Institute of Technology of Cambodia

Sustainable Arsenic Removal System for affected Communities in Cambodia using Haix

By: HUL, Seingheng

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Introduction

- Arsenic is odorless and tasteless semi metal that occurs naturally in the rock and soil (FAO, 2006)
- The arsenic pollution in the groundwater became a serious problem on health of Cambodian people (Uy, 2010)
- The consumption over long period of time of arsenic water in excess of 10 micrograms per liter can lead to Arsenicosis (WHO, **2011**)
- Seeing this issue, different water sources are used currently by the community such as: well, surface water, water from SARSAC, rain water, etc.

Introduction

- To identify of alternative sources of drinking water for community
- To identify the number of wells and its information then test arsenic concentration in each well that water was not checked and analyzed.
- To survey people about their education level on arsenic and on the alternative sources of drinking water in the village.

Introduction

- Will know the water quality of their wells
- Be able to identify the alternative sources of drinking water
- Ability to prevent themselves from any unexpected diseases
- Specific solution can be applied to the study area

Arsenic Contamination

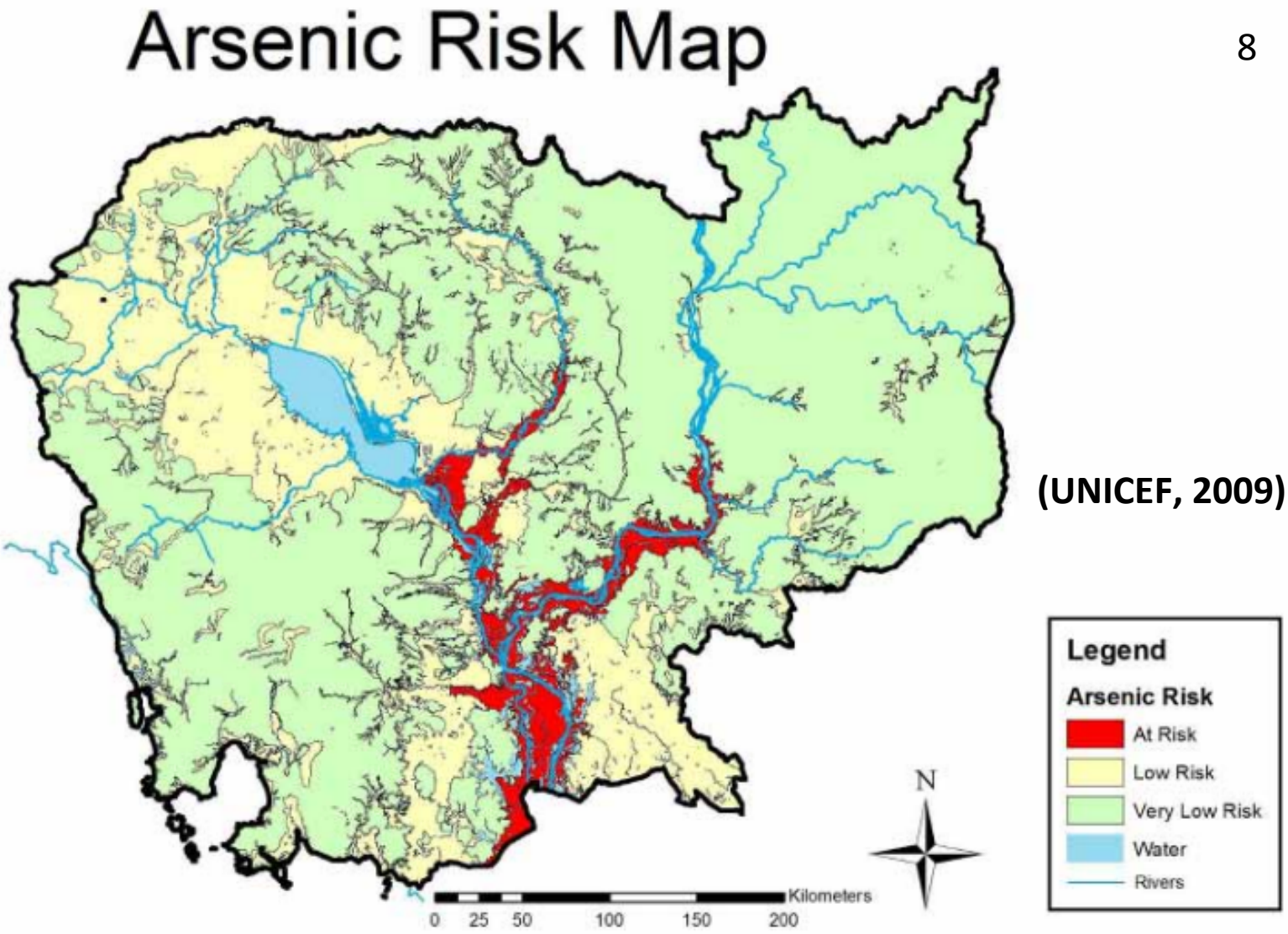
- Found in the groundwater system and can infiltrate to underground aquifers

- UNICEF (2009), arsenic in Cambodia was confirmed between 1990 and 2000 cooperated with MRD and MIME

Arsenic contamination level in Cambodia (Arsenic Center, 2009)

Provinces	Total wells tested	As >50 ppb	10 < As ≤ 50 ppb	As ≤ 10 ppb
Kandal	4,779	2,260	503	2,015
Peri-urban PP	612	33	109	470
Kampong Cham	1,576	218	88	1,270
Kampong Chhang	662	24	69	569
Kratie	1,248	94	116	1,038
Prey Veng	1,712	267	162	1,283
Kampong Thom	828	15	89	724
Kg.Speu	529	0	17	512
Otdar Mean Chey	147	0	2	145
Stung Treng	343	1	24	318
Svay Rieng	1,326	8	424	894
Krong Pailin	114	4	5	105
Preah Vihear	58	0	5	53
Pursat	1,236	0	26	1,210
Siem Reap	74	0	0	74
Takeo	429	0	18	411
Total	15,673	2,924	1,657	11,092

Arsenic Pollution site in Cambodia



(UNICEF, 2009)

Arsenicosis

What is Arsenicosis?

