Dissemination of *Kanchan*^{TM} Arsenic Filter (KAF) in Rural Nepal

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Environment and Public Health Organization (ENPHO), Nepal

Partner Organizations:

What are the Problems?

1. Unsafe Drinking Water

Arsenic Contamination

- Poison
- Skin disease such as melanosis, keratosis
- Cancer to lung, kidney, bladder, skin

Microbial Contamination

- Diarrhea, cholera,
- Stunted growth

2. Technological Deficiency

- Few mitigation are available
- Most are expensive, difficult to operate and maintain, use of imported materials, unacceptable to users

What are the Problems?

3. Implementation Deficiency

- Sustainability ?
- Disregard user demand, ownership, and involvment

Results:

- Millions of people have no choice
- Continue to drink contaminated water
- Suffer from preventable water-borne diseases

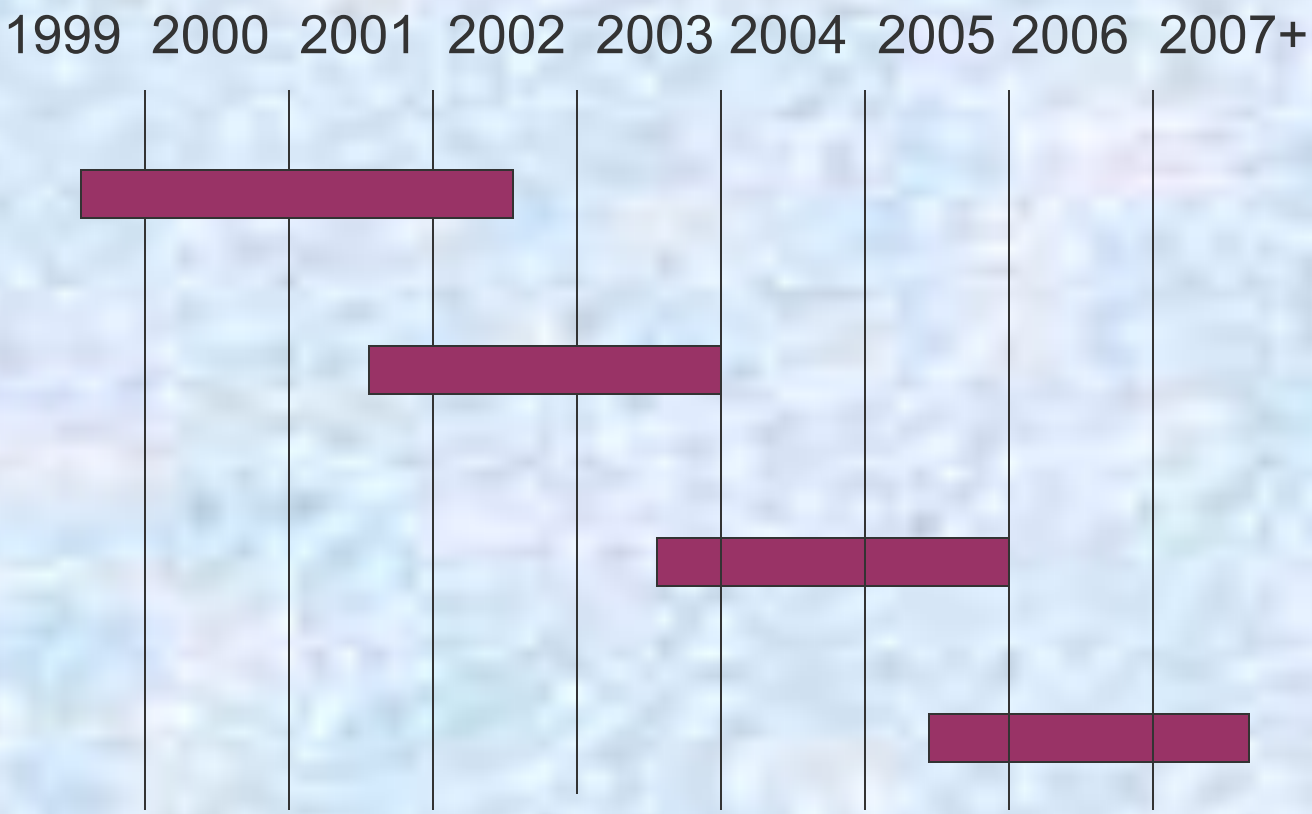
Our Solution

1. Develop an Appropriate Technology:
Kanchan Arsenic Filter

2. Develop an Appropriate Implementation Model:
Train local Entrepreneurs

Project Timeline

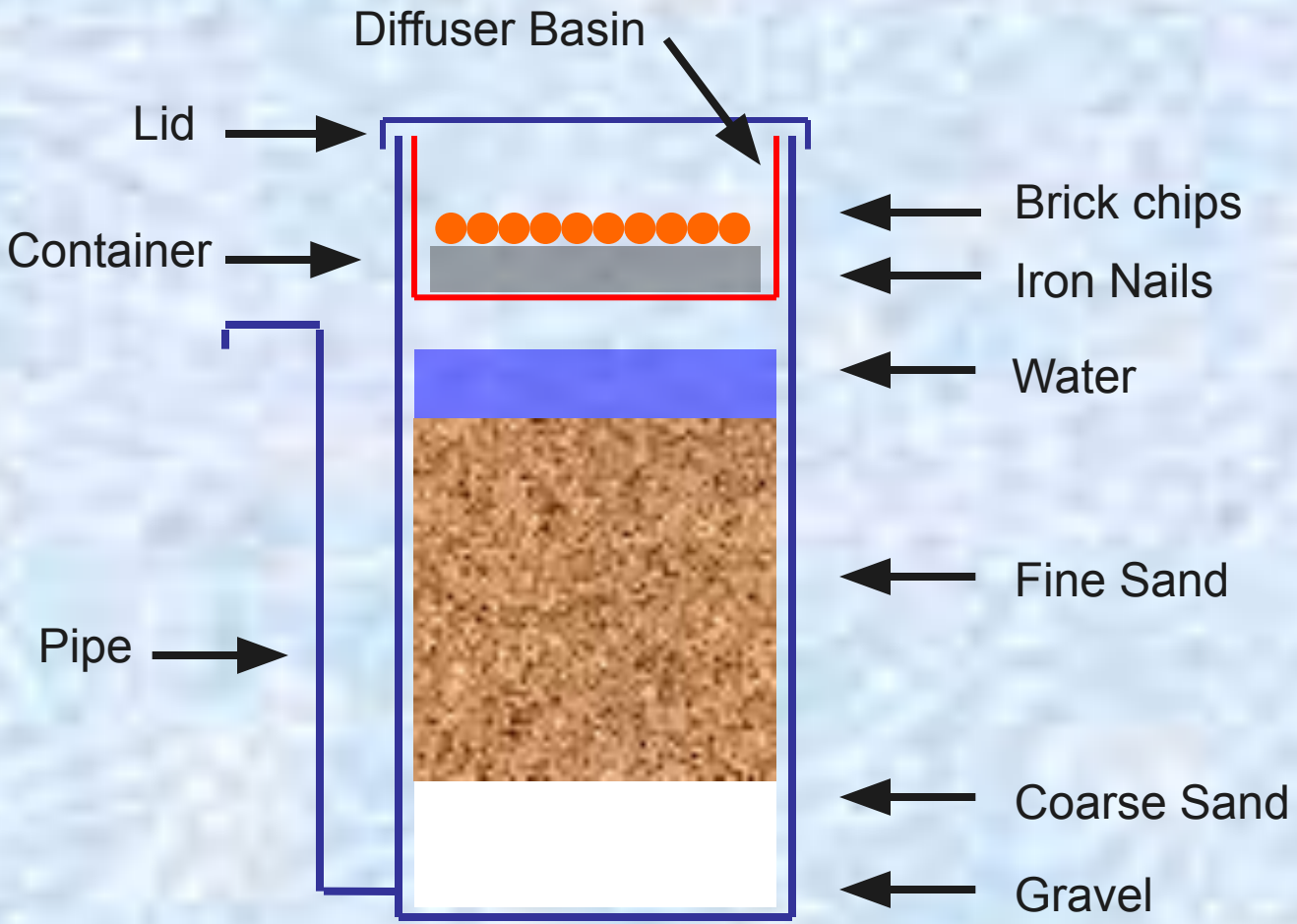
1. Background research
2. Technology development
3. Initial Implementation
4. Scale-up



