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The effect of digestate on indigenous soil microbial communities and mesofauna diversity and activity

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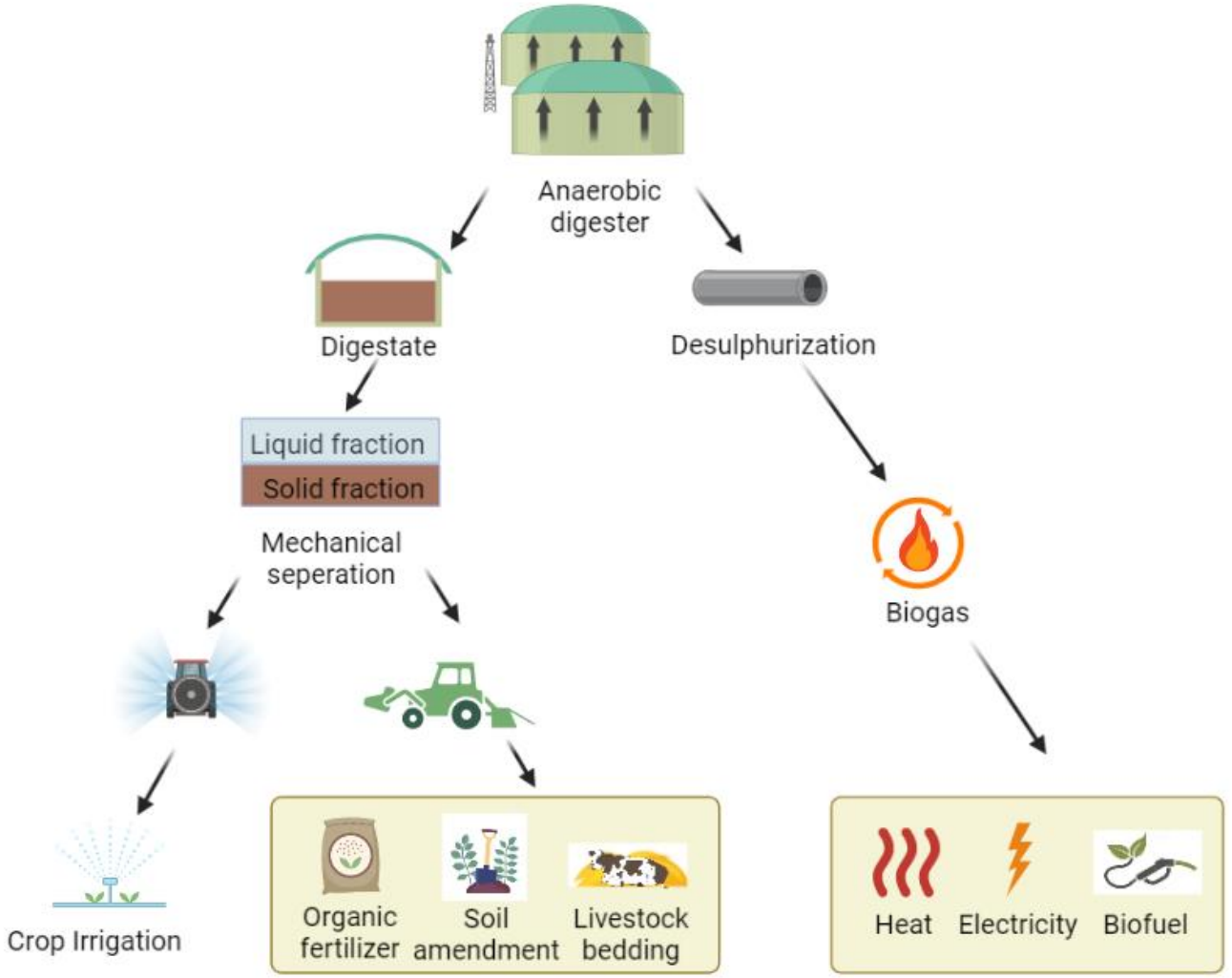
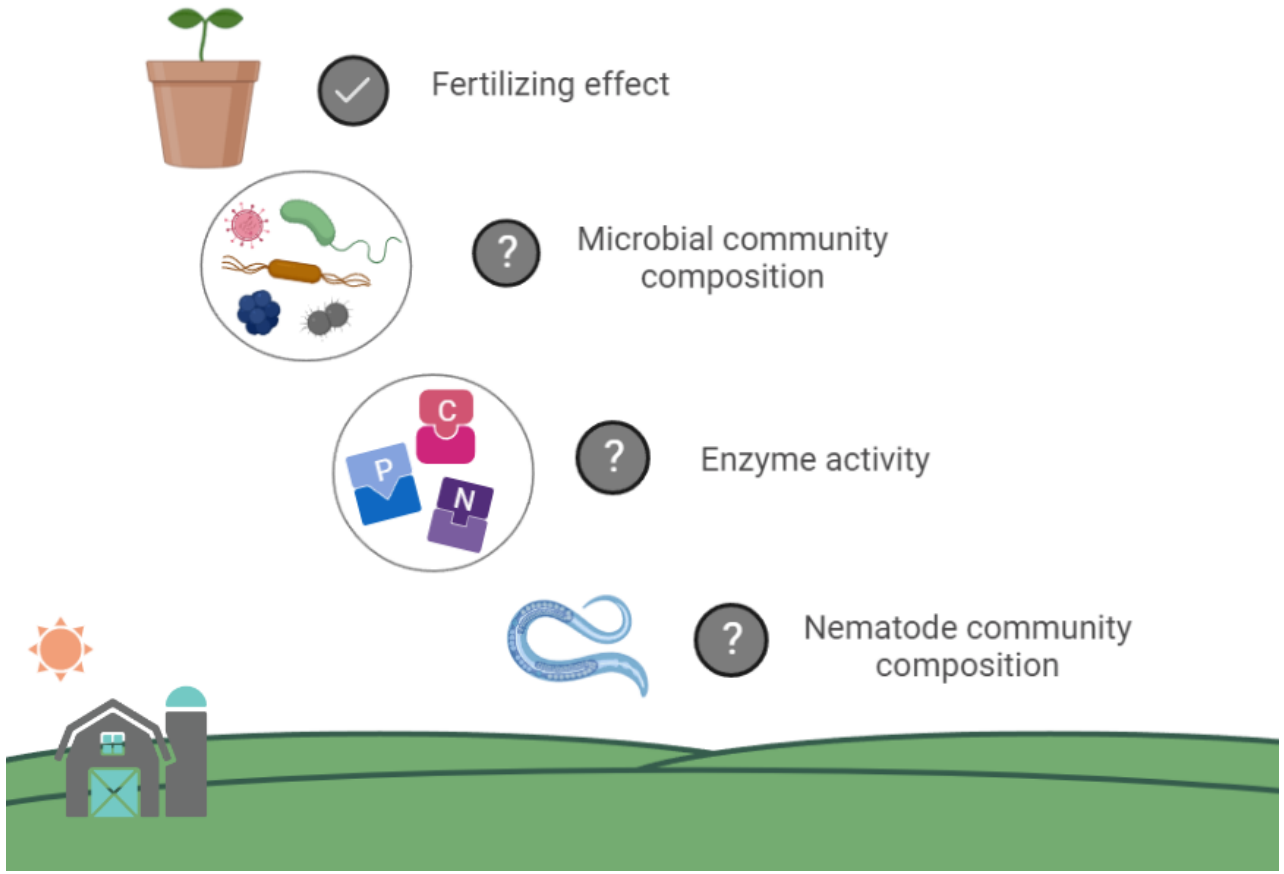
Digestate production & applications

