

Ground Water Arsenic Contamination & Its Mitigation

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Arsenic ?

- Arsenic is a metalloid toxic element also called “Secret Poison”
- It is soluble in water and found in nature in rocks, sediments and arsenic rich minerals e.g. arsenopyrite (FeAsS). realgar (As_2S_2); orpiment (As_2S_3); arsenic trioxide (As_2O_3).
- It is generally associated with :
 - Basin full of alluvial deposits
 - Volcanic deposits
 - Uranium and Gold mining
- Anthropogenic activities like :
 - Smelting operations, fossil fuel combustion, wastes from different uses of arsenic chemicals.

Causes of Arsenic Contamination in Groundwater

Not clearly known

- Natural geological changes are presumed to be the primary reason for arsenic contamination
- Three factors are supposed for groundwater arsenic contamination in this region :
 - Arsenic present in the aquifer sediments
 - Arsenic released from the sediments to the groundwater
 - Arsenic flushed away in the natural groundwater circulation

Toxicity of Arsenic

- The total daily intake of Arsenic by the general population is usually less than 0.2 mg/day.
- Exposure to arsenic through ingestion occurs mainly by drinking As contaminated water.
- Levels exceeding maximum permissible limit (0.05 mg/L) in water may lead to health effects.
- WHO standard for Arsenic in drinking water 10 ppb and Nepal, India & Bangladesh – 50 ppb
- Symptoms of Arsenic toxicity can be observed within 2 to 10 years of exposure. However it depends upon the dietary and metabolism factor of individual.

Clinical Feature of Arsenicosis Patient

Pre Clinical Stage

Not detectable by clinical manifestation

Initial Stage

Melanosis, Keratosis, Bronchitis, Gastroenteritis



Clinical Feature (..... Cont)

Second Stage

Depigmentation – rain drop pigmentation,
Hyperkeratosis, Oedma of legs.....



Clinical Feature (..... Cont)

Last Stage

Gangrene, Cancer (skin, bladder and lung)....



History of Arsenic Study in Nepal

- DWSS/WHO, 1999 first tested about 268 samples from eastern Nepal (Jhapa, Morong and Sunsari)
- Indicate the possibility of arsenic contamination in ground water in Nepal.
- Three years Drinking water quality improvement program has been launched by NRCS under technical collaboration with ENPHO in September, 2000
- A National Steering Committee on Arsenic has been established by Government in 1999
- An Interim National Policy on Arsenic has been prepared by Steering Committee on May, 2001.
- Other agencies like DWSS, FINNIDA, and NEWAH, are also starting water testing program in their program area.

Well ID

Location information

Geographic coordinate

Depth of well

Age of well

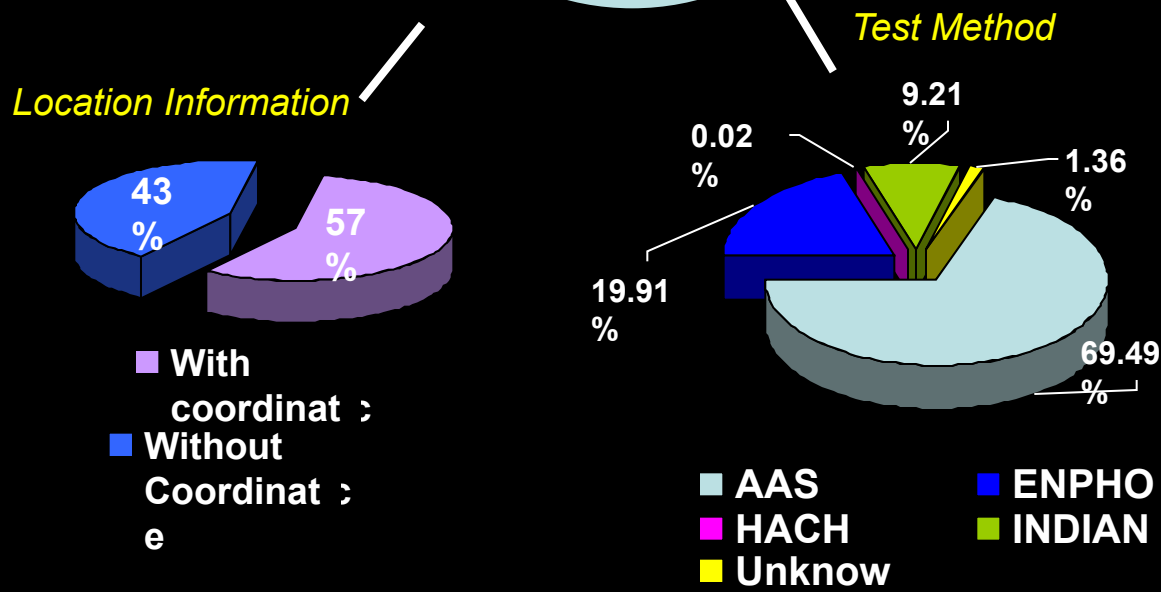
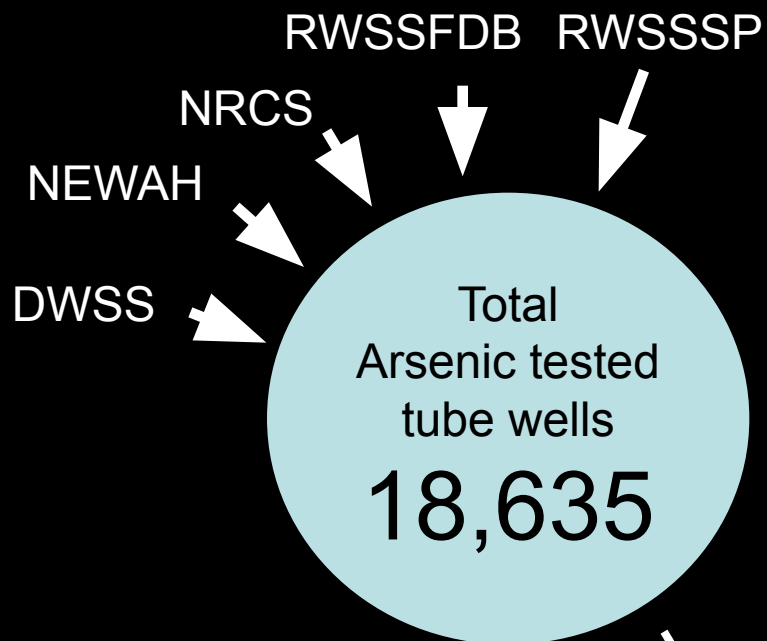
Users information

