MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

CREATING A CIRCULAR FUTURE

How to gradually acclimate MELiSSA's nitrification compartment to urine mixed with VFA-rich anaerobic digestion (C1) effluent

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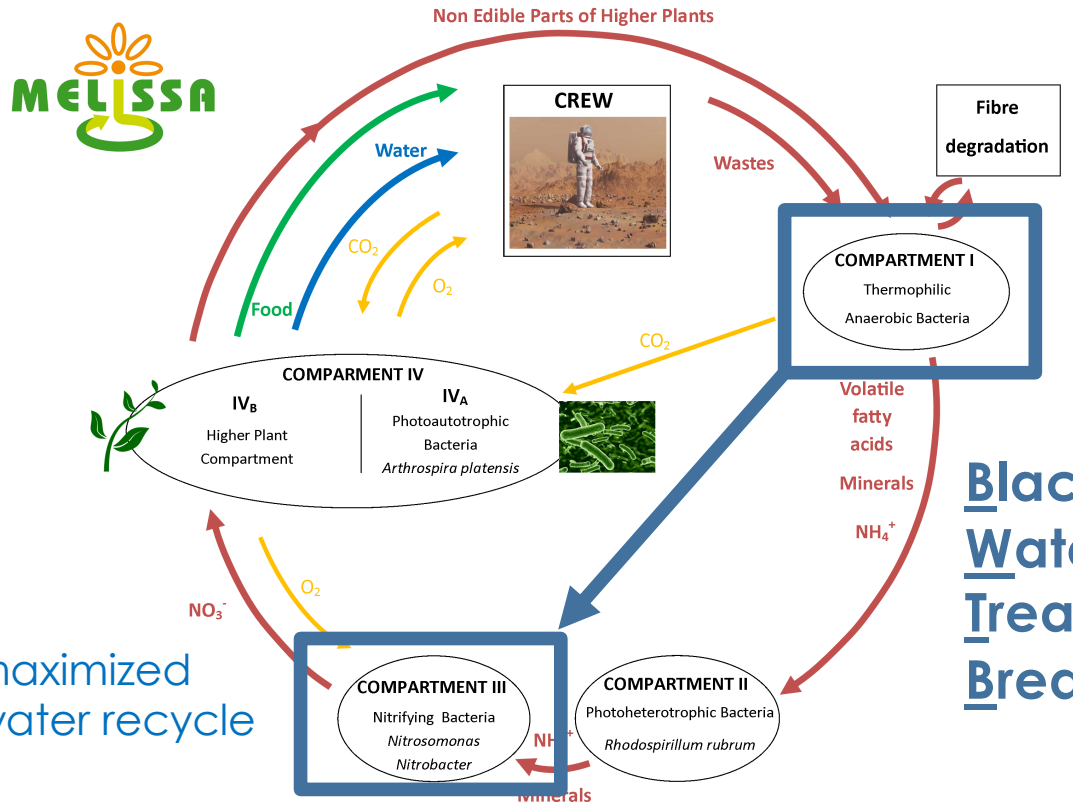
Problem statement & Space relation

