Treatment and valorisation of HTL waters via AD

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Overview

AD is a widespread technology to convert organic (waste) streams to energy and soil conditioner

Feasibility of (co-)digesting HTL Process water in AD

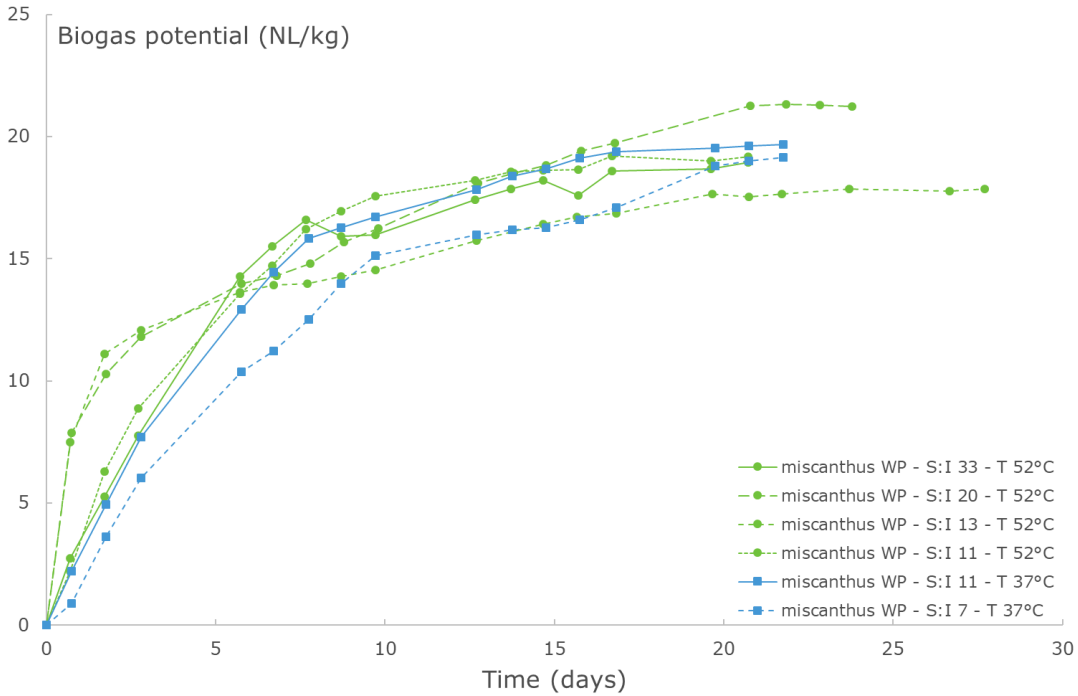
- ***Phase 1: Characterisation and batch tests***
- ***Phase 2: (semi-)continuous tests***
- ***Phase 3: Ecotoxicity***