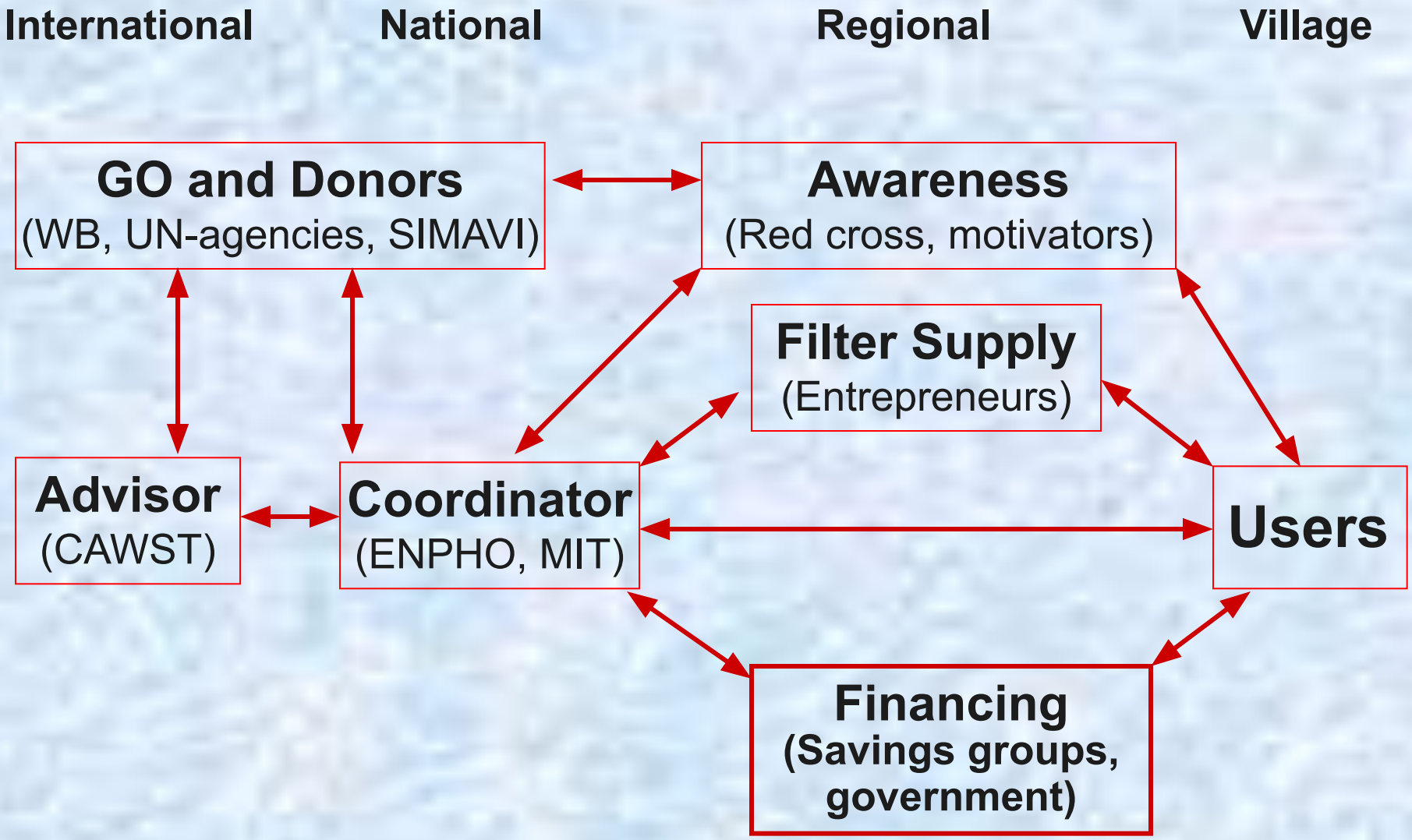
Kanchan^{TM} Arsenic Filter

- Based on 5-years of collaborative research between MIT, ENPHO, and local partners
- Local cost (US$20), innovative household-level filter considering the socio-economic conditions of rural Nepali communities
- Use of natural processes to removal arsenic, pathogen, iron, turbidity, and odour
- Highly accepted by users because of the simple O&M and the use of locally available materials and labour

Kanchan™ Arsenic Filter



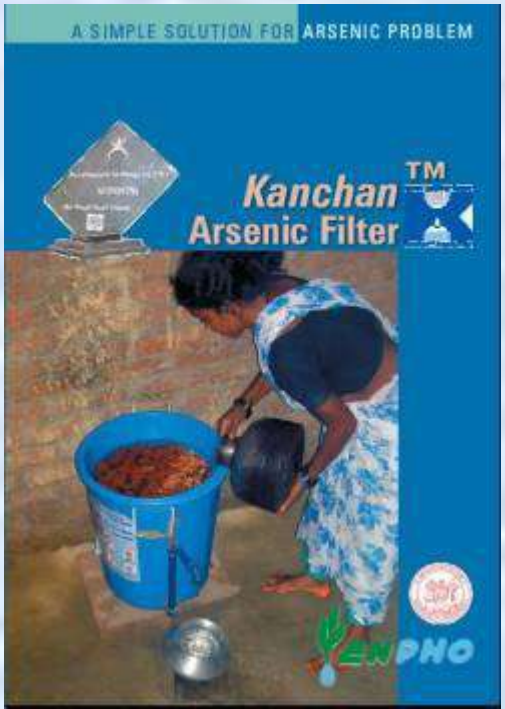
Implementation Model



Implementation Activities

1. ***Established an in-country KAF reference and resource center at ENPHO***

- Provide technical support and training
- KAF information available to general public



Implementation Activities

2. Conducted targeted education/awareness workshops in 200 villages

- School education programs
- Street drama
- Village-level discussion
- Household visits and health survey
- Health workers and teachers training
- Radio, posters, mass media

Implementation Activities

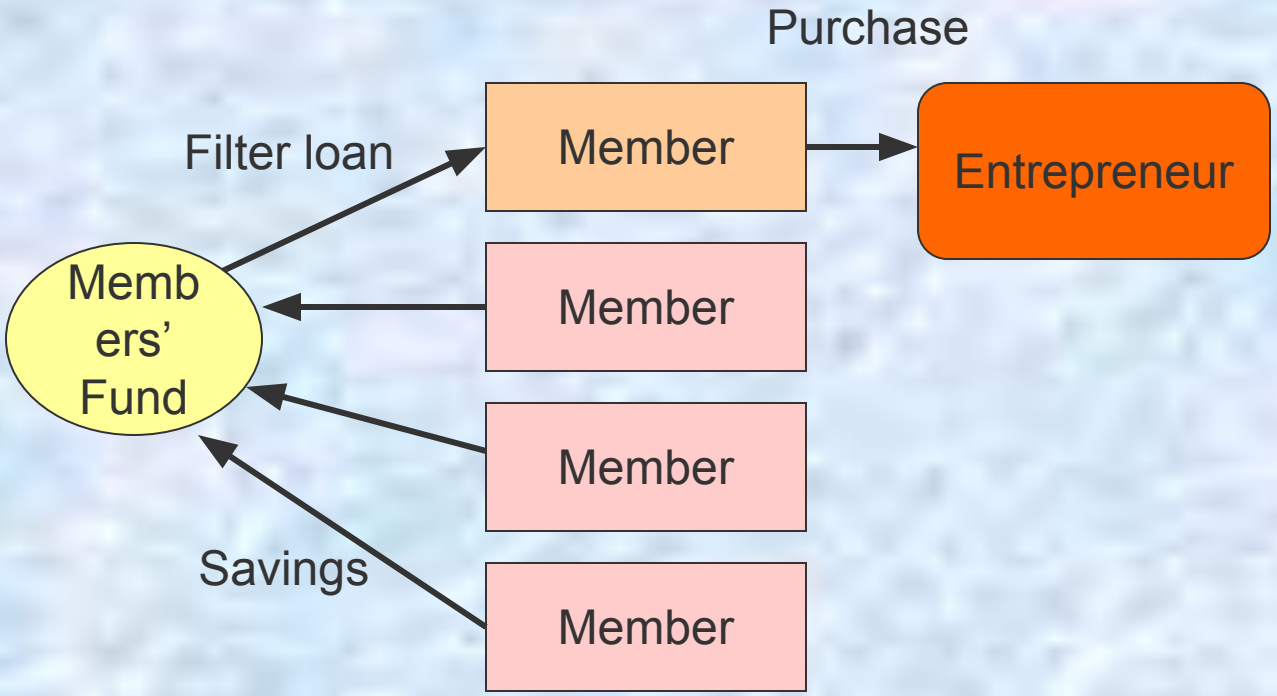
3. ***Trained 20+ local entrepreneurs on KAF construction, promotion, sales, and distribution***

- KAF immediately available at grass-root level
- Job creation, poverty alleviation
- Capacity building of local organizations

