

ENPHO's Experience on Arsenic Investigation & It's Mitigation

Dr. Roshan Raj Shrestha



Environment & Public Health Organization

Thapagaon, New Baneshwor,

email: enpho@mail.com.np, website: www.enpho.org

History of Arsenic Study in Nepal

- 47 % population live in 20 Terai districts of Nepal where about 90 % people are using ground water for drinking.
- It is estimated that there are about 700,000 tubewells in Nepal that provides water to about 9.7 million people.
- 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.
- Nepal Red Cross Society (NRCS) initiated the testing program after DWSS/WHO.

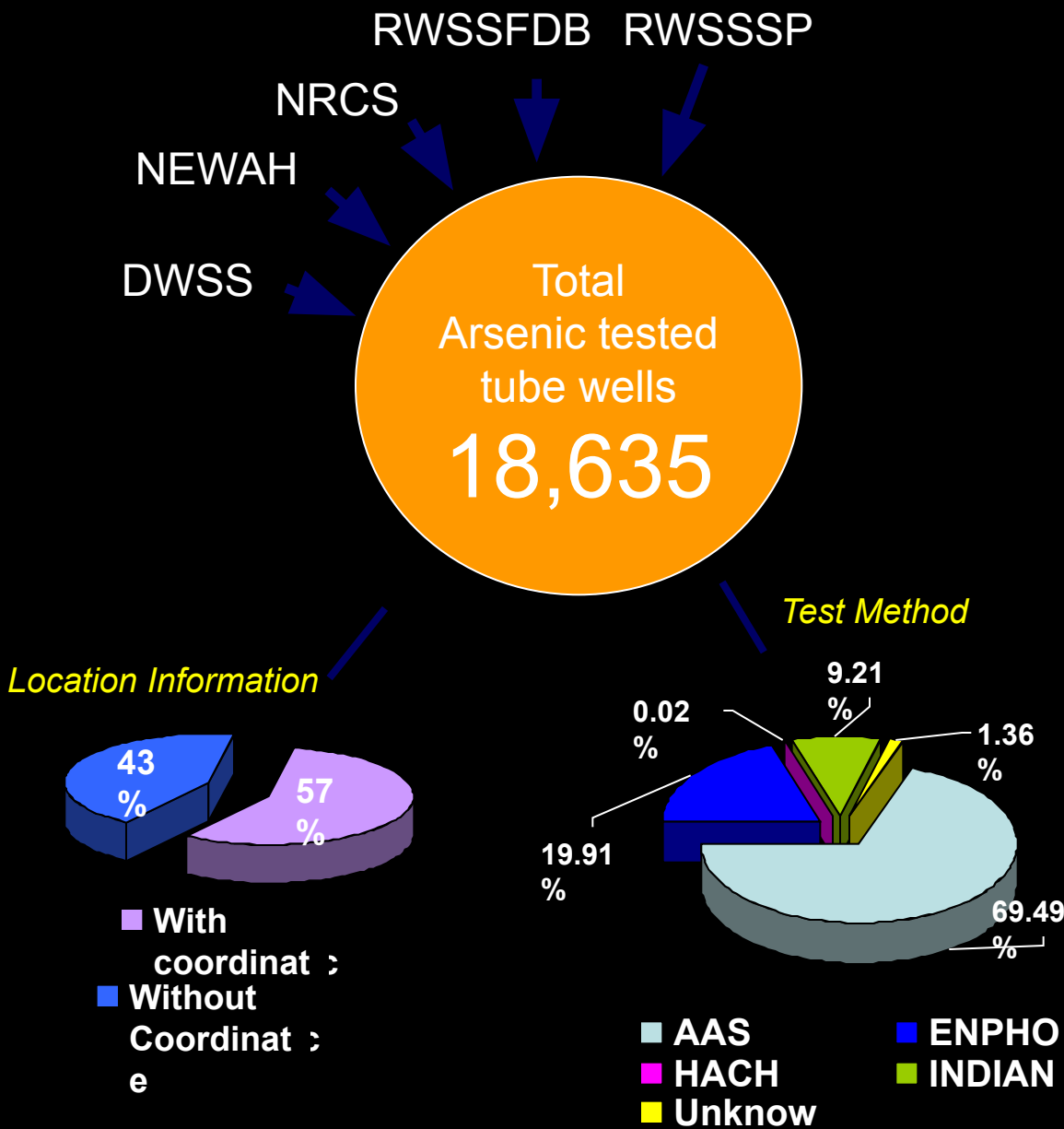
History of Arsenic Study in Nepal

- NRCS tested about 2000 samples where – 3 % found more than 50 ppb (Preliminary investigation).
- A 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.

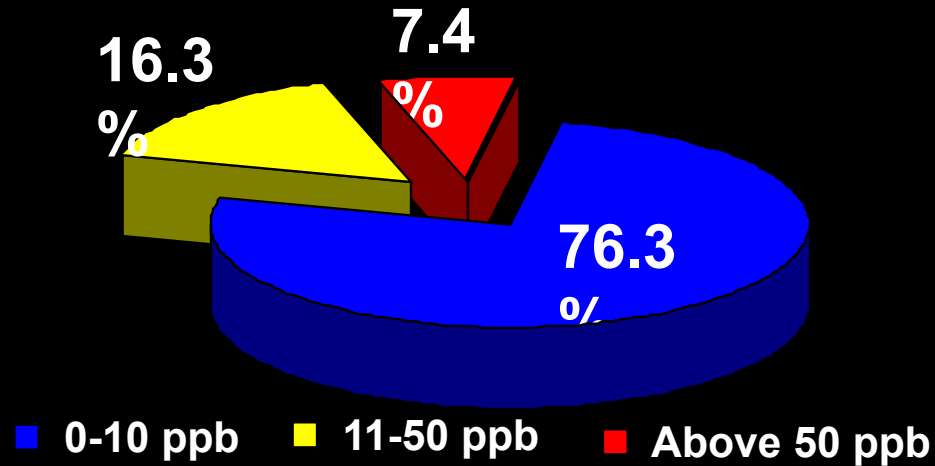
Working With Different Partners

- NRCS & JRCS – Testing, Health Survey & Mitigation - Jan 2000 to Dec 2003
- RWSSSP/FINNIDA – Testing, Health Survey, Arsenic Removal Filter & Mapping 2001 to date
- DWSS/UNICEF – Health Survey, Field Test Kits and As removal filter
- NSCA – Development of National Policy, IEC material, Testing Protocol
- NEWAH – Testing
- RWSSFDB – Mitigation in Siraha and Saptari
- Department of Education – Testing, Policy formulation & Filter
- TU – Testing of Water & Rocks for As
- USGS – Arsenic Mapping and State of Arsenic Report
- MIT – Research & Development
- World Bank DM 2003 – Promotion of Kanchan Arsenic Filter
- AAN – Asia Arsenic Network – Arsenic Investigation and Mitigation
- JICA Expert Office – Ministry of Physical Planning & Works

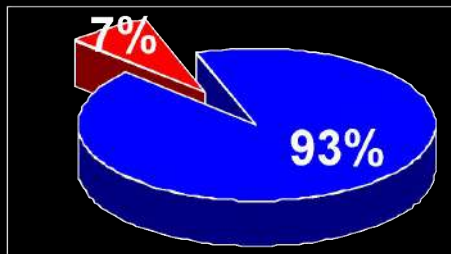
Well ID
Location information
Geographic coordinate
Depth of well
Age of well
Users information
Arsenic concentration
Test method
Microbiological result
Data Source



