

Arsenic Contamination in Ground Water

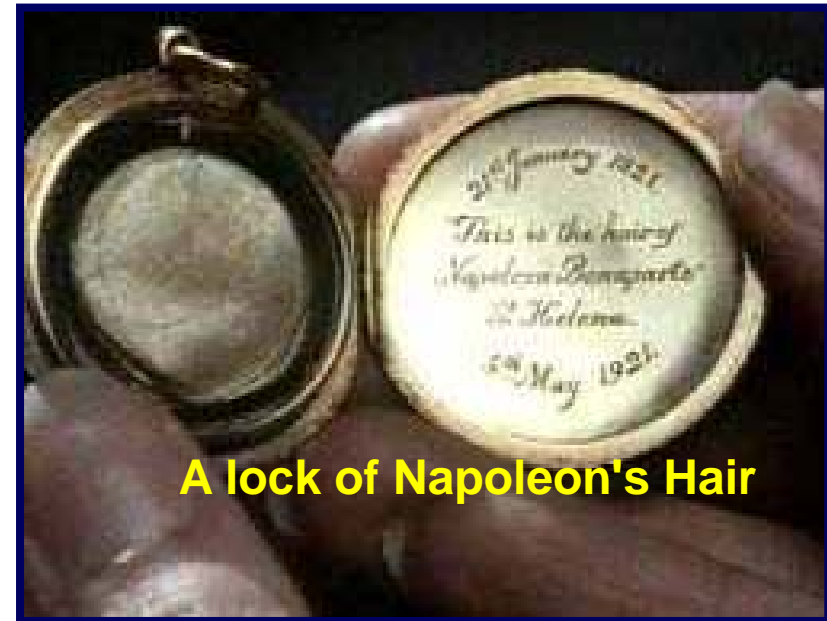


Arsenic Mitigation: The Way Forward

Dr.Ashok Ghosh
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Dept. of Environment and Water Management
A.N.College, Patna

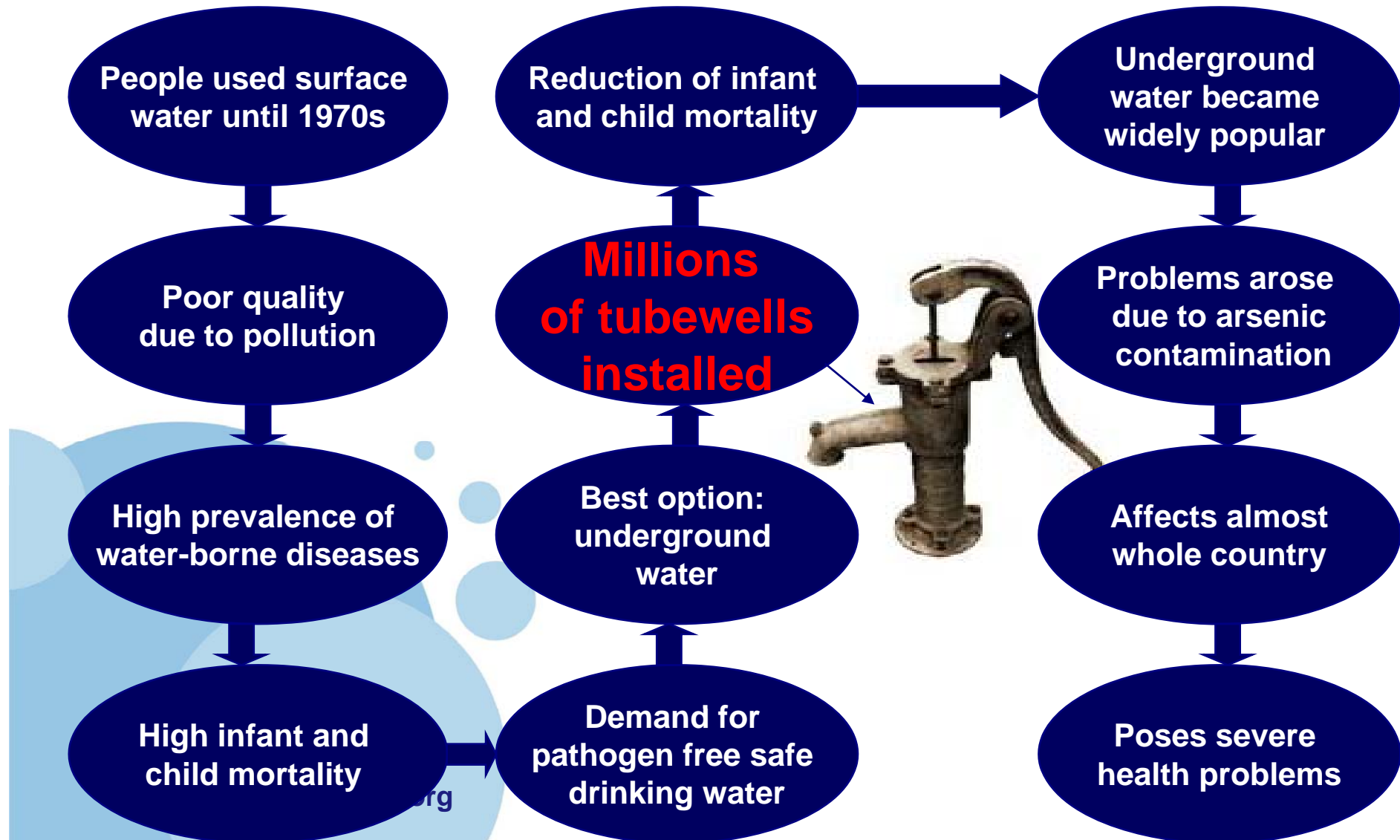


Napoleon Bonaparte

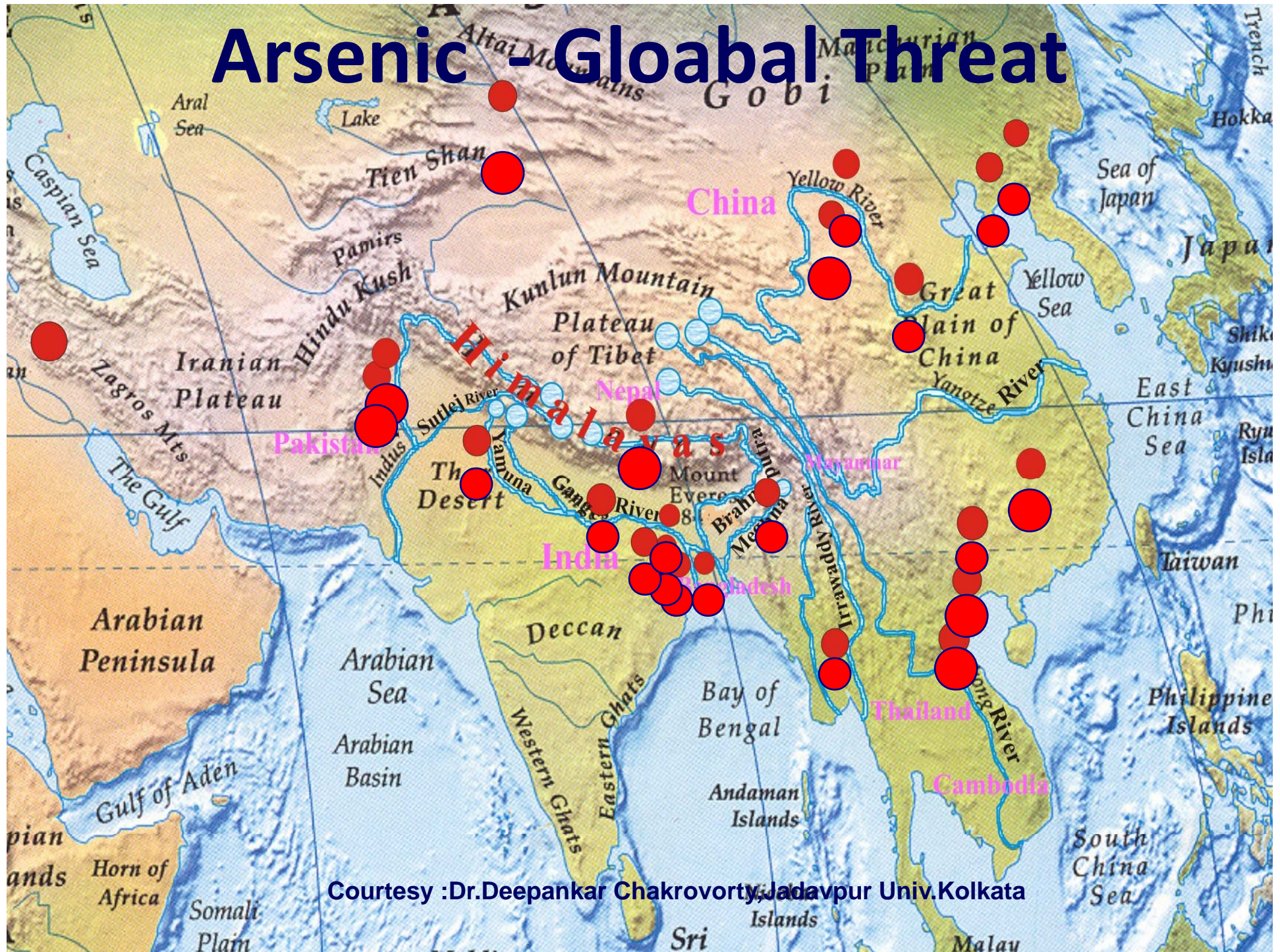


A lock of Napoleon's Hair

Origin of arsenic crisis in Indian subcontinent [switching from surface water to underground water]



