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Root Exudates Alters Nutrient Transport in Soil

Amit Paporisch[1], Harel Harel Bavli[1], Rachel Strickman[2], Rebecca Neuman[2], and Nimrod Schwartz[1]
[1]The Hebrew University of Jerusalem, The Robert H. Smith Faculty of Agriculture, Food and Environment, The Institute of Environmental Sciences, Israel (amit.paporisch@mail.huji.ac.il)
[2]Department of Civil and Environmental Engineering, University of Washington, Seattle, WA

Root exudates affect the physical properties of the rhizosphere, but how these changes affect its solute transport properties is unknown. Understanding how exudates affect the rhizosphere's transport properties could advance the knowledge on nutrient dynamics in soil and its availability to plants. In the current study, we tested the effects of two exudates (chia mucilage and wheat root exudates) on the transport of iodide and potassium in soil. Solute breakthrough experiments, conducted in saturated loamy sand or coarser textured quartz sand, revealed that increasing the exudate concentration in soil results in increasingly non-equilibrium transport of both solutes. This was demonstrated by an initial solute breakthrough at a lower pore volume, followed by the arrival of the peak solute concentration at a higher pore volume. These patterns were more pronounced in soil mixed with mucilage, and in the quartz sand. An equilibrium or a physical non-equilibrium mobile-immobile transport model, fitted to the measured results, indicated an increase in the fraction of immobile water when increasing the exudates' concentration in soil. For example, the estimated fraction of immobile water was up from 0 in quartz sand without exudates to 0.75 at a mucilage concentration of 0.2% in quartz sand. The solutes' breakthrough under variably saturated conditions was also altered by the exudates, demonstrated by higher amounts of the solutes measured per volume of water extracted from soil mixed with exudates, compared to soil without exudates. The results indicate that exudates have a major effect on the rhizosphere's transport properties, most likely since in its presence low-conducting flow paths are formed, resulting in a physical non-equilibrium during solute transport.