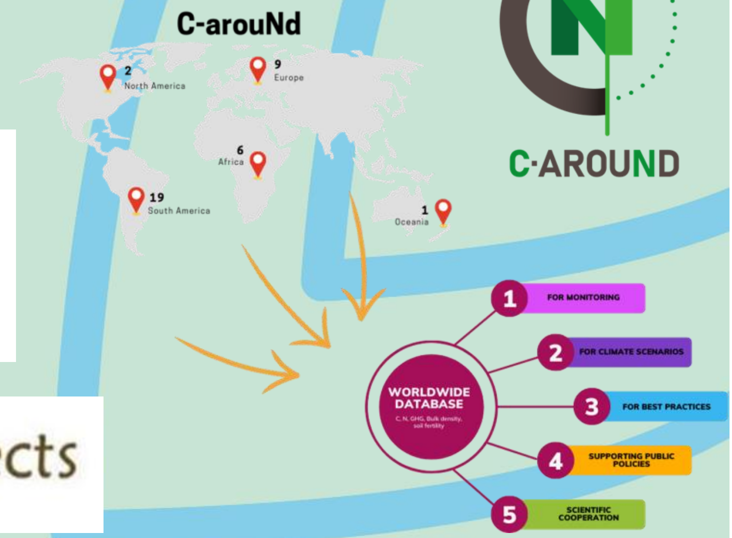
Norwegian Centre for Organic Agriculture

Long-term impact of anaerobic digestion of dairy cattle slurry on grass-clover yields and soil properties

Rittl Tatiana F., Pommeresche R., Johansen A., Steinshamn H., Riley H. and Løes A.K.



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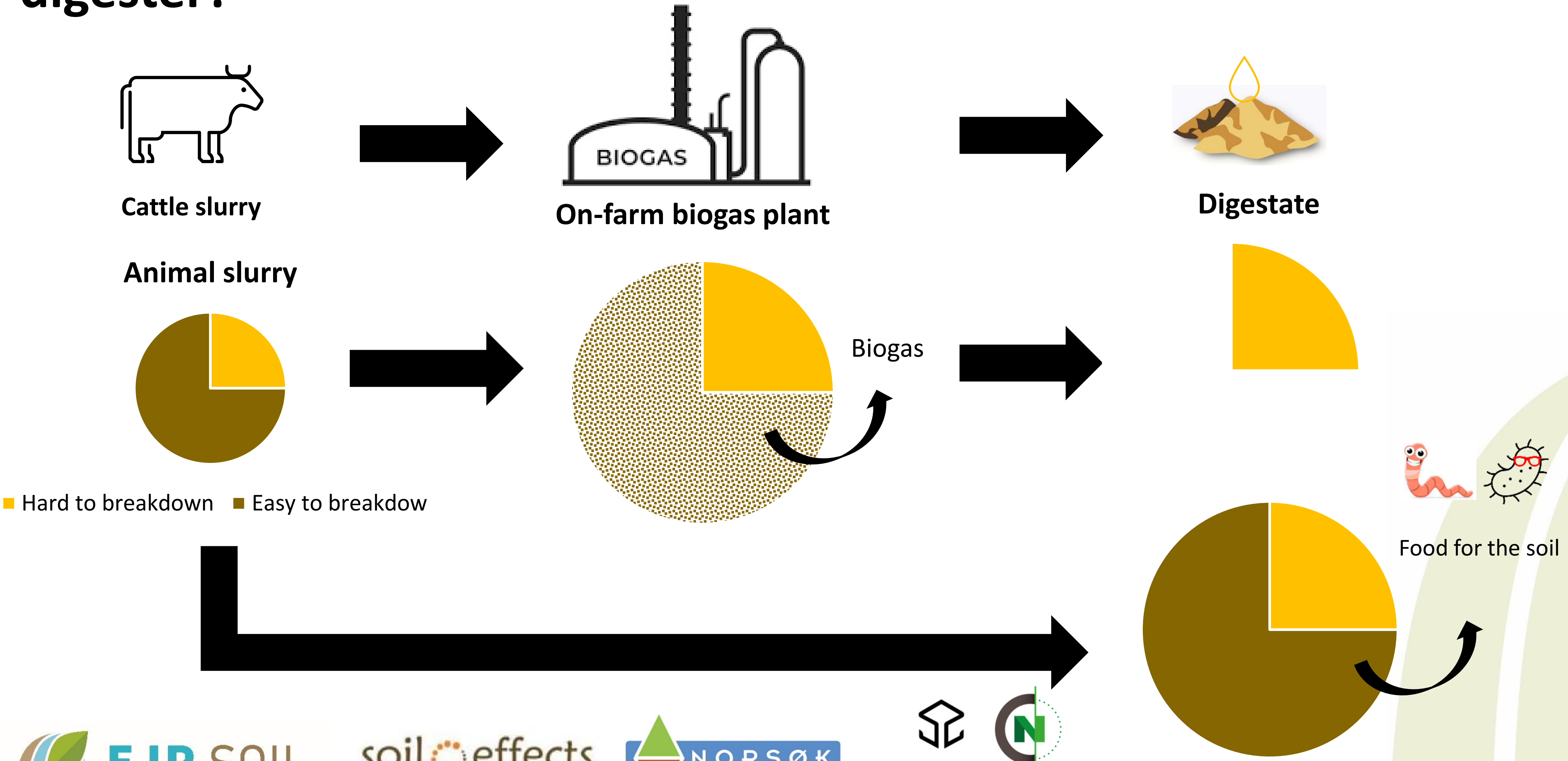
What happens to the soil if the farmer puts the manure in a biogas digester?