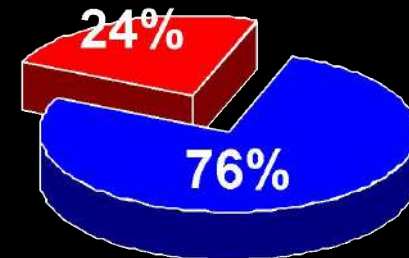
Classification of Arsenic Concentration



Nepal Interim Standard

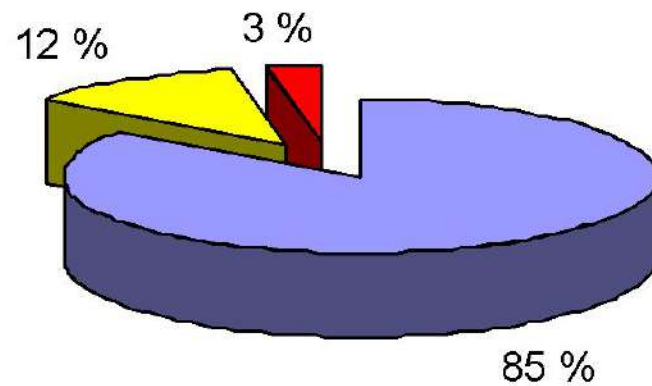


WHO Guideline



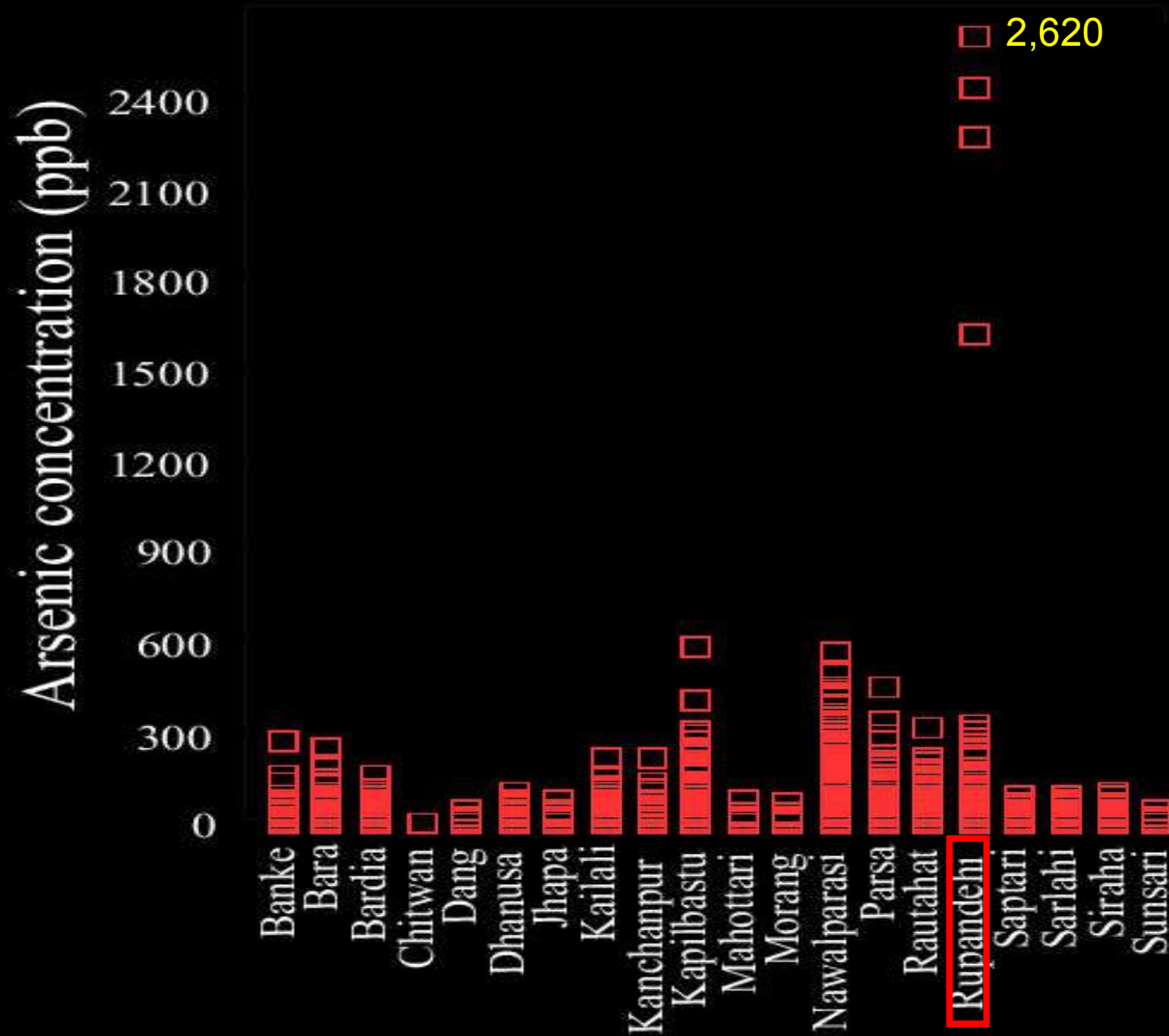
NASC Report

Total Test : 339515

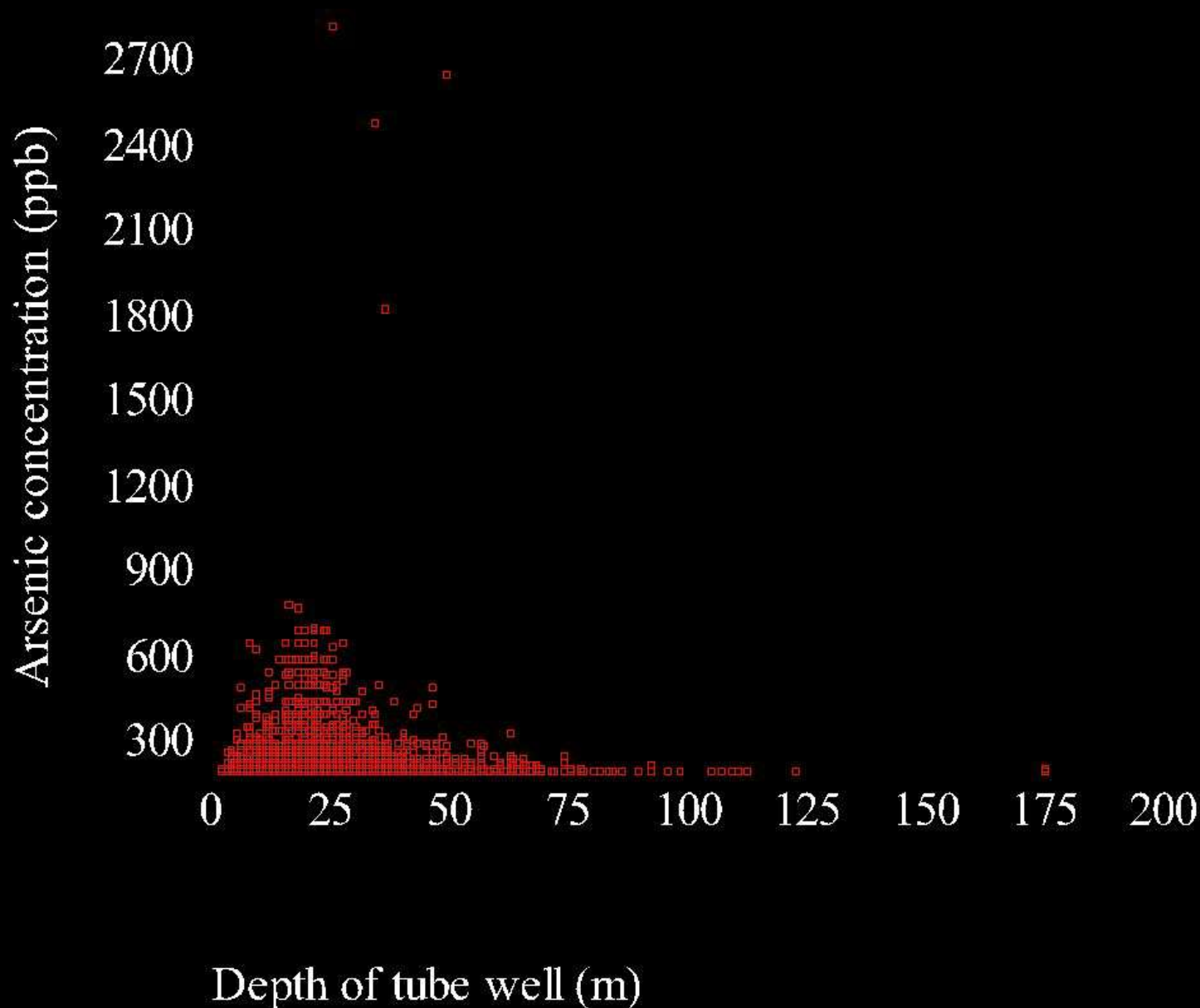


■ < 10 ppb ■ > 10 to 50 ppb ■ > 50 ppb

Distribution of Arsenic Concentration by District



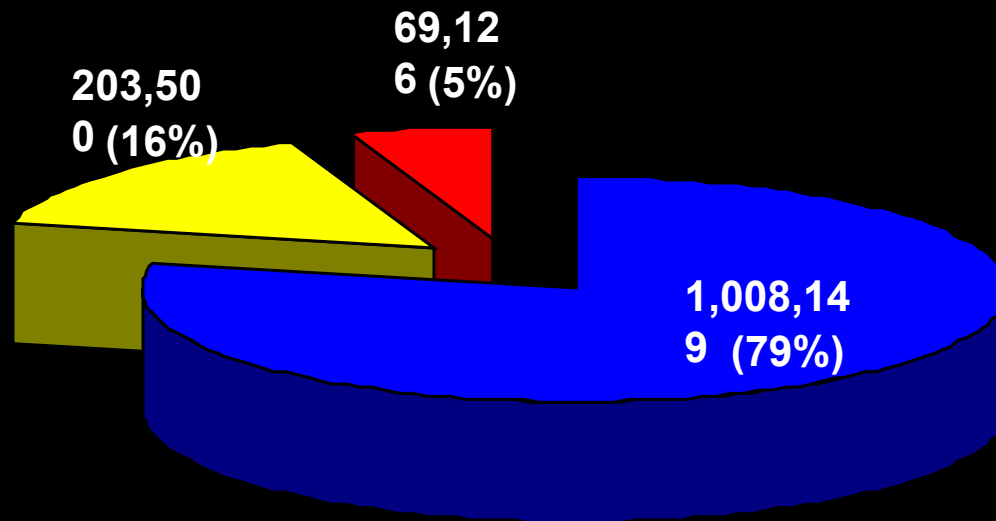
Arsenic Concentration and Depth of Tube Well



Arsenic Exposed Population

Total Population using Arsenic Tested Tube Wells is

1,280,775



■ 0-10 ppb ■ 11-50 ppb ■ Above 50 ppb

Vulnerability to Arsenic

Arsenic vulnerability was defined based on the percentage of arsenic tested tube wells exceeding the WHO Guideline.

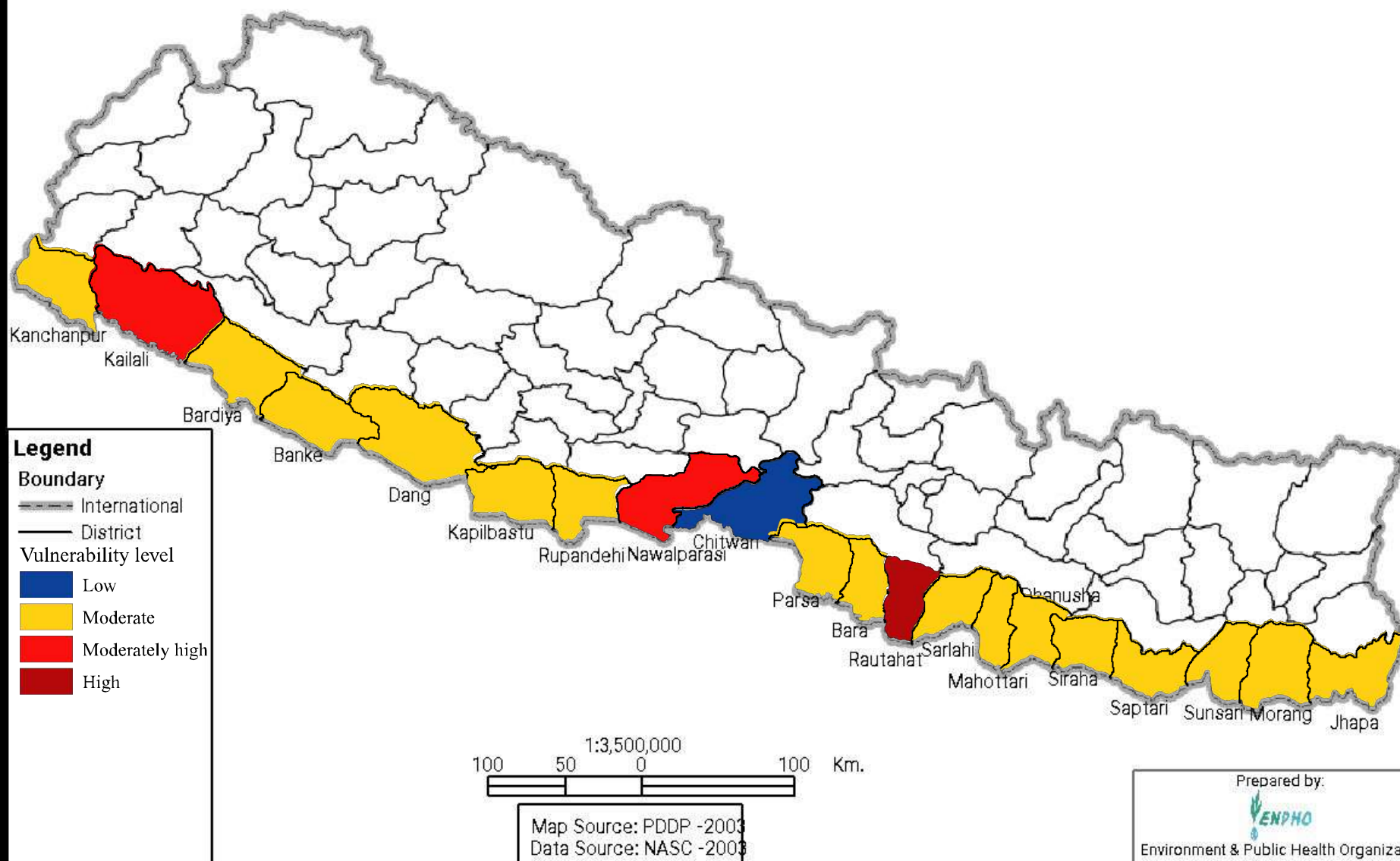
Low (0%)