Arsenic - Global Threat

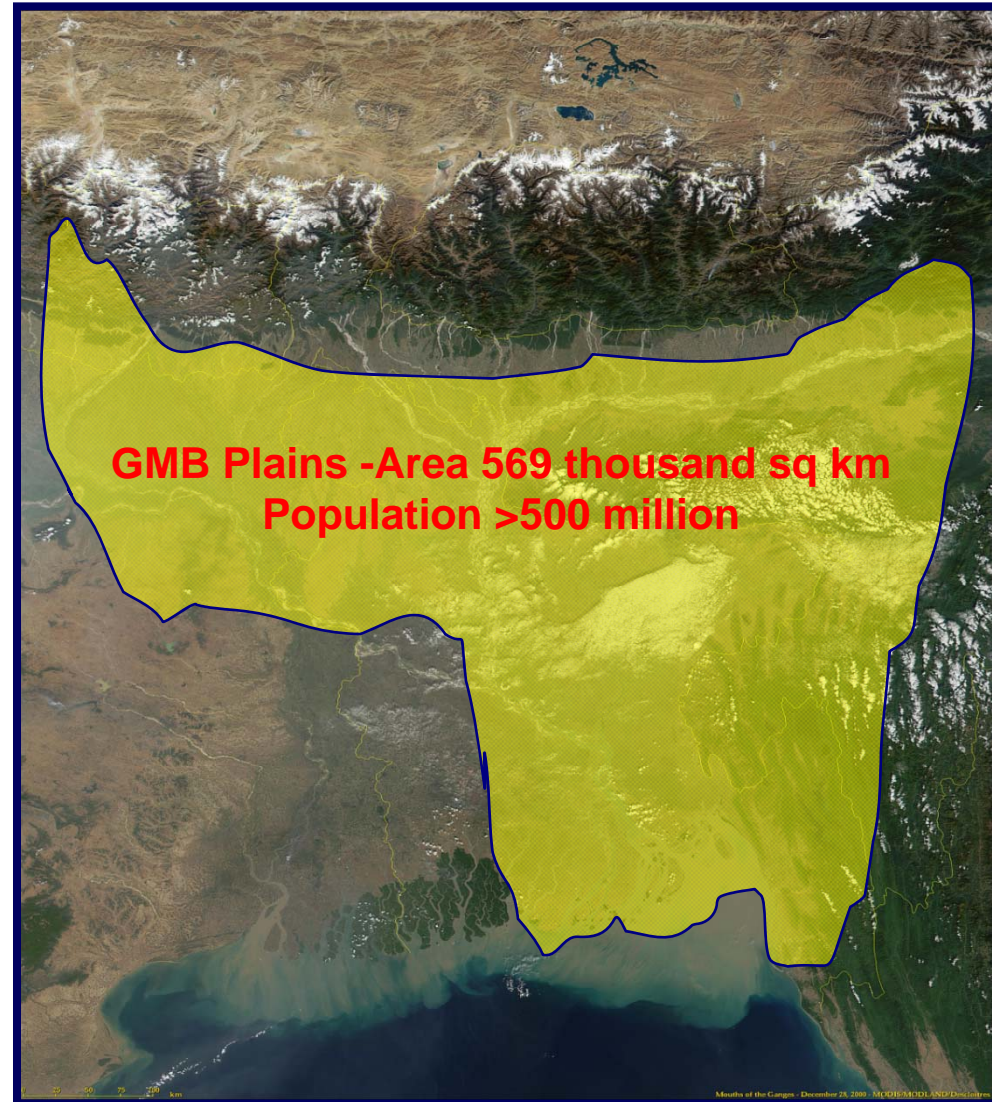


Courtesy :Dr.Deepankar Chakroverty,Jadavpur Univ.Kolkata



Arsenic in India
GANGA-
MEGHNA-
BRAMHAPUTRA
RIVER BASINS
Arsenic Hotbed

www.ancollege.org





Arsenic in Bihar

- In 2002 Mr. Kuneshwar Ojha, a school teacher living close to river Ganga in Ojhapatti, Bhojpur, became very concerned after his wife and mother died of liver cancer and other family members developed skin lesions.
- He took water samples from family tube well to SOES, Jadavpur University, Kolkata
- Subsequently, high Arsenic content was detected in these samples



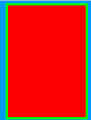
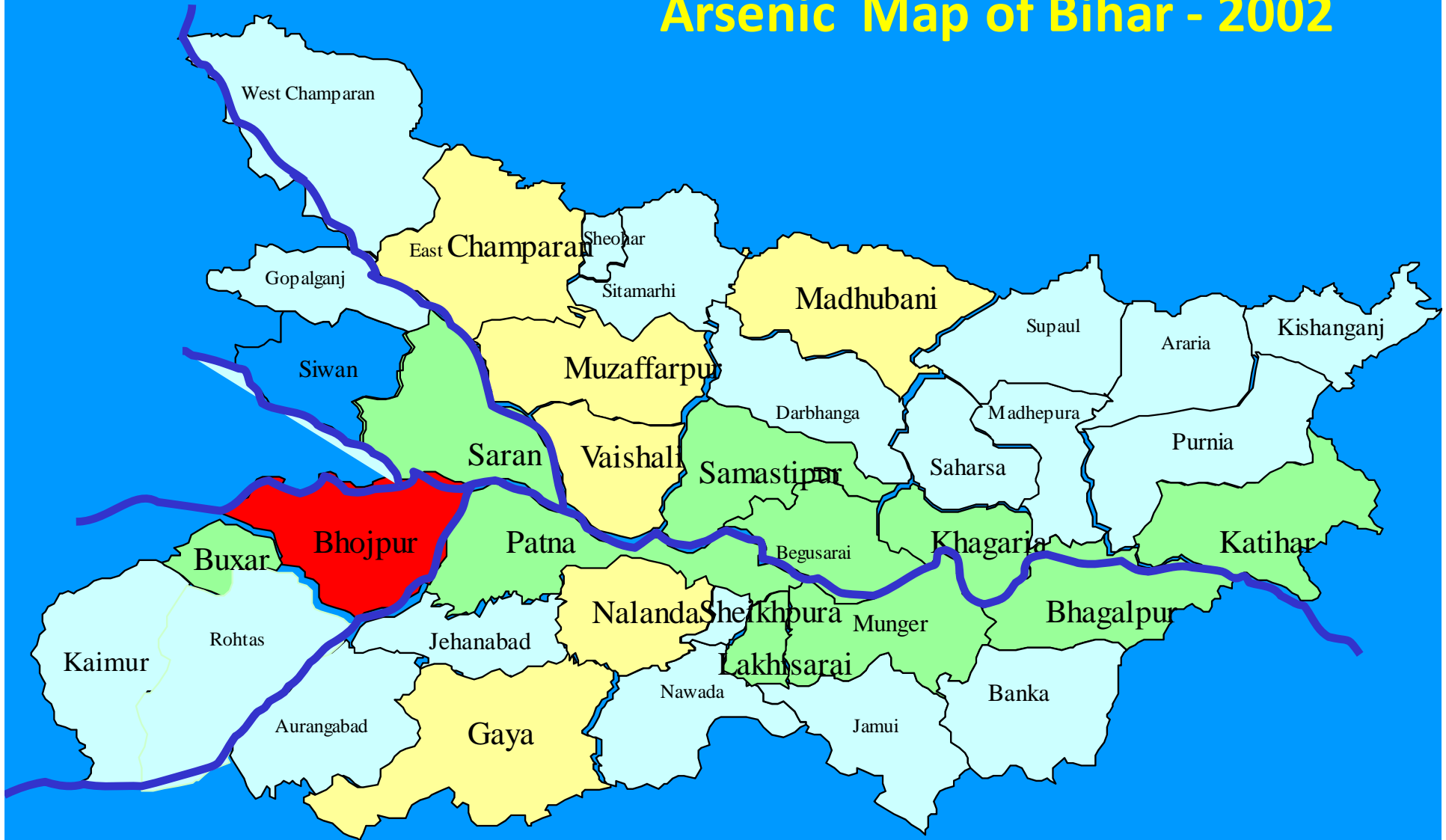
Mr. Kuneshwar Ojha