Micro-Ecological Life Support System Alternative

Kitchen waste
Black water
Yellow water

→ maximized water recycle



Black Water Treatment Breadboard

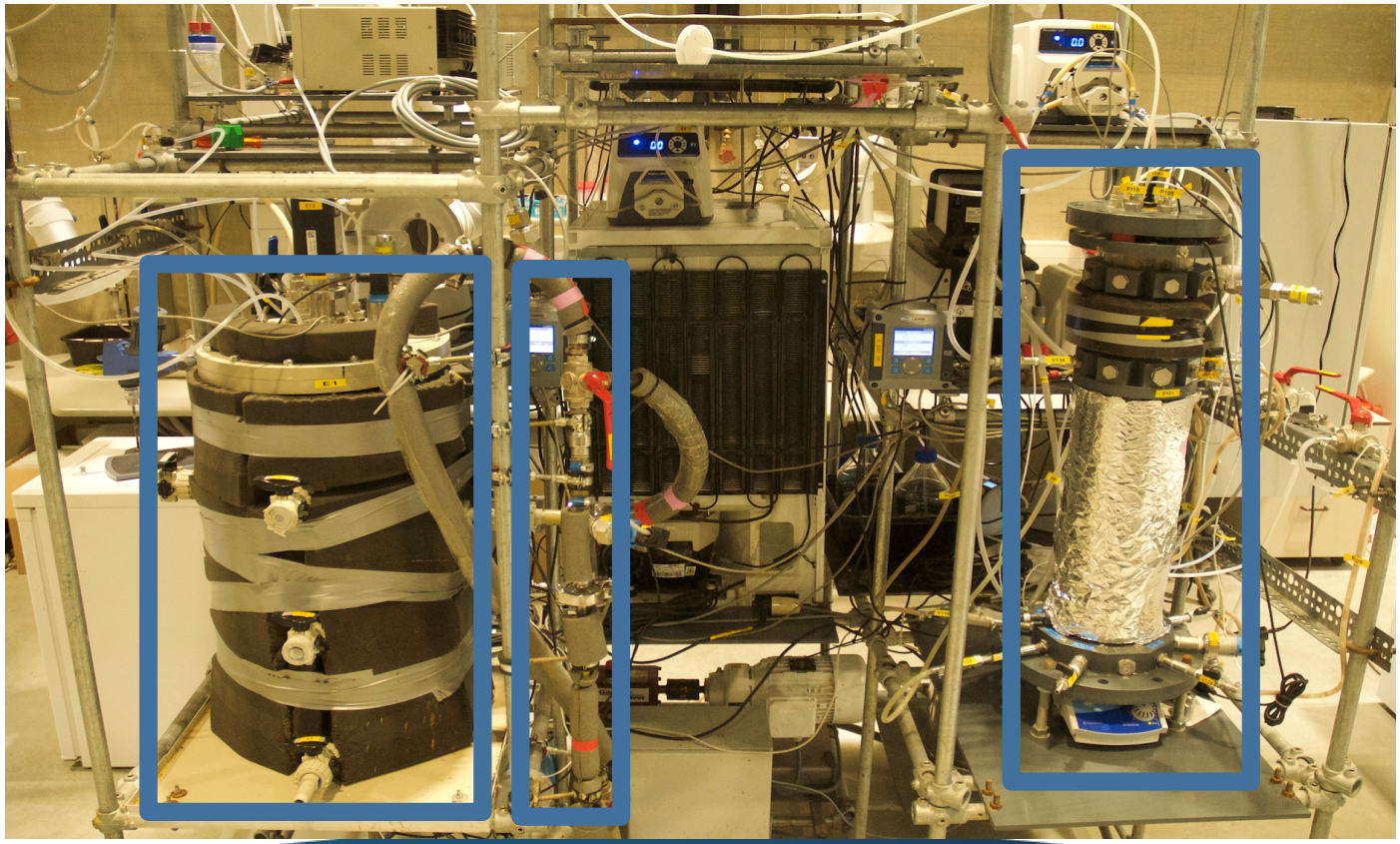
Solution = BWT Breadboard

anaerobic membrane bioreactor (ALSS/C1)

black water/ kitchen waste

CO_2

organic acids (VFA)



nitrification reactor (NSS/C3)

urine

NH_4^+

NO_3^-

organic acids (VFA)

CO_2

Solution = BWT Breadboard

- **general goals**
  - digestion of waste (water) produced by 1/4th of person per day
  - direct coupling of anaerobic membrane bioreactor to nitrification reactor

- **anaerobic membrane bioreactor goals**
  - treatment of waste 1/4th person = 2.5 L/day & 48 g DM/day
  - steady state approximating performance of previous run at MPP
  - carbon balance & conversion efficiency

- **nitrification reactor goals**
  - treatment of waste 1/4th person = 350-400 mL urine/day & 3 g N/day
  - coupling: organic effluent + urine (4:1 composition) to nitrification reactor
  - balance of heterotrophic and nitrifying bacteria (mixed non-axenic cultures!)