Phase 1 AD-tests: characterisation and batch tests

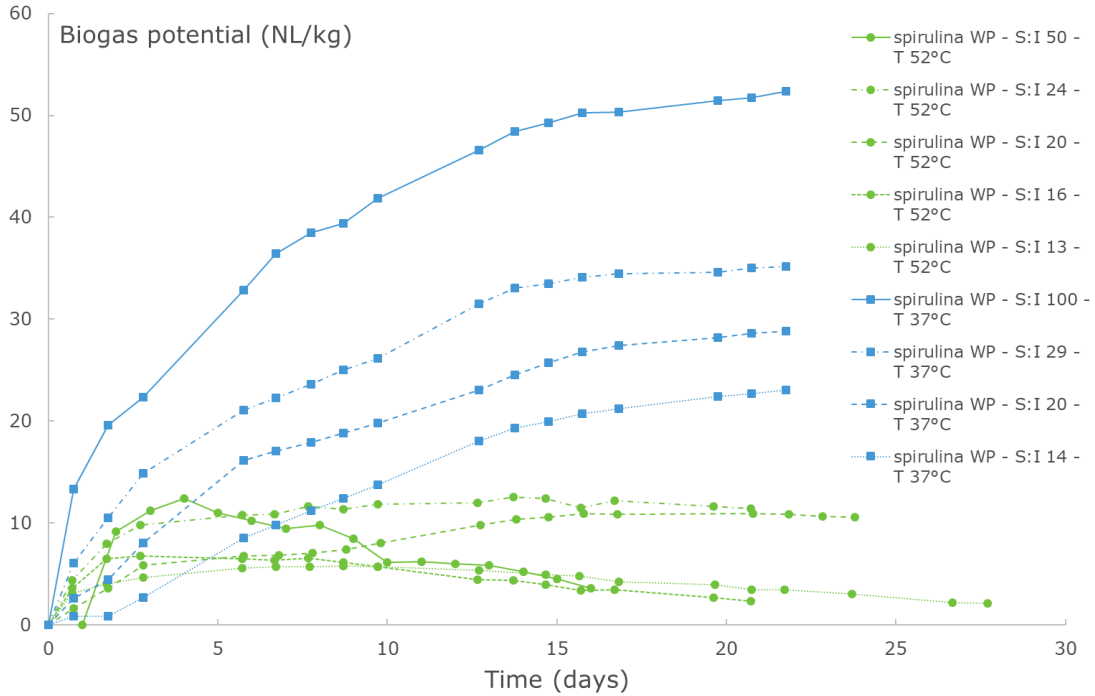
- *21 samples of HTL process water tested*
- *Derived from several organic sources: Spirulina (8), sludge (6), Miscanthus (3), mix Miscathus/sludge (1), corn stover (1), manure (1) and pine (1)*
- *Characterisation: analyses of COD, carboxylic acids, nutrients (NPK) and heavy metals…*
- *Biogas production potential in batch test*
- *Both thermophilic (52°C) and mesophilic (37°C) tests*
- *Different substrate to inoculum ratios (S:I)*
- *Effect of filtration of HTL-water*

Phase 1 AD-tests: characterisation and batch tests

- ***Miscanthus HTL water***
  - **Good biogas potential**
  - **No effect of temperature**
  - **No effect of S:I ratio**

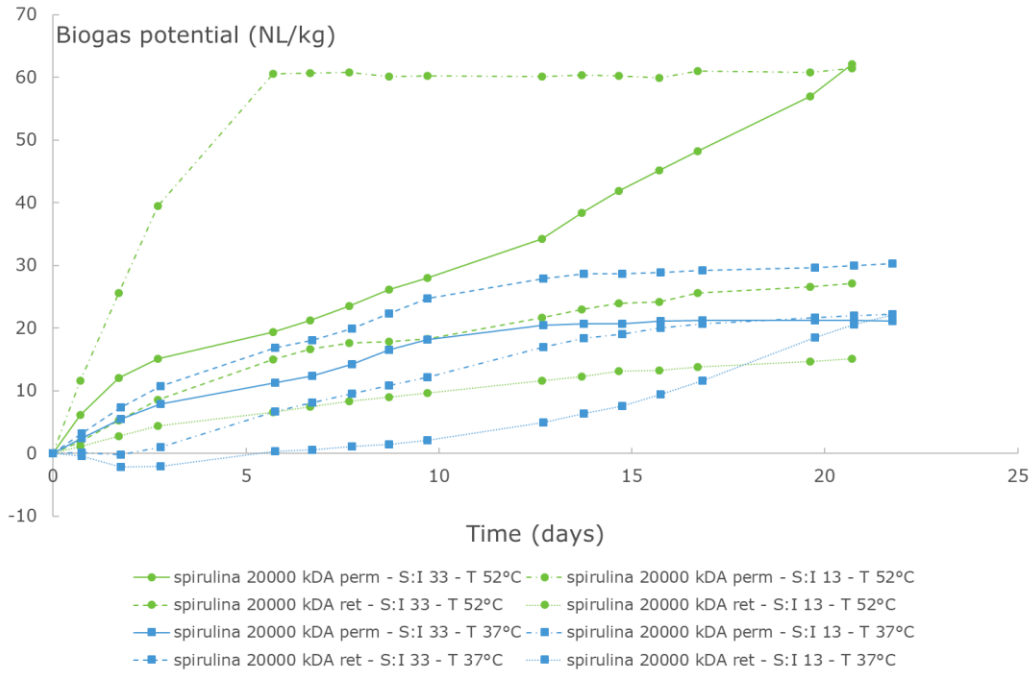


- ***Spirulina HTL water***
  - **Important effect of temperature: more biogas at 37°C, less at 52°C**
  - **Clear effect of S:I ratio**

