

Effect of arsenic risk assessment in Pakistan on mitigation action

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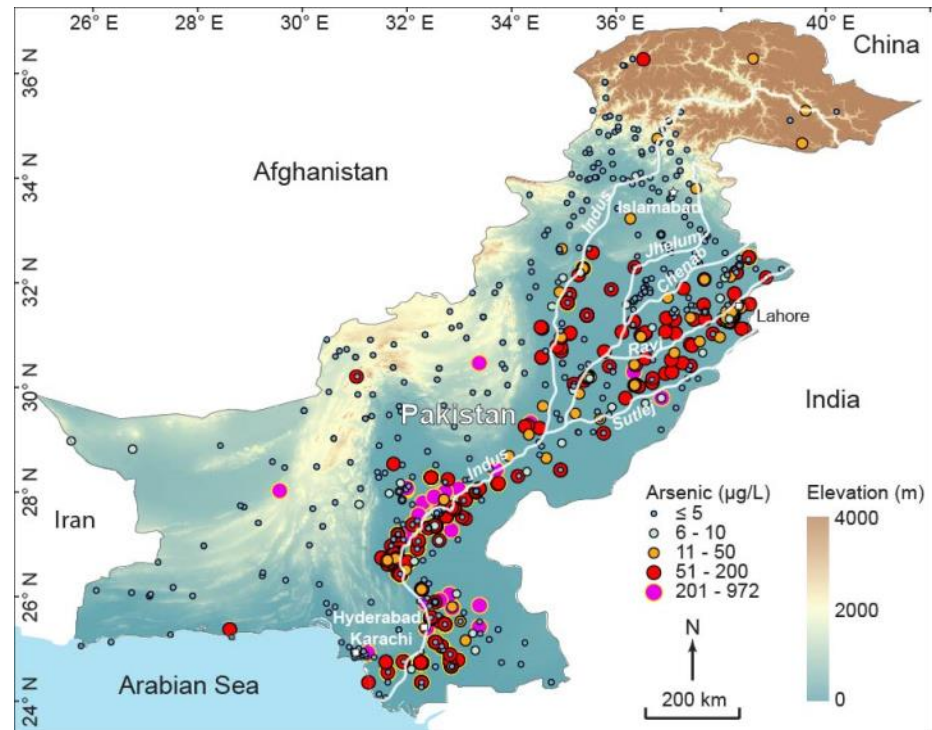


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Goals of study

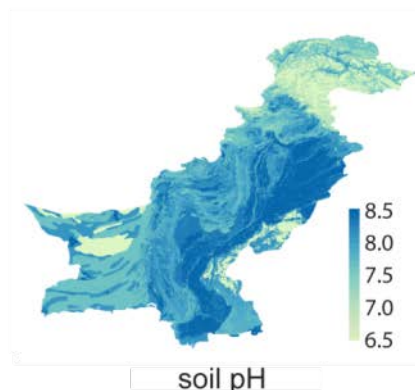
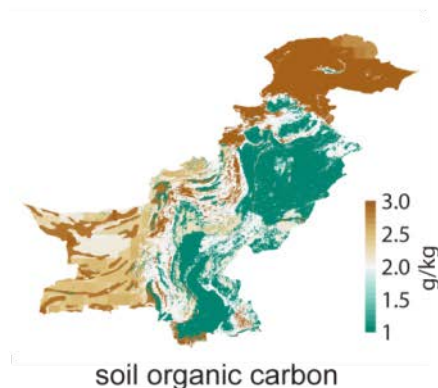
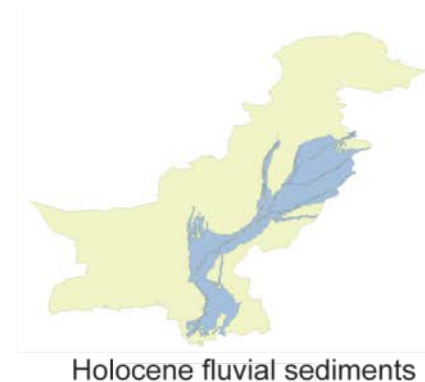
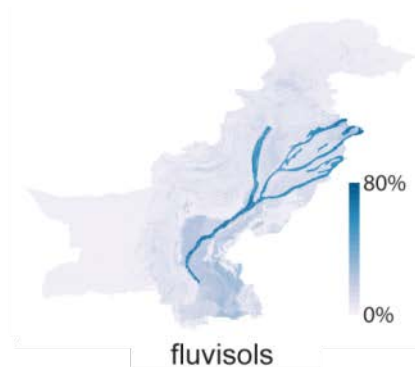
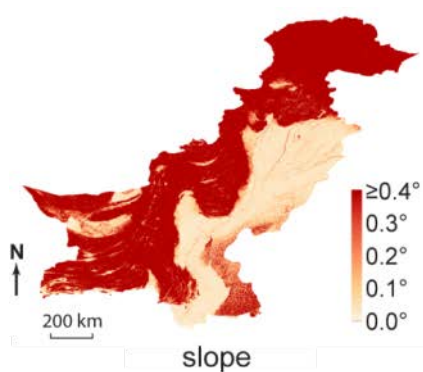
- Collect groundwater samples from across Pakistan and analyze for arsenic:



