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Root exudate induced microbial activities and phosphorus cycling in soil: An application of phosphate oxygen isotopes

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Rhizosphere is the most biologically active region between the plant and the surrounding soil where plant release their fixed carbon into the soils. Depending on the availability and types of carbon compounds released from the plant, they can directly solubilize nutrient or indirectly influence nutrient cycling by promoting increased microbial activity in the rhizosphere. In this study we applied phosphate oxygen isotope ratios ($d^{18}O_P$) to determine how root exudate influences temporal variation in microbial activities and P cycling in the rhizosphere. Rhizoboxes were filled with soils, watered to 75% water holding capacity and equilibrated for 10 days. After equilibration labeled phosphate isotopes synthesized using ^{18}O labeled water was applied. Then a mixed exudate (i.e., glucose, alanine, and oxalate in the ratio of 1:1:1) was introduced into the soil for 4, 10, and 20 days via an artificial root. We used a sequential extraction technique (i.e., resin-Pi, $NaHCO_3$-P, NaOH-P, and HCl-P) to track the fate of applied P in bulk and rhizosphere soils. The root exudate effects on the rate of P cycling and microbial activity were investigated using phosphate oxygen isotope ratios in the resin-Pi pool. Microbial community structures was determined using phospholipid fatty acids (PLFA) profiles. After supplying root exudate for 4, 10, and 20 days, the results showed that bioavailable P (i.e., resin-Pi) concentration was always higher in the bulk soil compared to rhizosphere soil and originally bioavailable P transformed gradually into unavailable P (i.e., NaOH-P and HCl-P). After supplying exudate compound for 4 days, the applied PO_4 was mostly in the resin-Pi pool and its isotopic composition was heavier than the equilibrium isotopic composition suggesting that this Pi pool was not completely cycled by the microorganisms. As we continue supplying exudate compounds, the concentration of resin-Pi gradually decreased and as microbial activities increased, its isotopic composition got closer to the equilibrium isotopic composition. Further the microbial community structure in the rhizosphere soil after supply of root exudate were distinctly different then the bulk soil. Using phosphate oxygen isotopes this study shows the influence of root exudates on the rate of P cycling in rhizosphere soils.