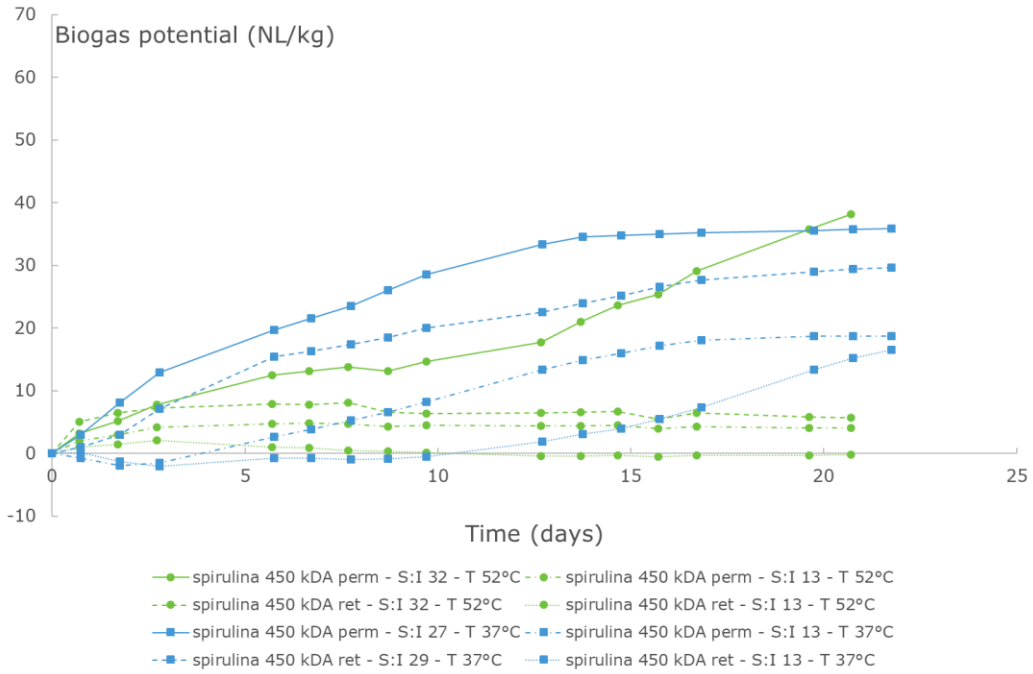


Phase 1 AD-tests: characterisation and batch tests

- **Spirulina HTL water 20 kDa**
  - Best result in permeate at 52°C
  - No clear effect at 37°C
  - Clear effect of S:I ratio
  - Both permeate and retentate perform better



- **Spirulina HTL water 450 kDa**
  - Highest biogas production in permeate
  - Highest values at 37°C
  - Clear effect of S:I ratio



Phase 1 AD-tests: characterisation and batch tests

Conclusions phase 1:

- ***Fairly low biogas production (though in line with TS and VS content)***
- ***High levels of K may adversely effect digestion process on the long term***
- ***Often inhibition, especially N-rich products (Spirulina, sludge, manure)***
- ***HTL resulting from lignocellulosic materials (Miscanthus, pine, corn stover) most promising, also for mono-digestion***
- ***Co-digestion seems a feasible way to process HTL waters***

