Supercritical Water Oxidation and a Preliminary Concept for Lunar Application

A Solution for Wastewater Recovery on the Moon

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BACKGROUND

Recycling wastewater presents an efficient solution to providing potable water to astronauts on extended missions. A Supercritical Water Oxidation (SCWO) technology being researched at NASA Glenn Research Center (GRC) has been shown to eradicate all hydrocarbons in the waste stream. Results of greater than a 99% reduction in Total Organic Carbon (TOC) with residence times less than 3s have been observed using a waste simulant provided by NASA Ames Research Center. These results were used to create a conceptual design of a SCWO-based lunar platform for use in future Artemis missions.

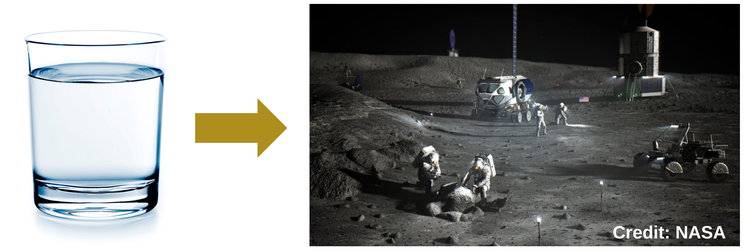


Figure 1. Artist's Concept of a Lunar Base

EXPERIMENTATION

The setup at GRC features a tubular reactor-based design pictured in Figure 2.

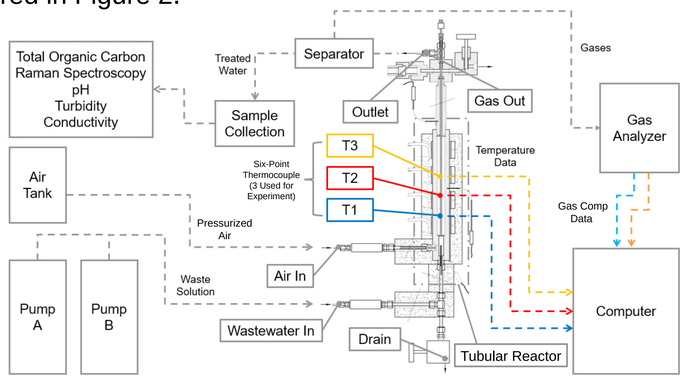


Figure 2. Glenn Supercritical Water Oxidation Setup

Key diagnostics include:

- Temperature
- Gas Composition
- Total Organic Carbon (TOC)
- Raman Spectroscopy
- pH
- Turbidity (for cloudiness)
- Conductivity (for ionic content)

RESULTS

Post treatment, the samples showed improvements in the following characteristics:

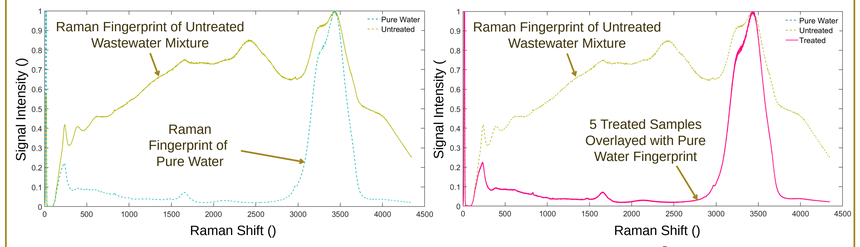
- Removal of yellowish hue
- Loss of odor
- Removal/reduction of foaming
- Reduction in TOC of 99% or greater

3a

3b

Figure 3. Samples from NASA GRC, **a.** Untreated vs. Treated Sample Bottles, **b.** Foaming of an Untreated Sample Bottle

Quantitatively, the Raman fingerprints of each treated sample show chemical makeups similar to that of pure water.



4a 4b

Figure 4. Normalized Raman Spectrums, **a.** for an Untreated Wastewater Sample, 532 nm Laser, **b.** for 5 Treated Wastewater Samples, 532 nm Laser

LUNAR ZERO PLATFORM (LZP)

Using the experimental design from GRC as a starting point, a conceptual design was iterated upon to develop a Lunar Zero Platform: a setup curated for use on an early lunar base.

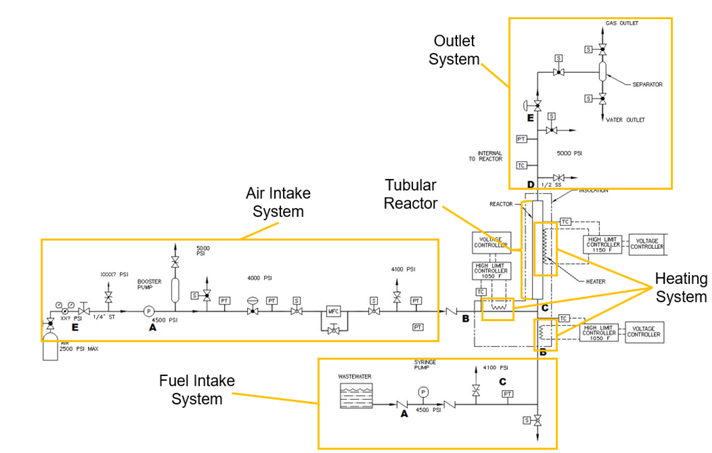


Figure 5. Early Schematic of Lunar Zero Platform Concept

EQUIVALENT SYSTEM MASS (ESM)

Below is a comparison of ESM and footprint of the LZP and the delivery of water outright. (Includes equivalent masses of components, volume, and power)

Estimated Mass to Deliver Water Outright:
537.60 kg

600L

Figure 6. Footprint of Water Delivery Tank

Estimated ESM of Lunar Zero Platform:
173.85 kg

118L

Figure 7. Footprint of Lunar Zero Design

CONCLUSIONS

- An investigation of SCWO was performed at NASA GRC
  - Results proved that this method of wastewater recovery is viable for providing potable water to astronauts
  - Reductions in TOC of 99% or greater and Raman characterizations across multiple samples further proved the validity of SCWO
- A conceptual design of a Lunar Zero Platform was created
  - A preliminary analysis of ESM and footprint were performed to compare the differences between the LZP and the delivery of water outright
  - The preliminary analysis leaves room for further shedding of cost as the layout of Artemis missions become clearer

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