a storage period of 8 weeks.
- No further reduction at higher pH values than 10

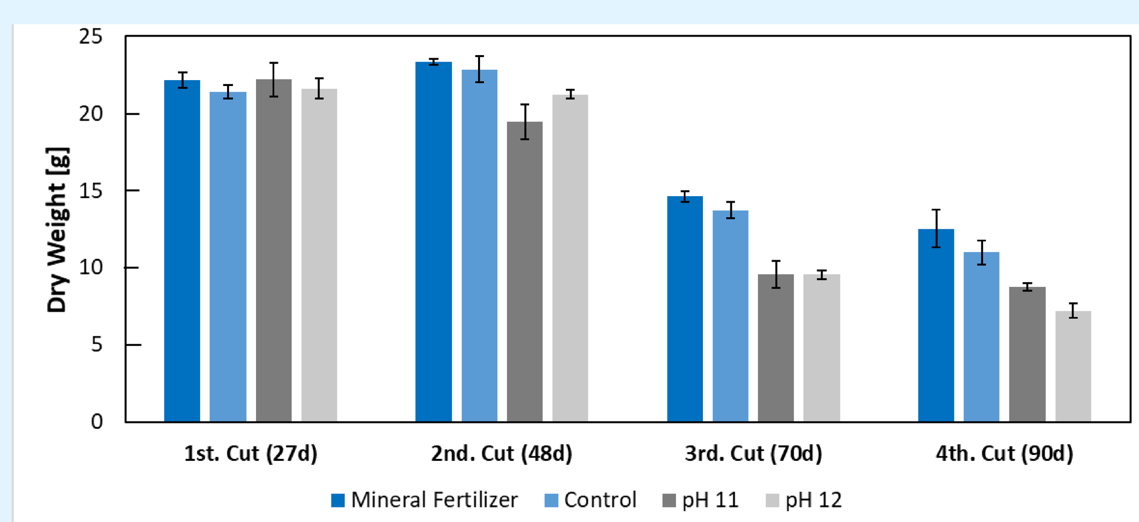


Study C – Plant Growth

IDEA: Ryegrass plants grew in a greenhouse for 90 days in pots, which were filled with 10 kg of soil. Each pot was fertilized with 500 mg N before sowing and with 250 mg N after each cut. The fertilizers used were a mineral fertilizer, a separated fattening pig slurry and the same, which however was alkalized to pH 11 and 12 before each fertilizer application. In total, 4 cuts were made to measure the dry matter accumulation during the whole growing period in order to assess the effect of the fertilizer.

RESULTS:

- Yield decreased from cut to cut in all treatments
- More pronounced yield reduction in the alkalized variants



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With support from
Federal Ministry of Food and Agriculture
by decision of the German Bundestag

Project manager
Federal Office for Agriculture and Food