Implementation Activities

4. Developed pro-poor micro-financing and subsidy scheme

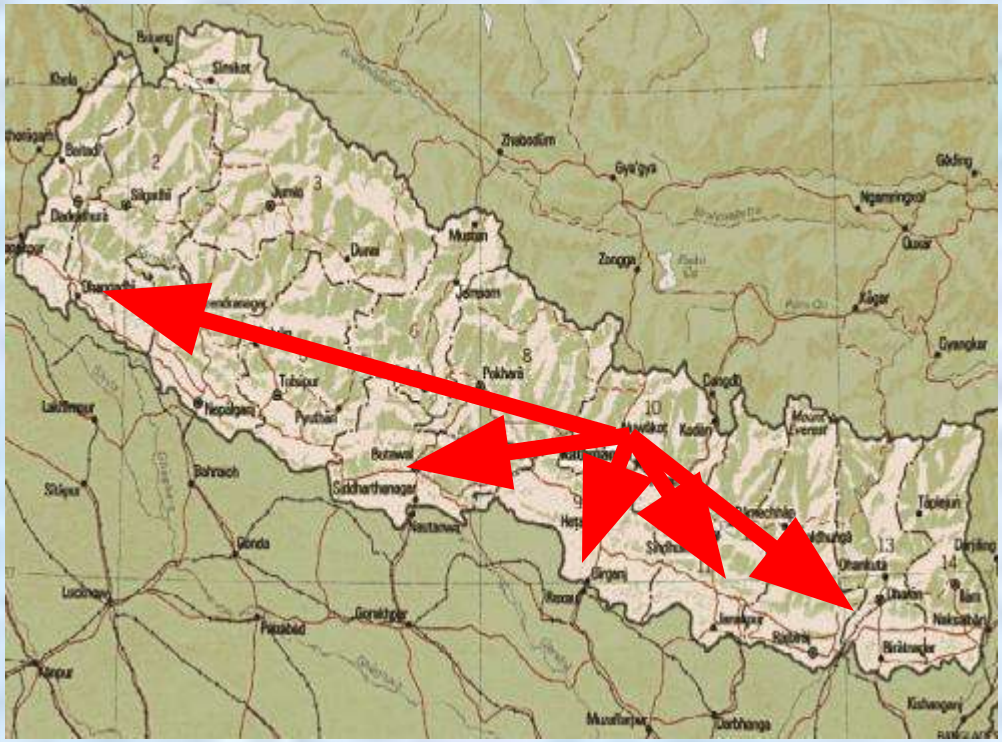
- Strengthen local women savings groups
- KAF more accessible to the poor



Implementation Activities

5. Improved filter design and supply chain

- Better technical performance and user-friendliness
- Lower cost, easier supply and distribution network
- Use of local materials and mechanisms



Implementation Activities

6. Coordination with national and local governments and NGOs

- Open and clear communications with key stakeholders
- Effective planning, minimal conflicts
- Receive in-kind and financial support

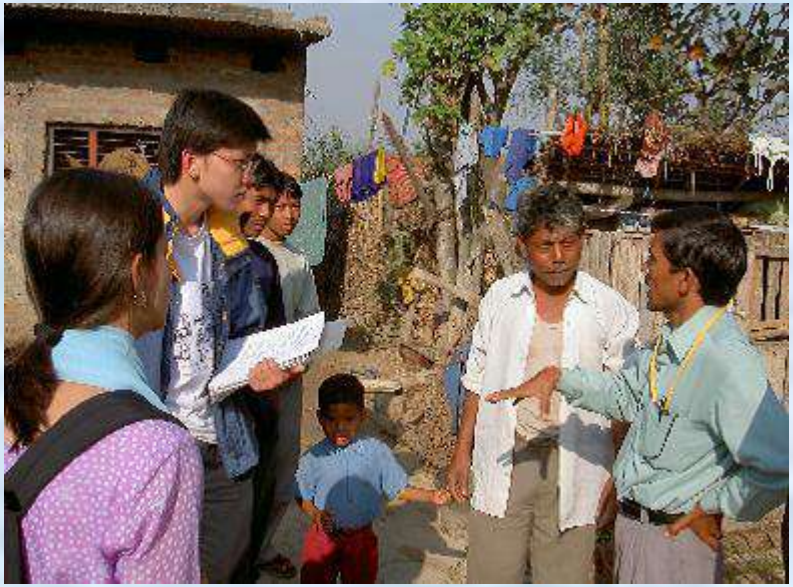
Innovations

Long-Term Self-Reliance Model

- Strengthen local organizations in safe water provision
- Provide locals with all necessary hardware and software to construct and maintain KAF
- Ensure sustainability

Sustainable Development

- Placed technological design within local socio-economic context
- native design process involving users, implementers, entrepreneurs, village leaders, etc.
- Use of local resources and labour



Recognitions and Awards

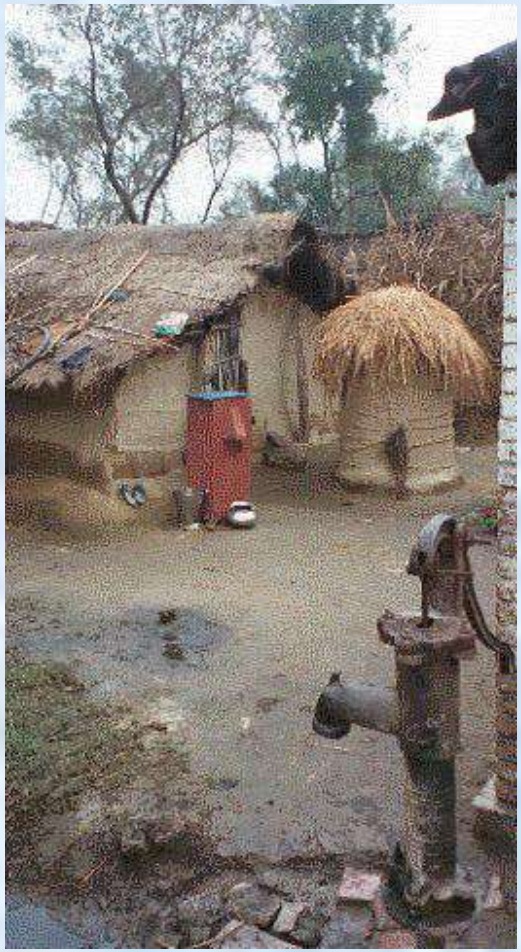
Nepal National Arsenic Steering Committee, MDG report, UNICEF, and prominent NGOs consider KAF as one of the best safe water options

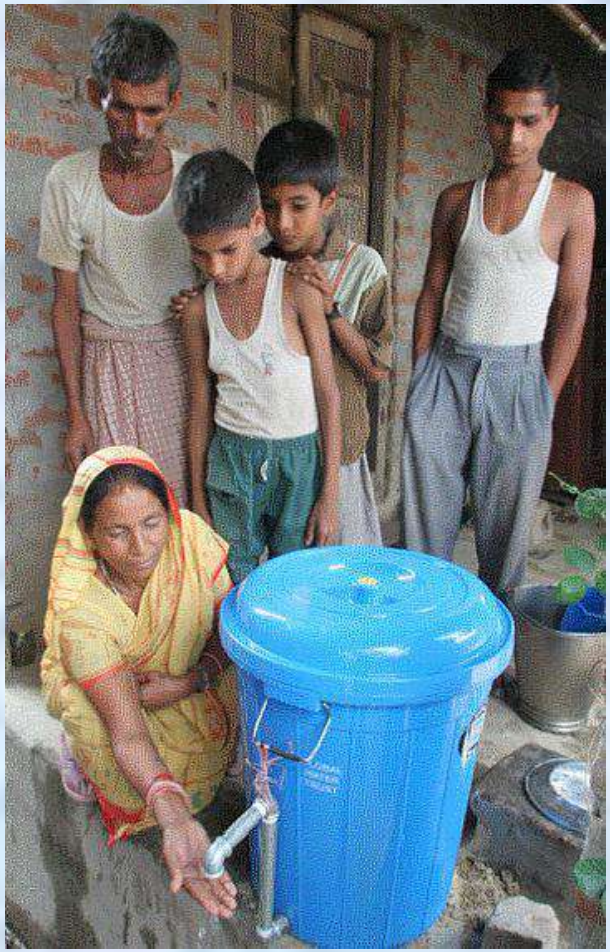
KAF won prestigious awards such as:

- MIT IDEAS Design Competition 2003
- World Bank Development Marketplace Global Competition 2003
- World Bank Nepal Marketplace Competition 2005
- Wall Street Journal 2005 Technology Innovation - Environmental Category
- USEPA P3 Design Competition 2005
- Recognized in Kyoto World Water Prize, 2006 by listed in TOP TEN

Impact

- As of March 2006, 3000+ filters in operation, serving 25000+ people
- Another 5000 filters installed within 18 months