Arsenic in Bihar - Highly Arsenic Infested

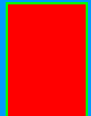
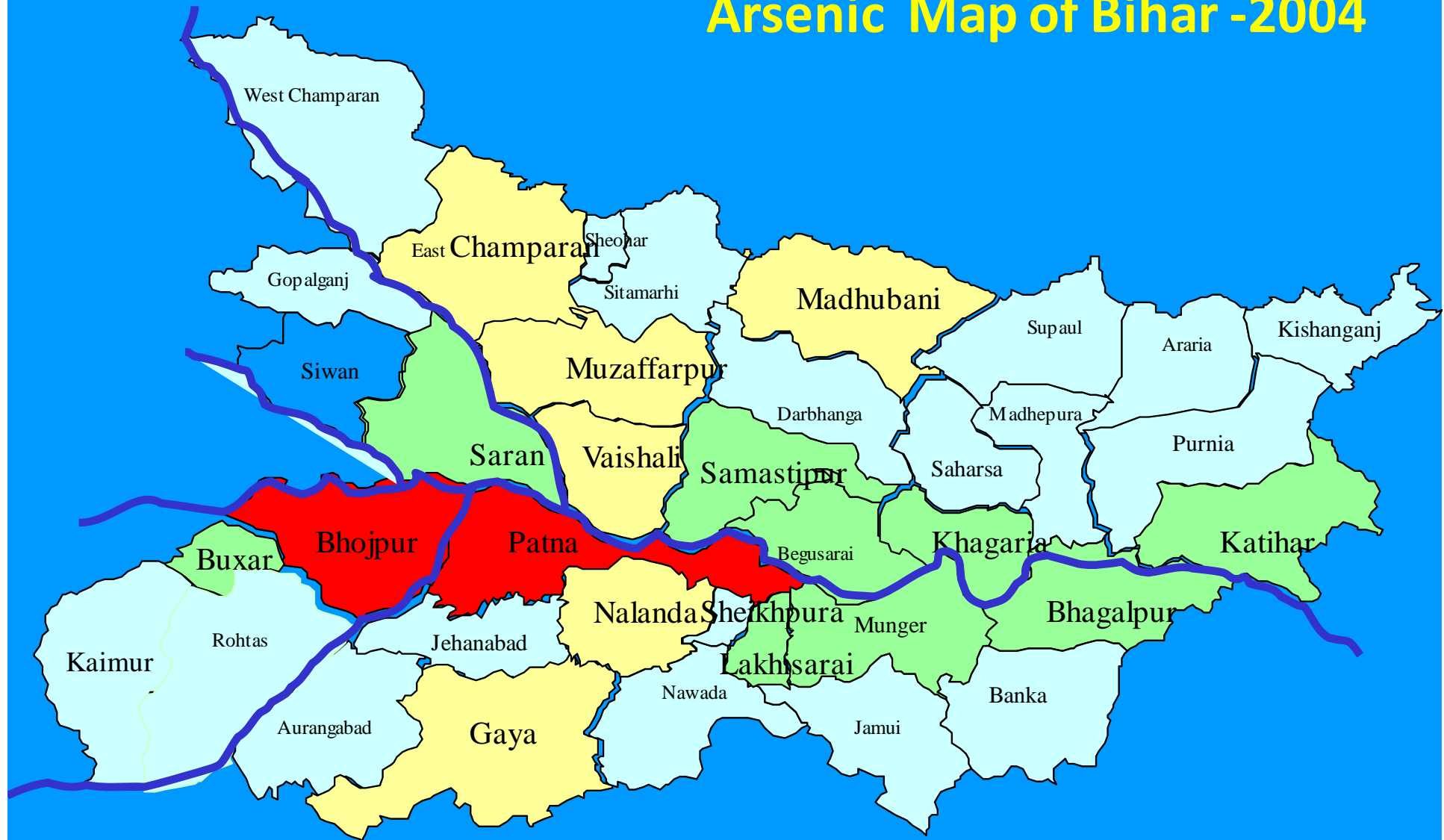


Arsenic Map of Bihar - 2002



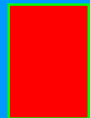
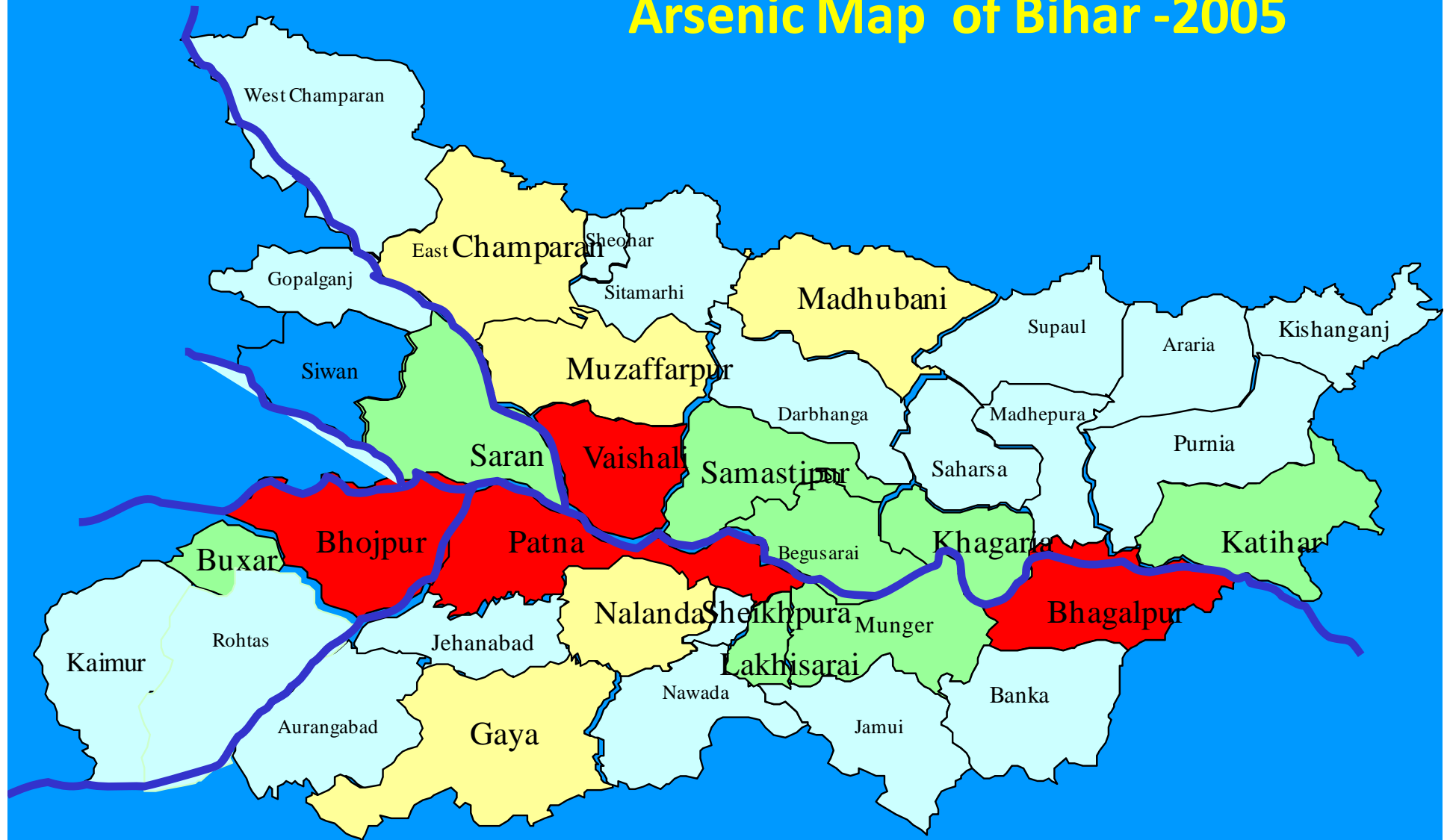
1 Arsenic Affected District