Moderate (1-25%)

Moderately high (26-50%)

High (>50%)

Drinking Water Vulnerability to Arsenic - Terai

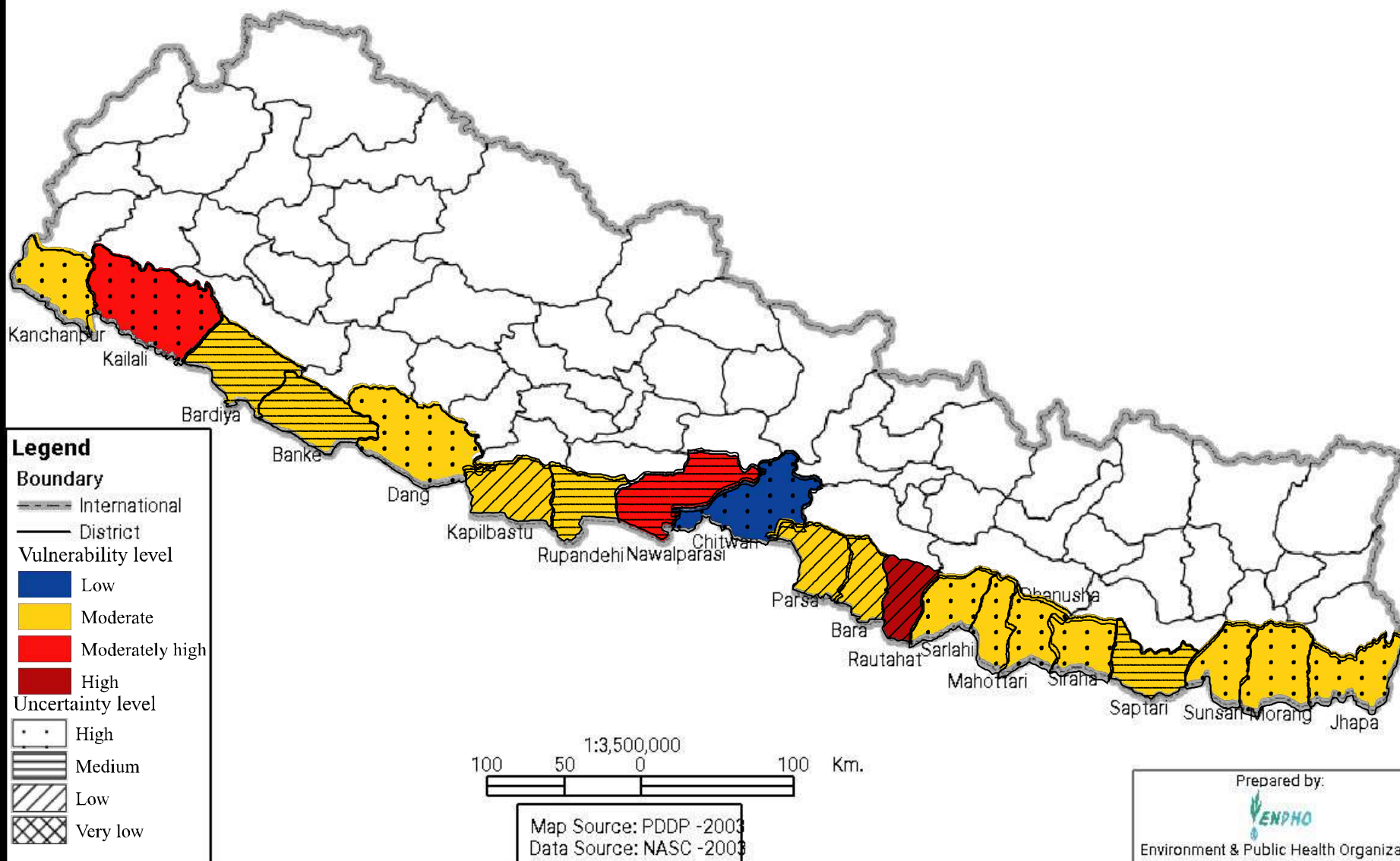


Level of uncertainty

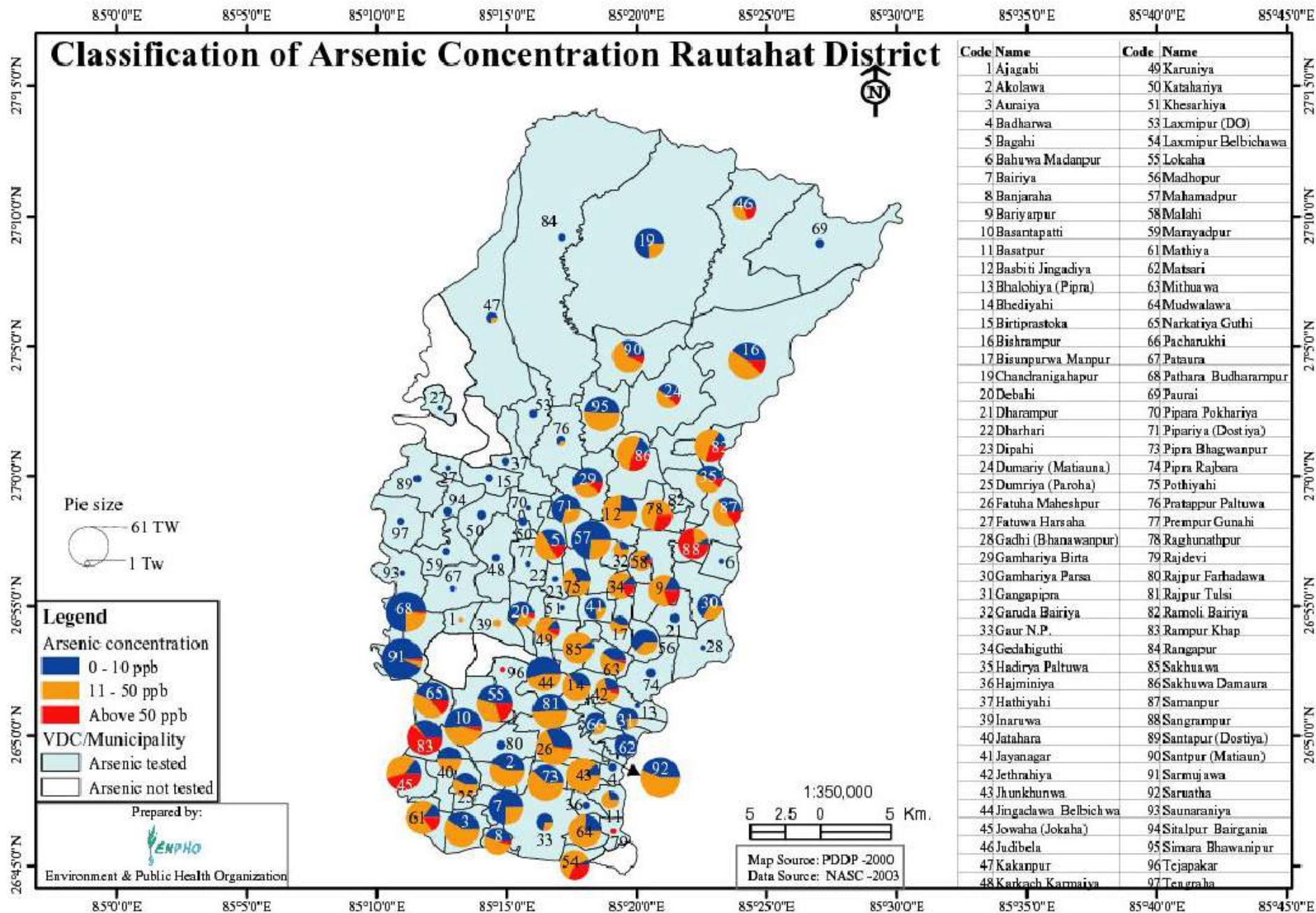
Level of uncertainty was defined based on proportion of household using arsenic tested tube wells to total households.

- High uncertainty $\leq 5\%$
- Medium uncertainty 6-25%
- Low uncertainty 26-50%
- Very low uncertainty $> 50\%$

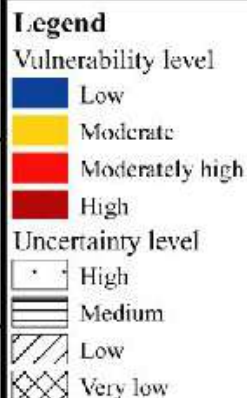
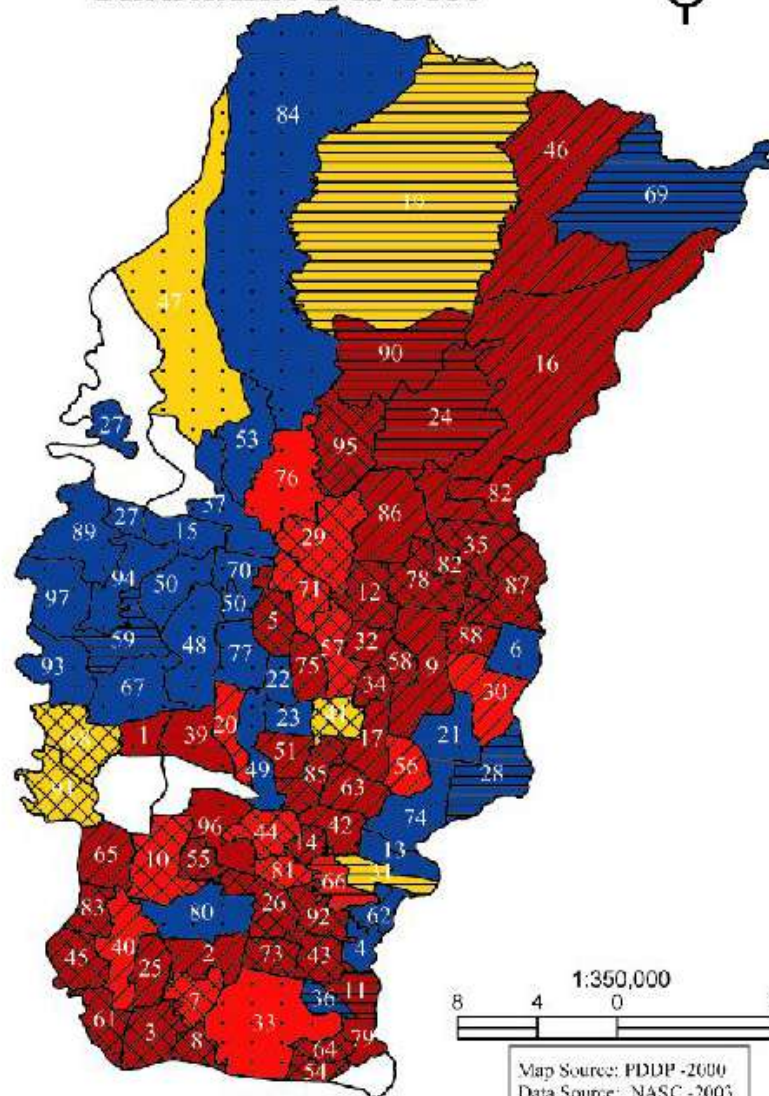
Drinking Water Vulnerability to Arsenic - Terai



