Passive Soil Water Sampler for Monitoring Movement of Agrichemicals to Groundwater

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Sampling agrochemicals in the unsaturated (vadose) zone of soils provides an early warning system for detecting groundwater pollution. However, accurate in-situ determination of agrochemical in the vadose zone is often not feasible because of lack of appropriate sampling equipment. We developed a new passive soil water sampler to effectively collect vadose zone leachate. A lab experiment using three soil types was performed to compare the new designed passive pan sampler (PPS) with the commonly used suction cup lysimeter (SCL).

Annual fluxes of agrochemical to the groundwater must be estimated in order to evaluate the influence of different agricultural practices on groundwater quality. Many studies have shown that water and chemicals can move through soil along preferred pathways, such as macropores, cracks, root channels, and worm holes. The rapid movement of water and solute can significantly enhance leaching of surface-applied chemicals to below the root zone and into groundwater. Also, fast transport of fertilizers and other agrochemicals into subsurface drainage systems has been recognized as a serious threat to surface waters.

To better understand leaching mechanisms of pesticides and nutrients, especially nitrate, we need reliable monitoring techniques. Various methods are being used to collect leachate to evaluate the fluxes of pollutants to groundwater. These include tile, soil coring, suction-cup lysimeters, zero tension (or pan) samplers and wick pan samplers. These devices generally have low collection efficiencies defined by the ratio of observed to expected percolation. While wick pan samplers, using suction created by a fiberglass wick have proven to be useful in collecting water samples in well-structured soils with dominant preferential flow and in sandy soils, they have not performed well in non-structured loamy soils in which water moves mainly through the soil matrix. In 1998, we installed 40 wick pan samplers (lysimeters) in sandy loam soils in two field studies at UMass Research Farm in South Deerfield, MA, however they did not work efficiently. Only during early spring did 5 out of 40 samplers collect water. Suction created by wick is small, being less than -5 kPa, compared to -30 kPa for field capacity.

Because of difficulties with the aforementioned samplers, we contend there is a pressing need to develop and test a soil water collection system that mimics more realistically the movement of soil water through the vadose zone collecting both macro- and micropore soil water. The objective of this study was to design of a new passive soil water sampler for vadose zone leachate collection. This uniquely designed sampler was tested in different soil textures at two initial soil water potentials, and compared to the SCL.

Three soil samples were collected from Agronomy Research farm in South Deerfield. Nine soil columns (three per soil type) with a diameter of 340 mm and height of 500 mm were used. The PPS was installed in one side of each soil column. Three tensiometers were positioned at three depths of 25 and 50 mm above the PPS, and 25 mm below the PPS in soil around the PPS. TDR probes were installed horizontally 25 mm above the PPS. A SCL (Soil Moisture Equipment, Sanata Barbara, CA, Model no. 1990) was positioned vertically in each soil column 50 mm away from the PPS and at the same depth of the PPS position and 200 mm from the TDR probe center. The soils were put through four wetting and drying cycles. Cumulative leachate collection of the PPS and SCL were determined.

Changes in the tensiometer readings and the applied vacuums indicated a consistent trend of changes in soil moisture throughout the experiment (Fig. 1). The results of statistical analysis indicated that the differences between the applied vacuums and the tensiometer readings were not significant, indicating a similar trend of change in the soil water potentials and the applied vacuum to the PPS.

The cumulative water volumes collected by different devices in the three soils were consistent and were highest for the PPS (Fig. 2). The statistical analysis indicates that both samplers had significant differences in the cumulative leachate collection values. The soil water samplers, soil types and time of leachate collection were significantly different, indicating the greater performance of the PPS for leachate collections in the three soils at different times. The calculated leachate efficiency ratios (outflow volume to added water volume) for PPS in silt loam and sandy loam soil were 94% and 78%, respectively. However, the SCL had the lowest leacheate collection efficiency, which ranged from 31% up to 59% in these soils.