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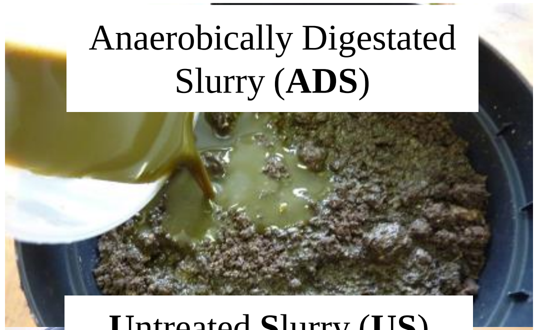
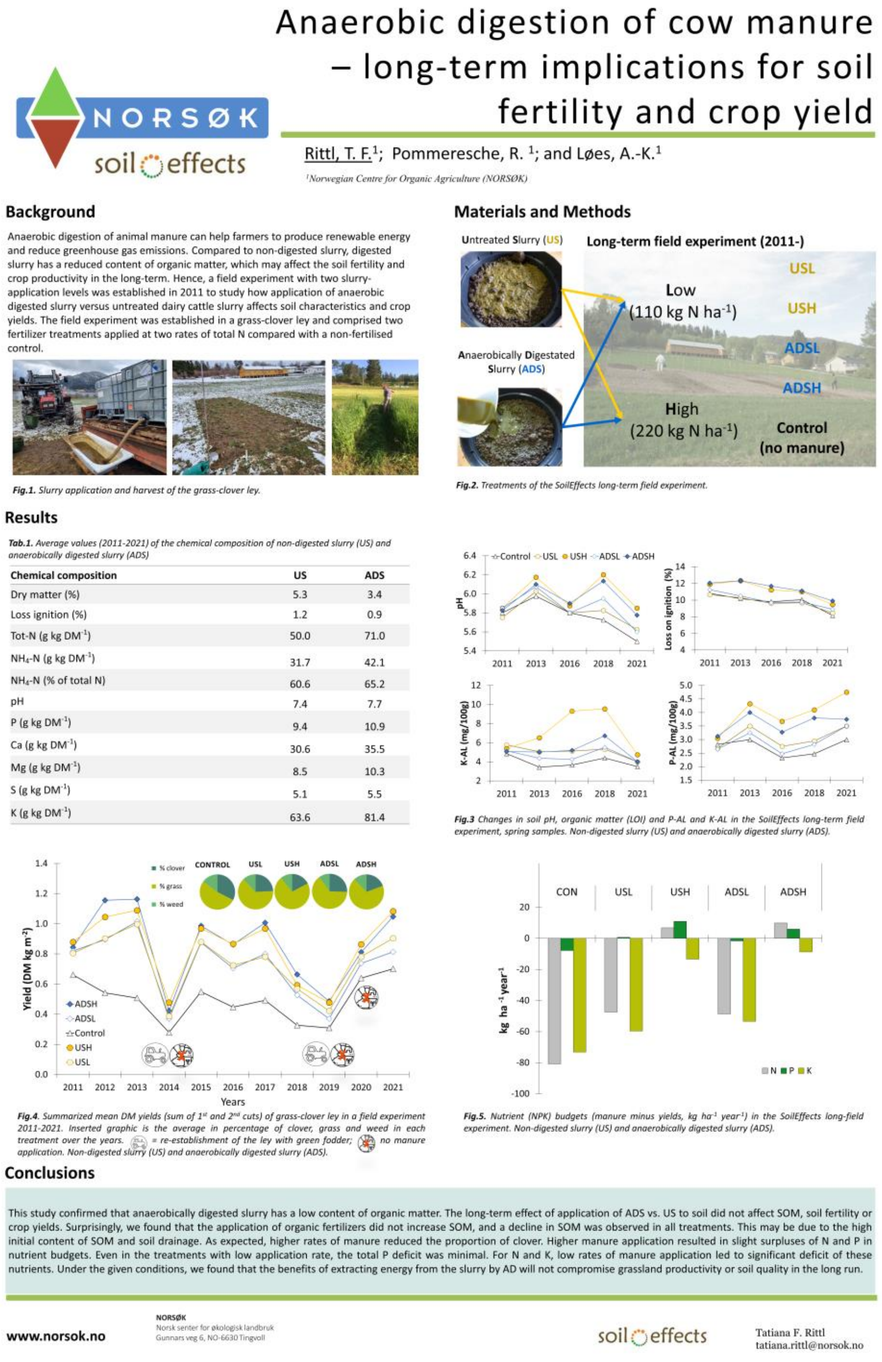
SoilEffects experiment: 2011-