Activity description

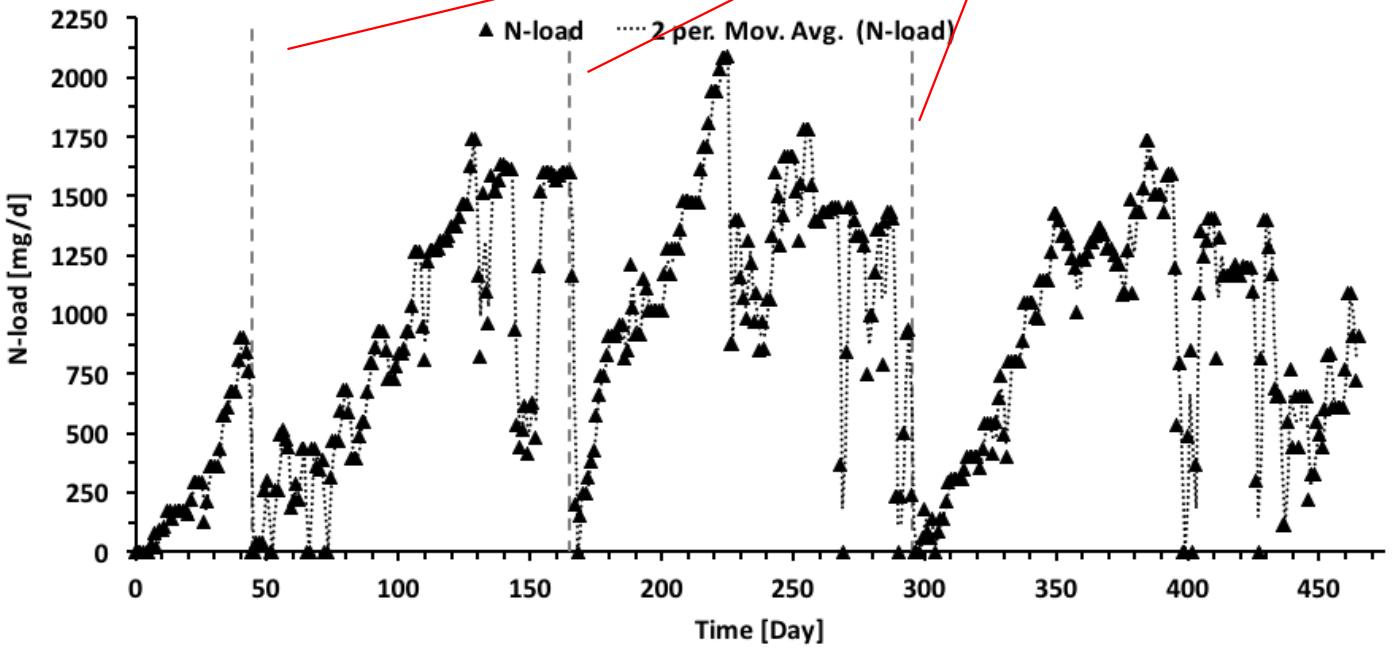
NITRIFICATION REACTOR

Results nitrification reactor

Packed bed configuration

- Biostyr styrofoam beads
- 6 L beads & 3.7 L reactor fluid
- Surface area = 5.27 m^2

Gradual increase in N-loading needed to be restarted after technical issues.



Results nitrification reactor

Packed bed configuration

- Biostyr styrofoam beads
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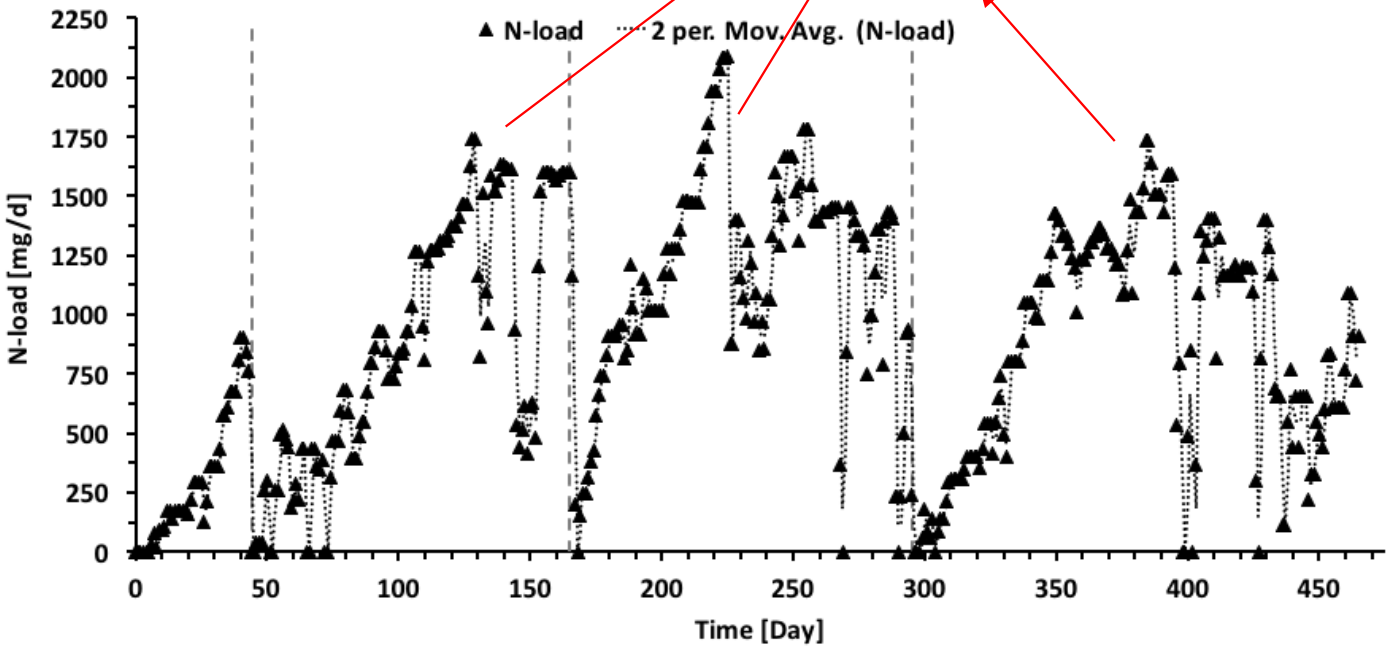
- Surface area = 5.27 m^2

