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PRO AGRO LECTORIUM

Greenhouse gas emissions from digestate composting

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Overview

- Digestate and compost and GHG
- GHG from digestate in soil
- GHG from digestate composting
- Mechanism and mitigation of GHG from digestate composting

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Digestate

Anaerobic Digestion

Recovery of organic fraction of municipal waste

Energy production

Digestate production: soil quality improvement | fertilizer

It is evident that Anaerobic Digestion is a sustainable way to recover the organic fraction of municipal waste and to produce energy (Romerike has a capacity to produce 4.5 million NM^3 methane/year – equal to 4.5 million liter diesel). Digestate is often used as a Soil quality improvement (improves infiltration, structure, increases WHC etc.). They also contain valuable nutrients and are therefore suitable as agricultural fertilizers. BUT, the application of fertilizers, including digestates, can enhance greenhouse gas (GHG) emissions.

Digestate – optimization use | treatment

Anaerobic Digestion

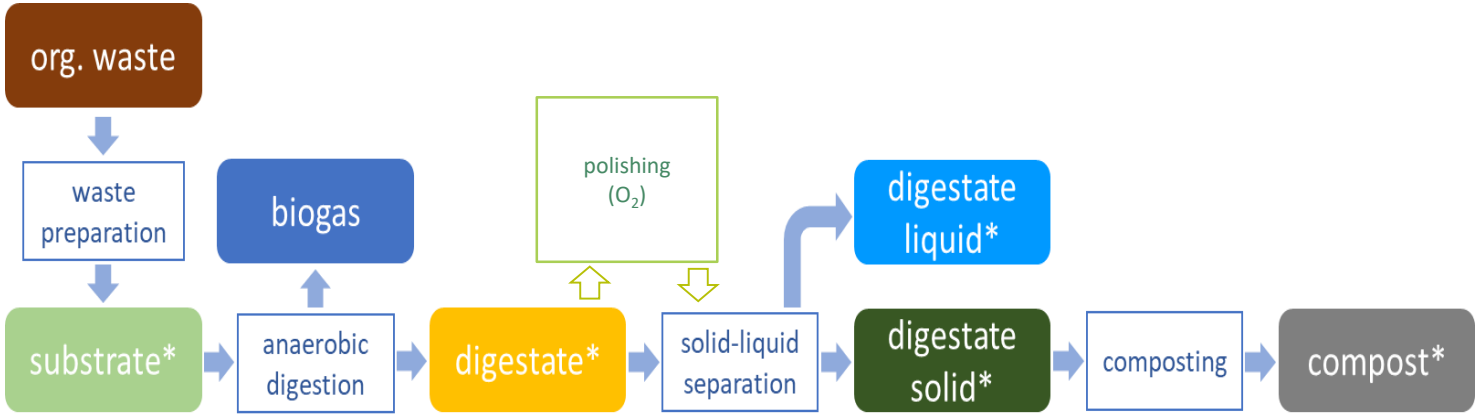
Recovery of organic fraction of municipal waste

Energy production

Digestate production: soil quality improvement | fertilizer

Optimization of use and treatment of digestate:
Where and how could we optimize processes of digestate treatment/use?
How to treat digestate best for agricultural use?

Digestate – optimization use | treatment



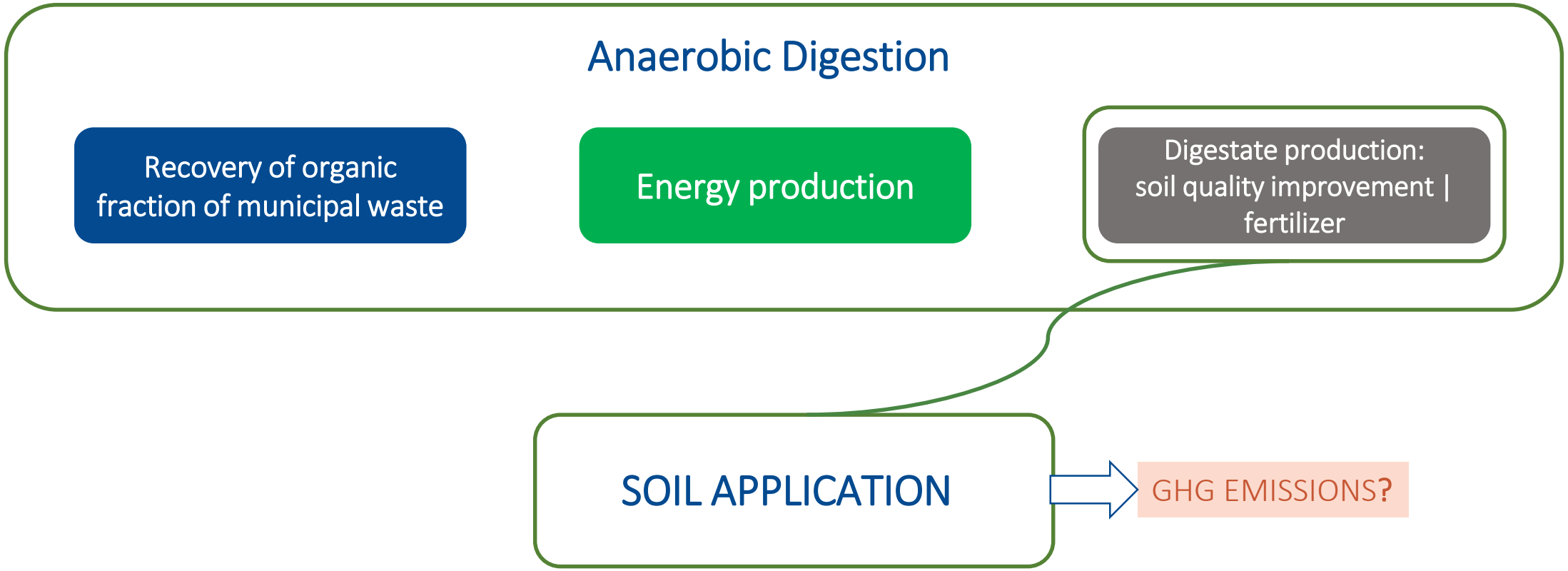
SUBSTRATE and DIGESTATE
2 biogas plants processing food waste – different processes

RBA - THP / mesophilic process

HRA – thermophilic process

Digestate is often separated into a liquid and a solid phase. The liquid can e.g. directly be applied to the field (fertilizer with high ammonium content). The solid digestate can be used as a soil improver or is often composted and then used in agriculture.

