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A novel automated fluctuating water table column system to study redox oscillations in saturated and unsaturated media

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An automated, computer-controlled soil column experimental setup was developed to simulate in detail the effects of water table dynamics on the biogeochemical transformations of nutrients and other redox-sensitive chemical species at the interface between groundwater and surface waters. The experiments were conducted using two parallel soil columns, one under stable and the other under fluctuating water table conditions. The water table in the soil columns was controlled by an automated multi-channel pump connected to two equilibrium and storage columns. In the stable column, the water table was maintained at -20 cm below the soil surface while it fluctuated between the soil surface and -45 cm in the fluctuating column at a rate of 4.8 cm/d. Redox potential (Eh), pH profiles were measured continuously using high temporal resolution microsensors (10 μm glass tip) installed into the columns at different depths. The results show striking geochemical contrasts between the fluctuating and the stable columns, demonstrating that the setup is able to impose redox potential oscillations ranging from oxidizing ($\sim$+700 mv) to reducing ($\sim$-200 mv) conditions. CO_2 fluxes were monitored in the headspace above the soil surface using a LICOR LI-8100 automated soil CO_2 flux system. The mean CO_2 emission in the stable water table column was $\sim$20 ppm/min. In the fluctuating soil column, the CO_2 flux varied between 4 and 110 ppm/min and the lowest were measured at the highest water level. Water samples obtained from micro-Rhizon samplers installed into the columns at various depths. Additionally, the physical, chemical and microbial characteristics of the media were characterized by centimetre scale slicing of the soil columns at the end of the experiment. The impacting of these oscillations on the distribution of chemical species will be discussed in term of the interactions between soils, solutes, microbial activity, and hydrology.