Arsenic concentration

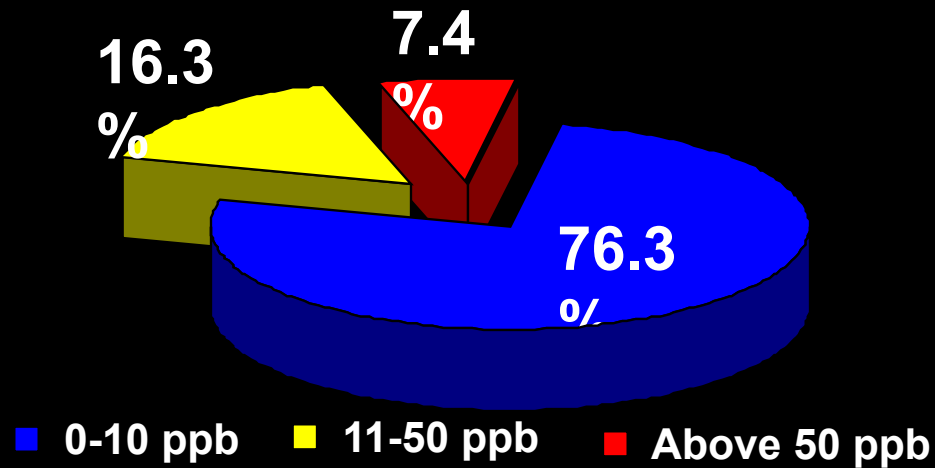
Test method

Microbiological result

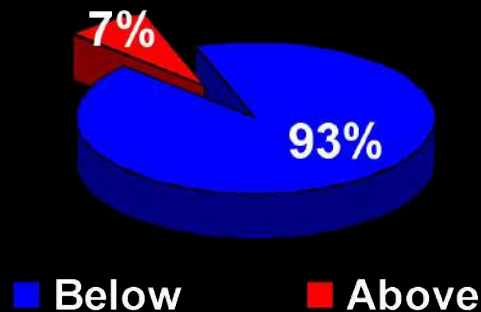
Data Source



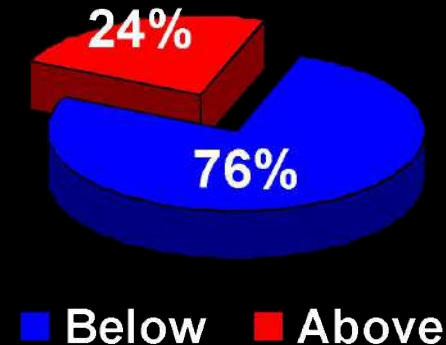
Classification of Arsenic Concentration



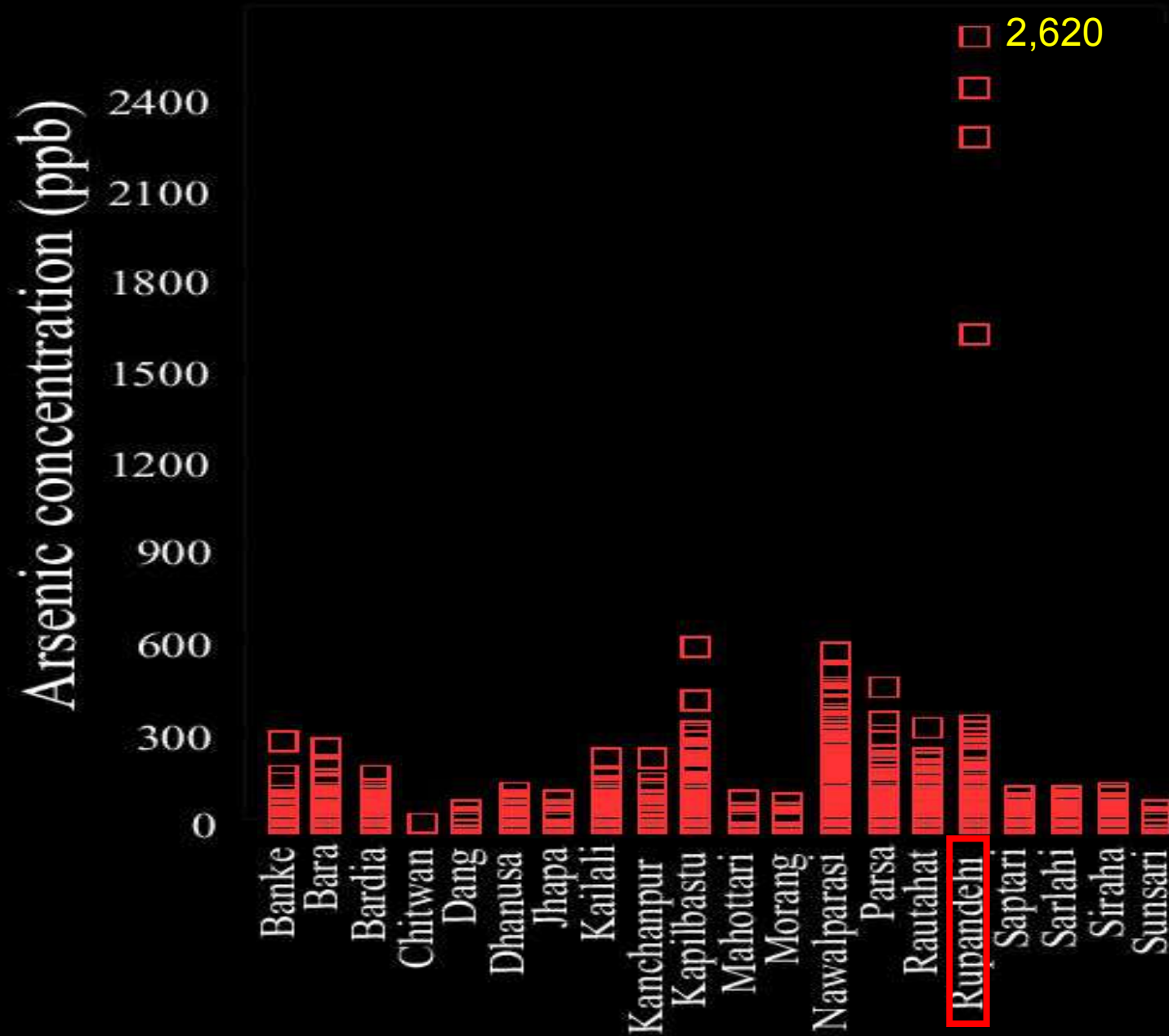
Nepal Interim Standard



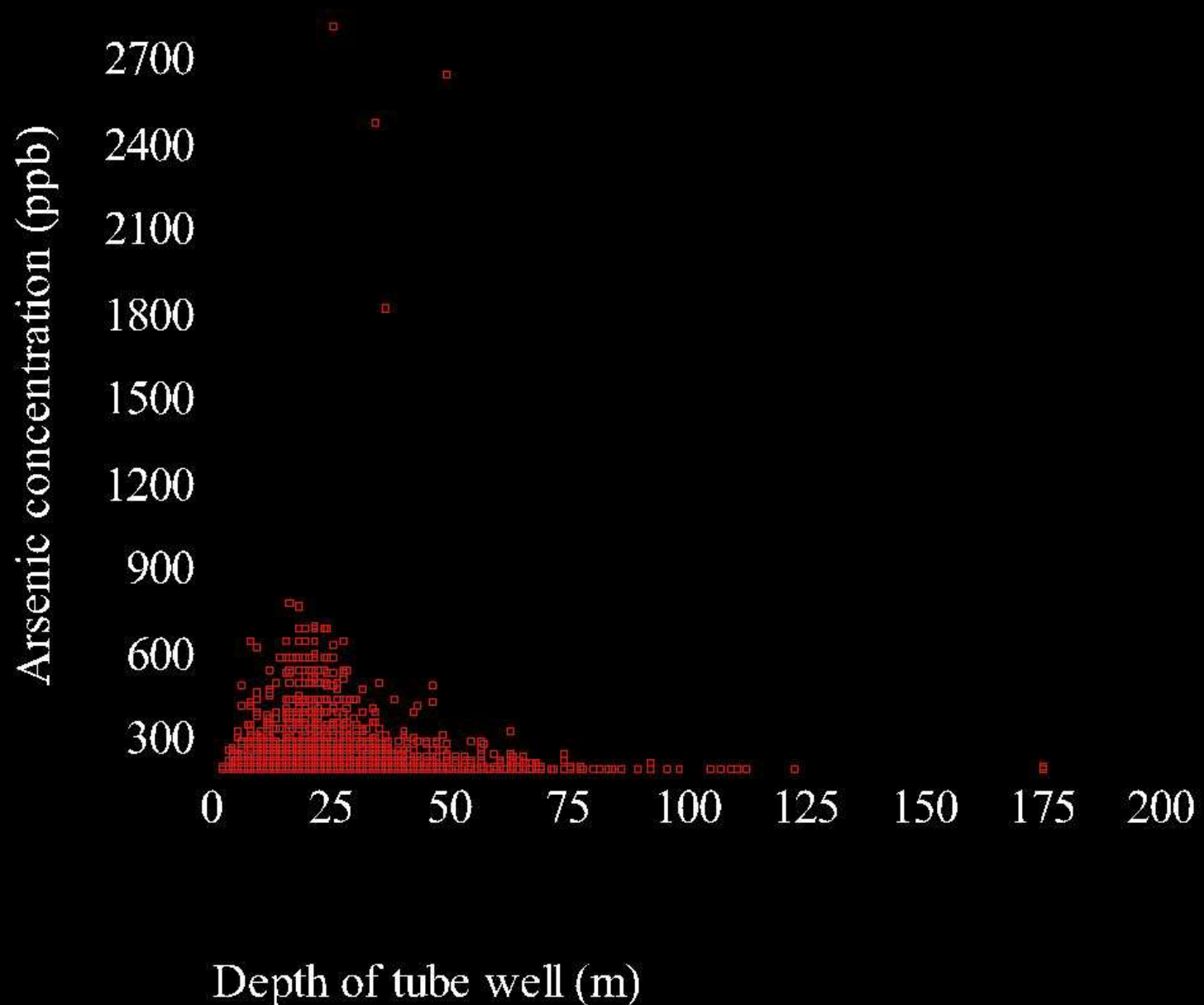
WHO Guideline



Distribution of Arsenic Concentration by District



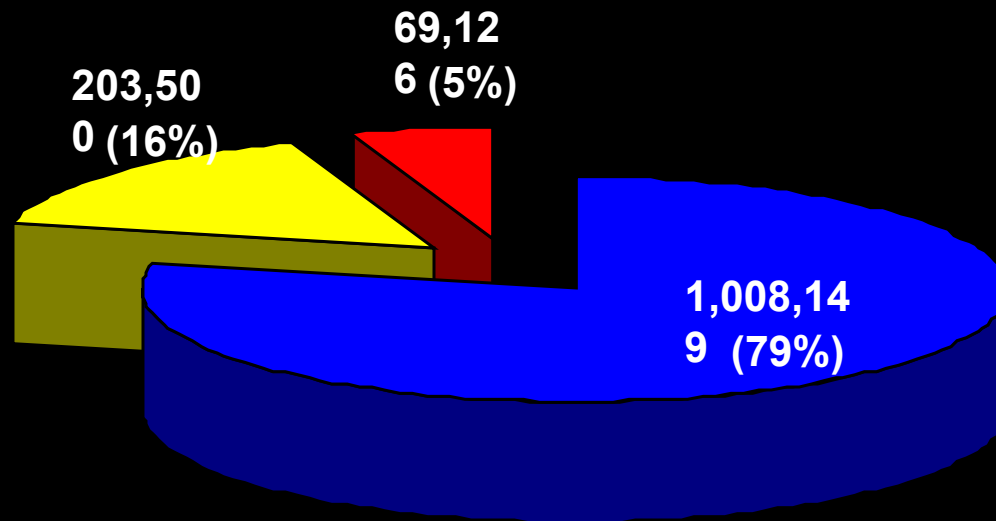
Arsenic Concentration and Depth of Tube Well



Arsenic Exposed Population

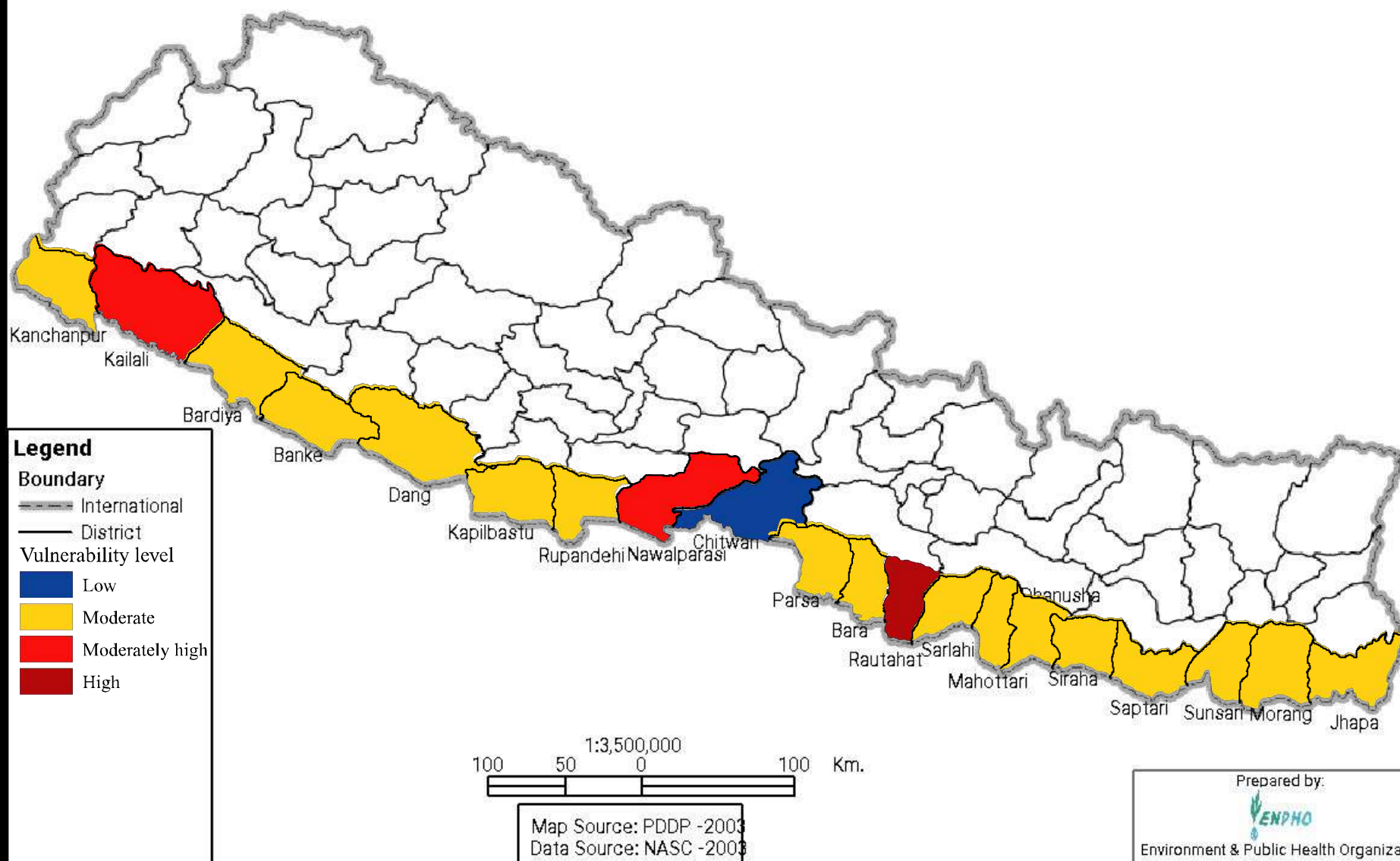
Total Population using Arsenic Tested Tube Wells is

