



Accurate measurements of vadose zone fluxes using automated equilibrium tension plate lysimeters: A synopsis of results from the Spydia research facility, New Zealand.

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Automated equilibrium tension plate lysimeters (AETLs) are arguably the most accurate method to measure unsaturated water and contaminant fluxes below the root zone at the scale of up to 1 m². The AETL technique utilizes a porous sintered stainless-steel plate to provide a comparatively large sampling area with a continuously controlled vacuum that is in “equilibrium” with the surrounding vadose zone matric pressure to ensure measured fluxes represent those under undisturbed conditions.

This novel lysimeter technique was used at an intensive research site for investigations of contaminant pathways from the land surface to the groundwater on a sheep and beef farm under pastoral land use in the Tutaeuaua subcatchment, New Zealand. The Spydia research facility was constructed in 2005 and was fully operational between 2006 and 2011. Extending from a central access caisson, 15 separately controlled AETLs with 0.2 m² surface area were installed at five depths between 0.4 m and 5.1 m into the undisturbed volcanic vadose zone materials. The unique setup of the facility ensured minimum interference of the experimental equipment and external factors with the measurements.

Over the period of more than five years, a comprehensive data set was collected at each of the 15 AETL locations which comprises of time series of soil water flux, pressure head, volumetric water contents, and soil temperature. The soil water was regularly analysed for EC, pH, dissolved carbon, various nitrogen compounds (including nitrate, ammonia, and organic N), phosphorus, bromide, chloride, sulphate, silica, and a range of other major ions, as well as for various metals. Climate data was measured directly at the site (rainfall) and a climate station at 500m distance. The shallow groundwater was sampled at three different depths directly from the Spydia caisson and at various observation wells surrounding the facility. Two tracer experiments were conducted at the site in 2009 and 2010. In the 2009 experiment, 663 kg/ha Br[–] (as KBr) was applied at the site. The second, more complex tracer experiment was conducted with cow urine that was enriched with Cl[–]. A proportion of the enriched tracer was additionally enriched with Br[–]. The 2010 dual-tracer experiment was designed to investigate conservative and reactive contaminant transport as well as the extent of lateral flow components in the vadose zone. The investigations were also complemented by isotopic analysis of ¹⁸O and ¹⁵N isotopes of nitrate.

In this contribution, we present a synopsis of the novel lysimeter facility, the data set, and a summary of main results from the long-term experiment and from corresponding modelling studies about the dynamics and variability of vadose zone water and contaminant fluxes which have been published in several individual Journal papers.