Arsenic Map of Bihar -2004



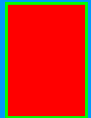
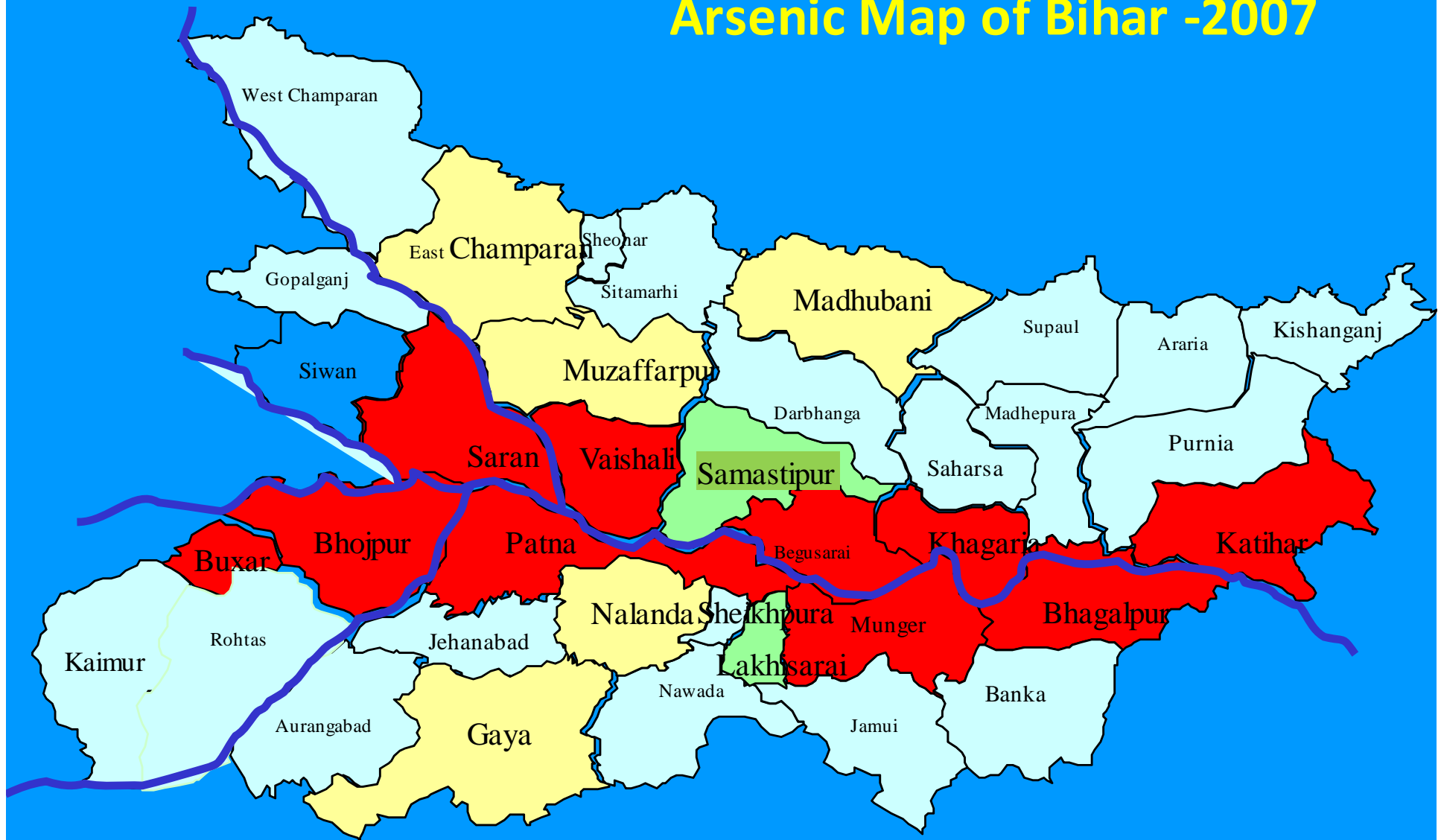
2 Arsenic Affected Districts

