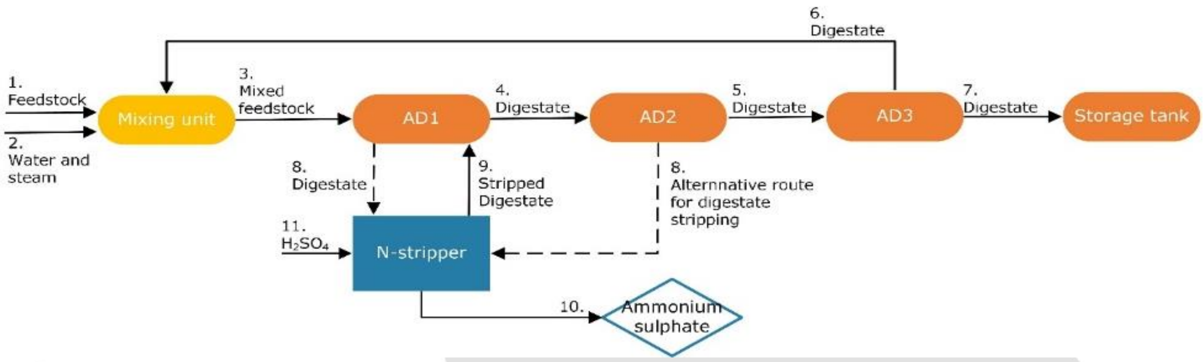
23 April 2021

SYSTEMIC
Circular solutions for biowaste

# TECHNOLOGY FACT SHEET

## Ammonia stripping-scrubbing

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 and lower biogas production (Krakat et al. 2017; SYSTEMIC et al. 2018). Recirculation of N-depleted digestate after N stripping to the AD has proven to be effective in diluting ammonia concentrations within the digester (Ghyselbrecht et al. 2017).
Within the SYSTEMIC project, Acqua & Sole (Italy) has implemented an inline N-stripper to reduce the $NH_3$ concentration in the digester during the digestion process.




*Scheme inline ammonia stripping-scrubbing from digestate at Acqua e Sole (Italy).*

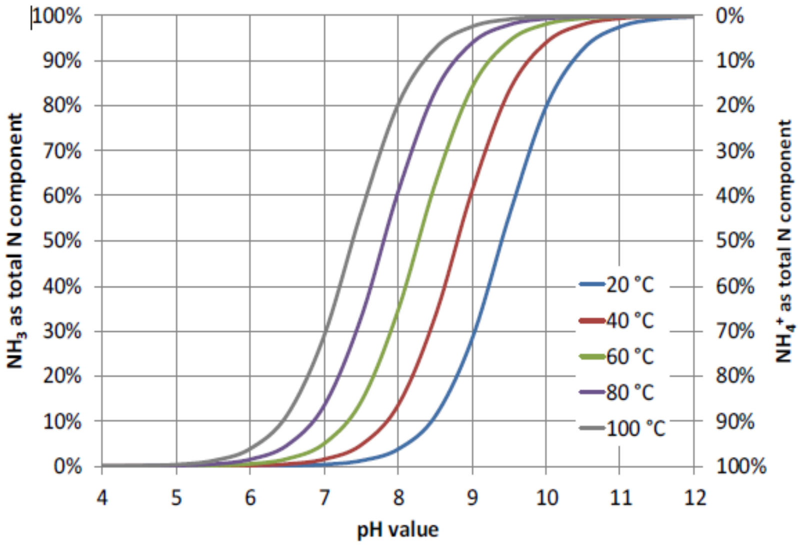
The ammonia stripping-scrubbing technique can be applied on a nitrogen (N) rich waste stream, such as (liquid fraction) of digestate.

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]].

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).

[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.

*The H2020 EU-project SYSTEMIC (**Sy**stemic large **s**cale eco-innova**t**ion to advance circular **e**conomy and **mi**neral re**c**overy from organic waste in Europe) receives funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 730400. (www.systemicproject.eu).*




*Equilibrium of $NH_3$ and $NH_4^+$ in water at different pH and different temperatures*

**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 can be done either by increasing the pH with caustic lime ($Ca(OH)_2$) or by sodium hydroxide (NaOH).

