Survivability and Life Support in Sealed Mini-Ecosystems with Simulated Planetary Soils

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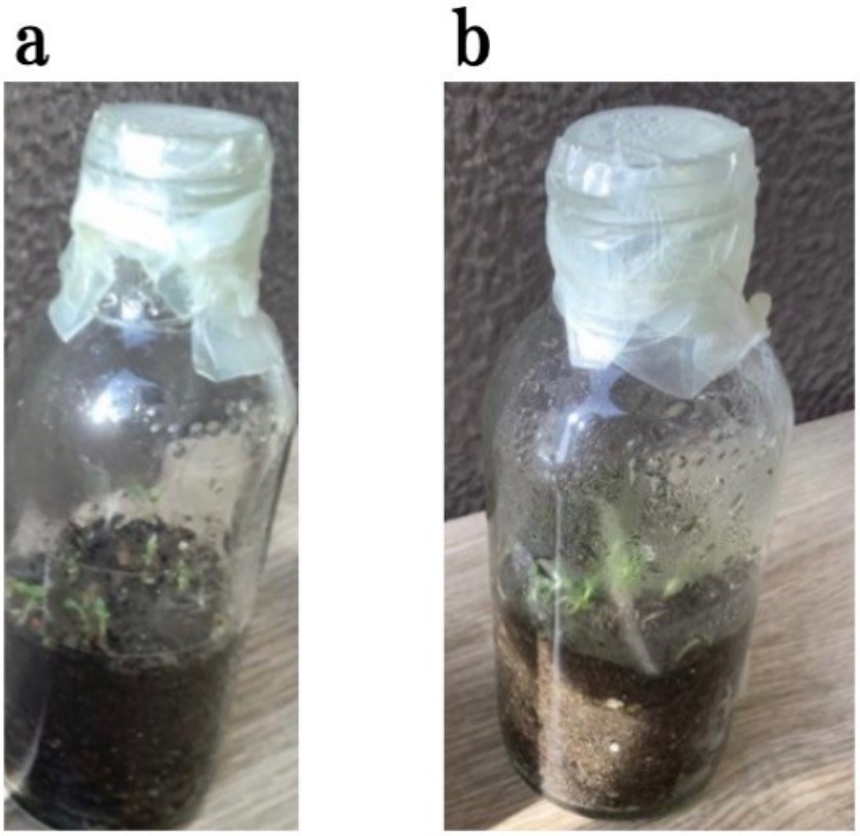
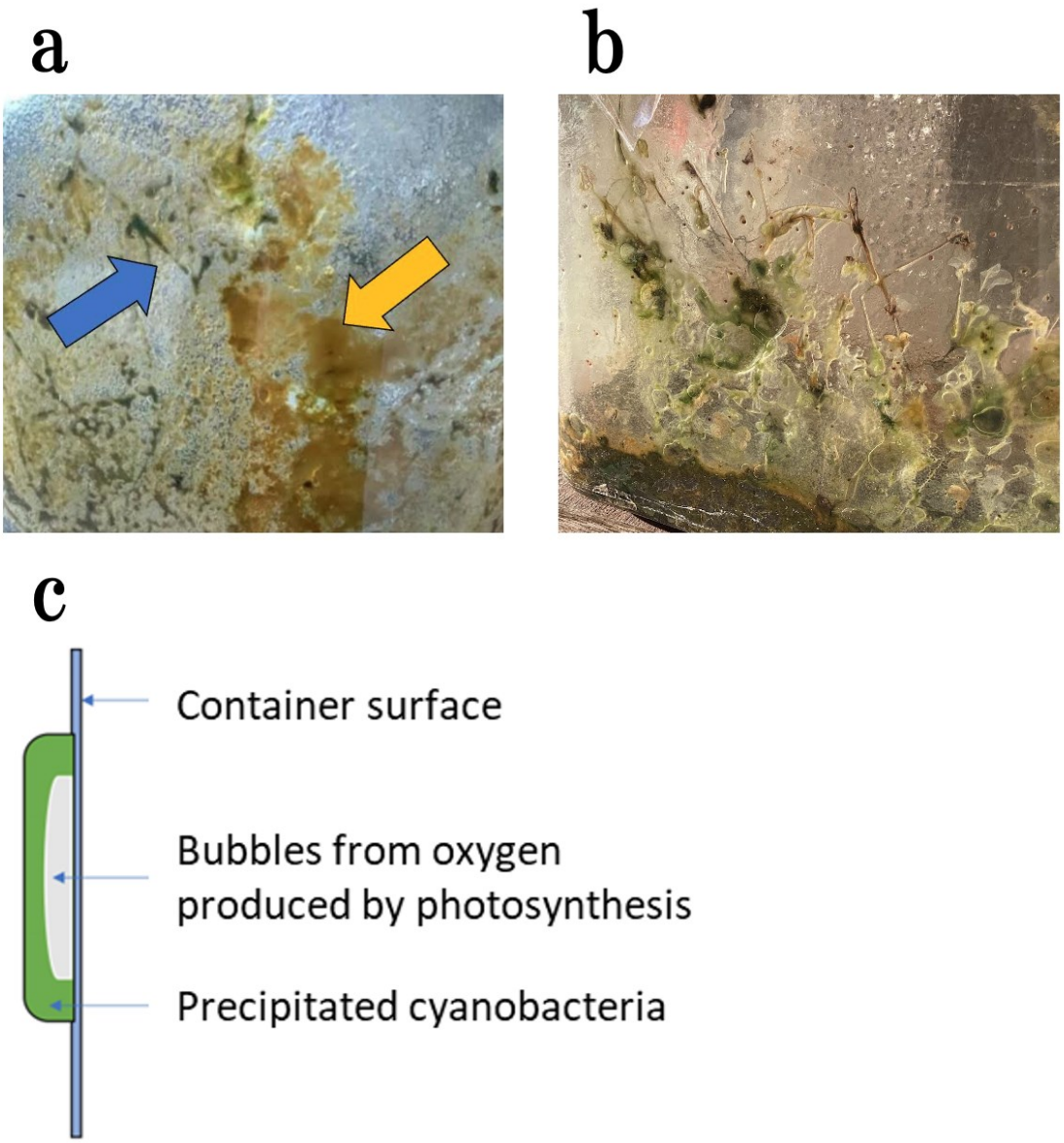
Supplemental Inventory