Classification of Arsenic Concentration Rautahat District



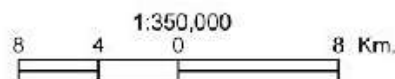
Drinking Water Vulnerability to Arsenic Rautahat District



Prepared by:



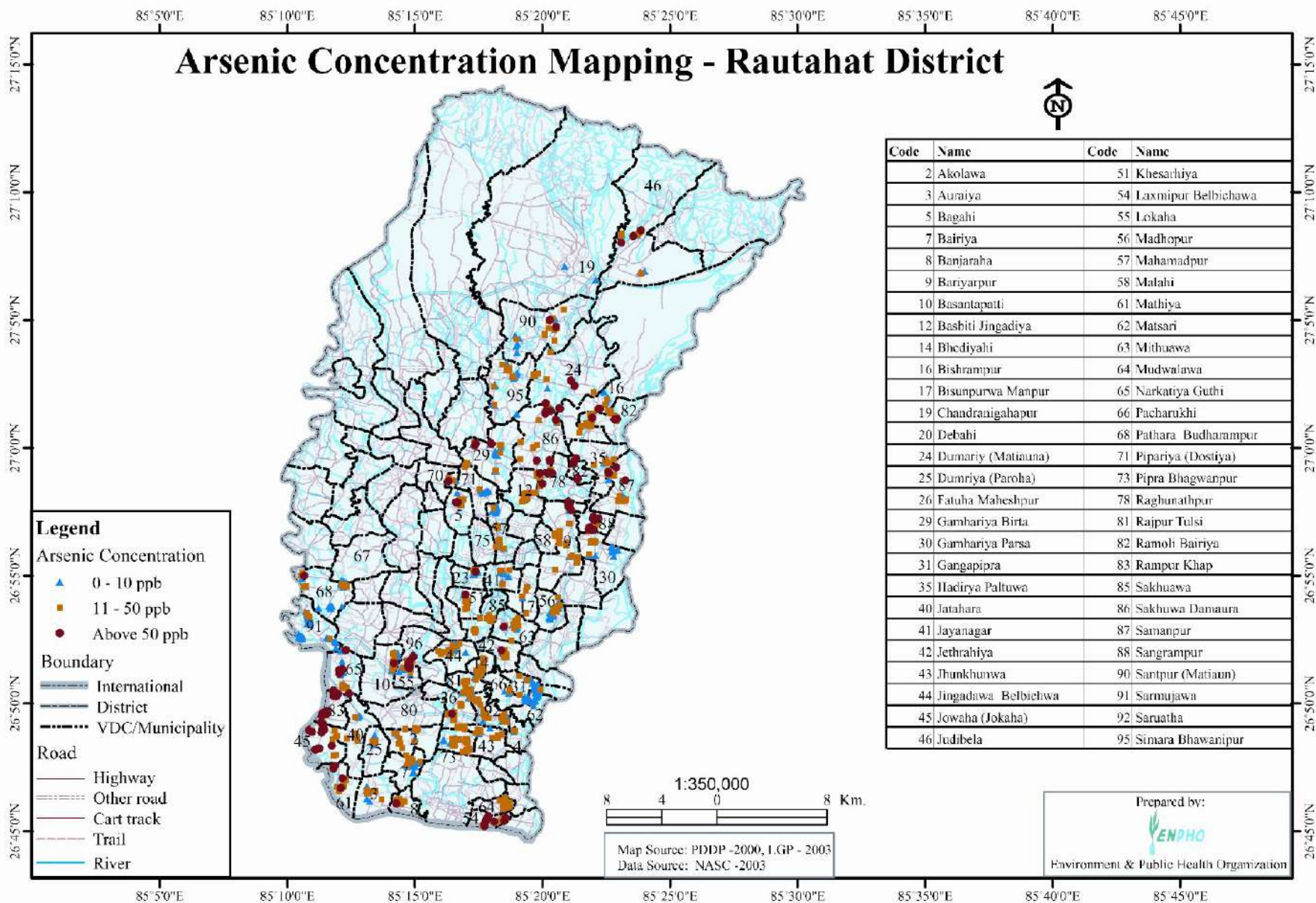
Environment & Public Health Organization



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

Code	Name	Code	Name
1	Ajagabi	49	Karuniya
2	Akolawa	50	Kataharaya
3	Auniya	51	Khesariya
4	Badharwa	53	Laxmipur (DO)
5	Bagahi	54	Laxmipur Belbichawa
6	Dahurwa Madanpur	55	Lukha
7	Bairiya	56	Madhopur
8	Banjaraha	57	Mahamadpur
9	Banyarpur	58	Mulani
10	Basantapatti	59	Marayadpur
11	Basatpur	61	Machiya
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	Gangupura	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



Methods of Sampling and Testing of Arsenic



Case found outside the DWQIP program area in Nawalparasi
district

Health Impact Study in the Arsenic affected Areas of Nepal



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

- 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.
- 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



