



The role of matric potential, solid interfacial chemistry and wettability on isotopic fractionation of soil water

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Recent observations using stable isotopes indicate that hydrological process within the unsaturated zone are more compartmentalized than originally thought. The interaction between mobile and immobile water, water vapor and its relationship to root water uptake by plants is not yet fully understood. Especially the contribution of biogeochemical processes forming the isotopic environment and the compartmentalization of water pools at the micro scale remains still unclear. Since most processes are entangled it is difficult to determine the relative contribution of each of the involved individual physico-biogeochemical processes. This is important in order to formulate models structures and reliable predications of water and carbon cycles under changing environmental conditions.

Here we present a soil water isotope retention curve approach illustrating isotope effects at the dry end of the water retention curve. Equilibrium experiments using the well-known bag-method have been done with soil samples of different grain size and different physico-chemical surface properties. Sampling has been done after one hour, one day and three days to show the effect of equilibration fractionation factors. Isotope signatures were analyzed using laser spectrometry. Subsequently to the isotope measurements sub-samples were taken from the zip-loc bags and measured for their combined osmotic and matric potential. The surface chemistry of the soil particles was analyzed using X-ray photoelectrons spectroscopy.

Our results showed that similar grain sizes but different contact angles resulted in different equilibration fractionation factors. Those can be largely explained by thermodynamic theory. The contact angle, however, as a result of an energetic equilibrium was not able to explain the different fractionation factors. This suggested that fractionation factors cannot be explained by physical parameters alone. In addition to temperature and soil matric potential, the biogeochemical composition of interfaces has some control on the equilibration fractionation factor. We introduce a new soil water isotope retention curve approach to summarize how all these factors (matric potential, contact angle and particle surface chemistry) each control the equilibrium fractionation factor for $^{18}\text{O}/^{16}\text{O}$ and $2\text{H}/\text{H}$. The retention curve approach could be useful to others to follow as new experiments to quantify soil water fractionation effects are made and compared.