Hybrid Adsorption and Biological Treatment System (HABiTS) for enhanced nitrogen removal in onsite wastewater treatment systems

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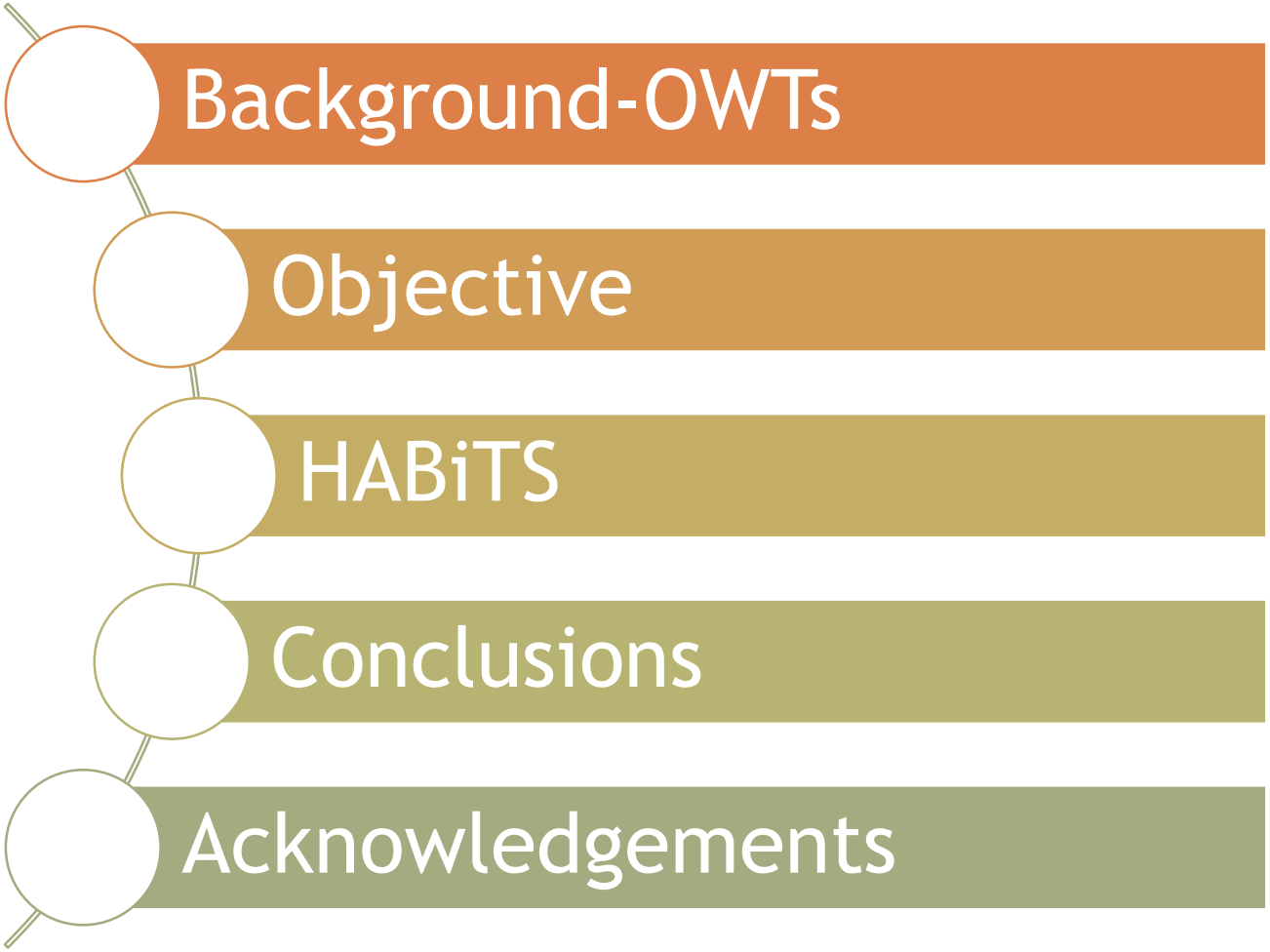
Outline