- Anaerobic waste treatment plants produce a vast amount of by-product, called “**Digestate**”
- Rich in nutrients & low organic load
- In 2019 European Commission authorized its use as fertilizer component on crop lands.
- Characterization of the harmful or beneficial impacts on the environment is crucial

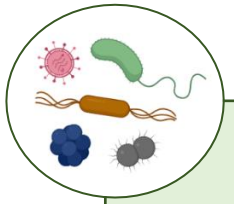


Impact of digestate on plant & soil health



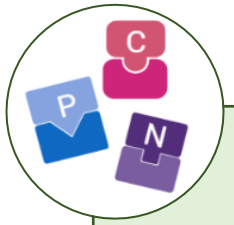
- Crop productivity increase (crop growth rates and yields).
- The impact on the whole **soil biological quality** is still unclear.
- The soil biological quality is defined as the capacity of a soil to host a large **quantity and diversity of organisms**
  - promote organic matter degradation
  - create barrier effect to pathogens
  - maintain the soil structure
  - reduce plant sensitivity to drought

Soil health parameters



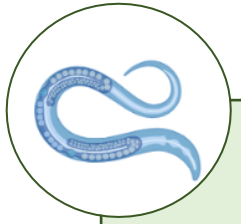
Microbial communities

- Actively participate in nutrient cycling, plant development and disease prevention.
- Few studies have been conducted that compare changes in soil microbial populations after digestate application.



