Agriculture and Water on the Moon

A Little Sweat Goes a Long Way for Exploratio

There's a whole lot of sweating going on in one building at NASA's Marshall Space Flight (Huntsville, Ala.

Marshall Center employees are donating their time, energy -- and sweat -- during monitorec on bikes, rowing machines and treadmills to test part of the life support system that provide International Space Station with clean air, a comfortable living environment and drinkable \

The system is called the Regenerative Environmental Control and Life Support System, or l NASA engineers at the Marshall Center are responsible for designing and developing the W Recovery System, which reclaims potable water from Space Station wastewater, including (-- condensed water vapor and trace contaminants from crew perspiration and respiration -- a

The Water Recovery System includes a Urine Processor, designed, assembled and tested in- Marshall that recovers water from urine. This resulting "product" is then combined with the latent for processing to attain potable quality by the Water Processor Assembly. That assem provided to NASA by Hamilton Sundstrand Space Systems International of Windsor Locks cleans wastewater through a series of treatment processes. Those processes primarily incluc adsorption, which takes the organic contaminants such as caprolactam, which comes from \ of the water; ion exchange, which takes salt out of the water; and catalytic oxidation, which the volatile organics such as methanol and other contaminants that adsorption and ion excha remove.

"The resulting product water is cleaner than municipal water on Earth," said Layne Carter, l systems engineer for the Water Processor at Marshall. "On the Station, this water will be us crew for everything from drinking to hygiene activities, as well as the operation of payloads

To reduce costs and take advantage of existing facilities, the qualification test of the Water Assembly treatment process is being performed in the ECLSS Test Facility at Marshall. Th recovered water must meet stringent purity standards before it can be used to support the cr why these tests use the actual chemical "beds," or expendables, that will process water on th The objective of the tests is to verify the entire assembly works properly. The chemical "be of the Water Processor Assembly that removes the different types of contaminants from the that it can be re-used by the crew as potable water.

More than 100 employees are participating in the Water Processor Assembly Expendables Qualification Test. For the study, they exercise for an hour a day, generating water vapor th perspiration and respiration, in the Regenerative ECLSS Module Simulator -- a mockup of a Station module filled with treadmills, a bicycle, rowing machine and other exercise equipm also brush their teeth, wipe themselves down with wet towels and male participants even sh simulating the daily routine of a Station crewmember -- to get every bit of moisture into the atmosphere.

"It's my chance to get in shape, literally to contribute to science and prove this equipment -- people here have worked to design and build -- works flawlessly," said Gray Marsee, an att is participating in the tests. "I'm literally donating my sweat to the Space Station and future exploration."

Before stepping into the mockup for a session, participants are provided with a white T-shir a towel for drying off and a bottle of water or a sports energy drink to consume as they exer weigh-in on a computerized scale, with the bottle of water in-hand.

"We want to see how much weight goes in and calculate how much condensate is left inside module," said Gene Hartsfield, manager of the ECLSS test facility. "The T-shirts and towel hanging inside overnight to evaporate to get more sweat out of them and into the condensat

Meals also are an important part of the testing. The participants microwave meals inside the generate water vapor and the aroma from the food. The condensate is then combined with tl Processor product and sent to the water processor for treatment. Water quality samples are t key locations in the water processor to assess the performance of the expendables and deter often they must be replaced.

The testing began in October and is expected to wrap up later this month. The results will v water processor chemical "beds" are ready to fly in 2007.

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http://www.nasa.gov/vision/space/livinginspace/eclss1.html

Solar Growth Chambers for NASA
Exploring agriculture for space colonies

Want to go live on the moon for a few months and still eat fresh vegetables? The idea of growing food in a space colony is not as far off as you might think. Engineers from The University of Arizona's Department of Agricultural and Biosystems Engineering are working on it right now, thanks to two grants from NASA. Growth chambers lit with both solar and artificial discharge lights are producing crops of fresh lettuce at the College of Agriculture's Environmental Research Laboratory (ERL).

"NASA has an Advanced Life Support program," says Joel Cuello, the UA biosystems engineer in charge of the solar chamber project. "Its main goal is to be able to provide the energy and materials astronauts will need to survive in enclosed space conditions. One way is through physical/chemical means, the other is through biological regenerative methods--using plants, for example, which can produce oxygen for breathing and also edible crops for food."