Anaerobic digestion of cow manure – long-term implications for soil fertility and crop yield

Rittl, T. F.[1]; Pommeresche, R.[1]; and Løes, A.-K.[1]

[1]Norwegian Centre for Organic Agriculture (NORSØK)

Background

Anaerobic digestion of animal manure can help farmers to produce renewable energy and reduce greenhouse gas emissions. Compared to non-digested slurry, digested slurry has a reduced content of organic matter, which may affect the soil fertility and crop productivity in the long-term. Hence, a field experiment with two slurry-application levels was established in 2011 to study how application of anaerobic digested slurry versus untreated dairy cattle slurry affects soil characteristics and crop yields. The field experiment was established in a grass-clover ley and comprised two fertilizer treatments applied at two rates of total N compared with a non-fertilised control.

Fig.1. Slurry application and harvest of the grass-clover ley.

Materials and Methods

Untreated Slurry (US) — Anaerobically Digestated Slurry (ADS) — Long-term field experiment (2011-): Low (110 kg N ha-1), High (220 kg N ha-1); USL, USH, ADSL, ADSH, Control (no manure)

Fig.2. Treatments of the SoilEffects long-term field experiment.

Results

Tab.1. Average values (2011-2021) of the chemical composition of non-digested slurry (US) and anaerobically digested slurry (ADS)

Chemical composition	US	ADS
Dry matter (%)	5.3	3.4
Loss ignition (%)	1.2	0.9
Tot-N (g kg DM^{-1})	50.0	71.0
NH_4-N (g kg DM^{-1})	31.7	42.1
NH_4-N (% of total N)	60.6	65.2
pH	7.4	7.7
P (g kg DM^{-1})	9.4	10.9
Ca (g kg DM^{-1})	30.6	35.5
Mg (g kg DM^{-1})	8.5	10.3
S (g kg DM^{-1})	5.1	5.5
K (g kg DM^{-1})	63.6	81.4

Fig.3 Changes in soil pH, organic matter (LOI) and P-AL and K-AL in the SoilEffects long-term field experiment, spring samples. Non-digested slurry (US) and anaerobically digested slurry (ADS).

Fig.4. Summarized mean DM yields (sum of 1st and 2nd cuts) of grass-clover ley in a field experiment 2011-2021. Inserted graphic is the average in percentage of clover, grass and weed in each treatment over the years. = re-establishment of the ley with green fodder; no manure application. Non-digested slurry (US) and anaerobically digested slurry (ADS).

Fig.5. Nutrient (NPK) budgets (manure minus yields, kg ha^{-1} $year^{-1}$) in the SoilEffects long-field experiment. Non-digested slurry (US) and anaerobically digested slurry (ADS).

Conclusions

This study confirmed that anaerobically digested slurry has a low content of organic matter. The long-term effect of application of ADS vs. US to soil did not affect SOM, soil fertility or crop yields. Surprisingly, we found that the application of organic fertilizers did not increase SOM, and a decline in SOM was observed in all treatments. This may be due to the high initial content of SOM and soil drainage. As expected, higher rates of manure reduced the proportion of clover. Higher manure application resulted in slight surpluses of N and P in nutrient budgets. Even in the treatments with low application rate, the total P deficit was minimal. For N and K, low rates of manure application led to significant deficit of these nutrients. Under the given conditions, we found that the benefits of extracting energy from the slurry by AD will not compromise grassland productivity or soil quality in the long run.