Background-OWTs
Objective
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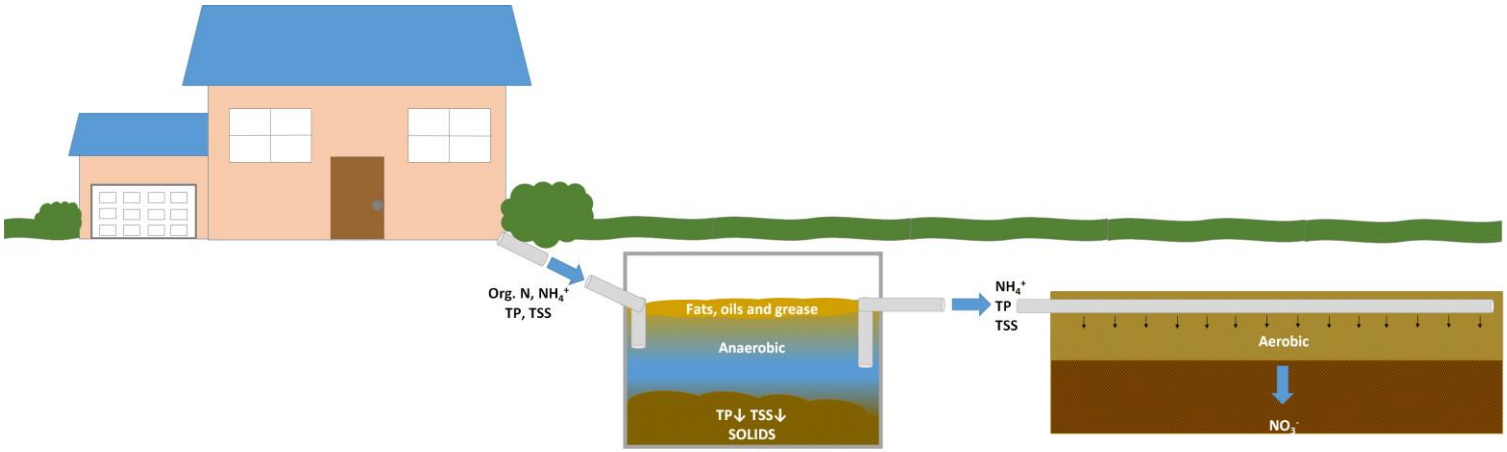
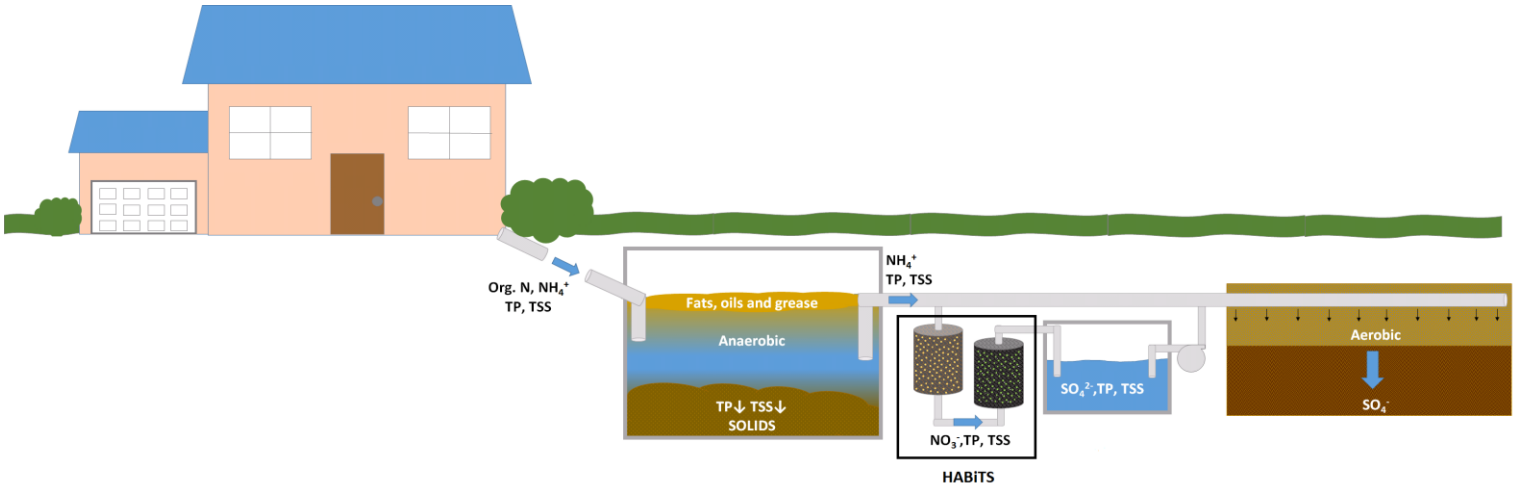
Background: Conventional Onsite Wastewater Treatment Systems (OWTs)