- WHO, the common symptoms are Leukomelanosis (rain-drop pigmentation on skin) and Nodular Keratosis

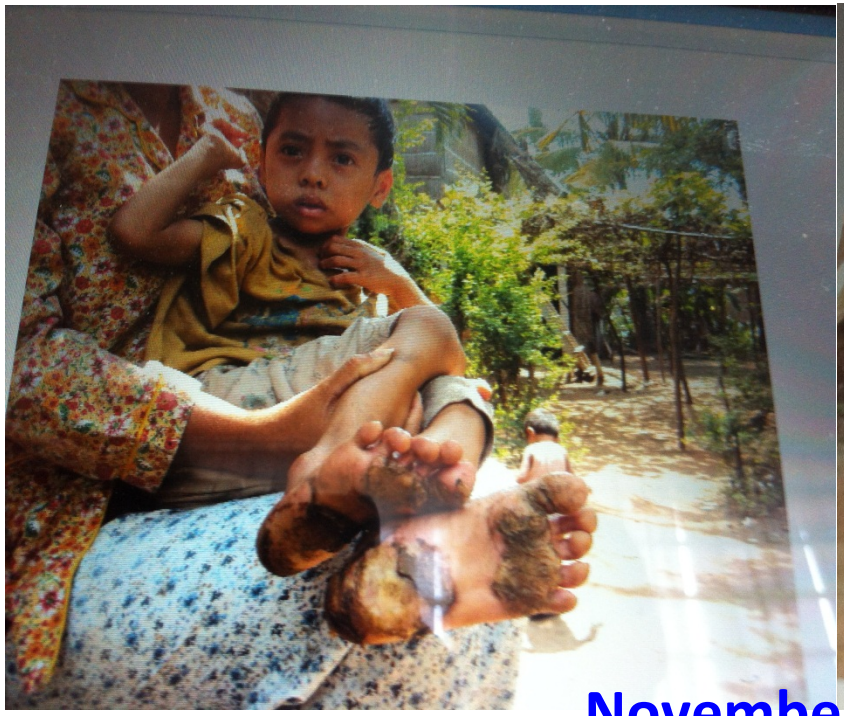
Arsenicosis Symptoms Identified in Kandal Province, (UNICEF, 2009)

Arsenical Nodular Keratosis: a picture from Kandal province- this woman and her family have similarly affected and her symptom has recently lead to cancer, reported by PDRD As team.

Arsenical Nodular Keratosis: a picture from Kandal province- a man with his son has serious problem with cancer; his son was operated with support from RDI.

Arsenical Leukomelanosi- picture from Kandal province.

Arsenicosis Symptoms Identified in Preaek Traeng



November, 2013 picture

Further stakeholder analysis is a need for long term solution such as: Source Identification, socio-economic study, involvement of stakeholders…

Bad Effect from Arsenic Contamination

- Dermal lesions such as hyperpigmentation and hypopigmentation
- Skin cancer,
- Bladder and lung cancers and

- Agricultural production. Change, complexity, uncertainty

Arsenic awareness

- Khaira, P., (2009) estimated that up to a million people in Cambodia are at risk.
- Not much people are aware of arsenic and received mitigation and education
- Scientific attention in Cambodia so far has tended to focus on technical solutions.

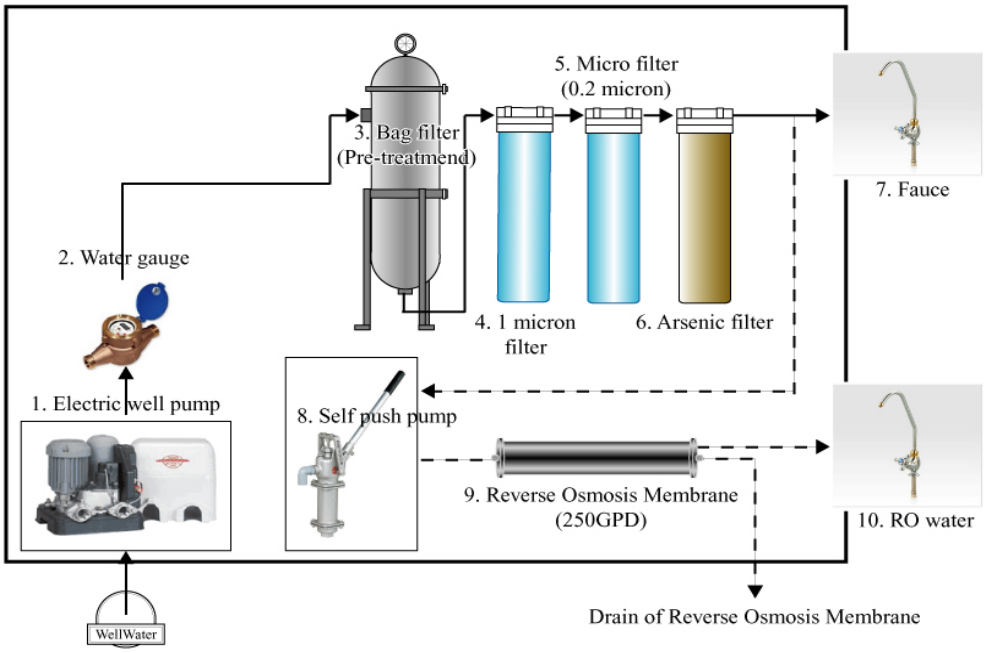
Drinking Water Sources for Community

- KAP (Knowledge, Attitude, Practice) survey by UNICEF (2009) surface water is the source of drinking water
  - ➢40% relied on surface water
  - ➢22% relied on tube-wells in dry season and 17% in the rainy season
  - ➢And approximately 13% relied on unprotected shallow wells

Our Past experiences

Removing Arsenic from Groundwater using High Performance Iron Adsorbent in Cambodia:

- The analysis results indicated that around 95% of As was removed in average by using the equipments, which ranged from 89-100%
- Efficacy is good, but effectiveness is a challenge and the system need more research on it application

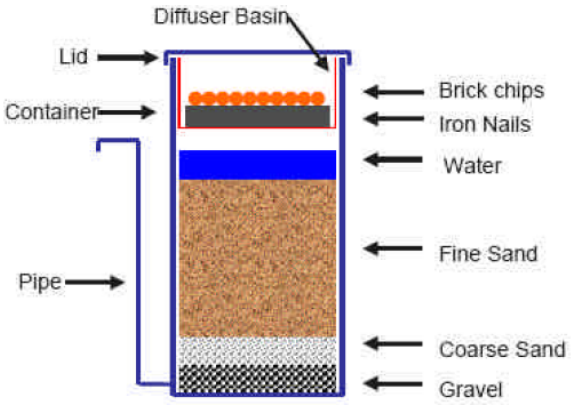


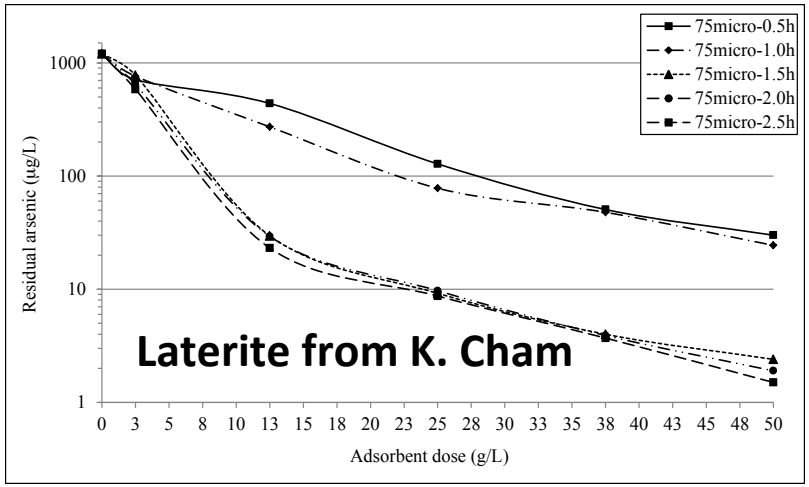
Introduction, As contamination and Arsenicosis, Sarsac and analysis, Result, Conclusion and Recommendation, NEXT…

