Task 2.1 – Air stripping (coupled to scrubbing with alternative acids (citric acid and CO_2))

Objective

To explore the recovery of ammonia from digestate, alternative acids are investigated as scrubbing agent with lab-scale tests, and process design for practical application are made. Successful processes are validated on larger scale.

The objective of this Task is to determine the applicability of citric acid ($C_6H_5O(COOH)_3$) and carbon dioxide (CO_2) as alternative scrubbing agents via lab-scale tests, benchmarked against H_2SO_4. The alternative counter acids, i.e., citric acid and CO_2, improve the sustainable character of ammonia scrubbing. Ammonium citrate as a fertilizer can enhance the bioavailability of micronutrients (Fe) and P for plant uptake. CO_2 from biogas engine off-gas can be re-used and fixated for the formation of ammonium bicarbonate.

The raw digestate (RD) will be centrifugated to obtain a P-rich solid fraction (SFD) and an N-rich liquid fraction (LFD) of digestate. Together with the RD, the LFD will be used for further testing, whereas the SFD will undergo testing for P-recovery.

Set-up

A small stripping unit is used, consisting of an air pump (flow: ca. 8L/min, controlled via flow meter), a reactor with a water jacket (5L) (magnetic stirring: 100 rpm; water bath to have a stable operational temperature) and a scrubbing unit, all connected via tubing. A pH range of 8-11 and a temperature range of 40 to 80°C is explored to determine the most optimal stripping conditions for combined ammonia recovery and digestate disintegration. A G/L of min. 1000 will be maintained to ensure at least 80% removal efficiency. The scrubbing unit is filled with a citric or sulfuric (= benchmark to evaluate efficiency) acid solution to form ammonium citrate or ammonium sulphate, respectively. During stripping and scrubbing, pH and TAN we be used to determine removal (stripping) and recovery (scrubbing) performance. Besides citric acid, also CO_2 is used as alternative scrubbing agent. Now the stripped ammonia in not collected in citric acid, but in water. Pure, gaseous CO_2 is passed through the airtight scrubbing unit as gas bubbles via a diffuser (flow rate 5L/min via flow meter).

Figure 1: stripping-scrubbing set-up

Results

Different stripping conditions for the removal of ammonia from digestate and subsequent scrubbing to obtain ammonium salts are investigated.

Table 1: stripping – scrubbing (sulfuric and citric acid) of dairy manure digestate

Origin substrate	Dairy manure	Dairy manure
pH (-)	9,5	9,5
Temperature (°C)	70	70
G/L	1000	1000
Flow (l/min)	8	8
Scrubbing acid	sulfuric acid 1M	citric acid 60g/L
TN digestate. (gN)	5,25	6,86
TN stripped digestate (gN)	0,5	0,93
TN washing bottle 1 (gN)	3,57	4,22
TN washing bottle 2 (gN)	0,7	0,62

In Table 1 the different stripping parameters (i.e., pH, temperature, G/L and flow) are displayed. Under those conditions (pH 9,5; 70°C; G/L 1000 and air flow of 8 L/min) 91% of N recovery in sulfuric acid and 84% in citric acid is concluded.

Table 2: stripping (different conditions) of digestate, concentration soluble TOC (g/L) and concentration TAN (g N/kg digestate) in the striped digestate

Parameter	Stripped digestate	Stripped digestate	Stripped digestate	Stripped digestate
Origin substrate	Dairy manure	Dairy manure	Dairy manure (+ extra N)	Dairy manure
pH (-)	9,5	9,2	9,5	8
Temperature (°C)	57,5	70	70	70
G/L	1000	1000	1000	1000
Flow (L/min)	8	8	8	8
Soluble TOC (g/L)	+53%	+92%	+73%	+87
TAN (g N/kg digestate)	-79%	-92%	-90%	-89

Table 2 gives an overview of the different stripping conditions tested. We concluded that a higher temperature (i.e., 70°C) yields better results for the solubilisation of the organic matter and for the TAN removal. The effect of lowering the pH (i.e., from 9,5 to 8) is very limited.

Conclusions

A pH range of 8 – 11 and a temperature range of 40 to 80°C is explored to determine the most optimal stripping conditions for combined ammonia recovery and digestate disintegration. A G/L of 1000 is maintained to ensure at least 80% removal efficiency.

Stripping the digestate at pH 8 and at 70°C ensures an N-removal and disintegration efficiency of almost 90%.

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BioDEN

A biorefinery approach to exploit digestate as key feedstock in the energy – nutrient nexus

More information about the project: check out the project website.

Project partners: Biogas-E, KU Leuven, Ghent University, Marmara University, VCM, OSTIM

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