The Implementation of an Arsenic Removal Water Filter in Rural Nepal

International Business & Education Conference:
A Focus on Water Management

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Presentation Outline

1. Introduction
2. Description of the Arsenic Biosand Filter technology
3. Implementation scheme
4. Conclusions

1. Introduction

Map of South Asia

Timeline - Drinking water in South Asia

Pre-1970s:	Surface water for drinking, caused many diseases
1970s:	Groundwater was tapped as a safe, pathogen-free alternative for drinking
1980s:	Naturally occurring arsenic found in groundwater
1990s:	Millions of people found affected, serious disaster

Arsenic background

- Source: Natural
- Toxicology
  - Poison
  - Skin disease such as melanosis, keratosis
  - Cardiovasular diseases
  - Cancer to lung, bladder
- World Health Organization guideline: 10 ppb (parts per billion)
- Nepali interim guideline: 50 ppb
- Nepal Terai Region 25% tubewells >10 ppb
  7% tubewells >50 ppb

Population affected by Arsenic (>50 ppb)

- Nepal: 0.5 million
- Bangladesh: 25 - 40 million
- West Bengal (India): 4.5 - 6.9 million

2. Arsenic Biosand Filter

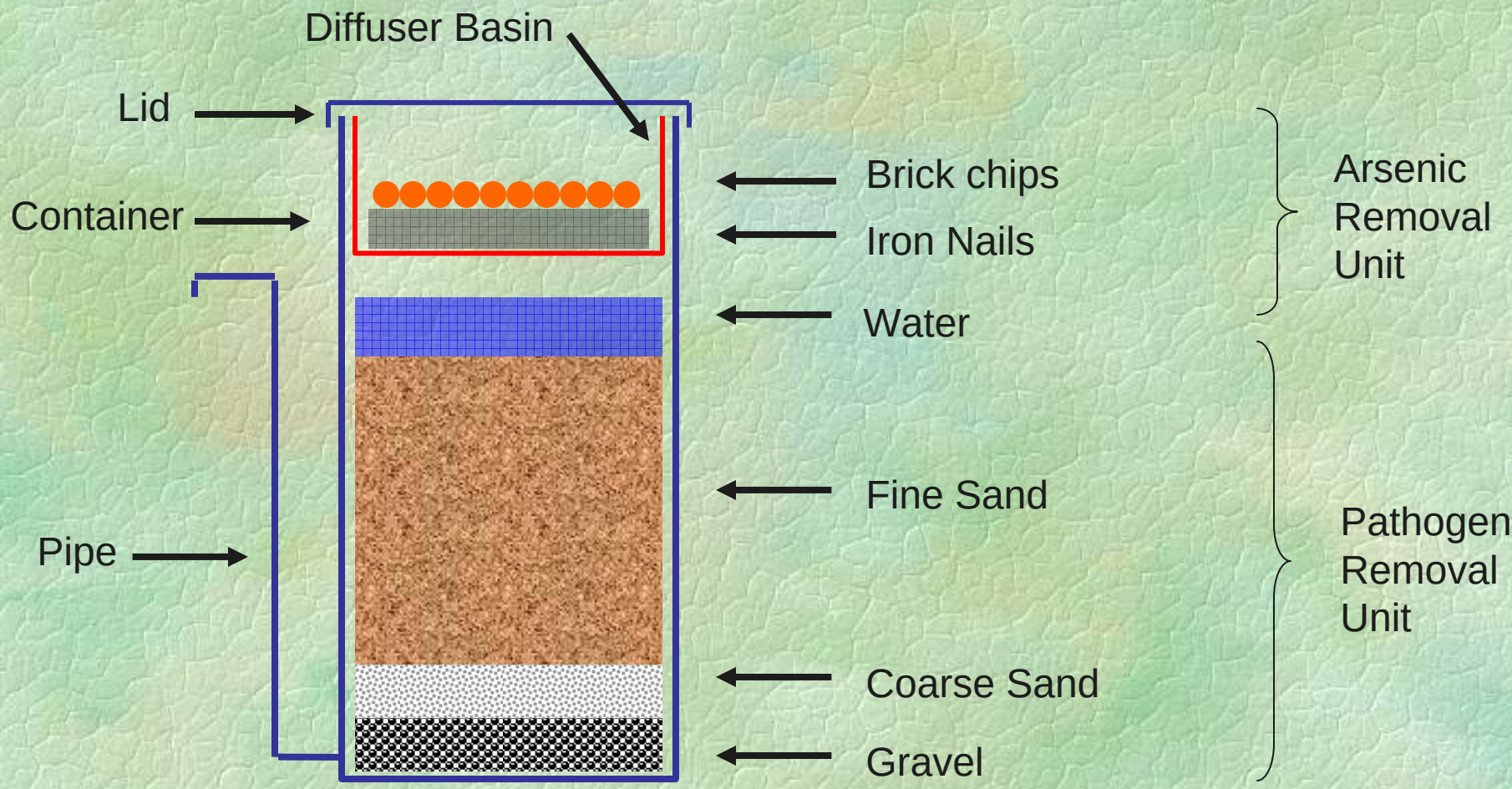
Arsenic Biosand Filter

- Developed by Massachusetts Institute of Technology (MIT) as part of the MIT Nepal Water Project since 1999