- Advantages:
  - Cost-efficiency for rural and suburban areas
  - Low energy
  - Simple design
  - Simple maintenance
- Challenges:
  - Simple maintenance
  - Limited nitrogen removal
  - Transient loading
  - Pathogens, PCPs and Pharmaceuticals

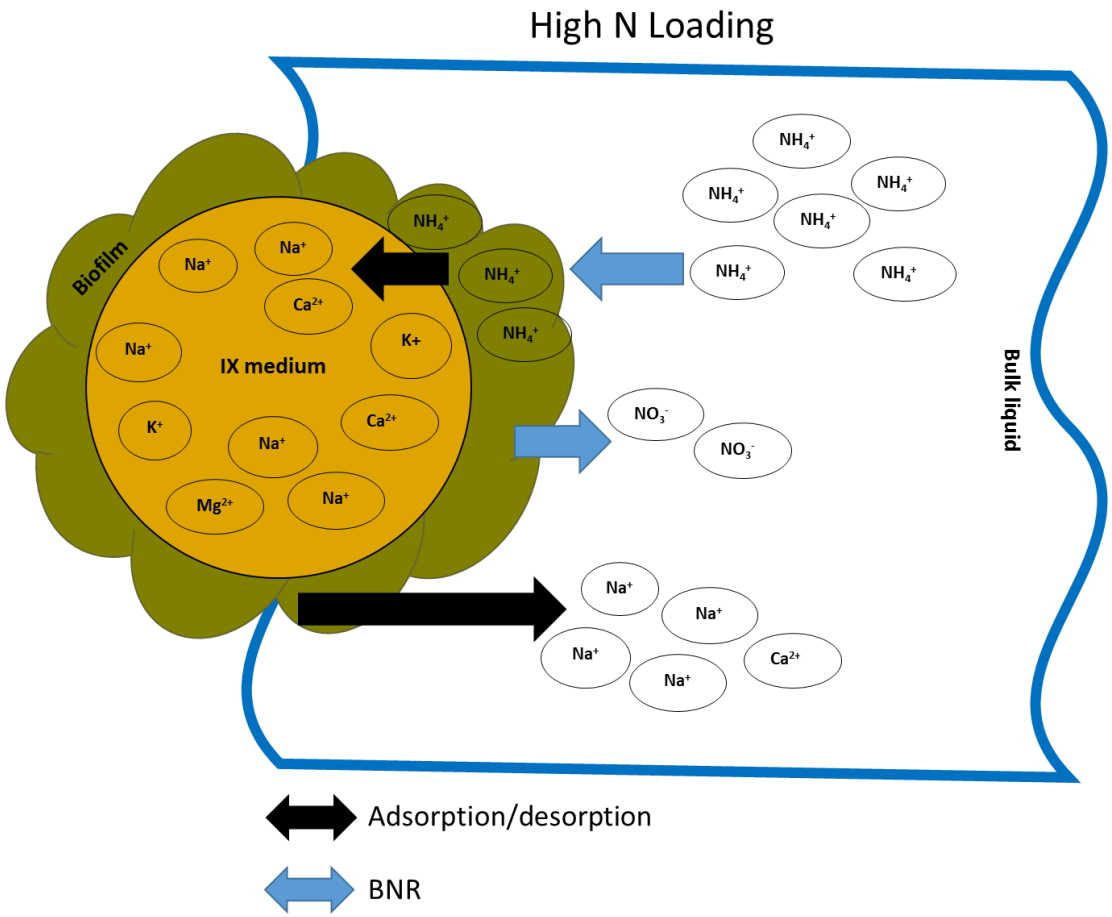
Goal and objective

Develop and study a Hybrid Adsorption and Biological Treatment System for the enhancement of nitrogen removal in onsite wastewater treatment systems.



