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Technology for arsenic-free drinking water: Electrochemical Arsenic Remediation (ECAR)

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Background

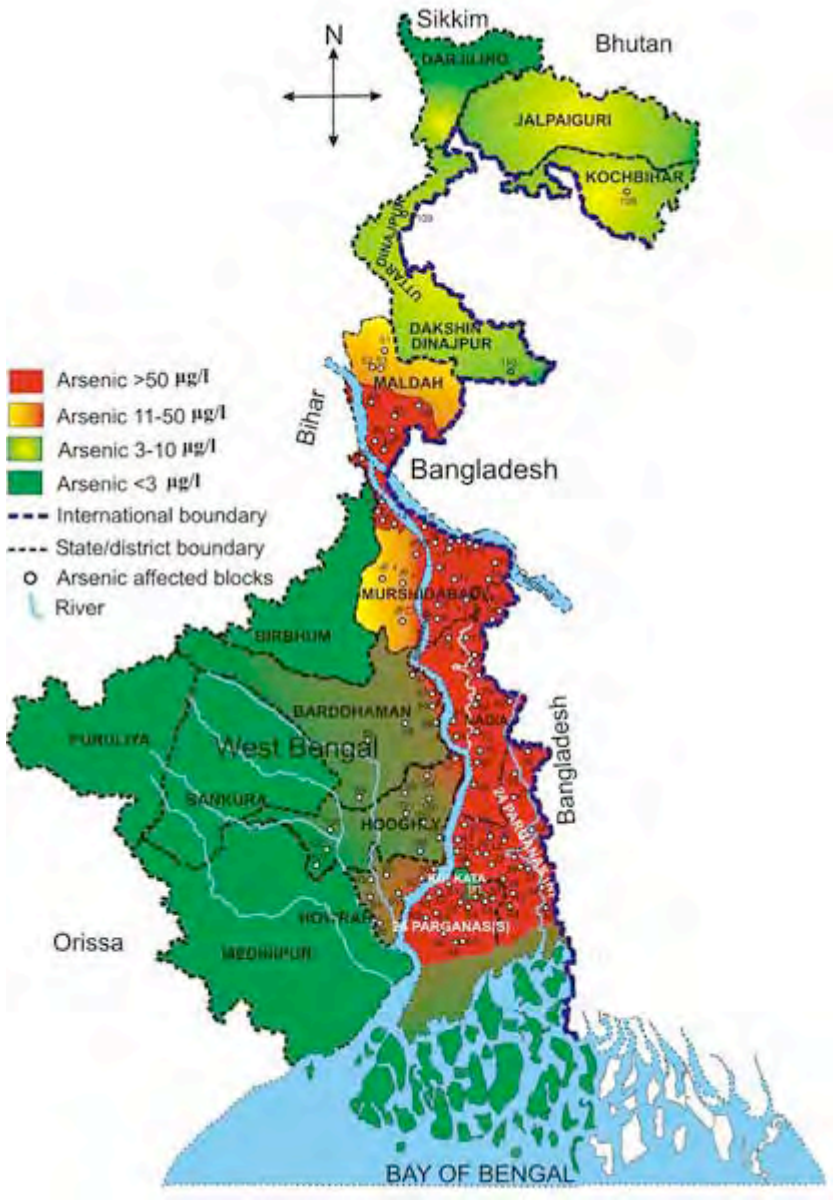
Arsenic in groundwater - a worldwide problem

Garelick and Jones, Chemistry International, 2008

West Bengal

60 lakhs affected

> 50% districts have unsafe arsenic levels



http://www.enviswb.gov.in

jscms.jrn.columbia.edu

http://www3.lehigh.edu

Health Effects

- Skin lesions,
- Cancers,
- Child morbidity,
- Developmental problems,
- Cardiovascular disease,
- Gangrene, &
- Premature death.