Digestate – optimization use | treatment



So, our question was:
What happens when digestate is applied to the soil regarding greenhouse gas emissions (CH_4, N_2O)?

Green house gas emissions from digestates in soil

Comparison of applicated material with respect to greenhouse gas emissions:

food waste (liquid)

digestate

de-watered digestate liquid / solid

Composted digestate

2 contrasting soils:

Chernozem

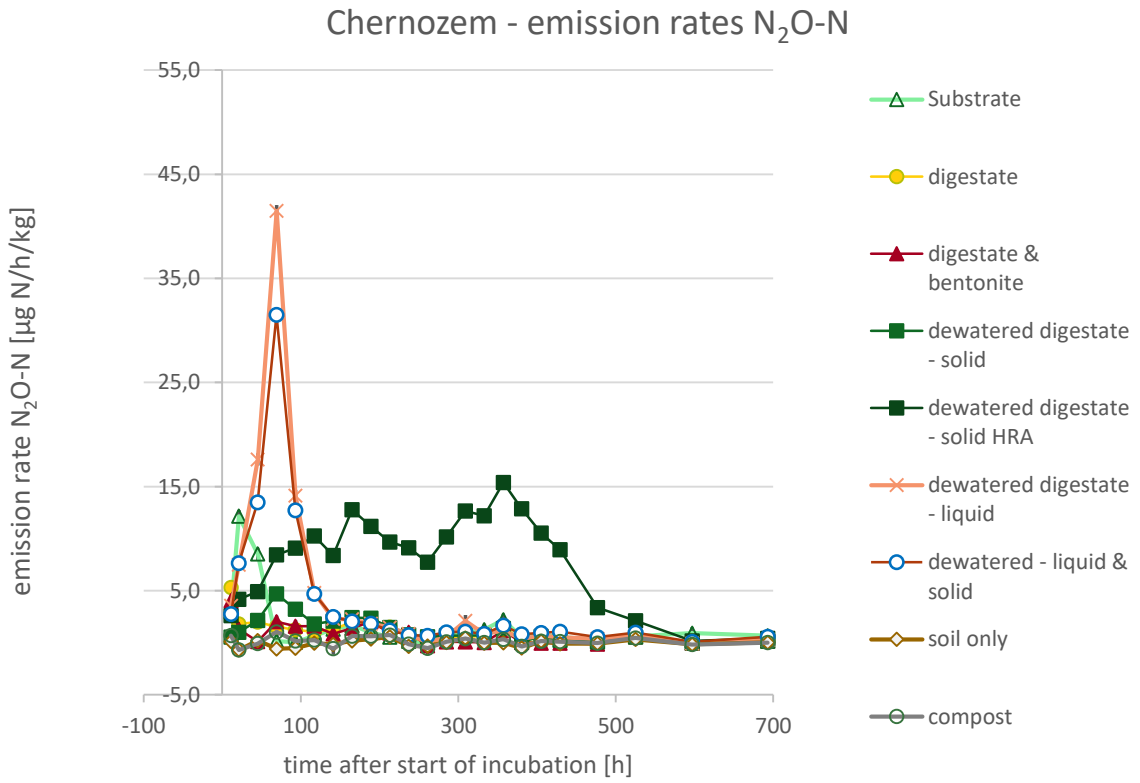
Sandy soil

Measuring GHG from soil after digetate application

- Digestate in soil incubated open
- Closed ca 1 hour and sampled for GC
- 3 weeks

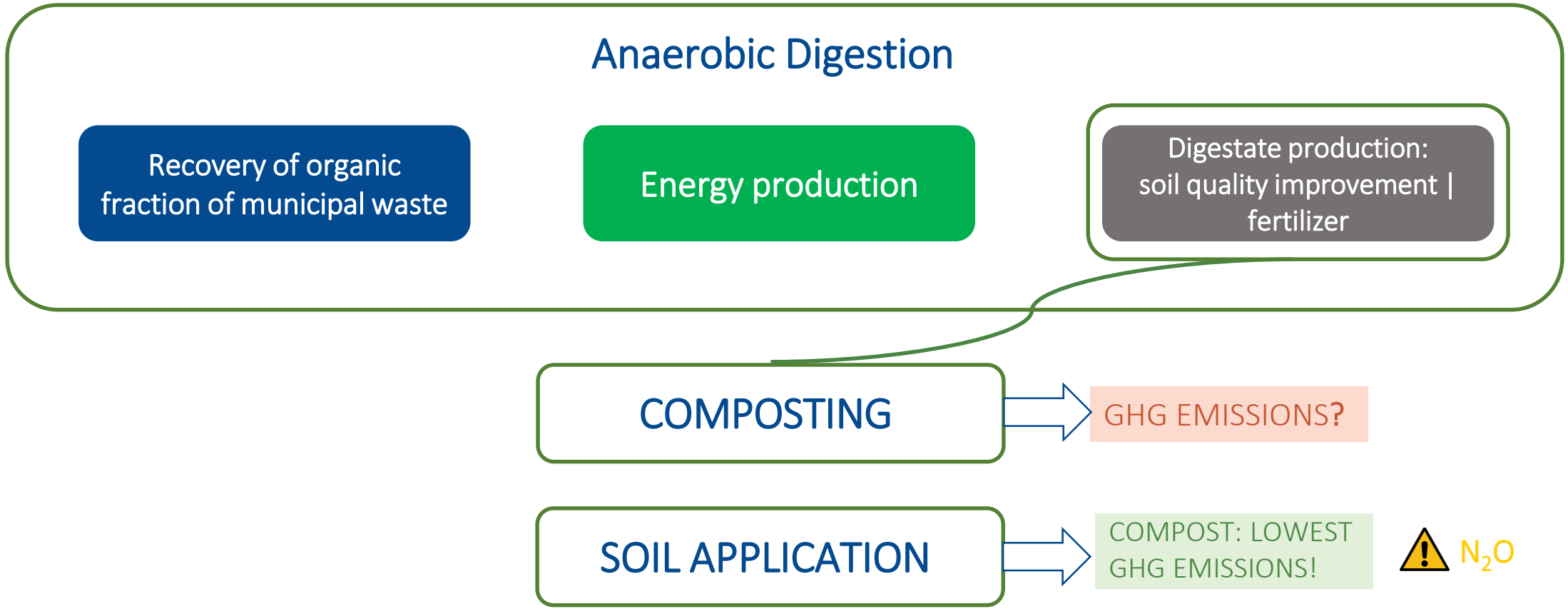
Greenhouse gases from digestate in soil

- Nitrous oxide after application in soil
- High peak initially for liquid fractions
- Sustained emission from solid fraction
- Sandy soil lower emissions, but same pattern
- Zero emission from composted digestate