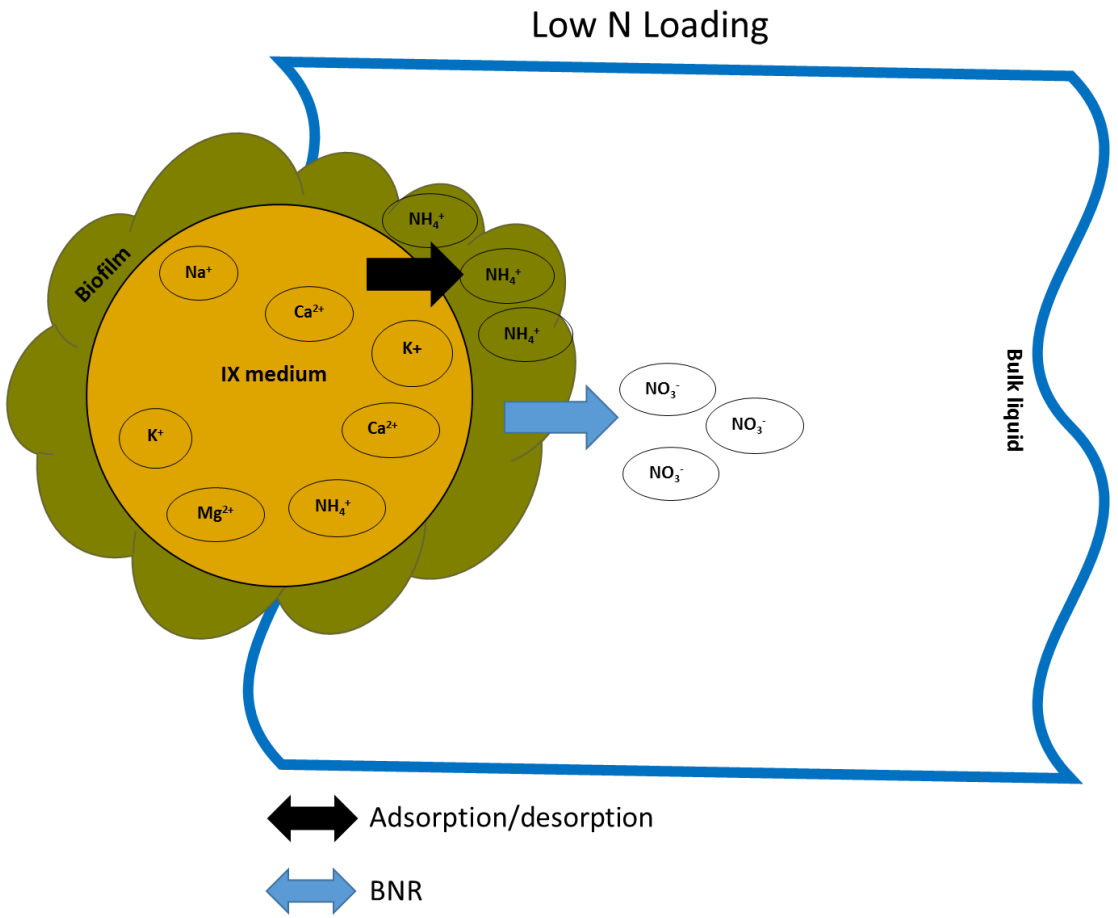
- Compare nitrifying biofilter performance with septic tank effluent under variable loading rates using HABiTS and conventional media.

HABiTS: ion exchange (IX) and biological nitrogen removal (BNR)



- High loading periods:
  - NH_4^+ in excess of nitrification capacity adsorbed to zeolite (clinoptilolite)
  - NH_4^+ exchanged with Na^+
  - Low N effluent