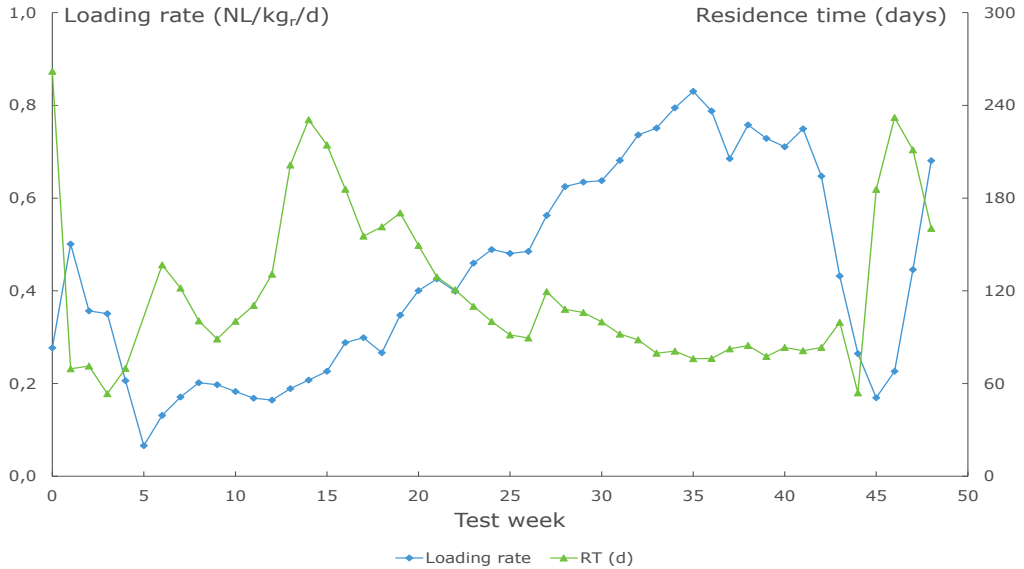
Phase 2 AD-tests: Semi-continuous tests

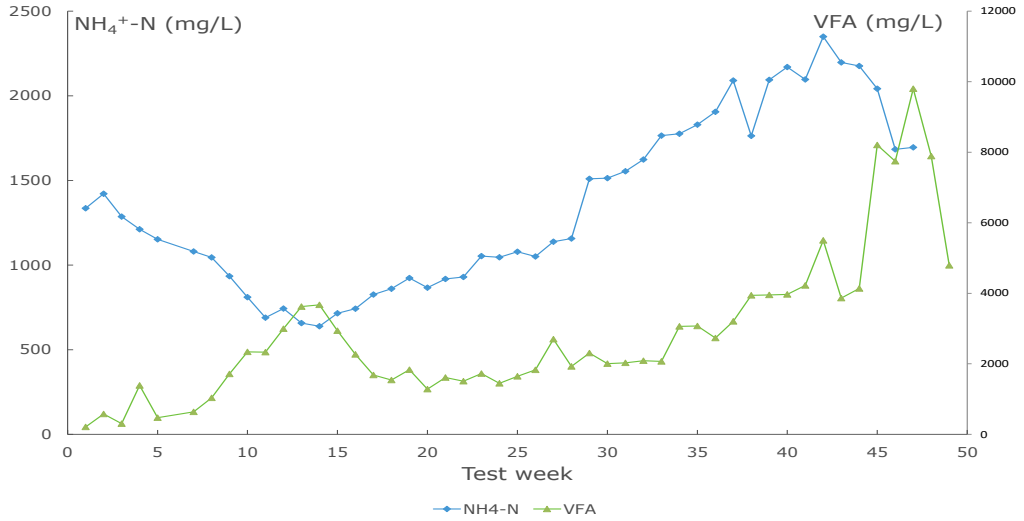
- ***Continuous fermentation test (feeding 3 times per week)***
- ***Long term effects (deficiency, toxicity), loading rate etc…***
- ***6 reactors***
  - **Miscanthus HTL water (+ chicken manure)**
  - **Miscanthus HTL water + household organics**
  - **Spirulina HTL water + household organics**
  - **Sludge HTL water + household organics**
  - **Miscanthus HTL water + Spirulina HTL water + household organics**
  - **Miscanthus HTL water + Spirulina HTL water + Sludge HTL water + household organics**

Phase 2 AD-tests: Semi-continuous tests

- ***Miscanthus HTL water***
  - **Mono-digestion not possible (nitrogen deficiency)**
  - **With addition of N-source (in this case 15-15% chicken manure): improved process stability**
  - **Good methane content**
  - **All in all limited loading rate; max 0,8 NL/kg_r/d**
  - **Sensitive to process disruptions**

