Gravity effect on water movement in pore space of glass beads porous media under microgravity.

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Water movement in porous media plays an important role, not only under Earth gravity (1 G), but also under microgravity. Previous research, glowing red romaine lettuce under microgravity on International Space Station, reported that water hardly infiltrate into porous media by capillary force and the lettuce was stunted by low water event. Another research reported that water infiltration rate in porous media was slower under microgravity than under 1 G. Development of air entrapment on pore space and fingering of wetting front may restrict water movement under microgravity. Furthermore, square widening shape (0.8 mm to 2.3 mm) restricted capillary flow in glass tube under microgravity, it is, however, unclear that widening shape of pore space in porous media, which is smaller and has concave surface, restrict water movement under microgravity. Our objectives of this study are (1) to evaluate gravity dependence on development of air entrapment and fingering of wetting front in porous media, and (2) to reveal the shape which restricts capillary flow in porous media under microgravity, especially the widening shape which was reported as restricting factor of capillary flow in glass tube. To capillary flow visible, thin acrylic column (20 x 70 x 2 mm inside dimension) was chosen. 2 layers of glass beads which were 40 mm layer of 0.8 mm glass beads and 30 mm layer of 1.0 mm glass beads were filled into the column to create widening shapes on the border of beads layer. Distilled water dyed by methylene blue solution was infiltrated into the glass beads and capillary flow was captured by high speed (960 fps) and closeup camera (DSC-RX100M5A, SONY). The movie was split into image sequences and the pictures were analyzed by PC software (ImageJ). The experiment was conducted both under 1 G and under 2.4 s microgravity induced by 45 m free fall from drop tower. Both under 1G and under microgravity, capillary flow temporarily stopped on 2 points which is before concave surface of bead and on pore space between bead and next bead. Once wetting front lost balance and overleaped the concave surface or attached to the next glass beads, water moved fast to the next stop point. Although, capillary flow restricted on widening shape of pore space, there were no gravity dependences on capillary flow restriction. Development of air entrapment on pore space and fingering of wetting front were not observed in this research. Narrower particle size distribution (0.71 mm to 0.99 mm) may restrict development of fingering of wetting front comparing with particle distribution in previous research (1 mm to 2 mm). Capillary flow on the border of the glass beads layer stopped longer than on other pore space. When the head of wetting front reached to the border of glass beads layer, the wetting front stopped on the border until surrounding wetting front caught up. The border disturbed the wetting, however, did not shut off the capillary flow.

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