The Utilization and Initial Testing of the Closed Loop Enthalpy Recovery DRYER System in Biological Environmental Systems for Prolonged Space Missions

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It has long been known that where there is water, there is life. In the empty, void of space, the need to sustain an astronaut’s life by being able to reuse the water brought into space is vital to the success of future missions. Having a method to reclaim water from human wastes, washed clothing and food solids that is also safe and energy efficient is crucial to the upcoming lunar and Mars missions. Hypothesis: A closed loop enthalpy recovery system, the DRYER, allows for a contained and energy efficient way of recovering waste water for reuse in a low-G environment. Methods: The previous lab testing on the DRYER was compared to the results from other methods, such as using pyrolysis, compaction, and incineration and oxidation. New lab test data was also used as a companion to earlier testing. Results: The DRYER method is energy efficient, does not produce dangerous chemicals or residue, and operates at low temperature, making it a safe and completely contained alternative to other methods. Testing done at Ames has shown smaller yields and issues keeping the prime on the thermoelectric plates. Conclusion: The DRYER has many benefits over other methods for removing water from wastes. Removing and reusing water in space is necessary for extended missions, and the benefits and efficiency of the DRYER need to be further explored.

Significance
Water has often been called the “Elixir of Life,” without which human beings would not exist. Being able to supply astronauts with a safe way to reuse water brought up into space is important in lengthening upcoming space missions. Recovering used water safely in space will save 15,960 pounds of payload to the ISS and can save up to $2.9 billion on upcoming missions.

Methods

Other methods of waste containment have already been researched and tested:
- **Pyrolysis** heats materials to very high temperatures absent of O2.
- **Heat compaction** heats up wastes to the water can be evaporated and the solids compressed.
- Oxidation and Incineration both burn wastes, removing the water and making CO2 and ash.

Heat manifold

- **The vessel holds the wet trash.**
- **The reservoir collects the condensation.**
- **The air flows through the vessel, picking up moisture from the trash, and carries it down the manifold.** Once there, the airflow splits to one of three sets of condensing plates. The plates condense the moisture back to liquid form, and the water runs down the hoses to the reservoir. The newly dried air is then pre-warmed from before and is recycled for the next cycle. A computer is connected to the various sensors on the motherboard of the machine. The sensors relay the information to the board which then relays the feedback to the computer.

Insulated heater which warms the dry air heating to the vessel

**Results**
- **Technique**
  - Pyrolysis
  - Heat Compaction
  - Oxidation/Incineration
  - Closed Loop Enthalpy Recovery

- **Advantages**
  - Reduces waste
  - Removes O2 gases
  - Sterilizes material
  - Removes water
  - Contains, stabilizes and shrink materials
  - Low energy, low temperature, little maintenance
  - Process is too slow, surface area is a key factor

- **Disadvantages**
  - High energy, high temperature, produces toxins
  - Traps water, high energy, high temperature
  - Very high energy, multiple catalysts, many forms

A strong linear correlation was found in the data sets. Despite additional water being added to the trash, it was not driven off any faster.

This indicates that further testing must be done to reduce total drying time.

The large discrepancy between the water evaporated from the rag vs. sponge also indicates that the material is an important consideration. This comparison can be seen in the final graph.

**Conclusions**
- The closed loop enthalpy recovery system is a solution to the problems of other drying methods.
- Because the engineering is in the early stages, at TRL 3-4, more work is needed to make the process timely and effective.