Health Worker
conducting survey
at the household

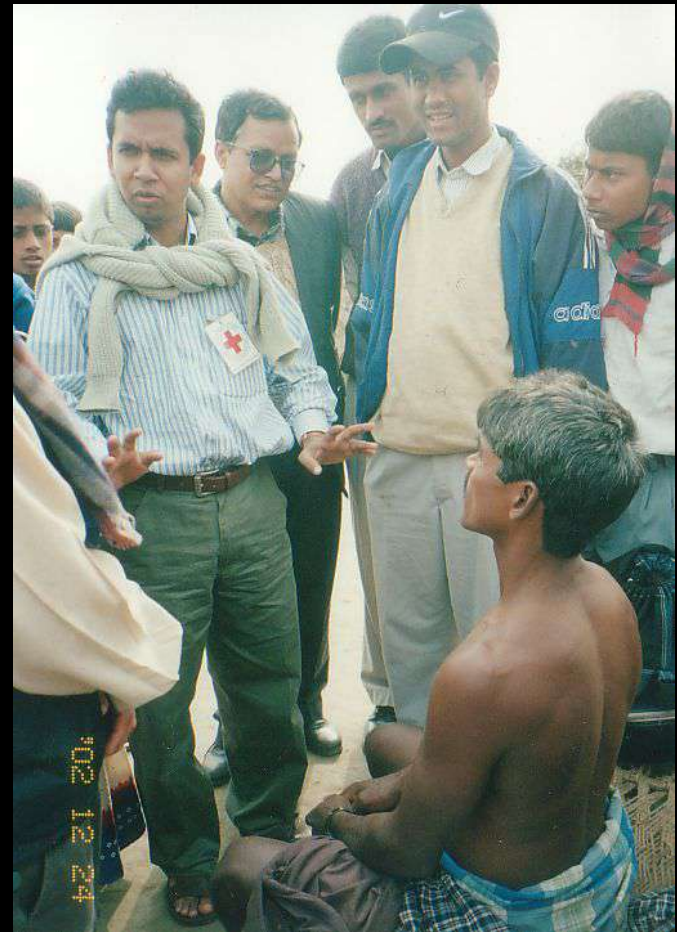
Health worker
collecting hair
samples



Senior Health advisor observing the suspected persons



Medical Doctor from Bangladesh confirming the suspected patients in Nawalparasi



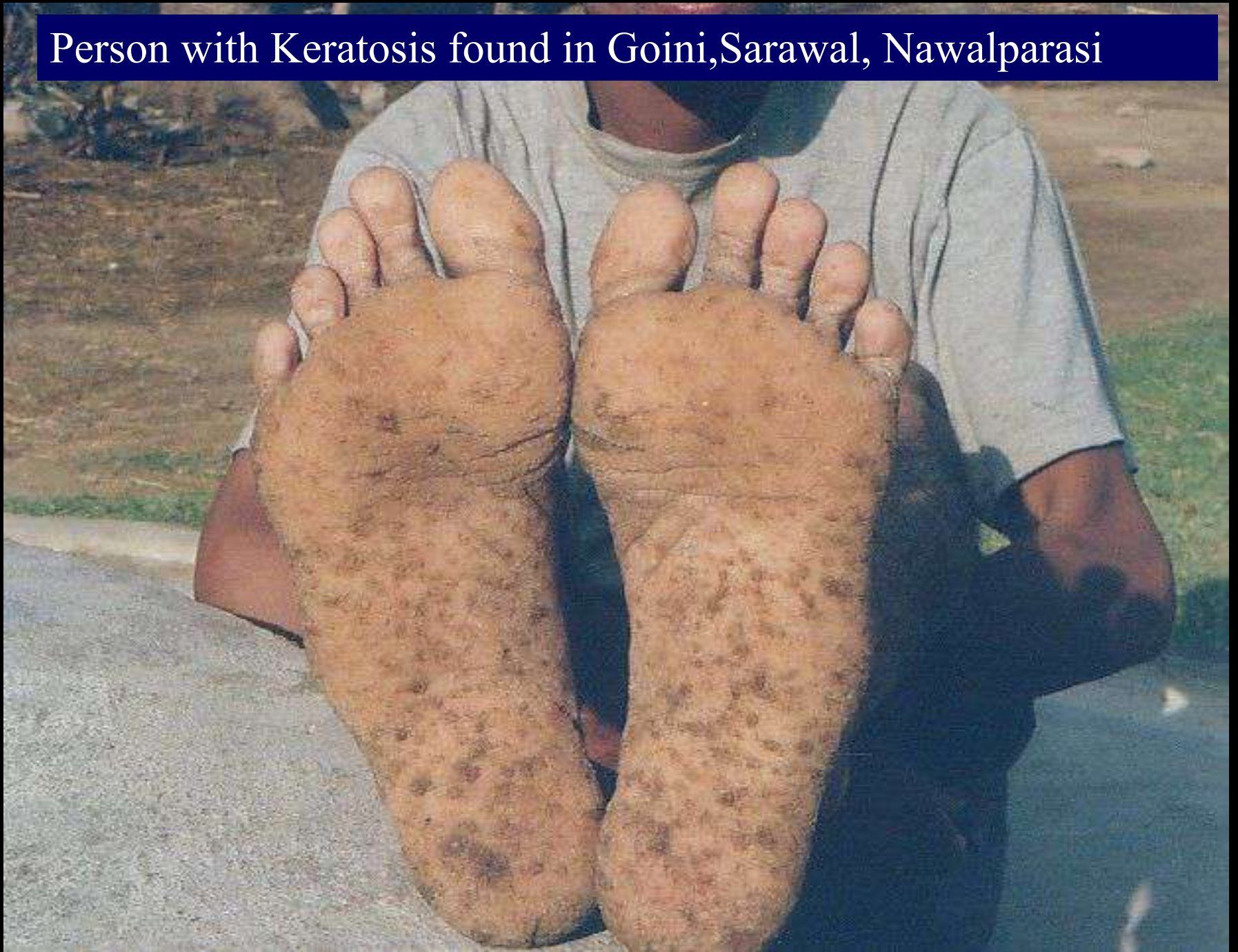




Person with initial
stage of Keratosis
found in Parsa
District



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

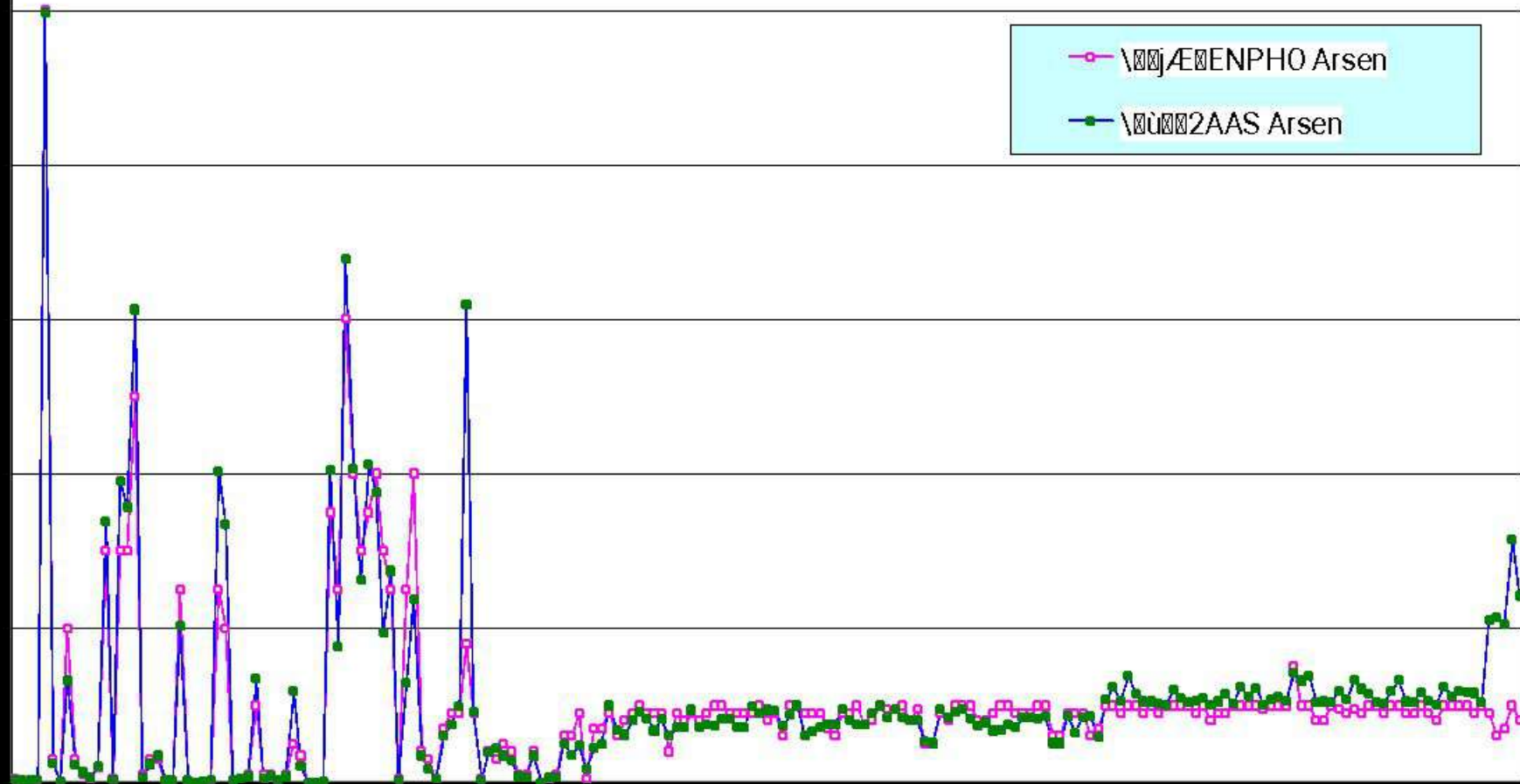
Mitigation Program

More Testing

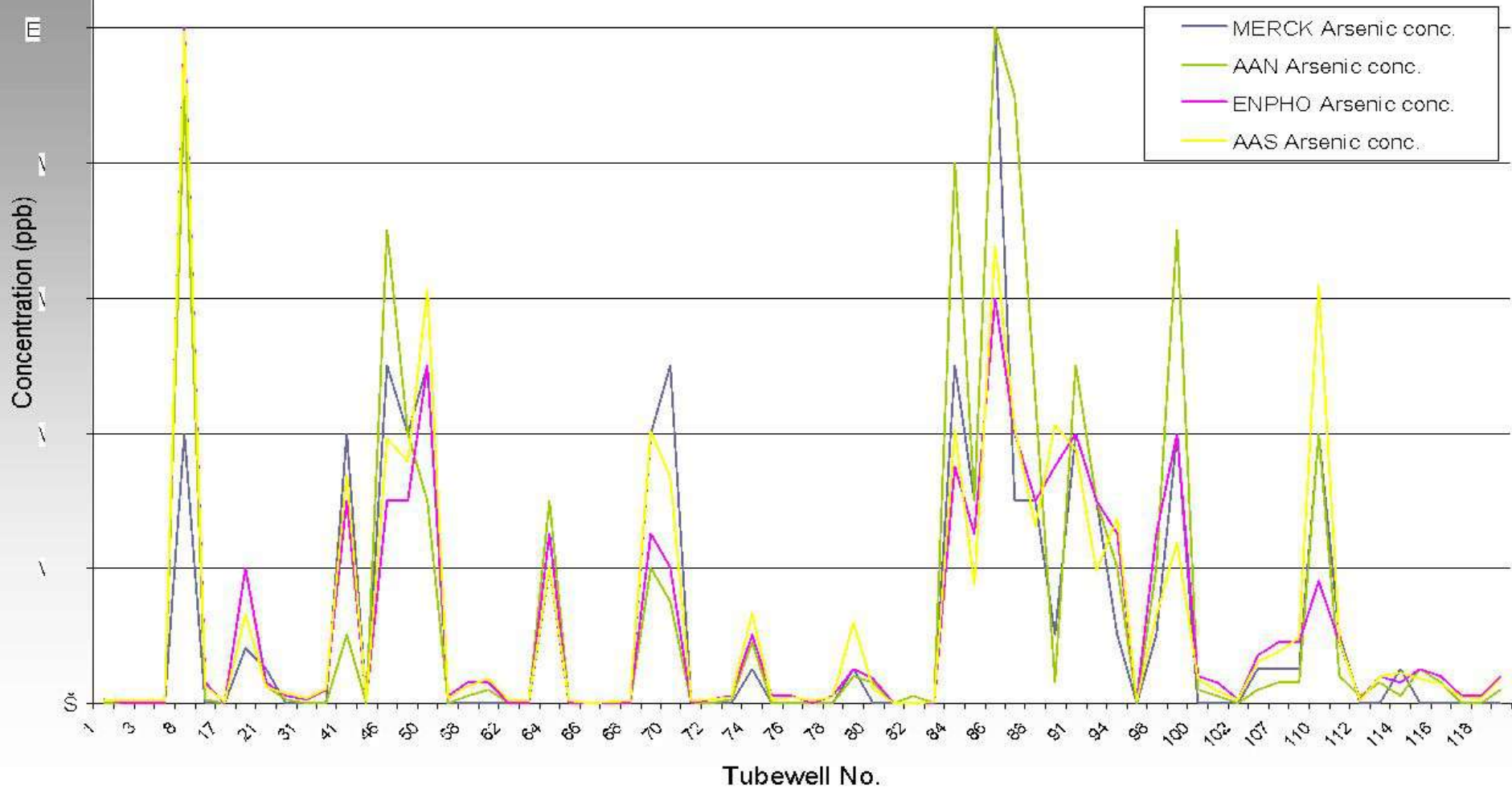
आर्सेनिक टेस्ट किट
ARSENIC TEST KIT



Comaprision between results of ENPHO test Kit and AAS

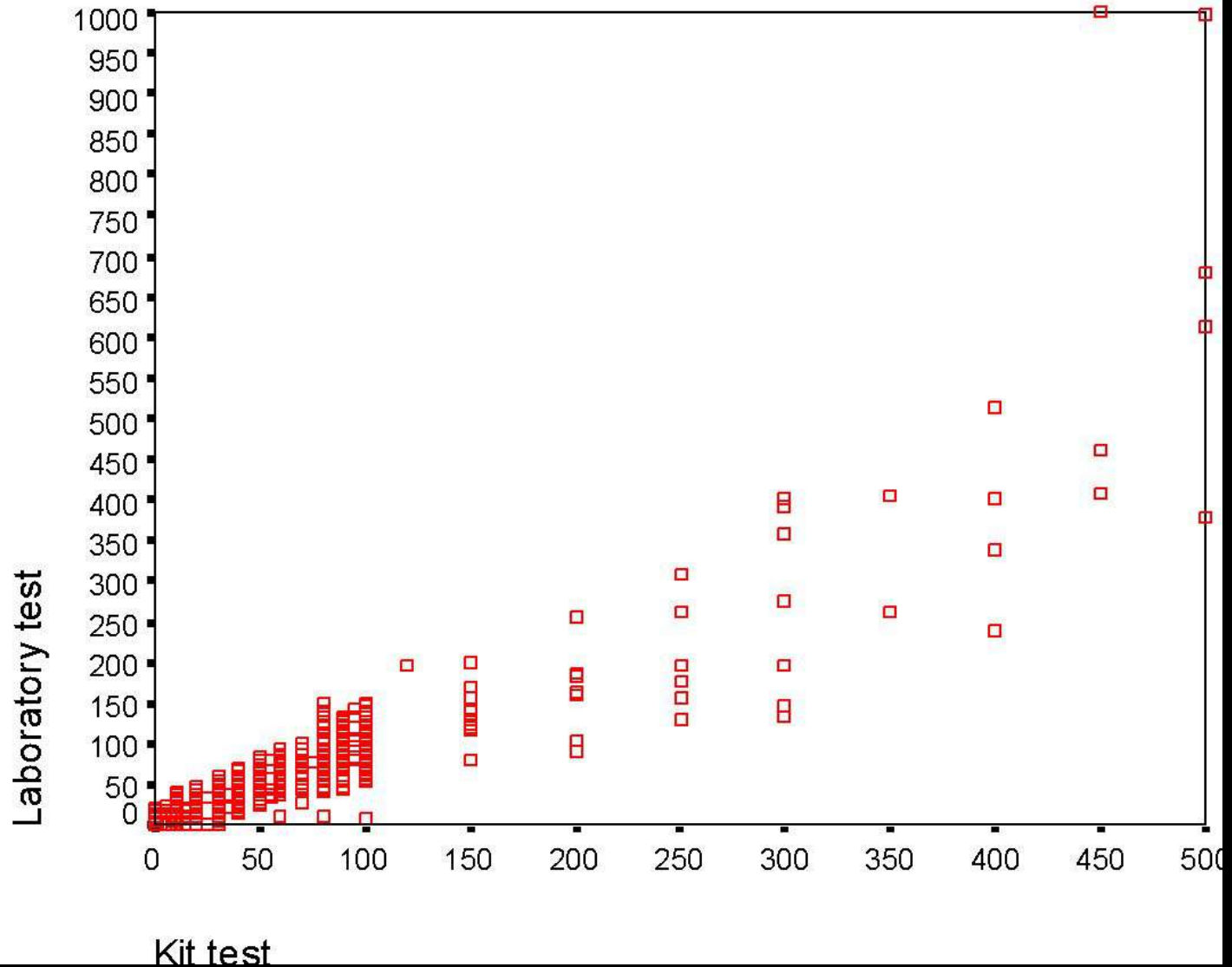


Comparison between the results from MERCK, AAN, ENPHO test kit with AAS



ENPHO kit vs. Lab Test

(3000 samples)