Arsenic Map of Bihar -2005



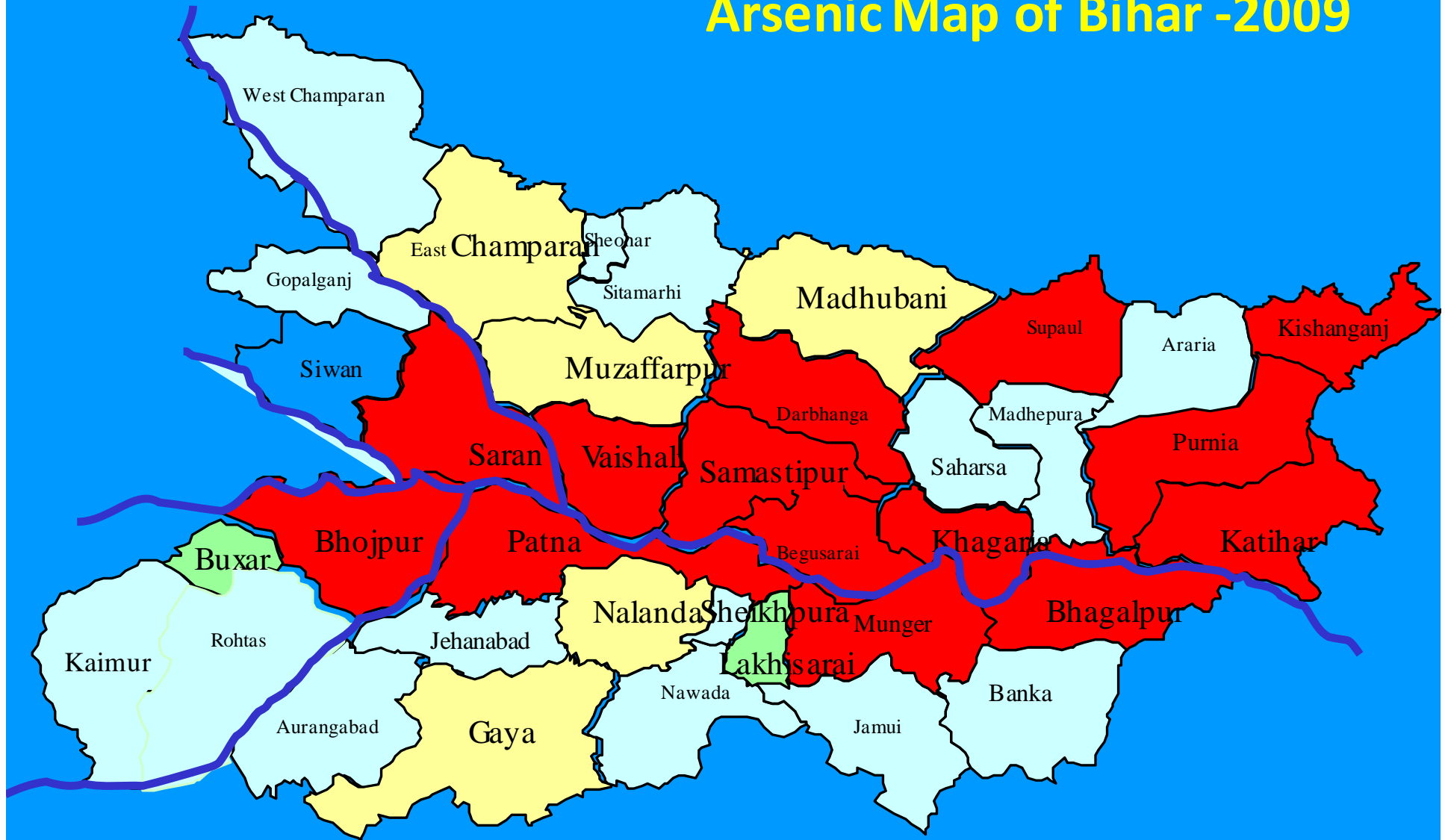
4 Arsenic Affected Districts

Arsenic Map of Bihar -2007



12 Arsenic Affected Districts

Arsenic Map of Bihar - 2009



16 Arsenic Affected Districts

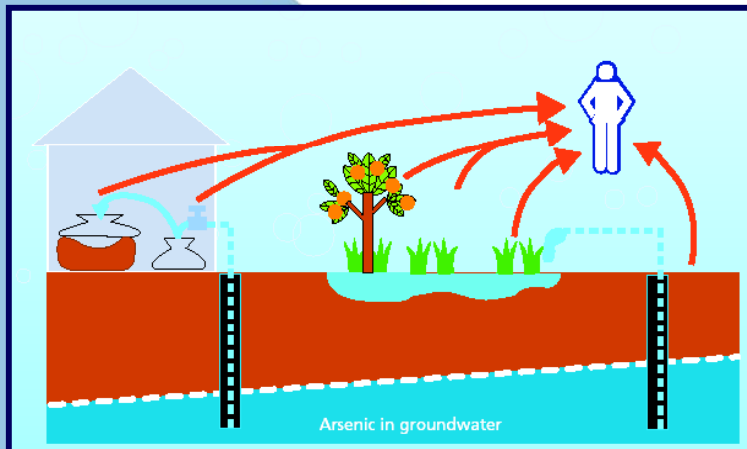


Sources of arsenic affecting human health



Arsenic Ingestion Routes

- Drinking Water
- Irrigation Water - Food Chain
- Burning Cowdung Cake





The Hottest Arsenic Hand Pump of Bihar 1860 ppb - Panday Tola, Bhojpur



Panday Tola – 100 % hand pumps with arsenic > 50 ppb



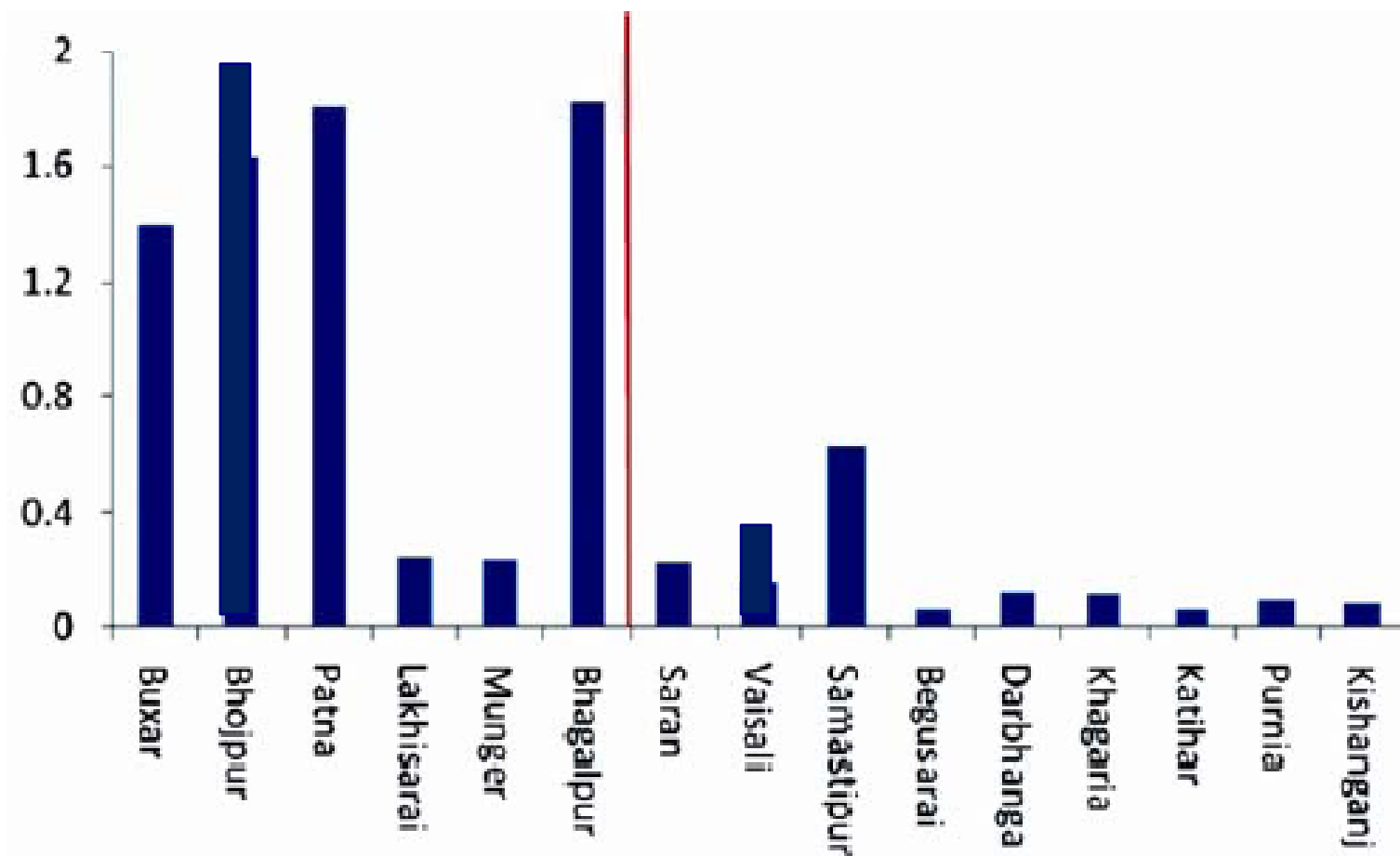
Krishna Kumar Panday



Arsenic Concentration of 1861 ppb



Maximum As. Conc. In Different Districts of Bihar in mg/l





BIHAR FINDINGS (Ghosh et.al.-2008)

- 7,218 of 27,061 hand pumps tested had arsenic contaminated water of >10 ppb. [26.67%]
- Highest As. Value Recorded – **1861 ppb**
- A total of **16 Bihar districts (57 blocks)** are affected by high level of arsenic in the groundwater
- **Trivalent arsenic 87 %** in ground water of Bihar
- Worst-affected districts are **Bhojpur, Buxar, Vaishali, Bhagalpur, Samastipur, Khagaria, Katihar, Chapra, Munger and Darbhanga.**





Arsenic in food chain of Bihar Food Chain



Irrigation Tube well = As 980 ppb

Arsenic in River Water – Jamunia, Bhagalpur



As Content > 50 ppb

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आर्सेनिक का बढ़ता दायरा

तिलका मांझी विश्वविद्यालय भागलपुर के वनस्पति विभाग की टीम ने डा. सुनील कुमार चौधरी और पटना स्थित अनुग्रह नारायण कॉलेज के पर्यावरण और जल प्रबंधन विभाग के डा. एके घोष के नेतृत्व में एक सर्वे किया। इसमें भागलपुर होकर बहने वाली जमनिया नदी की सतह पर भी आर्सेनिक की मौजूदगी पायी। जमनिया नदी गंगा से लिंक नदी है और इसी नदी के पानी का ट्रीटमेंट कर भागलपुर के लोगों को पानी आपूर्ति की जाती है

Source:http://hindi.indiawaterportal.org/pollution_arsenic



Consequences of Arsenicosis



Consequences of arsenicosis (Health)

Health consequences

Dermatological

Respiratory

Gastrointestinal

Cardiovascular

Hepatic

Neurological

Haematological

Renal

Mutagenesis

Reproductive

Cancer

Mental health





Consequences of arsenicosis

Social consequences

Social
hazards/instability

Marriage related
problems

Stigmatization

Superstition

Poverty



A few arsenic poisoning symptoms in Bihar detected by my research group

Gift of home coming.....Keratosi



Ram Ashan Panday – Ex Army Man – Developed Symptoms after his Return to native village - Panday Tola, Bhojpur



Diffuse and Spotted Keratosis on Palm





Gift of home coming.....



Kisan Panday
Ex army man
developed
symptoms after his
return to native
village, PandayTola,
Bhojpur six years
ago.



Low Blood Pressure and Anemic



Wife of Munna Panday
[25 years old
with 4 children] –
Arsenicosis with low
Blood Pressure – Panday Tola,
Bhojpur, Bihar



Arsenicosis with Low BP



**Aunty of Munna Panday [45 years] – Panday
Tola, Bhojpur, Bihar**

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Hypertension – Depression



Anuj Panday of Panday Tola with early symptom of arsenicosis has very high BP and depression - due to uncertain future



Arsenic Toxicity and Obstetric Outcome

Arsenic in drinking water = **630 $\mu\text{g/L}$**

Arsenic in urine = **900 $\mu\text{g/L}$**

Anita Devi expired in 2007 due to
arsenic poisoning

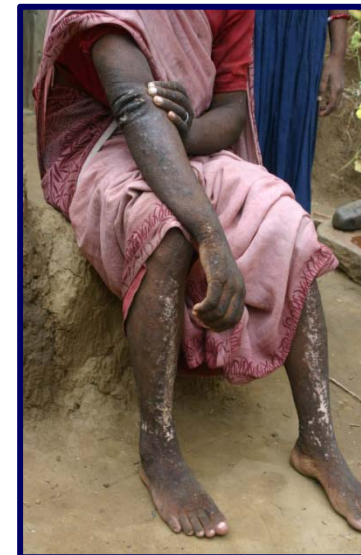
Obstetric outcome of Anita Devi, Maner, Patna

First Pregnancy: **Preterm Stillbirth**

Second Pregnancy: **Abortion**

Third Pregnancy: **Early neonatal death**

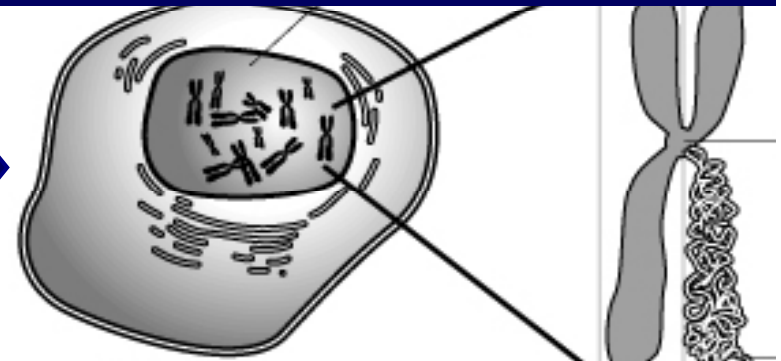
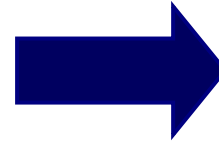
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Arsenic Induced Cytogenetic and Gene Mutation

