Biosolids Hydrothermal Processing: SCWO & HTL

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Project Overview

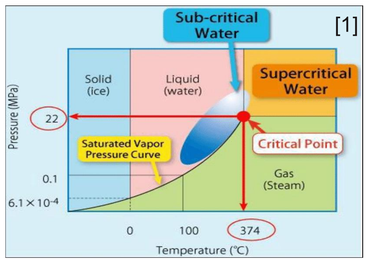
Traditional Disposal Methods for Biosolids
- Land application
- Incineration
- Landfill

Considerations
- Emerging contaminant elimination
- Beneficial end-products
- Regulatory considerations

Goal

Feed Mixture
- 25 dry tons/day of wastewater sludge
- 80% dewatered feedstock

Compare Commercial Scaling of 2 Biosolids Hydrothermal Processes:
- Supercritical Water Oxidation (SCWO): Oxidation reaction that occurs above the critical point of water, destroying organic material
- Hydrothermal Liquefaction (HTL): Non-oxidative process that occurs below the critical point to produce biocrude and biochar



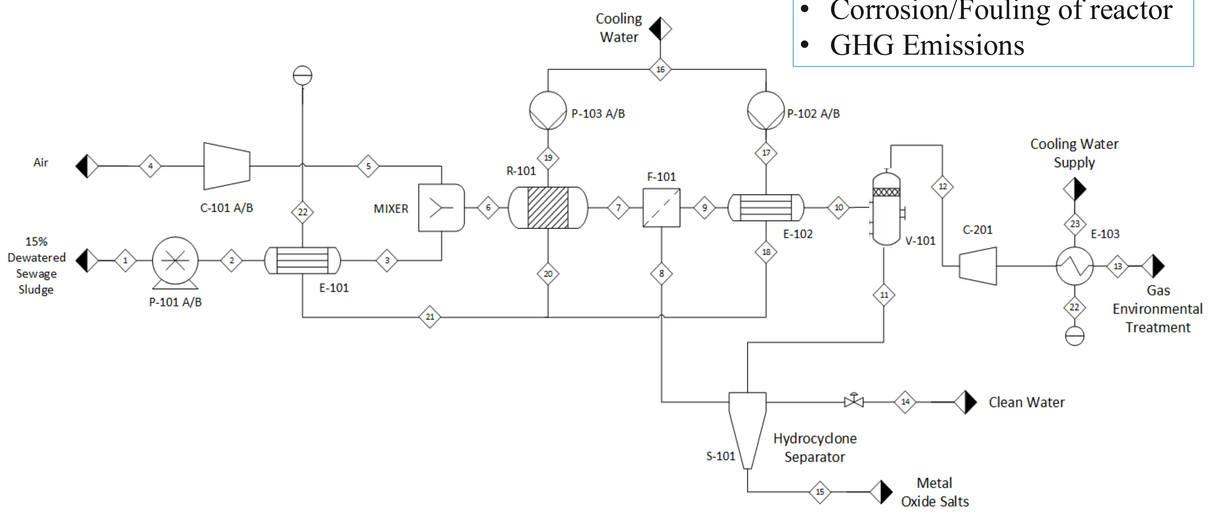
Supercritical Water Oxidation

Process Design
- Operates at 600 °C & 250 bar
- Reactor type: PFR, Inonel-625
- Reactor volume: 533.63 gallons
- Separation: Hydrocyclone

Process Outputs
- Water
- Gases (CO_2, trace NO_x, O_2, N_2)
- Minerals + Metal Oxide Salt

Advantages
- >99% PFAS removal
- Energy recovery
- Clean water effluent
- Short residence time