Metabolic activities

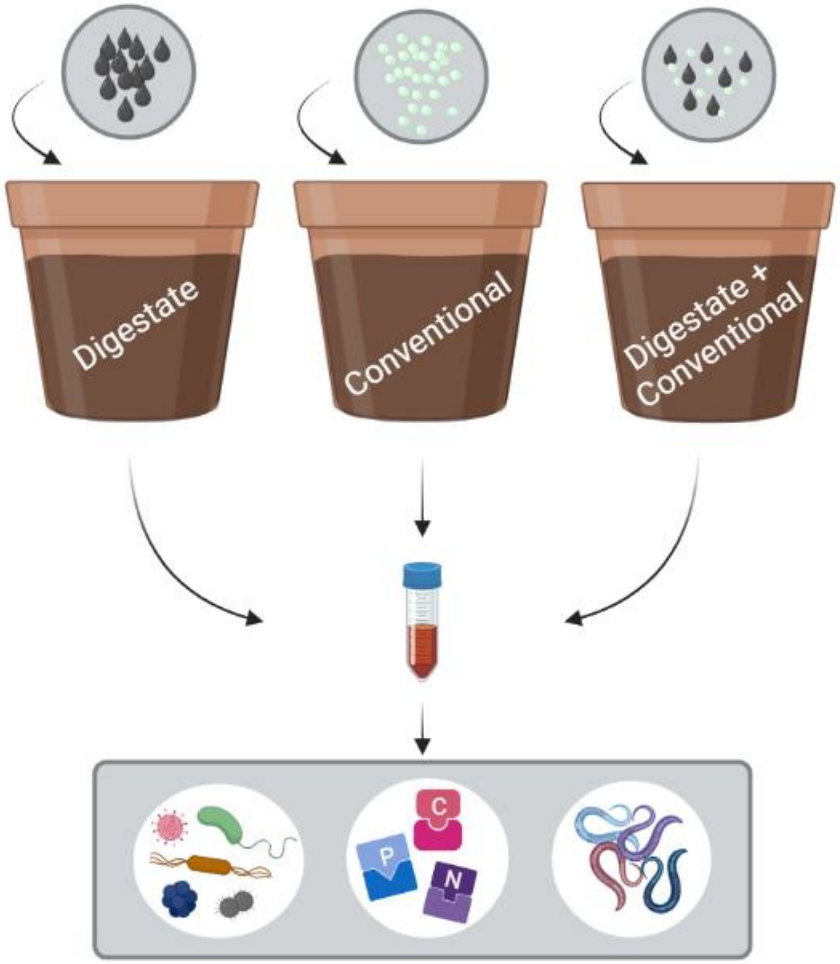
- The enzyme activity associated with the soil microbial communities is a key element.
- They mediate numerous chemical reactions involved in soil nutrient cycling.



Nematodes

- Neglected soil taxonomic group
- Prevalent metazoan in the soil biota
- Widely used as biological markers
- Reflect soil's physico-chemical conditions & the microorganisms that inhabit it