Current Situation

In Bangladesh, 40,000 already showing signs of poisoning

UNICEF predicts it could soon be 10 lakhs

The Challenge

Increase access to safe water in low income, low infrastructure rural communities

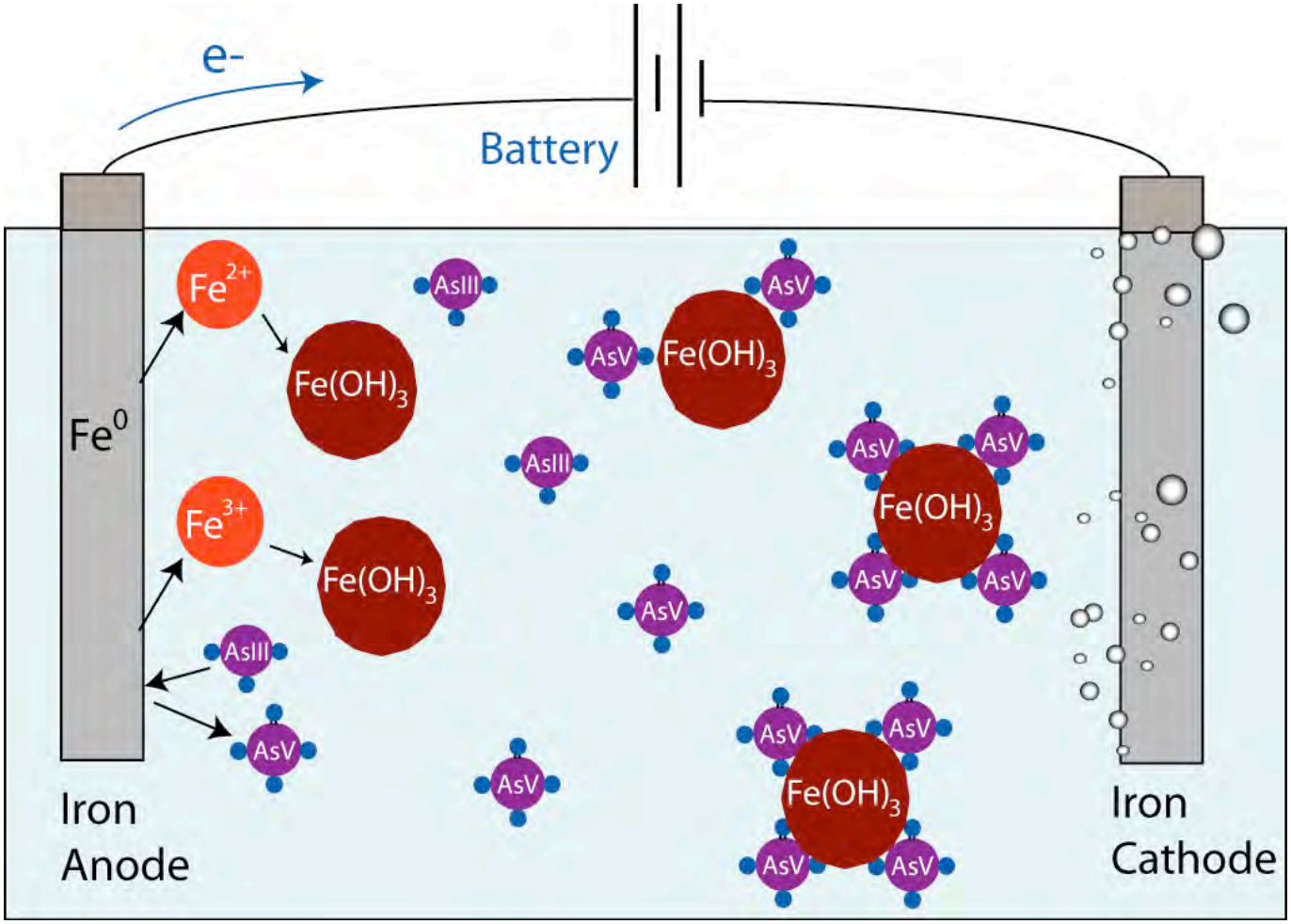
Technology must be:

- Effective
- Affordable
- Culturally acceptable
- Convenient
- Safe

ECAR – Potential Technical Solution

***E**lectro**C**hemical **A**rsenic*
***R**emediation (ECAR)*

Electrochemical removal of arsenic



Key Processes

1. Iron dissolves & AsIII --> AsV
2. Rust forms
3. Arsenic binds to rust

(*not pictured*)

