Geophysical Research Abstracts
Vol. 13, EGU2011-10434, 2011
EGU General Assembly 2011

Testing the use of unsaturated zones as archives of past infiltration: application to the Campine area, Northern Belgium

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Natural tracers have commonly been used in vadose zone research to determine infiltration rates in arid and semi-arid regions. We present preliminary results of a feasibility study aiming at the use of unsaturated zones as archives of past infiltration for humid regions. Results were obtained from a 2-m thick sediment-soil profile in the Campine area, Northern Belgium. The profile is believed to contain valuable information on pedological and hydrological processes, the understanding of which is crucial in the proper assessment of the long-term evolution of engineered barriers consisting of earth covers typically used to enclose near-surface landfills and disposal sites. The chloride mass balance approach (CMB) was used to determine an estimate of long-term mean infiltration rates based on natural tracers. Considering the relatively large infiltration rates characteristic of humid climates, and the limited thickness of the unsaturated zone (2-3 m) in our study, the time window of the archive is expected to be relatively small.

At the base, the profile shows a well-developed podzol soil (spodozol) in fine, slightly loamy, quartz sands (windblown cover sands), from which the A1-horizon has been removed by subsequent soil erosion. The truncated podzol is overlain by a 1.5-m thick dune sand deposit that shows four alternating phases of landscape instability (sand drift and dune accretion or deposition) and stabilization (witnessed by the development of thin O-horizons, i.e. more or less decomposed organic matter). Fixation of the dune is thought to have started around 300 years ago, based on OSL measurements, palynology and historical archives (Beerten et al., this volume). The podzol soil is believed to have been developed between $\sim$ 11 ka and $\sim$ 1 ka ago.

Pore-water chloride (Cl) concentrations measured along the profile ranged between $\sim$ 5-75 mg/L with a prominent peak around 20 cm below the surface probably due to evaporation close to the surface. A second peak was observed in the Bh-horizon of the podzol soil, possibly linked to a higher chloride inventory associated with the higher organic matter content (5.2%). Apart from this horizon, Cl-concentrations are somewhat lower in the podzol soil, compared with the overlying drift sands.
The relation between water inventory (integrated volume of water in m3/m2) and chloride inventory (integrated Cl content in mg/m2) was used to calculate infiltration rates, based on an average bulk chloride deposition rate (CMB method). Interestingly, two different relationships between both inventories were found in the investigated profile, leading to two 'apparent' recharge rates. In the upper meter (drift sands), an infiltration rate of $\sim$ 200 mm/year was apparent, while $\sim$ 500 mm/year was obtained for the podzol soil. Based on these results, the chloride profile is thought to represent two different recharge events with a time-scale yet to be defined.

Several explanations may be put forward to explain this large range of infiltration rates. It may reflect variability in precipitation and evapotranspiration over the past few years. Meteorological data is compiled together with soil hydraulic properties to test this hypothesis by simulating variably saturated flow and the concomitant chloride migration using the simulation model HYDRUS-1D. Another hypothesis being tested considers the role of the compacted organic-rich horizon with the podzol soil as a hydraulic barrier, possibly preserving a somewhat older recharge signal.

References

Beerten, K., Deforce, K., Mallants, D. Age constraints for pedological and hydrological processes in natural analogues of earth covers for waste disposal: case study from a sediment-soil sequence in Dessel, Northern Belgium. This volume.