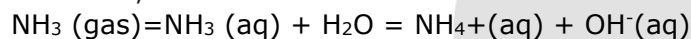# TECHNOLOGY FACT SHEET
Ammonia stripping-scrubbing
FiberPlus

Some feedstock (such as poultry manure, protein-rich feedstock) have relatively a high N content, which may cause high concentrations of ammonia to be released in the digester during anaerobic digestion. When reaching toxic concentrations, this can cause inhibition of the Archaea (methane producing bateria) and lower biogas production (Krakat et al. 2017; SYSTEMIC et al. 2018).

The ammonia stripping-scrubbing technique can be applied on a nitrogen (N) rich waste stream, such as (liquid fraction) of digestate.
Recirculation of N-depleted digestate after N stripping to the anaerobic digestion has proven to be effective in diluting ammonia concentrations within the digester (Ghyselbrecht et al. 2017).

A solution like (liquid fraction of) digestate, contains anhydrous ammonia dissolved in water, in which the ammonium ion in solution exists in equilibrium with unionized (free) ammonia, which can volatize.
NH_3 (gas)$=NH_3$ (aq) $+ H_2O = NH_4^+$(aq) $+ OH^-$(aq)
This equilibrium or the "urge to escape as a gas or stay in solution" depends on pH and temperature [1].
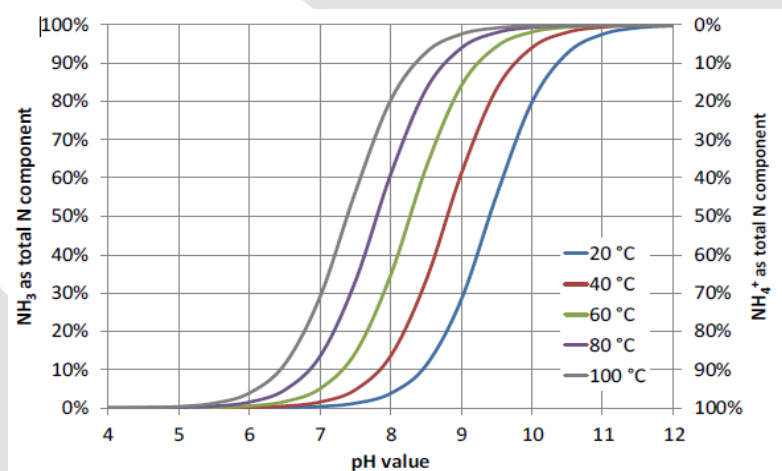
Equilibrium of NH_3 and NH_4^+ in water at different pH and different temperatures

Increasing pH and/or temperature pushes the equilibrium from soluble ammonium (NH_4^+) towards gaseous strippable ammonia. The partial pressure of NH_3 will also rise with the falling pressure (when working under vacuum conditions).

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[1]The base ionization constant is Kb = 1.8×10−5 and within the temperature range of 0°C-50°C and a pH range of 6.0 to 10.0, the relation with temperature is pKa = 0.0901821 + 2729.92/Tk where Tk is temperature in degrees Kelvin, Tk = °C + 273.2.

Within the SYSTEMIC project, Benas (Germany) has implemented the FiberPlus ammonia stripping-scrubbing system (formerly known as ANAStrip), designed by GNS.

pH increase and temperature increase

In the first step, the liquid fraction is manipulated to ensure that more nitrogen becomes available in the form of ammoniacal nitrogen (NH_3-N) as only this form of gaseous nitrogen can be recovered.

This isachieved by stripping CO_2 from the input, which will also prevent the formation of $CaCO_3$ precipitates in the N stripper (Vaneeckhaute 2015).