Dietrich et al. 2020

Digestate – optimization use | treatment



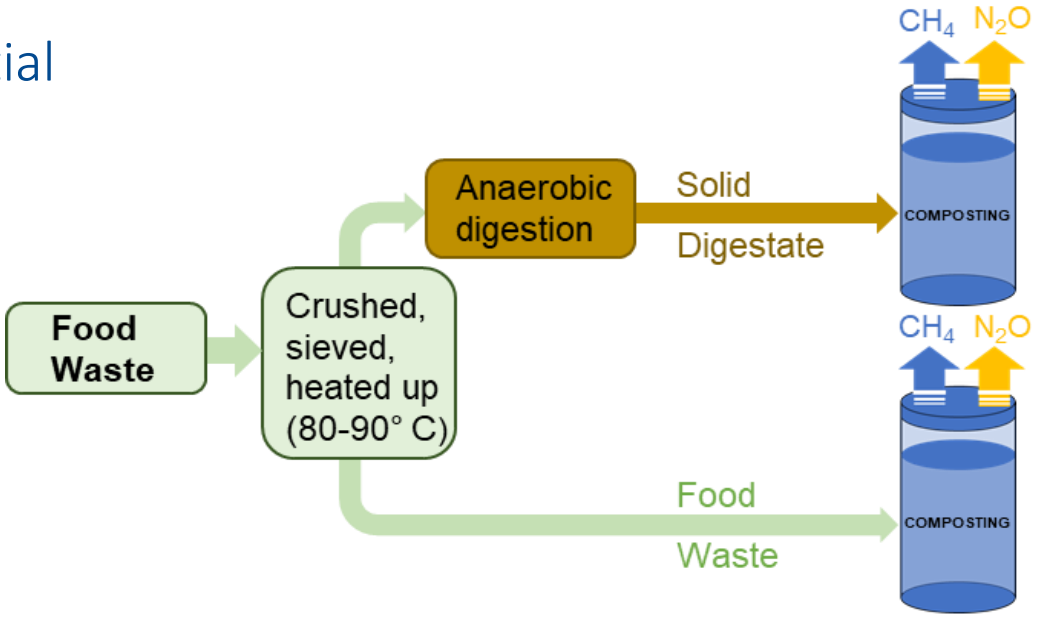
What happens when digestate is composted regarding greenhouse gas emissions (CH4, N2O)?
This lead to another experiment…

How does anaerobic digestion before composting affect GHG emissions?

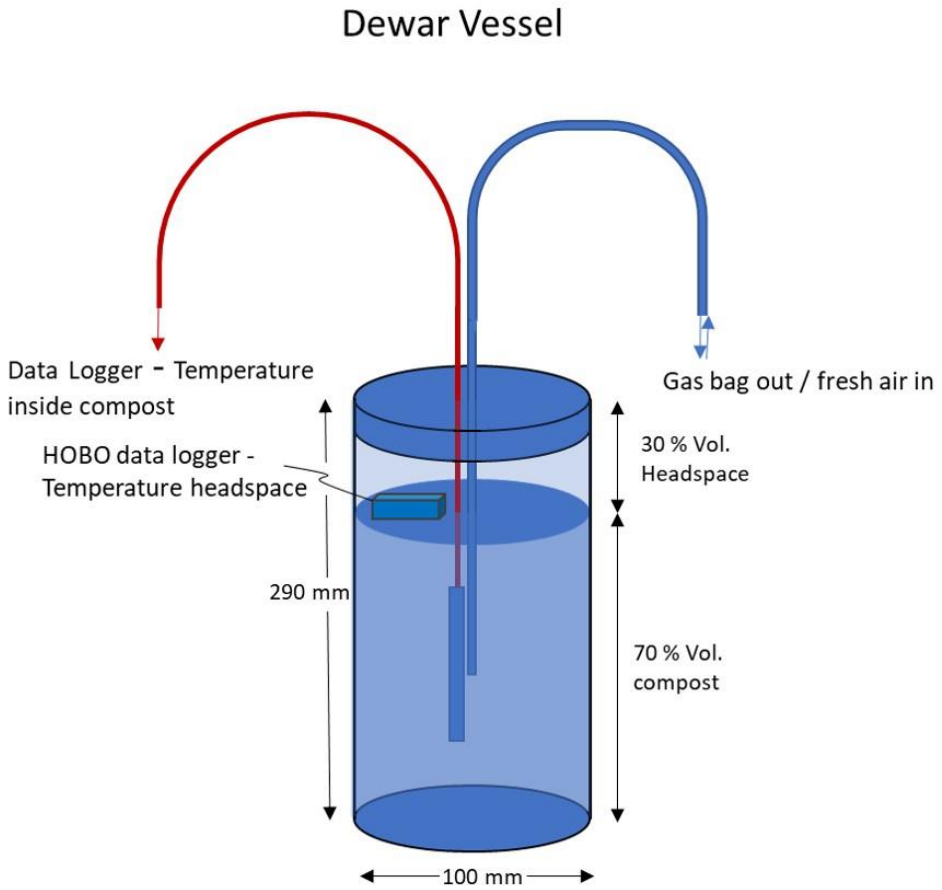
Assumption: lower CH4 emission from composted digestate because methane potential is used up.