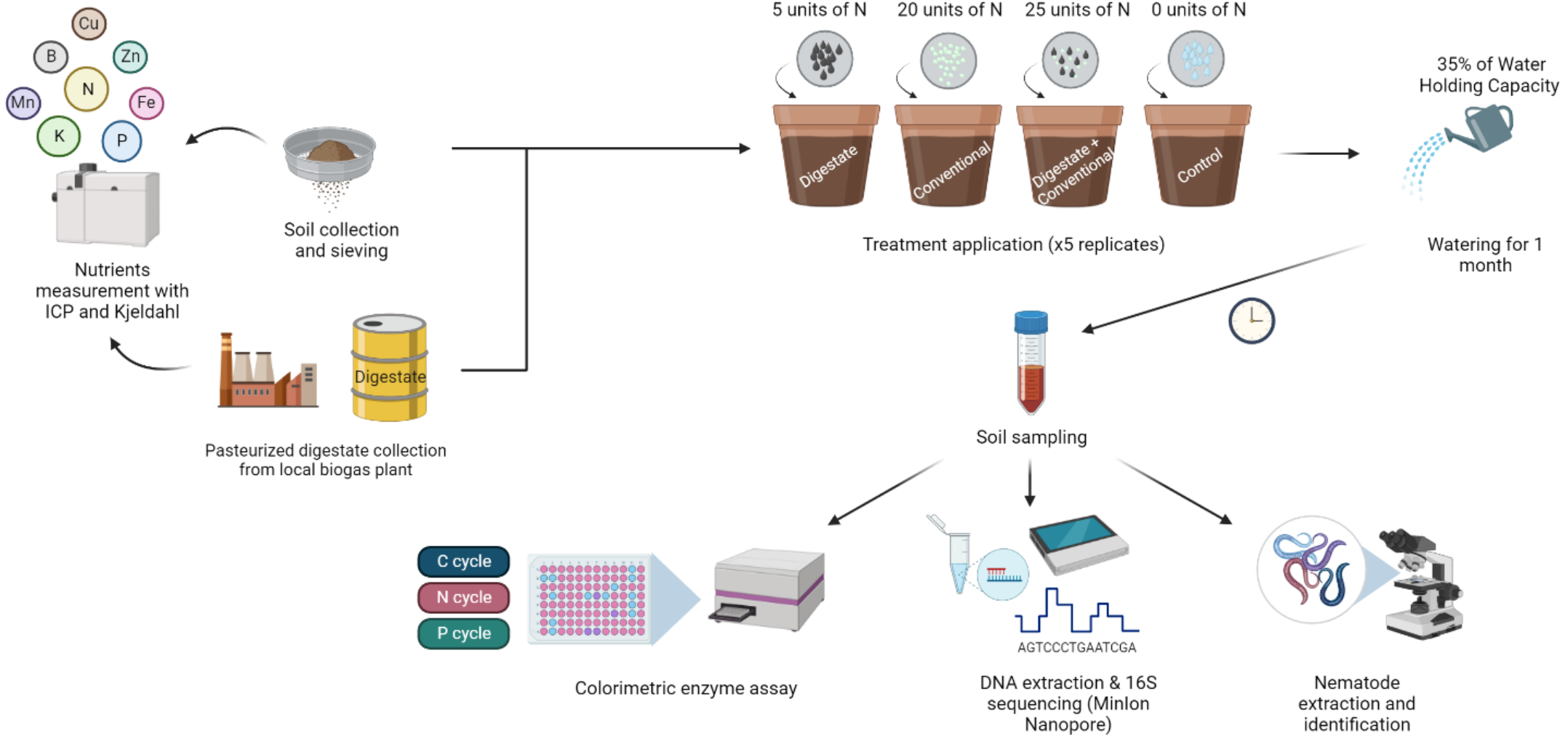
Aim & Objectives



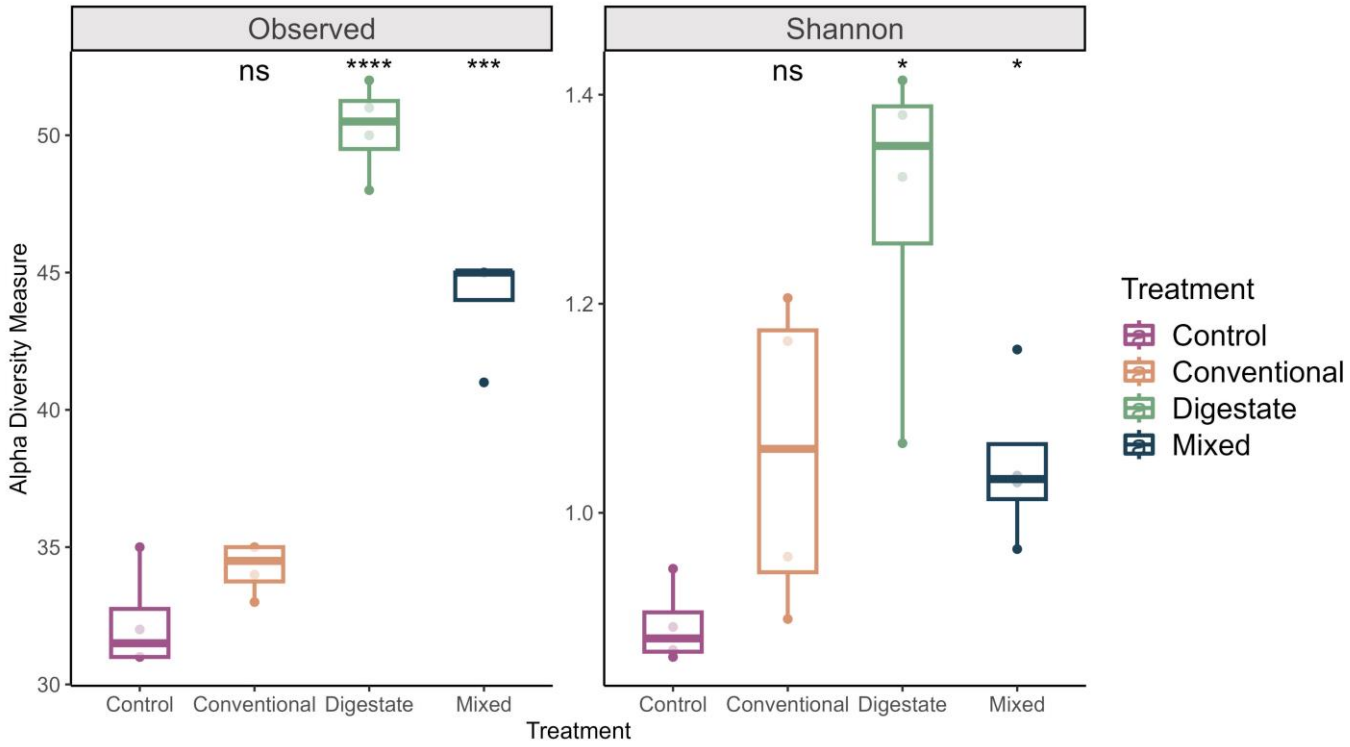
In depth investigation of the effect of **digestate application** on the soil in comparison with a **conventional fertilizer** and their **combination** not from a fertilization perspective, but in terms of

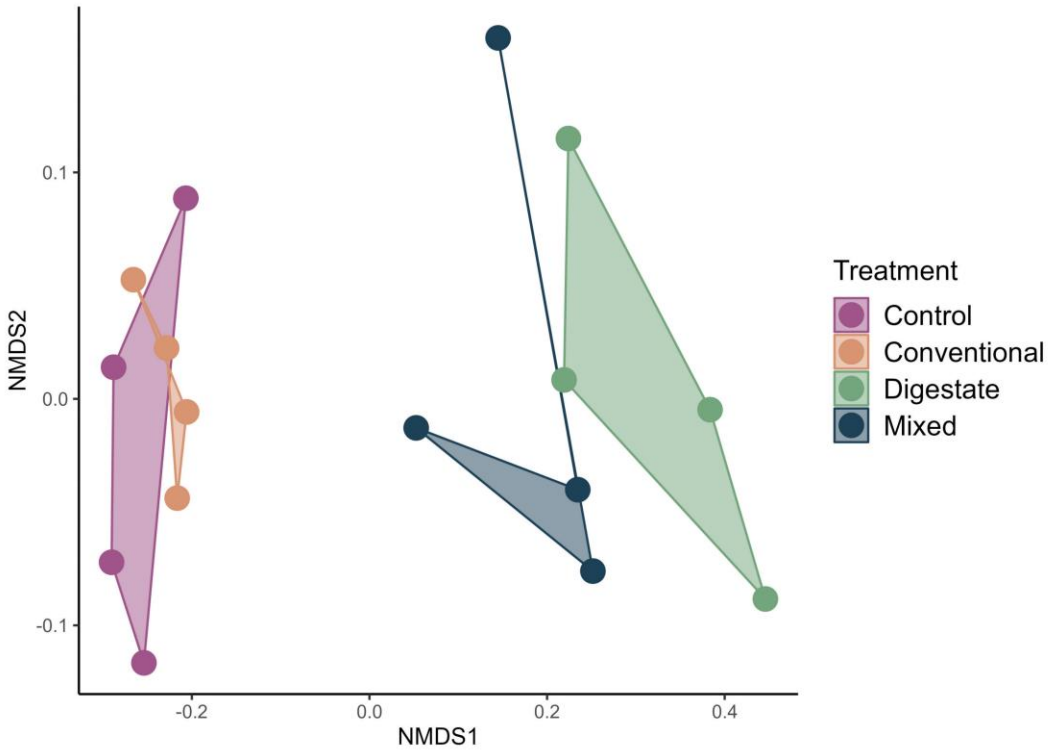
- microbial diversity
- nematode diversity
- enzyme activity

