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Developing an in-situ monitoring system for groundwater recharge flux, nitrate and DOC concentrations

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The contamination of aquifers by polluted recharge from agricultural areas remains a major danger to water resources. But continuous observations are limited due to a lack of adequate monitoring systems. So far, commercial UV-Vis spectrometers have been used to continuously monitor dissolved organic carbon (DOC) and nitrate levels in surface waters and in water treatment facilities. While commercial UV-Vis spectrometers have been combined with suction cups to measure in-situ the nitrate concentration of soil water, this solution is costly and difficult to operate. Instead, we are developing a robust, compact, and user-friendly in-situ system that provides real-time data on drainage water quantity and quality like dissolved organic carbon (DOC) and nitrate concentration, electrical conductivity, and water temperature. All system components undergo rigorous laboratory testing, and initial prototypes are currently being installed and continuously operated under selected agricultural areas below the rooting zone.

In our system, we use a passive system with fiber glass wicks to quantify the amount of drainage water present. The wicks draw water from the soil at field capacity, eliminating the requirements for pumps as required by suction cups and avoiding saturation commonly found in free draining lysimeters. The extraction area and the length of the horizontal stainless-steel rod that holds the wicks provide enough coverage to average the spatial variability in typical vegetation patterns beneath agricultural fields. The quantity of drainage water is measured using a specifically developed 3D-printed tipping bucket system.

In addition to measuring drainage water quantity, our system will evaluate in-situ water quality. Parameters measured include electrical conductivity, temperature, as well as the concentration of DOC and nitrate. We have developed a fluorescence system to detect DOC concentrations in a small flow-through cuvette connected to the wicks. We are in the process of inventing an LED based optical sensor that detects nitrate absorption in the UV-C range, instead of employing costly UV/Vis spectrometers with xenon lamps to measure the complete spectrum. Preliminary tests indicate that determining nitrate concentration from groundwater samples is possible using

absorbance at a wavelength of 235 nm. A calibration with standard solutions shows a linear relationship between concentration and absorption with a R^2 of 0.99 for concentrations between 0 and 100 mg N/l. To adapt the system for analyzing the soil water solution, a combined sensor for nitrate, DOC and turbidity is needed to correct the nitrate absorption for interfering high concentrations of DOC and turbidity. We will discuss the overall system, its performance and preliminary results from a field deployment.