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Millimeter scale water movement on convex and concave surfaces of porous media under microgravity.

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Human's sphere of activities is going to expand to Moon and Mars on 2030s. As manned space mission getting longer, the importance of extra-terrestrial agricultural production increase not only for food production, but also for phycological benefit for astronauts. Water movement in porous media must be understood for secured plant growth, previous researches, however, reported that slower capillary flow was observed under microgravity than under Earth gravity (1 G). Air entrapment on pore neck may induce higher tortuosity and made capillary flow slower under microgravity. It was also reported that widening shape on capillary tube restrict water movement in capillary tube under microgravity. The diameter of capillary tube was relatively large (0.8 mm to 2.3 mm in-diameter) in the previous report; therefore, it is unclear that the result is applicable to the smaller pore structure like porous media. The objective of this study is (1) to evaluate capillary flow rate on convex and concave surface on the particle of porous media under microgravity and under 1 G, (2) to evaluate the water movement on widening area made by boundary between 0.8 mm and 1.0 mm glass beads. To make water movement visible, acrylic column of 2 mm thickness was chosen and was filled with 4 cm layer of 0.8 mm diameter glass beads and 3 cm layer of 1.0 mm diameter glass beads. Distilled water dyed with methylene blue solution was infiltrated into the glass beads under 2.4 s microgravity condition induced by 50 m free fall or under 1 G condition. Capillary flow was taken by high speed (960 fps) and closeup camera (DSC-RX100M5A, SONY) and split into image sequences to analyze with software (ImageJ). Both under microgravity and under 1 G, capillary flow stuck on the convex surface and hardly infiltrated into the concave surface, however, once water crossed over the convex surfaces, water moved on concave surfaces very fast. Pore was filled with water and air entrapment on pore neck, predicted on previous research, was not observed. The water front firstly reached on the boundary of 0.8 mm to 1.0 mm glass beads stopped, however, after the surrounding water front catch up, water crossed over the boundary. This result suggested that widening area restricted capillary flow, however it did not shut-off.