Experimental layout



Microbial community diversity & patterns





- In total 61 taxa >0.01% abundance identified
- Higher α-diversity indices in treatments with digestate and mixed fertilization
- Conventional fertilizer presented no differences with control

NMDS: Community similarities based on distances

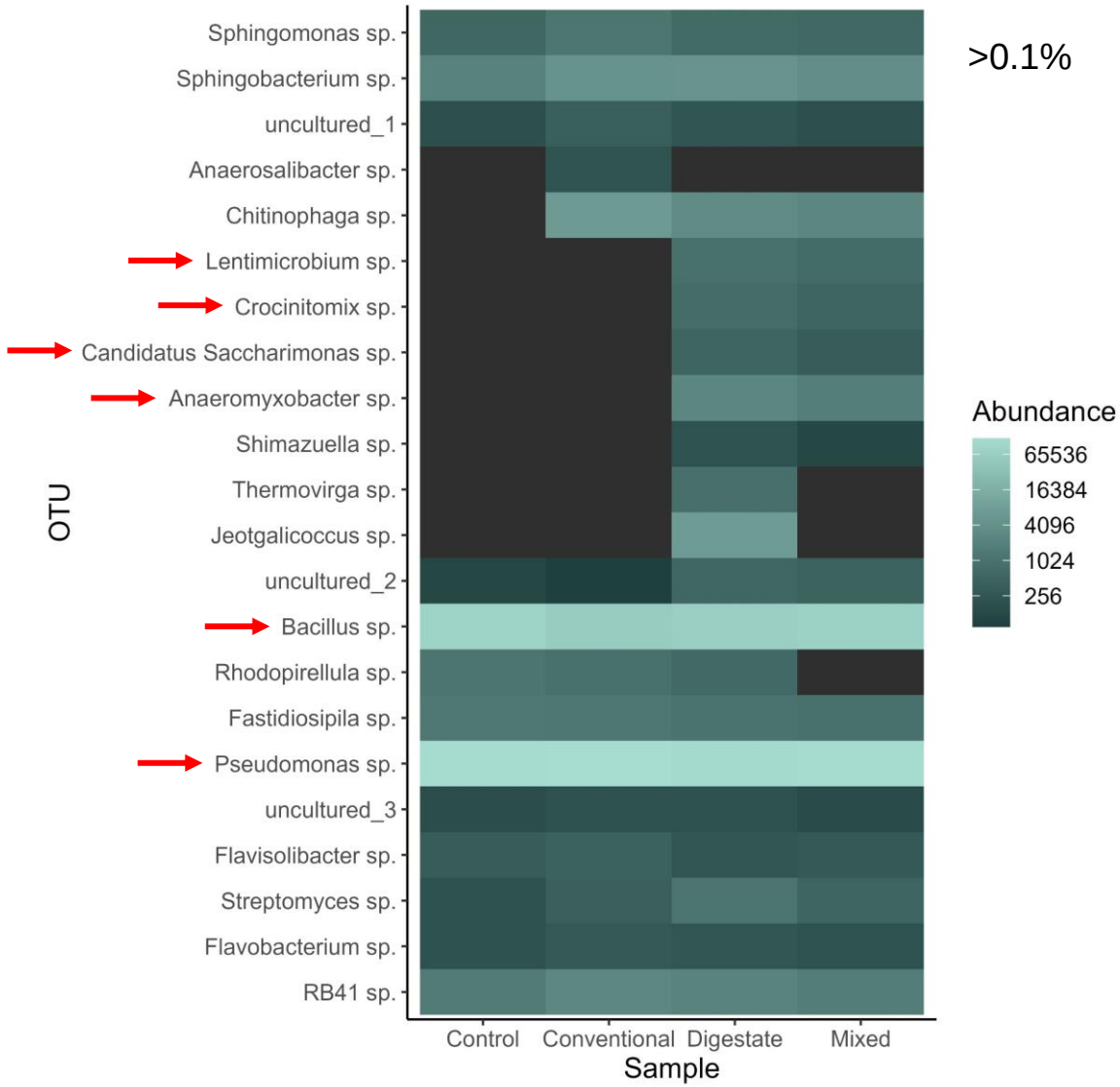
Conventional ≈ control

≠

Digestate ≈ mixed

Prevalent microbial taxa

- ***Bacillus*** sp. and ***Pseudomonas*** sp.: ubiquitous Plant Growth Promoting Bacteria (PGPB) in soil and make nutrients like P and Fe accessible - biocontrol agents.
- ***Anaeromyxobacter*** and ***Lentimicrobium*** genera: involved in N cycle and contribute to mitigation of N_2O emissions and removal of high concentrations of NO_3- from the soil.
- ***Candidatus saccharimonas*** sp.: positive correlations with metabolites involved in amino acid biosynthesis
- ***Crocinitomix*** sp.: produce catalase, an enzyme that protects cells from oxidative damage

