The effects of cattle manure and straw co-digestion on the digestate carbon stability

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Introduction

- Results from the EOM4SOIL project, which had a dedicated work package for EOM processing technologies
- The aim of the task focusing on anaerobic digestion was to investigate how the anaerobic digestion alters the carbon content and stability of feedstock materials
  - Process technologies, for example, anaerobic digestion changes the composition of the treated organic matter
  - It converts easily degradable organic matter into biogas, concentrating more stable forms of carbon in the digestate
- From a process perspective, C retention in anaerobic digestates is not well studied topic

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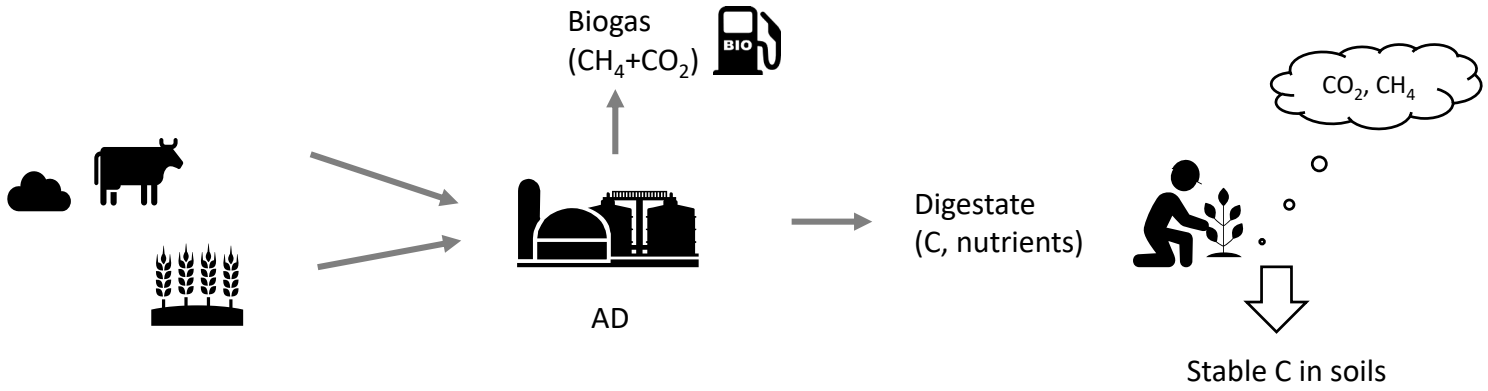
Materials and methods (1/2)

Raw materials

- Solid cattle manure (CM)
- Wheat straw (WS)



Anaerobic digestion experiment

- The co-treatment of manure and straw was studied in two 1 m^3 pilot-scale leach-bed batch reactors for 139 days
- The experiment was conducted under mesophilic conditions (37°C) by circulating leachate through the bed of manure and straw
- Straw accounted for 16% of the total feedstock mass
- Biogas (CH_4+CO_2) production (quantity and quality) was continuously monitored
- At the end of the experiment, the reactors were drained and digestate samples were collected

Photos: Niina Honkala

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Materials and methods (2/2)

Photo: Niina Honkala

Feedstock and digestate characterisation

- Chemical characteristics were analysed (total solids, CHNSO, ash)
- The produced digestate was characterised and the digestate carbon was fractionated into acid-soluble (A), water-soluble (W), ethanol-soluble (E), and non-soluble (N) fractions, i.e., AWEN fractions[1]