Chromosomal anomalies
Cytogenetic Mutation



Cell

Arsenic – A
human
carcinogen

Genotoxic events
Gene Mutation

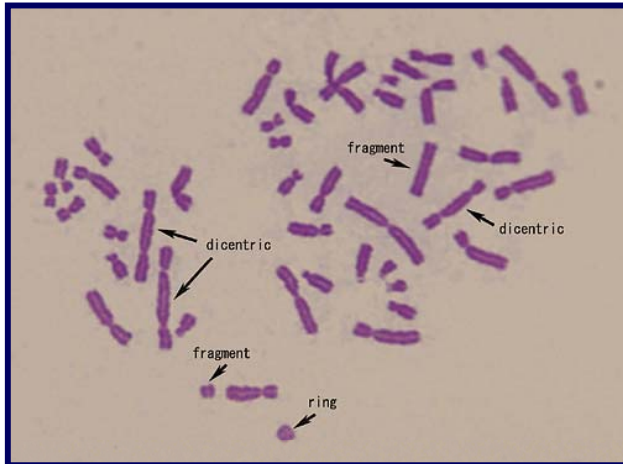


Base Pairs

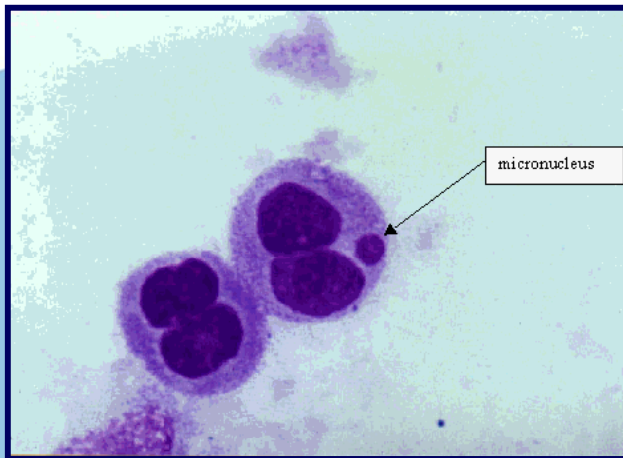




Genotoxicity of Arsenic in humans

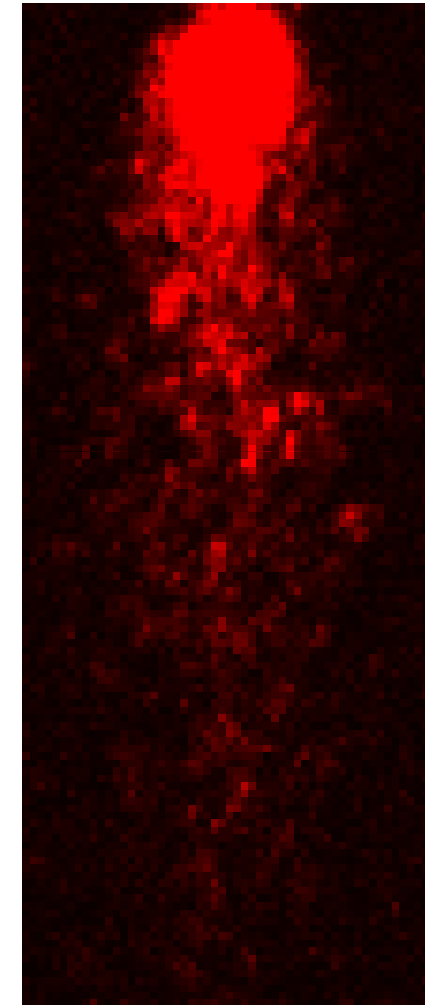


Chromosomal Aberrations



Micronuclei

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DNA Damage



Some additional findings

- Consistent dose-response relationships were found between As. exposure and risk of skin lesions.
- Thinner/weaker persons are more likely to be affected by As exposure.
- Use of fertilizer and excessive sun exposure increase the susceptibility to risk of skin lesions due to Arsenic exposure.
- Tobacco smoking and high level of Arsenic exposure synergistically increase the risk of skin lesions and cancer.



Other emerging health problems identified by our research group

- Adverse relationship between arsenic level and intelligence in young children?
- Adverse affect on foetus
- Low birth weight
- Obstructive airway diseases in young adult and children



Factors which may aggravate Arsenicosis

- Type of arsenic and level of exposure
- Body immunity and genetic configuration plays significant role
- Nutritional status and food habit
- Low haemoglobin level may enhance ill effects of arsenic



Arsenic Management

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Management of arsenicosis

- Arsenic free safe water
- Dietary Supplement and anti-oxidant fruits/vegetables/protein is important along with application of ointment (5 – 20% Urea and salicylic)
- Complicated cases like skin cancer, ulcer, gangrene needs specialized medical and surgical management
- Social, economic and physical rehabilitation.
- Mass community awareness and support to develop community based rehabilitation system.



Improvement by Drinking Arsenic Free Water

A 37 years old female (ID no. 022), right palm



Before provision of arsenic-safe water



6 months after provision of safe water



12 months after provision of safe water

B 47 years old male (ID no. 119), abdomen



Before provision of arsenic-safe water



6 months after provision of safe water



12 months after provision of safe water



MAJOR PROBLEMS OF “ARSENICOSIS” MANAGEMENT

- Lack of knowledge information and training for case detection and management by field workers
- Poor community motivation for safe water use complicated by physical nature of arsenic in water (tasteless, colorless and odorless)
- Socio-economic hazards due to ill-conceived idea about “Arsenicosis”
- Poor Resource allocation for rehabilitation and treatment
- Indiscriminate installation of Tube-well both private and public sector



Lack of Awareness



- The unsafe sources (PAINTED RED) are still being used by villagers due to lack of awareness.
- Intensive awareness campaign is required in affected villages.



Arsenic Mitigation Options

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Arsenic mitigation strategies and sustainability

Options

Pond

Rainwater harvesting

Dug well

Water source

Surface

Rain

Sub-surface

Problems

- Pollution
- Accessibility
- Acceptability

- Collection
- Preservation
- Seasonal variability

- Bacterial contamination
- Acceptability

Feasibility

Low

Low

Better

Arsenic mitigation strategies and

Options

Deep well

Piped water

Arsenic removal filters

Water source

Deep aquifers

Deep aquifers/treated
Surface water

Arsenic contaminated
water

Problems

- Uncertain
- Expensive

- Expensive
- No infrastructure

- Effectiveness?
- Expensive
- Environmentally
problematic

Feasibility

Better but.....

Low

Better



Most of mitigation strategies have failed in Bihar



Results of Arsenic Mitigation Strategies



**REDUNDENT RAINWATER
HARVESTING UNIT**



**DEFUNCT OVERHEAD TANK TO TAP
SAFE AQUIFER**



**REDUNDENT RESTORED
OPEN WELL**



Rs.53 Crore GoB initiative in Bhojpur



- Ganga Water to be supplied after treatment
- Dependent on electric power , a scarce commodity in Bihar
- Ganga is shifting from its current location as per our studies

GOVERNMENT OF BIHAR PUBLIC HEALTH ENGINEERING DEPARTMENT P.H. DIVISION, ARA

NAME OF PROJECT

Design, Drawing supply of all materials, Execution, Testing and commissioning of works for multivillages rural piped water supply scheme for Arsenic affected villages/tolas of Bhojpur district on Turnkey basis.

CAPACITY OF TREATMENT PLANT

6.40 MLD

NAME OF PROJECT

Govt. of Bihar Public Health Engineering Department.

VALUE OF PROJECT

Rs. 53.91 Crores

COMPLETION PERIOD

30 months (Phase I & Phase II)

CONTRACTOR

IVRCL INFRASTRUCTURES PROJECT LTD.