HABiTS: Bio-regeneration

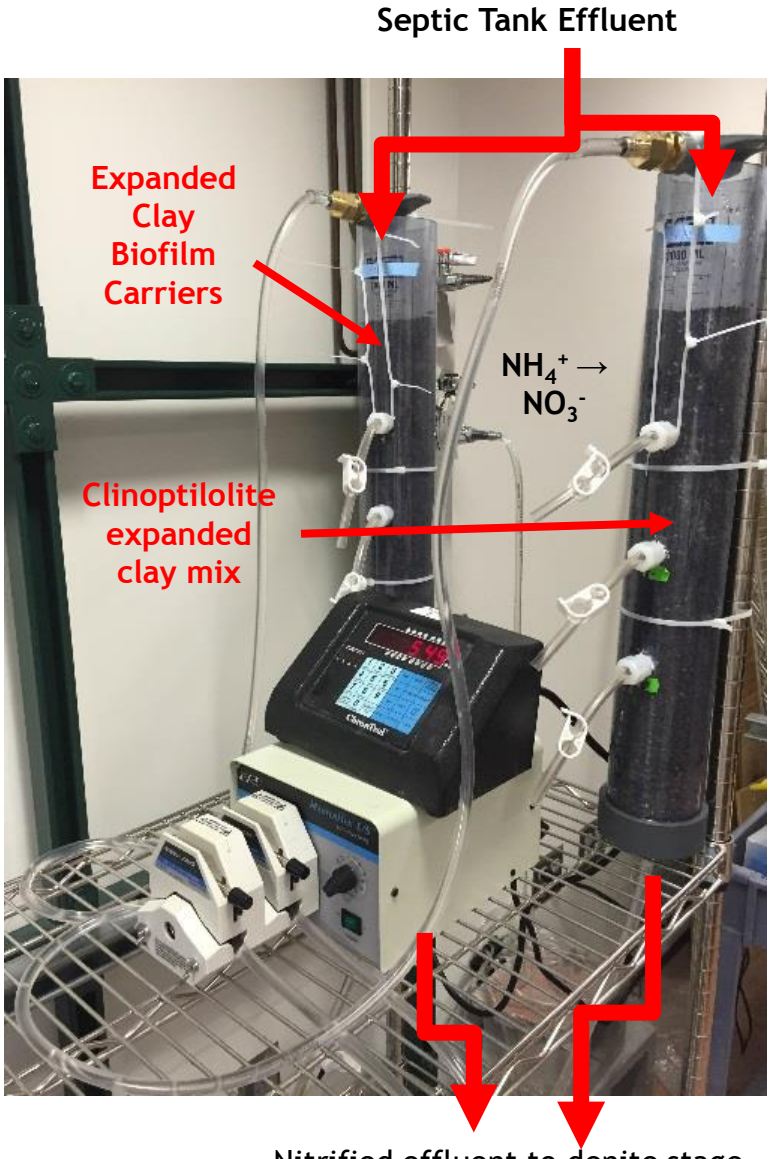


- Low loading periods
  - NH_4^+ oxidized to NO_3^- and desorbed from medium
  - Steady substrate input for nitrifying bacteria

HABiTS Benefits

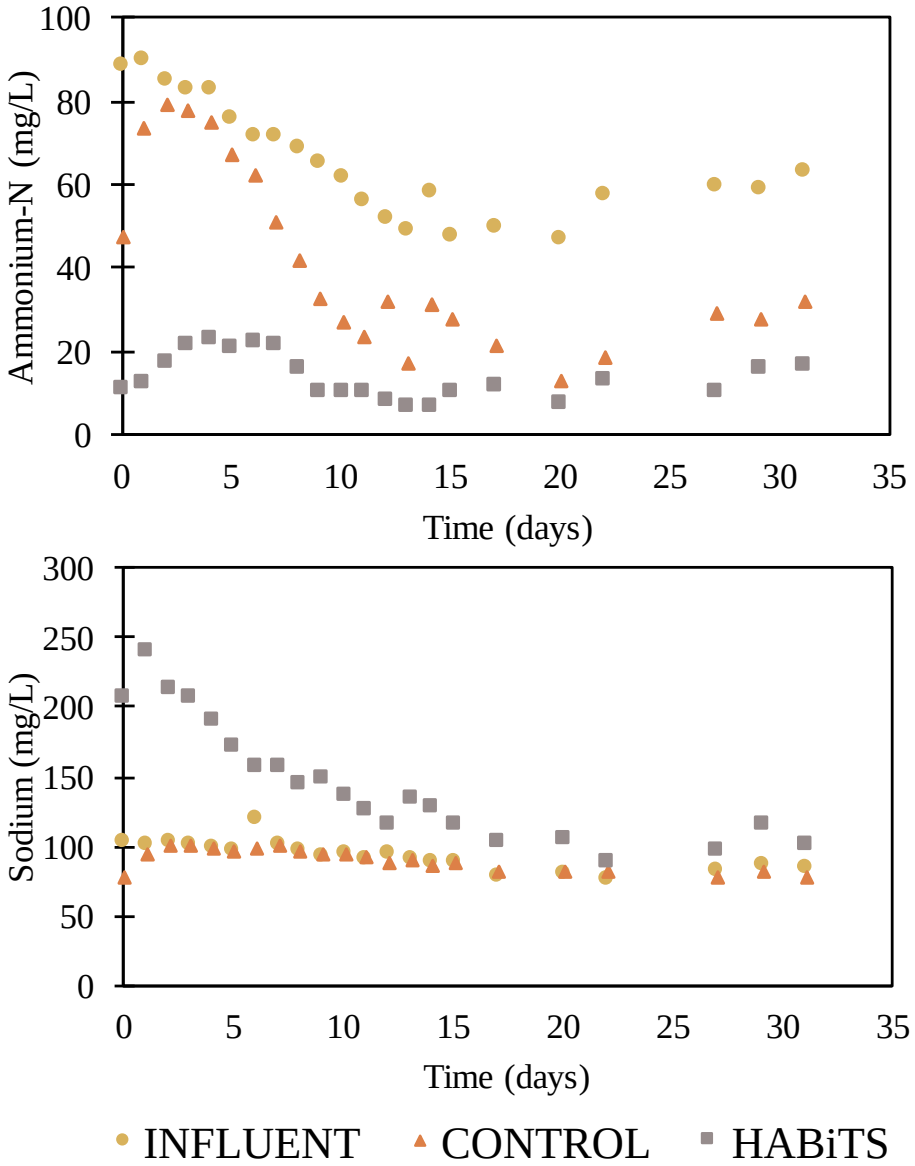
1. Buffers transient loadings
   - Adsorbs ammonia during high loading periods, slow release of ammonia during low loading periods
2. Sustains microbial communities during idle times
   - Substrate adsorbed will continue slow release
3. Faster start up and recovery from idle periods (e.g. after vacations)
   - During idle period medium is completely bio-regenerated. Adsorption during start up (or restart) will allow for low effluent concentrations while biofilms are established.
4. Potential for reactor and drainfield size reduction