No further (urine) N-loading increase possible due to oxygen transfer limitations



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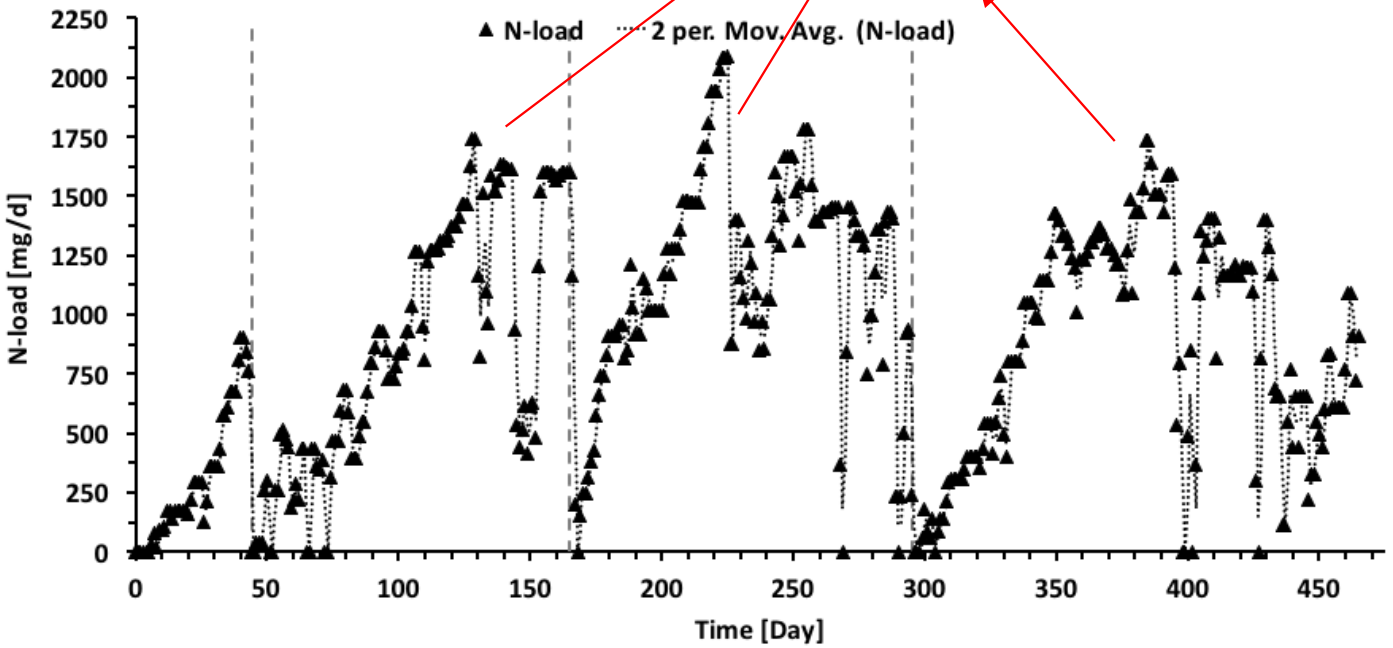
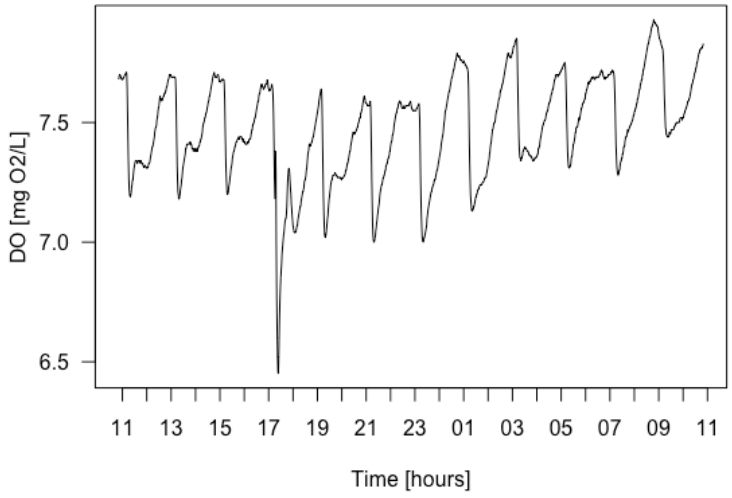