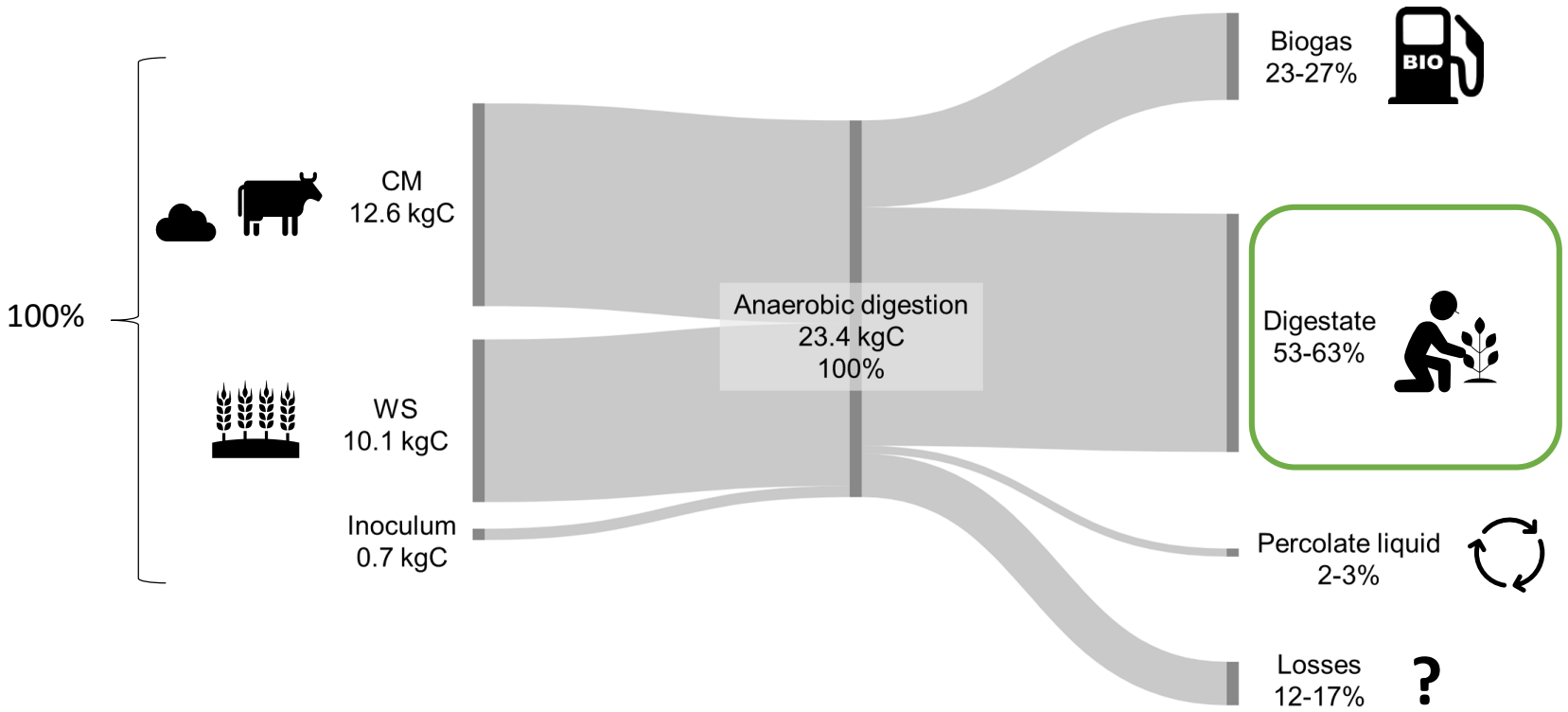
Modelling of C retention in soils

- The results of the AWEN fractionation were used in the Yasso07 modelling[2] to examine the stability of digestate carbon in the soil
- The model calculates changes in soil organic carbon pool
- Modelling up to 100 years under the climatic conditions of Southern Finland and on mineral soils

	TS (%)	VS (%)	C (%TS)
CM	23.9	91.3	48.0
WS	91.4	93.2	46.3
Digestate1	12.5	83.5	46.0
Digestate2	12.9	85.4	46.1

[1]Heikkinen J. et al. 2021. Chemical composition controls the decomposition of organic amendments and influences the microbial community structure in agricultural soils. Carbon Manag 12, 359-376.
[2]Tuomi M. et al. 2011. Soil carbon model Yasso07 graphical user interface. Environ Modell Softw 26, 1358-1362.; Tuomi M. et al. 2008. Heterotrophic soil respiration—Comparison of different models describing its temperature dependence. Ecol Modell 211, 182-190.