- Create hazard model of As-contaminated aquifers based on statistical relationships with determining factors
- Estimate risk to population of As exposure
- Deduce processes responsible for As accumulation

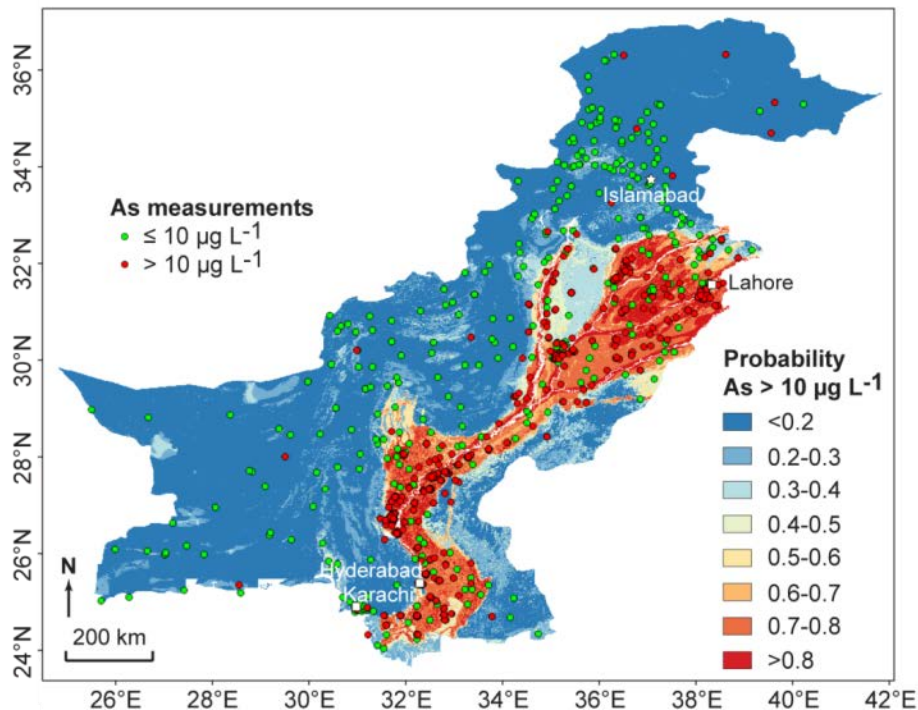
Modeling procedure

- 1262 measurements averaged to 743 data points
- Dataset made binary based on the WHO guideline of 10 $\mu\text{g/L}$
- Logistic regression run 1000 times with forward & backward stepwise variable selection; 80% training / 20% testing
- Predictor variables used:

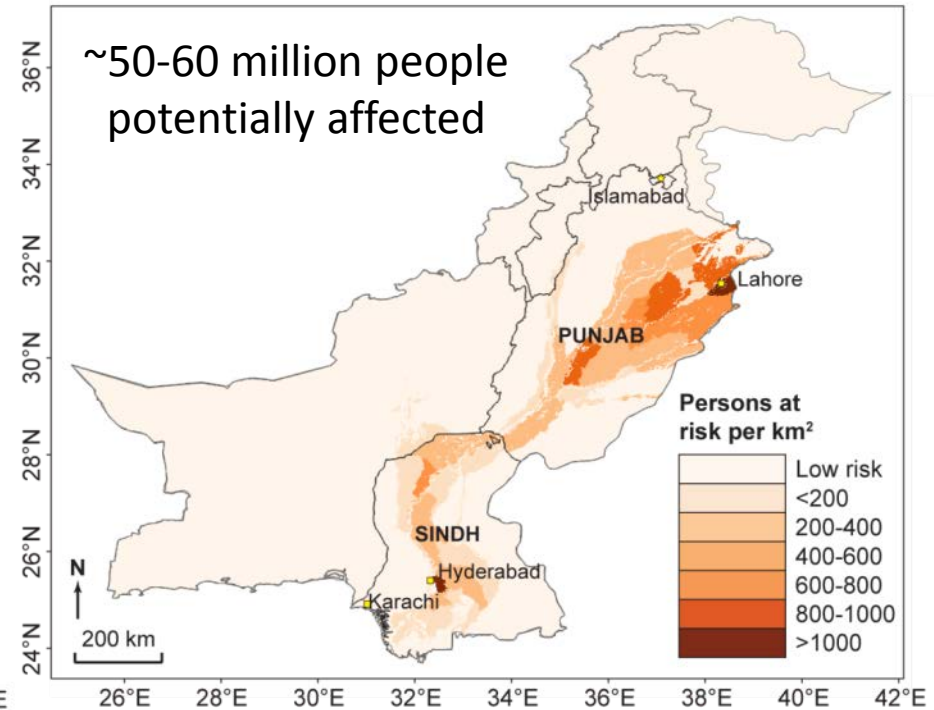


Study results

Probability of As > 10 µg/L in groundwater



Population at risk of exposure to groundwater As > 10 µg/L



- Arsenic release into groundwater in a generally oxidizing environment with localized pockets of reductive dissolution
- Arsenic likely released by pH-induced desorption
- Higher concentrations due to evapotranspiration and shallow aquifer gradients

Media attention



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Extensive arsenic contamination in high-pH unconfined aquifers in the Indus Valley

Joel E. Podgorski^{1,*}, Syed Ali Mushtab Akber Shah Eqani^{2,3}, Tasawar Khanam², Rizwan Ullah⁴, Heqing Shen...

* See all authors and affiliations

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Science & Environment

'Alarming high' levels of arsenic in Pakistan's ground water

By Matt McGrath
Environment correspondent



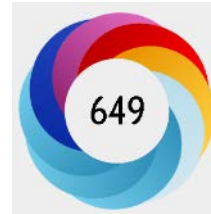
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Arsenic in Pakistan groundwater 'alarming high': study

By AFP
PUBLISHED: 19:50 BST, 23 August 2017 | UPDATED: 19:50 BST, 23 August 2017

Altmetric



In the top 5% of all research outputs scored by Altmetric

High Attention Score compared to outputs of the same age (99th percentile)

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New Delhi Times



Reaction in Pakistan

- Intensive debates in the media among government officials, concerned citizens and other researchers
- Pakistan supreme court expressed concern about high arsenic levels
- Rejection of the study by the Pakistani senate and local researchers, but later confirmed by widespread surveys:
 - Shahab, A., Qi, S., & Zaheer, M. (2018). Arsenic contamination, subsequent water toxicity, and associated public health risks in the lower Indus plain, Sindh province, Pakistan. *Environmental Science and Pollution Research*, 1-21.
 - Shakoor, M. B., Bibi, I., Niazi, N. K., Shahid, M., Nawaz, M. F., Farooqi, A., ... & Lüttge, A. (2018). The evaluation of arsenic contamination potential, speciation and hydrogeochemical behaviour in aquifers of Punjab, Pakistan. *Chemosphere*, 199, 737-746.



World Health Organization (WHO) mission

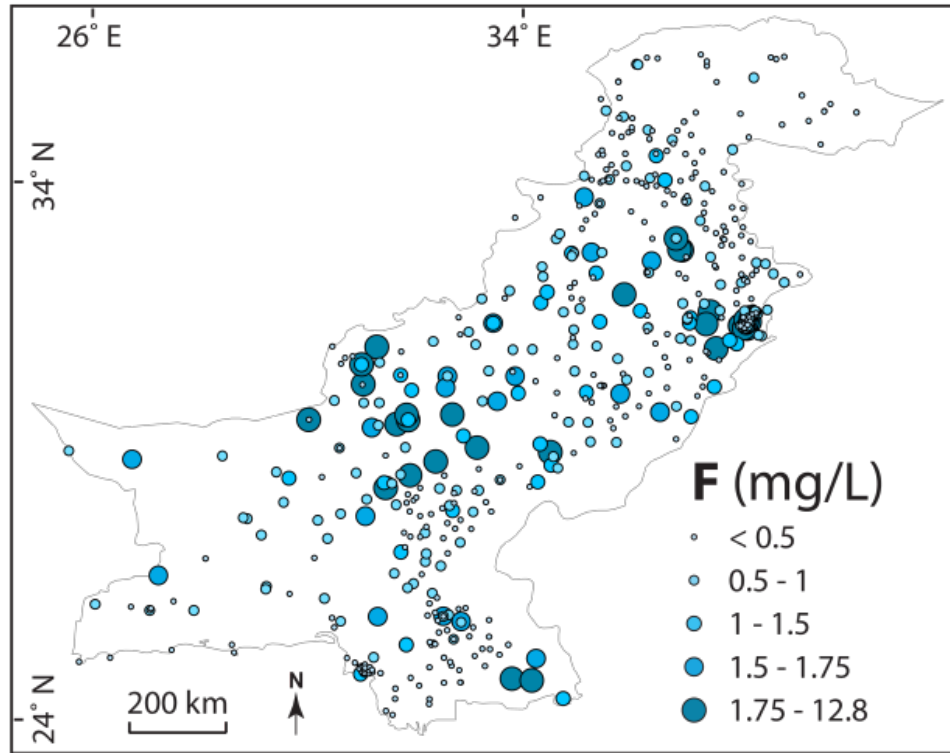
- Publication incited a special WHO envoy to Pakistan with the objectives:
 - Management of arsenic in drinking water sources
 - Public health assessment and management of arsenicosis and other health impacts of arsenic
- Example activities:
 - Advising on national mapping of arsenic in all drinking water sources
 - Advising on establishing a provincial level drinking water quality surveillance system
 - Advising on an epidemiological survey to determine arsenicosis prevalence
 - Visits to arsenic hotspots to assess local situation
 - Develop integrated approach to minimize As exposure
 - Improve detection & management of health impacts