HABiTS: Bench-scale design



- Control- 100% expanded clay
- HABiTS-20% clinoptilolite and 80% expanded clay
- Treats effluent from a bench-scale septic tank
- Transient load according to NSF Standard 40.
  - 6-9am: 35% daily volume
  - 11-2pm: 25% daily volume
  - 5-9pm: 40% daily volume

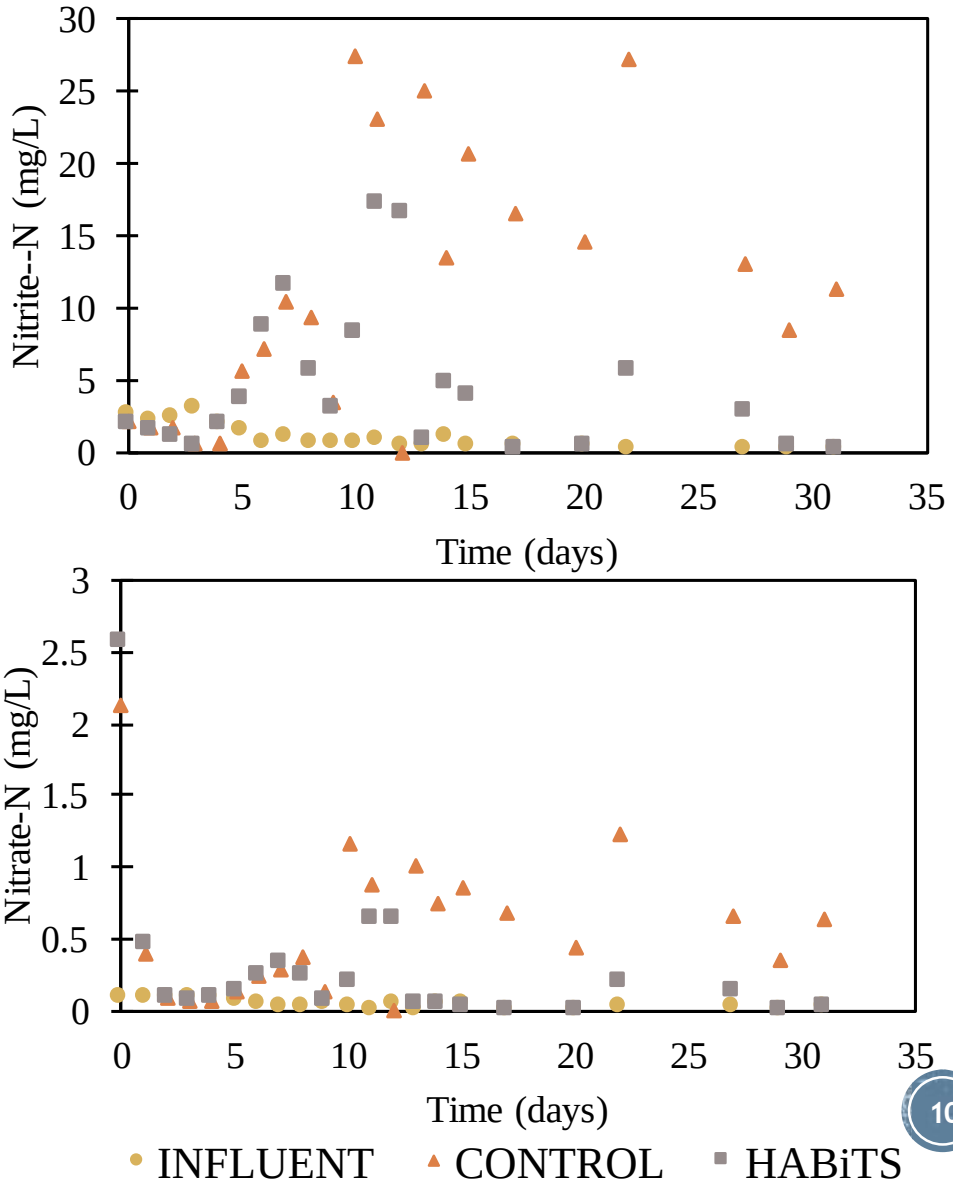
HABiTS Nitrification: Startup



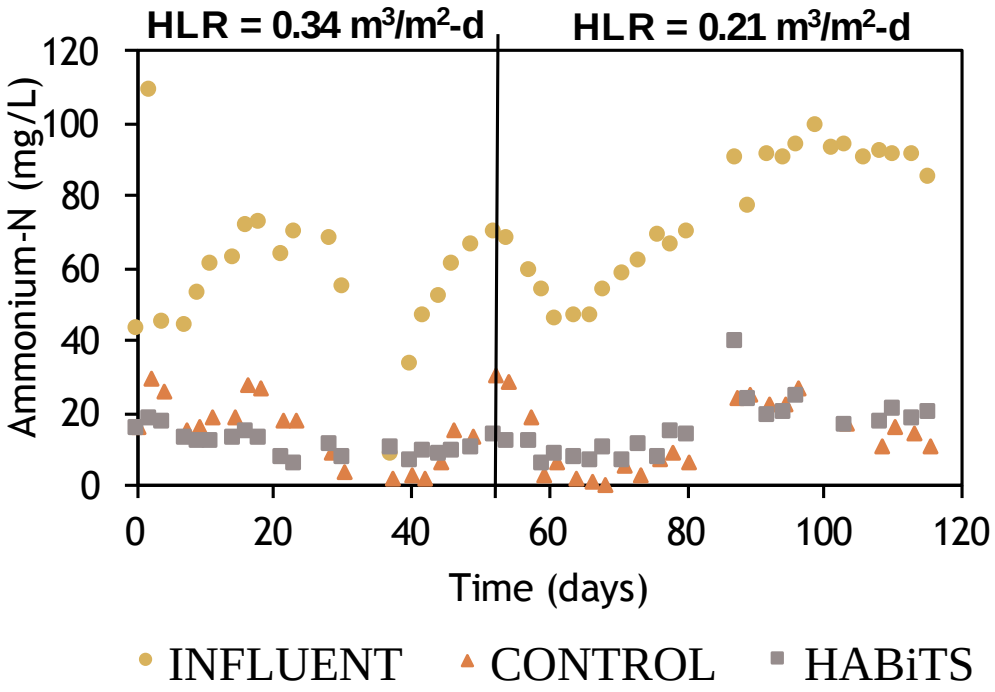
- Faster start-up with HABiTS than control column due to IX by clinoptilolite.
- Removal of NH_4^+-N in HABiTS ranged from 75 to 85%, significantly greater than the control
- Ion exchanged with NH_4^+ was Na^+; however, high effluent Na^+ concentrations decreased within 12 days.

HABiTS Nitrification: Startup

- Transient NO_2^--N production observed in both columns.
- NO_2^- and NO_3^- production in HABiTS confirmed clinoptilolite bioregeneration.
- Denitrification studies currently underway using sulfur oxidizing denitrification column with and without scrap tire chips (a NO_3^- IX material).