Results
C balance in anaerobic digestion



- After anaerobic digestion, 23-27% of feedstock's C was in biogas
  - 53-63% in the digestate
- Some discrepancies (losses) were detected
- More thorough examination of the digestate quality

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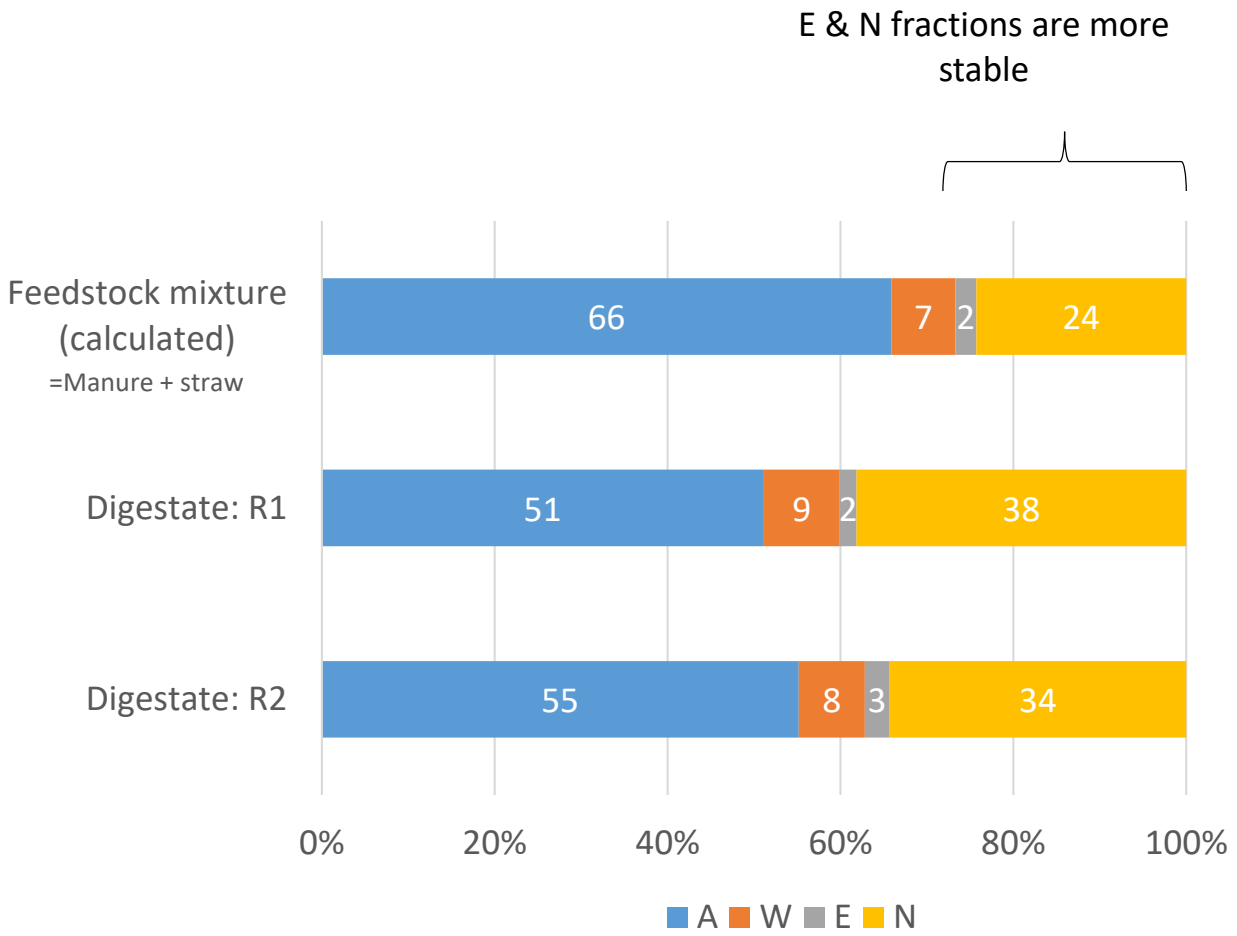
Results
AWEN extractions

- Digestion increased the share of E and N fractions from 26% to 37-40%

➢ Stabilisation of C
  - Degradation of organic matter to CH_4+CO_2

- Changes between digestates from parallel reactors were due to differences in leachate circulation
  - Also, changes in the biogas production rates were detected