Composting raw food waste vs. Composting digested food waste:

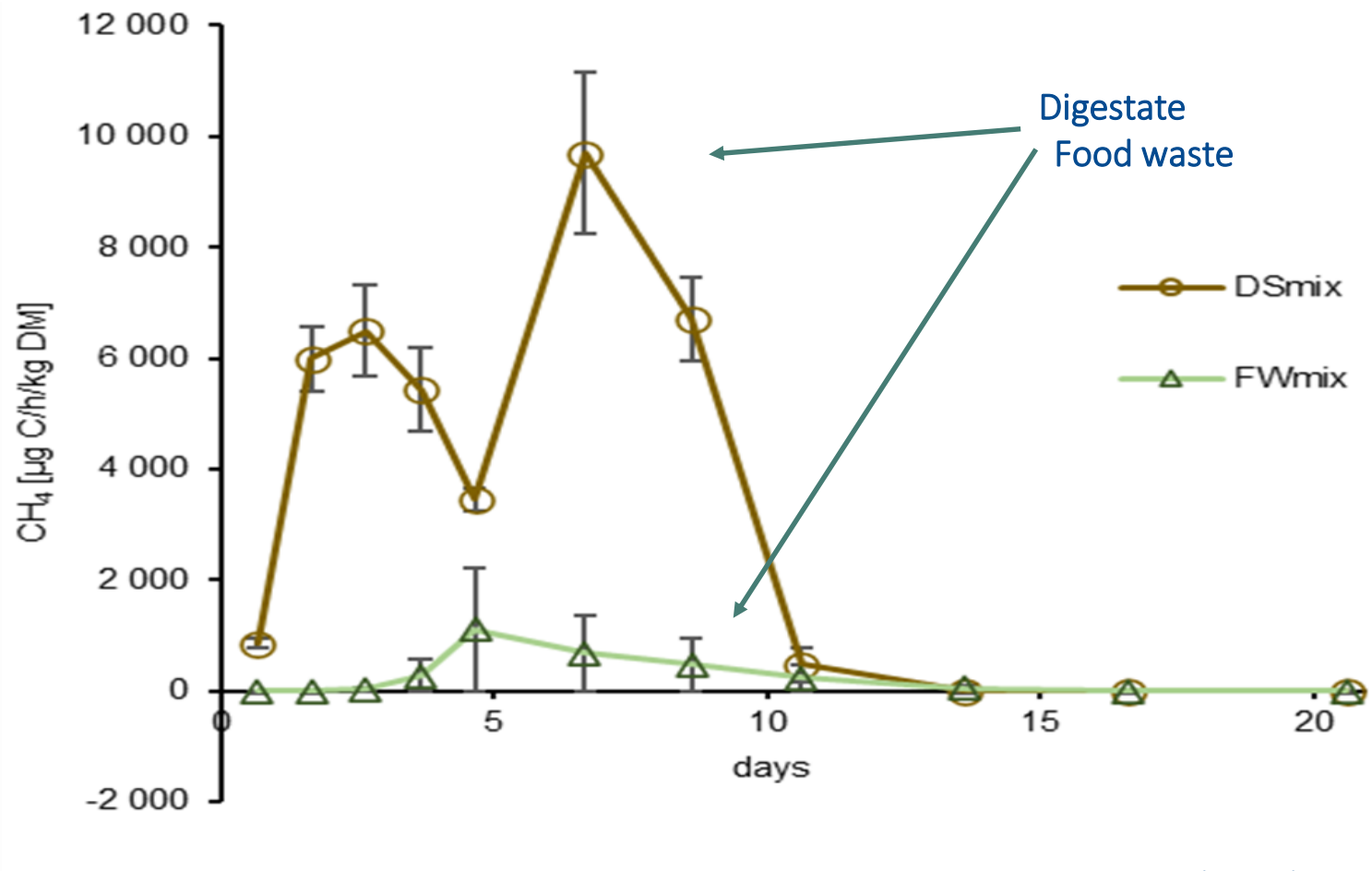
- GHGs: N2O and CH4
- Composting process (Temperature, O2 and CO2)



Composting digestate



Methane from composting digestate



Dietrich et al. 2021

Results – cumulative CH4 and N2O emissions

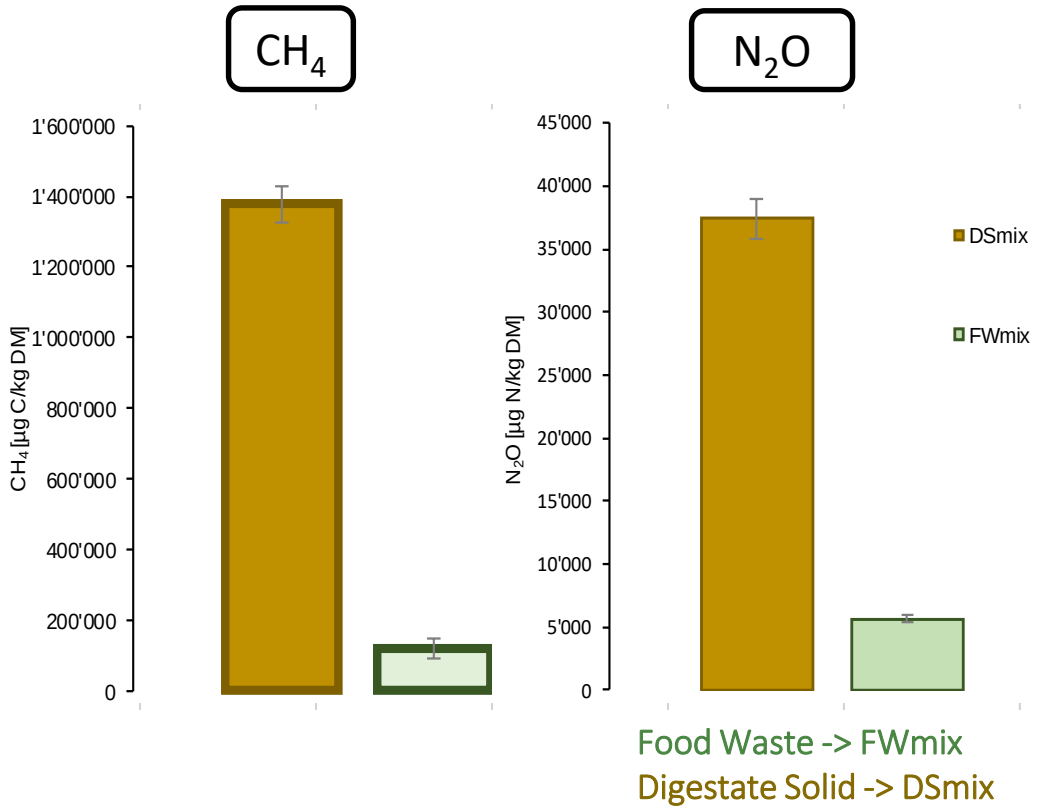
- Cum. N2O-N emissions after 3 weeks:

7 times higher from Dsmix than from FWmix

- Cum. CH4-C emissions after 3 weeks:

12 times higher from Dsmix than from FWmix

IS IT STILL A GOOD IDEA TO COMPOST DIGESTATE?



