Nitrogen availability as influenced by pre-treatment technologies of biowastes in two-step anaerobic digestion for biogas

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Introduction

- Anaerobic digestion (AD) is known to change the availability of nutrients in the digestates.
- Different bio-waste pre-treatment methods and two-step AD can increase biogas yields, but we have limited information on how nutrient availability is affected.
- Pre-treatment of substrates, e.g. by **ultrasonication** or high-voltage **(electrokinetic)** treatment, may increase the nutrient solubilisation in AD and influence the soil-infiltration properties of the digestate.

Aims

- Evaluate the effects of pre-treatment techniques and two-step anaerobic digestion on N availability and fertiliser value in digestates.
- Evaluate effects of secondary anaerobic digestion step on nitrogen mineralisation dynamics in soil.

Methods

Solid biomass

Biogas plant

Cattle slurry

Primary anaerobic digestion

Ultrasonication treatment (US)

Pre-treatment of bio-waste pre-digested at 15 and 60 days hydraulic retention times (HRT)

Electrokinetic treatment (EK)

Secondary AD step of digestates in 15L CSTR with or without pre-treatments (batch AD)

Secondary anaerobic digestion

Digestates were applied to a loamy sand soil, incubated for 80 days at 10°C and the net release of mineral N determined

Pre-treated and untreated digestates

NH_4^+-N pool of digestates were labelled with ^{15}N

Digestates (150 kg total N/ha) were applied to confined winter wheat plots in the field by surface banding to measure N fertilizer value and estimate NH_3 losses

Field and incubation experiments

Results

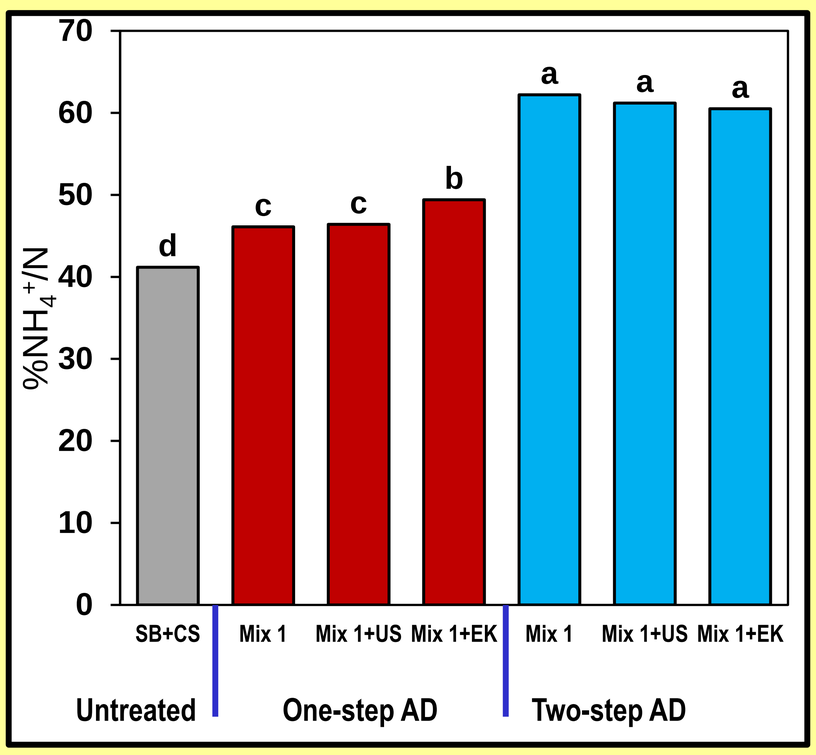

Fig 1: $\%NH_4^+$-N/N of digestates as influenced by ultrasonication (US) and electrokinetic (EK) pre-treatments and two-step AD of a mixture of cattle slurry (CS) and grass-clover solid biomass(SB)

Treatment	Digestion step	% Mineral fertiliser equivalence (MFE) of ammonium-N	Estimated ammonia losses (% ammonium-N)
Mix 1	One-step AD	58 ^{bc}	35
Mix 1+EK		61 ^{b}	34
Mix 1+US		59 ^{bc}	37
Mix 1	Two-step AD	71 ^{a}	24
Mix 1+EK		71 ^{a}	22
Mix 1+US		72 ^{a}	19
Mix 2	One-step AD	48 ^{d}	43
Mix 2+EK		50 ^{d}	43
Mix 2+US		49 ^{d}	46
Mix 2	Two-step AD	49 ^{d}	45
Mix 2+EK		48 ^{d}	46
Mix 2+US		52 ^{cd}	45

Table 1: Mineral fertilizer equivalence (MFE) of pre-treated and untreated digestates from one and two-step AD in winter wheat calculated based on ^{15}N recoveries. Ammonia losses were estimated from differences in MFE between winter wheat (surface banded) and spring barley (Injected).

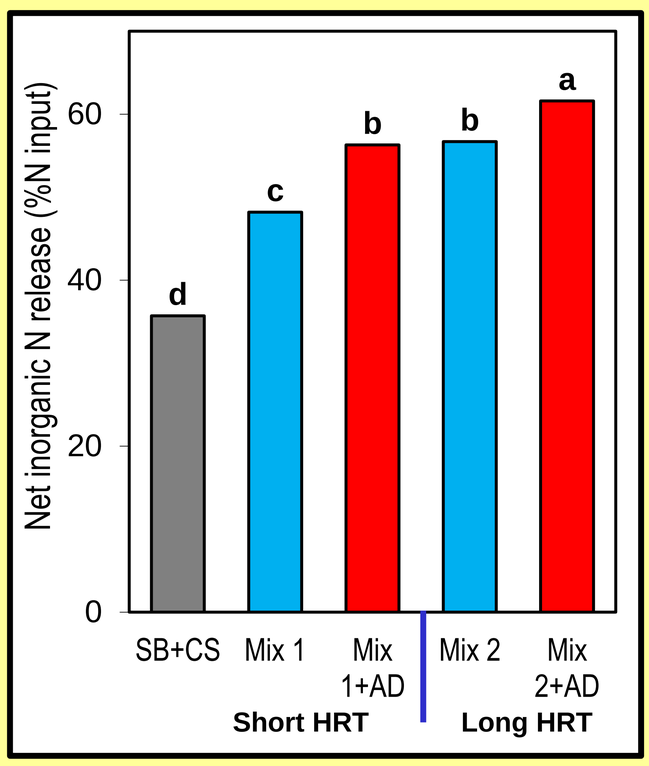

Fig 2: Net release of inorganic N after application of digestates from one-step AD (mix 1=15 days HRT, mix 2=60 days HRT) and two-step AD (+AD).

Conclusions

- Electrokinetic pre-treatment significantly increased the NH_4^+-N/N ratio in digestates before the secondary AD step but only tended to give a higher N fertilizer value.
- Ultrasonication pre-treatment tended to give a higher fertilizer value after the two-step AD; this is attributed to better infiltration in soil and reduced ammonia volatilisation.
- Two-step AD of digestates resulted in significant increase in inorganic N release in soil.
- Integration of Pre-treatment techniques to the AD process could improve the fertilizer value of digestates.

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