Mitigating Future Arsenic Catastrophes within Asia: An integrative study of processes controlling arsenic release

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Asian Water Crisis

>600 Million People without Safe Water

A result of Pathogens and Poisons
Arsenic in Drinking Water

>100 Million People Drinking Hazardous Levels of Arsenic
Conditions in Bangladesh

**Exposure**

60,000,000 people (46%)

**Arsenosis**

2,000,000 people (1.8%)

**Skin Cancer**

>200,000 people (0.2%)

**Internal Cancers**

3,000-7,000 people/yr

*Based on epidemiological reports from 2003*
Critical Need: Forecasting

1) Predict locations of low-arsenic groundwater
2) Project changes in arsenic concentration (including impacts of land use change).
Needed Expertise

To understand the processes driving arsenic concentrations we needed:

1. Geo/soil chemistry – S. Fendorf
2. Microbiology – C. Francis
3. Hydrology – S. Benner (established)
4. Land Use – K. Seto
Major River Systems of Asia being Impacted
Arsenic Distribution

[As]
- 850+ µg/L
- 400 – 850 µg/L
- 100 – 400 µg/L

Depth (m)
- 0 m
- 60 m
- 3000 m

Distance (m)
- 0 m
- 3000 m
Clay Aquifer River

As-FeS

As transport

As(V)

As(V)

As(V)

As(V)

Depositional As flux \approx \text{Groundwater efflux}

Predicting Arsenic Distribution within Aquifers

Measured

Simulated

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Thanks
Why is arsenic in the groundwater?
Source and liberation process(es)?
Why Does Arsenic Come Off the Solids?
Arsenic Source and Transport

- Coal Seams and Sulfide Mineral Outcrops
- Arsenic Bearing Iron Oxides (rust)
Arsenic Source and Transport
Arsenic Transport and Deposition
Arsenic Transport and Deposition
Arsenic Release to Water

Bangladesh: Dry Season
Bangladesh: wet season
How Arsenic Gets into the Water: Bacteria Again!

**Eating**
- Food
- CO₂

**Breathing**
- As(V) in sediment
- As in water

*Break-down of iron minerals and chance in arsenic chemistry*
Controlling Processes

Sediment Transport
Deposition

- Clay
- Aquifer
- River
- As-FeS
- As(V)
- Wetlands
- Deposition
Release

Release is initiated upon sediment burial
Aqueous-Phase Transport

Clay

Aquifer

River

As-FeS

Groundwater Flow

As transport

Wetlands

As(V)

As(V)

[As(III)]

[As(III)]
Arsenic Cycle

Depositional As flux ≈ Groundwater efflux
Options?
Filtering Groundwater

More than 3 million contaminated wells
No existing infrastructure for mass disposal

What do you do with ‘used’ filters?
Rainwater Harvesting
Filtered Surface Water
Deep Wells

- Cost
- Longevity
Need a Portfolio of Options

Arsenic-free Shallow Well?
- yes
  - Use shallow well
- no
  - Viable deep-well?
    - yes
      - Use deep well
    - no
      - Sufficient rainwater storage?
        - yes
          - Use rainwater harvesting
        - no
          - Effective surface water filtration?
            - yes
              - Use filtered surface water
            - no
              - Arsenic filtration?
                - yes
                  - Use filtered groundwater
                - no
                  - Other