HYDERABAD-500 057 (A.P)

Ganga Riv

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Sustainable arsenic mitigation technologies for rural population **[possible alternatives]**



Possible alternative I: Gravity driven filter

- Gravity Driven Filter not dependent on electricity
- Easy to maintain
- Easy to operate
- Low cost
- Quick disposal of backwash and sludge through bioremediation





Possible Alternative II- TRADITIONAL DUGWELLS PROPERLY SANITIZED [Project Well Initiative]

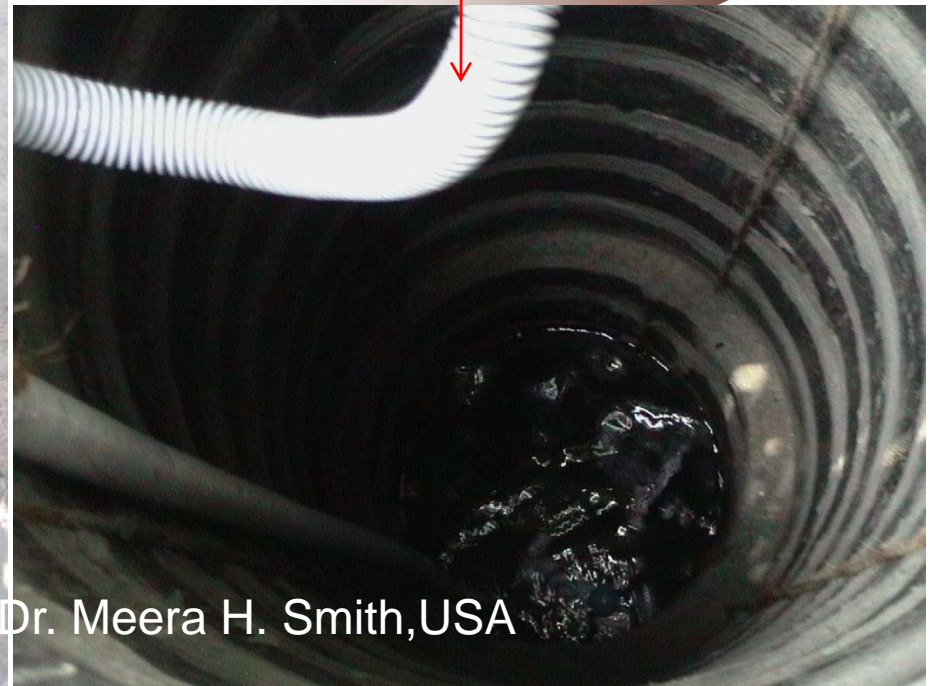


Courtesy :Project Well- Dr .Meera H. Smith, USA



The pvc pipe is shortened after insertion

The delivery pipe is flexible for self adjustable water level



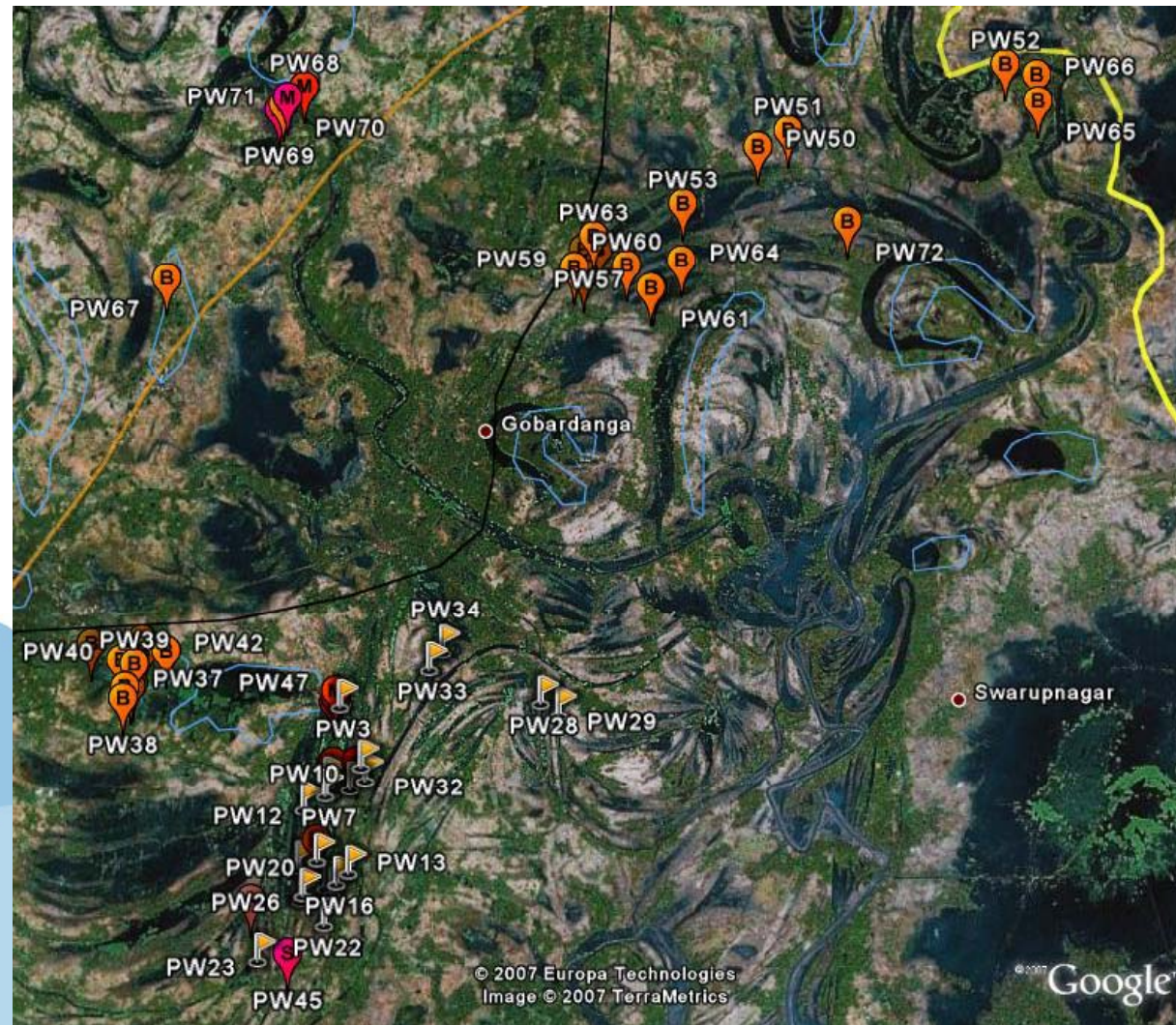
Courtesy :Project Well- Dr. Meera H. Smith, USA



**The net and the tin cover
are used for protection from
external debris and
tampering.**



There are 112 PROJECT WELL DUGWELLS as of 2009 in N24 PARGANAS, WEST BENGAL, INDIA



www.a

Courtesy :Project Well- Dr.Meera H. Smith

Possible alternative III: In Situ Arsenic Treatment [TiPOT technology of Queen's University Belfast, UK]



**Rangapur, Nilgunj (WB) Plant
Supported by World Bank**



Shower Head

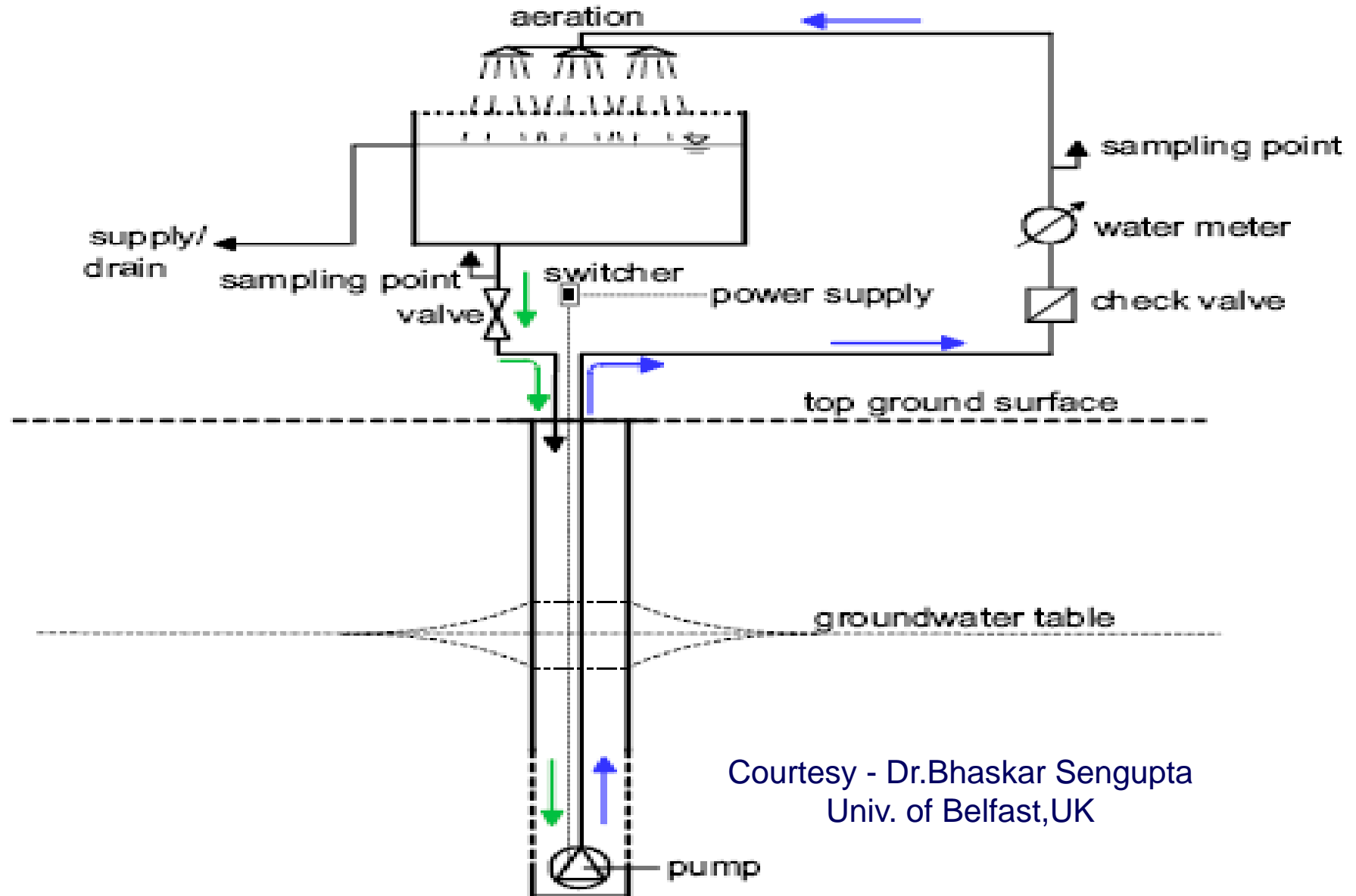
Courtesy - Dr.Bhaskar Sengupta
Univ. of Belfast, UK



In Situ Arsenic Treatment.....