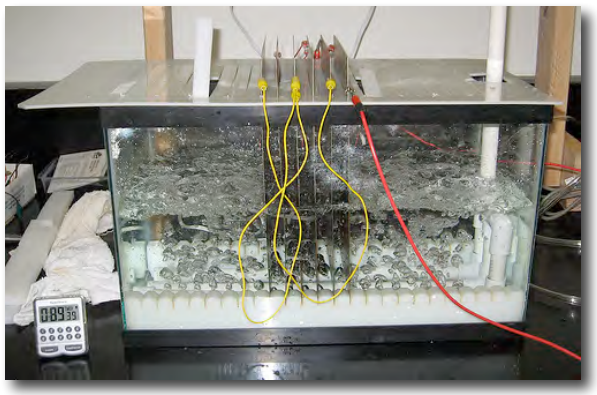
4. Rust settles --> leaving water iron- and arsenic-free

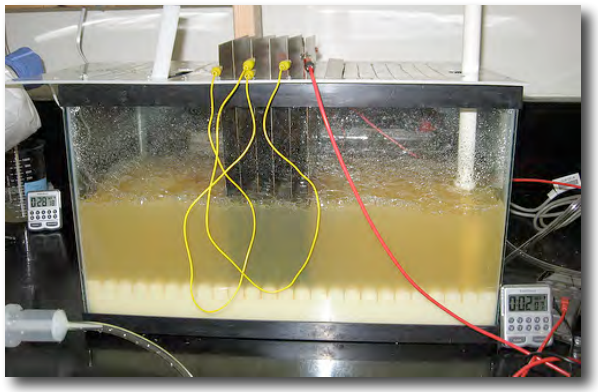
ECAR Treatment : 3 Stages

Charge Input
5 min – 1.5 hrs

Mixing
30 – 60 min

Separation
5 min – 3 days





ECAR Operating Parameters

Charge Input
5 min – 1.5 hrs

Mixing
30 – 60 min

Separation
5 min – 3 days

- **Current Density (mA/cm^2)**
  - Type of rust
- **Charge Input (C/L)**
  - Amt of rust
- **Current Processing Time (s)**
  - Contact time

