Title

CON 1: Embedded Networked Sensing of Subsurface Water Quality Calibration, Fault Detection and Feedback Control

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Embedded Networked Sensing of Subsurface Water Quality: Calibration, Fault Detection, and Feedback-Control

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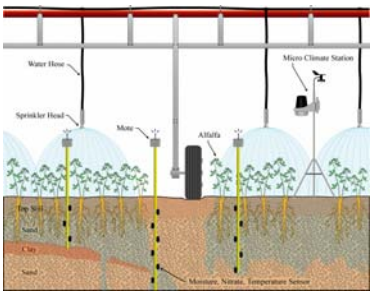
Problem Description: Creating a modular sensing platform for the subsurface environment

Nitrate in Reclaimed Wastewater in Palmdale, CA



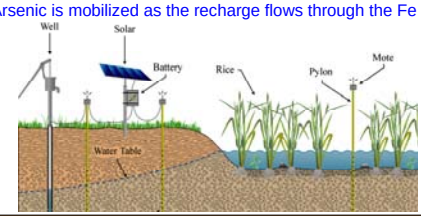
A precision agriculture and environmental protection problem:

(1) Reclaimed wastewater can help to extend irrigation water supplies in arid climates
(2) Over-taxing of the soil's nutrient assimilation capacity can threaten underlying groundwater supplies (water regulatory authorities require strict monitoring)
(3) CENS has created an embedded network using soil pylons to observing and managing nitrate propagation through the Palmdale soils

Arsenic in Bangladesh Groundwater

A current working hypothesis to be investigated:

(1) During irrigation, rice-paddy return flow is the main water infiltrating through the Fe band
(2) Anoxic irrigation water causes changes in the redox environment of the Fe band and below
(3) Arsenic is mobilized as the recharge flows through the Fe band.

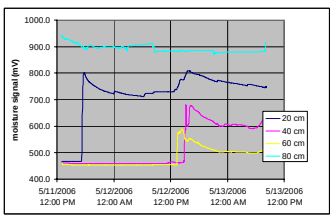


Proposed Solution: Soil "pylons" have been developed and piloted in several scientific contexts

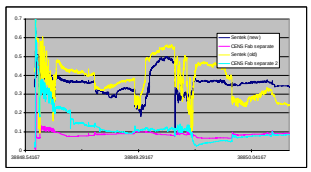
Palmdale Engineering Objectives

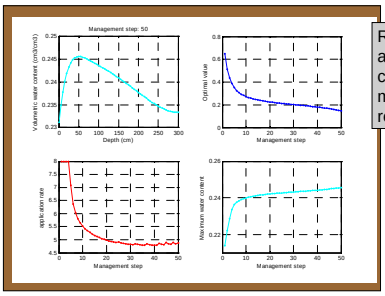
- Develop soil pylons for observing mass and energy fluxes in soils
- Validate these pylons for the case of irrigation using nitrate-laden reclaimed water
- Scale up a distributed network of soil pylons to a meaningful agricultural scale (10s of hectares)

- Local rain gauge sensors monitor spatially distributed irrigation rate
- Soil moisture sensors monitor local water content to support the observations of water infiltration and redistribution
- Thermistors monitorlocal a ir temperature and below-ground gradient to support energy balance in evapotranspiration calculations
- Off-the-shelf vs. CENS-fabricated nitrate sensors (in situ test bed system for CENS Sensor Group)



Moisture (left) and nitrate (below) time series from the Palmdale irrigation experiment





Receding Horizon Feedback Control algorithm uses the data to forecast conditions and proposes modifications to the irrigation rate to reduce the

Bangladesh Science Goals

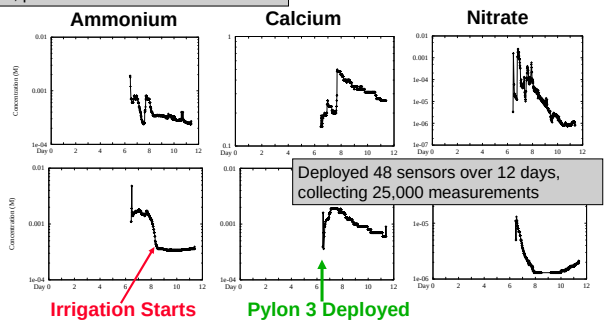
- Use dense temporal/spatial sensing of a sensor network to validate hypothesis
- Develop proxy geochemical measurements to indicate elevated arsenic concentrations, as arsenic sensors are not available (previous work showed that ammonium and calcium correlated with arsenic at our site)
- Develop a reactive transport model for arsenic mobilization. This will inform well placement decisions and deep well construction.

Systems Challenges and In-field Approaches

Rapid Deployments i.e. a short or temporary deployments
Are portable, reusable, and can *take advantage of a human user in the field*
However, *even small disruptions or problems in collected data must be addressed quickly*, as overall quantity of gathered data is small relative to long-term deployments

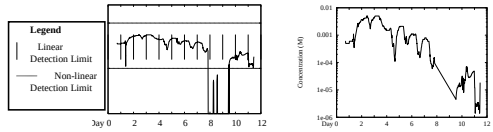
Full Suite of 7 Ion Selective Electrodes (ISEs): Ammonium, Calcium, Carbonate, Chloride, Nitrate, Oxidation-reduction potential, pH

Pylon 3



Deployed 48 sensors over 12 days, collecting 25,000 measurements

Ammonium Before… and After Fault Filtering



Don't just throw away faulty data. Designed a script to detect calibration, orientation, bio-fouling, or sensor hardware faults in-field, and suggest actions a user can take in the field to fix/validate problem to maximize data flow