Title

Sensor Measurements and Sediment Incubations Indicate Diurnal Redox Cycling Associated With Arsenic Mobilization at a Bangladeshi Rice Paddy

Authors

Lin, Tiffany
Lin, Chu-Ching
Ramanathan, Nithya
et al.

Publication Date

2007-10-10

Sensor Measurements and Sediment Incubations Indicate Diurnal Redox Cycling Associated With Arsenic Mobilization at a Bangladeshi Rice Paddy

Tiffany Lin[1], Nithya Ramanathan[2], Christine Lee[1], Chu-Ching Lin[1], Rebecca Neumann[3], Charles Harvey[3], A.B.M. Badruzzaman[4], Thomas Harmon[5], Deborah Estrin[2], Jennifer Jay[1]
[1]UCLA Civil and Environmental Engineering, [2]UCLA Electrical Engineering, [3]MIT Civil and Environmental Engineering, [4]Bangladesh University of Engineering and Technology, [5]UC Merced Civil and Environmental Engineering

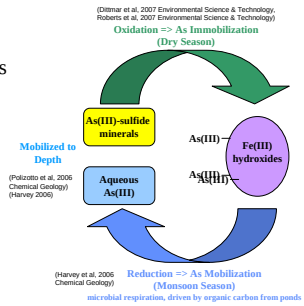
Introduction: Why is Arsenic Contamination Important?

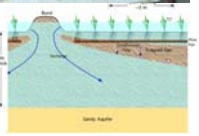
Environmental Impact

- Arsenic in groundwater has lead to largest environmental poisoning in history
- Tens of millions of people in the Ganges Delta drink water dangerously contaminated with arsenic
- Health problems as a result of consumption (Yu et al, 2003):
  - Arsenicosis 2,000,000 cases/year
  - Skin cancer 100,000 cases/year
  - Death from arsenic-induced cancer 3,000 case/year

Current Goal

- Currently accepted:
  - Dry season: As(III)-containing minerals oxidized, As(V) released and adheres to Fe hydr(oxide) minerals
  - Wet (monsoon) season: sediments are inundated with water, Fe hydr(oxides) reduced, As released
- Current aim:
  - Highlight importance of diurnal redox cycling in arsenic mobilization
  - Diurnal cycling possibly plant induced





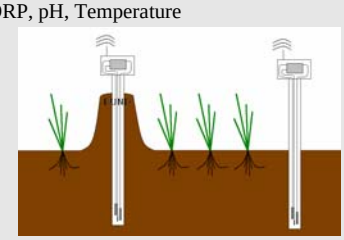
Problem – How is Arsenic Mobilized?

- It is not fully understood the mechanism that mobilize arsenic into groundwater and other factors affecting the mechanism
- Rice fields receive large loads of arsenic with irrigation water and provide recharge to the underlying aquifer
- It is unknown whether rice fields act as a sink or source of arsenic in the hydrologic system

Proposed Solution: Sensor Network to Monitor In-Field Data & Laboratory Microcosms

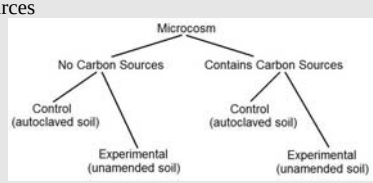
Sensor Network

- Use dense spatial/temporal sensor network to monitor oxidative-reductive geochemical parameters in-field
- Deployed ISEs: Ammonium, Calcium, Carbonate, Chloride, DO, Nitrate, ORP, pH, Temperature



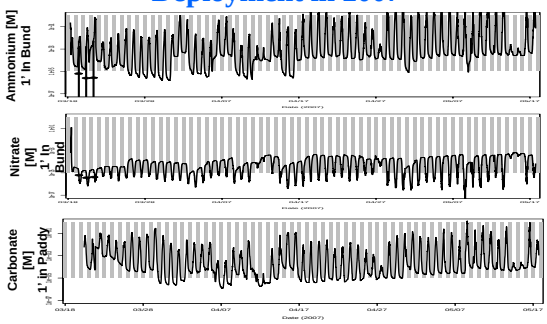
Laboratory Microcosm

- Use Bangladeshi soil with artificial groundwater microcosm to simulate diurnal trends observed with sensor network
- Monitor iron and arsenic trends to validate importance of diurnal redox cycling in arsenic mobilization
- 2 amendments to microcosms to test for biotic role: with and without carbon-sources

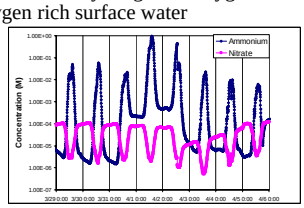


Results: Diurnal Cycling Observed Both In-Field and in Laboratory

Diurnal Cycles Observed in 2 Month Sensor Deployment in 2007

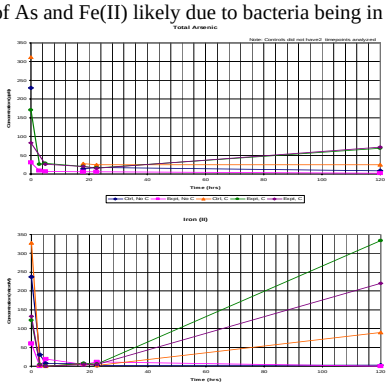


- Diurnal cycles presumably due to temperature driven reductive processes
- Nitrate concentrations in the subsurface increase while ammonium levels decrease
- Ammonium levels peak during the day; Nitrate levels peak at nighttime
- Possible causes for diurnal cycling: root oxygen leakage or rapid infiltration of oxygen rich surface water



Diurnal Cycle Observed on the Order of Days in Laboratory Microcosms

- Initially, all microcosms were anoxic and spiked with As(III) and Fe(II)
- Once were made oxic, As(tot) and Fe(II) levels for all microcosms decreased
- Once made anoxic again,
  - Unamended microcosms showed an insignificant or no increase in As or Fe(II) levels
  - Carbon-amended microcosms showed a significant increase in As and Fe(II) levels
  - Control microcosms, where soil is autoclaved and bacteria killed, showed no increase in As and Fe(II) levels
- Lag in rise of As and Fe(II) likely due to bacteria being in lag phase



- While it is currently accepted that seasonal redox cycling drives As oxidation and then mobilization upon reduction, these results indicate that diurnal oscillations in redox conditions may also be very important in the mobilization of As to groundwater at this site

- The authors gratefully acknowledge support from the National Science Foundation, CBET-0651968, and CBET-605515, as well as seed funds from CENS