- Collaborated with two local water supply agencies in filter development: Environment & Public Health Organization (ENPHO), and Rural Water Supply and Sanitation Support Programme (RWSSSP)
- The filter was developed based on years of field experience and with consideration of the socio-economic situation of rural Nepal
- Design is based on an improvement on the Biosand Filter developed by a Dr. David Manz of the University of Calgary in Canada

Arsenic Biosand Filter

- Intended for arsenic and bacteria removal
- Made with easily available materials: concrete or plastic container, PVC pipe, sand, gravel, iron nails, and lid
- Manufactured by trained local technicians
- Adequate flow rate for a large family (15L/hr)
- No chemical additives
- Easy to operate and clean
- Immediate arsenic removal after installation
- Require 2 to 3 weeks to reach optimum removal of bacteria & viruses

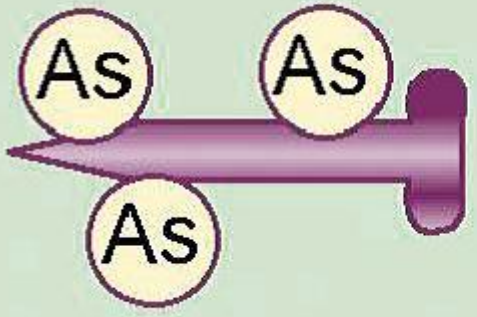
Arsenic Biosand Filter Cross Section



Arsenic Removal Mechanism

- After contact with water and air, iron nails in the diffuser basin will quickly rust

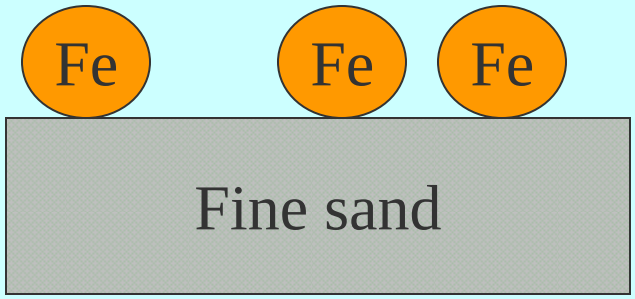
- Iron rust (ferric hydroxide) is an excellent adsorbent for arsenic



Arsenic (As) particles are effectively adsorbed on the rusted iron nails surface.

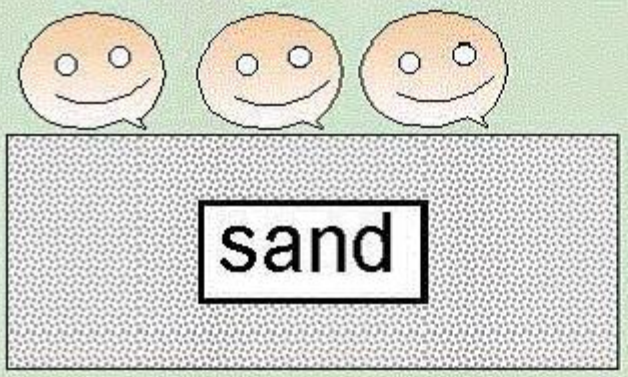
Iron Removal Mechanism

- Soluble iron(II) in raw water is oxidized in air to insoluble iron(III)
- Iron is trapped on top of sand layer by physical straining

