Space bricks for lunar habitation

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Credit: Divakar Badal

In what could be a significant step forward in space exploration, a team of researchers from the Indian Institute of Science (IISc) and the Indian Space Research Organisation (ISRO) has developed a sustainable process for making brick-like structures on the moon. It exploits lunar soil, and uses bacteria and guar beans to consolidate the soil into possible

load-bearing structures. These 'space bricks' could eventually be used to assemble structures for habitation on the moon's surface, the researchers suggest.

"It is really exciting because it brings two different fields—biology and mechanical engineering—together," says Aloke Kumar, Assistant Professor in the Department of Mechanical Engineering, IISc, one of the authors of two studies recently published in *Ceramics International* and *PLOS One*.

Space exploration has grown exponentially in the last century. With Earth's resources dwindling rapidly, scientists have only intensified their efforts to inhabit the moon and possibly other planets.

The cost of sending one pound of material to outer space is about $10,000. The process developed by the IISc and ISRO team uses urea—which can be sourced from human urine—and lunar soil as raw materials for construction on the moon's surface. This decreases the overall expenditure considerably. The process also has a lower carbon footprint because it uses guar gum instead of cement for support. This could also be exploited to make sustainable bricks on Earth.

Some micro-organisms can produce minerals through metabolic pathways. One such bacterium, called *Sporosarcina pasteurii*, produces calcium carbonate crystals through a metabolic pathway called the ureolytic cycle: it uses urea and calcium to form these crystals as byproducts of the pathway. "Living organisms have been involved in such mineral precipitation since the dawn of the Cambrian period, and modern science has now found a use for them," says Kumar

To exploit this ability, Kumar and colleagues at IISc teamed up with ISRO scientists Arjun Dey and I Venugopal. They first mixed the bacteria with a simulant of lunar soil. Then, they added the required urea

and calcium sources along with gum extracted from locally-sourced guar beans. The guar gum was added to increase the strength of the material by serving as a scaffold for carbonate precipitation. The final product obtained after a few days of incubation was found to possess significant strength and machinability.

"Our material could be fabricated into any freeform shape using a simple lathe. This is advantageous because this completely circumvents the need for specialized molds—a common problem when trying to make a variety of shapes by casting. This capability could also be exploited to make intricate interlocking structures for construction on the moon, without the need for additional fastening mechanisms," explains Koushik Viswanathan, Assistant Professor in the Department of Mechanical Engineering, IISc, another author.

The *PLOS One* study, conceived by Rashmi Dikshit, a DBT-BioCARe Fellow at IISc, also investigated the use of other locally available soil bacteria in the place of *S. pasteurii*. After testing different soil samples in Bangalore, the researchers found an ideal candidate with similar properties: *Bacillus velezensis.* Just a vial of *S. pasteurii* can cost Rs. 50,000; *B. velezensis*, on the other hand, is about ten times less expensive, the researchers say.

The authors believe that this is the first significant step towards constructing buildings in space. "We have quite a distance to go before we look at extra-terrestrial habitats. Our next step is to make larger bricks with a more automated and parallel production process," says Kumar. "Simultaneously, we would also like to further enhance the strength of these bricks and test them under varied loading conditions like impacts and possibly moonquakes."

More information: Dikshit R, Jain A, Dey A, Kumar A (2020), Microbially induced calcite precipitation using Bacillus velezensis with

guar gum, *PLOS One*, 15(8): e0236745
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