Title
Networked Sensing of Nitrate in Support of Groundwater Quality Protection

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Introduction: Soil sensor networks in a real-world application

Municipal wastewater flows in a megapolis like Los Angeles exceed 100s of millions of gallons per day. In land-locked areas, prudent watershed management demands that we monitor and control the release of treated wastewater, and the associated contaminants and nutrients, into the environment. If the release is into the soil, such as for irrigation or artificial recharge of aquifers, monitoring networks are currently sparse due to costs of deployment (well drilling and construction).

The objective of this project is to systematically develop all aspects of a chemical sensor network, from sensor development to systems design. The work is being completed in the context of a real-world problem of *monitoring nitrate propagation in soil* being irrigated with reclaimed wastewater.

Problem Description: Creating sensors that scale to error resilient, large-scale deployment

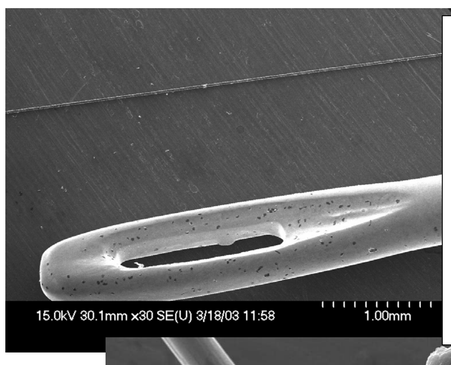
1. Sensor development

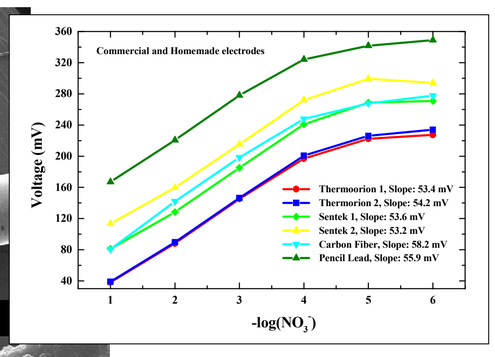
A potentiometric ion selective electrode (ISE) approach by Hutchins and Bachas *Anal. Chem.* *67*, 1654(1995) is being investigated.

The ion selective membrane used is polypyrrole doped with nitrate anions.

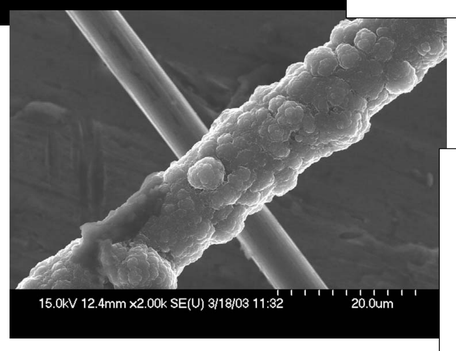
This approach is relatively simple and expected to scale down to the microchip.

- **Presently attempting silicon-based prototypes**
- **Current recipe not long-lived**

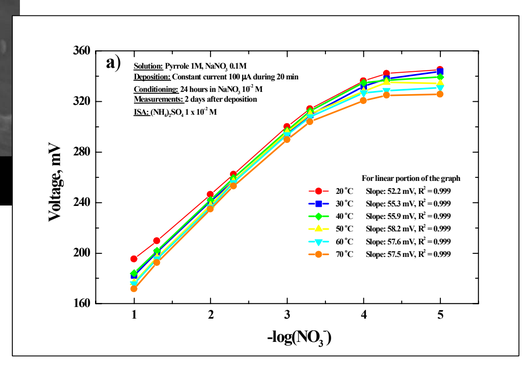




Comparison of lab-fabricated microsensor response to COTS sensors



Response of the microsensor to different nitrate concentrations and temperatures (right).



2. Calibration and testing

Sensor-level calibration is being undertaken under a range of environmental conditions (pH, temperature, salinity, etc.)

Sensor *network* calibration will focus on minimizing the error transmitted from an array of sensors.