1,280,775

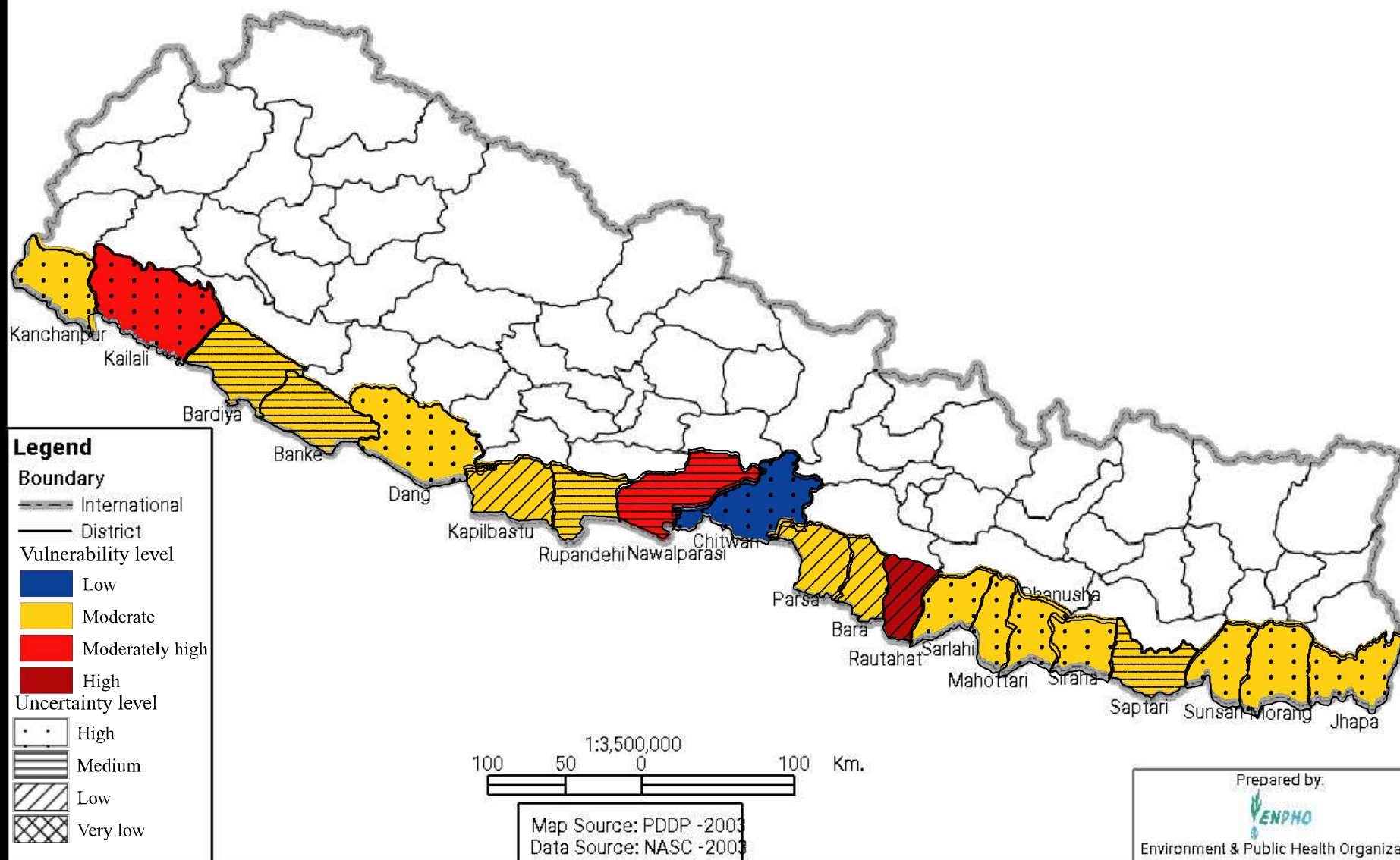


■ 0-10 ppb ■ 11-50 ppb ■ Above 50 ppb

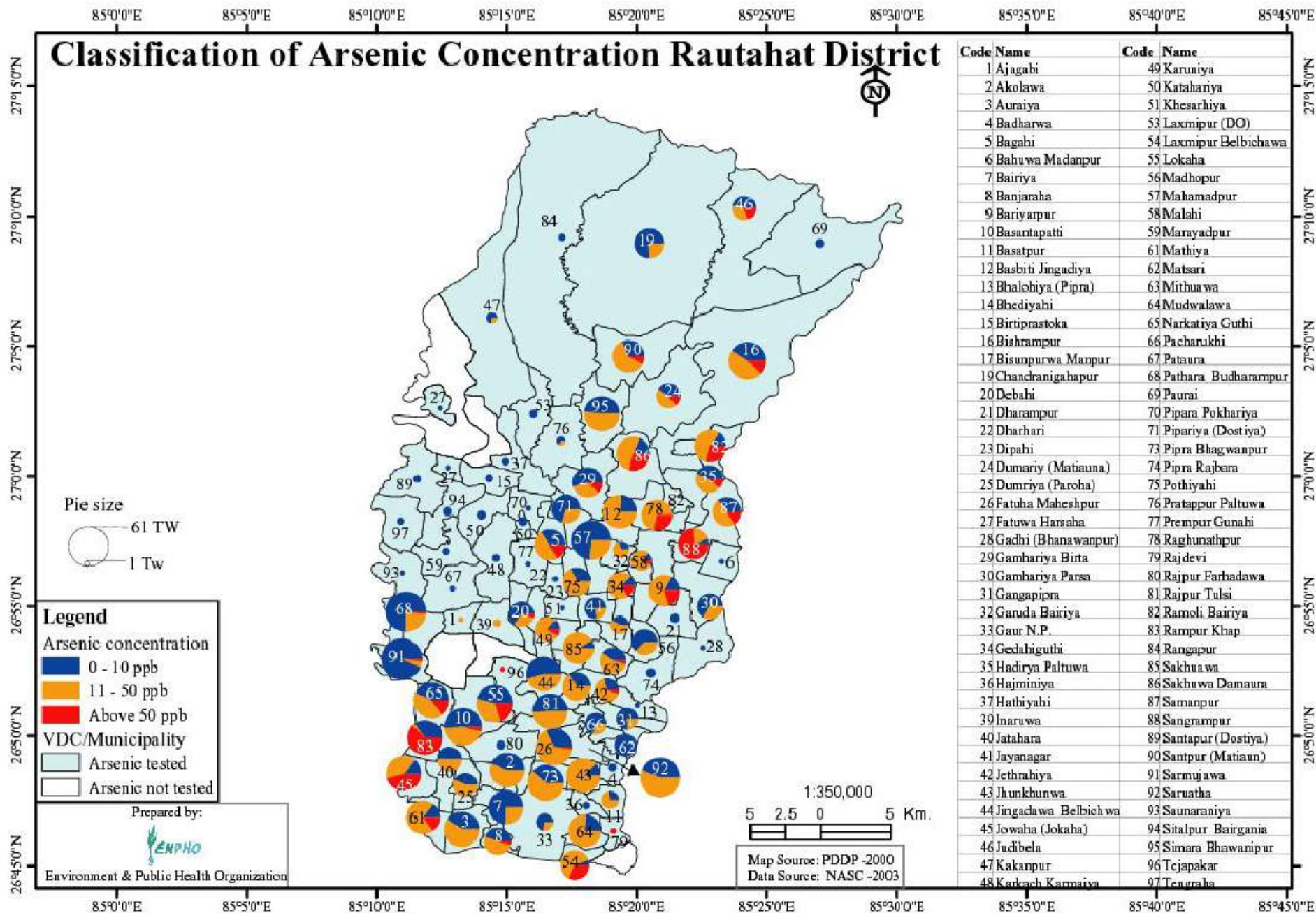
Drinking Water Vulnerability to Arsenic - Terai



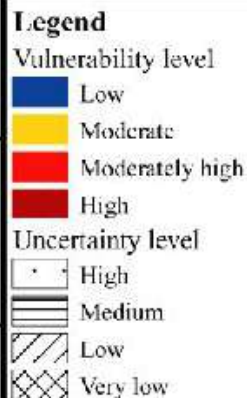
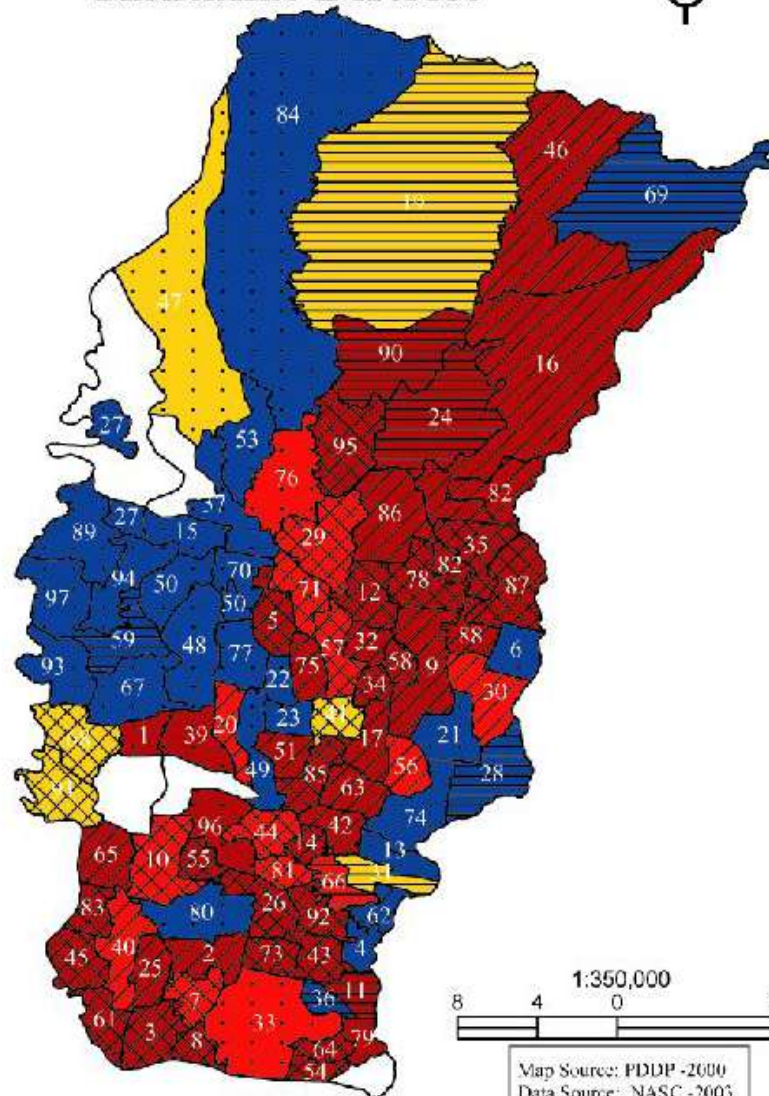
Drinking Water Vulnerability to Arsenic - Terai



Classification of Arsenic Concentration Rautahat District



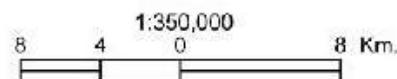
Drinking Water Vulnerability to Arsenic Rautahat District



Prepared by:



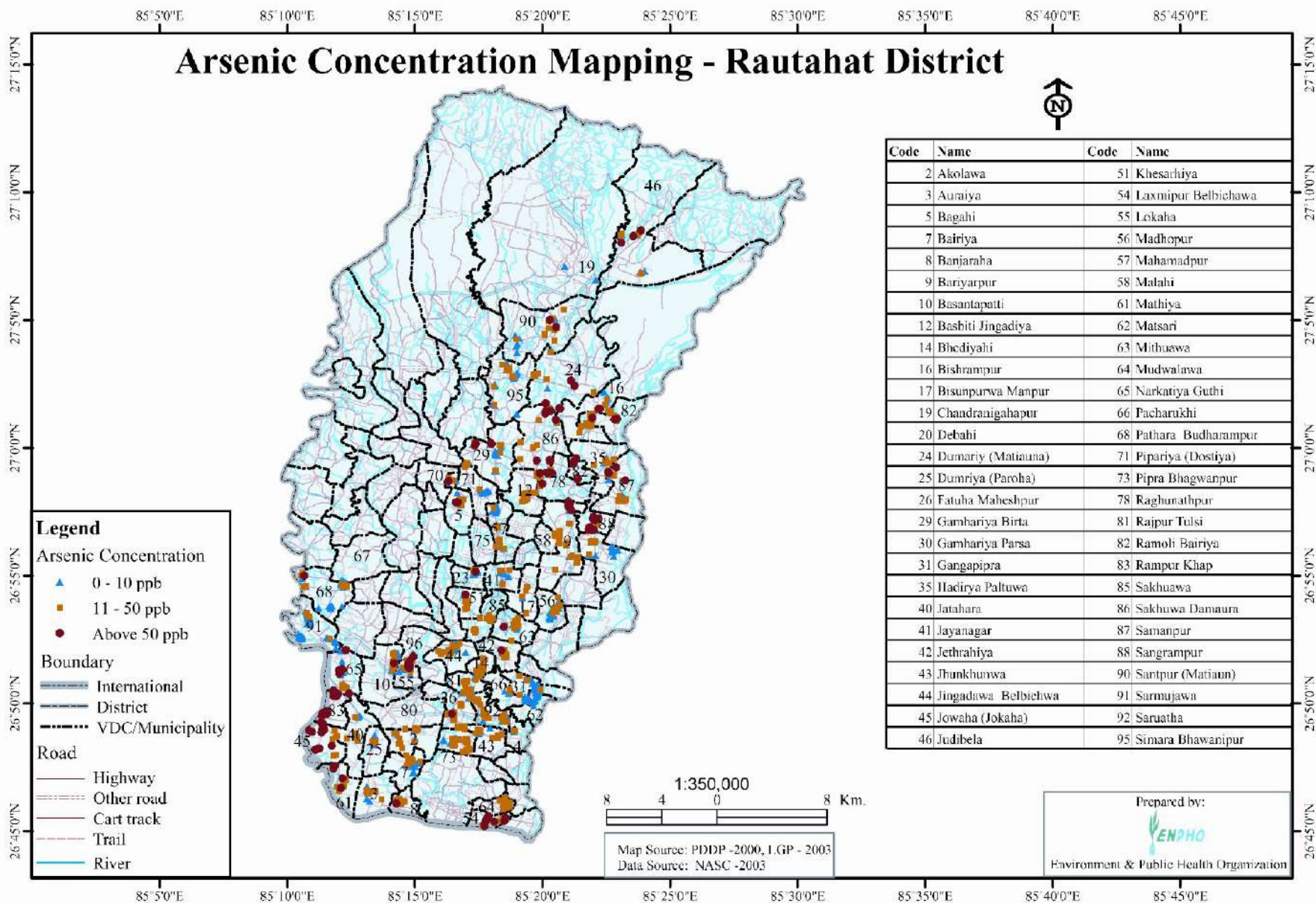
Environment & Public Health Organization



Map Source: PDDP -2000
Data Source: NASC -2005

Code	Name	Code	Name
1	Ajagabi	49	Karuniya
2	Akolawa	50	Katahariya
3	Auniya	51	Khesariya
4	Badharwa	53	Laxmipur (DO)
5	Bagahi	54	Laxmipur Belbichawa
6	Dahurwa Madanpur	55	Lukha
7	Bairiya	56	Madhopur
8	Banaraha	57	Mahamadpur
9	Bunyarpur	58	Mulani
10	Basantapatti	59	Marayadpur
11	Basatpur	61	Madhiya
12	Bashiti Jigadiya	62	Masari
13	Bhalchiya (Pipa)	63	Mithuwa
14	Bhediyahi	64	Mudwalawa
15	Biriprastola	65	Nakatiya Guthi
16	Bishrampur	66	Pacharukhi
17	Bisunpurwa Manpur	67	Patawa
18	Chandranigahapur	68	Pathara Budharampur
20	Debahi	69	Paurai
21	Dharampur	70	Pipara Pokhariya
22	Dharhari	71	Pipariya (Dostiya)
23	Dipali	73	Pipra Bhagwanpur
24	Dumariy (Matiaura)	74	Pipra Rajbara
25	Dumriya (Paroha)	75	Potayahi
26	Fatua Maheshpur	76	Pratappur Paltawa
27	Fatua Harsaha	77	Prempur Gunahi
28	Gadhi (Bhanawanpur)	78	Raghunathpur
29	Gandhariya Birta	79	Rajdevi
30	Gandhariya Parsa	80	Rajpur Pachadawa
31	Gangapur	81	Rajpur Tulsi
32	Garuda Bairiya	82	Ramoli Bariya
33	Gaur N.P.	83	Rampur Khap
34	Gedahiguthi	84	Rangapur
35	Hadiya Paltawa	85	Sakhuwa
36	Hajiriniya	86	Sakhuwa Damaura
37	Hatuyahi	87	Samaipur
38	Inaruwa	88	Sangrampur
40	Jatahara	89	Santapur (Dostiya)
41	Jayanagar	90	Sampur (Matiaur)
42	Jethrahiya	91	Sarmuwa
43	Thunkhunwa	92	Saruatha
44	Jigadawa Belbichwa	93	Sauaraniya
45	Jowaha (Joxaha)	94	Sitalpur Baigania
46	Judibela	95	Simara Bhawanipur
47	Kakanpur	96	Tajapasar
48	Karkach Karnaiva	97	Teneraha

Arsenic Concentration Mapping - Rautahat District



10 Hotspots VDC / Municipalities

<u>Ramgram Municipality</u> (445)			Nawalparasi
Manari	VDC	(69)	Nawalparasi
Swathi	VDC	(68)	Nawalparasi
Tilakpur	VDC	(62)	Nawalparasi
Sunwal	VDC	(46)	Nawalparasi
Mahendrakot VDC (38)			Kapilbastu
Jahada	VDC	(31)	Nawalparasi
Rampur Khap VDC (28)			Rautahat
Devadaha VDC (28)			Rupandehi
Sangrampur VDC (26)			Rautahat