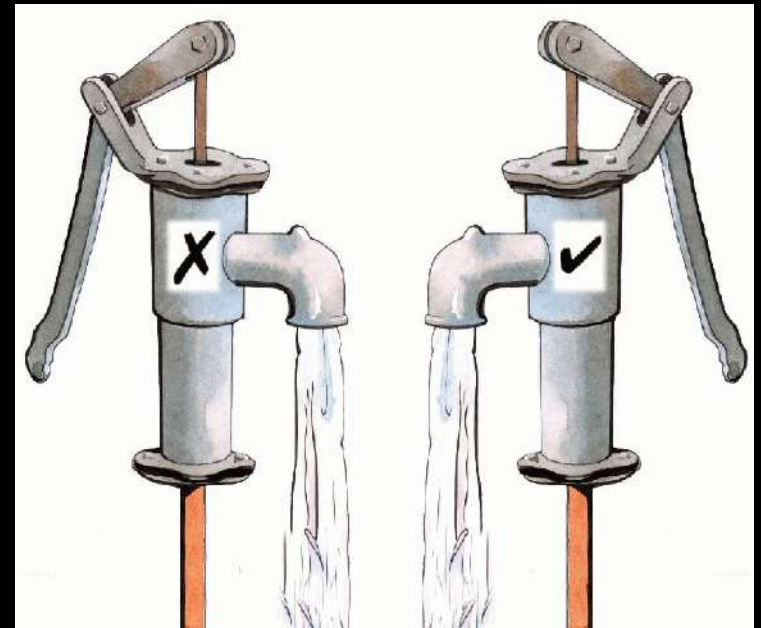


Alternative Options

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

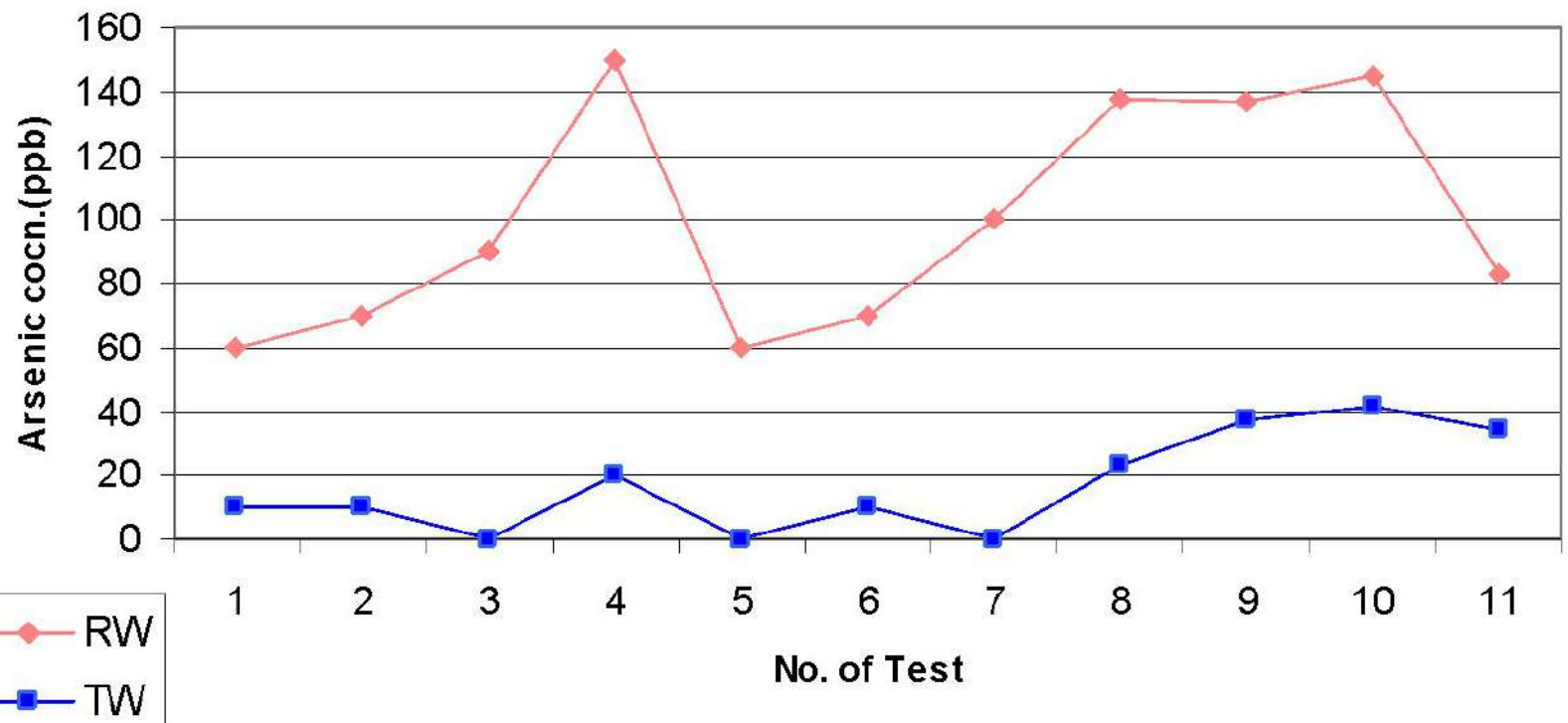


Community level Arsenic Removal Treatment Plant under construction (Nawalparasi)



Arsenic- Iron Removal Plant in Badera VDC in Nawalparasi

Efficiency of AIRP



Household Arsenic Removal Filters

ENPHO Two Gagri Filter

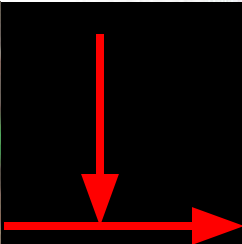


Chemical packet contains:

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



Raw Water



Mixing & Settling



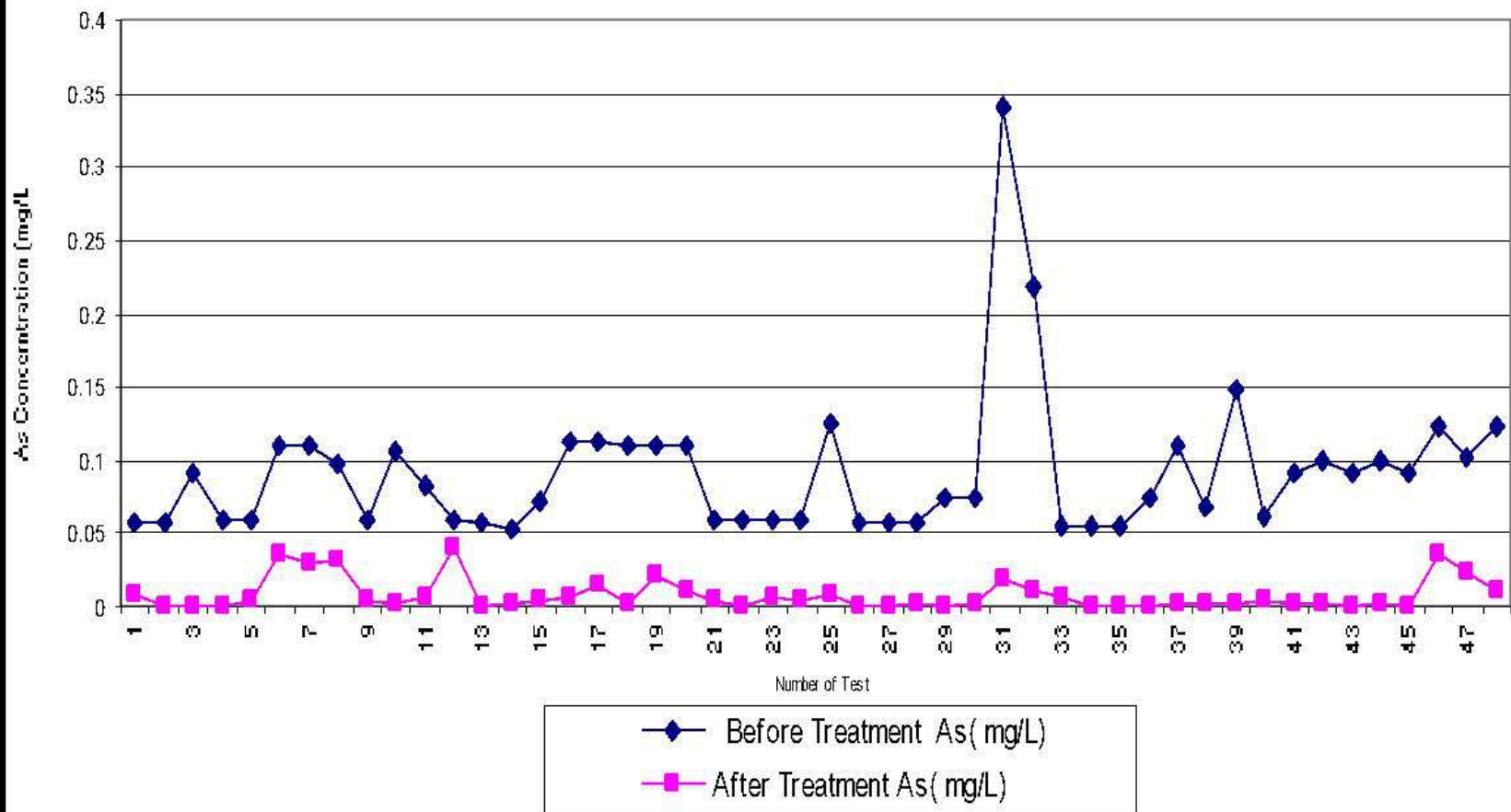
Filtration (ceramic filter)