Lessons Learned

- Implementation model can be replicated in other regions
- Require government recognition for quick dissemination
- Local people equipped with knowledge to solve their problems is effective and sustainable
- High risk of inferior copy-cat without regulatory mechanism

Acknowledgements

In Nepal:

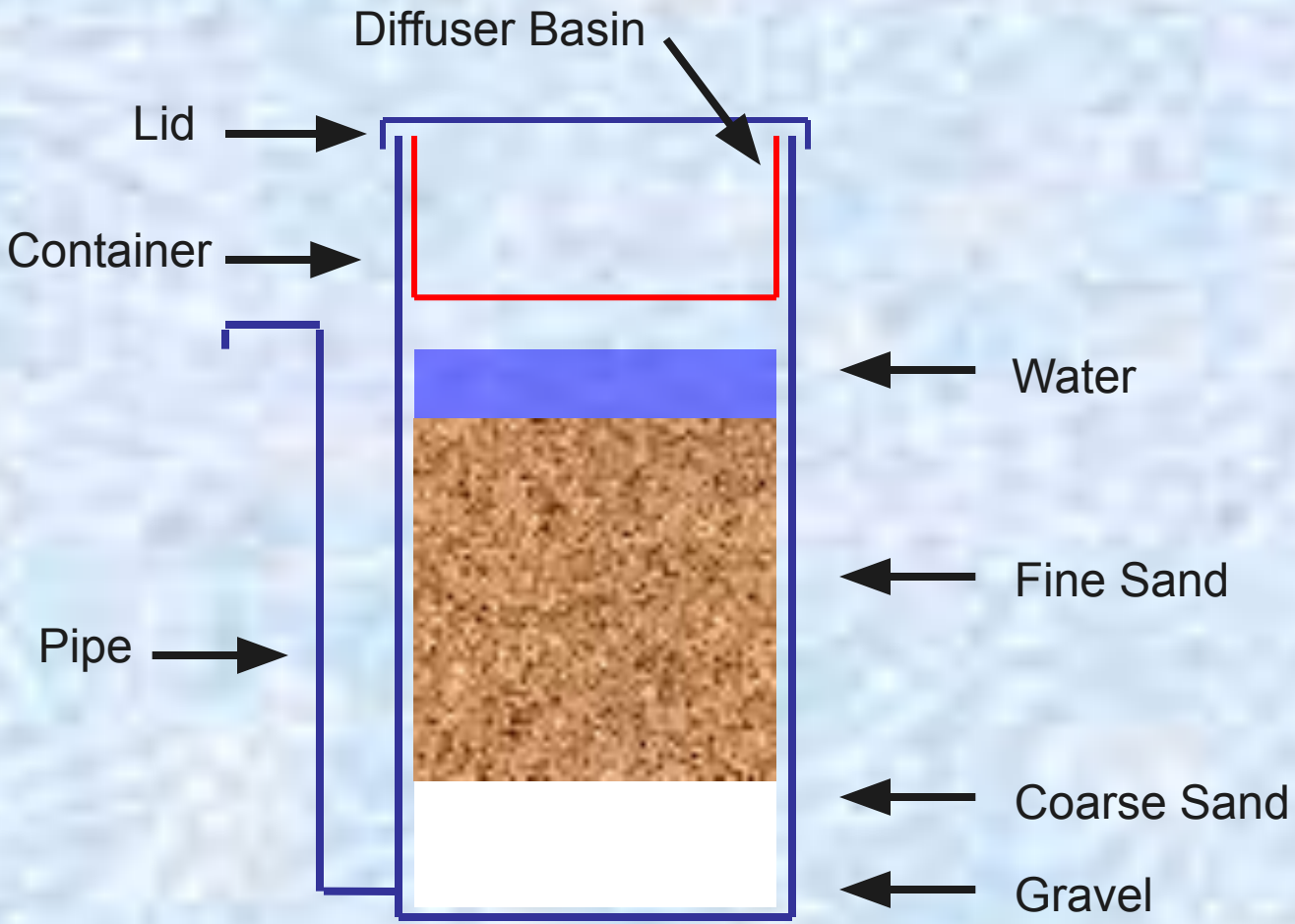
- Rural Water Supply and Sanitation Support Programme (RWSSSP)
- Nepal Red Cross Society (NRCS)
- National Arsenic Steering Committee
- Department of Water Supply & Sewerage (DWSS)
- Rural Water Supply and Sanitation Fund Development Board (RWSSFDB)
- Department of Education (DOE)
- Department of Irrigation (DOI)
- Nepal Water for Health (NEWAH)
- Save the Environment Nepal (STEN)
- UN-Habitat Water for Asian Cities
- UNICEF Nepal
- WaterAid Nepal
- Kathmandu University
- Tribhuvan University
- Kathmandu Rotary Club

Internationally:

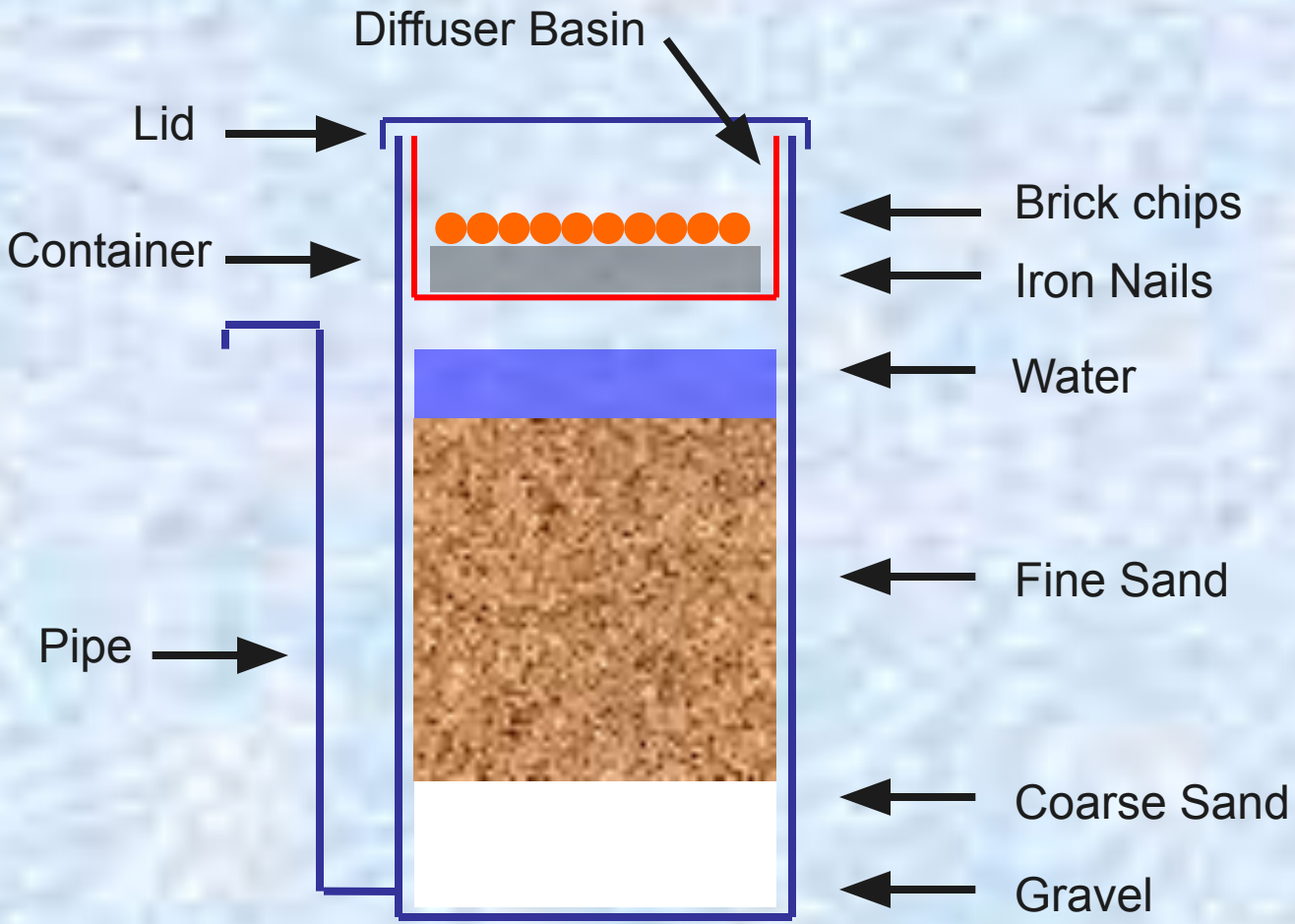
- MIT Department of Civil and Environmental Engineering, USA
- MIT IDEAS Competition, USA
- The Lemelson Foundation, USA
- MIT Sloan School of Business, USA
- The World Bank, USA
- Stanford University, USA
- Filters for Families, USA
- Global Water Trust (GWT), USA
- US Geological Survey (USGS)
- US Peace Corps
- US Environmental Protection Agency (EPA)
- Rotary International
- Centre for Affordable Water and Sanitation Technology (CAWST), Canada
- Asia Arsenic Network (AAN), Japan
- Japanese Red Cross Society (JRCS)
- Kyoto Institute of Eco-Sound Systems (KIESS), Japan
- Simavi Foundation, Netherlands