- **Mixing Time (s)**
  - Contact time

- **Settling Time (s)**
  - Contact time

Tradeoffs between arsenic removal, treatment time, and cost

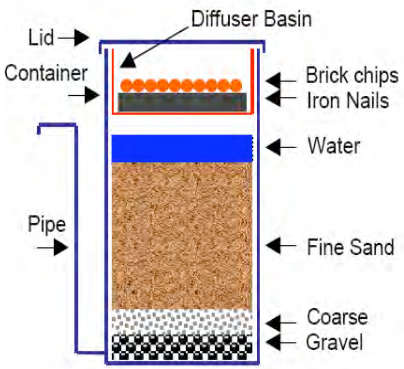
Berkeley ECAR History

2005 2006 2007 2008 2009

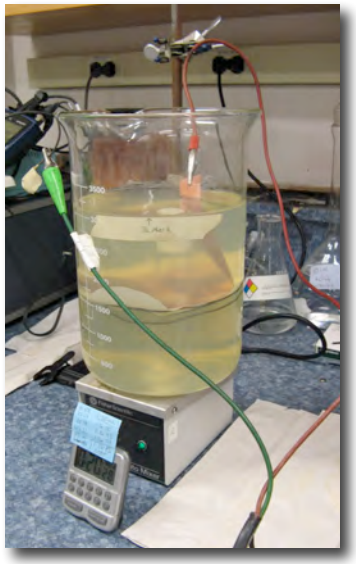
Ashok Gadgil Invents ARUBA

Electricity Added to accelerate rusting

Kanchan filter built in Berkeley



Lab Testing/ ECAR Development



Bench-Scale

