## Title

Progress toward deployment of a wireless sensor network to understand arsenic mobilization in a Bangladeshi aquifer



## Authors

Nithya Ramanathan
Marci Burt
Genevieve Fernandez
et al.

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# Progress toward deployment of a wireless sensor network to understand arsenic mobilization in a Bangladeshi aquifer

Nithya Ramanathan[1], Marci Burt[2], Genevieve Fernandez[2], Thomas Harmon[3], Jennifer Jay[2], Charles Harvey[4], Rebecca Nuemann[4], Deborah Estrin[1]
[1]UCLA Computer Science, [2]UCLA Civil & Environmental Engineering, [3]UC Merced School of Engineering, [4]MIT

## Problem Description: What is Mobilizing Arsenic into the Groundwater ?

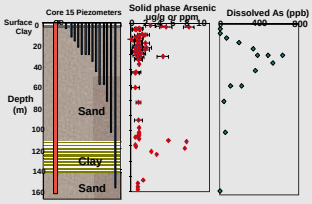
### Arsenic Prevalent in Bangladeshi Groundwater

- **Arsenic in groundwater has lead to a massive poisoning in Bangladesh**
  Tens of millions of people are currently drinking dangerously high levels of naturally occurring arsenic in groundwater, resulting in adverse health effects.



- **We lack a full understanding of the factors controlling arsenic (a naturally occurring element) mobilization to groundwater.**
- **A current working hypothesis: Influx of dissolved arsenic to groundwater is greatly enhanced where rice cultivation provides the primary source of aquifer recharge, because anoxic irrigation-return flow mobilizes arsenic (As) as it passes through an As-enriched iron oxide band in the sediment.**

## Proposed Solution: Deploy a Wireless Sensor Network to Monitor a Field in Bangladesh



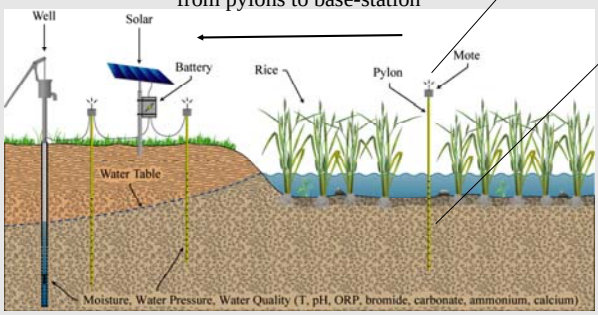

**Panel A** Lithology showing the upper and lower aquifer

**Panel B** Shows clear dependence on depth so we know some process solid phase arsenic is not above crustal average

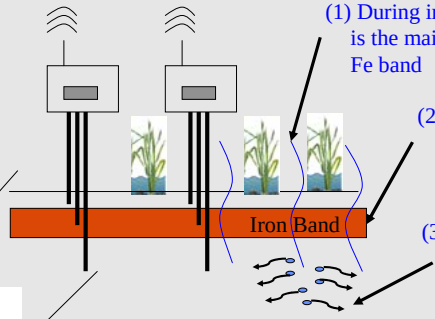
**Panel C**

**Sensors at Each Depth (.5, 1, 2 meters)**
ORP
Moisture
Soil Temperature
Calcium
Ammonium
pH
Oxidation
Nitrate

Motes transmit data wirelessly from pylons to base-station




### Hypotheses to be Validated

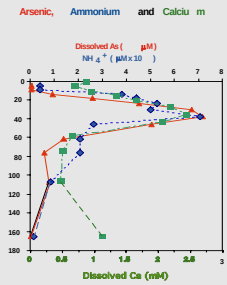



(1) During irrigation, rice-paddy return flow is the main water infiltrating through the Fe band

(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.

(4) At our site, sensor measurements of calcium and ammonium correlate with the arsenic concentration in well water, and can be used to trigger manual arsenic sampling.




### Environment Science Research Goals

•Use dense temporal/spatial sensing to understand link between irrigation well pumping and arsenic in groundwater.

•Develop proxy geochemical measurements to indicate elevated arsenic concentrations, as arsenic sensors are not available.

•Develop a reactive transport model for arsenic mobilization. This will inform well placement decisions and deep well construction.

### Systems Research Goals

•Address challenges that arise in short-term deployments
  •Failures must be detected and fixed quickly
  •Minimize perturbation of environment when placing pylons because we don't have time for the environment to naturally overcome them
•Test/refine our network management tools to address deployment challenges listed below
•Explore solutions to barriers to deploying sensor networks in under-developed regions: mainly cost and usability

| System/Deployment Challenges | Solutions |
|---|---|
| Ensuring sufficient data flow from sensors | Use Sympathy – system management tool to detect network failures |
| Monitor network for faulty hardware/software | |
| Detect sensor errors caused by faulty calibration/orientation, bio-fouling, sensor failures, low batteries | Ongoing experiments in order to write scripts to test for simple sensor failure modes |
| Ensure connectivity with environment (gaps in the soil => bad measurements) | Input pulses of known solutions upon deployment to calibrate sensor output and ensure good connectivity |
| Avoid short-circuiting between surface and groundwater | Use clay at pylon surface |