Health Impact Study in the Arsenic affected Areas of Nepal



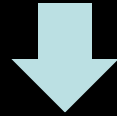
Dr. Mathura Prasad Shrestha

Senior Health Advisor

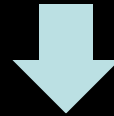
(Drinking Water Quality Improvement Program- NRCS/ENPHO)

Methodology used for Health survey

Tube wells with arsenic contamination > 50 ppb were selected for Health survey



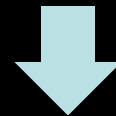
Information on the recipients were taken with the help of structured questionnaires



Trained Health workers who conducted the survey also observed the population and collected hair/nail samples of the symptomatic persons



- Hair/nail samples were brought to ENPHO lab for analysis



- Final confirmation of the symptomatic patients were done by Medical doctor/Senior Health Adviser . In addition these patients were again confirmed by Doctors from Bangladesh: Dr, Rumi(NGO- Forum Bangladesh and Dr Akhtar, NIPSOM

Number of VDCs in the study

Findings

Health Survey Results

Health Survey was done by NRCS, DWSS and FINNIDA in its project areas

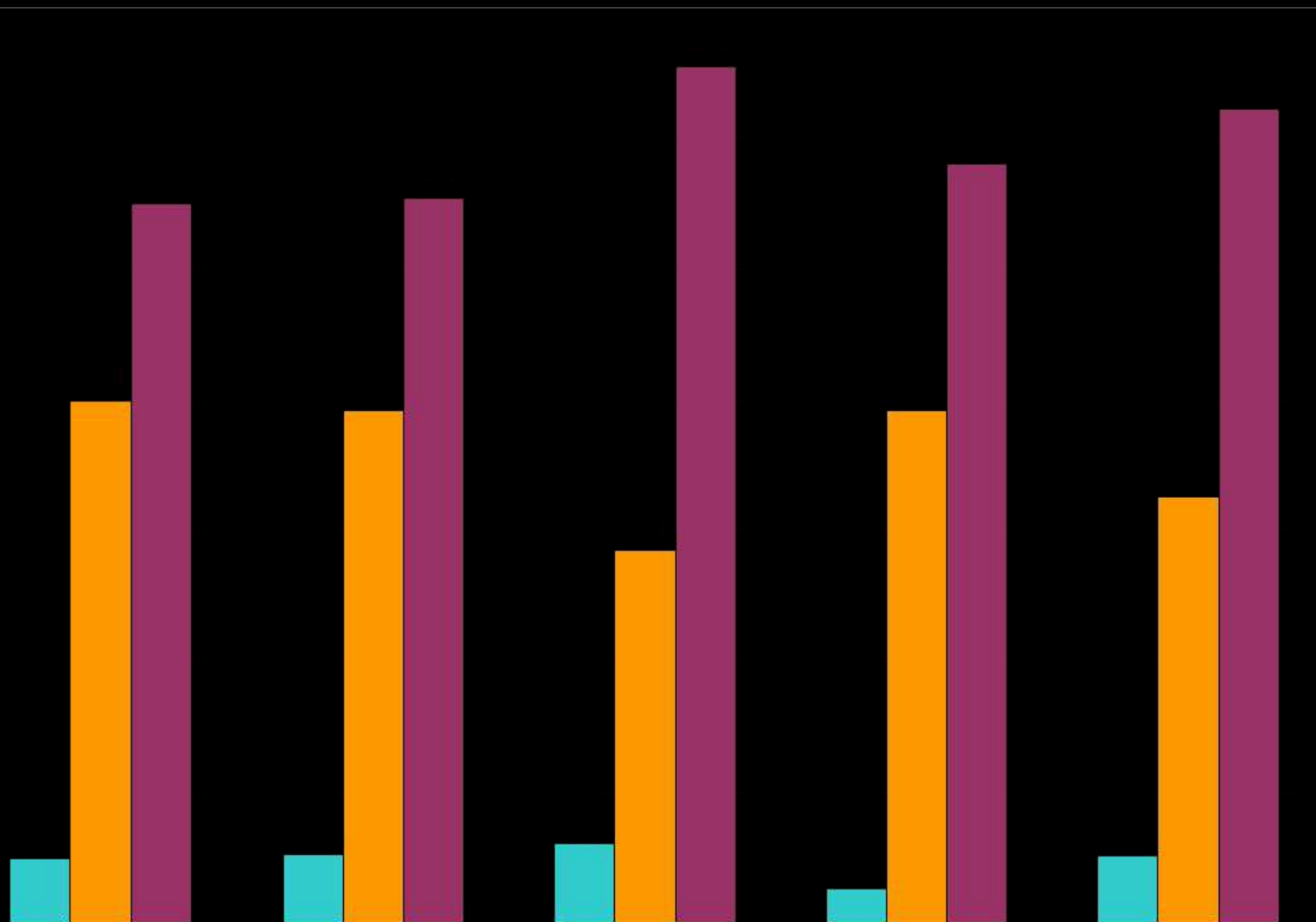
Note: Tube wells that had arsenic $>50\text{ppb}$ were only considered for the study. Thus the entire population is not covered or population consuming from particular tube well is only covered

Arsenicosis symptomatic cases outside survey area in Nawalparasi district

- 17005 individuals observed – 3.1 % prevalence of arsenicosis.
- Prevalence tends to increase by age
- Prevalence rate is higher in the age group 50 and over.
- Prevalence rate higher in Male than Female
- Most of the symptomatic patient show early stages of arsenicosis symptoms like melanosis and keratosis
- However, serious arsenicosis patient also reported in non study area

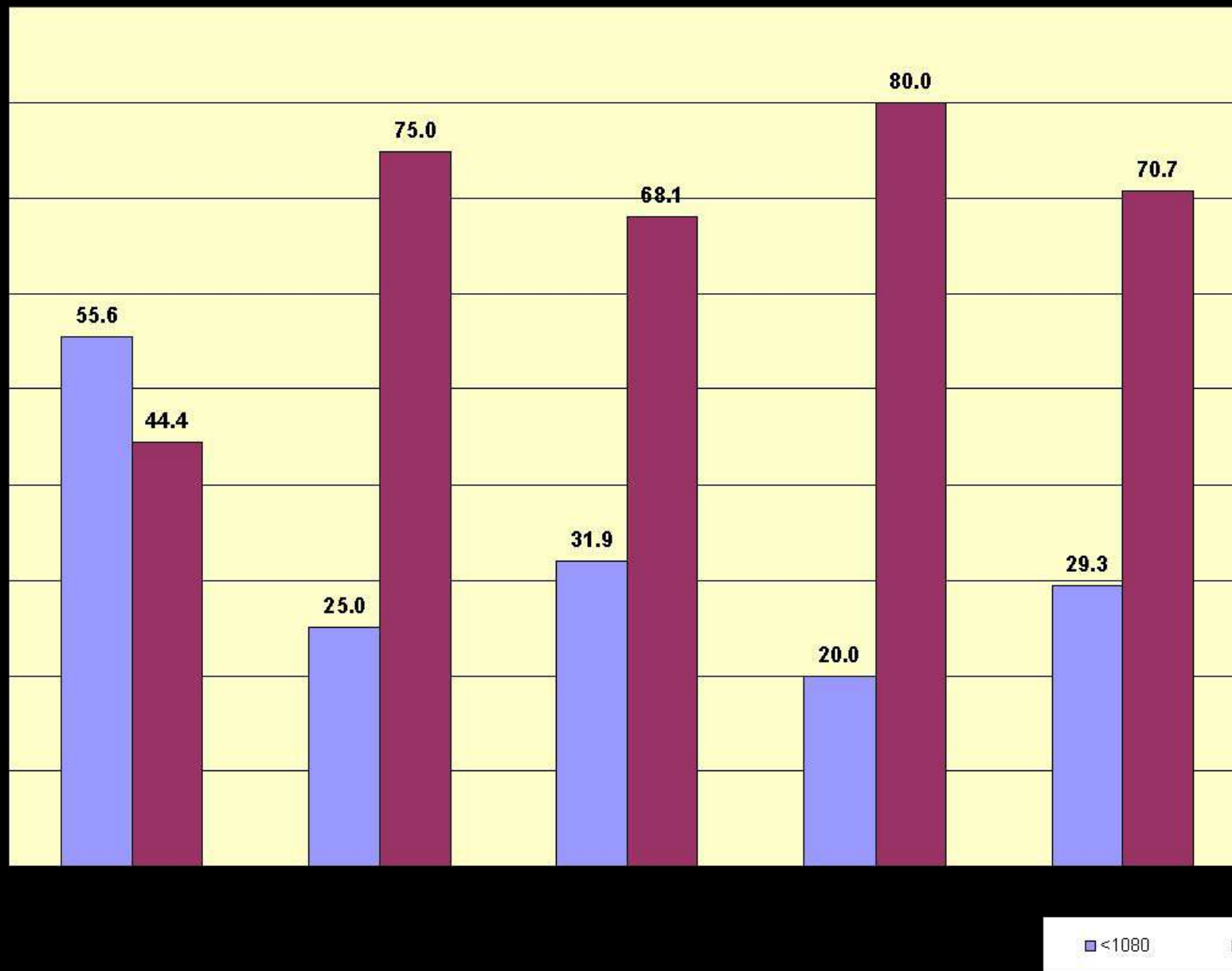
*Result of Hair and Nail test in the
Suspected Persons*

Percent Distribution of Hair Samples by Arsenic Content



80-250 >250-1000 >1000

Percent Distribution of Nail samples by Arsenic Content

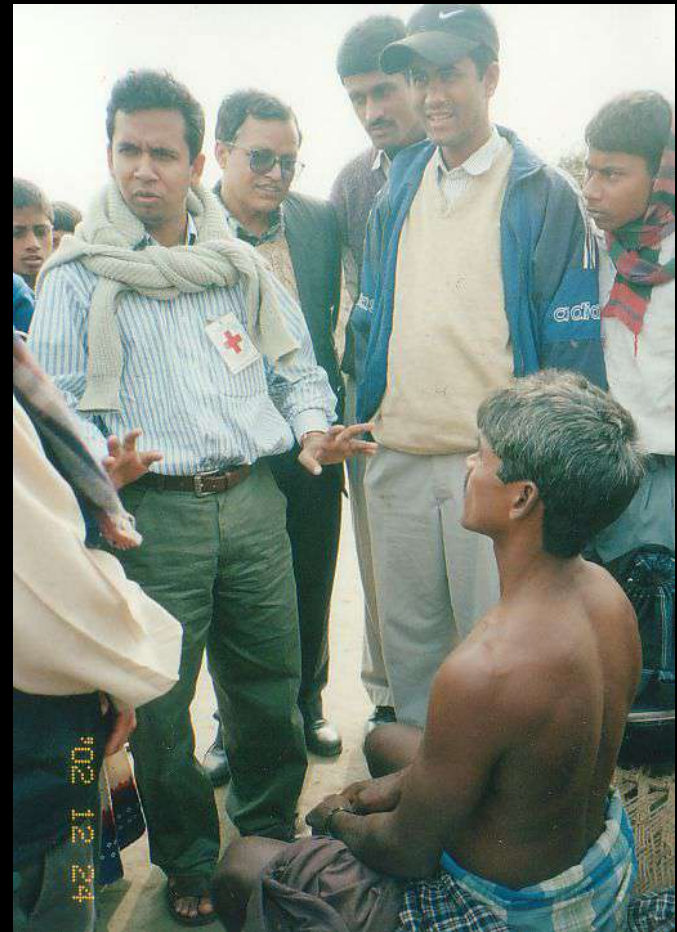


Pictures





Medical Doctor from Bangladesh confirming the suspected patients in Nawalparasi





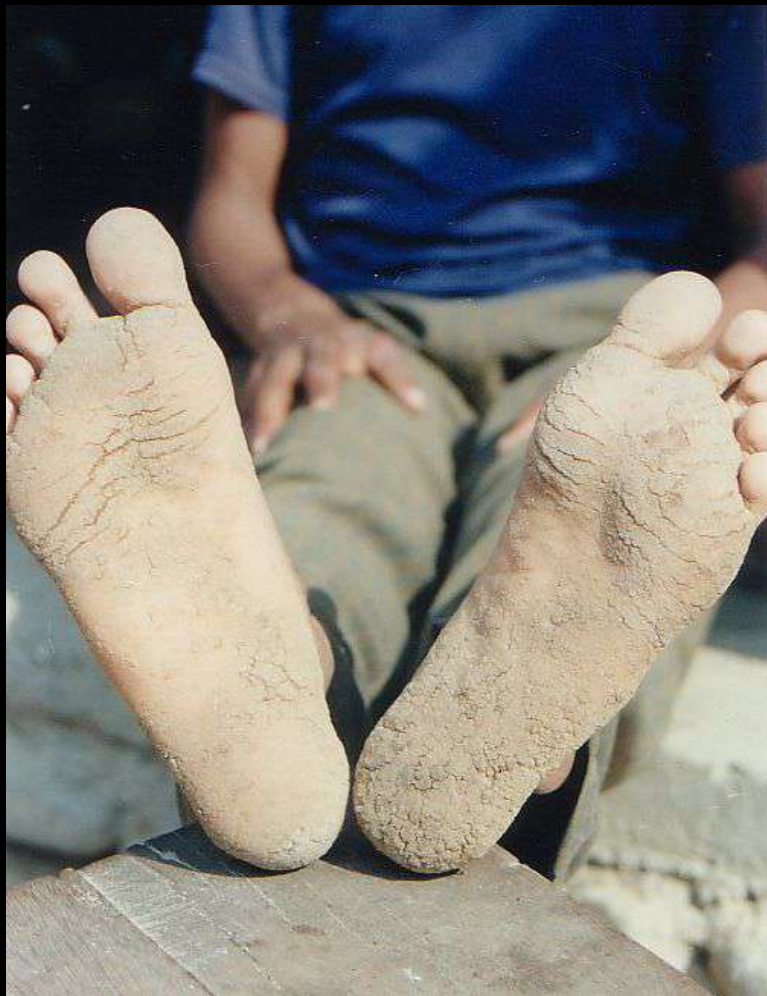
Person with Melanosis
found in Parsa District