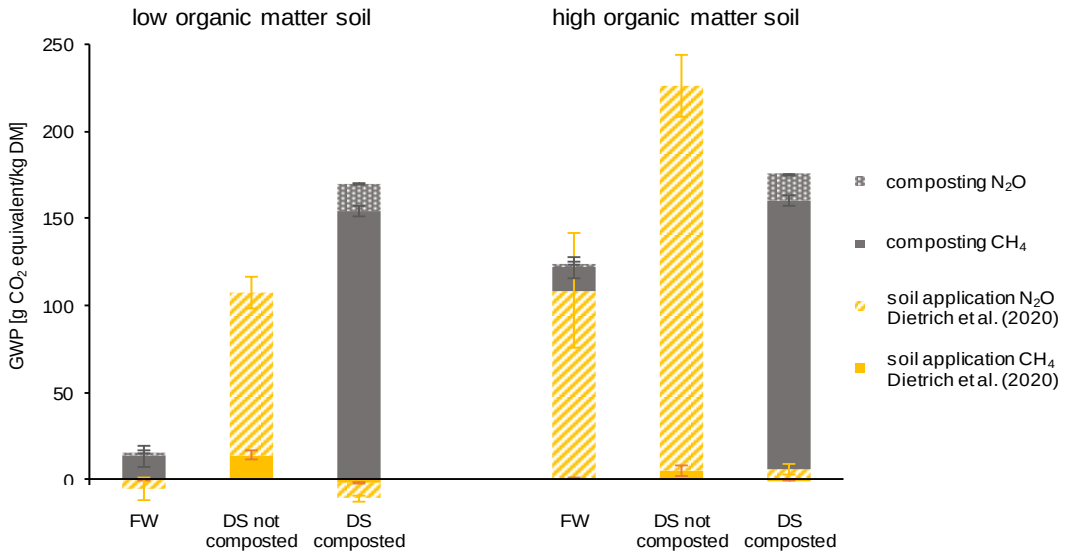
Dietrich et al. 2021

Results – GWP of CH4 and N2O emissions

- GWP of CH_4 and N_2O from composting:

10 times higher from DSmix than from FWmix

- Contribution to GWP of **CH_4-emissions** were bigger than N_2O contribution



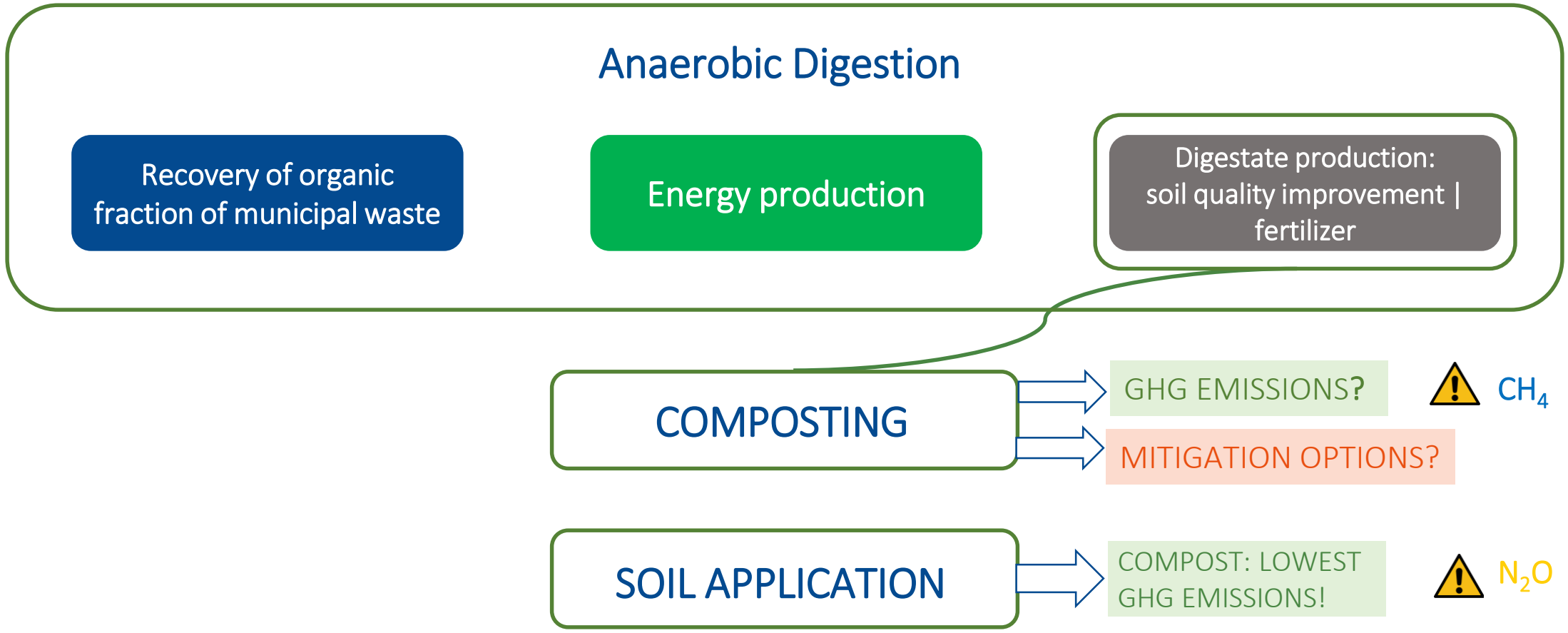
IPCC – 20 yr.
N_2O: 264
CH_4: 84

lower GHG emissions of composted DS after soil application could **compensate** for the high GWP of composting DS

BUT: organic matter content of the FW input is reduced during AD by half!
Dietrich et al. 2021

When we merge the results/GWP from application to the soil and from the composting process, this can be relativated again!
I do not have the time to go into details here, but we found that lower GHG emissions of composted DS after soil application could compensate for the high GWP of composting DS and…