Supplementary Figures and Tables



Supplementary Figure 1: Appearance of Ecosphere 1 Used in the Mass Conservation Experiment.

(a) Exterior of Ecosphere 1 (Sample 1) used for the mass conservation experiment. (b) Exterior of Ecosphere 1 (Sample 2) used for the mass conservation experiment.

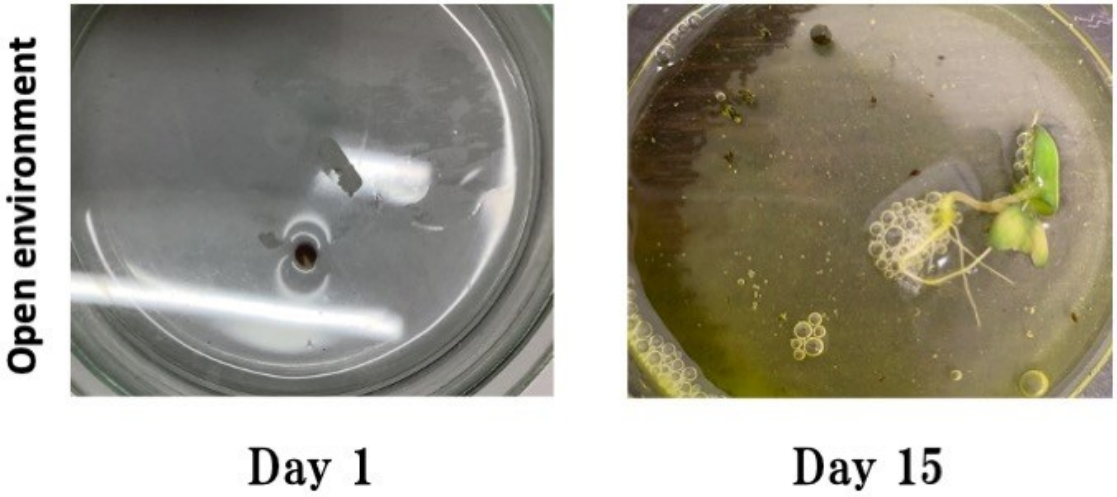


Supplementary Figure 2: Observable Microorganisms in Ecosphere 1

(a) Microorganisms proliferating within Ecosphere 1, visibly observed (Blue arrow indicates decomposition of stems, yellow arrow indicates the proliferation of jellyfish-like organisms). (b) Oxygen bubbles produced by cyanobacteria through photosynthesis. (c) Diagram showing that the bubbles on the container surface were generated by the photosynthesis of cyanobacteria.