Results nitrification reactor

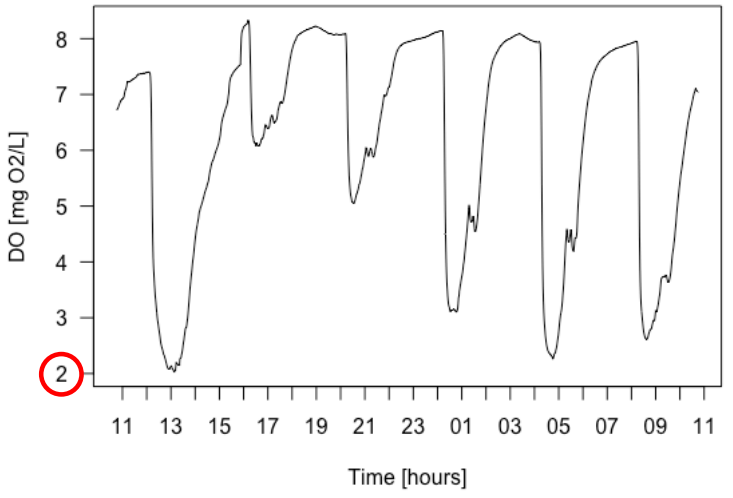
Good oxygen recovery

- Fed 12 times a day (once every 2 hours)
- Fast recovery
- Small drop in oxygen concentration



Bad oxygen recovery

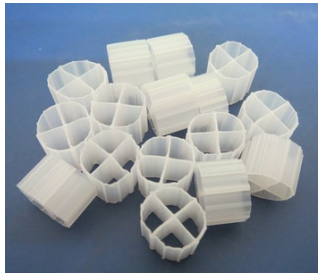
- Fed 6 times a day (once every 4 hours)
- Slow recovery
- Large drop in oxygen concentration