Thank You

Regular Biosand Filter



Kanchan™ Arsenic Filter



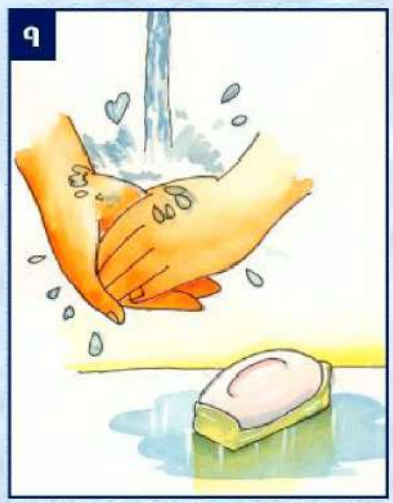
Filter Operation

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

2. Collect filtered water at the pipe outlet

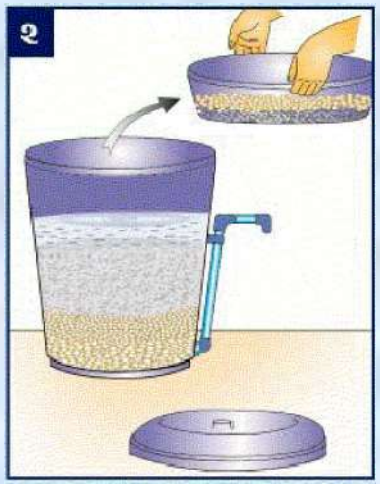
3. If flow rate is insufficient, then cleaning is required

Filter Cleaning/ Maintenance



साबुन पानीले हात राम्रो संग धुने ।

1. Wash your hands with soap



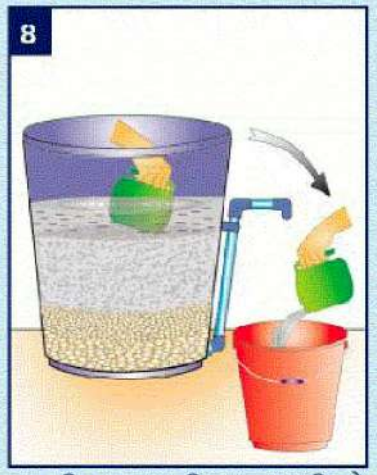
किला राखेको बाटा बाहिर निकाल्ने ।

2. Remove diffuser basin

बालुवाको माथिल्लो सतह बाट आधा इन्च जति भित्र सम्म हात छिराएर राम्रो संग बालुवालाई चलाउने ।

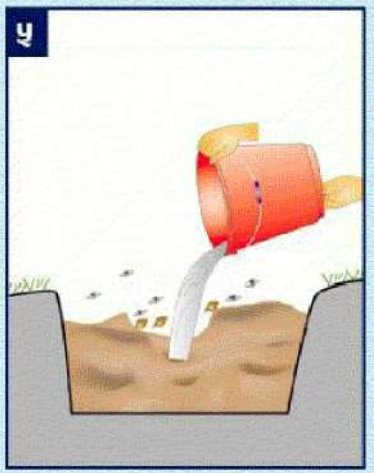
3. Stir the uppermost ½ inch of sand with your fingers

Filter Cleaning/ Maintenance



एक छिन चलाएपछि बालुवामाथिको फोहर पानी मगले बाहिर बाल्टिनमा निकाल्ने । पुनः बाटा राखेर पानी खन्याई दुई पटक सम्म यसरी नै सफा गर्ने।

4a. Remove turbid water with a cup.
4b. Replace the basin and add more water.
4c. Repeat the stirring process for two additional times.



सफा गर्दा निस्केको फोहर पानीलाई खाल्डो खनी थुपारेको गोबरमा फ्याल्ने ।

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

बाटा लाई पहिले जस्तै गरी फिल्टरमा मिलाएर राख्ने । त्यसपछि पानी खन्याई फिल्टर प्रयोग गर्न सकिन्छ ।

6. Now the filter can be used again

Filter Cost (Gem505 Model)

Item	NRs	$US
Container, Basin & Lid	540	7.71
Piping System	160	2.29
Sand & Gravel	40	0.57
Iron Nails	350	5.00
Bricks	5	0.07
Piyush (disinfection)	35	0.50
Transportation	50	0.71
Labor	50	0.71
Documentation	20	0.26
Tools	15	0.21
Cost per Unit	1265	18.07
Profit 10%	127	1.81
Selling Price	1392	19.88

Note:
No replacement parts needed except iron nails (nails can last at least 3 years)

Assume exchange rate of US$1 = 70 Nepali Rupees

Arsenic Performance

(all filter version, monitoring Nov04 to Mar05, n=1034)

Effluent Arsenic Concentration (ug/L)

Influent Arsenic Concentration (ug/L)	ND	10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400	450	500
1000	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0
500	2	2	4	2	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
400	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
350	0	2	1	2	1	0	0	0											
300	2	3	1	1	1	0	0	0											
250	7	3	0	0	0	0	0	0											
200	49	11	3	3	1	0	0	0	0	2	3	0	0						
150	50	14	5	1	0	1	0	0	0	0	2	1							
100	132	11	3	4	1	0	1	0	0	0	0								
90	91	4	4	3	0	0	0	0	0	0									
80	50	11	1	1	1	0	0	0	0										
70	39	1	0	0	0	0	0	0											
60	42	2	0	1	0	0	0												
50	53	4	1	0	0	0													
40	35	0	0	0	0														
30	52	1	0	0															
20	45	1	0																
10	85	0																	
ND	157																		

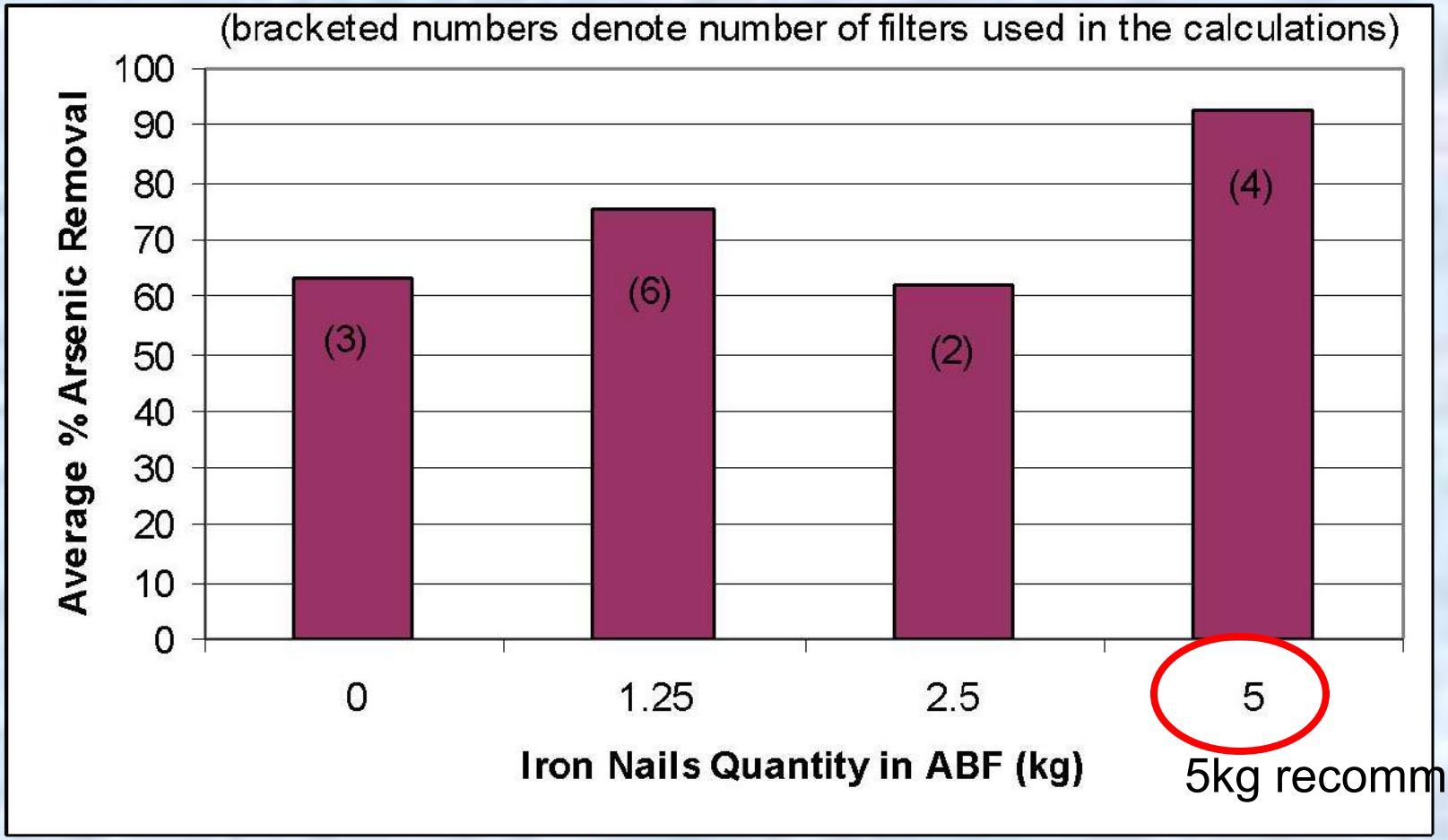
Correct installation and maintenance are highly important