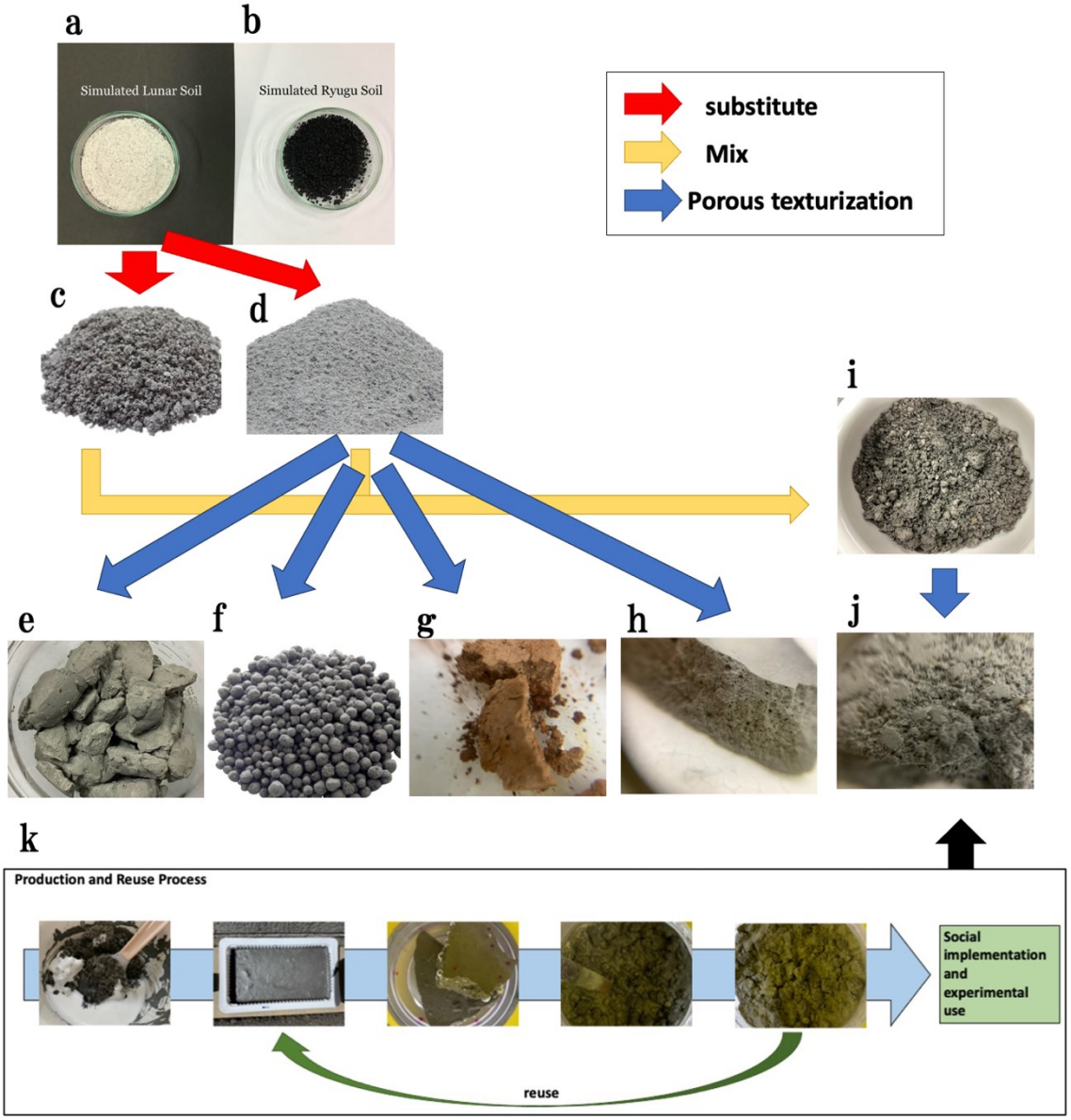
Supplementary Figure 3: Appearance of Ecosphere 2

With a groundwater layer created using red clay at the bottom.