→ negative impact on process economics

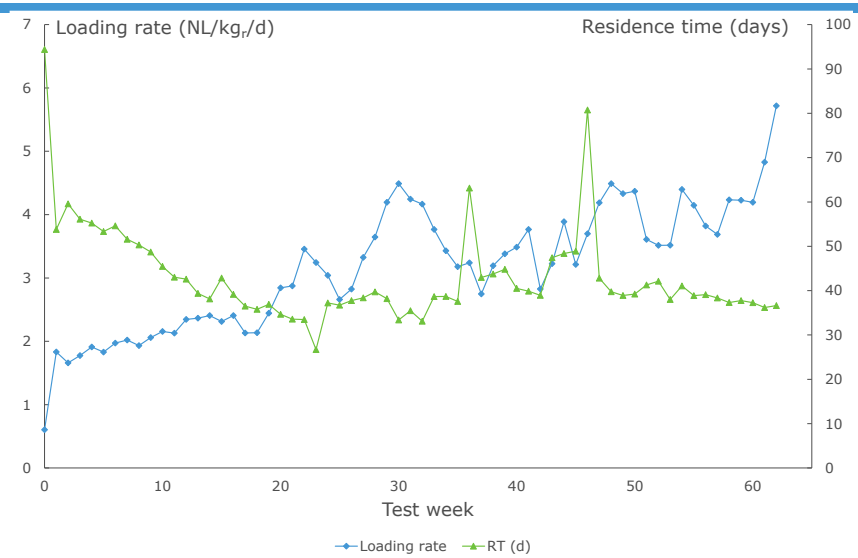


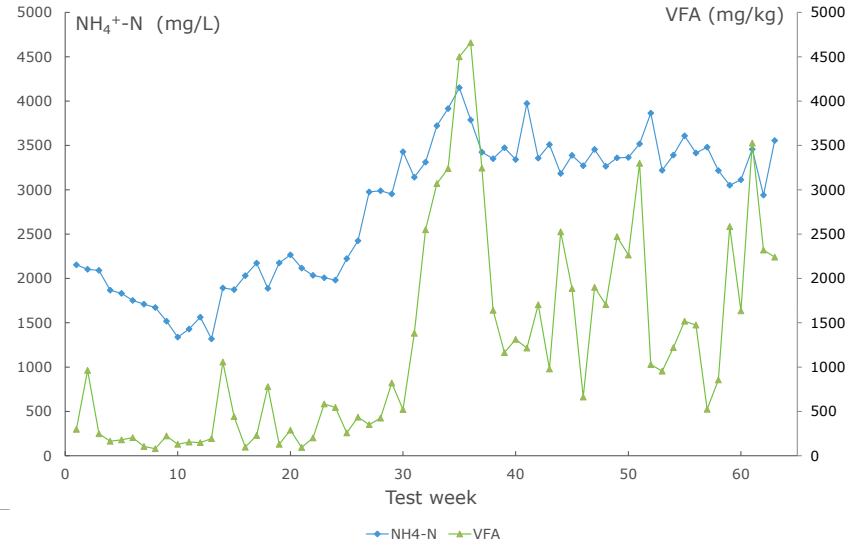


Phase 2 AD-tests: Semi-continuous tests

- ***Miscanthus HTL water + household organics***
  - **Relatively stable process, N-source needed (3-5% chicken manure)**
  - **Some VFA build-up at higher loading rate, but not alarming**
  - **Moderate loading rate: 4-4,5 NL/kg_r/d**
  - **Good methane content**

→ Miscanthus HTL water can be used as addition in the AD of dry (and N-rich) substrates, relatively high doses (34% of input mixture)





Phase 2 AD-tests: Semi-continuous tests

Conclusion phase 2:

- ***Non of the HTL-waters are digestible as a sole substrate***
- ***All of them can be used as co-substrate (e.g. biowaste), depending on the type of HTL water less or more can be dosed***
- ***Relatively high concentrations of Miscanthus HTL-water can be used without problems***

→ AD is possible but challenging

Phase 3 Ecotoxicity

- ***Effect of degradation products on plants and soil organisms***
- ***Required for application in soil (digestate and substrates)***

- ***Plants: barley and cress***
- ***Soil organisms: earth worms***
- ***Nitrification test: soil microorganisms***