Our research experiences

- Air oxidation of arsenic
- Kanchan Arsenic Filter Evaluation of Applicability to Cambodia: The average removal percentage is in the 95-97% range, difficult for high As concentration water
- Laterite as an adsorbent material for removing arsenic from polluted groundwater in Cambodia (Local resources: Efficacy is high (respect WHO standard)

Kanchan As filter





Drinking Water Sources for Community

- SARSAC:

Supported by: Dr. Arup Sengupta, (Haix), Lihigh University, US

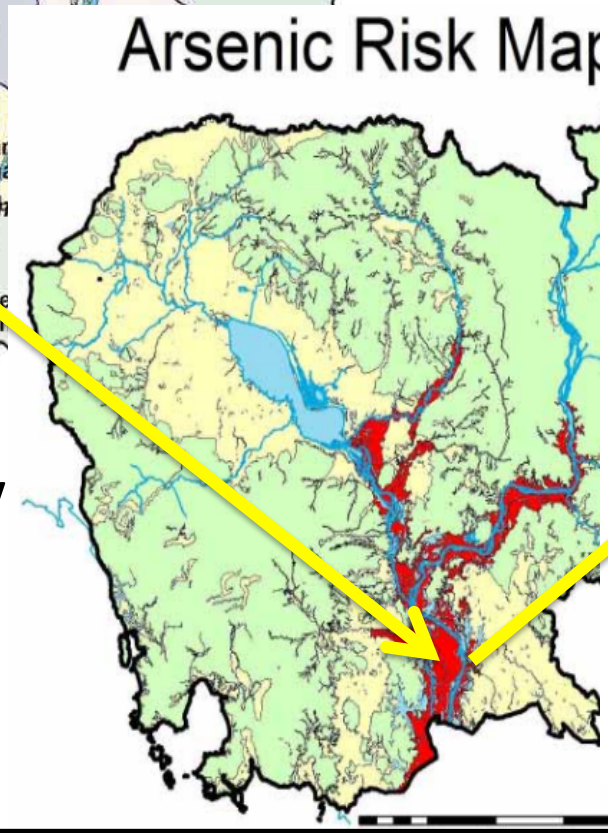
Water test after Sarsac installed

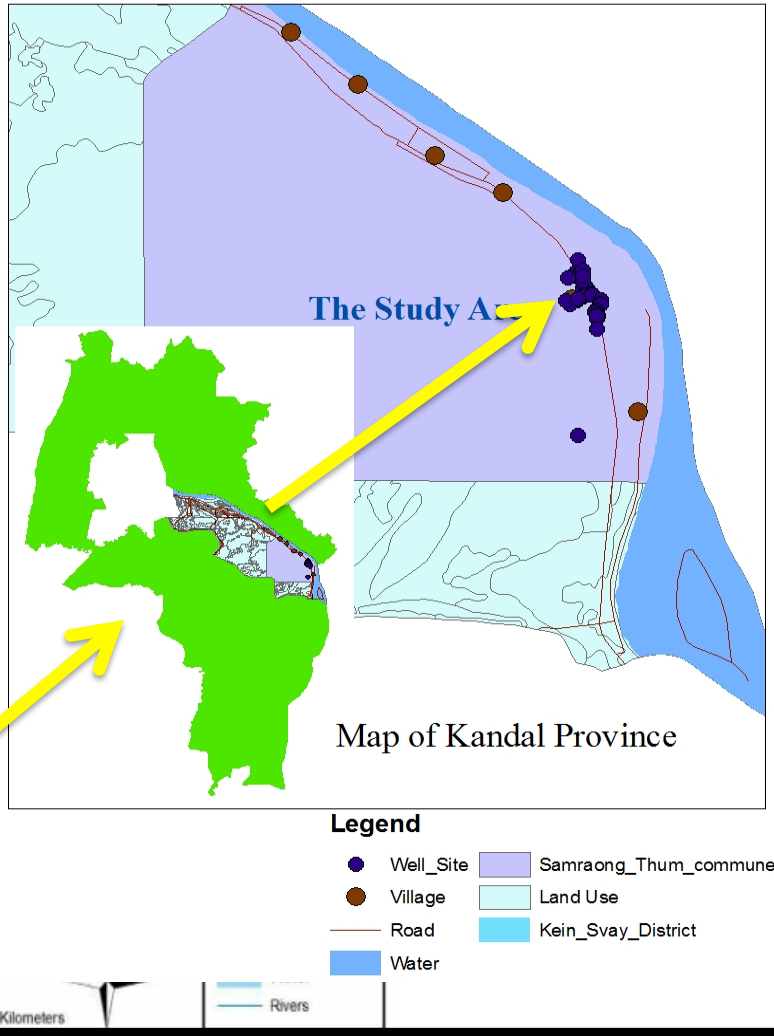
Result of Sarsac

Parameter	Unit	Testing Result		CDWQS
		Influent	Effluent	*
Arsenic	ppb	133,4	0	50
Manganese	mg/L	0,1	0	0,1
Iron	mg/L	0	0	0,3
pH		7,3	7,5	6,5-8,5
Turbidity	NTU	1,70	1.21	5
Conductivity	$\mu S/cm$	800	560	NL
Temperature	(^{0}C)	30,2	32	NL
TDS	mg/L	410	420	800
Total coliforms	cfu/100 ml	22	6	0
E.Coli	cfu/100 ml	18	0	0