Composting – mitigation of GHG emissions



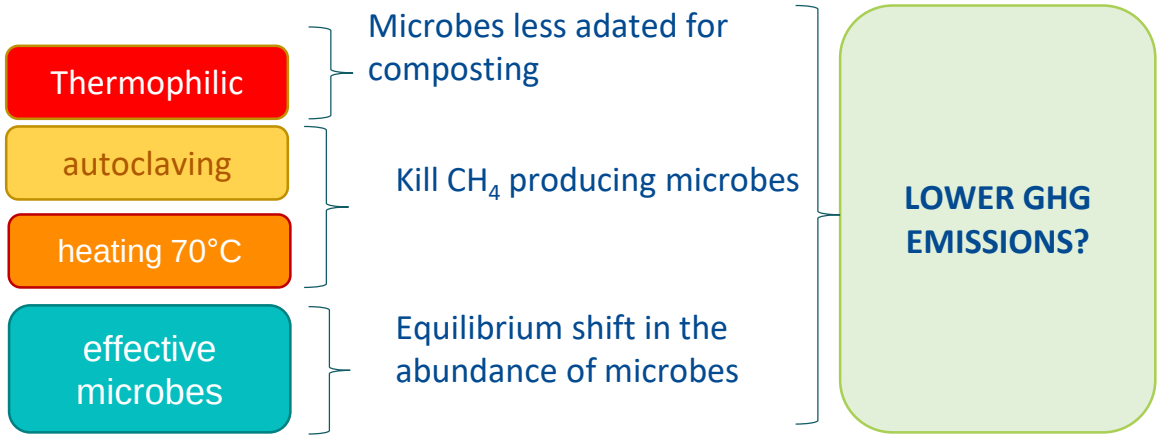
Which is: Are there mitigation options leading to lower GHG emissions during the composting process?

New questions

- Can we prove that microbes imported with digestate are an important cause of emissions? - autoklaving
- Are emissions lower from plant with thermophilic process?
- Can we mitigate emission?

  Hygenisation -> 70C, 1 hour

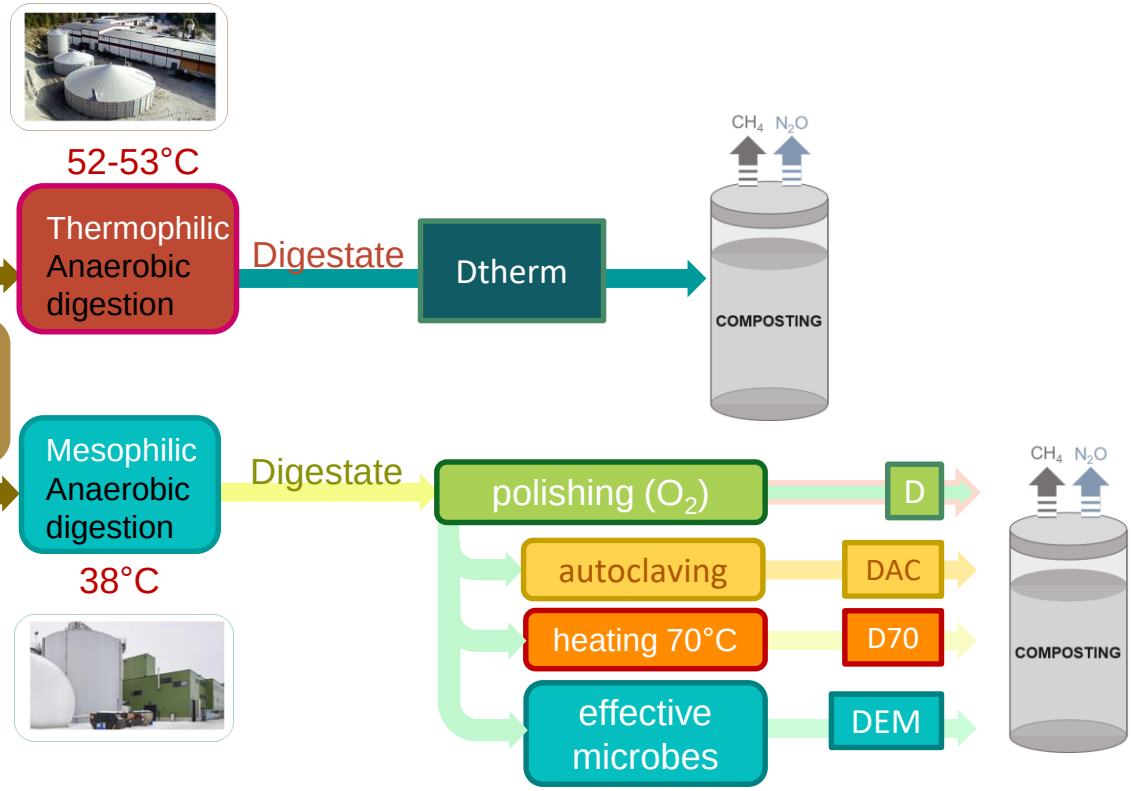
  Effective microorganisms



Same setup as in previous experiment!

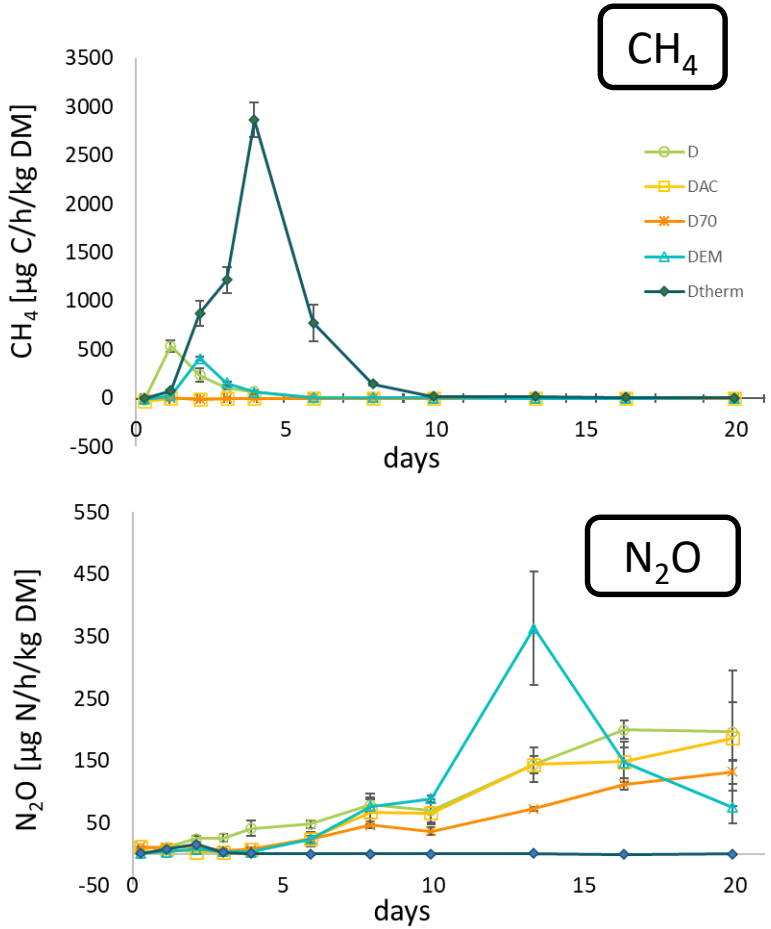
We believe that an adapted microbial community transferred from the anaerobic digestion to the compost process may be the reason for the enhanced methane emissions.
We are now carrying out a study to investigate this, as well as assessing some possible mitigation option.