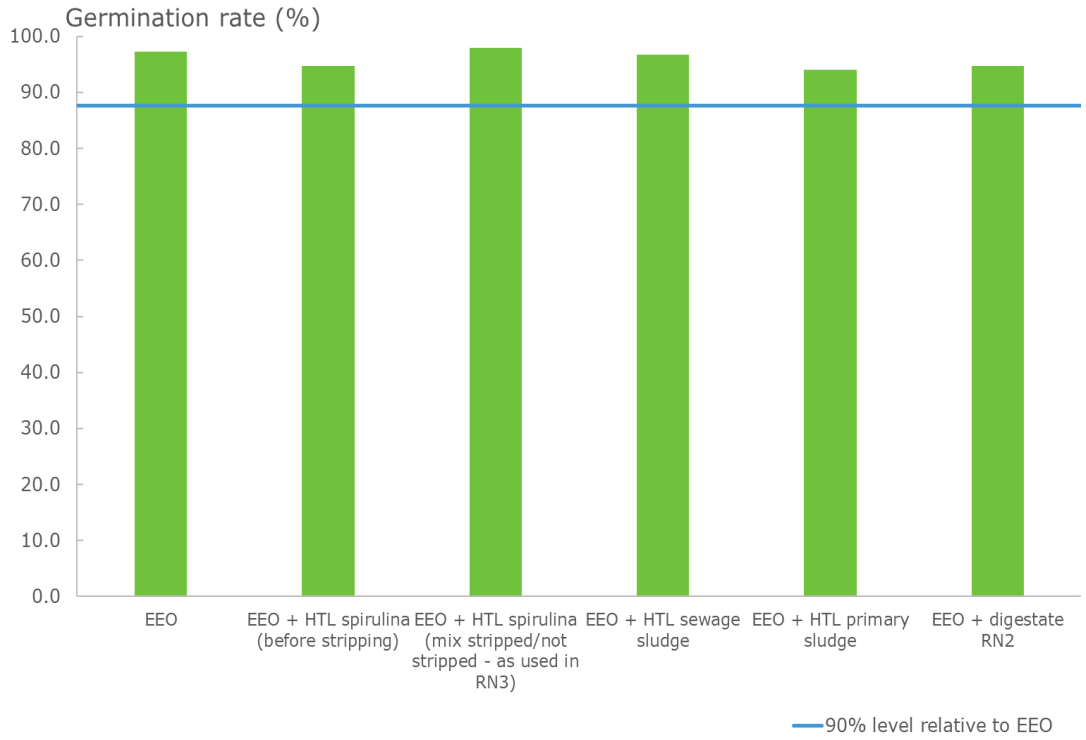
- ***Substrates as well as digestate tested***