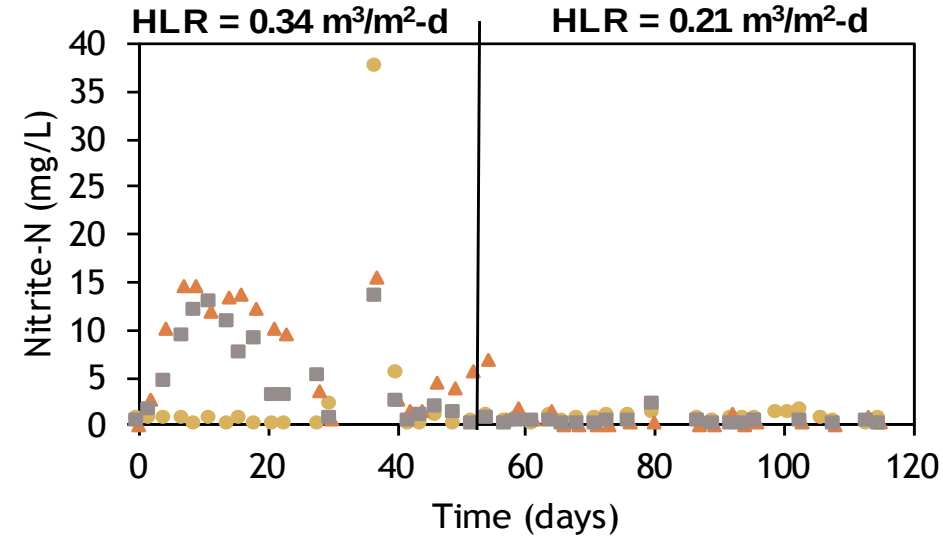
HABiTS Nitrification: Variable load

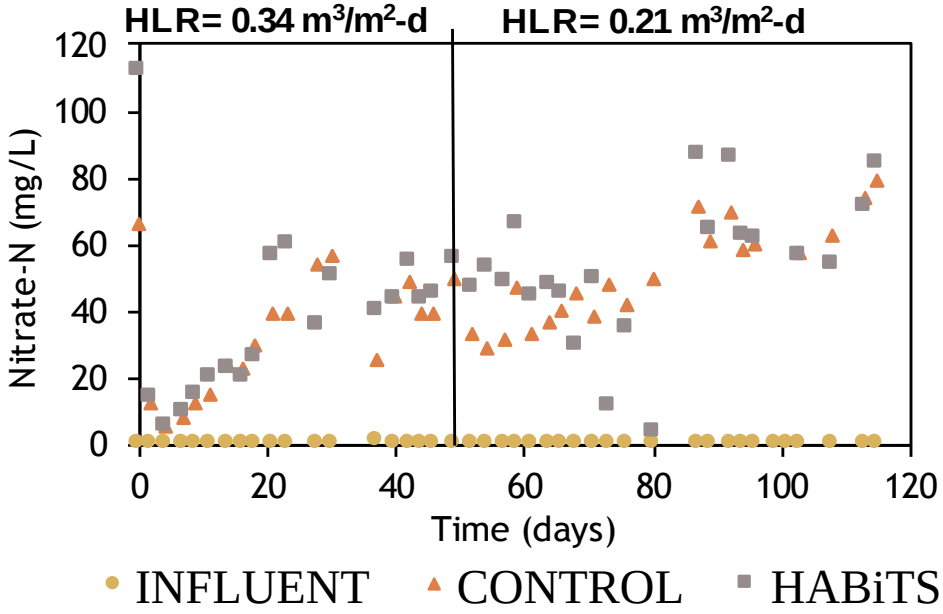


- Highly variable influent (57.49 ±19.78) affected control column effluent NH_4^+-N concentrations (15.78±9.24).
- Little variability in HABiTS effluent NH_4^+-N concentrations (11.03±3.45).

- HLR was reduced to 0.21 m^3/m^2-day after day 52 to improve nitrification and reduce clogging. Similar removal performance was observed in both columns at lower HLR.

HABiTS Nitrification: Variable Load





- At high HLR, IX and bio-regeneration were important NH_4^+ removal processes in the HABiTS column.
- At low HLR, nitrification was the main NH_4^+ removal process for both control and HABiTS.

Conclusions

- HABiTS are a promising alternative for passive N removal in OWTs.
- At loading rates > 0.34 m^3/m^2-day, HABiTS achieved >80% NH_4^+ removal while conventional BNR achieved 73% NH_4^+ removal.
- Under lower loading rate conditions NH_4^+ removal was due to nitrification in both columns.
- Addition of a denitrification stage containing scrap tire chips that adsorb NO_3^- is currently underway.
- HABiTS is expected to effectively reduce total N concentrations and lower the environmental impact of OWTs.

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