AMMONIUM RECOVERY FROM LIQUID ANIMAL MANURE USING A NOVEL LIQUID-TO-GAS-TO-LIQUID STRIPPER

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As manure application is limited by EU regulation, removal of excess nutrients from liquid animal manure has received much attention. Current technologies include:

Steam or gas stripping, where the volatiles are taken up by a gas stream that is brought into contact with the liquid animal manure. The forced liquid gas contact and subsequent necessary treatment of the gaseous phase make this an expensive technique.

Nitrification/denitrification of ammonia, where bacteria break down the ammonia into nitrogen (N_2) in two steps. The sustainability of this technique is questionable, since a valuable nutrient is broken down into components that have no agricultural value.

Reversed osmosis of liquid manure where water is separated from the liquid manure phase over a membrane layer using high pressure (>50 Bar). This volume reducing technique only yields moderate concentrations of nutrients in the retentate due to concentration polarization at the membrane surface. The typical Nitrogen concentration of about 4 to 5 % N (kg/kg) is low compared to artificial fertilizers.

Precipitation of ammonium as struvite ($MgNH_3PO_4$) under alkaline conditions. Control of the precipitation is however difficult, and may result in unwanted scaling of pipes. The nitrogen to phosphate ratio in liquid animal manure is too high to remove all ammonia.

The drawbacks of the techniques presented above were the trigger for the invention of a new (patented) system for the sustainable removal ammonia from liquid manure. Key parameters in this were low cost, low energy use, durable, simple and fool proof. The first step in this novel system consists of evaporation of the ammonium from the liquid manure into a closed-off gas phase. In the second step the ammonia is recaptured from the gas-phase with an acid. The evaporation and recapturing is substantially enhanced by using a rotating disc as a transport medium, which maximizes the use of space compared to the available surface and therefore a compact unit can be used for the on-farm ammonia stripping from manure. The end product is a liquid that can be considered as an artificial nitrogen fertilizer. Although the methodology of the ammonia exchange system resembles that of air treatment systems, the system is essentially different since there is no gas exchange with the environment.

The proof of principle of the two-step physical-chemical recovery apparatus was demonstrated in our laboratory setup which used a single LGL-unit as a batch treatment. The ammonia transfer between household ammonia and hydrochloric acid, and coarsely filtered manure and several strong acids was chemically measured. In the first step, ammonia was allowed to diffuse from the liquid donor phase into a closed-off gas phase. In the second step, ammonia was recaptured from the gas phase into an acidic liquid acceptor phase. The first with household ammonia showed a recovery of more than 76%. In a second test with two batches of manure it was proven than concentrating of the ammonia in one batch of acceptor acid.

Modeling of the basic principle using an Euler approximation model gave insight into the main parameters determining the overall mass transfer of ammonia. This knowledge was used to scale-up the system in collaboration with Dorset Green Machines into an on-farm prototype capable of treating 100 L/hr liquid manure (figure 1). The mathematical model was expanded accordingly to calculate the ammonia mass transport of 10 LGL units put in series. The model also showed that further optimization of the ammonia mass transfer from manure by addition of sodium hydroxide was possible, and that near identical exchange characteristics as household ammonia could in principle be achieved.

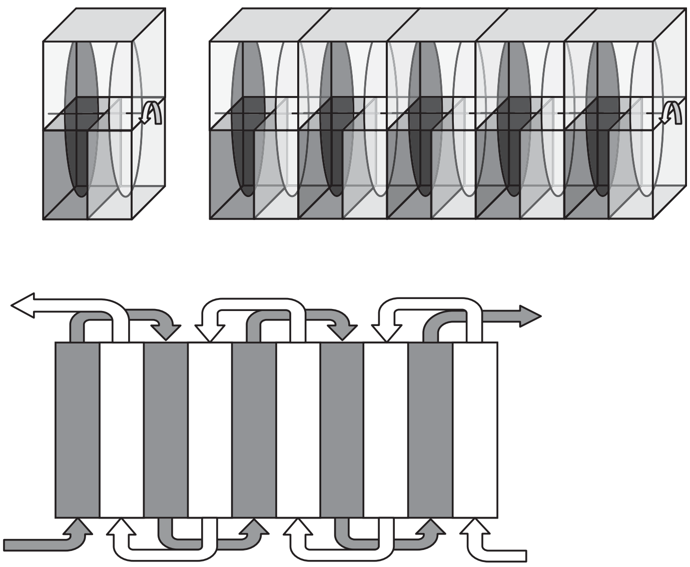

Figure 1: Top: schematic of a single (left) and multi-unit (right) prototype of the Liquid gas liquid ammonia exchange system. Bottom: schematic top view of the manure flow (dark) and acid flow (light) through the apparatus.

The multi-unit model indicated that from a 100 L/hr manure flow containing 2 g/kg ammonium, 73% of the ammonia nitrogen could be recovered. The ammonia was taken up in the acid, that was discharged in intervals of about 30 hours providing an average flow of 0.8 L/hr of used acid with a final concentration of 10.1 mol/L, which roughly equals a 14% N-solution. The model calculations will be verified during the summer of 2013 by testing the prototype on the experimental dairy farm KTC De Marke.

References

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EU-BIOREFINE– RECOVERY OF INORGANIC MINERALS FROM ORGANIC SIDESTREAMS

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Nutrients are essential for maintaining soil fertility and ensuring sufficient global food production. Due to the world's ever-growing population, the demand for food and therefore nutrients is constantly increasing, rendering chemical fertilizers indispensable. In addition, minerals are also required in other sectors such as in inorganic chemistry applications.
At the same time there are regions in North-West Europe that suffer from a surplus of nutrients present in waste streams which can have an adverse effect on the environment.

Although EU environmental legislation covers an increasing number of environmental aspects, there are still important challenges ahead to harmonise standards, techniques and markets in this area. The NWE region, is a region characterised by a high population density as well as intensive industrial and agricultural activity producing large amounts of residues. In addition, these activities almost exclusively rely on import for as far as nutrient minerals are concerned. An asserted action on resource recovery is therefore crucial to sustain our state of society.

The BIOREFINE initiative brings together institutes from 5 NW European member states in a designated action on stimulating market implementation of technologies focusing on mineral recovery from waste & sidestreams originating from Agro & Foodsectors.

The different project activities are covered under 5 work packages (WP).

- (Trans)national Nutrient Platform(s) will be established to interlink between experts, and other running projects & initiatives (**WP1**),
- State-of-the-art of mineral recovery technology in different sectors will be mapped (**WP2**),
- Show cases / pilots will serve as illustrative examples for industry (**WP3**),
- Novel strategies & synergies in cross-sectoral resource recovery will be explored (**WP4**),
- Life cycle assessments on different recovery pathways will be performed, and legislative bottlenecks for implementation will be identified and addressed (**WP5**).