- In the in-situ treatment method, the aerated tube well water is stored in feed water tanks and released back into the aquifers.
- The dissolved oxygen in aerated water oxidizes arsenite to less-mobile arsenate, the ferrous iron to ferric iron and Manganese(II) to Manganese(III), followed by adsorption of arsenate on Fe(III) and manganese(III) and subsequent precipitation resulting in a reduction of the arsenic content in tube well water.
- Oxidation is further enhanced biologically by bacteria living in the subsurface - bioremediation

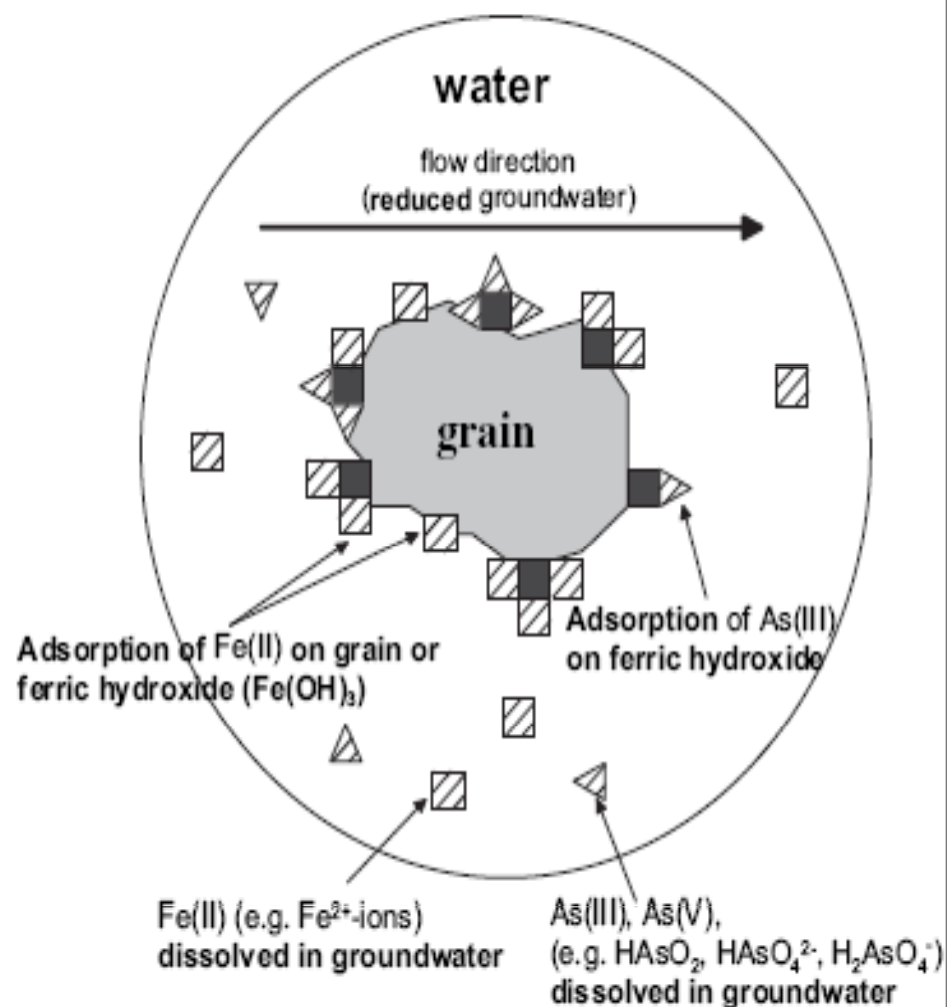
In Situ Arsenic Treatment.....



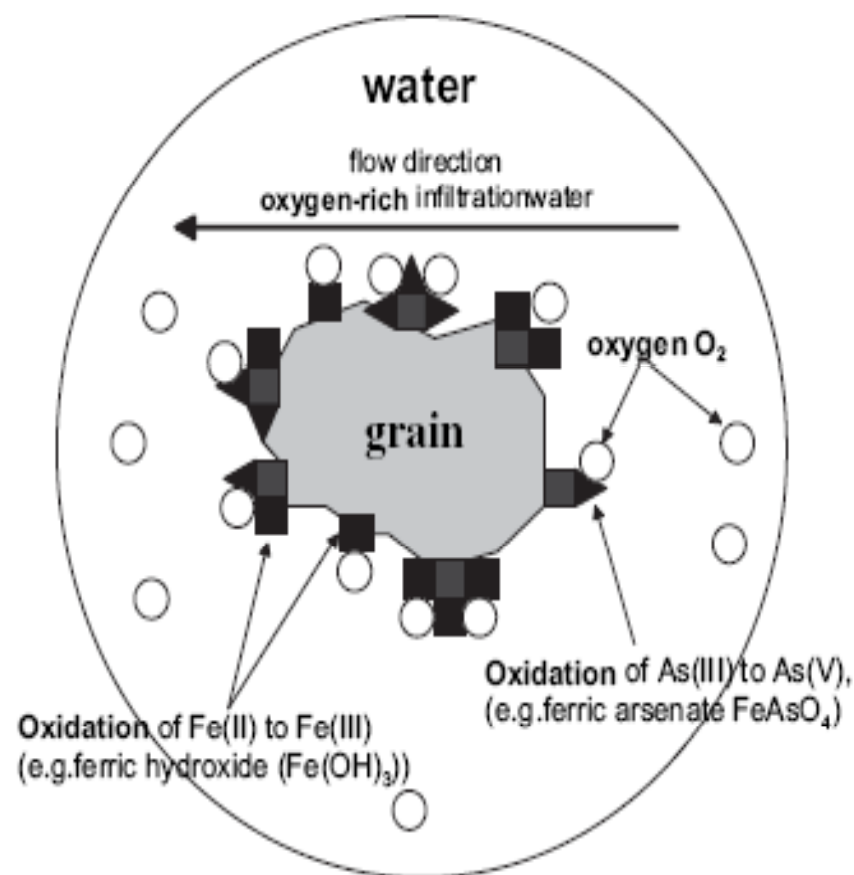
Courtesy - Dr. Bhaskar Sengupta
Univ. of Belfast, UK

In Situ Arsenic Treatment.....

Delivery/Adsorption-Phase



Infiltration/Oxidation-Phase



Courtesy - Dr. Bhaskar Sengupta
Univ. of Belfast, UK



Possible alternative IV -RO /nano membrane system attached with solar power





UNRESOLVED ISSUES RELATING TO ARSENIC CONTAMINATED DRINKING WATER SOURCES

- Research into Arsenic speciation, mobilization largely fragmented and repetitive
- Almost entire investigation into the hydro-geological aspects of arsenic contaminated aquifers have been confined to Bengal basin, the geological variations along the entire river basins warranting immediate attention.
- Lack of knowledge and medical infrastructure relating to diagnosis and treatment of arsenicosis.
- Lack of comprehensive database on arsenic contaminated aquifers and its implications
- Lack of maintenance and monitoring of mitigation structures
- **Lack of Community Participation**



Vision of the Action Group Solution Exchange –Water Community

Establishing a multi-disciplinary, holistic
Centre of Excellence for Arsenic Studies
in the sub-continent, that will bypass
political boundaries, and work for
comprehensive solution to the scourge
of arsenic.



Centre of Excellence for Arsenic Studies

AIMS & OBJECTIVES

- To preserve and conserve the quality of ground water reserves in terms of Arsenic contamination.
- To prepare and maintain a comprehensive database on all issues related to arsenic contaminated ground water.
- To provide low-cost, local resource–based, sustainable mitigation strategies to the rural poor
- To provide consultancy and linkage to communities, research organizations, NGOs & funding agencies in water sector .



YES

*We strive for
Community based
Knowledge!*

THANKS

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