Mitigation - GHG emissions from composting



All in all we had 5 different feedstocks:
Dtherm – solid digestate from the thermophilic process
D – solid digestate from the mesophilic process
DAC – autoclaved digestate
D70 – hygienised digestate (heated up to 70° C for one hour)
DEM – digestate where we added so called effective microbes.

Results – emission rates



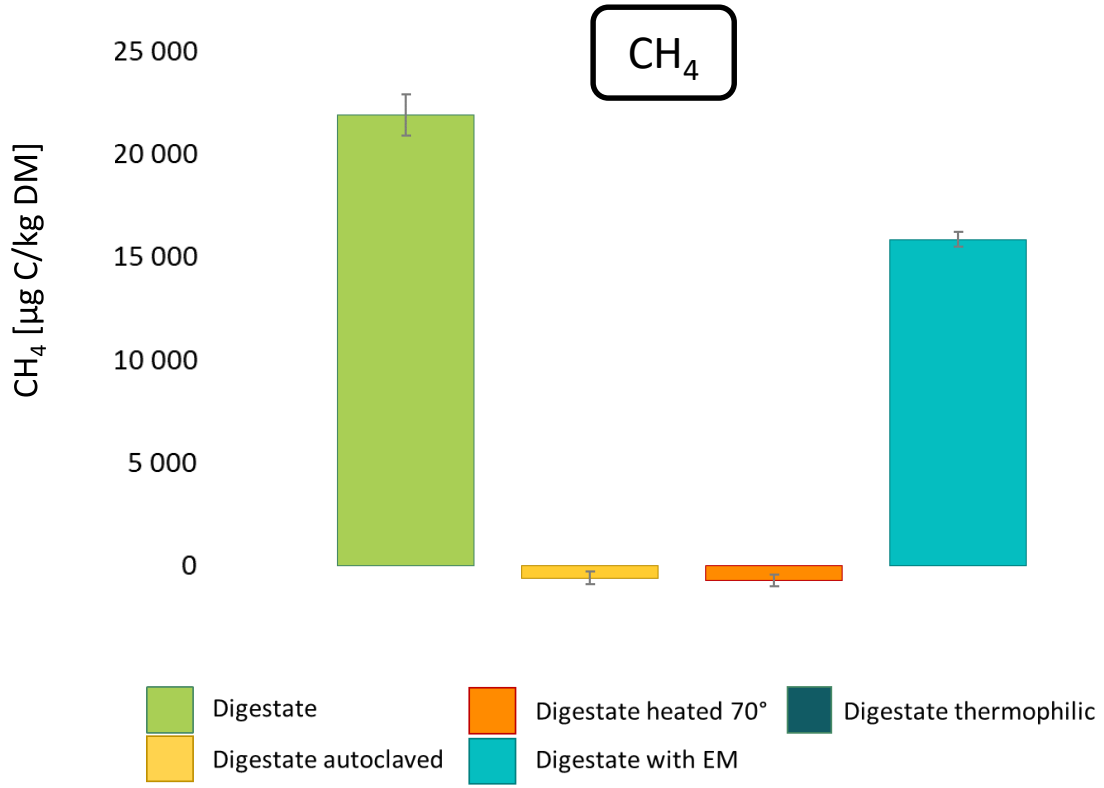
Digestate
Digestate autoclaved
Digestate heated 70° C
Digestate with EM
Digestate thermophilic

- Thermophilic gave higher and later peak
- Both autoclaved and heated to 70C had very low/no emissions
- Effect of effecive microorganisms was rather „delaying“ than „mitigating“

- Thermophilic: very low N2O emissions
- N2O emissions – increasing trend over time for the other

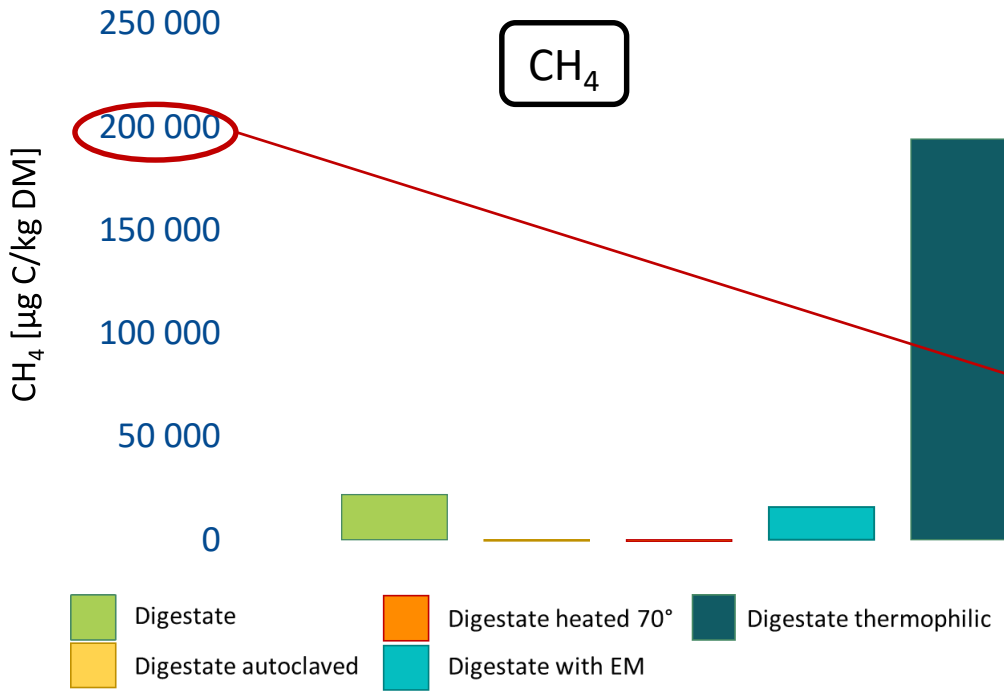
Digestate thermophilic showed a higher and later methane emission peak than D. The emission curve had similarities with the temperature curve: When T came down, methane emission did so too.

