The Ultimate Future of Wastewater Treatment: Harnessing nature's remedy to Tackle the Untreatable

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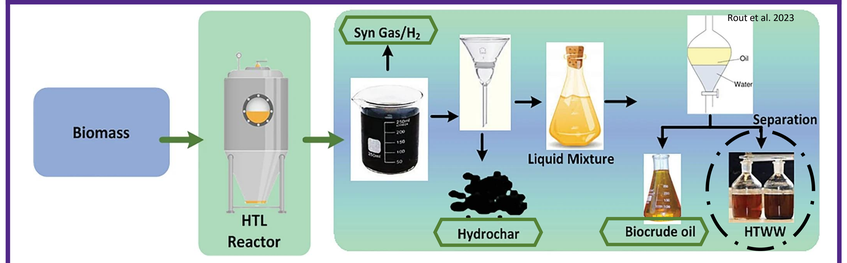
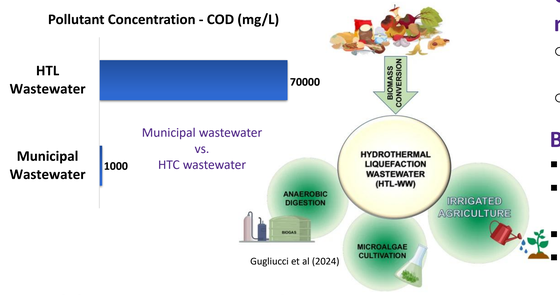
Let's connect

Background





Conventional HTCWW management

- Composting /anaerobic digestion (AD)
- Irrigated agriculture

Biomass source

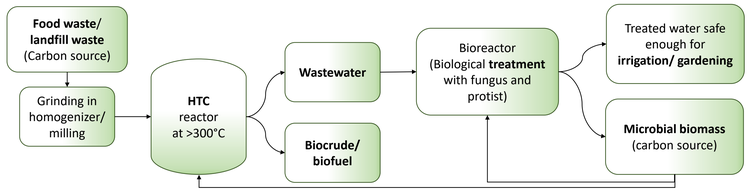
- Kitchen food waste
- Lignocellulosic biomass such as corn stover and hemp biomass
- Sewage sludge
- Municipal solid waste (mixture of plastic, paper, food, crushed glass and metal)

Problem encountered

❑ Inhibition to microbial degradation during AD and harmful to direct application to irrigation due to the presence of **metal impurities, toxic chemicals** such as furfural, organic acids, phenolic compounds and N-heterocyclic compounds

❑ **Upcycling /valorization** of HTCWW

Objectives



Upcycling of HTCWW

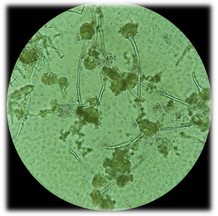
- ✓ **Treatment** of HTCWW with marine protist and fungal consortium to yield **bio-granules**.
- ✓ **Activated sludge** production and preservation.
- ✓ Recirculation of bio-granules to the HTC reactor as a **carbon source**.
- ✓ Lower chemical oxidation demand (COD) in treated wastewater to make it **environmentally safe**.

Relevance to Kansas

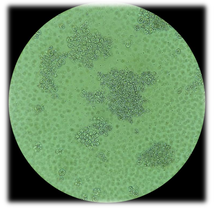
As Kansas embarks on new **thermal treatment technologies** for wastewater, this research supports the state's progress by addressing the **growing challenges of wastewater** from both households and biofuel industries. By harnessing Kansas's rich agricultural potential, this study encourages **expanding industries beyond biodiesel into other promising biofuels such as biocrude, syngas, and biochar**. Together, these efforts create a sustainable path to **protect water resources** and strengthen Kansas's renewable energy future.

Methods

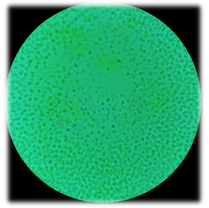
Microorganisms used



Aspergillus terreus (I)



Schizochytrium sp. (II)

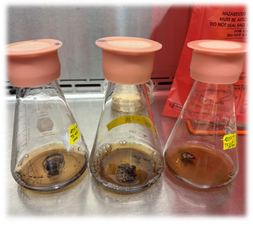


Thraustochytrium striatum (III)

Fungus **Marine protists**

Dark fermentation (in flask)

