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Continuous Passive Sampling of Solutes from Agricultural Subsurface Drainage Tubes

Anders Lindblad Vendelboe (1), Hubert de Jonge (2), Joachim Rozemeijer (3), and Lis Wollesen de Jonge (1)

(1) Department of Agroecology, Aarhus University, Tjele, Denmark, (2) Sorbisense A/S, Denmark, (3) Deltares, Soil and Groundwater Quality Department, Utrecht, Netherlands

Agricultural subsurface tube drain systems play an important role in water and solute transport. One study, focusing on lowland agricultural catchments, showed that subsurface tube drainage contributed up to 80% of the annual discharge and 90% of the annual NO_3 load from agricultural fields to the receiving water bodies. Knowledge of e.g. nutrient loads and drainage volumes, based on measurements and modelling, are important for adequate water quality management. Despite the importance of tube drain transport of solutes, monitoring data are scarce. This scarcity is a result of the existing monitoring techniques for flow and contaminant load from tube drains being expensive and labor-extensive.

The study presented here aimed at developing a cheap, simple, and robust method to monitor solute loads from tube drains. The method is based on the newly developed Flowcap, which can be attached to existing tube drain outlets and can measure total flow, contaminant load and flow-averaged concentrations of solutes in the drainage. The Flowcap builds on the existing Sorbicell principle, a passive sampling system that measures average concentrations over longer periods of time (days to months) for various compounds. The Sorbicell consists of two compartments permeable to water. One compartment contains an adsorbent and one contains a tracer. When water passes through the Sorbicell the compound of interest is absorbed while a tracer is released. Using the tracer loss to calculate the volume of water that has passed the Sorbicell it is possible to calculate the average concentration of the compound. When mounting Sorbicells in the Flowcap, a flow-proportional part of the drainage is sampled from the main stream. To accommodate the wide range of drainage flow rates two Flowcaps with different capacities were tested in the laboratory: one with a capacity of 25 L min-1 (Q25) and one with a capacity of 256 L min-1 (Q256). In addition, Sorbicells with two different hydraulic resistances were tested, again to accommodate a large range of potential drainage flows rates. The experiment was continued until the Sorbicell's capacity was exhausted, which gave experimentation times from 6 to 34 days, while continuously changing the drainage flow rate to simulate field drainage conditions, and to test the range of the Flowcap. The laboratory testing yielded a very good linear correlation between drainage flow rates and Sorbicell sampling rates, giving r = 0.99 for both the Q25 and the Q256 Flowcap. The Sorbicells in this experiment were designed to measure NO_3, but the Flowcap can be used with any Sorbicell and thus be used to measure any compound of interest.

The Flowcap does not need housing, electricity, or maintenance and continuously register drainage volumes and contaminant loads for periods up to one month. This, in addition to the low cost of the monitoring system, enables large-scale monitoring of contaminant loads via tube drains, giving valuable data for the improvement of contaminant transport models. Further, these data will help select and evaluate the different mitigation option to improve water quality.