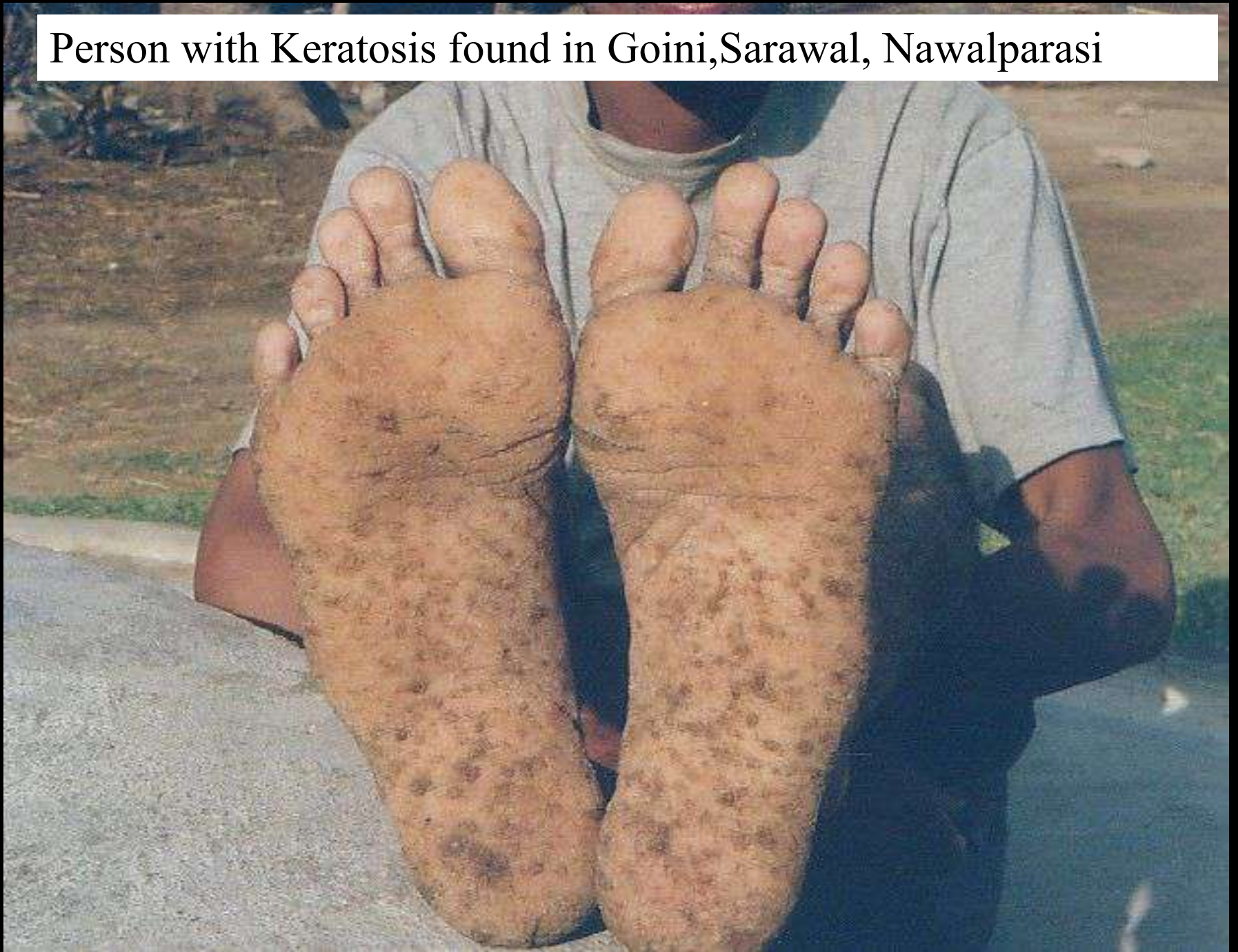
Person with initial
stage of Keratosis
found in Parsa
District





Cases found outside the surveyed areas

Person with Keratosis found in Goini, Sarawal, Nawalparasi



Keratosis in sole, Goini



02 12 24



Keratosis in palm, Goini

Keratosis in palm, Goini





Keratosis in sole, Goini



Keratosis in palm and
sole, Goini



Health Worker giving consultation to affected household

Mitigation Program

297

110

110

297

297

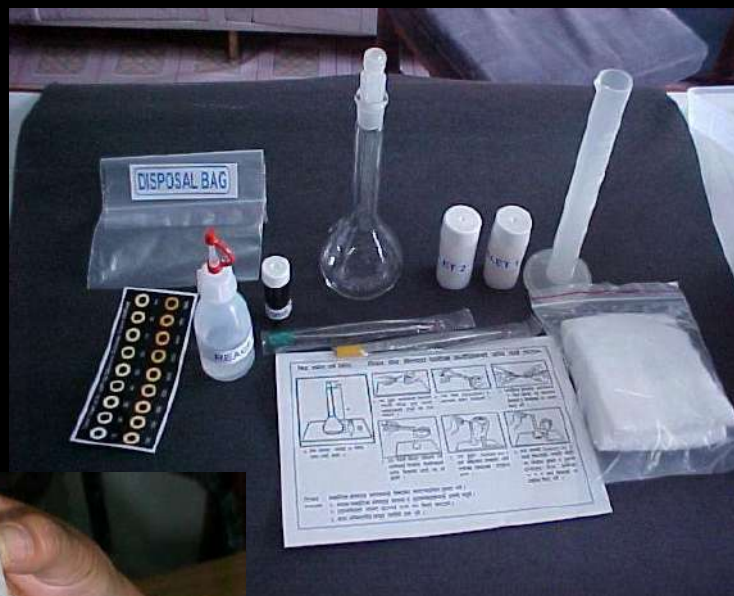
110

297

110



Arsenic Test Kit

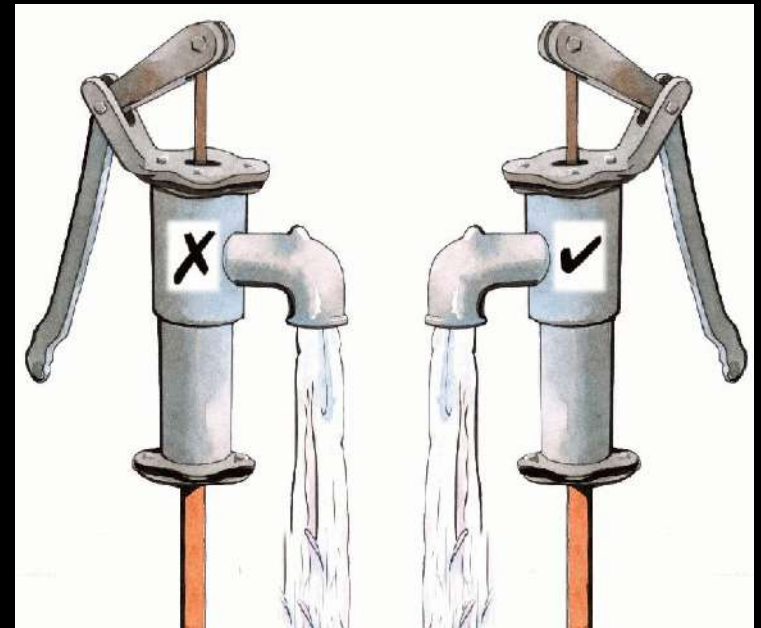


Alternative Options

Search for other alternative Water Sources

- Safe Tube well around the area in different water depth
- Dug wells and other sources and its improvement
- Possibilities of Gravity flow Water Supply
- Coordination with different Water Supply Agencies
- Rainwater Harvesting

Marking Tube-well



Dugwell as alternative option







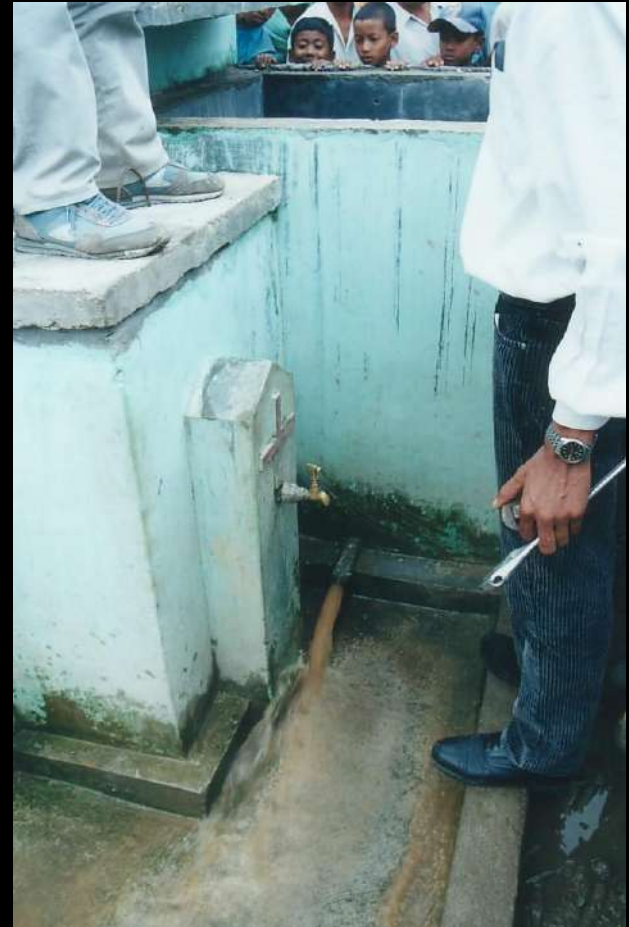
AIRP



Community level Arsenic Removal Treatment Plant under construction (Nawalparasi)