NaOH consumption can be decreased or avoided when the excess carbonate buffer capacity in the input is removed. This can be achieved 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 sprayed over a packing material to increase the contact surface of liquid and air. These packed towers are most commonly used, because they have a low surface footprint.
However, they are easily fouled when input steam contains a lot of suspended solids or fibres. Total suspended solid levels (TSS) > 2 % must usually be removed using a solid-liquid phase separation unit prior to stripping to prevent a decreased stripping performance.
Nonetheless, it is unavoidable that the packing material will have to be cleaned periodically (Vaneeckhaute 2015).

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. When stripping with air, the oxygen in the stripping gas can also lower the activity of the anaerobic bacteria and therefore stripping with biogas can lead to higher biogas production (Bousek et al. 2016; VCM 2018a).

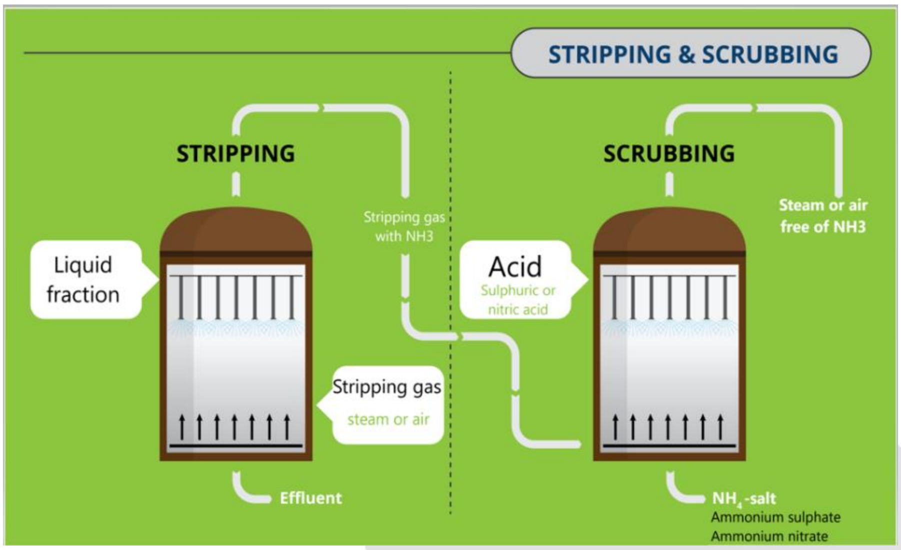
*The H2020 EU-project SYSTEMIC (**Sy**stemic large **s**cale eco-innova**t**ion to advance circular **e**conomy and **mi**neral re**c**overy from organic waste in Europe) receives funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 730400. (www.systemicproject.eu).*

SYSTEMIC
Circular solutions for biowaste

**Ammonia scrubbing**

The stripping gas, charged with ammonia, is then captured and the ammonia is removed (scrubbed) by washing it with a strong acidic solution, such as sulphuric acid or nitric acid, in the scrubbing system. The scrubber water, is an ammonium salt solution of ammonium sulphate or ammonium nitrate, which can be used as an alternative crop fertiliser (see D 3.4 Market research in Europe ).

$2\ NH_3 + H_2SO_4 = (NH_4)_2SO_4$




*Scheme of N stripping-scrubbing. Adapted from: Intereg Flanders-the Netherlands project NITROMAN.www.nitroman.be*

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/nitrate 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.

Ammonia stripping-scrubbing can also be useful before or after biological treatment (nitrification-denitrification), when focussing on lowering and recovering the nitrogen of the digestate for marketing reasons (f.e. low N fertilising application limits in nitrate vulnerable zones).

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"

*The H2020 EU-project SYSTEMIC (**Sy**stemic large **s**cale eco-innova**t**ion to advance circular **e**conomy and **mi**neral re**c**overy from organic waste in Europe) receives funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 730400. (www.systemicproject.eu).*

# References

Gruwez, Jan. 2012. *Wegwijs in de Industriële Afvalwaterzuivering*. edited by H. Suijkerbuijk. Wolters Kluwer Belgium.

Lebuf, V., F. Accoe, S. Van Elsacker, C. Vaneeckhaute, E. Michels, E. Meers, G. Ghekiere, and B. Ryckaert. 2013. "Inventory:Techniques for Nutrient Recovery from Digestate."

*The H2020 EU-project SYSTEMIC (**Sy**stemic large **s**cale eco-innova**t**ion to advance circular **e**conomy and **mi**neral re**c**overy from organic waste in Europe) receives funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under Grant Agreement no. 730400. (www.systemicproject.eu).*