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Coupled migration of water, and stable isotopes of water, during prolonged (7 year) evaporative drying of a dune sand

S. Lee Barbour (1) and Michael J. Hendry (2)

(1) Department of Civil Engineering, University of Saskatchewan, Canada (lee.barbour@usask.ca), (2) Department of Geology, University of Saskatchewan, Canada (jim.hendry@usask.ca)

This paper describes the results of a long-term drying experiment involving of a large column (4.6 m tall and 2.4 m in diameter) of dune sand with a water tabled fixed at a depth of approximately 3 m. The column had been previously used to study microbial respiration within a deep unsaturated sand profile and had been maintained under field capacity conditions during that study. The sand column was then left exposed to atmospheric relative humidity conditions which varied seasonally but were approximately 30% on average and at relatively constant temperature (18-23 degrees C) conditions. During that time an abrupt drying front (defined as the transition from liquid to vapour phase water migration) advanced to a depth of approximately 50 cm. The water content profile through the column was monitored using frequency domain reflectometry techniques and a neutron probe. Profiles of the stable isotopes of water across the full depth of the column were measured on samples of vapour collected through gas ports mounted along the full depth of the column. These samples were analyzed using a cavity ring-down spectrometer to establish the isotopic composition of pore-water and water vapour. Numerical modeling was undertaken to simulate water movement and the drying front advance over the 7 year period. Advective and diffusive migration of the stable isotopes of water between the water table and the evaporative front were then simulated using estimated liquid and water vapour fluxes and the observed fractionation of the water at the evaporative front. The measured and simulated profiles of the stables isotopes of water and water content provide unique insight into the development of evaporative fronts and profiles of the stable isotopes of water during extreme drying cycles. Infiltration experiments using water spiked with deuterium are currently underway to track the advanced of water infiltration events using both near continuous monitoring of water content and vapour phase deuterium. The goal of this research is to develop practical methods of tracking recharge rates over large surface deposits of mine waste through the use of natural or artificially spiked water tracers monitored solely by gas sampling.