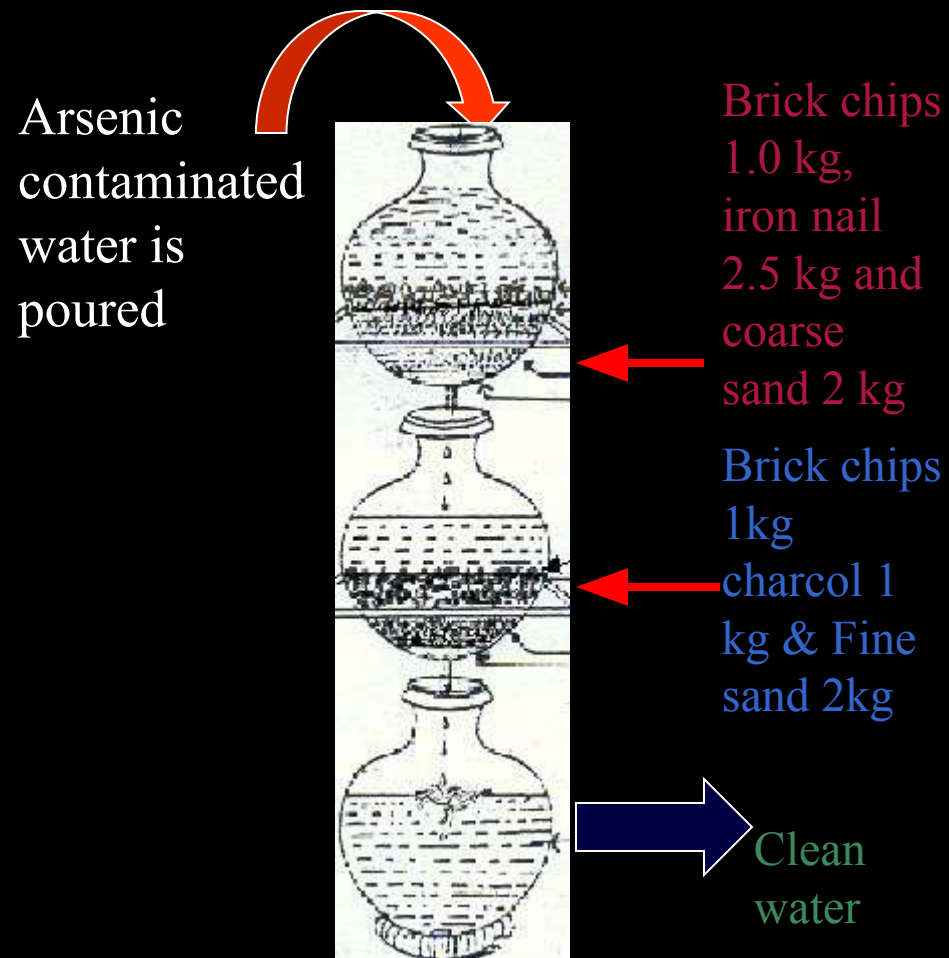
Treated Water



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



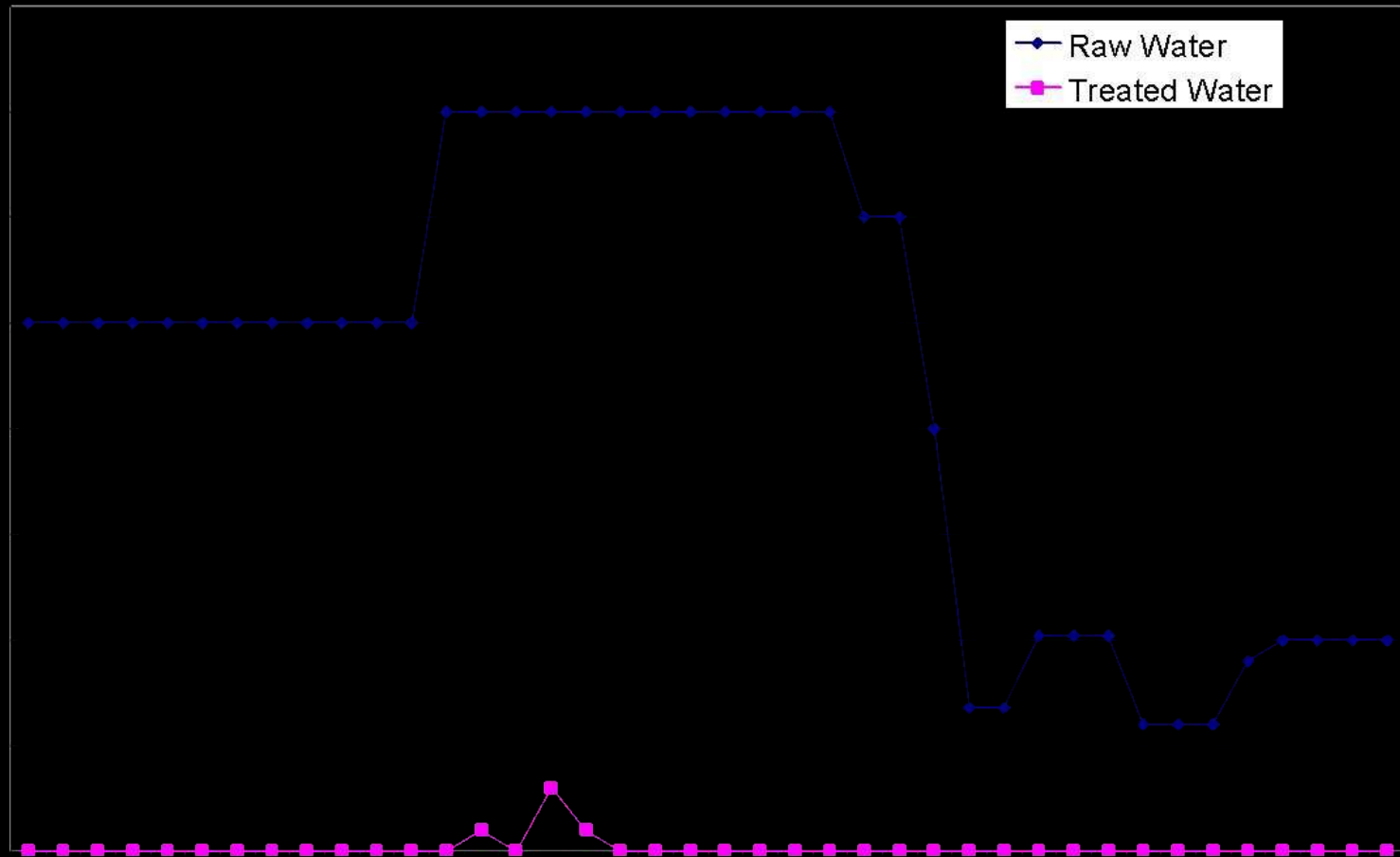
Three-Gagri System



Treatment Process: Adsorption, Precipitation, and Filtration



Efficiency of Three Gagri Filter



Kanchan Arsenic Filter

Kanchan Arsenic Filter

- Developed by Massachusetts Institute of Technology (MIT), ENPHO, and 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

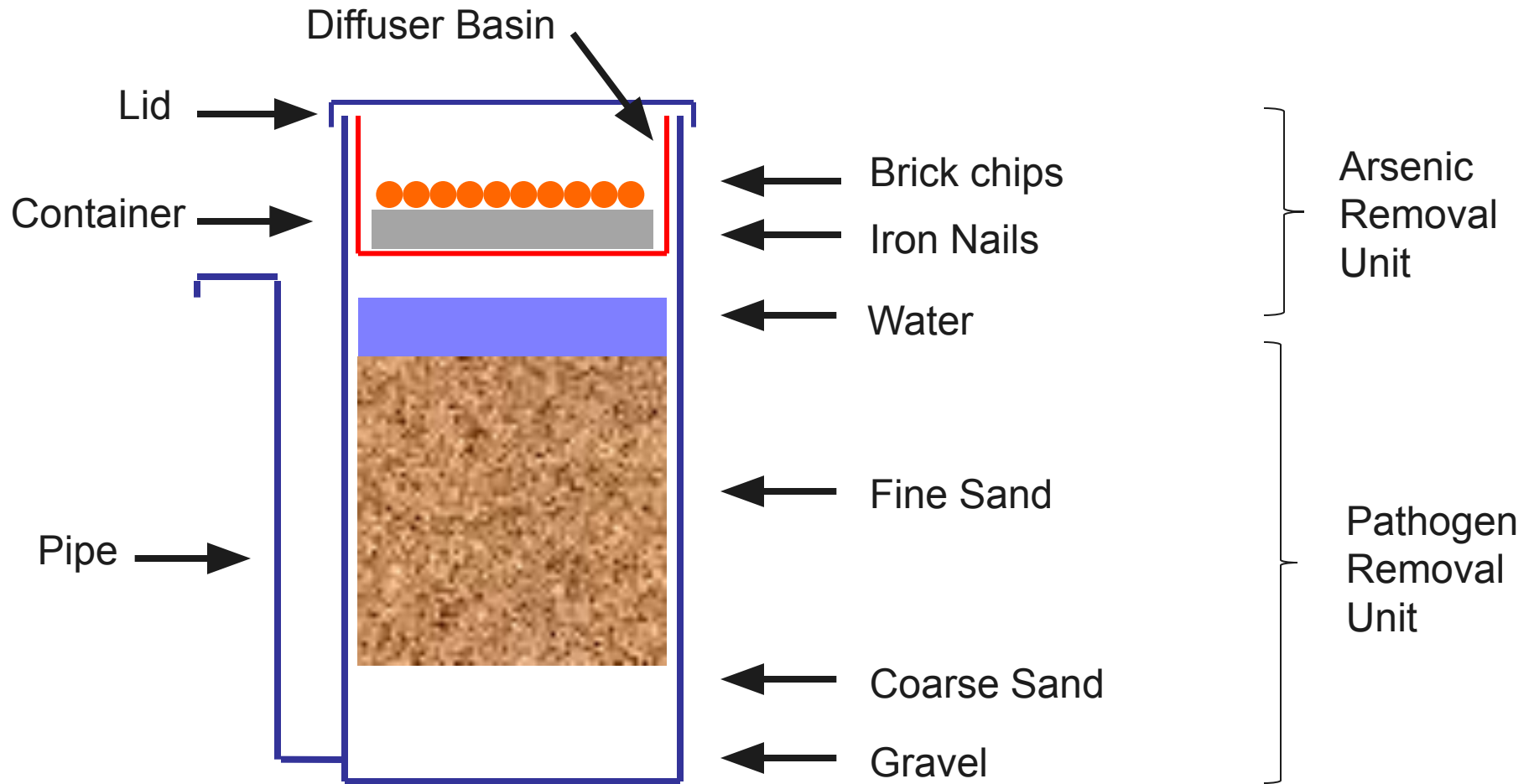


Kanchan Arsenic Filter

- 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

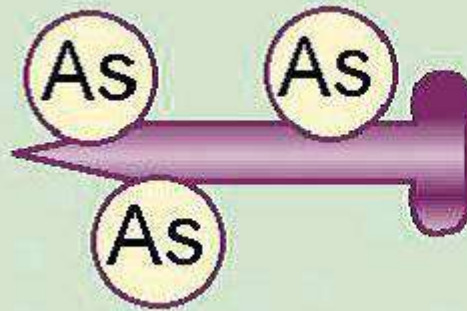


Arsenic Biosand Filter Cross Section



Arsenic Removal Mechanism

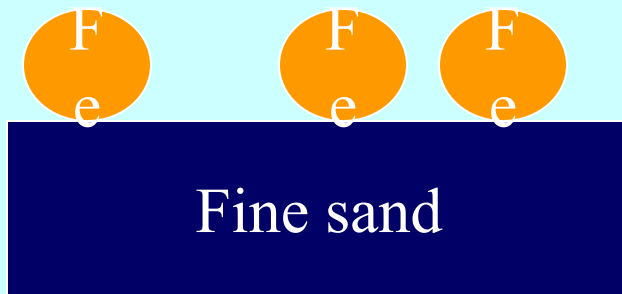
- After contact with water and air, iron nails in the diffuser basin will quickly rust
- Iron rust (ferric hydroxide) is an excellent adsorbent for arsenic