** : Cambodian drinking water quality standard (CDWQS)*

Study Area





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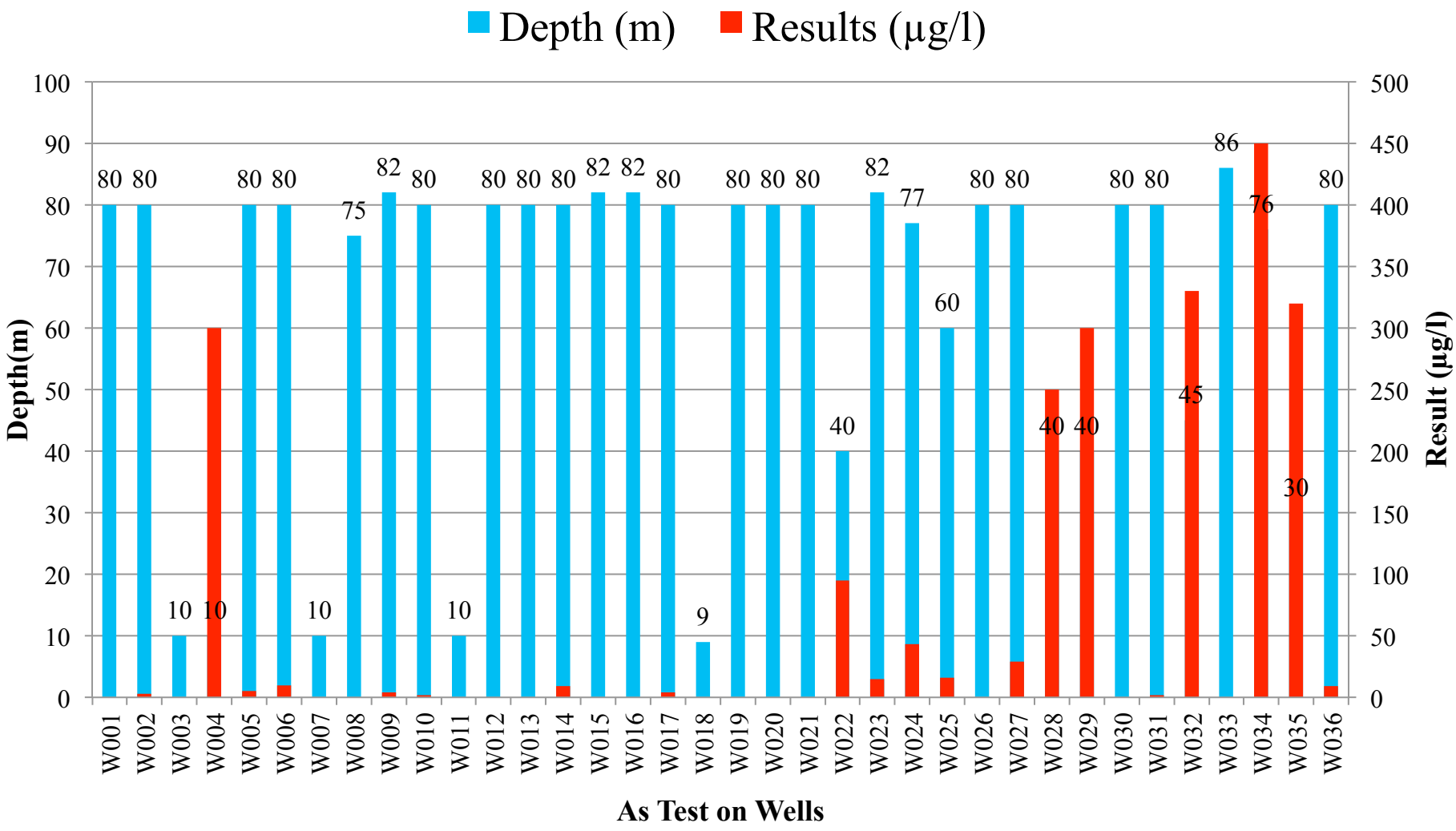
Sampling and Sample Preparation

On Site Survey

- The questionnaires were randomly asked 101 families related to:
  - Water sources
  - Arsenic awareness,
  - Arsenic mitigation
  - SARSAC
- The question of household surveys were encoded and analyzed by Microsoft Excel 2010 and SPSS version 21 program.