Proposed Solution: Irrigation using reclaimed wastewater—protecting the groundwater

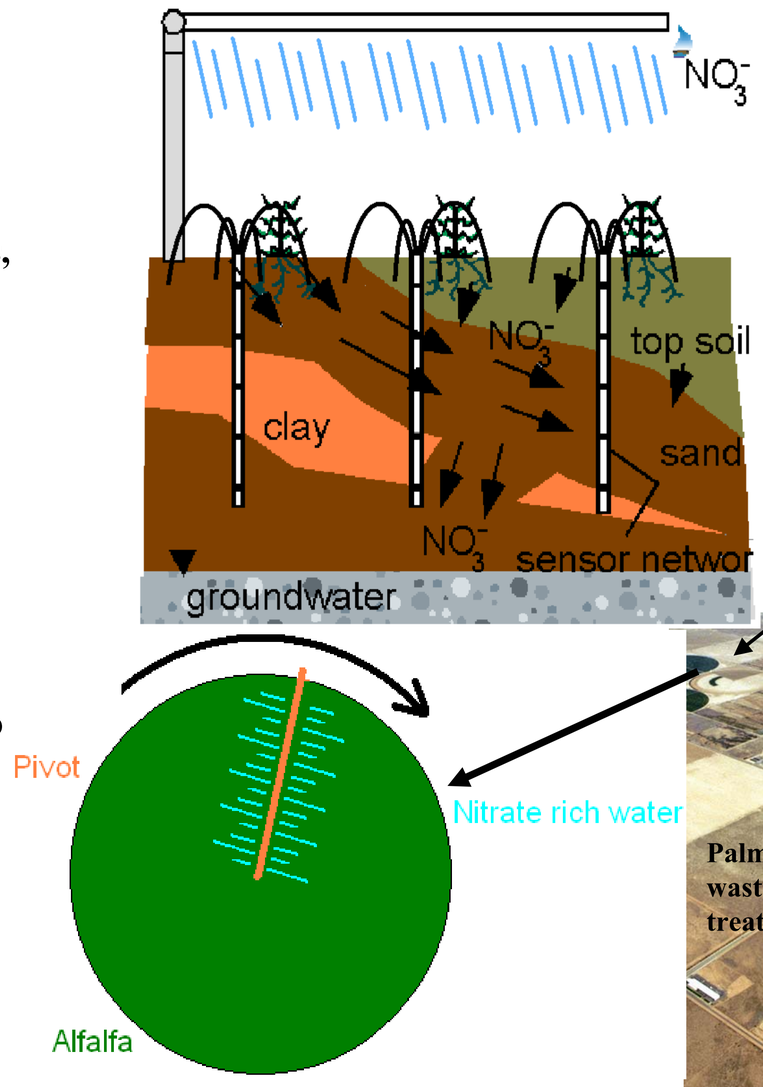
- **We are designing novel multi-level sensing stations (pylons) for temperature, moisture and nitrate, and deploy these nodes at varying spatial densities over a portion of a 30 acre test plot in Palmdale, CA.**

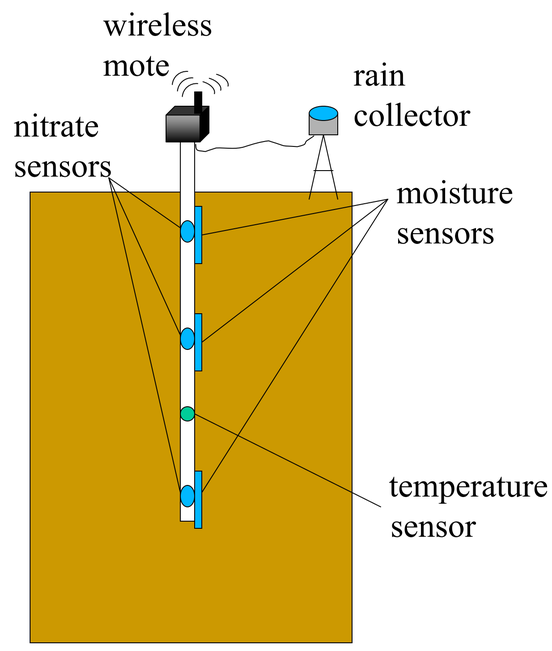
Prototype Pylon Design

- **Pylons are equipped with multiple sensor groups, each containing temperature, moisture and nitrate senors**
- **Sensor groups are deployed along the trunk of the pylon for sensing at multiple soil depths**
- **Multiple runners/tentacles protrude from the pylon at the surface for supplemental near-surface sensing**
- **Each pylon monitors conditions (temperature, moisture and nitrate distributions) in its own region**
- **Pylons communicate with other nearby pylons to delineate nitrate concentration distribution in time and space**

Pivot

- **The watering pivot is instrumented with high accuracy nitrate and flow sensors**
- **The pivot communicates with nearby pylons to inform them of current water conditions**
- **Feedback from the pylons can be used to help control pivot operation, maximizing the safe discharge of nitrate-laden wastewater.**





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