



Development of micro push-pull tests to investigate rhizosphere processes

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The rhizosphere differs from the bulk soil due to the influence of the roots and the associated microbial and fungal activity. Most mechanistic rhizosphere research is undertaken in microcosms, often in the absence of soil. This has resulted in a fragmented understanding of many rhizospheric processes. The use of micro-techniques for the collection of soil solution enables non-destructive in situ observation of soil solution chemistry and aspects of soil solution biology. In conjunction with rhizoboxes that allow observing the development of root systems through a transparent front plate, micro-suction cups have been used successfully to collect soil solution adjacent to roots. This permits the determination of solute concentrations in the rhizosphere at high spatial and temporal resolution. Our goal now is to combine micro-suction cups with the technique of push-pull tests to create a miniaturized system that will be applicable to study reactions and exudation rates in the rhizosphere under conditions as undisturbed as possible. Push-pull tests have been used extensively on a larger scale for the investigation of chemical, physical and biological pollutant transport and degradation processes in aquifers. In a push-pull test, a solution containing reactive and non-reactive tracers is injected into an aquifer. After a defined time the test-solution/groundwater mixture is then extracted from the same location.

As a first step we developed and tested a micro push-pull test procedure in sand-filled boxes under water-saturated conditions. We slowly injected about 250 μl solution and extracted 800 μl solution in increments of about 70 μl . As conservative tracers we used Acid Red 1 and bromide. The data were successfully modeled taking account of advection, dispersion and molecular diffusion. To study microbial degradation of exudates (e.g. citrate), push-pull tests were carried out in sand-filled boxes inoculated with denitrifying bacteria in the absence and presence of a disinfectant. Citrate concentrations in the extracted solution samples were significantly lower in presence of active bacteria than in the experiment with disinfectant. These results show that the new micro push-pull test can be a valuable method to observe local biodegradation processes in situ. In a next step, the method will be adapted to unsaturated conditions.