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NORSØK
Norsk senter for økologisk landbruk
Gunnars veg 6, NO-6630 Tingvoll

soil effects

Tatiana F. Rittl
tatiana.rittl@norsok.no

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Fertilizer quality of anaerobic digestate produced from marine residual resources (CIRCULIZER)

Rittl T. F.[1], Lied J. G.[2], Aker M.[2], Kvande I.[1], Brod E.[3], Lyng K.-A.[4]

[1]Norwegian Centre for Organic Agriculture (NORSØK); [2]Norwegian Agricultural Extension Service (NLR);

[3]Norwegian Institute of Bioeconomy Research (NIBIO); [4]Norwegian Institute for Sustainability Research (NORSUS)

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On-farm biogas plant

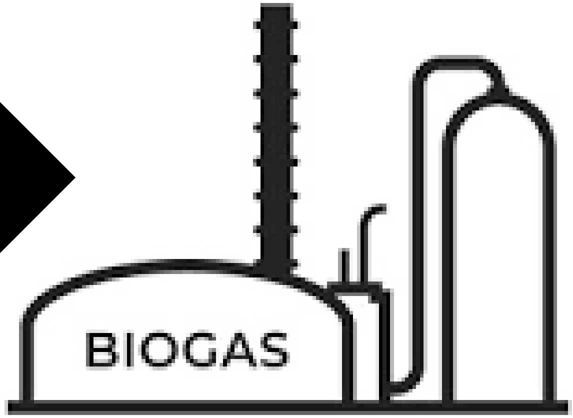

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Foto sources: NORSØK (above); NOFIMA (below)

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- **What are the potential impacts on the quality of digestate when incorporating increasing proportions of new marine residual resources?**

- **How do these changes affect its suitability for agricultural use?**

Fertilizer quality of anaerobic digestate produced from marine residual resources (CIRCULIZER)

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Background

Circulizer project aims to improve the circularity between the blue and green sector, by increasing the knowledge of the use of marine residues (i.e. fish sludge and fish silage) for biogas production and its effects on the fertilizer quality (digestate) and environment.

While the quality of digestate from food waste and animal manure has been extensively studied, the impact of incorporating increasing proportions of new marine residual resources remains to be investigated. **Circulizer** will run lab and field scale experiments where the biogas process performance and digestate quality will be assessed.

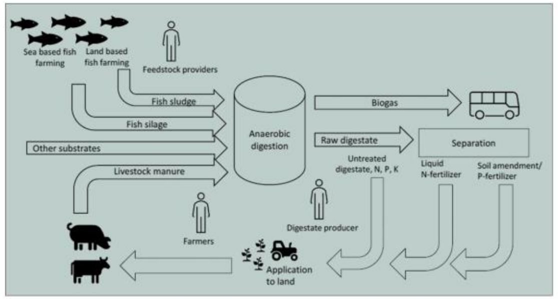

Fig.1. *Value chain for digestate production, including relevant actors. Source: NORSUS*

On-farm biogas plant, fertilizer quality and newly started experiments

On-farm biogas production plant & digestate separator

Fig.2. *On-farm biogas and separator. Source: Svanem biogas and J.G.Leid*

Experiment I : Vestland

Fig.3. *Field experiment established in 2024. Source: Aker M.*

Fertilizer quality

Parameters	Units	Animal + fish slurry		
		Undi-gestate	Di-gestate	Liq. fraction digestate
Dry matter (DM)	%	6,4	5,0	3,7
Total nitrogen	kg/ton	3,9	3,8	3,6
NH_4-N	kg/ton	1,9	2,0	2,0
Phosphorous (P)	kg/ton	0,7	0,6	0,6
Potassium (K)	kg/ton	3,5	3,7	3,0
Cadmiun (Cd)	mg/kg DM	0,2	0,3	0,3
Zink (Zn)	mg/kg DM	190	240	300

Experiment II : Møre og Romsdal

Fig.4. *Field experiment established in 2024 Source: J.G.Lied*

Expected outcomes

(i) Enhancing the green transition and circularity of Norwegian food production by recycling valuable nutrients from fish production for agricultural use; (ii) Ensuring environmental safety by addressing concerns related to heavy metals and organic pollutants; (iii) Increasing the utilization of marine residual resources for biogas production; (iv) Supporting the growth of the fish farming industry in Norway by improving waste treatment and recycling options for unavoidable residual resources, thereby facilitating increased fish production and nutrient recycling.

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NORSØK
Norsk senter for økologisk landbruk
Gunnars veg 6, NO-6630 Tingvoll

Tatiana F. Rittl
tatiana.rittl@norsok.no

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