Results indicated a superior performance of PPS in both sandy loam and silt loam soils. The results of this experiment also showed that the PPS is a valid and reliable method for collecting the vadose zone leachate, and has distinct advantages over the suction cup lysimeter and zero tension or gravity pan sampler, and will perhaps give a better determination of soil water flux in the vadose zone. The apparatus proved to be easy to use, providing accurate results. Further work should aim at evaluating the PPS in the field, at different landscape, and soil and crop management systems to determine the efficiency of this method, so that solute and contaminants movement in the vadose zone can be monitored with greater accuracy.

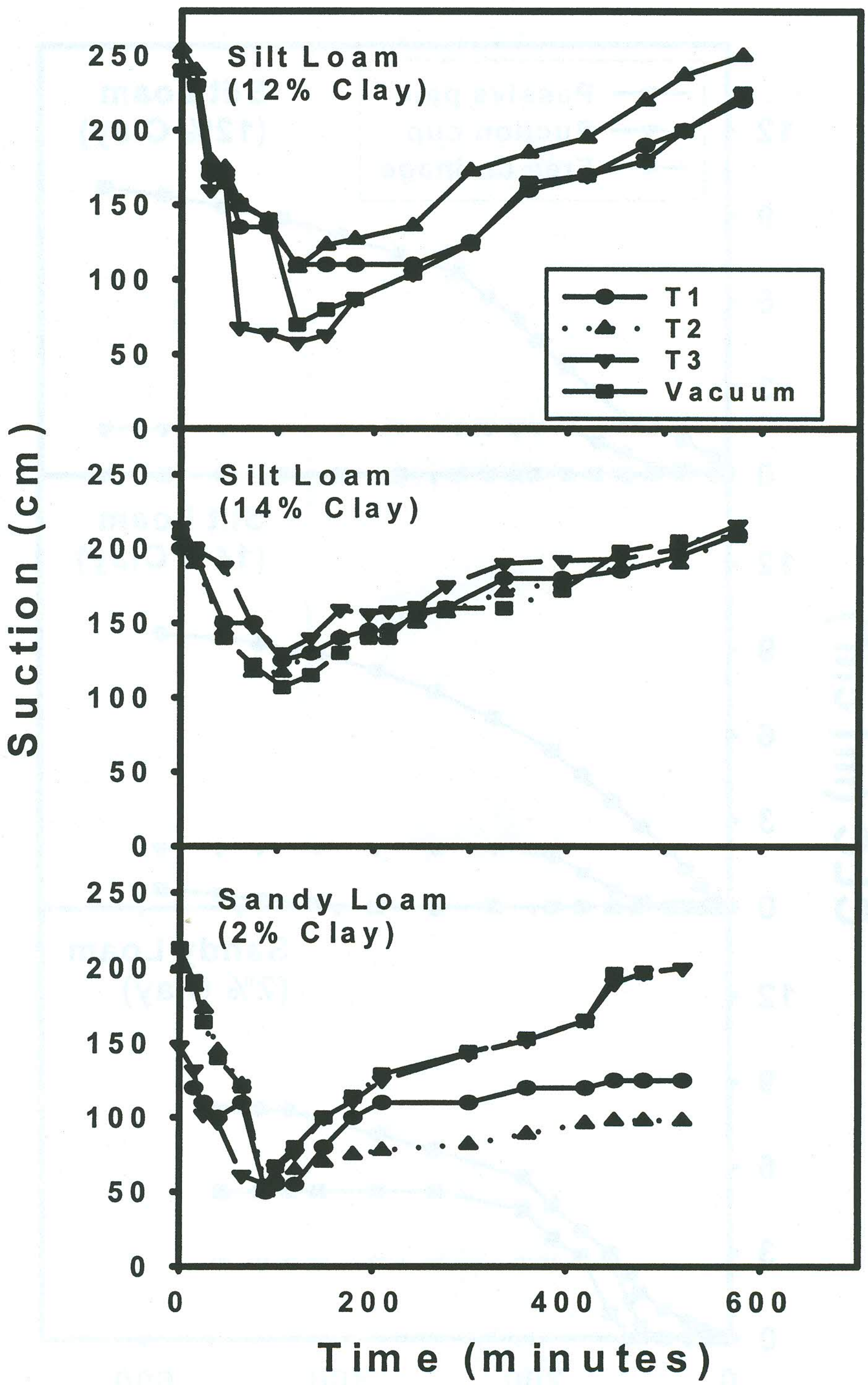

Figure 1. Tensiometer readings and the applied vacuum; T = tensiometer

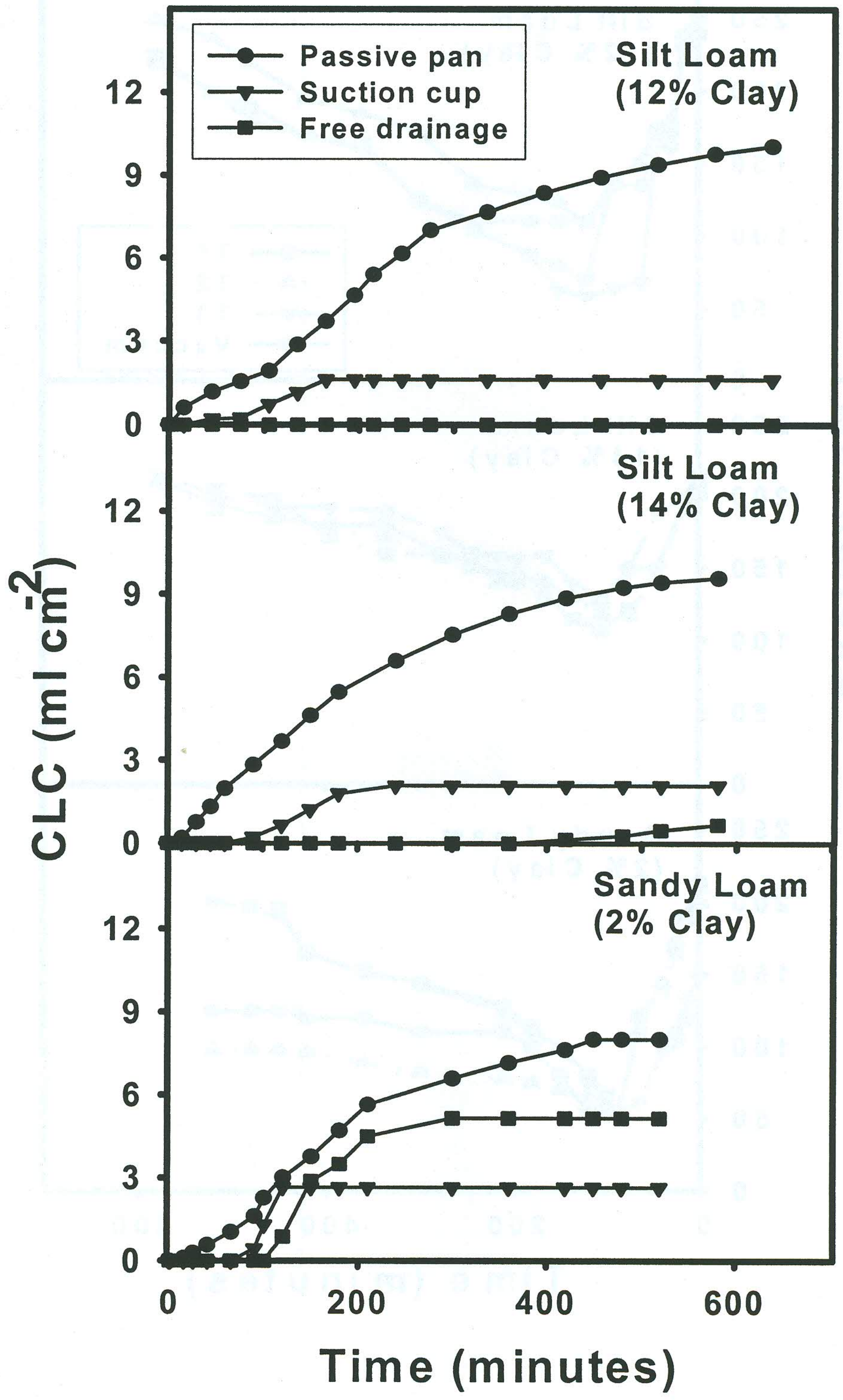

Figure 2. The cumulative leachate collection (CLC) of the passive pan sampler suction cup lysimeter and the free drainage.