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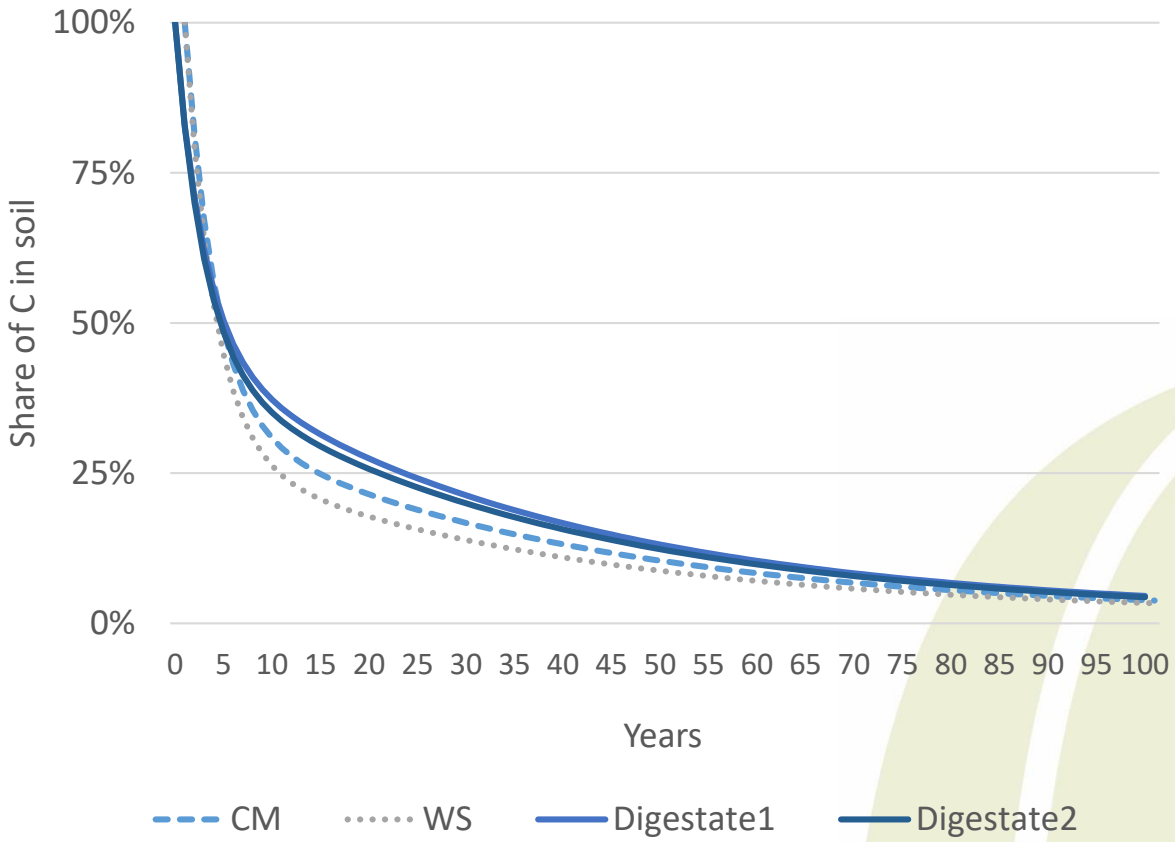
Results
Yasso-modelling

- Modelling showed that anaerobic digestion improved the retention of C in soils
  - Digestate C had longer retention time in soils compared to untreated CM and WS
  - Effect most visible after 10-40 years from the application
- 48-50% of digestate C remained in soils after 5 years
  - 26-27% after 20 years