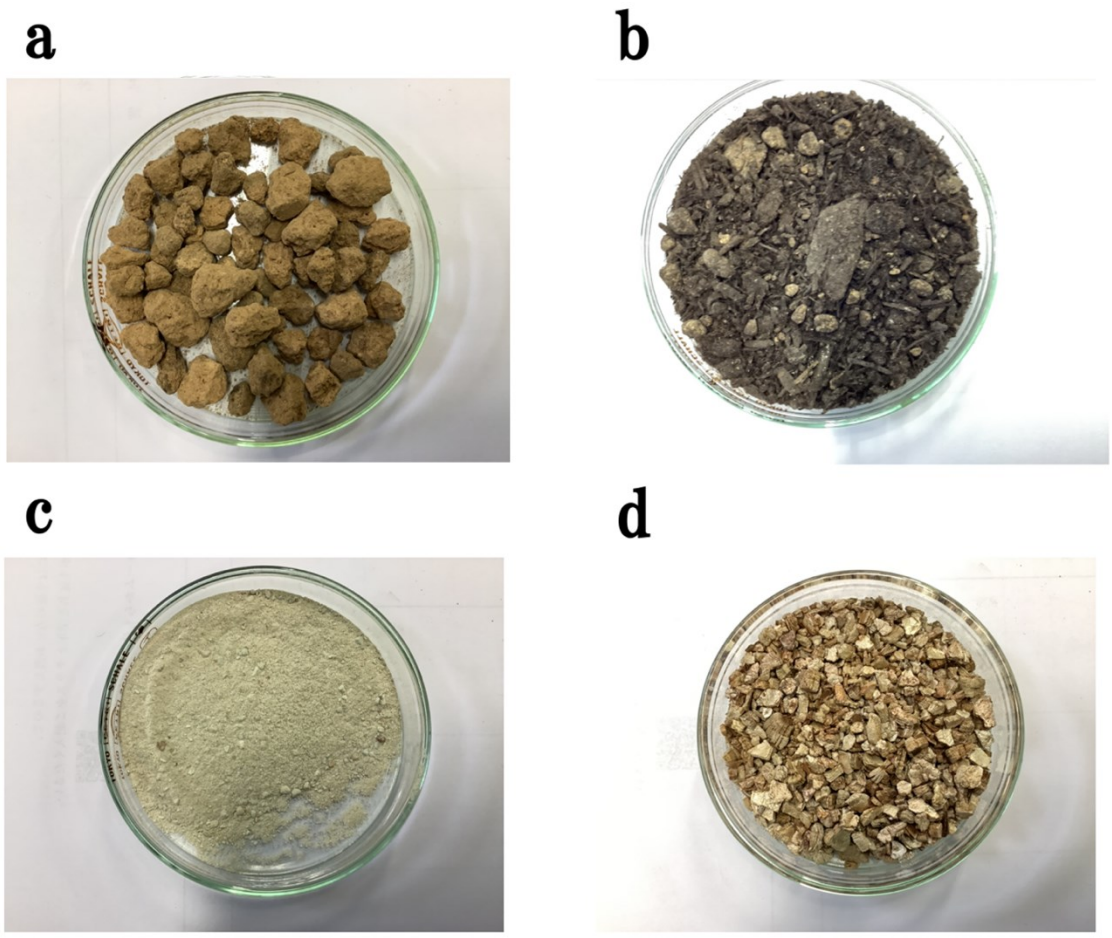
Supplementary Figure 4: Plant Growth Under LED Light Conditions

Observations of plant growth experiment using LED light in an open environment without soil, utilizing cabbage.



Supplementary Figure 5: Overview of Simulated Extraterrestrial Soil and Its Modification Methods Used in the Experiment:

(a) Simulated lunar soil (similar composition). (b) Simulated Ryugu soil. (c-d) Types of coal ash similar in characteristics and composition to lunar regolith: Clinker ash and Fly ash. (e) Lump of fly ash mixed with water. (f-h) Various modifications of fly ash using different binding agents. (i-j) Mixed soil of fly ash and clinker ash, including a porous version using a bonding agent. (k) Diagram showing the creation stages and recycling process of Boncrete.