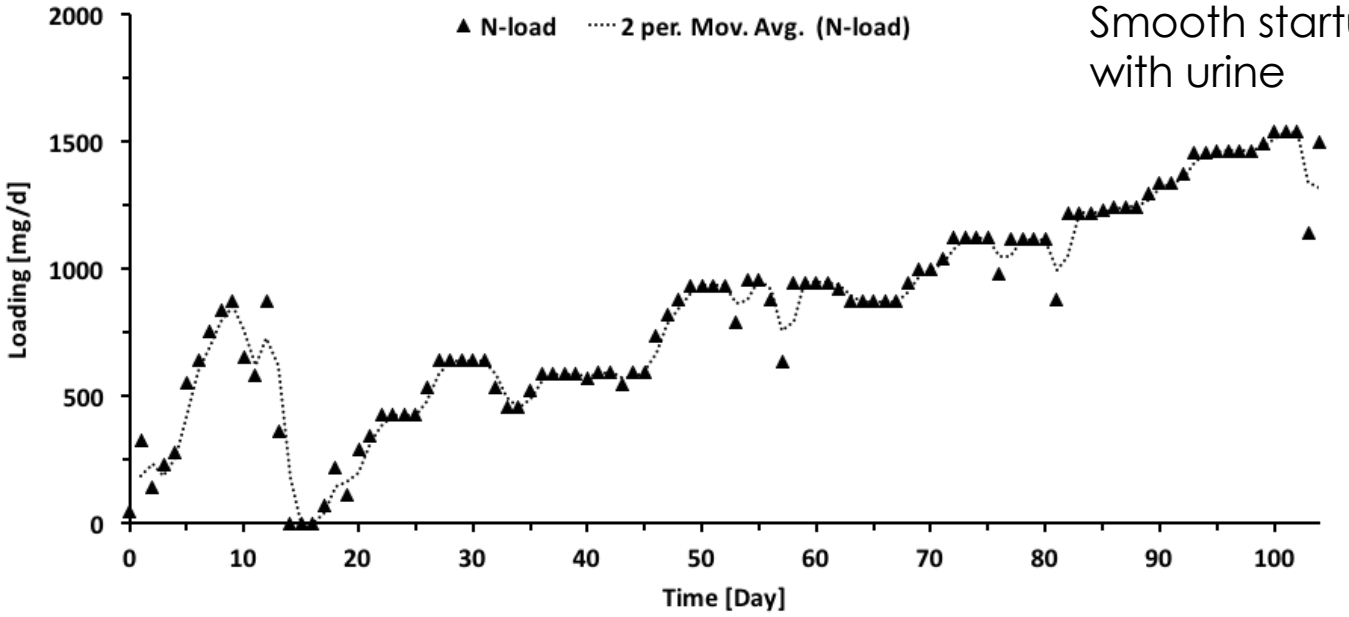


Results nitrification reactor

Fluidized bed configuration

- K1 AnoxKaldnes carriers (50 % filling ratio)
- 3 L carriers + 7.5 L reactor fluid
- Surface area = 2.07 m^2
  Protected area = 1.51 m^2