Results – cumulative emissions

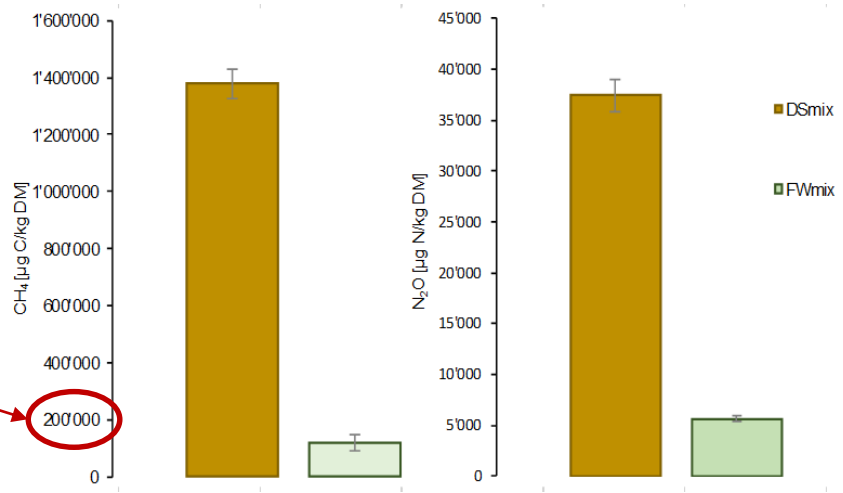


- Autoclaving: significant reduction
  ➡ **Methanogens caused emissions!** ✓
- Hygienization (70°): significant reduction!
  ➡ **Hygienization kills methanogens!** ✓
- EM: reduction but not significant!

Results – cumulative emissions



- Digestate thermophilic higher than mesophilic,…BUT: Digestate was polished

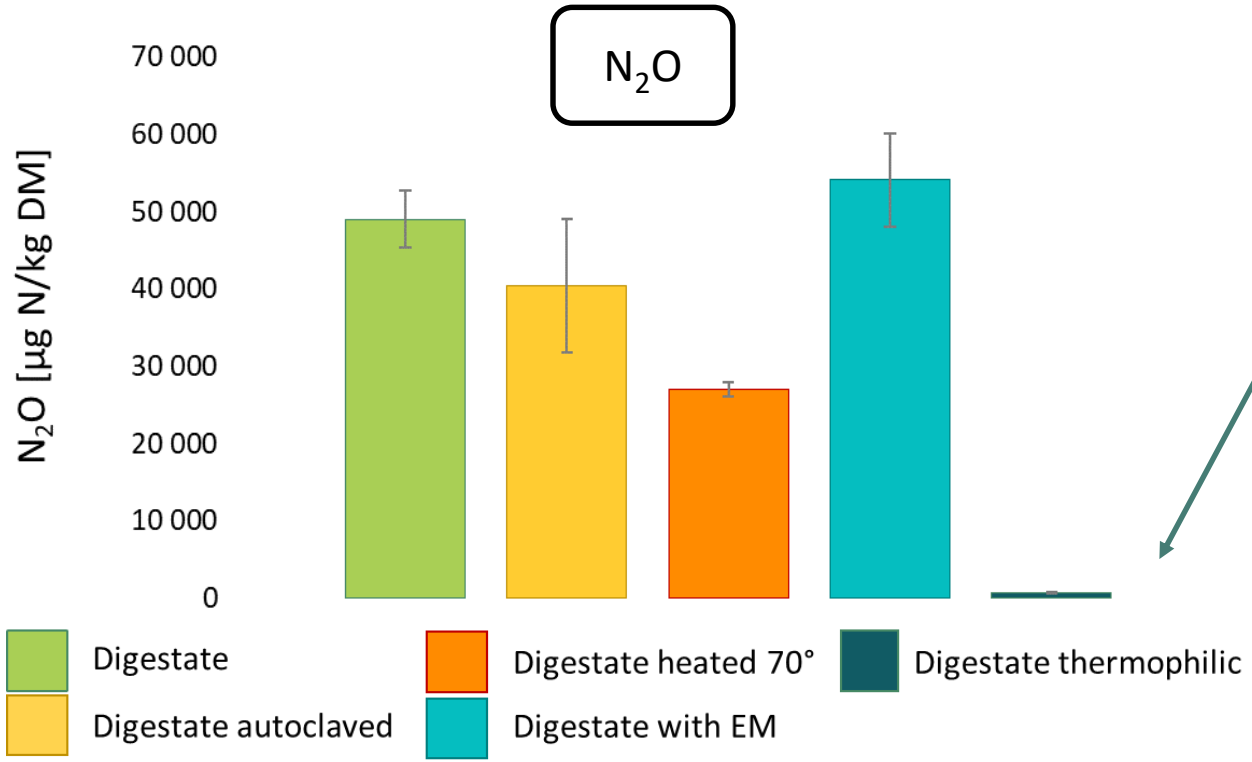


- Thermophilic methanogens produce less CH4 during composting than mesophilic ones ✓
  - ➡ Unfavourable conditions for thermophilic microbes

But we have to keep in mind that D was polished before, means that many of the methanogenic microbes were already inactivated or killed

-> So the composting process might offer unfavourable conditions for thermophilic microbes!

Results – cumulative N2O emissions



- Digestate thermophilic: very low N_2O emissions – significantly lower than from mesophilic, all treatments
- Emissions from digestate autoclaved higher than from digestate heated 70° - because more C was available after autoclaving?

Digestate thermophilic had very low N2O emissions!

Conclusions

- Application of digestate to soil cause N_2O emissions
- GHG emissions from application of composted digestate are ~0
- Composting cause GHG emissions, particularly CH_4
- Emissions are higher from composting digested food waste than from composting raw food waste
- Microbes imported from the digestion process are the main cause of high CH_4 emissions
- Hygensation of digestate (70C) kills relevant microbes effectively
- Effective microorganism may reduce emissions slighgtly
- Emissions from compsting digestate from a therophilic process are lower than from a mesophilic process
- Polishing, airarating digestate lowers emissions from subsequesnt composting

Romerike Biogas plant
Hadeland and Rigrike Biogas plant

Tormod Briseid
Carl Frisk
Torfinn Torp
Jan Erik Jacobsen
Ove Bergersen

The Research Council of Norway

Questions?

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THANK YOU!