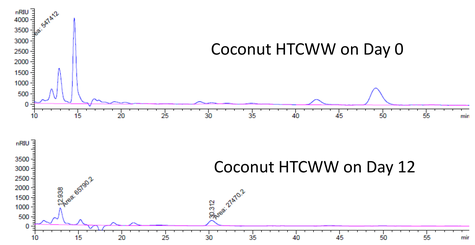
- HTCWW was prepared by Dr. Kumar's group at Old Dominion University at 350°C for 5 min
- **Biomass** with respective **dilution factors** was used to prepare individual HTCWW:
  - Coconut shell @ 10X
  - Pasta @ 6X
  - Walnut shell @ 8X
- **3 fungal-protist combination** was used: (I+II), (I+III) and (I+II+III)
- **Artificial Seawater** (ASW) was prepared mimicking the salt concentrations in seawater to ensure the thriving of marine protists
- Supplemental **nutrient salts** were determined and optimized in the ASW media using MTT assay in well plate
- Influence of **glucose supplementation** was observed
- A full cycle of **12 days fermentation** was conducted at 25°C with an agitation speed of 150 rpm to maximize the cell mass based on the depletion of carbon content in the media
- An intermediate **COD testing** was done at the regular interval of 3 days starting from the zeroth day
- **Organic salts, furfural and phenolics concentrations** in the media were observed via HPLC at the regular interval of 3 days starting from the zeroth day
- Spent media except **activated biomass** was repleted with fresh media for the next cycle.



Conclusions and Future Work

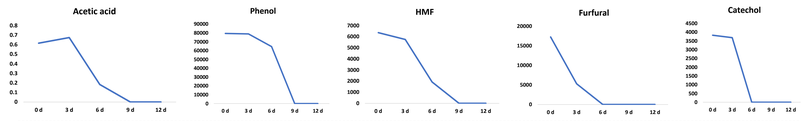
- ❖ **CONCLUSION:** The **combination of both protists with fungi** was observed to remove almost **80% of original COD** in wastewater and was effective as activated biomass in the next cycle, compared to the other two combinations.
- ❖ **FUTURE PROSPECTS: Scaling up the process** using a reactor with **fed-batch or continuous-feed operation** and **protein extraction/ ammonia removal** before treatment could increase efficiency.

Results

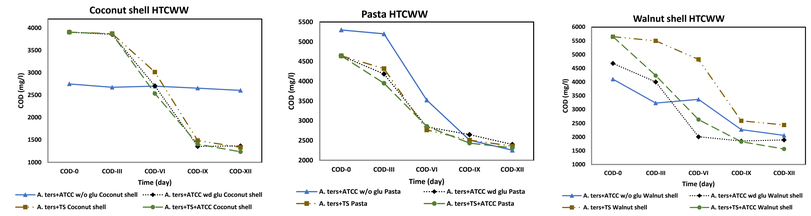


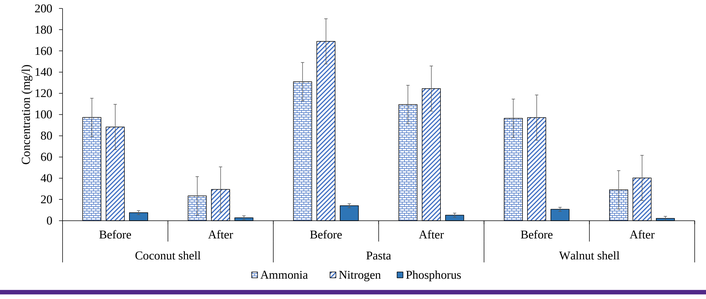
HPLC analysis on HTCWW

- Organic acids except glycolic acid were consumed initially along with furfural and phenols.
- Majority of the peaks including unidentified ones were reduced.



- ✓ Coconut HTCWW contained the highest levels of phenolic compounds and furfural, followed by walnut and pasta, which likely inhibited microbial growth. Therefore, dilution factors of **10×, 8×, and 6×** were applied, respectively.
- ✓ **Nitrogen, phosphorus and iron** had significantly different effects on the microbial growth while glucose supplementation was observed to support initial growth though it did not contribute to overall COD removal.
- ✓ **Activated biomass**'s achieved similar results in 6 days of second cycle compared to the 9th day's progress of first cycle. Accumulated biomass at the end of fermentation were **recirculated back to the HTC** reactor for more biofuel production.
- ✓ Coconut shell HTCWW achieved the highest COD removal (**79%**), followed by walnut (**71%**) and pasta (**57%**).
- ✓ Majority of **phosphorus and nitrogen content** in wastewater from coconut shell and walnut shell were **consumed**, unlike in pasta HTCWW





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