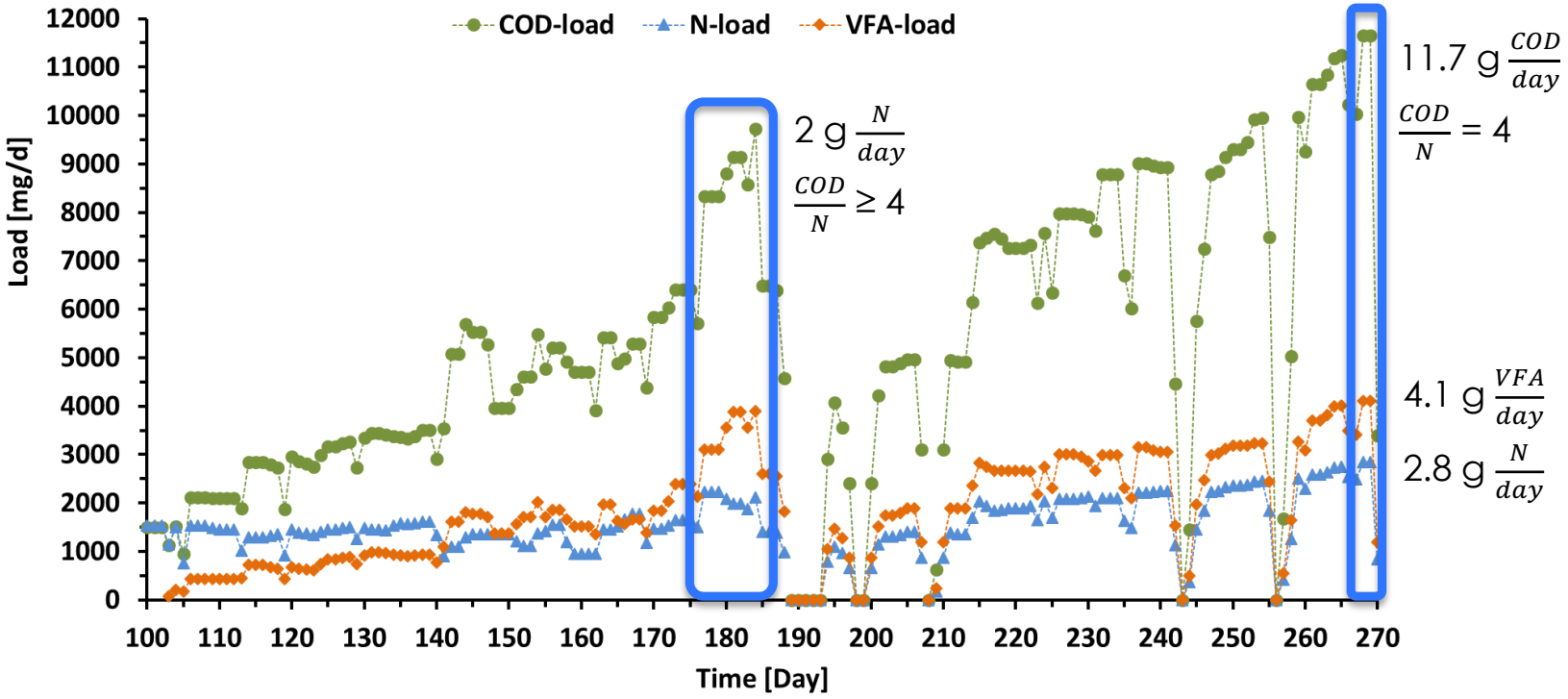




Smooth startup with urine

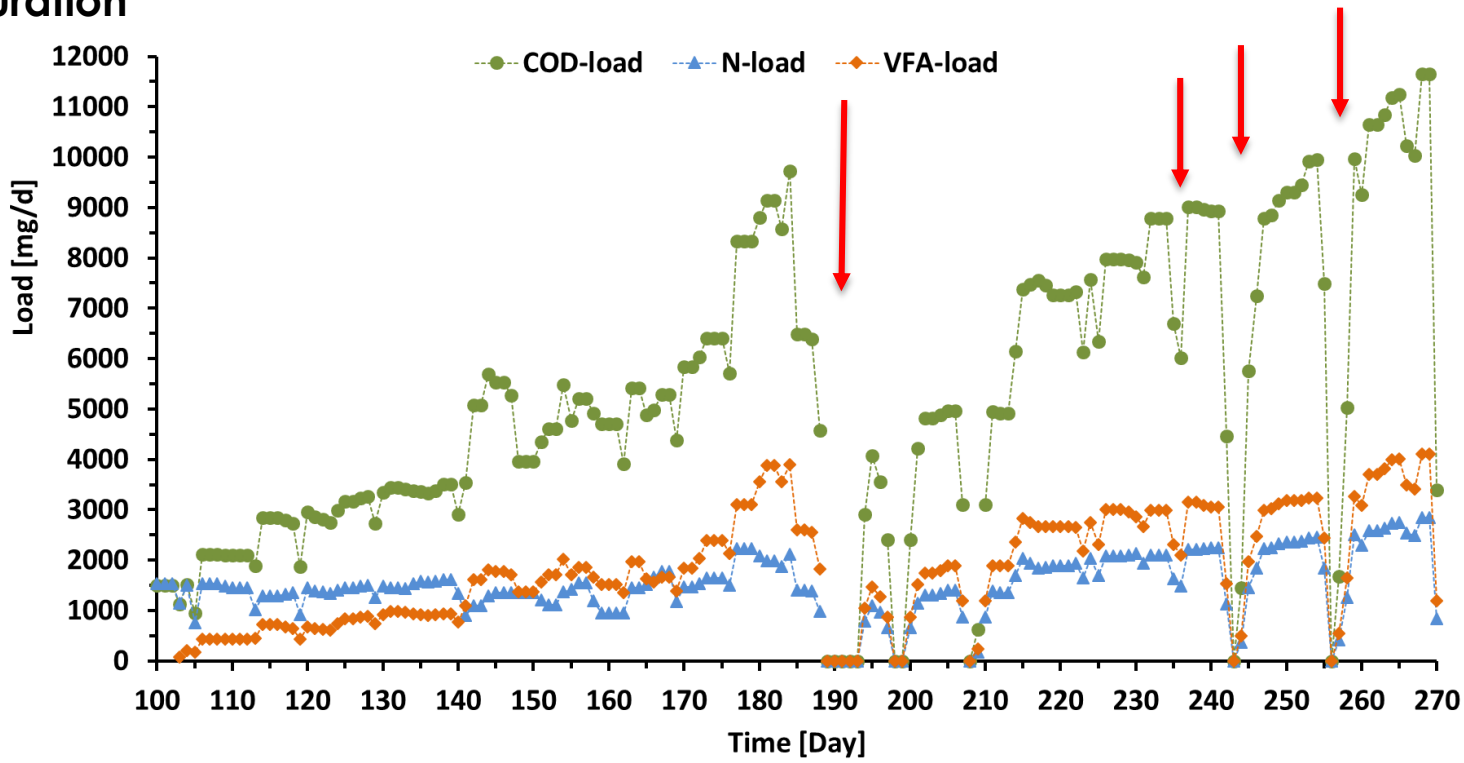
Results nitrification reactor

Fluidized bed configuration



Results nitrification reactor

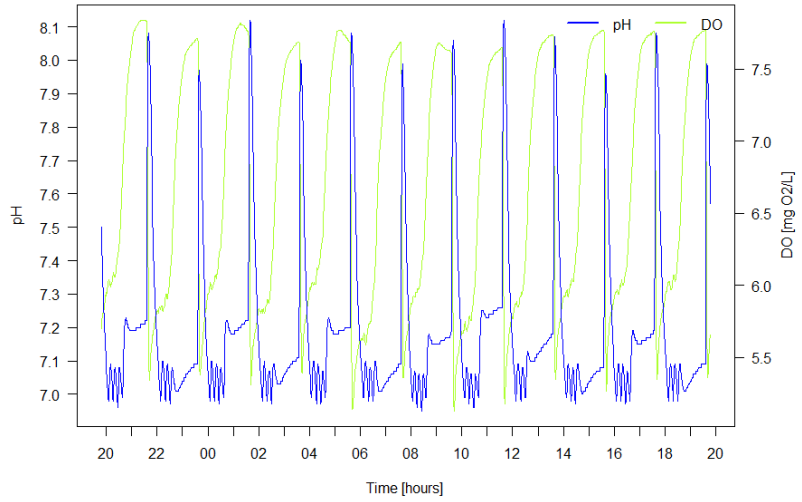
Fluidized bed configuration



Results nitrification reactor

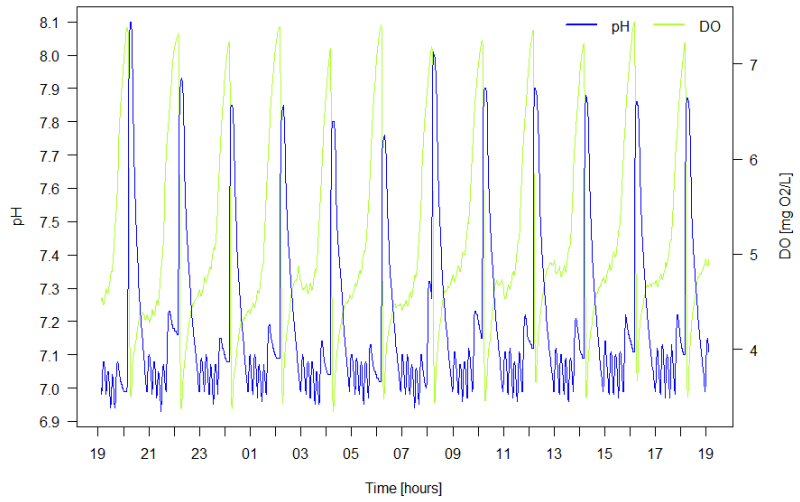
Lower loading (day 218)

- 1883 mg N/d
- 7258 mg COD/d (< 2668 mg VFA/d)
- influent flow rate 1224 mL/d



± Highest loading (day 270)

- 2734 mg N/d
- 11215 mg COD/d (< 4000 mg VFA/d)
- influent flow rate 1818 mL/d



Conclusions

- fixed bed operations can be replaced by e.g. **fluidized bed**
- nitrogen overload inhibition can be avoided by **gradually increasing N load** (**decision tree** is available)
- a feed with 2.85 g N/day and a C/N ratio of 4 is minimally feasible
- a very careful **control of the pH** (above 7!!) is crucial
- **temperature above 20 degrees** is a must
- a lot of **excess biomass** is produced

Collaboration between

- **KU Leuven**
  – Chemical Engineering Department - (Bio)Chemical Reactor Technology & Safety Division [Ilse Smets (coordinator), Kristel Bernaerts, Koen Rummens]
  – Earth and Environmental Sciences [Dirk Springael, Jaak Ryckeboer]
- **UGent**
  – cmet [Korneel Rabaey, Peter Clauwaert, Amanda Luther]
- **MPP**, Universitat Autonoma de Barcelona (UAB)
- Consulting partners
  - Université Blaise Pascal`-Polytech (UBP, Clermont-Ferrand, C3 expertise)
  - Sherpa (process control and data archiving)
  - VITO (C1 expertise, waste preparation unit)

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THANK YOU.

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