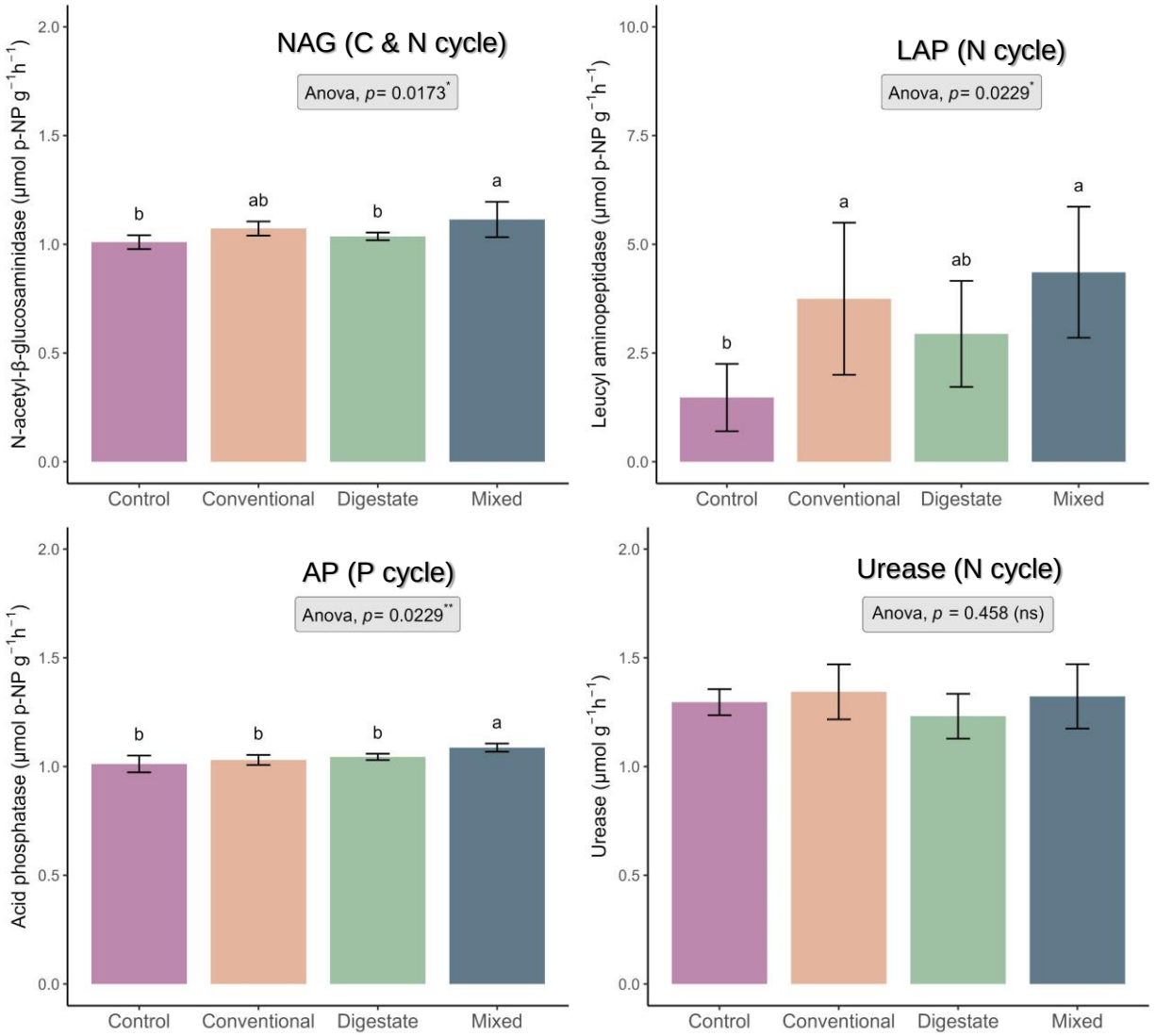


Enzyme activity

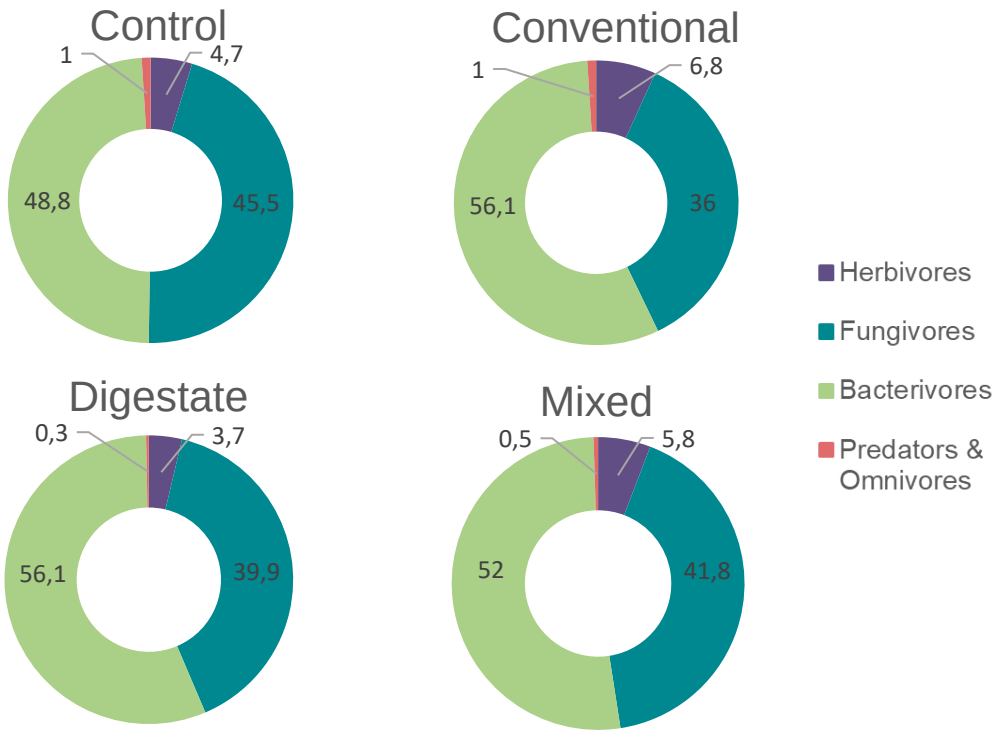
N cycle: Digestate treatment did not differ significantly from control and the other ammonia nitrate enriched treatments.

C cycle: Mixed treatment had the highest activity indicating higher depolymerization of organic substrates for assimilation of N.

P cycle: Mixed treatment had the highest activity indicating higher mineralization of P from soil organic matter.



Nematodes' community composition



- 17 genera in total
- Fertilization shifted community to bacterivores

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Bacterial over fungal dominance

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Easily degradable organic compounds in fertilized soils

- Herbivores' abundance was reduced after digestate application
- A group that causes major problems to crops and is difficult as well as expensive to control.

Conclusions

- **Digestate application** either alone, either as a complement to conventional fertilizers induced **higher biodiversity indices**, introducing **new genera to the soil biota** that participate in nutrient cycling, amino-acid biosynthesis and in the protection from abiotic stress.

- Soils fertilized with **digestate** as an **exclusive** nutrient source presented the **same enzyme activity** with conventional fertilized soils with even higher nutrient inputs.

- **Herbivore nematodes-** which are common and **harmful pests** for crops- were **suppressed** after **digestate application**, something that was not observed in the other fertilizing treatments.

Potential applications & future research

- Applications:
  - Use of digestate as a **soil conditioner** for the **restoration** of intensively exploited areas
  - **Basal fertilization** of fields before cultivation for the microbial enrichment of the soil

- Future research:
  - Project upgrade to pilot maize crops to take into account the **plant effect** on a **large-scale soil biocommunity** and vice versa.

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