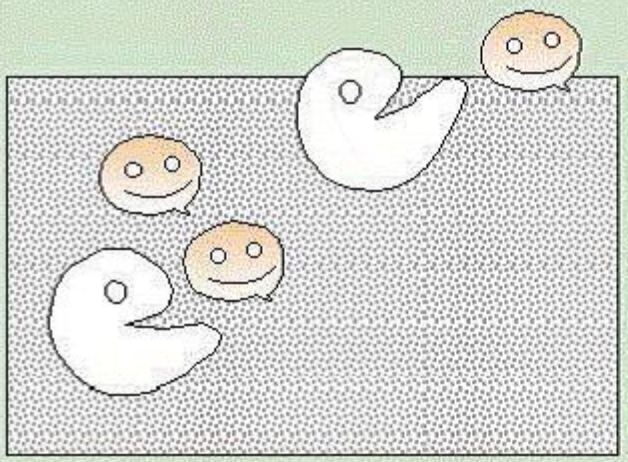


Iron particles are trapped on top of the fine sand layer by physical straining (i.e. too large to pass)

Bacteria Removal Mechanism



Larger pathogens will be trapped on top of the sand layer by physical straining.



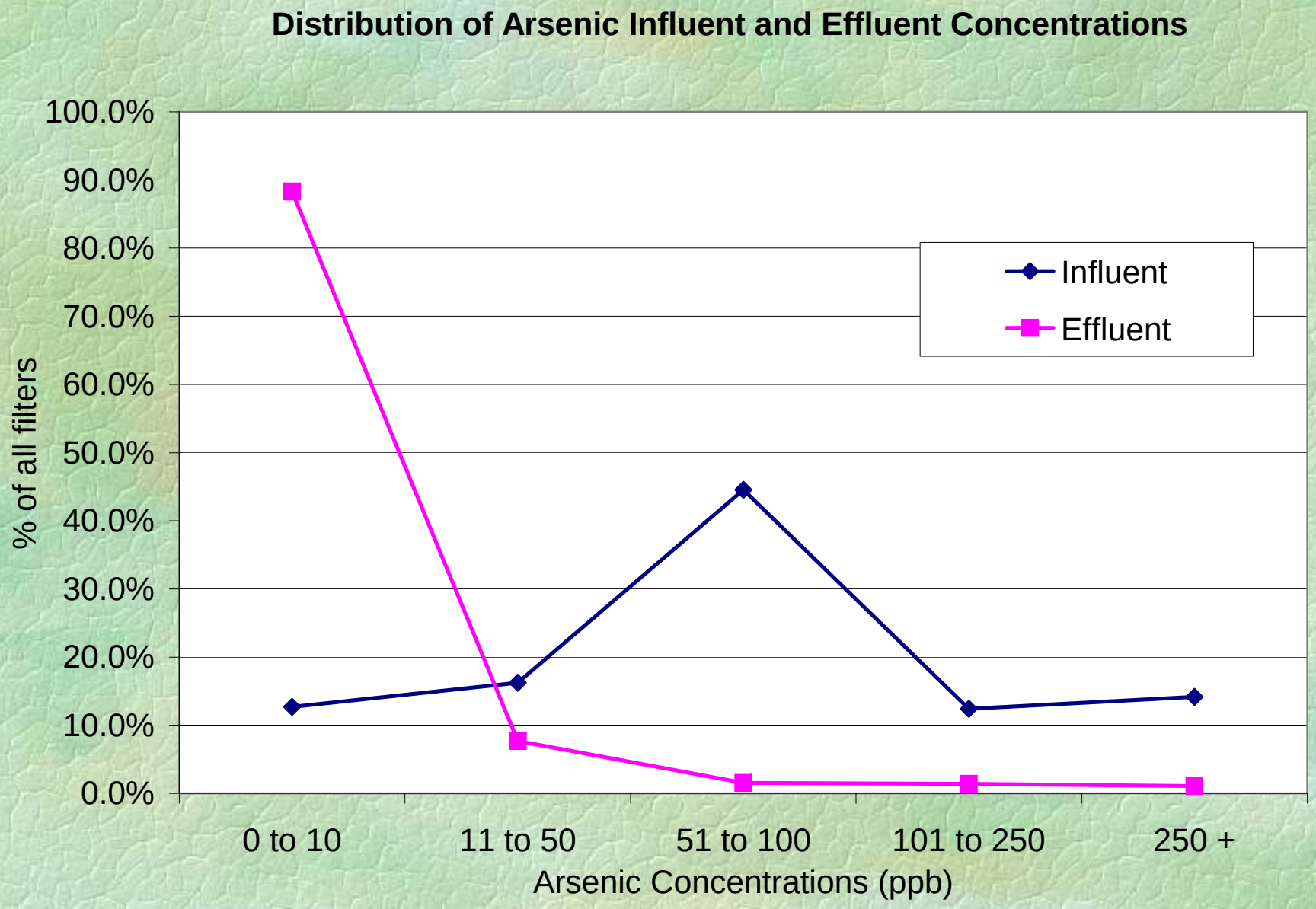
Smaller pathogens are removed by predation by microorganisms residing near the top sand layer.