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

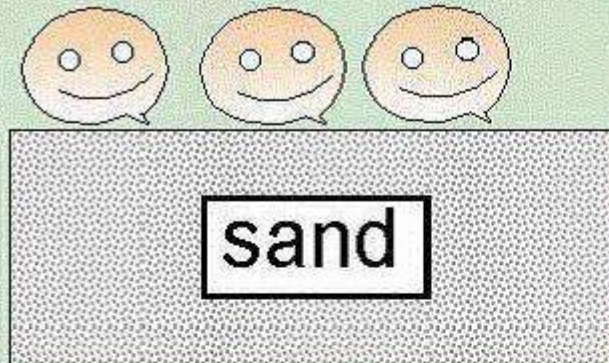
Iron Removal Mechanism

- 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

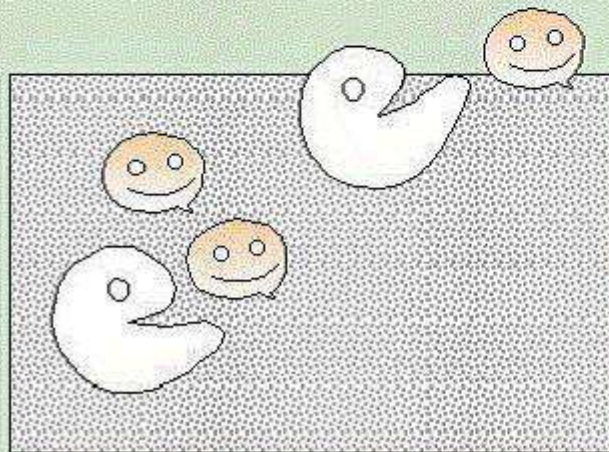


Iron particles are trapped on top of the fine sand layer by physical straining (i.e. too large to pass)

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

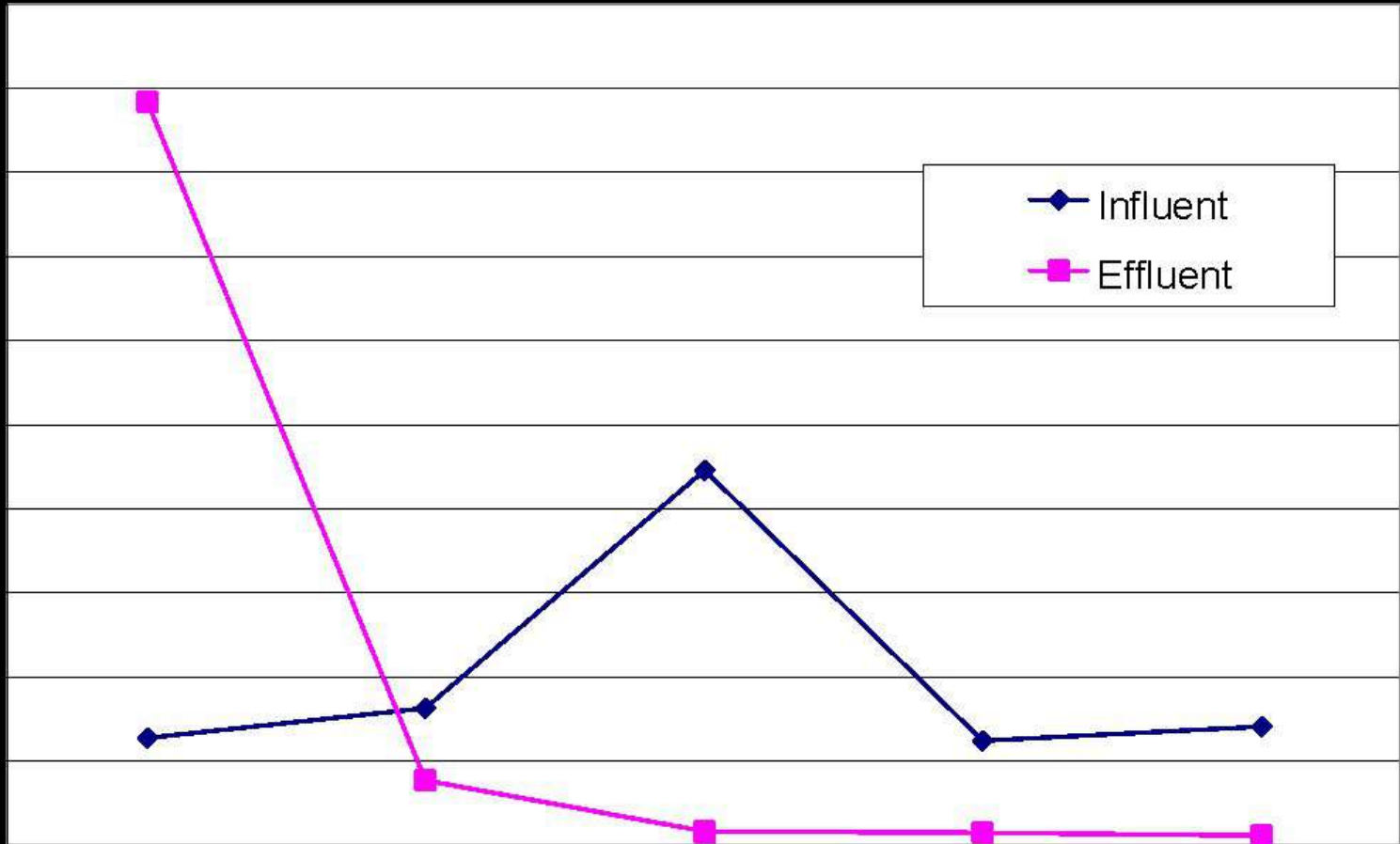
We have developed 4 configurations for the ABF:

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

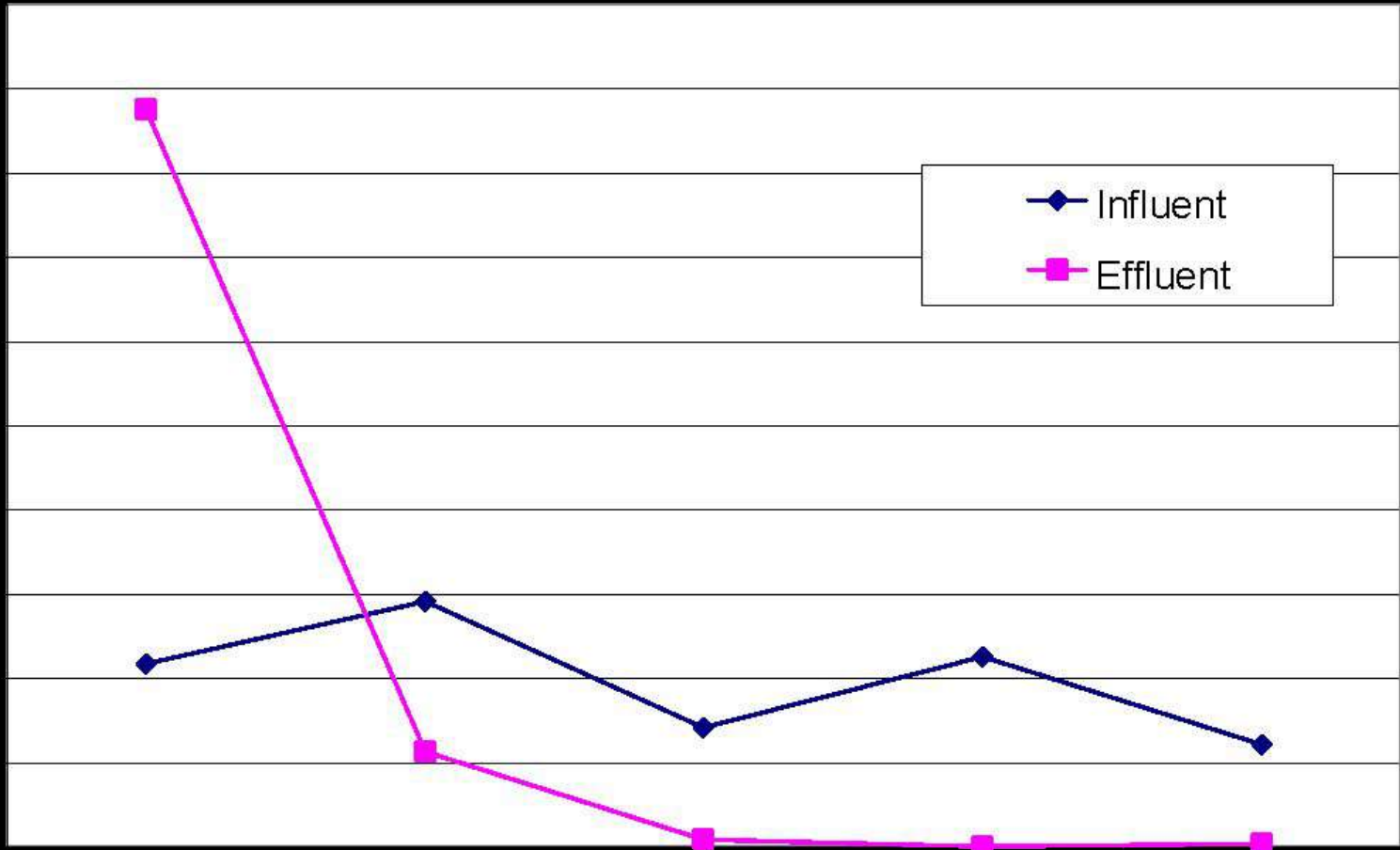




Filter Performance: Arsenic (n=650)



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

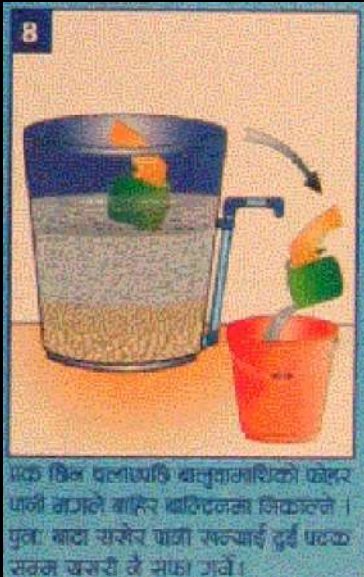


Remove diffuser basin



Stir the uppermost $\frac{1}{2}$ 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



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 January 2005

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 Patrika

आर्सेनिकको समस्या हटाउन सरल प्रविधिको फिल्टर विकास

● बिबेक राय
काठमाडौं

आर्सेनिकको प्रभावकारी फिल्टर विकास गर्न एक टोलीले नेपाल सरकारको सहयोगमा एक कार्यक्रम आयोजना गरेको छ। कार्यक्रममा आर्सेनिकको प्रभावकारी फिल्टर विकास गर्न एक टोलीले नेपाल सरकारको सहयोगमा एक कार्यक्रम आयोजना गरेको छ।

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Large Version of Kanchan Arsenic Filter



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

Lessons Learnt

- Improved Dugwells can be a best alternative option
- Improved Biosand filter is most effective option among other filters
- Need to promote Rainwater harvesting, Sand filter for pond water
- Need Demonstration Village !
- While conducting health survey, individual with basic training on diagnosis is sufficient
- Individual interest
- Individuals working in GOs are not supportive towards ENPHO
- Need authorization or certification for product
- Lack of recognition body
- Bitter Experience !!!

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 !