B'Desh Field test using "real" groundwater

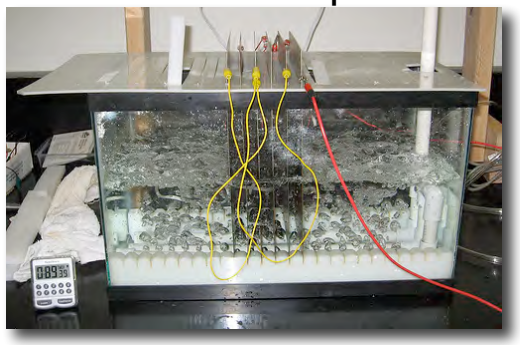
Prototype 1

Prototype 1 (P1) developed

P1 Field Test In B'Desh

P1 Field Test In Cambodia

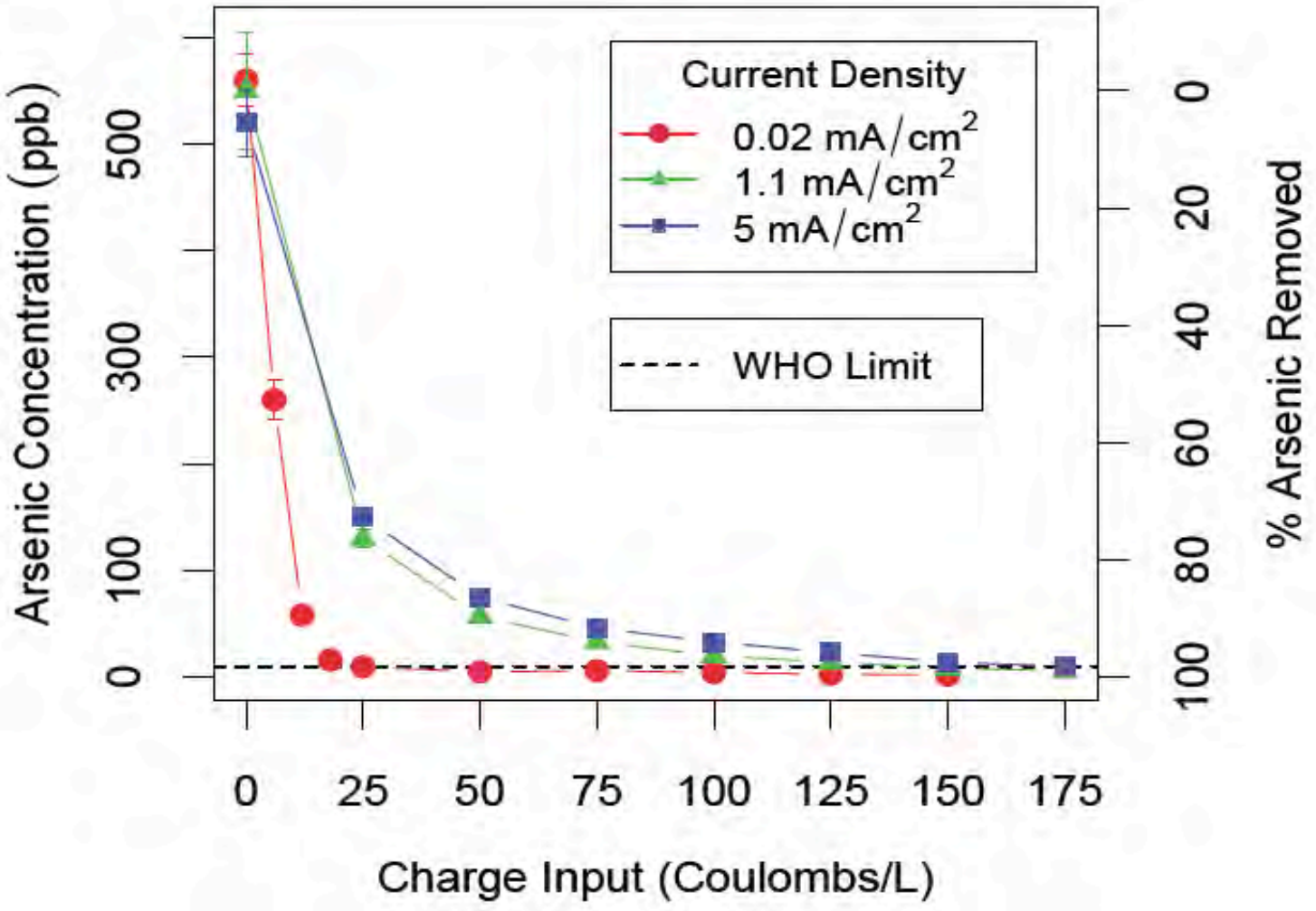
Prototype 2 (P2) developed



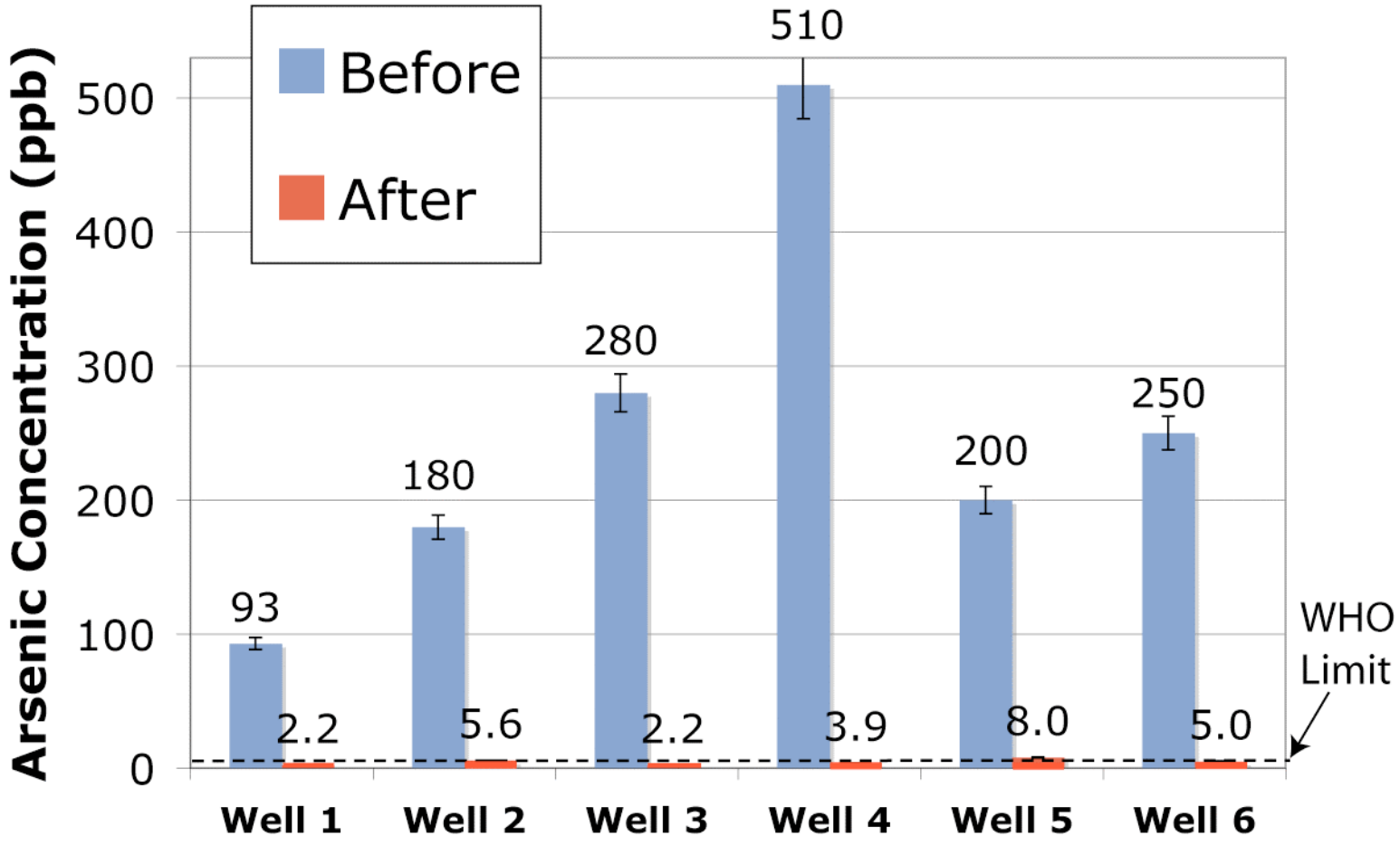
Prototype 2

Lab Results

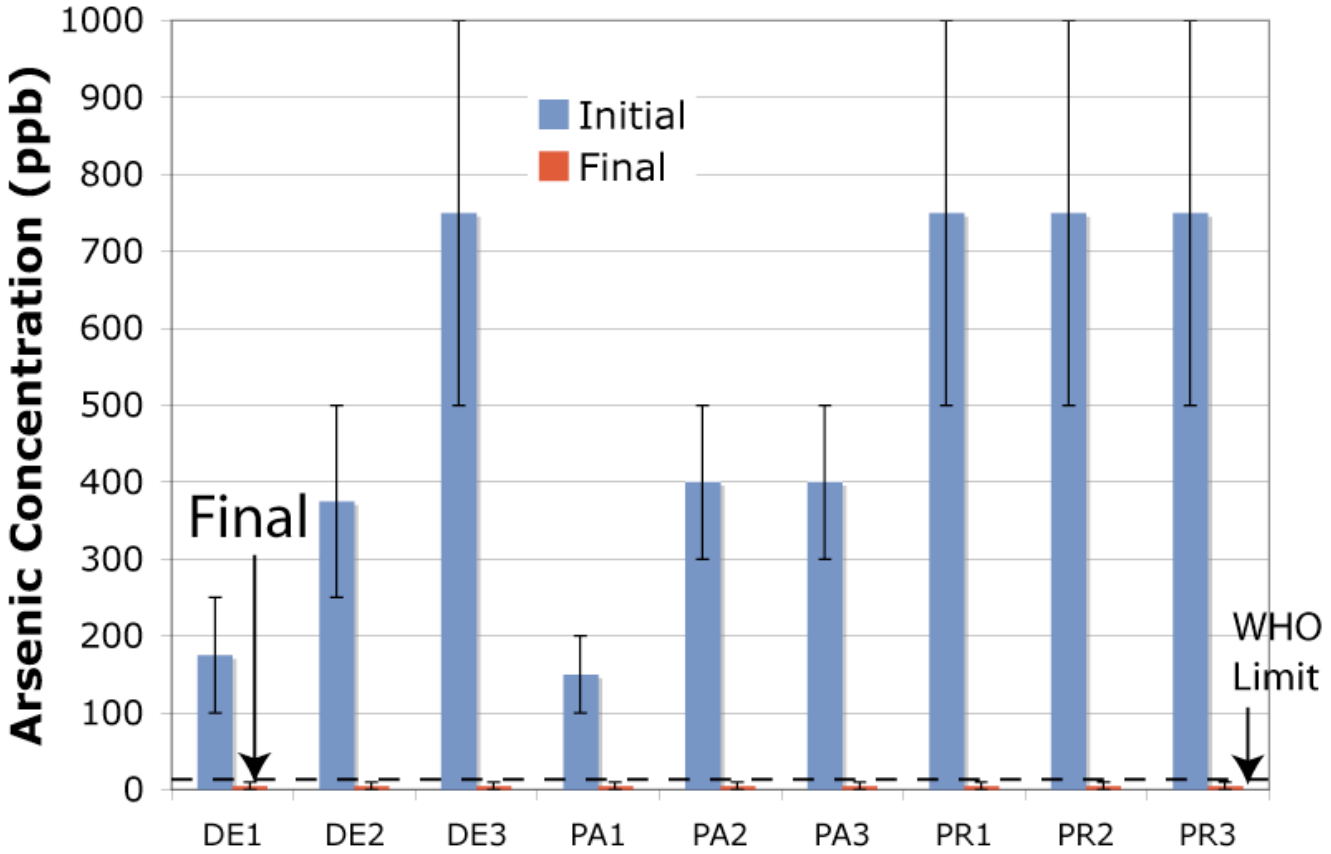
Arsenic Removal from synthetic Bangladesh Groundwater



Field Results - Bangladesh



Field Results - Cambodia



(X-axis is different sites)

Arsenic-Laden Waste

- Lab tests produce ~80 mg/L sludge ($As_{initial}$ = 600ppb)
  - **300g/person/year** (assumes 10 Liters/person/day)
  - **300kg/year for 1000 people** (200 families)

- Sludge passes US EPA standard TCLP test
  - Safe for US landfill disposal

- Up to 40% of concrete (by vol) can be sludge
  (Banerjee and Chakraborty, Clean Tech Environ Policy, 2005)
  - Currently used in China