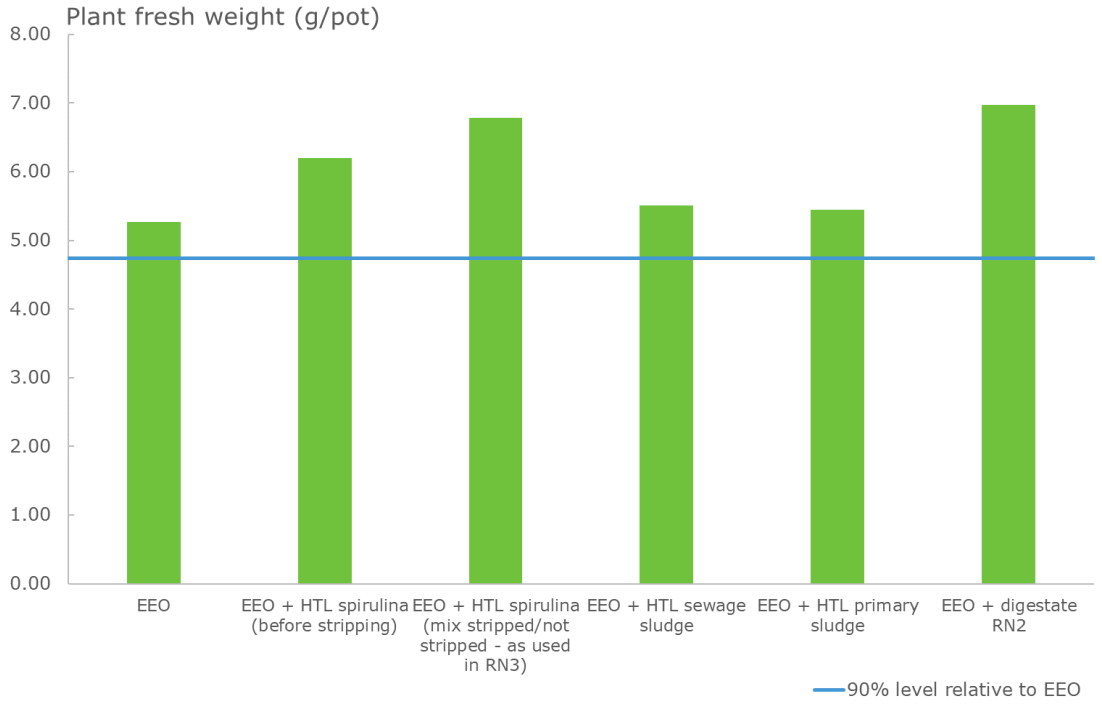
Phase 3 Ecotoxicity

- ***Plant tests:***
  - **Reference substrate (70% peat + 30% clay) + substrate or digestate**
  - **Substrate or digestate added to correspond with the addition of 170 kg of N per 10 000 m² (standard N fertilizer addition used in BE)**
  - **Two model organisms: Barley (monocotylous) and Cress (dicotylous)**

- ***Example: Barley tests with different HTL-waters and digestate from co-digestion of Miscanthus HTL water and household organics***

Phase 3 Ecotoxicity

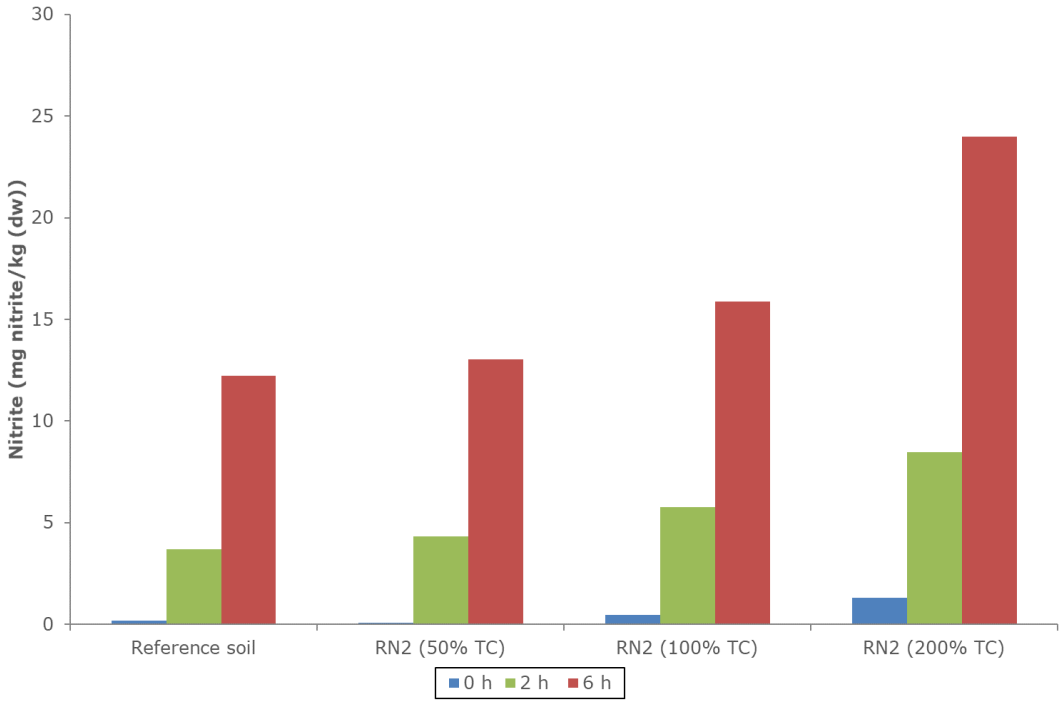




Phase 3 Ecotoxicity

- ***Micro-organism tests:***
  - **Reference substrate (70% peat + 30% clay) + digestate**
  - **Target concentration (TC): 56,7 mg N/kg soil**
  - **50% TC, 100% TC and 200% TC**