Result of 36 Sample Tests for Arsenic Concentration



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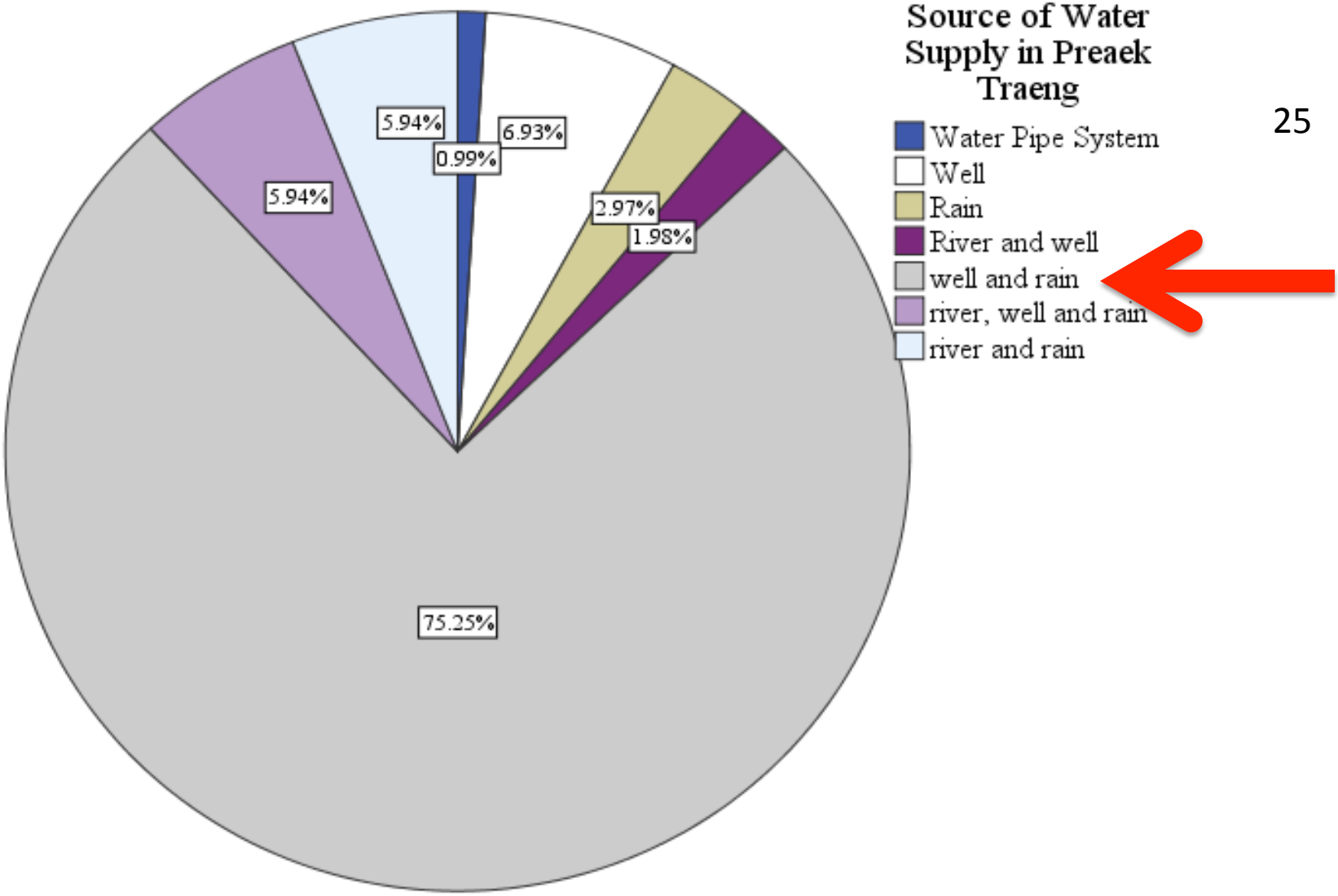
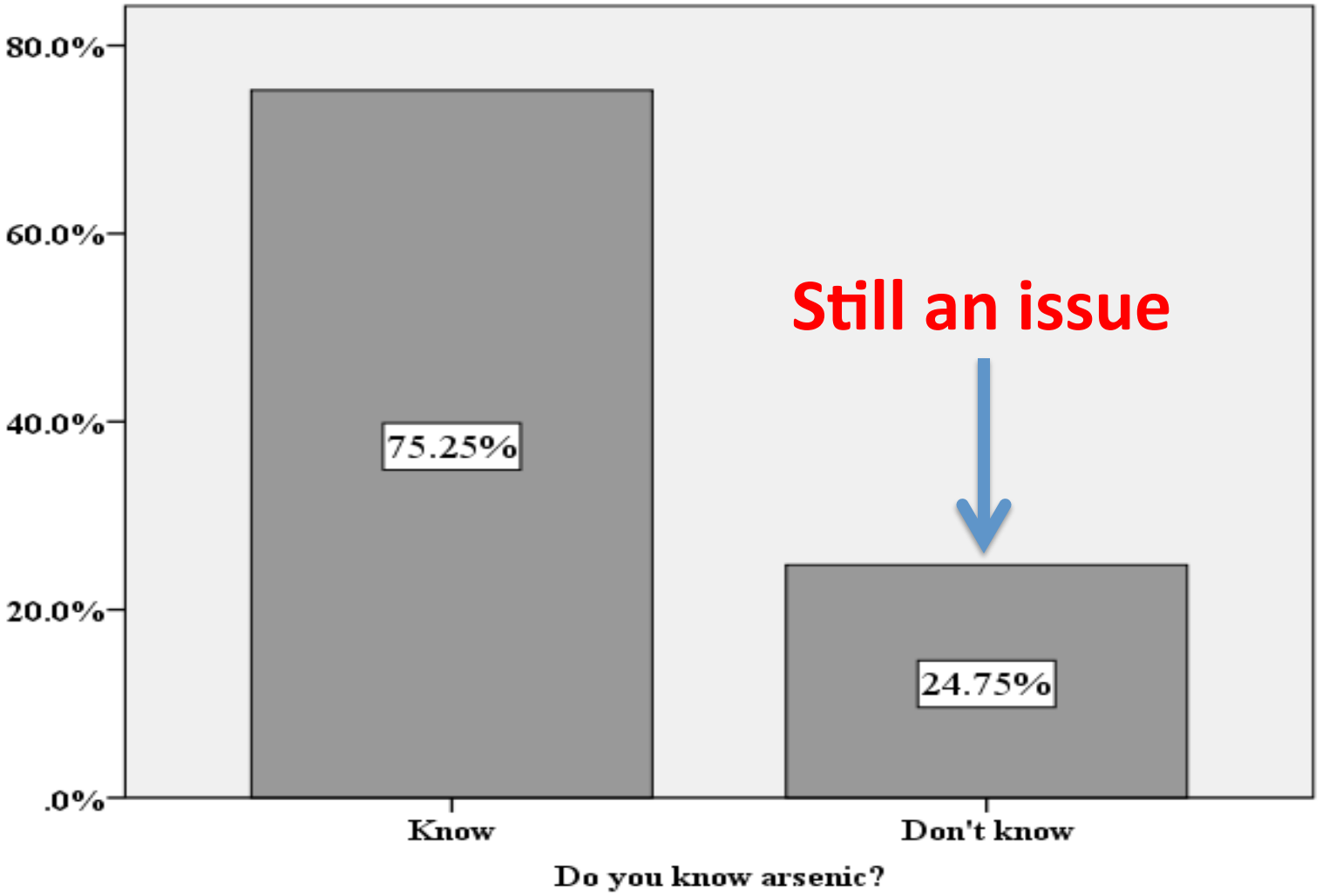
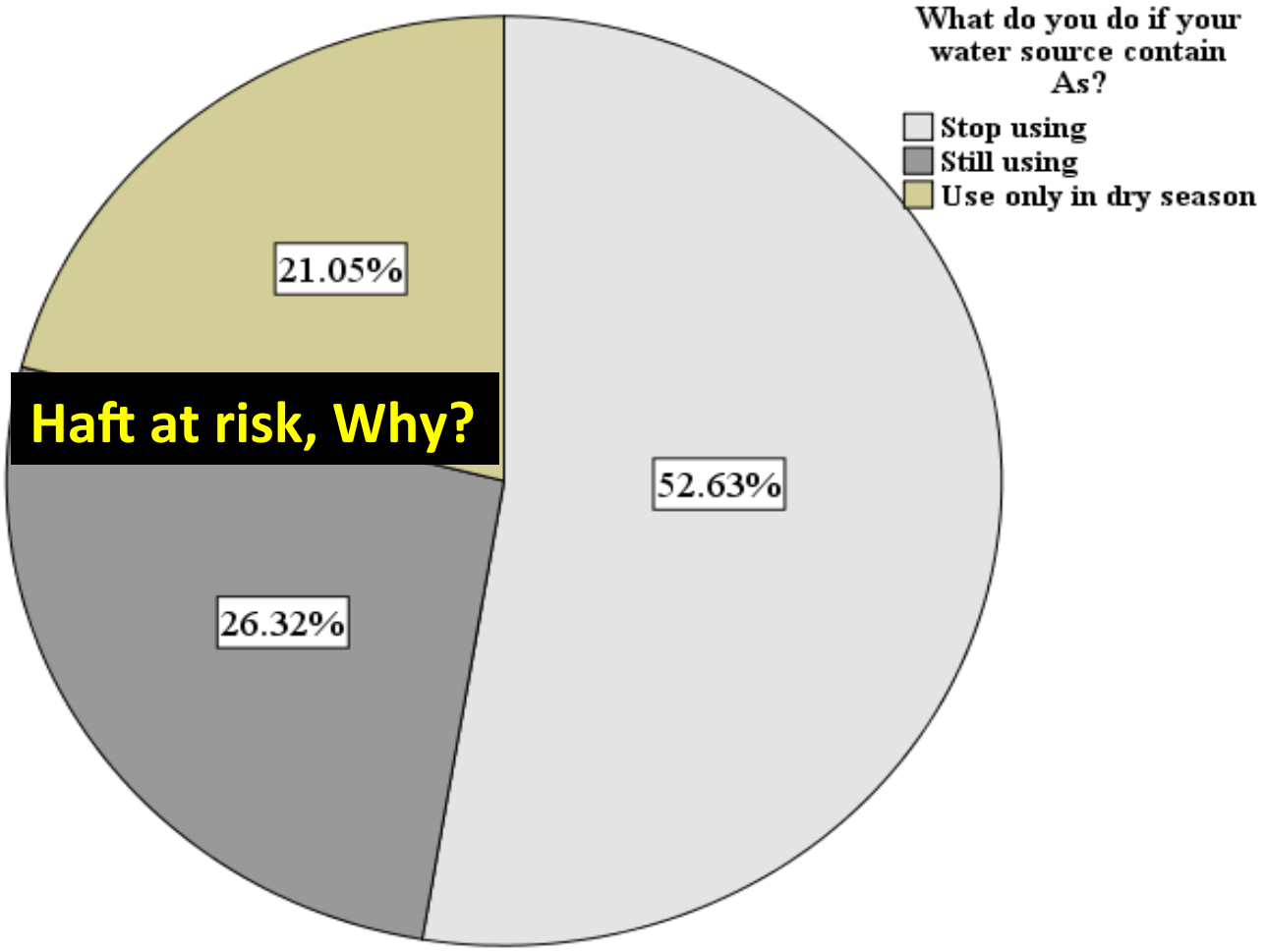
On Site Survey