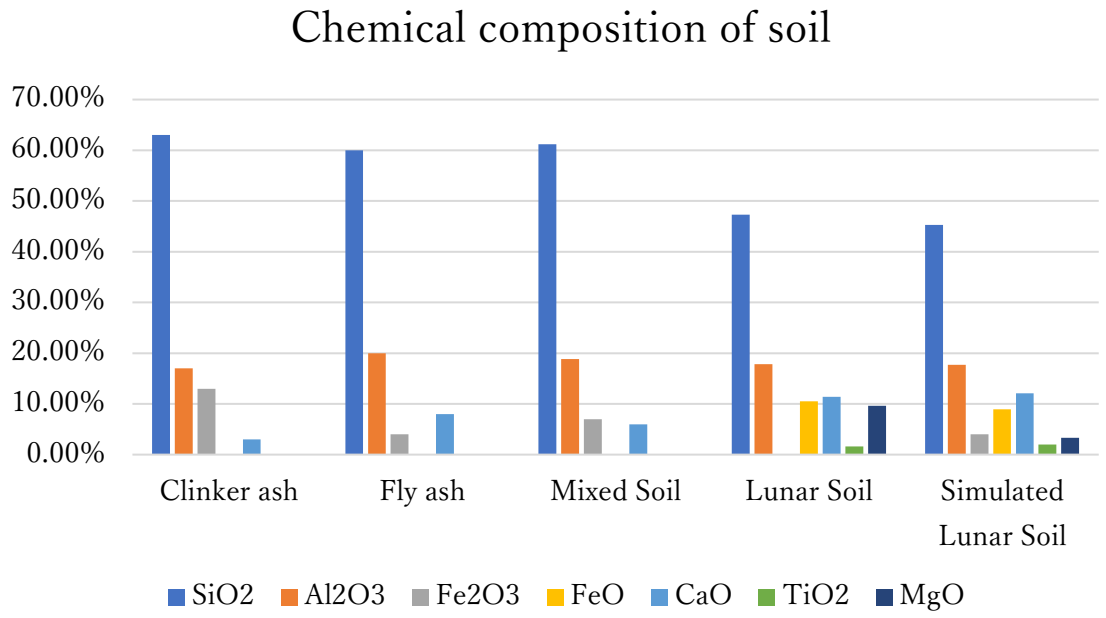


Supplementary Figure 6: Soil Used in Ecosphere 2

(a-b) Appearance of the soil used in Ecosphere 2. (c) Zeolite used in Ecosphere 2. (d) Vermiculite used in Ecosphere 2.

