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In-situ measurement of chloride movement in soils and evaporative-induced changes to soil salinity using a new low cost screen-printed potentiometric sensor

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We have developed low cost screen-printed potentiometric sensors to detect the presence of chloride ions in moist soils. Previous published data have shown sensor lifetimes in excess of 1 year with a near Nernstian response to the concentration of chloride ions (-49.8 $\pm$ 1.7 mV per decade) over the range 0.1 mM to 200 mM.

In this paper we investigate firstly, the ability of the sensors to quantify chloride transport through a repacked soil column (45 mm diameter by 300 mm height) and secondly, their ability to detect evaporative-induced changes to the salinity of the soil solution. The first experiment involved the installation of six sensors into a soil core with 50 mm spacing from 30 mm below the core surface. For this investigation we used one sensor per depth and potentials generated were measured with respect to a commercial Ag/AgCl reference electrode (VWR GelPlas, 3.5M KCl) located in the drainage channel at the base of the column, using a bespoke multi-channel data acquisition system based on a Libellium Waspmote wireless sensor node and a custom designed multipexed amplifier. Data were stored on an SD memory card and also sent wirelessly using IEEE802.15.4 to a local computer for real-time monitoring through a Matlab GUI. Sensor potentials were logged at a rate of one reading per sensor every 3 seconds, with each reading being the average of 10 successive samples. A steady-state saturated flow regime was maintained with a ponded head of 20 mm and an initial background solution of 10 mM chloride solution as NaCl. The chloride pulse was then supplied by switching to a solution of 100 mM and subsequently switching back to the background solution after 0.25 L had been supplied to the column. Results are presented for chloride concentration changes over time at each depth and data are fitted with the dispersion-convection equation including anion exclusion.

The second experiment used the same data acquisition system, but in this case the data was compensated for temperature variations as the experiment was located in a glasshouse. Six sensors were buried at a depth of 1 cm and a 7th was buried at a depth of 10 cm in a tub of freely-drained sand located in a glasshouse. The sand was wetted uniformly using a solution of 100 mM NaCl, and the sensor potentials were then logged for the next 13 days. The shallow sensors responded in a manner consistent with the increases in the salinity of the soil solution that would have been expected as chloride moved by capillarity to the soil surface and as the soil dried; there was a daily “pulse” in chloride concentrations overlying a gradual increase in average concentrations, with the daily maxima increasing to $\sim$750 mM chloride by Day 13. By contrast, potentials recorded by the 7th sensor varied little, indicating a more steady-state concentration at 10 cm depth.

We conclude that the sensors provide a reliable, low cost method for use in chloride tracer studies and in directly detecting changes to the salinity of rootzone soil water.