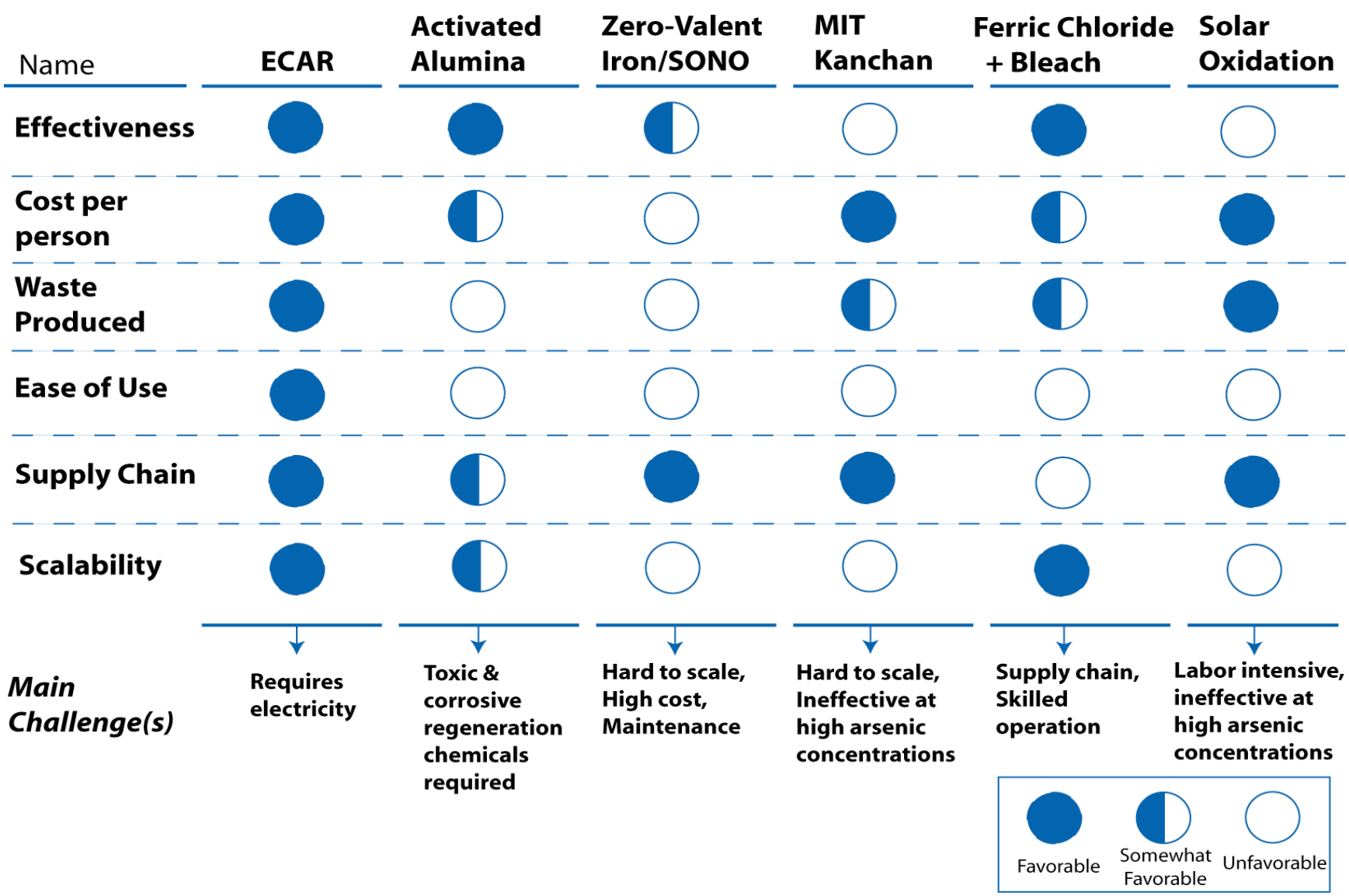
Advantages

- **Low cost of consumables**
  Operating Costs estimated at < 50 paise/person/day (assuming PV power)
- **Minimal supply chain**
  ~200g of iron/person/year
- **Produces very little waste**
  ~300g/person/year
- **Low maintenance**
- **Cost effective at many scales**

Challenges

- **Young technology**
  Extensive field testing is needed
- **Requires (intermittent) electricity**

Brief comparison to select technologies



Questions/Discussion

- Are there any questions about the technology?

(Questions regarding implementation -- after next talk)

More Information

http://arsenic.lbl.gov

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Supplemental Slides Follow

How we get there …