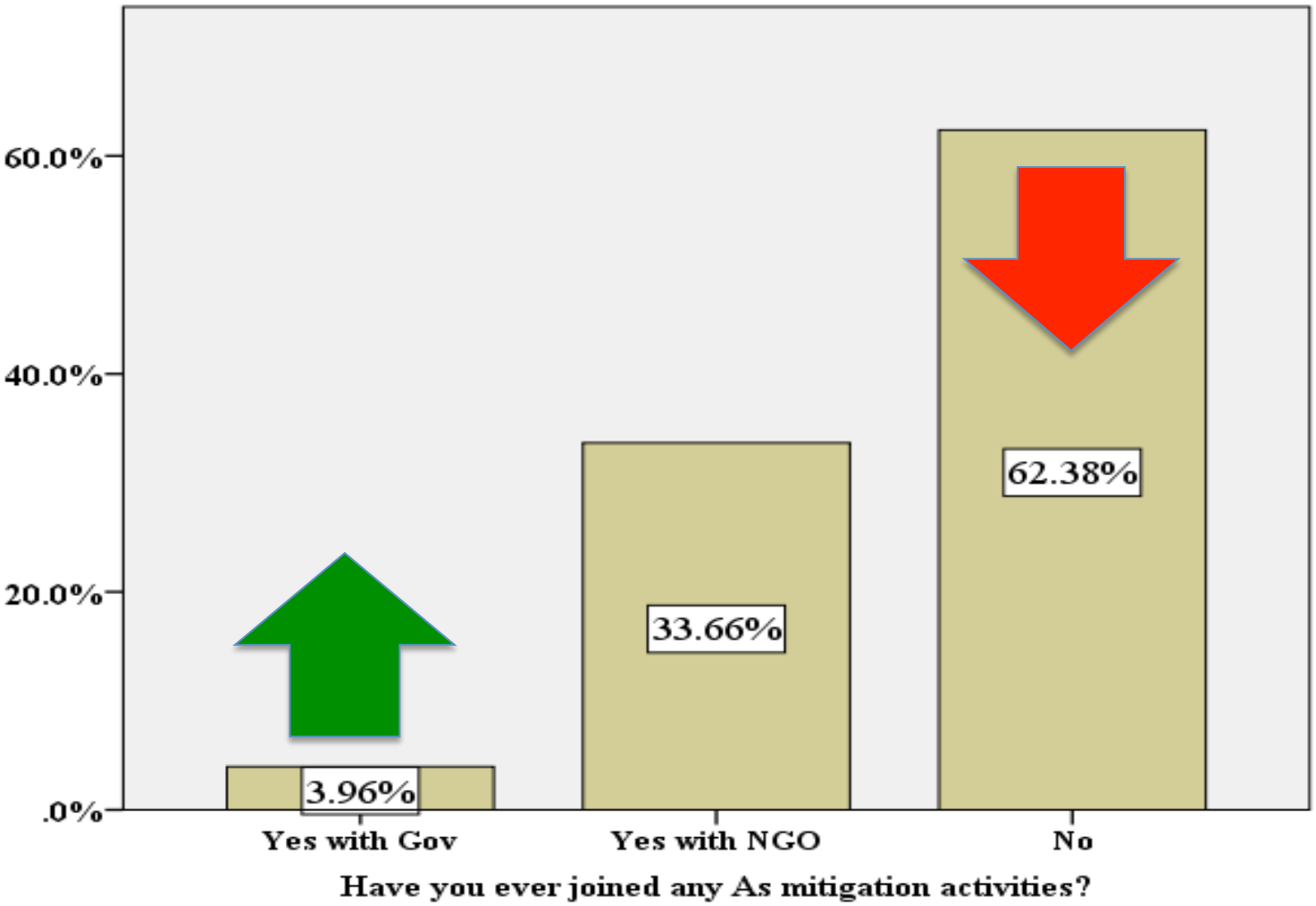
Difference supply of natural water source in Preaek Traeng village



