Title
SEN3: Potentiometric Nitrate Sensors in the Form of Plant Roots

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Potentiometric Nitrate Sensors in the Form of Plant Roots

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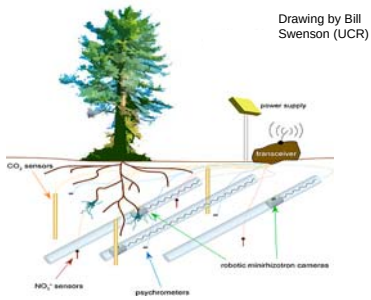
Introduction: Sensor fabrication in an environmentally relevant form factor

Nitrate sensors for deployment in soils

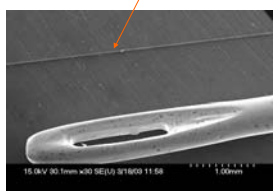
- ***Regulatory driver***: Nitrate levels in rivers, lakes and groundwater are regulated. Excessive levels pose a threat to human health and the environment
- ***Sources of nitrate***: Nitrate is relatively ubiquitous and is releases from point sources (wastewater treatment plant discharges) and nonpoint sources (agricultural fertilizer, atmospheric deposition)
- These factors point to a ***need for scaleable nitrate sensors*** (small, inexpensive) for distributed, embedded deployments



Drawing by Bill Swenson (UCR)

Problem Description: Can scaleable nitrate microsensors be fabricated for soils?

- We are working on a novel concept, that of scaleable nitrate sensors created in a form appropriate for dense soil deployments--***mimicking root fibers***
- Our sensors will be ***inexpensive and environmentally benign*** and minimally disturb the soil moisture propagation and chemical transport regime during observations
- ***proof of concept*** with nitrate-doped polypyrrole ion selective electrodes (Bendikov *et al*. 2005 *Sensors and Actuators B: Chemical*)



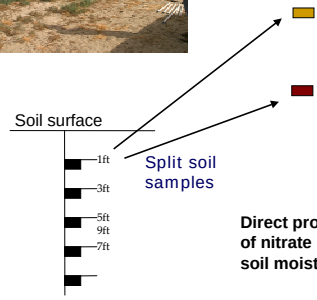
- Sensors suitable for long-term, low maintenance deployment will require further refinement, including:
- incorporation of ***conductive rubbery polymers*** with longer life cycles
- incorporation of materials ***resisting biofouling*** and/or develop systems for ***sample pretreatment*** (e.g., automated microfluidic prefiltration)

Proposed Solution: Nitrate ion selective electrodes on carbon microfibers

Testing microsensor utility: direct soil moisture probing

- Nitrate microsensors were fabricated by electropolymerizing pyrrole onto 7 micron diameter graphite carbon filters in a nitrate solution.
- Soil samples were collected at depths ranging from 0 to 3 m at the Palmdale test bed where irrigation water contains elevated nitrate levels.


Palmdale test bed

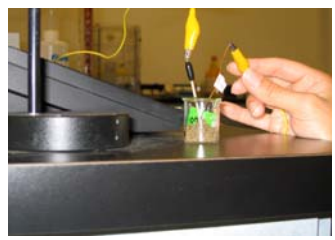


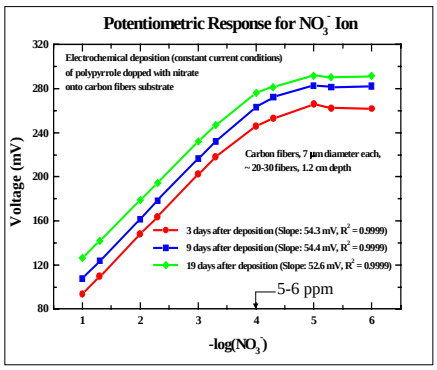
Direct probing of nitrate in soil moisture

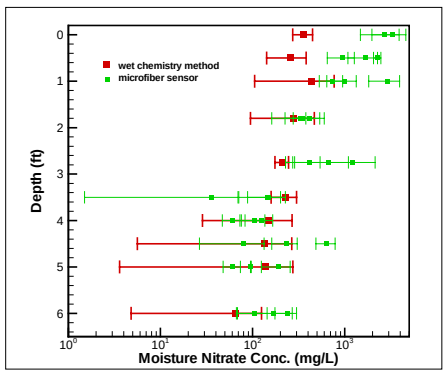
- ***Conventional sampling entails extraction of the nitrate from soil into an aliquot of water followed by "wet chemistry and spectophotometry***
- ***Conventional sampling requires time and effort, and results in hazardous chemical waste (cadmium reactant)***

Results for real soil samples

- 1st split of core sample
- extract soil in water
- analysis by Griess-Romijn method (Hach reagent kit)
- ***15-20 min/sample***
- 2nd split of core sample
- direct measure by contact with nitrate microsensor
- ***5-10 sec/sample***







- ***Direct probing technique successfully quantifies soil nitrate*** levels in a fraction of the time without wet chemistry waste
- ***Heterogeneity of nitrate levels*** observed that is unobservable by conventional techniques
- Next step is to ***deploy the nitrate microsensors in situ*** and ***explore more robust sensor designs***

Calibration curve for nitrate microsensors (left) and results for direct probing of nitrate levels in 12% (by weight) moisture content on Palmdale sandy soil (right).