Unacceptable

Acceptable

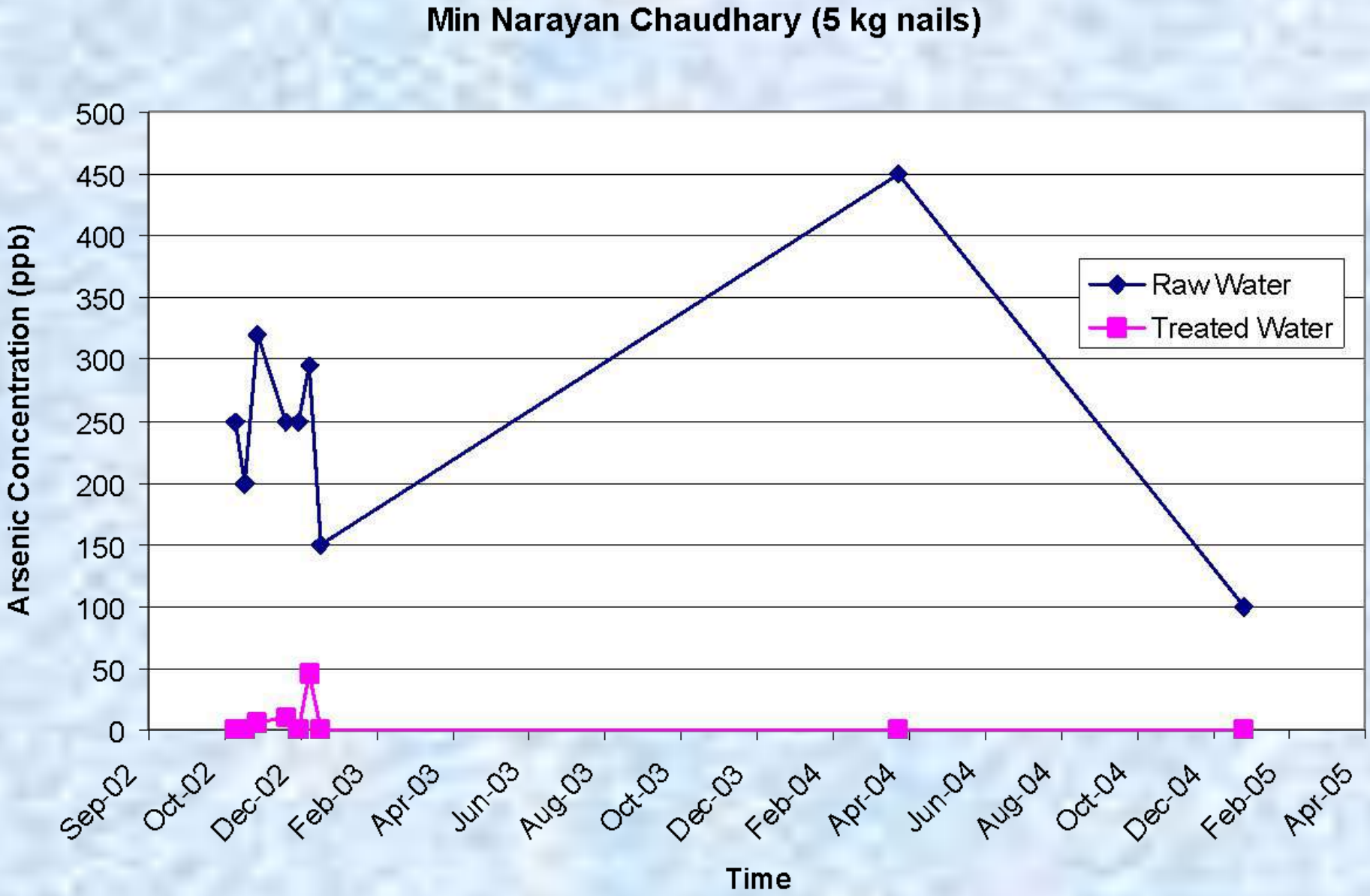
Figure indicates number of filters

Arsenic Removal Efficiencies for Different KAF Setups

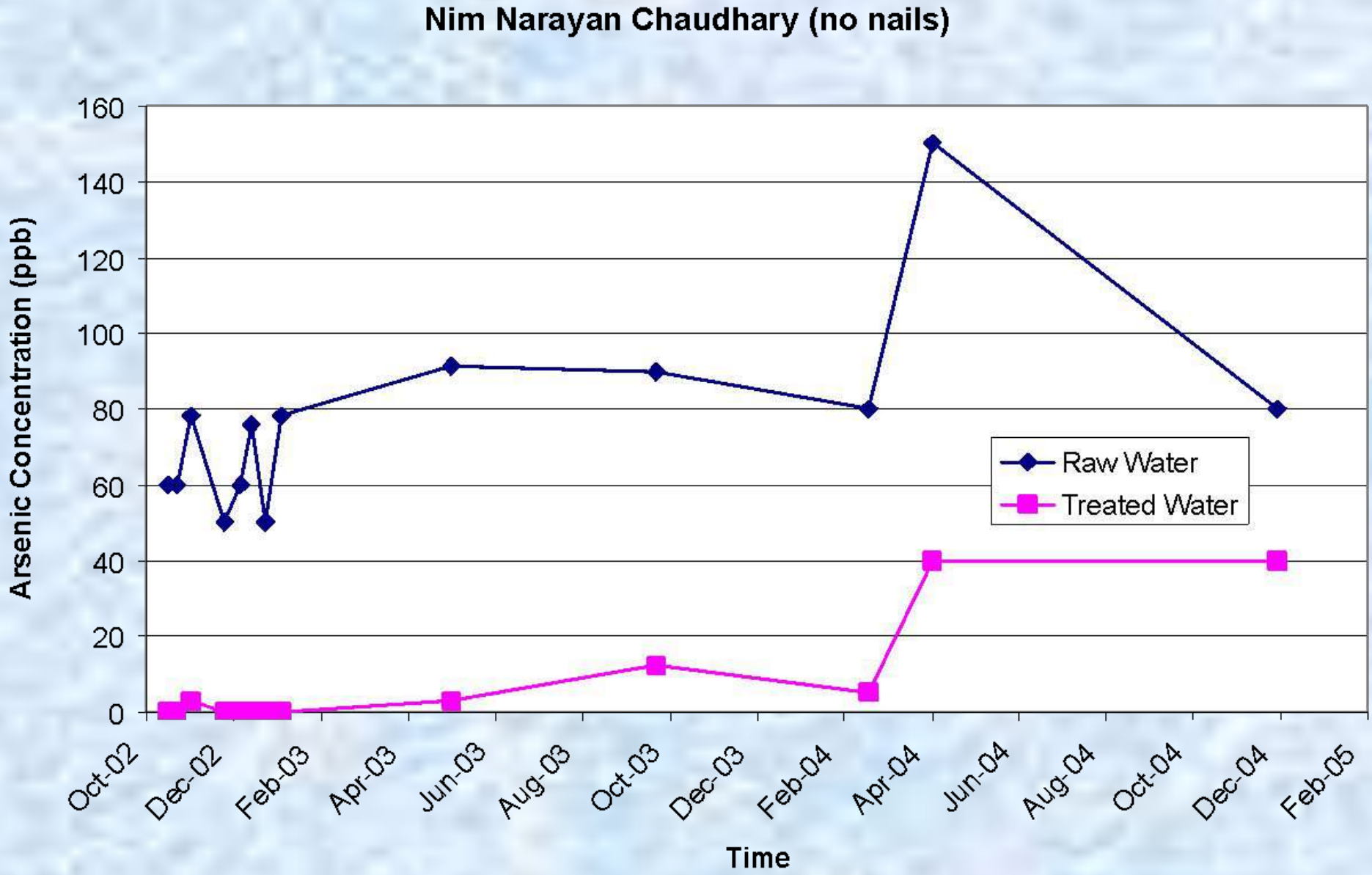


5kg recommended

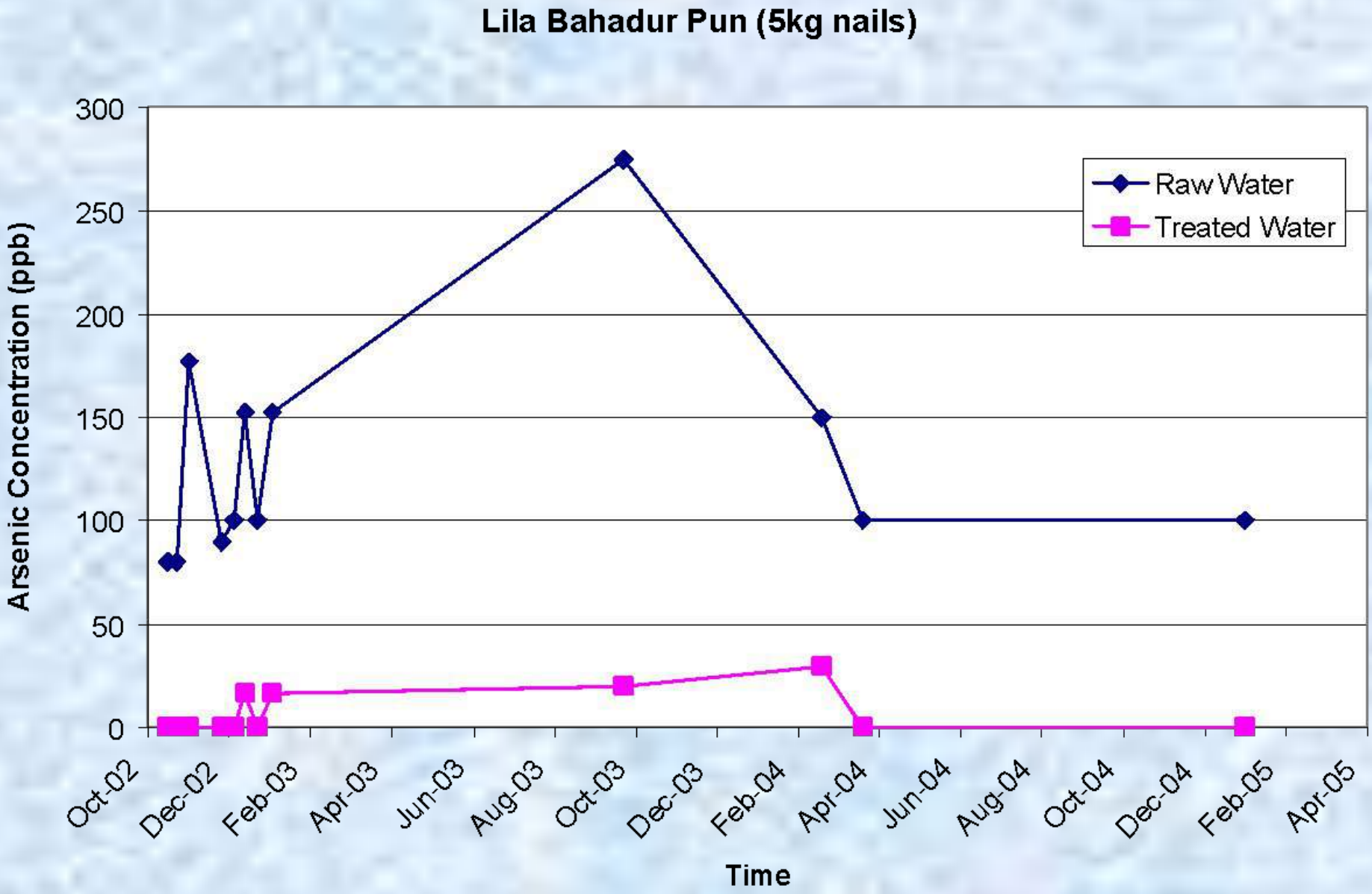
Arsenic Performance – Long Term



Arsenic Performance – Long Term



Arsenic Performance – Long Term



Iron Performance

(all filter version, monitoring Nov04 to Mar05, n=1019)

Influent Iron Conc. (mg/L)	Effluent Iron Concentration (mg/L)								
	ND	0.1	0.3	0.5	1	2	3	5	10
10	47	0	56	19	41	0	9	0	0
5	37	0	102	9	25	0	1	0	
3	104	0	61	0	2	0	0		
2	16	0	0	0	0	0			
1	219	0	26	0	0				
0.5	3	0	1	0					
0.3	176	1	6						
0.1	0	0							
ND	58								

KAF Technical Performance Summary

Parameters	Typical Range
Arsenic Removal	85% to 95%
Iron Removal	93% to 95+%
Coliform Removal	60% to 100%
Turbidity Removal	80% to 95+%
Flow Rate	15 to 20 L/hour
Iron Nails Media Life	At least 3 years

Users Survey Result

(all filter version, monitoring Nov04 to Mar05, n=1074)

	Everyday	Sometimes	No
Sustained use after 1 year	83%	12%	5%

	Better	*Same*	*Worse*
Appearance of filtered water	92.8%	6.9%	0.2%
Taste of filtered water	95.0%	5.0%	0%
Smell of filtered water	88.9%	11.1%	0%
Users' perceived health conditions after drinking filtered water	77.5%	22.5%	0%

	Yes	No
Filter simple to use	87%	13%
Will recommend KAF to other people	85%	15%

Arsenic Waste Generation & Disposal

Arsenic wastes are generated in two ways :

1. Waste water generated during sand cleaning
   - Usually 10-15 liters wastewater
   - Contains arsenic-loaded iron particles
3. Iron nail replacement
   - 5 kg of nails once every 3 years
   - Volume of 5 kg nails is about 4 liters

Disposal hole

Recommended Disposal Method:

- Small hole 20 cm diameter by 50 cm deep