People's awareness on Arsenic in Preaek Traeng village



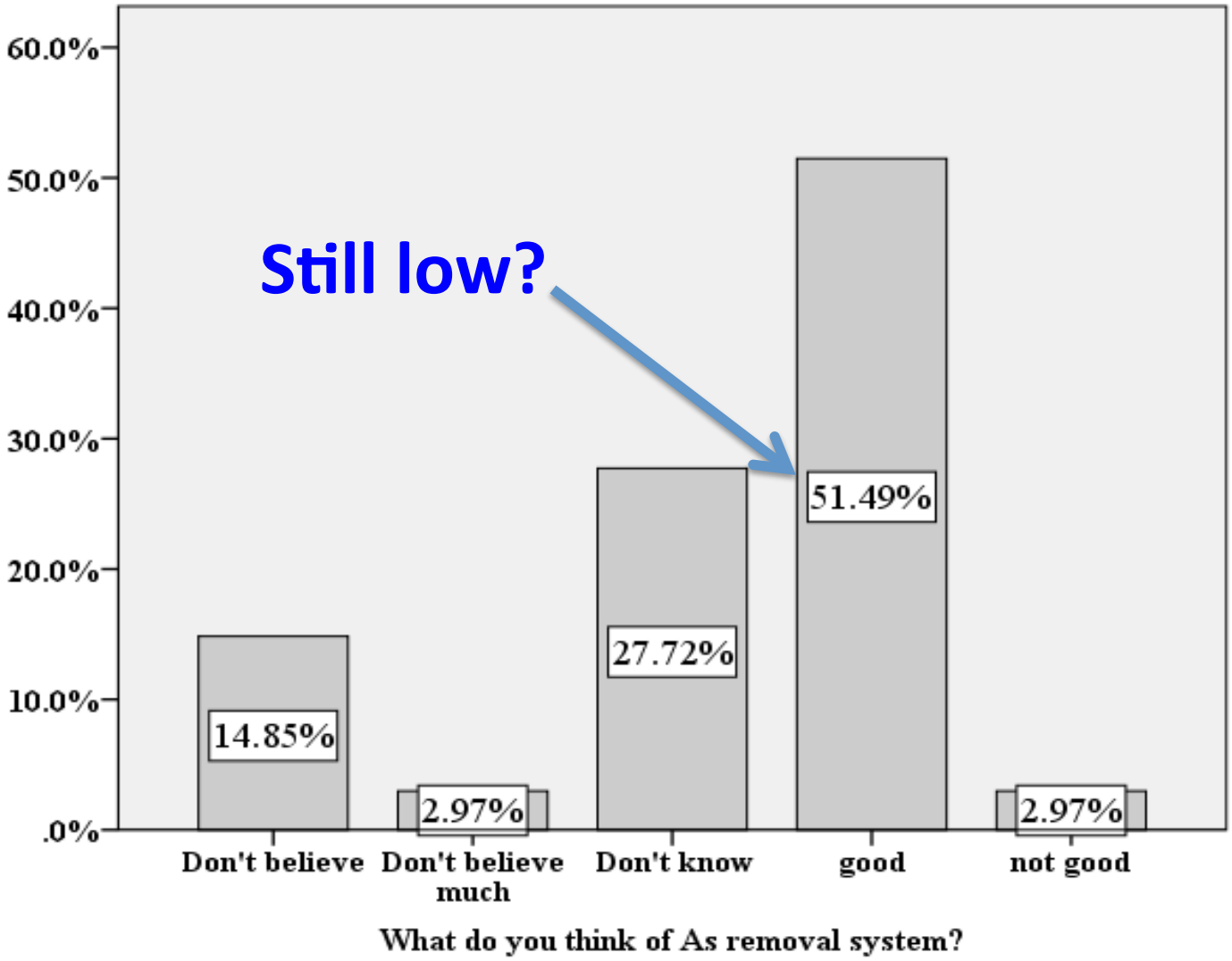
Water usage's decision on arsenic contaminated water



People participation in arsenic mitigation activities

SARSAC

- About 9% of total population in the village used water from that system and (MRD, 2012).
- 64% know SARSAC, but 36% don't know it.
- About 64% believe and 36% don't believe in SARSAC
- This research showed that about 58% used water from SARSAC but 42% don't



People's idea on the SARSAC

CONCLUSION

- Wells and rain water are the main source of their water supply. Thus people are still at risk in As contaminated water
- All shallow tube-wells are polluted while other new deep tube-wells present less Arsenic concentration around 29 ppb down to zero.
- SARSAC plays very important role to provide clean water. However, not all people access the water
- It was also found that people still have limited knowledge about Arsenic in their water and the effects of arsenic on health

RECOMMENDATION

- Private sector, NGOs, government, and relevant stakeholders should put more attention to provide sufficient safe drinking water for the whole community.
- Education on Arsenic should be provided to the residents there to give them more understanding on bad impact from its pollution.
- Similar study should be done also in other area and a national scale study is recommended.
- Stakeholders analysis about Arsenic issue in Cambodia

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Mitigating arsenic crisis in the developing world: Role of robust, reusable and selective hybrid anion exchanger (HAIX)

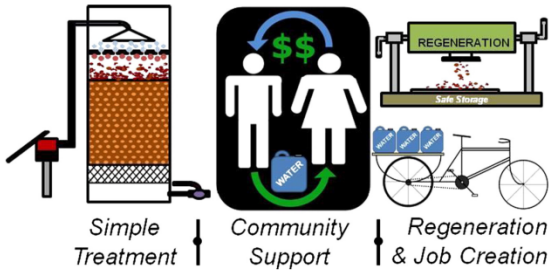
Michael German [a,1], Hul Seingheng [b], Arup K. SenGupta [a,*]

[a] Department of Civil and Environmental Engineering, Lehigh University, 1 W. Packer Ave, Bethlehem, PA 18015, United States
[b] Institute of Technology of Cambodia, PO Box 86, Russian Federation Blvd, Phnom Penh, Cambodia

HIGHLIGHTS

- Durable adsorbent-based systems provide arsenic-safe water for many years.
- Nanoparticle infused polymers are durable and selective trace contaminant adsorbents.
- Hybrid anion exchange resins create a synergy between metal oxide nanoparticles and their polymer support.
- Appropriate design and operation can make water systems profitable in remote and rural locations.

GRAPHICAL ABSTRACT



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ABSTRACT

In trying to address the public health crisis from the lack of potable water, millions of tube wells have been installed across the world. From these tube wells, natural groundwater contamination from arsenic regularly puts at risk the health of over 100 million people in South and Southeast Asia. Although there have been many research projects, awards and publications, appropriate treatment technology has not been matched to ground level realities and water solutions have not scaled to reach millions of people. For thousands of people from Nepal to India to Cambodia, hybrid anion exchange (HAIX) resins have provided arsenic-safe water for up to nine years. Synthesis of HAIX resins has been commercialized and they are now available globally. Robust, reusable and arsenic-selective, HAIX has been in operation in rural communities over numerous cycles of exhaustion–regeneration. All necessary testing and system maintenance is organized by community-level water staff. Removed arsenic is safely stored in a scientifically and environmentally appropriate manner to prevent future hazards to animals or people. Recent installations have shown the profitability of HAIX-based arsenic treatment, with capital payback periods of only two years in ideal locations. With an appropriate implementation model, HAIX-based treatment can rapidly scale and provide arsenic-safe water to at-risk populations.