➢ Applying digestate has short-term effect on soil organic carbon pools



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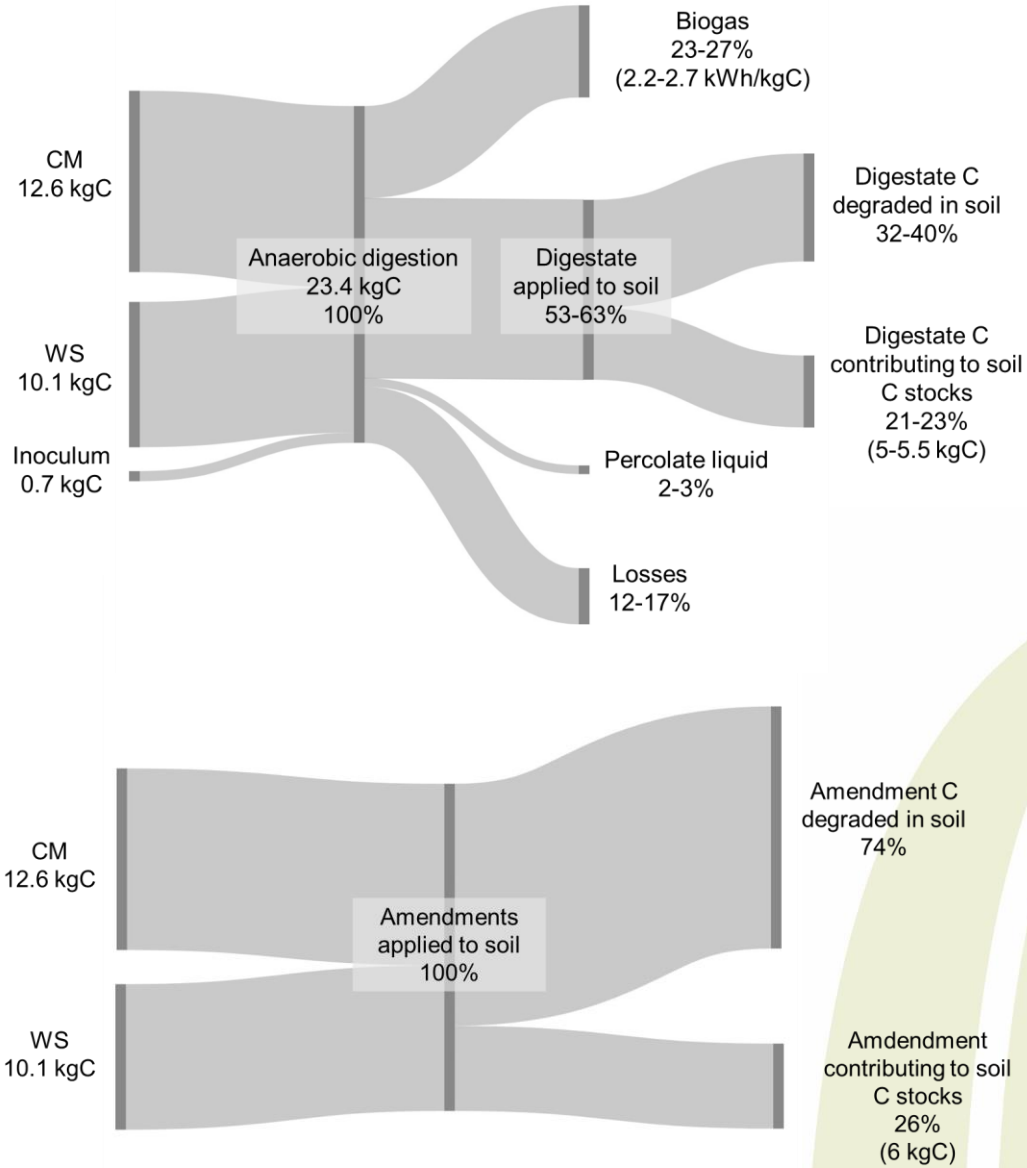
Results
Full C-balance

- The C balance was used to estimate the share of input C that has a longer retention time in soils
- 21-23% of C in anaerobic digestion feedstock potentially contributes to soil C stocks
  - Including E and N fractions
- Compared to the untreated feedstock mix, 26% of the input C contributes to soil C stocks

➢ Both untreated and digested materials contribute about the same amount of stable C to soils

  ➢ Anaerobic digestion also produces valuable biogas



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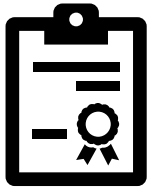
Conclusions

- The use of bio-based fertiliser products promotes nutrient recycling and adds organic matter to the soil
- Anaerobic digestion stabilises C in digestate
  - Double benefit: biogas production & C stabilisation!
  - ➢Better valorisation of C during processing
- Digestate C has longer retention time in soils
  - Compared to untreated CM and WS
- Results support the use of anaerobic digestion as the processing step for manure and straw, to enhance the build-up of soil organic carbon
  - As these types of organic amendments are often applied repeatedly each year



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Thank you!

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