Investigating the use of hydrochar and activated carbon for treating greenhouse nutrient feedwater"

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Background

- Greenhouse nutrient feed (GNF) water is a great challenge for greenhouse (GH) producers
- Nutrients in GNF cause algae bloom and lake eutrophication if disposed without treatment
- Unbalanced micronutrients occurs regularly. This can impact plant growth, but generally blamed on the presence of pathogens

Objectives

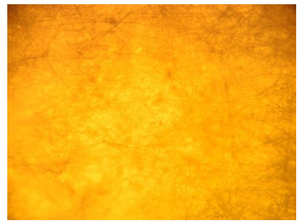
- Generate GNF treatment materials from waste biomass converting into hydrochar (HC) and activated carbon (AC)
- Assessment of reverse osmosis (RO) performance to ensure a complete solution of pathogen and nutrients issues
- Provides information on energy-efficient RO operations

Methods and materials

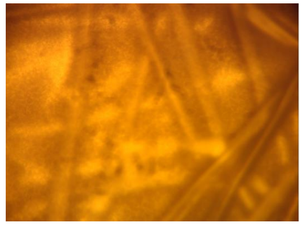
- Isotherm models for carbon sorption assessment
- Standard methods for nutrient and micronutrients measurements
- Digital imaging for pathogen detection
- HTC for HC, & quartz wool matrix reactor for AC production
- RO operations conducted following manufacturer's procedures
- Biomass and GNF materials were collected from local GHs
- Chemicals were procured from respective vendor or their agents

Results

1. Digital imaging (40X) revealed no pathogens in GNFs



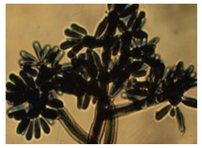
Cultured (72h) plate of 0.2 µm filtration



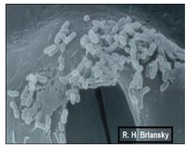
Cultured (72h) plate of 0.45 µm filtration

Results

Typical photographs of pathogens [1] – (not seen in GNF)



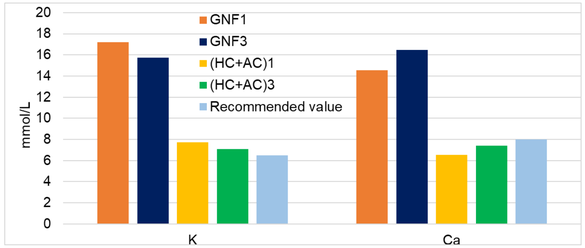
Botrytis spores (fungus)



Bacterial cells

Virus (tobacco mosaic)

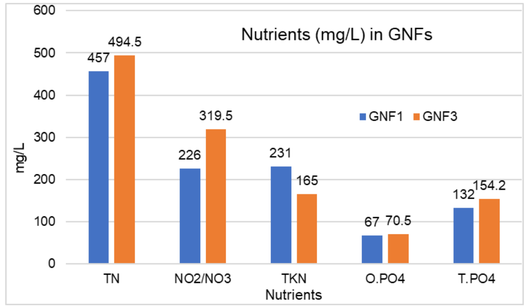
2. Higher concentrations of Ca and K, which were reduced to a safe recyclable level by HC+AC treatments



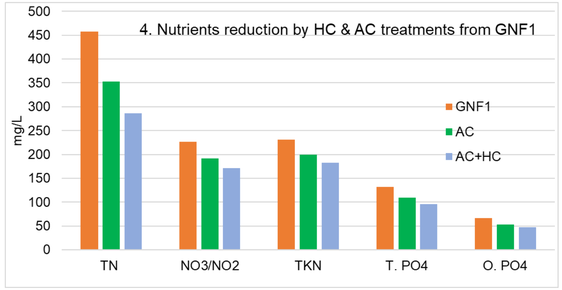
Excess K impacts [1]

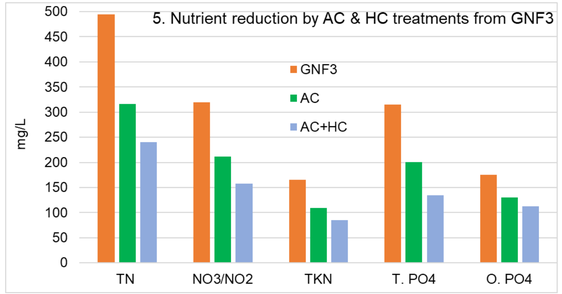
Excess Ca impacts [1]

3. Nutrients in GNFs were very high

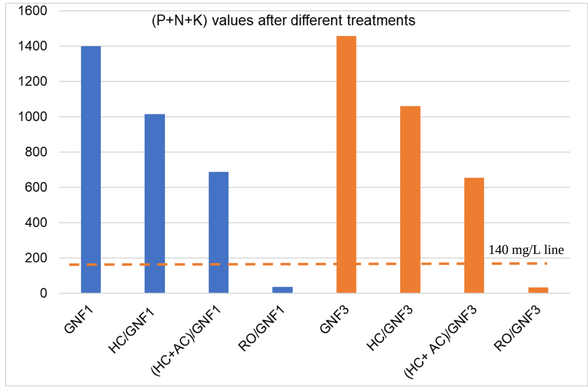


Results





6. Assessment of GNF disposal after different treatments (P+N+K threshold is <140 mg/L for disposal of1500 m^3/ha/y [3])



Notes on RO treatment

- Single step RO treatment reduced GNF nutrients below the threshold limit allowing direct disposal
- RO pore size (0.1 - 1.5 nm) ensures pathogen removal including viruses (20 - 400 nm)
- General notion exists - higher energy is needed to run RO system, thus RO is avoided considering energy expensive
- An energy-efficient RO setup is available to reduce RO energy substantially (> 90%) [4]
- GNF treatment requires very low pressure (<10 bar) pump, so no need to worry about high pressure pump purchase

Conclusions

- GNF recirculation and reuse is economic and easy option managing GNF
- Excess metals (K, Ca) impact plant growth, having phytotoxic effects
- HC and AC sorption can provide options for GNF recirculation and support land disposal
- RO filtration is a reliable option for nutrients management and pathogen control in the dirty GNF

References

[1] Elliott et al, (2008; 2014; 2017); Guidelines for Identification and Management of Plant Disease Problems: Part II. Document pp249; U.S. Department of Agriculture, UF/IFAS Extension Service, University of Florida, IFAS, Florida EDIS http://edis.ifas.ufl.edu.

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[3] O. reg. 300/14:GREENHOUSE NUTRIENT FEEDWATER Regulation

[4] Jamal-Uddin, A., Hassan, A.M., Al- Reweli, A., Al- Rubaian, A., & Hauge, L. (2002); An Efficient Energy Recovery Prospect In SWRO Process; The 6th Saudi Engineering Conference, KFUPM, Dhahran.

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