The Effect of Pore Structure on Water Infiltration under Different Gravity

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It is actively performed these days about research on life activities under different gravitational effects, such as long-term stays on the space station and life exploration on other planets. Life activity always requires a water retention by a porous body, and studying how liquids behave in regolith (soil) will contribute to elucidating the environment of the water planet. The outermost layer of the earth is called soil, not regolith. Our previous report showed that the presence of tubular pores formed by plants greatly affects infiltration process and organic matter conservation on 1G earth. The pores extending vertically downward play a certain role in conservation of water and organic matter and also supporting plant growth. It is known that infiltration would be poor under the micro-gravity condition, thus water infiltration and water holding properties would also change under the different gravity, such as 1/3 on Mars and 1/6 on Moon.

In this research, we applied pseudo gravity to soil column by rotating centrifuge tube horizontally. Toyoura Standard soil was used to imitate the regolith on the planet and water tank with a pin-hole touched on the soil surface so that water was supplied only when pseudo gravity applied. In this experiment, artificial macropore was created in the soil column to examine how vertical tubular pore effects water infiltration. 1,1/2,1/3,1/4,1/6 and zero gravity were applied to examine the infiltration reach and see how break through structure (macropore) affects the reach distance. Two dimensional simulation was also conducted to check the infiltration process.

The results showed that infiltration reach decreased as the gravity decreased. Infiltration was very small with zero gravity. These were explained that, when the gravity decreased, capillary force would become relatively large compare to inertial force. Thus most of the water was absorbed by bulk soil before it reaches to the deeper profile. However when there were macropore structure, like plant root created macropore, infiltration reach was kept large compare to control condition. Macrpore structure could work to maintain the inertial force and conduct the water to deeper profile effectively. These were also presented in the 2D simulation that infiltration reach maintained large even with the small gravity if the column has macropore structure inside. These results showed that, break through structure, tubular pore plays a role to conduct the water to deeper profile. It might be a small effect but in the long run, the effect would be large. The reports said that during the Silurian period, first lichens and then vascular plants appeared on terrestrial area. During this process, root created macropore could play certain role to keep moisture in the early soil. This could be also true for the planet evolution. Small gravity could not conduct the water to deeper profile effectively, however, if there is vertical pore structures, moisture could be kept under the ground, avoiding precious water to escape to the atmosphere.

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