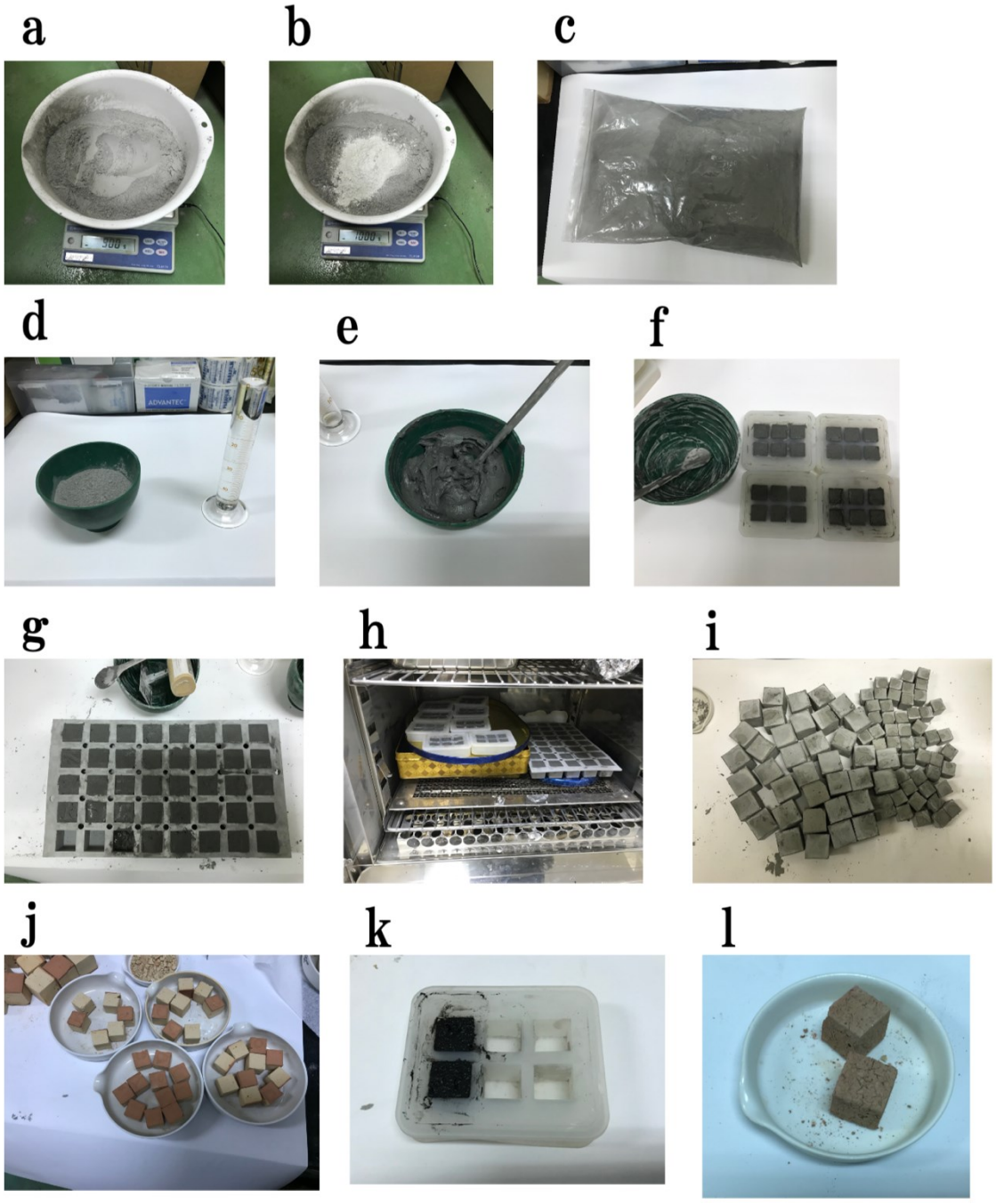
Supplementary Figure 7: Development of Biosealed 2

A larger version of Ecosphere and Biosealed designed to prevent entropy collapse in a small enclosed space. The structure and vinyl from an umbrella were separated, skeleton cut to 60cm sides, reinforced with string, and vinyl was secured around using silicone.



Supplementary Figure 8: Chemical Composition of Various Soils

Bar graph of the chemical composition of fly ash, clinker ash, their mixed soil, lunar soil, and simulated lunar soil.



Supplementary Figure 9: Creation of Porous Fly Ash Using Bentonite as a Binder
(a-l) Various steps in the process, from sampling to drying and firing.

Supplementary Table 1: Results of the Mass Conservation Experiment

	Before (2021/11/27)	After (2022/4/28)
Sample 1	365g	365g
Sample 2	431g	431g

Supplementary Table 2: Basic Information of Ecosphere 1 Used in the Mass Conservation Experiment

Sample Type	Sample 1	Sample 2
Number of seeds	10	20
Water content	20 ml	20 ml
Soil capacity	50 ml	50 ml
Air capacity	65 ml	65 ml
Total capacity	115 ml	115 ml

Supplementary Table 3: Chemical Composition of Fly ash, Clinker ash, their mixed soil, lunar soil, and simulated lunar soil

	Clinker ash	Fly ash	Mixed Soil	Lunar Soil	Simulated Lunar Soil
SiO_2	63.00%	60.00%	61.17%	47.30%	45.30%
Al_2O_3	17.00%	20.00%	18.82%	17.80%	17.70%
Fe_2O_3	13.00%	4.00%	7.00%	—	4.00%
FeO	—	—	—	10.50%	8.90%
CaO	3.00%	8.00%	5.96%	11.40%	12.10%
TiO_2	—	—	—	1.60%	2.00%
MgO	—	—	—	9.60%	3.30%