Filter Design

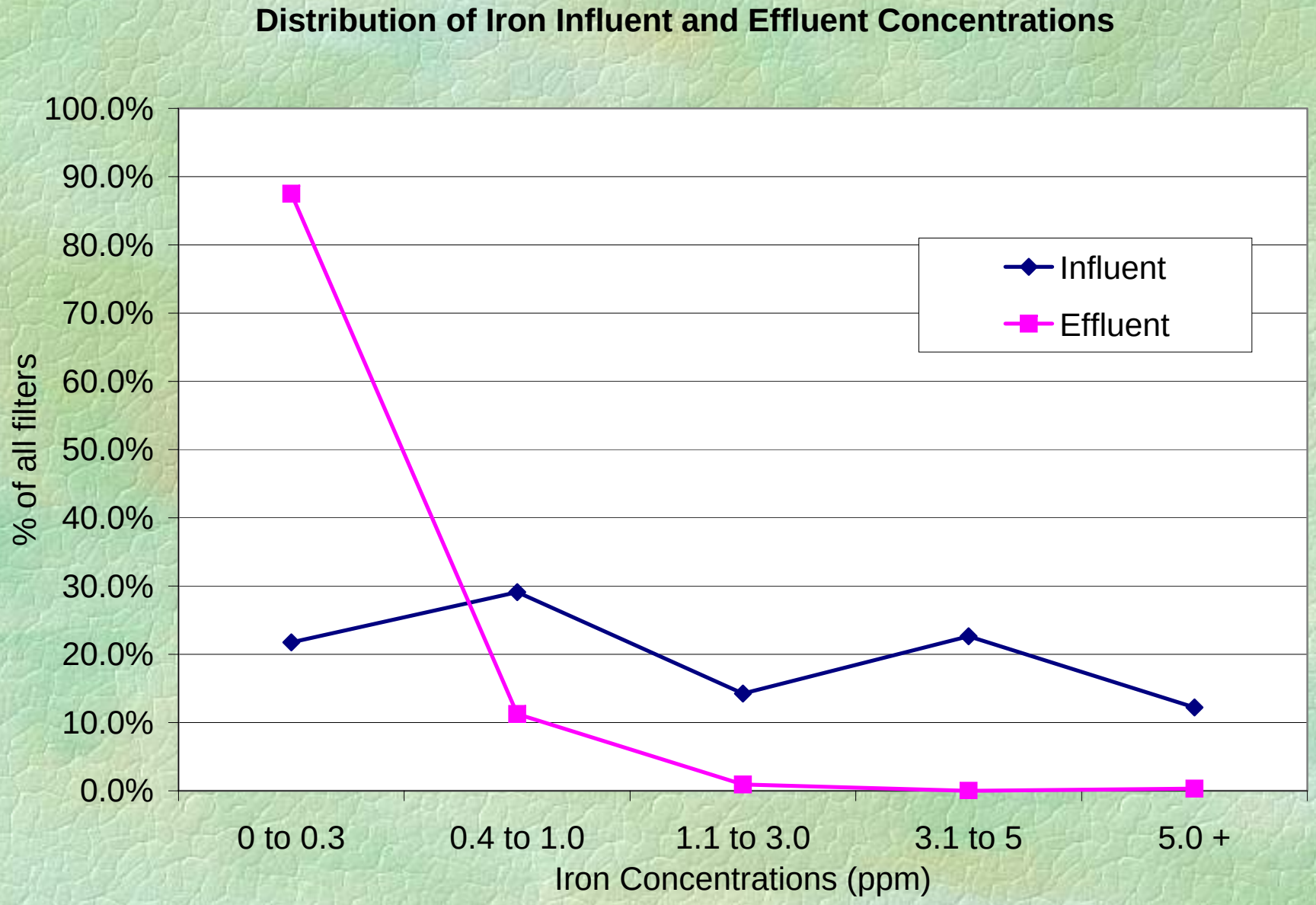
We have developed 4 configurations for the ABF:

1. Concrete Square
2. Concrete Round
3. Plastic Hilltake
4. Plastic Gem505

Filter Performance: Arsenic (n=650)



Filter Performance: Iron (n=611)



Filter Operation

1. Pour water into top basin. Water will pass through filter and flow up the pipe

2. Collect filtered water at the pipe outlet

3. If flow rate is insufficient, then cleaning is required

Filter Cleaning/ Maintenance

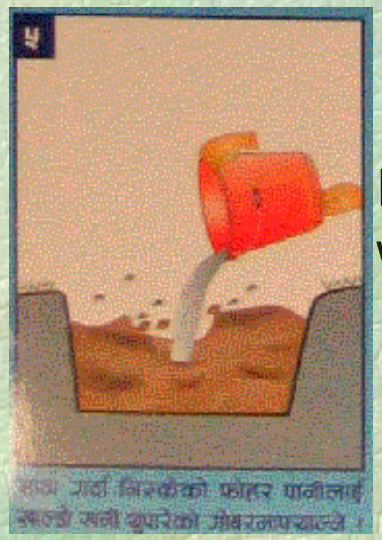
Wash your hands with soap

Remove diffuser basin

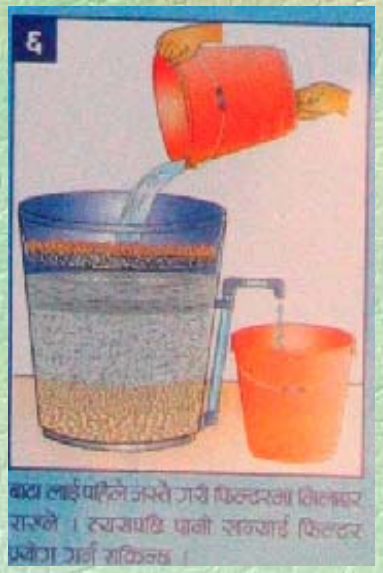
Stir the uppermost ½ inch of sand with your fingers

Filter Cleaning/ Maintenance

Remove turbid water with a cup.
Replace the basin and add more water.
Repeat the stirring process for two additional time.



Discard the turbid water in a dug hole with some cow dung in it



Now the filter can be used again

Filter Cost

	Gem505 ($US)
Container and Lid	$5.55
Basin	$1.03
Piping System	$1.82
Sand & Gravel	$0.04
Iron Nails 5 kg	$4.79
Transportation of sand & gravel	$0.27
Transportation of container & piping	$0.41
Labour	$0.74
Documentation	$0.34
Tools	$0.74
Total Per Unit Cost	**$15.73**

Note:
No replacement parts needed except iron nails (nails can last at least 1.5 years)

Assume exchange rate of US$1 = 73 Nepali Rupees

3. Implementation

Implementation Objectives

- To effectively transfer the ABF technology to Nepal
- To promote the ABF as an appropriate arsenic mitigation option for rural Nepal
- To make the ABF available throughout rural Nepal in a sustainable manner