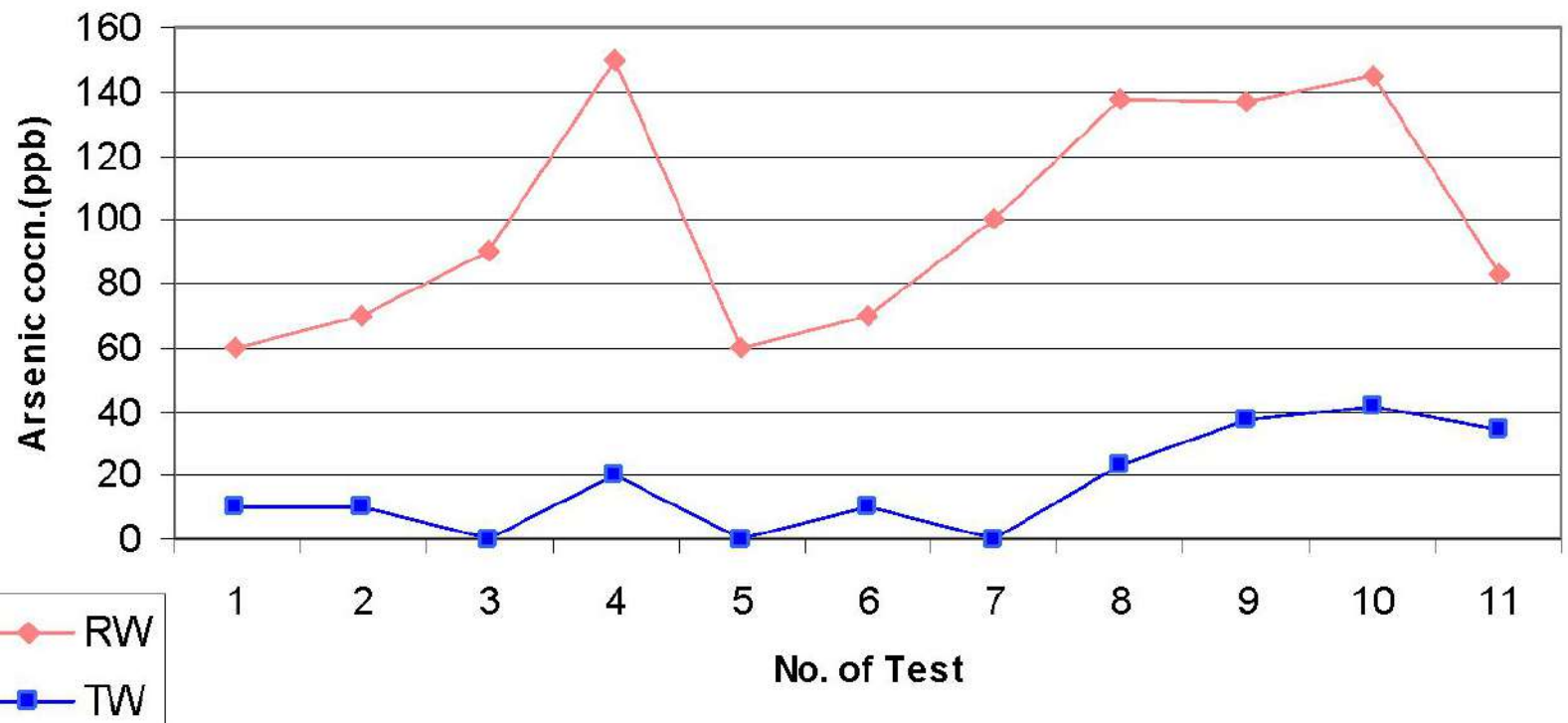


Arsenic- Iron Removal Plant in Badera VDC in Nawalparasi



Sludge Removal from Filter

Efficiency of AIRP



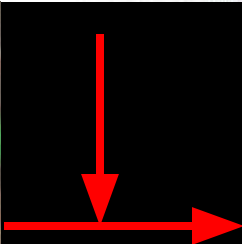
Household Arsenic Removal Filters

ENPHO Two Gagri Filter



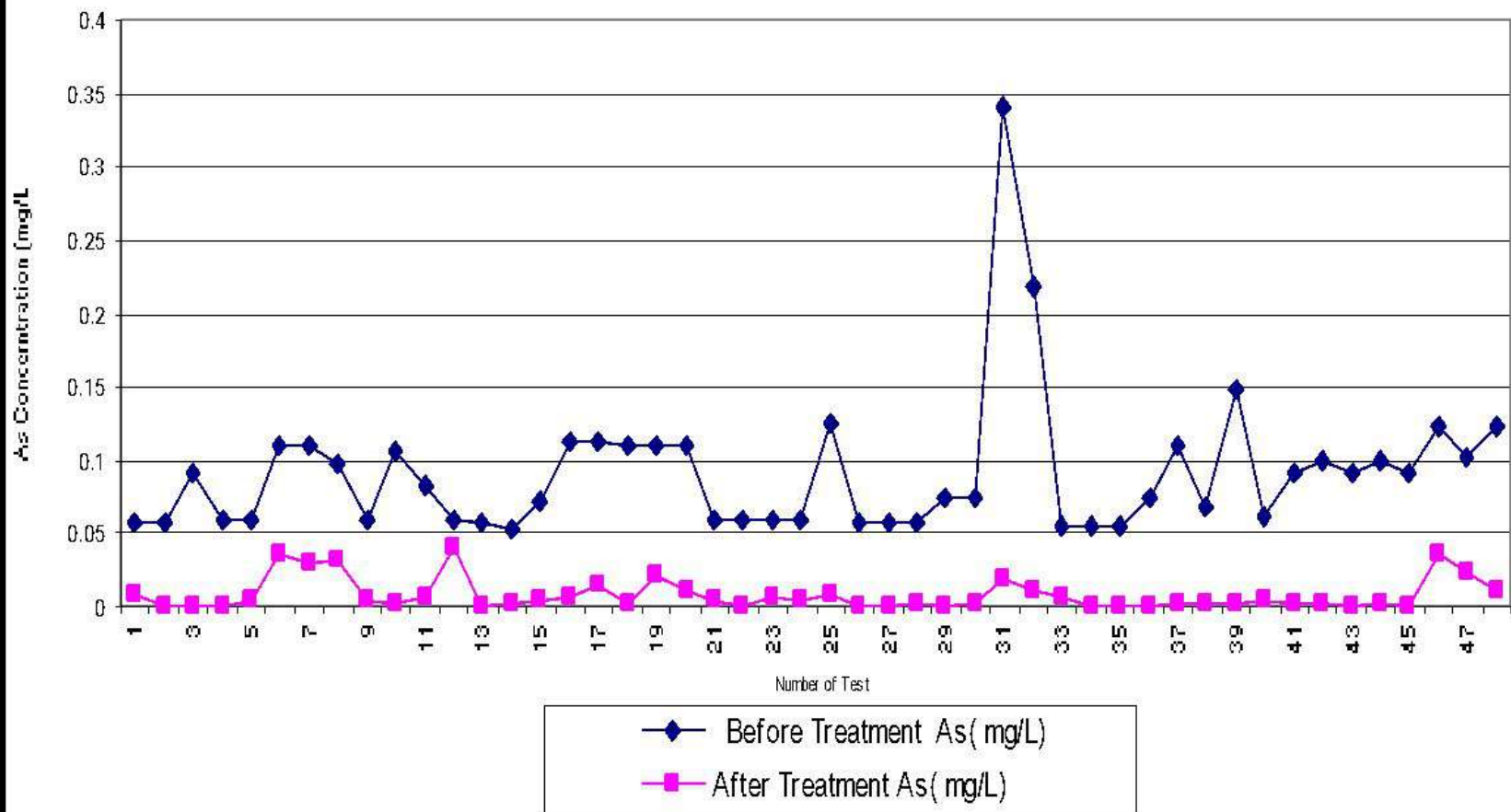
Chemical packet contains:

- Ferric chloride (coagulant)
- Sodium hypochlorite (oxidant)
- Charcoal (adsorbent)

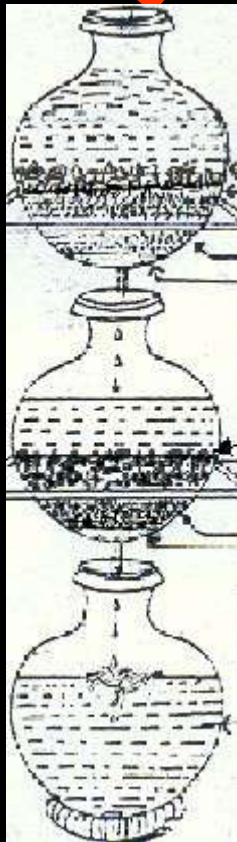




**Graph.1.Arsenic Removal Efficiency of Arsenic Removal Powder
Produced by ENPHO**



Three-Gagri System



Brick chips
1.0 kg,
iron nail
2.5 kg and
coarse
sand 2 kg

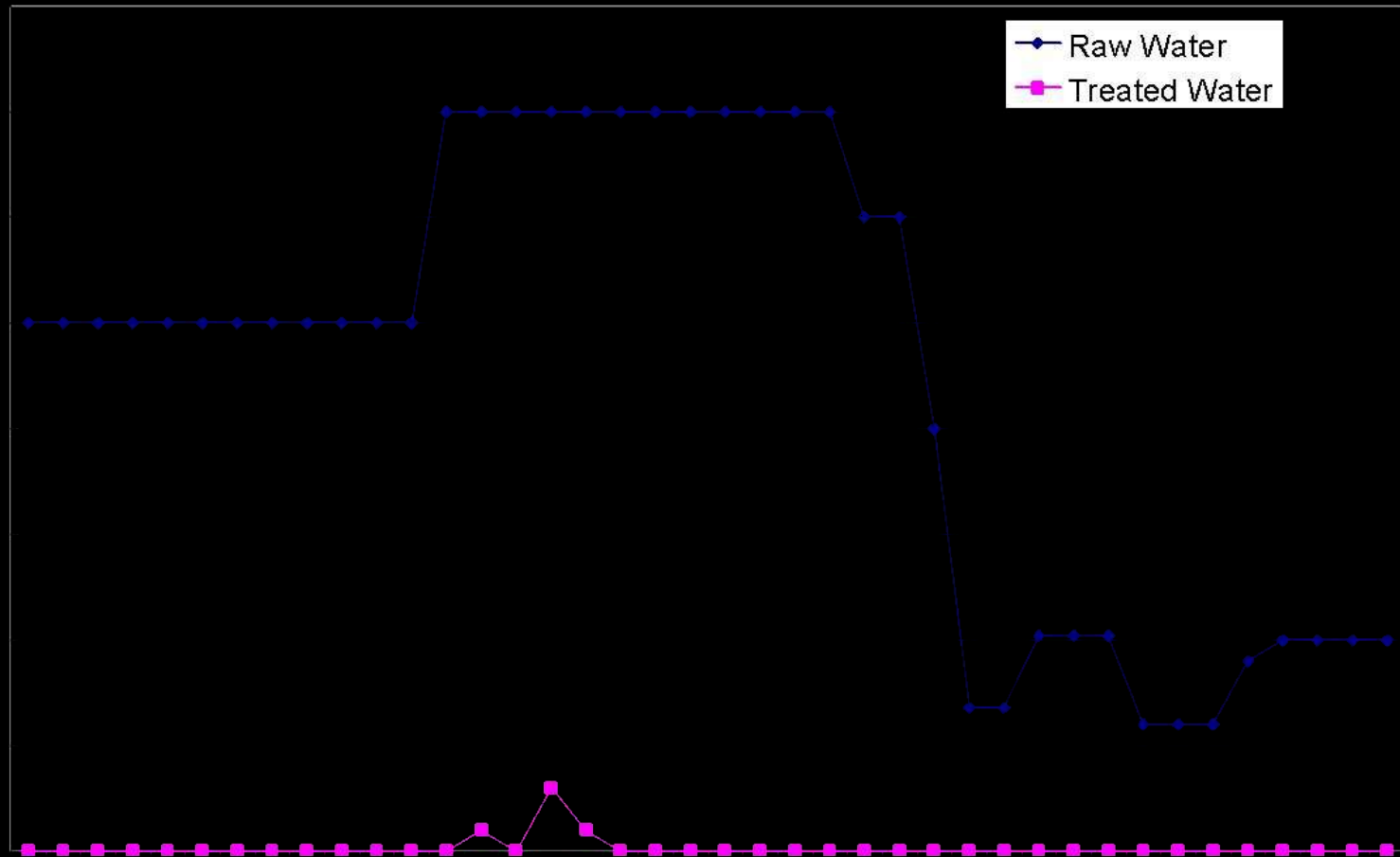
Brick chips
1kg
charcol 1
kg & Fine
sand 2kg