- Usually at the backyard of filter users household
- Pour all waste water and waste nails into the hole

Research Studies

Badruzzaman, A.B.M. "Leaching of Arsenic from Wastes of Arsenic Removal Systems". Proceedings of Fate of Arsenic in the Environment Workshop. Bangladesh University of Engineering and Technology and the United Nations University International Symposium. 5-6 February 2003. Dhaka, Bangladesh.

Ali, M.A., Badruzzaman, A.B.M, Jalil, M.A., Ahmed, M.F., Kamruzzaman, MD., Rahman, M.A., Masud, A.A. "Fate of Arsenic in Wastes Generated from Arsenic Removal Units". Proceedings of Fate of Arsenic in the Environment Workshop. Bangladesh University of Engineering and Technology and the United Nations University International Symposium. 5-6 February 2003. Dhaka, Bangladesh.

Eriksen-Hamel, N., Zinia, B.K.N. "A Study of Arsenic Treatment Technologies and Leaching Characteristics of Arsenic Contaminated Sludge" Proceedings to BUET-UNU Internation Workshop on Technologies for Arsenic Removal from Drinking Water. 5-7 May 2001, Dhaka, Bangladesh .

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Research Studies

USEPA TCLP (toxcity characteristics leaching procedure) performed on arsenic waste generated by a number of coagulation-based technologies (e.g. alum, ferric chloride) and adsorption-based technologies (e.g 3-Kolshi, Shalpa, activated alumina, Sidko GFH)

Testing results shows leaching from arsenic waste is usually very low or negligible.

None of the above technologies produces a leachate considered to be hazardous by USEPA definition.

Arsenic is usually strongly-bound to the adsorption media, and remains in a stable, non-mobile form.

Since the KAF chemistry is similar to some of the above technologies, it is believed that the KAF waste has similar leaching characteristics.