Implementation – World Bank Project

Funding Source:
• Won a US$115,000 award from the World Bank Development Marketplace Global Competition 2003

Project Duration:
• February 2004 to November 2004

Project Partners:
• MIT, ENPHO, RWSSSP

World Bank Project - Key Activities

1. Establishment of an in-country ABF reference center at ENPHO in Kathmandu

- To provide comprehensive training on ABF construction, maintenance, troubleshooting, etc. to all interested groups

- To setup a library to make available information about technology details, construction manuals, research findings, informational/educational materials, etc.

- To compile all ABF distribution & monitoring information into a database

World Bank Project - Key Activities

2. Training to Local Entrepreneurs

• Trained and certified 26 local entrepreneurs from 10 arsenic-affected districts as “local ABF agents”

• They are local non-government organizations (NGOs), Red Cross, or community groups who are active in water supply.

• They were trained in ABF construction, installation, maintenance, troubleshooting, water testing, and entrepreneurship techniques

World Bank Project - Key Activities

2. Training to Local Entrepreneurs (con't)

- They will gather all ABF construction materials from local suppliers at wholesale price

- They will construct the filter and pack into ready-to-use package.

- They will sell ABFs to individual customers or institutional buyers (e.g. donors) at cost plus profit. This ensures financial sustainability.

- They can also provide filter repair/ testing services at additional cost

World Bank Project - Key Activities

3. Orientation workshops to 30 local governments

- Explain about health, water management, treatment options, and ABF information

- Participants include: Village Development Committee (VDC) members, health posts officials, local teachers, local NGOs, and interested agencies.

World Bank Project - Key Activities

4. Orientation workshops at 150 villages

• Explain about health, hygiene, water-borne diseases, treatment options, ABF information, subsidy scheme

• Participants include: local villagers, men, women, children.
• Expect 50+ participants in each workshop

World Bank Project - Key Activities

5. Filter Monitoring and Database Compilation

• Currently over 1000 filters are in operation. We expect 2000 filters by the end of 2004.

• Filters were distributed starting from September 2002 until today

• Parameters monitored include: arsenic, iron, phosphate, pH, total coliforms (bacteria), flow rate. All results are compiled into an ACCESS database

World Bank Project - Key Activities

6. Research & Development

• Continue to research, develop, and test new filter designs based on field observations and feedbacks from users.

• For example, the latest design (Gem505) is 40% cheaper than the previous versions, easier to manufacture and transport, and have a better performance.