Ammonia stripping

Next, the liquid fraction enters on top of the system, where it is diffused by nozzles to increase the contact surface of liquid and air. The stripping gas enters usually from the bottom. In this way ammonia is transferred from the liquid to the gaseous phase in a counter current system. These liquid spraying systems would be capable of handling liquid flows containing up to 8-9 % total suspended solids (TSS), without addition of any chemicals. However, they require multiple vessels with diffuser systems in series to reach a maximal ammonia mass transfer area (communication with technology providers, 2020; Barampouti et al. 2020).
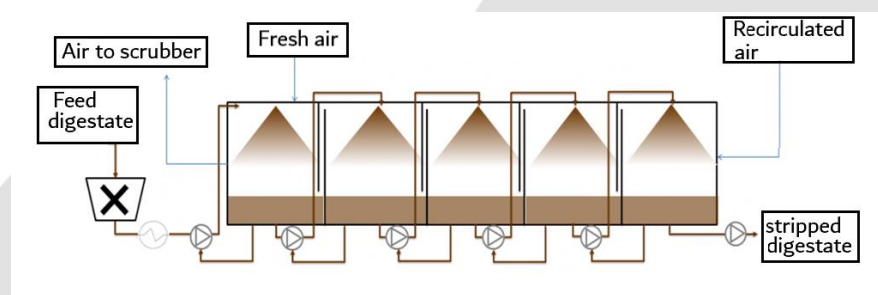

*Figure **Fout! Geen tekst met de opgegeven stijl in het document.**-1 Configuration of NH₃ stripping-scrubbing on manure or digestate* without packing tower. Source: AMFER, Colsen.

Ammonia scrubbing

The stripping gas, charged with ammonia, CO_2 and H_2O is brought into contact with wet gypsum ($CaSO_4.2H_2O$), a by-product of flue gas desulphurisation. This reacts with ammonia in the stripping gas to produce a suspension of ammonium sulphate and a liming product containing $CaCO_3$.

$$2\ NH_3 + CO_2 + H_2O + CaSO_4 = CaCO_3 + (NH_4)_2SO_4$$
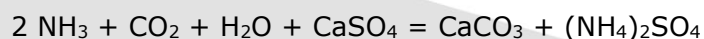
These two are separated by means of a chamber filter press.

The stripping gas from which the ammonia is removed, can be recirculated to the stripping tower.

As stripping and scrubbing of ammonia occurs in a closed system, emissions are generally low. Obviously, non-volatile components, like organic-bound N, phosphorus, potassium, metals, solids etc. will not be transferred to the ammonium sulphate solution, but will stay in the stripper effluent.

If the concentration of the ammonium sulphate solution rises above 40%, crystals can form which can cause blockage of the spraying system in the scrubber. Therefore, the ammonium sulphate solution needs to be diluted with water to avoid reaching these concentrations in the reactor.
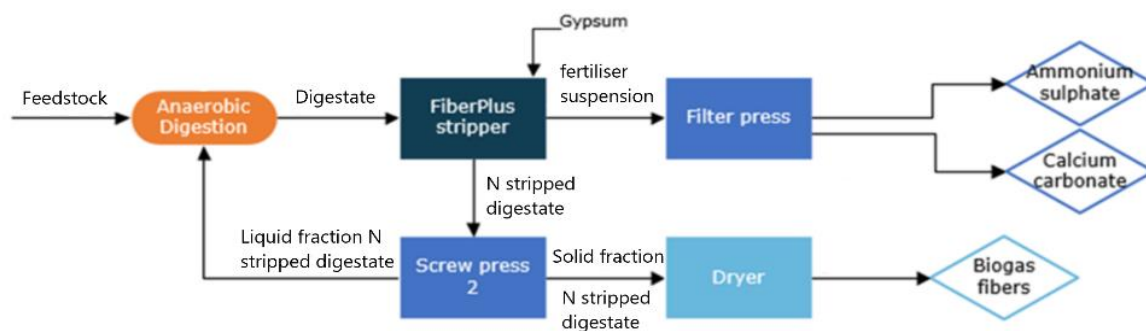
Scheme of ammonia stripping-scrubbing from digestate at Benas (Fiberplus system, GNS).

Read more about the separation efficiencies, use of additives, energy requirements and costs in Chapter 2.2.2 of D 3.2 Final report on schemes and scenario's for nutrient recovery and Reuse.
www.systemicproject.eu/downloads → "project deliverables"

References

Barampouti, E. M., S. Mai, D. Malamis, K. Moustakas, and M. Loizidou. 2020. "Exploring Technological Alternatives of Nutrient Recovery from Digestate as a Secondary Resource." *Renewable and Sustainable Energy Reviews* 134:1–2.

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