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Rhizosphere size

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Estimation of the soil volume affected by roots - the rhizosphere - is crucial to assess the effects of plants on properties and processes in soils and dynamics of nutrients, water, microorganisms and soil organic matter. The challenges to assess the rhizosphere size are: 1) the continuum of properties between the root surface and root-free soil, 2) differences in the distributions of various properties (carbon, microorganisms and their activities, various nutrients, enzymes, etc.) along and across the roots, 3) temporal changes of properties and processes. Thus, to describe the rhizosphere size and root effects, a holistic approach is necessary.

We collected literature and own data on the rhizosphere gradients of a broad range of physico-chemical and biological properties: pH, CO_2, oxygen, redox potential, water uptake, various nutrients (C, N, P, K, Ca, Mg, Mn and Fe), organic compounds (glucose, carboxylic acids, amino acids), activities of enzymes of C, N, P and S cycles. The collected data were obtained based on the destructive approaches (thin layer slicing), rhizotron studies and in situ visualization techniques: optodes, zymography, sensitive gels, 14C and neutron imaging.

The root effects were pronounced from less than 0.5 mm (nutrients with slow diffusion) up to more than 50 mm (for gases). However, the most common effects were between 1 - 10 mm. Sharp gradients (e.g. for P, carboxylic acids, enzyme activities) allowed to calculate clear rhizosphere boundaries and so, the soil volume affected by roots. The first analyses were done to assess the effects of soil texture and moisture as well as root system and age on these gradients. The most properties can be described by two curve types: exponential saturation and S curve, each with increasing and decreasing concentration profiles from the root surface. The gradient based distribution functions were calculated and used to extrapolate on the whole soil depending on the root density and rooting intensity. We conclude that despite the specific effects of plants and soil on the rhizosphere size, the most common distribution functions can be calculated for individual roots and extrapolated for the whole soil profile.