Cuello says the long-term goal is to set up a lunar or planetary space colony. "Because they've found ice on the moon, then water is present," Cuello says. "This points to the possibility of a colony on the moon." An extended stay in space means extensive food supplies must either be on board, re-supplied periodically from earth, or produced on-site. Bringing all of the food at once would require a fairly large space craft.

"And delivering from the earth to the moon--operating on a picnic or take-out principle--would be too expensive," Cuello adds. That leaves agriculture as the best possibility, but under more controlled conditions than we have on earth, where soil, light, water and air are more abundant. Funded by NASA through a university research grant and one of its Small Business Technology Transfer (STTR) grants, the latter in collaboration with a small company in northern California called Physical Science Incorporated, the UA project began in January of 1997 in an underground plant growth facility.

Cuello's research collaborators include fellow faculty members, Kenneth Jordan and Dennis Larson; research specialist Philip Sadler; company scientist Takashi Nakamura, of Physical Sciences, Inc.; UA plant physiologist Patricia Rorabaugh; UA environmental scientist Robert Frye, and graduate student Darren Jack.

"We used a combination of readily available solar collectors at the ERL, plus another developed by the company," Cuello says. He and his research team built the subterranean facility and lit one chamber with solar irradiance and the other with artificial light as a reference chamber. "We're testing lettuce in them, not because it's the ultimate crop that we want to grow but because it grows fast for experimental purposes," he explains.

Current crops NASA is considering for advanced life support include wheat, tomatoes, potatoes, sweet potatoes, rice and others. The larger program, conducted at a variety of institutions, including NASA Kennedy and NASA Johnson Space Centers, also includes research in plant production; fish production; waste management and recycling; and food processing. The goal is to link all these units into a self-sustaining life support system, according to Cuello.

"The problem right now is the very high energy requirement needed for life support," he says. Generating enough artificial light for enclosed agriculture on the moon or Mars would be difficult. Cuello sees solar irradiance as an important supplement to artificial light for space plant production. But at the same time, solar irradiance can't completely replace artificial lighting, because there can be 14 earth days in a row without light on the moon, for instance.

The combination of solar and artificial light ensures a constant energy supply, and transmitting the light through fiberoptic cables into the growth chamber reduces the heat that would be generated inside. Removal of any heat would require additional and wasteful energy expenditure.

Each chamber measures three feet by two feet in area. Mirrors on top collect and concentrate the light, and focus it into fiberoptic cables that transport the light from the point of collection into the growth chamber. The cables extend through the ceiling into the top of the solar growth chamber, where their individual fibers fan out in a frame to distribute the light evenly to the plants. The plants are grown hydroponically, supplied with liquid nutrients.

A computerized system monitors the conditions inside the growth chambers, tracking air temperature, light duration and intensity, and the pH of the nutrient solution. To keep light conditions as equal as possible, the researchers light up the solar chamber a day before the other one, measure how much light was used and then apply the same amount in the artificial light chamber.

Cuello says there has been an increase in yield in the solar chamber relative to the artificially lit chamber. "The only environmental difference between the two chambers is the quality of light," Cuello says, "one is natural light and the other is richer in the red spectrum." He notes that the project does not mimic weather conditions that might be encountered on the moon or on Mars. He says the weather might be more stable on the moon but dust could be a problem on Mars.

For this reason, Cuello would like to improve the design of the collectors. Right now he is using two different types. "The one provided by Physical Science, Inc. is more powerful, with larger mirrors and a larger collection area, but it has a primitive tracking system because that's what happens to be commercially available," Cuello admits. "The other one has a sophisticated tracking system but a smaller collection area."

He wants to develop a system with better mirrors *and* optical tracking systems. "NASA has just awarded us a new two-year grant to look into a system with a combination of natural and artificial lights, both delivered into a plant growth chamber through fiberoptic cables to provide stable lighting with minimized heat production," Cuello says. He and his team will be looking at different light sources, such as light-emitting diodes and xenon metal-halide lamps, to bring that salad on the moon or Mars closer to reality.

Article Written by Susan McGinley, ECAT, College of Agriculture

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