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Automated lab-on-chip system for time-series nitrate measurements from soil solution

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Precision agriculture, which involves the use of sensors, information databases, and high-tech machinery, can improve agricultural productivity achieving high yields with targeted fertilization. Today, soil nutrient measurements typically require manual soil sampling. First electrochemical sensors have been deployed in the field and show promising results, while still requiring manual intervention for calibration [1]. For natural water nitrite and nitrate measurements an automated lab-on-chip system with syringe pumps and solenoid valves has been demonstrated that uses on-chip reference liquids for calibration [2]. We investigate an automated lab-on-a-chip system for extracting soil solution and measuring nitrate based on the well-established Griess assay [3,4]. The sensor is intended for wireless battery-operated installation at the plant root level, where it takes nutrient concentration measurements as well as soil temperature and soil humidity data at regular intervals. Soil water is drawn into a microfluidic chip through a ceramic suction cup. The Griess assay results in a concentration-dependent color change. A light-emitting diode - photodetector pair is used for photometric readout. Once the concentrations have been determined, the mixture is pumped into a waste reservoir. Wireless data transfer is achieved via the LoRaWAN network [5]. We introduce the microfluidic chip based on a 3-layer PDMS-on-glass approach fabricated by photolithography and combined with pumps and valves. The measurement procedure and the fluidic control approach are discussed. System operation is demonstrated with laboratory tests for nitrate concentrations in a range from 0 to 50 mg/l. The results of pot tests and first field tests are presented. With our SOILMONITOR system we aim at contributing to a balance in the supply of soil nutrients to preserve resources, improve soil quality and reduce adverse effects on the environment.

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