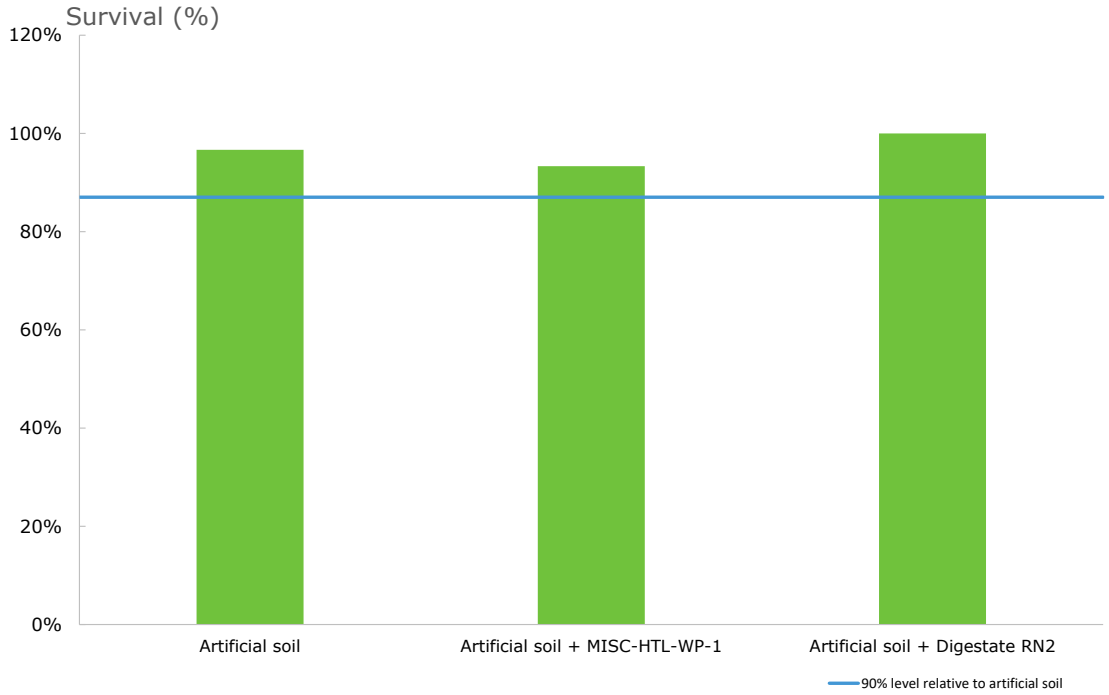
- ***Example: digestate from Miscanthus HTL water + household organics***

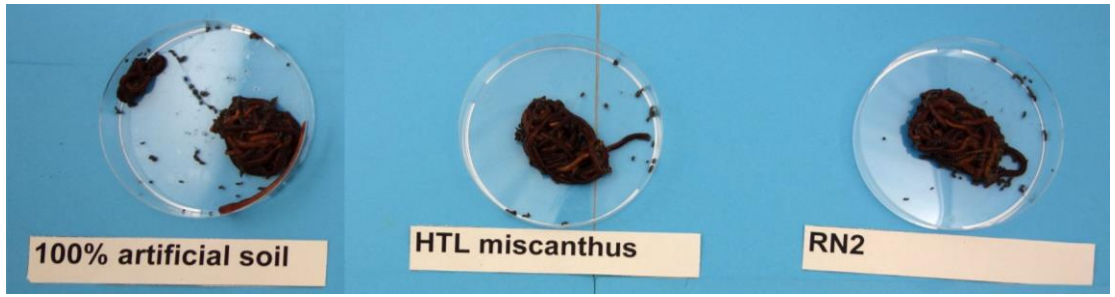


Phase 3 Ecotoxicity

- ***Earth worm tests:***
  - **Artificial soil + substrate/digestate**
  - **TC: 56,7 mg N/kg soil**
    note: for liquid subtrates this would result is unrealistically high doses, therefore, doses were reduced 5-fold

- ***Example: Miscanthus HTL water and digestate from Miscanthus HTL water + household organics***





Phase 3 Ecotoxicity

Conclusions Phase 3:

- ***No adverse effects were seen on plants, earth worms or microorganisms***
- ***Often positive effects on plant growth were seen (addition of nutrients***
- ***More testing needed***

Thank you!

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