Theoretical Calculations

Assume the case:

- Influent arsenic 250 ppb, Effluent 0 ppb
- Each household uses 50L per day
- All arsenic eventually ended up in the disposal hole

Calculations show:

- The annual amount of arsenic “pollution” created in the area immediately surrounding the disposal hole is less than the background arsenic found in natural soil

Further thoughts:

- Even if arsenic is “returned” to the environment, arsenic leaching is low or negligible
- Compare the amount of arsenic released to the environment by KAF to irrigation

Arsenic Waste Research Findings

Conclusions:
The current recommended KAF waste disposal method is believed to be safe and does not contribute to re-contamination of the environment

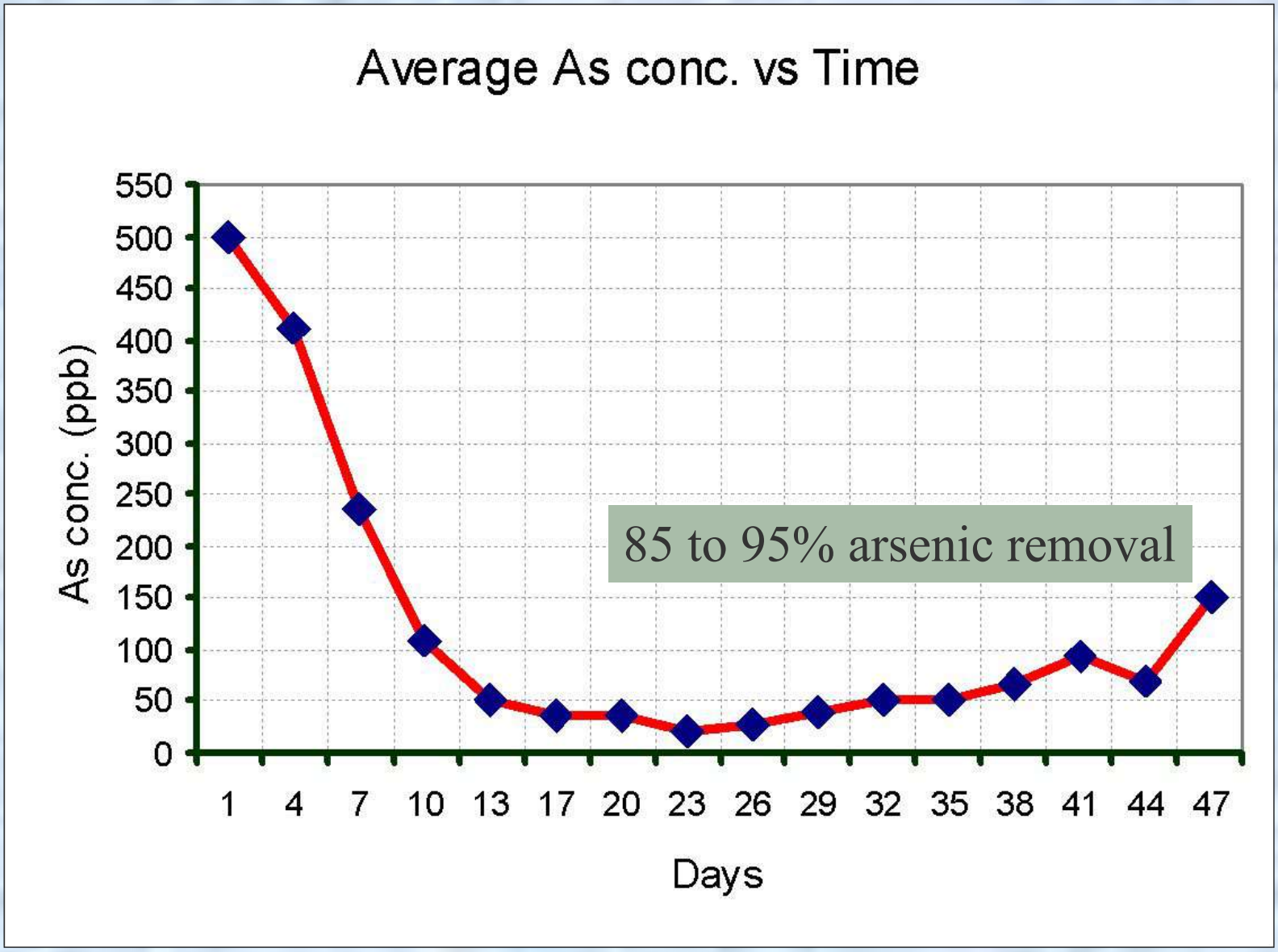
AIT Study

Source:
Personal communications with Mickey Sampson

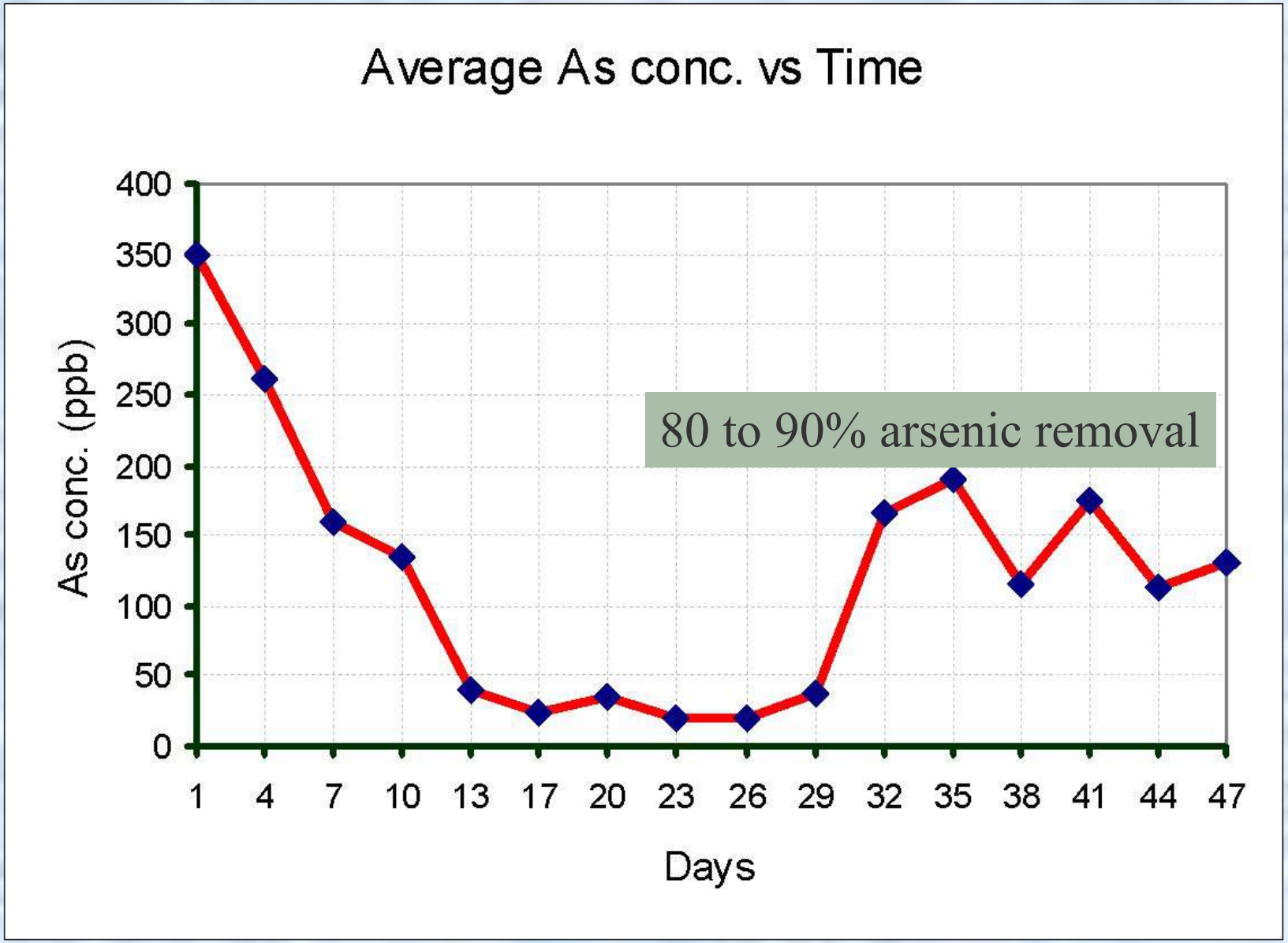
Experimental Design:

- 8 filters in RDI office
- 2 different water sources, one with high arsenic (1000 ppb) and high iron (6 ppm), one with lower arsenic (600 ppb) and lower iron (1ppm)
- 5 kg of locally found iron nails placed into the filter
- Arsenic concentration in the influent and effluent tested

Study Findings (1000 ppb arsenic well)



Study Findings (600 ppb arsenic well)



Iron nails not rusty
May be another type of iron nails is needed?

AIT Study Findings Summary

Although the initial study on the KAF by AIT/RDI shows inconsistent arsenic removal, data shows that KAF is a promising technology as arsenic is removed by 80 to 90%.

Modification to those filters such as using smaller rusty iron nails can improve performance further.

4. Supply Chain and KAF distribution

- Exploring possibilities for filter design improvement.