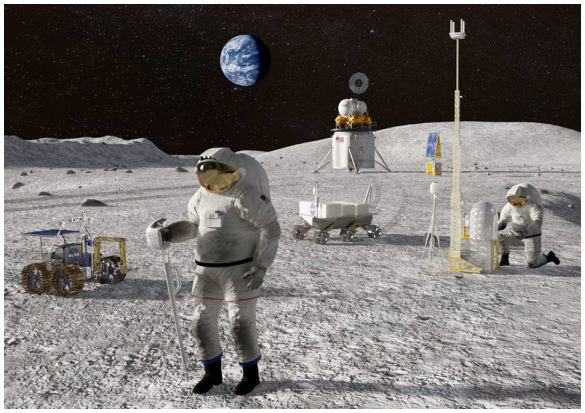
Engineering Design Challenge: Lunar Water

Scenario



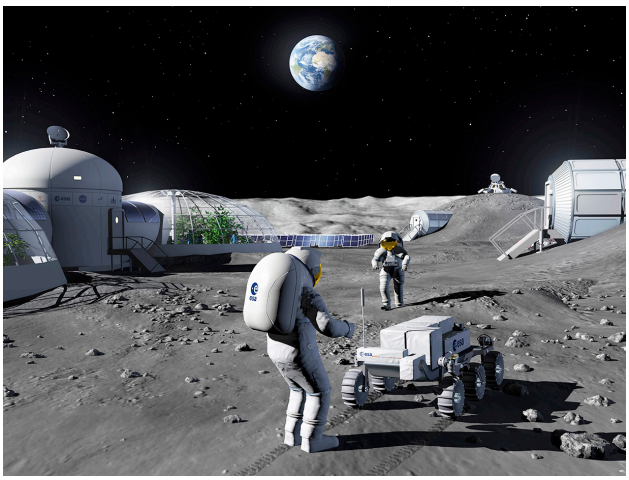
Artist's concept of astronauts walking on the Moon's surface during an Artemis mission. (NASA)

While living on the Moon, it is essential that water consumed in the lunar habitat is recycled, purified, and reused. Because of the limited-weight requirements to ship cargo on the Space Launch System and Orion spacecraft, the amount of water that can be transported and supplied for long-term missions must be precisely calculated.

All the water used by the astronauts on the International Space Station (ISS) is recycled, purified, and returned back into the ISS water systems. In a space habitat, this wastewater—also known as gray water—includes moisture exhaled by the astronauts, sweat from their workouts, and water from food preparation, shaving, and the bathroom shower.

During the Artemis program, the gray water will be recycled, purified, and reused both on the Gateway and in the lunar habitat. For the lunar crew living and working on the Moon, the purified water must have a pH range of 6.0 to 8.5 and be clear of all debris. It should also be odorless.

Lunar Water Challenge



Artist's impression of a multidome lunar base, based on a three-dimensional (3D) printing concept. Robots will cover the inflated domes with a layer of 3D-printed lunar regolith to help protect occupants against space radiation and micrometeoroids. (ESA, P. Carril)

The Lunar Water Challenge question is this: How can gray water be recycled, purified, and reused so that it can sustain our astronauts in the lunar habitat?

The challenge is for each team to design, develop, and test a water filter that will recycle, repurpose, and transform gray wastewater into purified drinking water for the lunar habitat.

To begin, each team will need to develop a water filter that consists of both a container and filtering material that will clean the pollutants and contaminants out of the water. The water filter will have an opening where the gray water is poured into the filter. Once the gray water has drained through the filter, the purified water will be collected in a graduated cylinder.

The second part of the Lunar Water Challenge will address the filtration materials themselves. Unlike on Earth, the used filter material cannot be distributed or buried. Each team will provide recommendations or suggestions describing the safest way to process the used filter material, which now contains contaminants that have been separated from the water.

Challenge Guidelines

Student teams will

1. Gather and record test data that describes both the clean water (bottled drinking water) and the gray water (four parts water and one part Italian salad dressing). Record pH levels and observations on odor, debris, and contaminants.
2. Measure and record the mass of the filtration materials used in the water filter in grams (g).
3. Using a graduated cylinder, measure and record the following:
   a. Amount of gray water to be poured into the filter
   b. Amount of water that drains out of the filter

This is just one example of a lunar water container that could hold the filtration materials.

4. With a timer, measure and record the amount of time it takes the gray water to seep through the filter.
5. Once the water filtration process is complete, develop a disposal plan that includes suggestions on how to safely dispose of the filtration material without dispersing it on the lunar surface.

Challenge Criteria

Develop a water filter that will clean 250 mL of gray water as determined by the following four tests:

1. pH Scale Test: The pH of the filtered water must measure as neutral (between 6.5 and 7).
2. Debris Test: The filtered water must be observed as clear, with no floating debris.
3. Odor Test: The filtered water must not smell like Italian salad dressing.
4. Contaminants Test: All pollutants and contaminants that were in the gray water must be removed by the filter.

Challenge Constraints

1. The filter must process 250 mL of water.
2. The mass of the filtration materials (up to three different types) together with the container must not exceed 1,000 g of mass.
3. The graduated cylinder used to collect the discharged water draining through the filter must be large enough to accommodate the filtered water.