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Abbreviations: AA, Activated alumina; BESU, Bengal Engineering Science University; BVs, Bed volumes; EBCT, Empty bed contact time; GFH, Granular ferric hydroxide; GFO, Granular ferric oxide; HAIX, Hybrid anion exchange; HFOs, Hydrated ferric oxides; HMOs, Hydrated metal oxides; ITC, Institute of Technology in Cambodia; LAB, Lewis acid–base; NF, Nanofiltration; RO, Reverse osmosis; Rs, Indian rupees (or INR); SARSACs, Sustainable arsenic removal systems for affected communities; TCLP, Toxicity characteristic leaching protocol; TDS, Total dissolved solids; THF, Technology with a Human Face; TSF, Tagore-SenGupta Foundation; USEPA, United States Environmental Protection Agency; WHO, World Health Organization.

* Corresponding author at: 1 W. Packer Ave, Bethlehem, PA 18015, United States. Tel.: +1 610 758 3534.
E-mail address: arup.sengupta@lehigh.edu (A.K. SenGupta).
[1] Currently on Fulbright-Nehru Fellowship in West Bengal, India.

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Transforming the arsenic crisis into an opportunity

● High levels of arsenic in drinking water in south-east Asian countries is having a serious impact on communities' health, but a community-based treatment system offers the potential for delivering safe water through a sustainable business model. **SUDIPTA SARKAR, HUL SEINGHENG, DAVIN UY** and **ARUP SENGUPTA** outline the approach and its ongoing application to countries in the region.

Although unknown 25 years ago, natural arsenic contamination of groundwater has now emerged as a major global crisis, affecting over 50 countries around the world. The adverse health effects are, however, most prevalent in south and south-east Asia where over 200 million people, according to World Health Organization (WHO), are threatened with arsenic-inflicted health impairment (i.e., arsenicosis) caused by drinking contaminated groundwater[1]. The use of groundwater in these regions is favoured because of its easy availability due to natural recharging of the aquifers by significant rainfall, low salinity and absence of microbial contamination.

The arsenic crisis in countries in south-east Asia, namely Cambodia, Laos and Vietnam, surfaced a decade ago in the wake of widespread reports in Bangladesh and eastern India. Although rainwater harvesting offers some relief to relatively affluent villagers during the monsoon period, arsenic-contaminated groundwater remains the only viable source for safe drinking water in hundreds of villages in the Mekong delta. The level of arsenic contamination in Kandal province in Cambodia and neighbouring regions is by far the highest, often exceeding 500µg/l, while the permissible level according to WHO is only 10µg/l. Arsenic does not affect the colour, taste or odour of water. Also, the health impact of arsenic poisoning from drinking water is slow and takes several years before becoming fatal. It is initially seen mostly by changes in the skin through the formation of hard, dark scales, accompanied by lesions (hyperkeratosis) and followed by malignancy in many cases.

Removing arsenic

Following an active collaboration between the Institute of Technology in Cambodia (ITC) and Lehigh University in Pennsylvania in the US, the first SARSAC (Sustainable Arsenic Removal System in Affected Communities) unit was installed in Preak Eng commune in Kandal province, Cambodia, two years ago, and several others quickly followed. The community-based plants are simple to operate and a reusable hybrid arsenic-selective adsorbent is used[2]. Figure 1 shows how the SARSAC unit is consistently removing arsenic from the severely contaminated groundwater.

Water vending is currently being introduced in the affected villages using local transport so that each community-based system can provide safe water to villagers within three kilometres. For economic sustainability, a business model was created where every participating household is required to pay a small amount of tariff (40 US cents per month per family for 20 litres of safe water a day) and all labour is fully or partially compensated using the tariff paid by villagers. Similar community-based systems have shown both economic sustainability and proactive villager participation in eastern India. Figure 2 shows the revenue collected from participating families, which has been increasing over time.

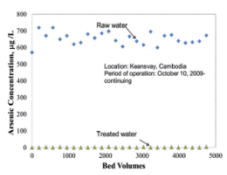

Figure 1 (FAR LEFT): Arsenic levels in raw and treated water in Keansvay, Cambodia.

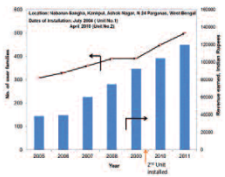

Figure 2: Revenue earned from collection of water tariff at the installation of an arsenic removal unit in Ashoknagar, West Bengal, India.

Implementation of a system in Po Ta Pang site in Kandal province in Cambodia, October 2011.

Conclusion

In the Mekong delta and other regions in south-east Asia, arsenic-contaminated groundwater is the only reliable water resource during the dry season. Household arsenic removal units, although easy to deploy, are economically unsustainable for prolonged use and they pose environmental hazards. In essence, through intervention of appropriate technology and a community-based business model, the arsenic crisis has the potential to be transformed into a business enterprise in remote communities, while also providing safe water. ●

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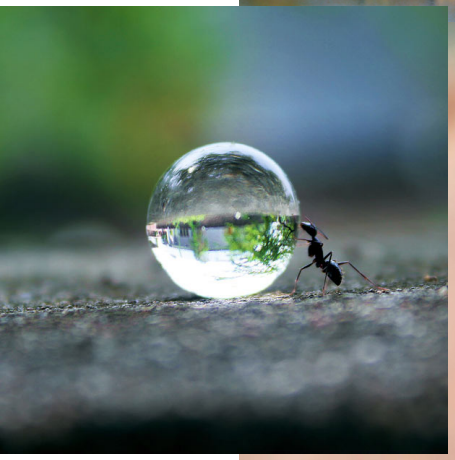
About the authors

Sudipta Sarkar is from the Department of Biotechnology and Environmental Sciences, Thapar University, Patiala, Punjab, India.
Hul Seingheng is from the Department of Food and Chemical Engineering, Institute of Technology of Cambodia, Phnom Penh, Cambodia.
Davin Uy is from the Department of Food and Chemical Engineering, Institute of Technology of Cambodia, Phnom Penh, Cambodia.
Arup SenGupta is from the Department of Civil and Environmental Engineering, Lehigh University, Bethlehem, Pennsylvania, US. Email: aks0@Lehigh.edu

Next …

- 3 more systems are being installed through the support of AUN/Seed-Net JICA with the support from Lehigh University, USA
- 1 system is going to be installed in LAO in collaboration with National University of Lao through the same fund
- Family scale system using RESIN Haix
- Standardize the regeneration system
- Family SARSAC



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ENVIRONMENTAL CHALLENGE

hul@itc.edu.kh