Clean
water



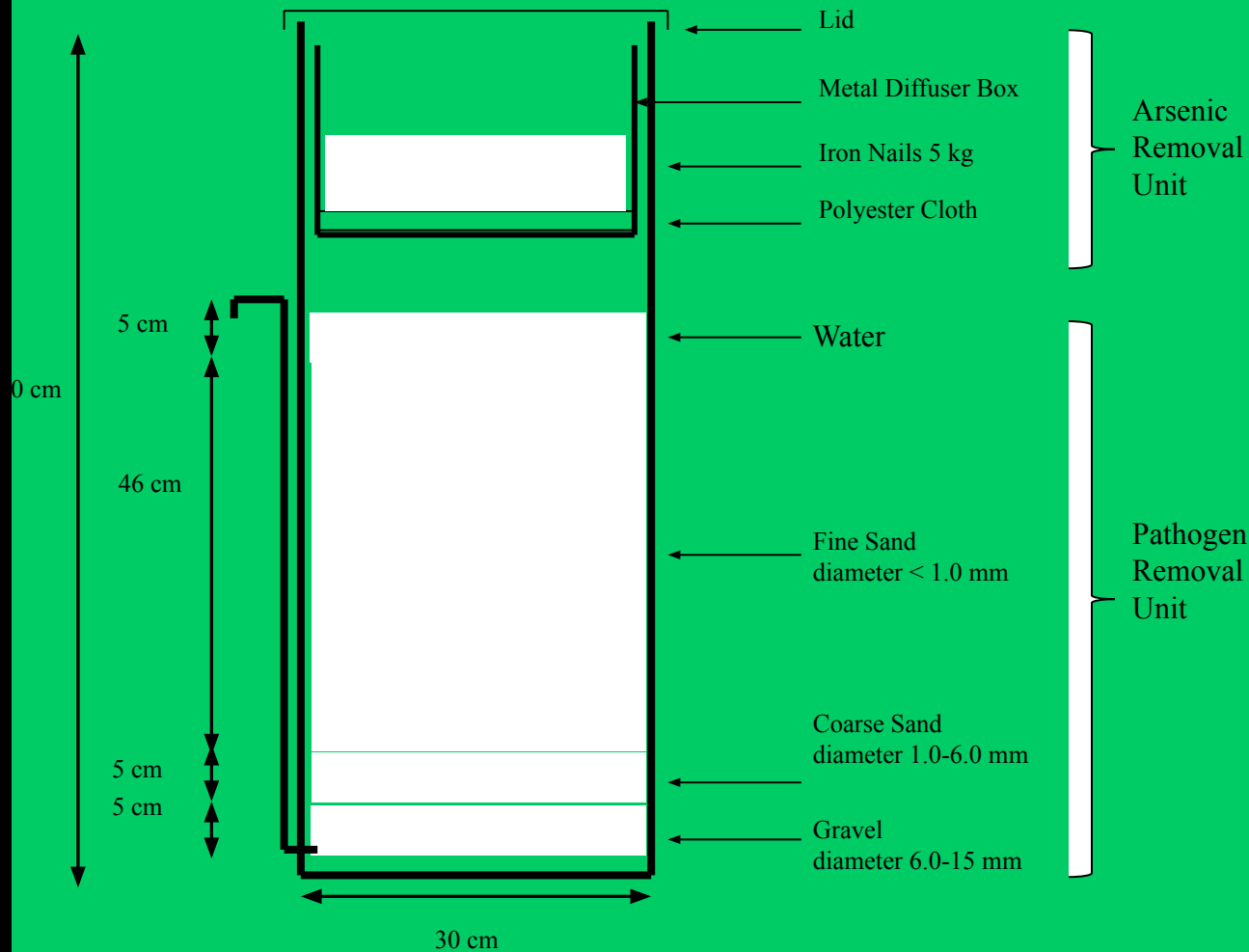


Efficiency of Three Gagri Filter

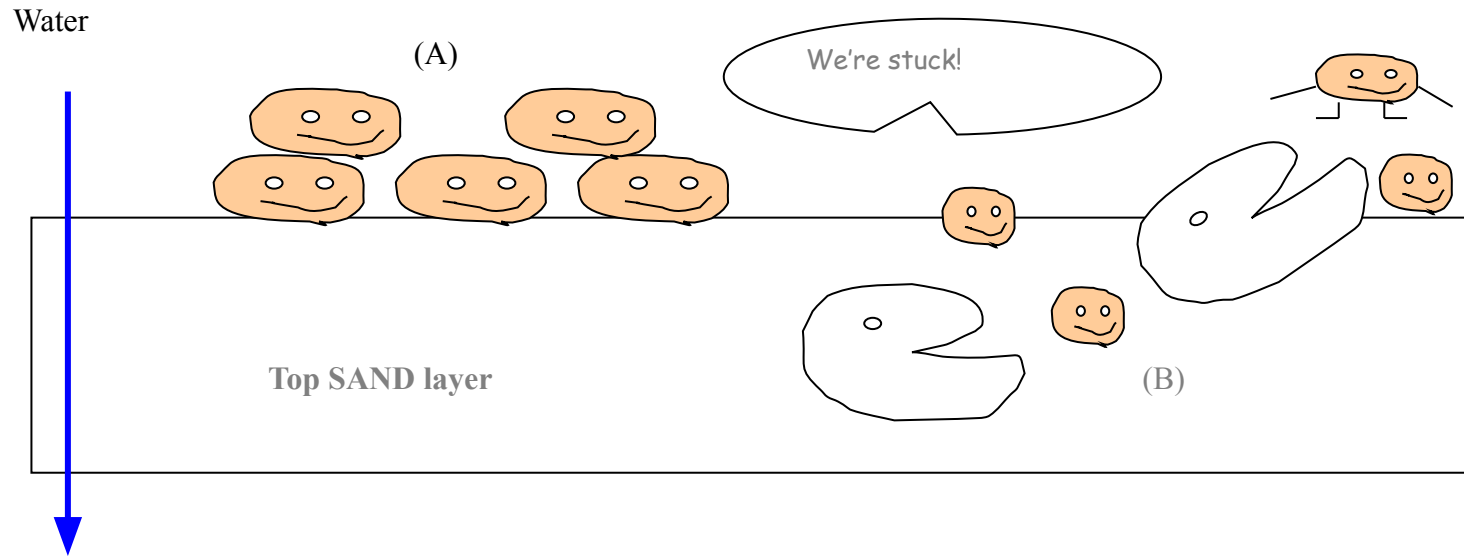




Cross Section of ABF



Pathogen & Arsenic Removal Mechanism

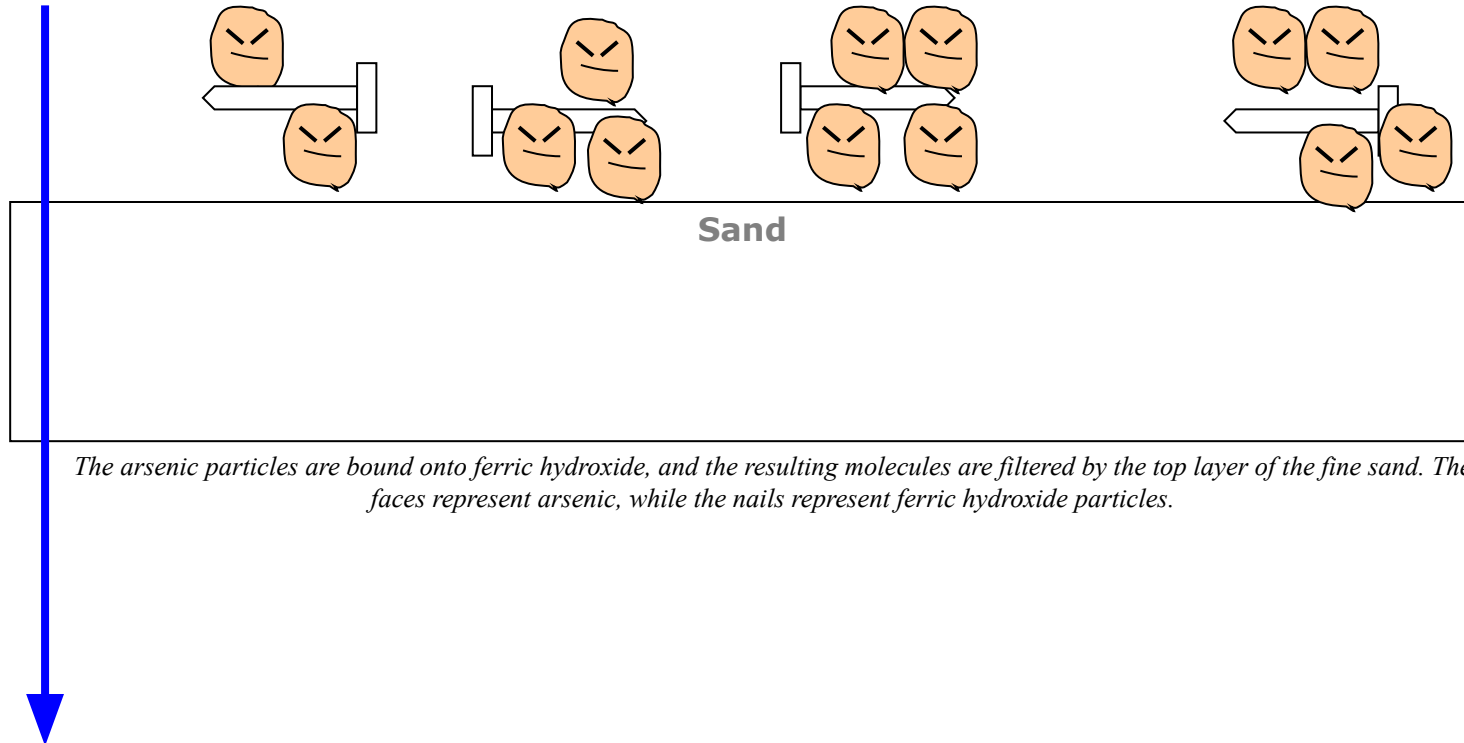


A : Physical Removal by surface straining – Bacteria are too large to pass through the sand layer

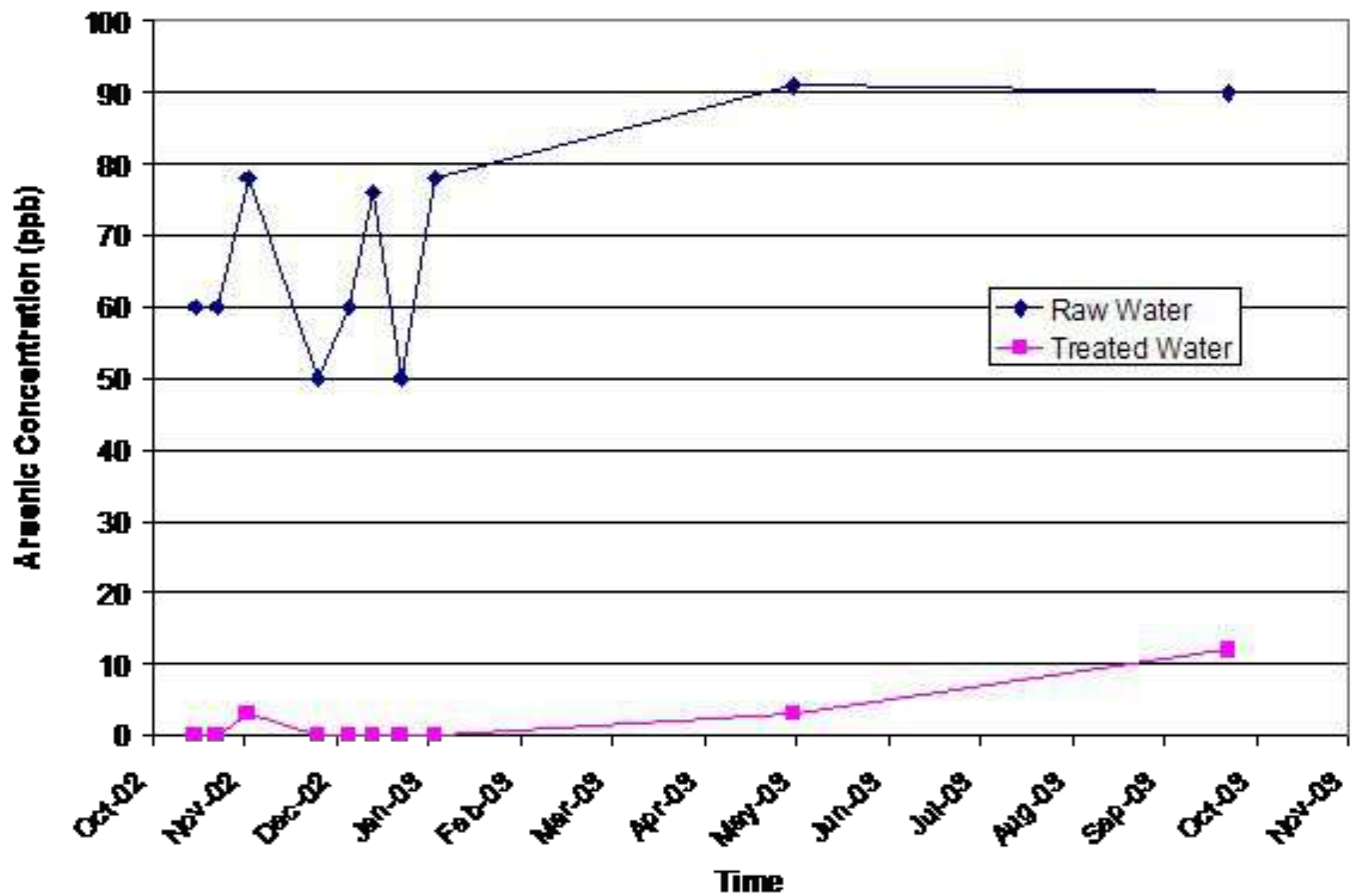
B : Biological removal by predation - The microorganisms living in the biofilm consume incoming bacteria.

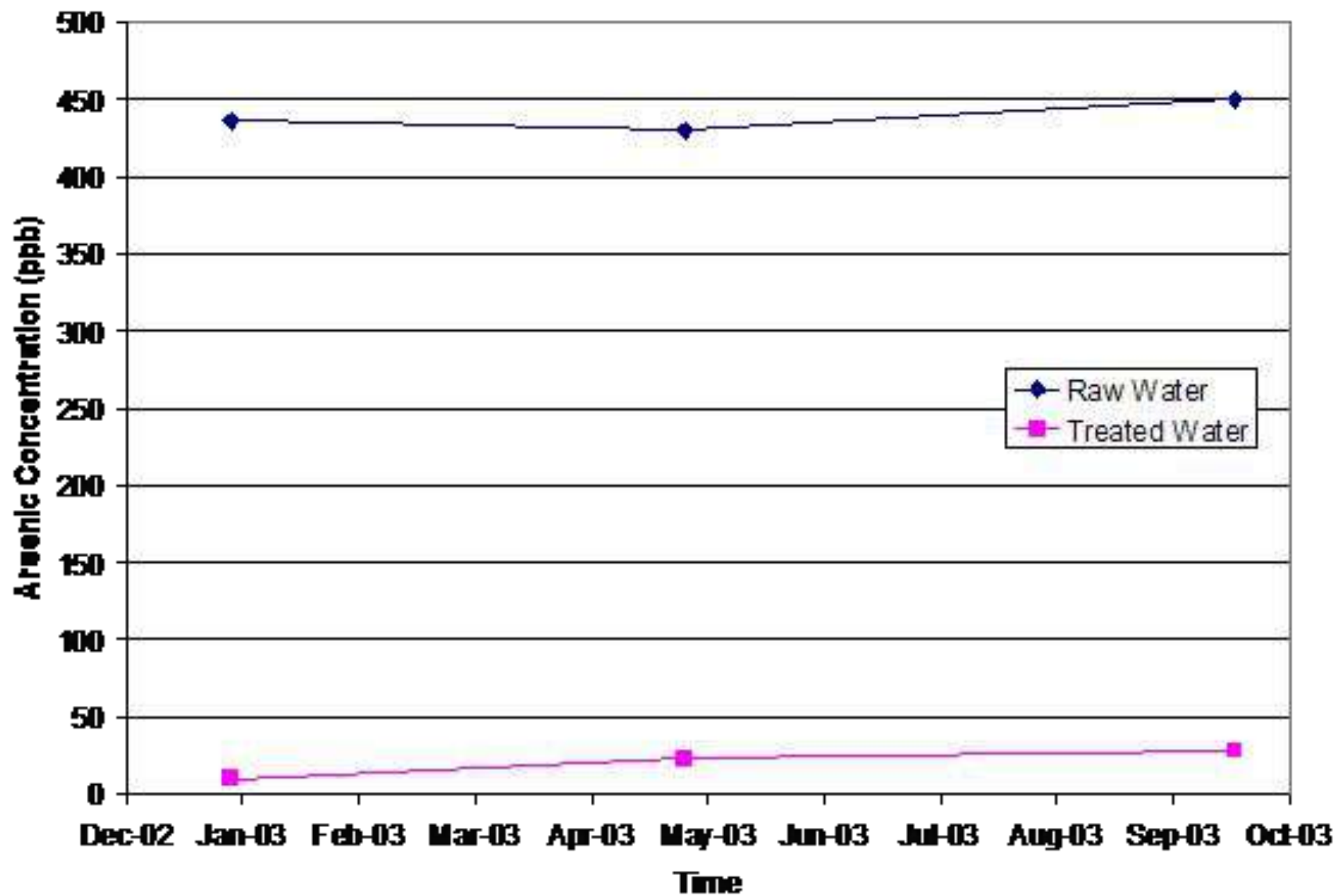
Arsenic Removal Mechanism

Water



- **Ferric hydroxide (iron rust) is an excellent adsorbent for arsenic.**
- **Surface complexation reaction occurs when aqueous arsenic species come into contact with Fe^{+++}**











- Tested 1476 samples – ENPHO test kit & AAS
- Installation of community level arsenic bio sand filter as a pilot scale.
- Formulation of tubewell installation policy
- Training to technicians



रामप्यारी घरमा गइन् र ट्यूबवेल्को पानी खिचिरहेका आफ्नो बुबालाई शंकालु मनले भनिन् "बुबा ! हाम्रो ट्यूबवेल्को पानी खानयोग्य छ होला ?" उनको बुबाले भने "हाम्रो ट्यूबवेल् पोहोर मात्र त्यत्रो पैसा खर्चेर अनुमती मिस्त्रीले गाडेको र यस ट्यूबवेल्को वरीपरि सिमेन्ट समेत लगाएको हुँदा खानयोग्य नहुने त कुरै छैन ।"



आर्सेनिक !