World Bank Project - Key Activities

7. Information Dissemination

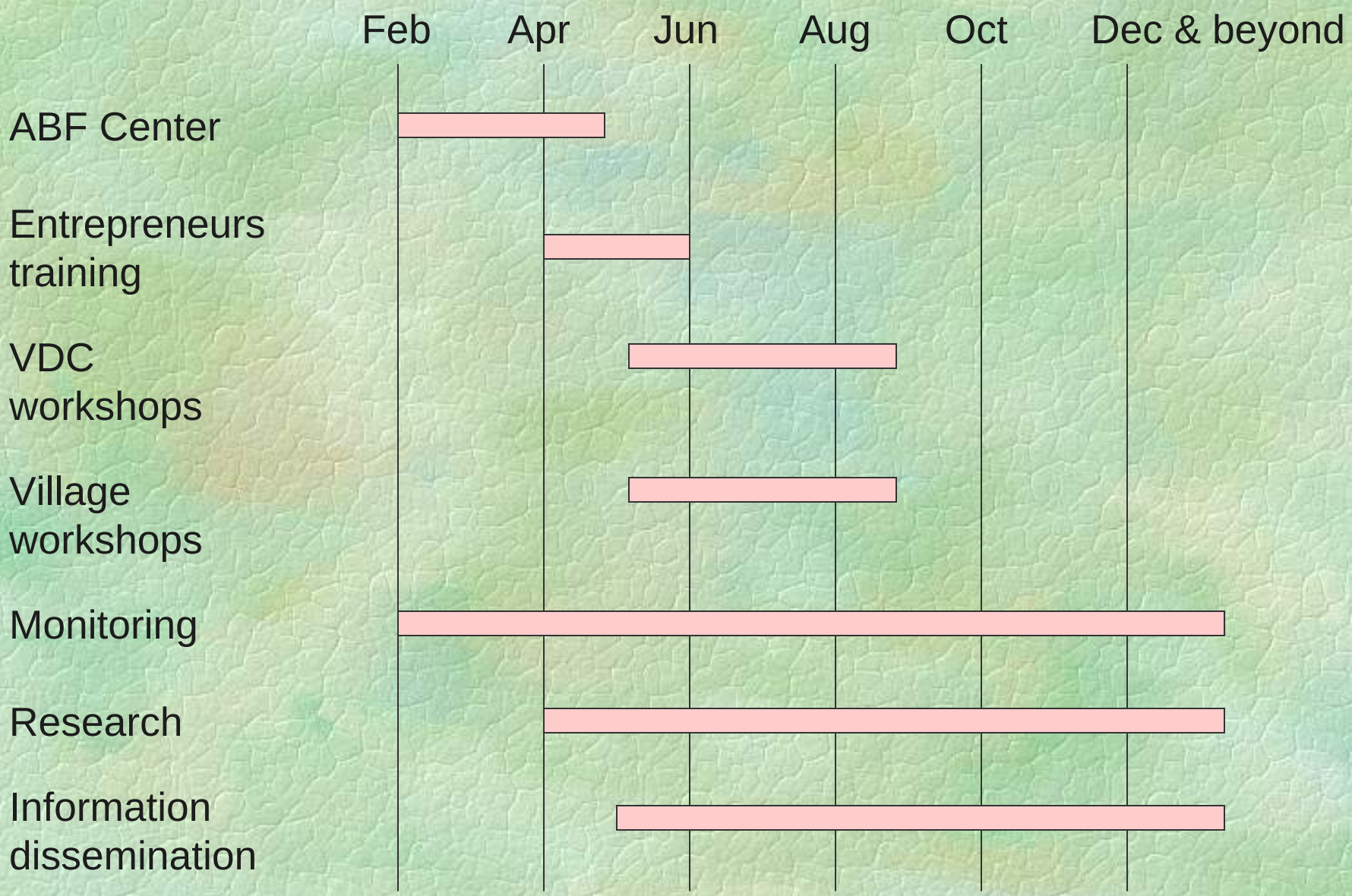
• Disseminate findings through conferences, journals, internet, TV, newspaper, radio, etc. to the development community and interested parties


उपत्यका/विविध

May 25, 2004 - Samachar Patra

आर्सेनिकको समस्या हटाउन सरल प्रविधिको फिल्टर विकास

World Bank Project - Timeline



4. Conclusions

Technical & Financial Sustainability

We believe this ABF project is both technically and financially sustainable

Technical sustainability:

- Filter constructed with locally available materials by local technicians

- Filter require minimal maintenance and replacement parts

- Filtered water tastes and looks significantly better than untreated water (according to many users) so users will continue to use the filter

Technical & Financial Sustainability

Financial sustainability = Margin per unit X Unit sales > Fixed cost

In our case:

- Fixed cost is minimal because these entrepreneurs have other water supply activities and other funds to pay for premise
- Temporary staff can be hired to construct filters based on demand

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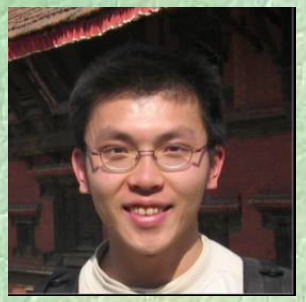

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Acknowledgements

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• Environment and Public Health Organization (ENPHO), Kathmandu
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• Department of Water Supply & Sewerage (DWSS)
• Kathmandu University

Internationally:

• The World Bank
• UNICEF
• MIT IDEAS Competition and Lemelson Foundation
• Stanford University
• Japanese Red Cross Society (JRCS)
• University of Calgary, Canada

Thank You

Thank You.
Any Questions?