Disadvantages
- High energy usage
- Corrosion/Fouling of reactor
- GHG Emissions



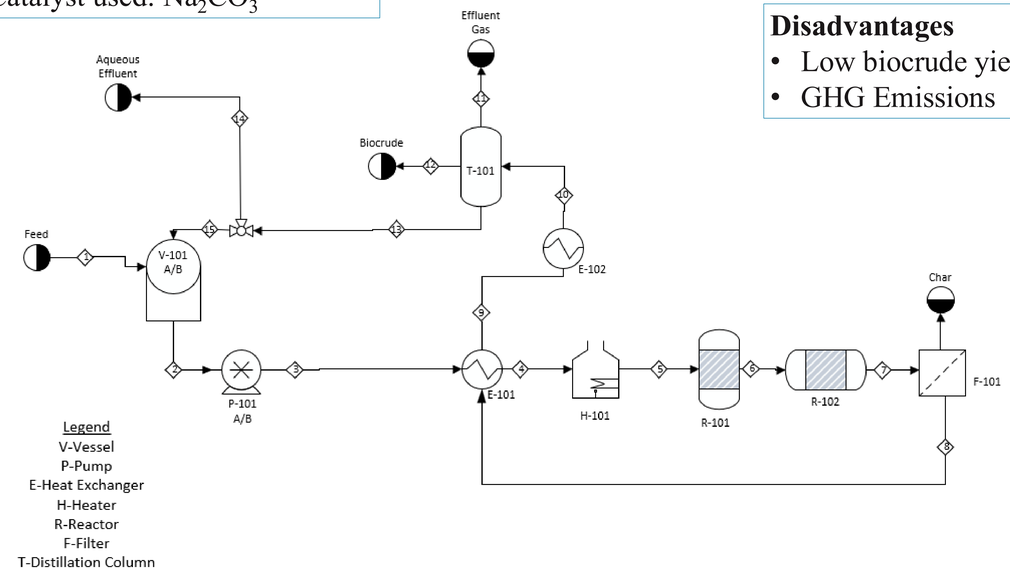
Hydrothermal Liquefaction

Process Design
- Operates at 350 °C & 200 bar
- Reactor type: CSTR & PFR
- CSTR volume: 19,468 gallons
- PFR volume: 10,322 gallons
- Catalyst used: Na_2CO_3

Process Outputs
- 10.6% Biocrude yield
- Biochar
- Effluent Gas
- Aqueous Effluent

Advantages
- 34-99% PFAS removal
- Usable products
- Milder reactor conditions

Disadvantages
- Low biocrude yield
- GHG Emissions



Economic Analysis

Item	SCWO (million USD)	HTL (million USD)
Fixed Capital Cost of Equipment	20.00 - 24.00	22.44 - 34.32
Cost of Operations	33.70 - 37.99	14.18 - 21.69
Cost of Utilities	13.00 - 23.19	3.71 - 5.68
Cost of Raw Materials	3.20 - 8.48	1.56 - 2.39

Itemized Costs of Both Processes Over 20-Year Period

Safety & Non-Economic

Process Safety
- Extremely exothermic reactions
- Hot Work safety protocols are needed

Regulations
- No federal regulations
- Unknown future for regulations around PFAS and land application of biosolids


[2]

Environment
- Increasing concern with PFAS contamination
- Moving away from land applications of biosolids
- Gaseous output streams containing GHG – require treatment

Recommendations

Supercritical Water Oxidation
- **Advantages:** More complete contaminant destruction and energy recovery
- Investigate transpiring wall reactor instead of PFR
- Use bioprocessing software instead of ASPEN

Hydrothermal Liquefaction
- **Advantages:** Beneficial resource recovery and lower operating costs
- More precise feed composition for a more accurate yield
- Further economic analysis should include specialized pricing from vendors instead of CAPCOST
- Use bioprocessing software instead of ASPEN

Image Sources: [1] Sharan, Promila & Singh, Sushila. (2018). Applications of green solvents in extraction of phytochemicals from medicinal plants: A review. 7. 238-245. Chaganti, V. (2025, January 22). [2] Biosolids. Virginia Cooperative Extension. https://ext.vt.edu/natural-resources/biosolids.html

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