आर्सेनिक समस्या र समाधानका बारे बुझिराख्नु राम्रो ।

सुन सुन बाजुलाई सुन गिरी बनिने भन् ।
कतै कतै बलको पानीमा आर्सेनिक मिसिरहेको ।

आर्सेनिक भन्ने तत्त्व मनुष्य विष पैछ ।
त्यसैले त हामी सबैले पुष्पचन्दु पर्छ नै होस ।

जानी राखौ, कुडी राखौ आमी सबैले,
ज-आफ्नो बलको पानी जँचाउँ हामीले ।

बिगर्छ बसले मराउने भन्ने स्वाच्छन्दलाई जानी,
छोडी हाली खान र पकाउन बस्ने नराखौ पानी ।

धक, धक केही पनि थाक्नु पर्ने छैन,
आर्सेनिकबाट हुने रोग सन् रोग होइन ।

हरियो सब्जी, कलमूल, माछामासु खान्छ जसले,
आर्सेनिकबाट लागेको रोगलाई कम पाउँ बसले ।

त्यसैले त फेरि हामी सबैले कुडी,
ज-आफ्नो बलको पानी चुल्हो जँचाऔ ।

जानी राखौ कुडी राखौ यसबाट बच्न,
गई हाली खानेपानी कार्यालय आर्सेनिकबारे बुझ्न ।

राष्ट्रिय आर्सेनिक निवेदन समिति
समस्यामा आएका सबैलाई निवेदन
पुर्वाधार, काठमाडौं

आफ्नो पानी, कुडी र अरुलाई पनि चुल्हाउँ ।

आफू ज्ञानी अरुलाई भनी सबै मिली प्रयास गरौ ।

ट्यूबवेल्को पानी पीएमा प्यार गर्न खने नहो ।

आर्सेनिक भएको पानी खाने ट्यूबवेल्को टुटिमा पानी
चुल्हाउँ नमानौं कुनै ठाउँमा (उप) निवेदन
गई बुझाएर काटौ ।

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चुल्हाउँ नमानौं कुनै ठाउँमा (उप) निवेदन
गई बुझाएर काटौ ।

सबै मिलेर प्रयास गरे आर्सेनिक समस्याको छैन कुनै भय ।

आर्सेनिक भएको पानी खाने ट्यूबवेल्को टुटिमा पानी
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आर्सेनिक नभएको साफ पानी पिउने बानी बसालौ
र स्वस्थ बनौ ।

आर्सेनिक भएको पानी पिउनाले देखिने रोगका लक्षणहरू

**दिला नगरौ! समयमै सचेत होऔ ।
आर्सेनिक नभएको साफ पानी पिउने बानी बसालौ ।**

राष्ट्रिय आर्सेनिक निवेदन समिति
समस्यामा आएका सबैलाई निवेदन
पुर्वाधार, काठमाडौं

Lessons Learnt

- Arsenic level fluctuate
- Need better future monitoring plan
- Needs to provide safe water option before recommending to stop contaminated water
- Need strong motivational program to change people's perception
- Mitigation program should not run agency wise approach
- Blanket testing
- Kanchan filter is most effective option among other filters
- While conducting health survey, individual with basic training on diagnosis is sufficient for patient screening

Recommendation for Health Investigation

- National prevalence study on arsenic should be conducted
- Train health post in charge and medical professionals from district hospitals
- Utilize existing trained human resources to train more professionals
- Utilize and expand existing laboratory services for biological analysis for arsenic
- Rehabilitation services for arsenicosis patient
- Include arsenic related course in academic institution related to health and engineering

Existing Trained Human Resources

Water quality experts - 2

Chemists - 3

Medical Doctors – 2

Public Health Experts - 2

Engineers – 3

GIS expert – 1

Geostatistician – 1

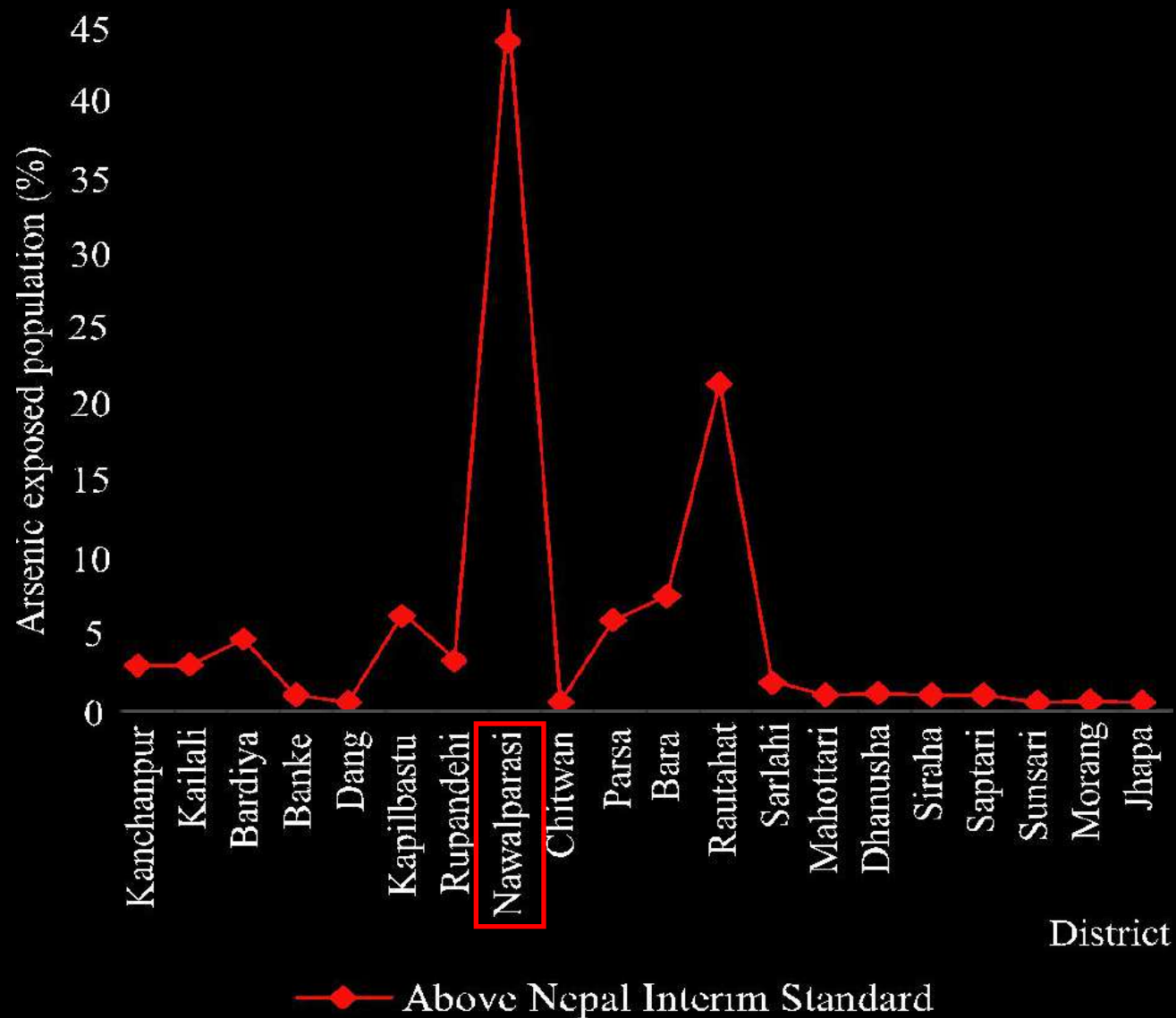
System Analyst 1

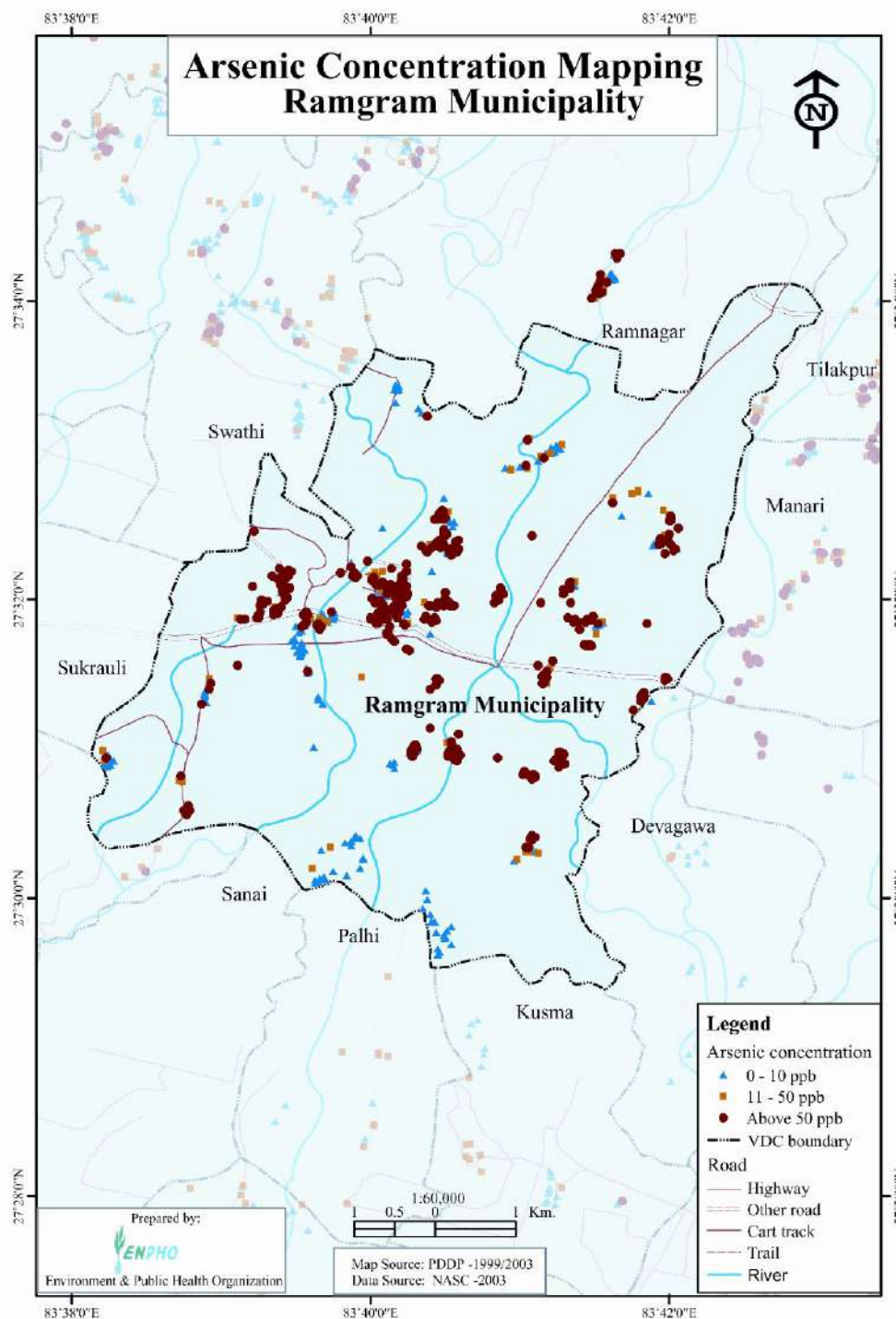
Health Workers – 8

Technicians – 8

Motivators - 15

Thank you !





Drinking Water Vulnerability to Arsenic - Terai