Outcome of WHO mission

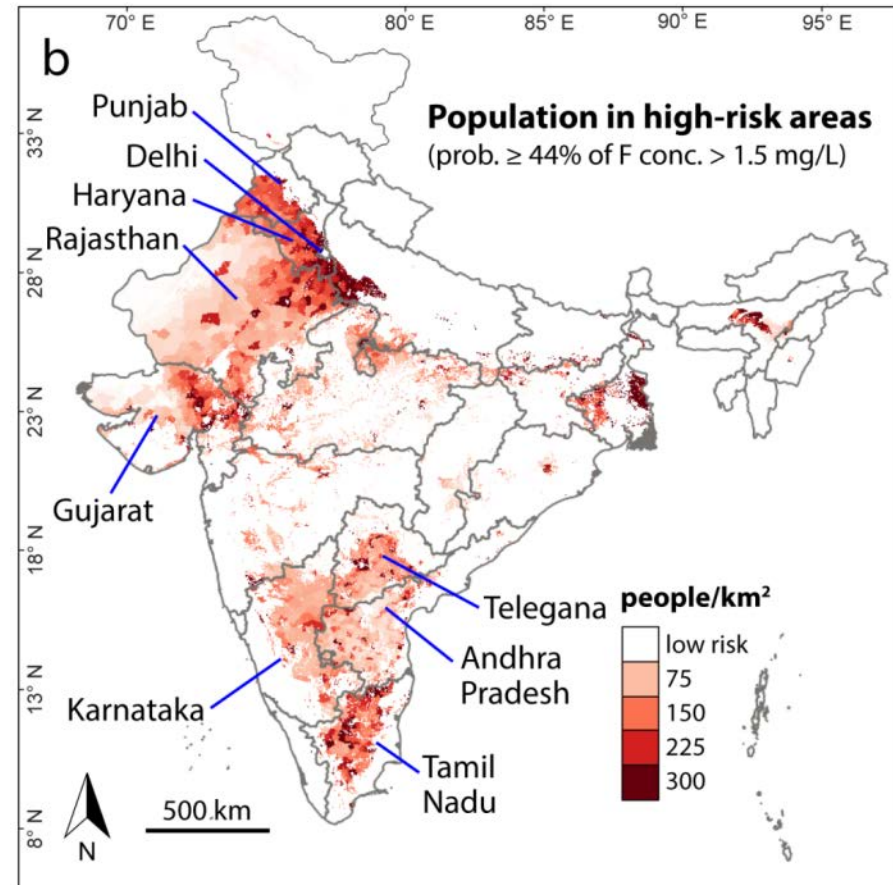
- WHO compared their own report and found agreement with our study as well as reports from:
 - Pakistan Council of Research in Water Resources (PCRWR)
 - Water and Sanitation Agency Pakistan (WASA)
 - UNICEF Pakistan
- Pakistan government eventually sided with WHO to launch national action plan and country-wide survey

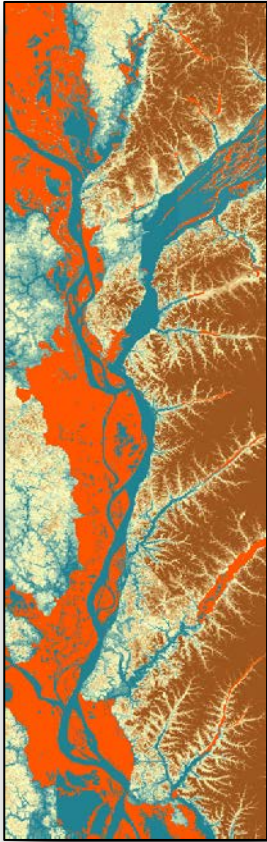
Study of fluoride in groundwater in Pakistan



Existing groundwater fluoride concentration measurements (n=450) collected by COMSATS Institute in Islamabad.

~400 additional fluoride samples have been analyzed in Eawag labs with more to come





Groundwater Assessment Platform GIS-based mapping and modelling



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www.gapmaps.org

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aquatic research ooo

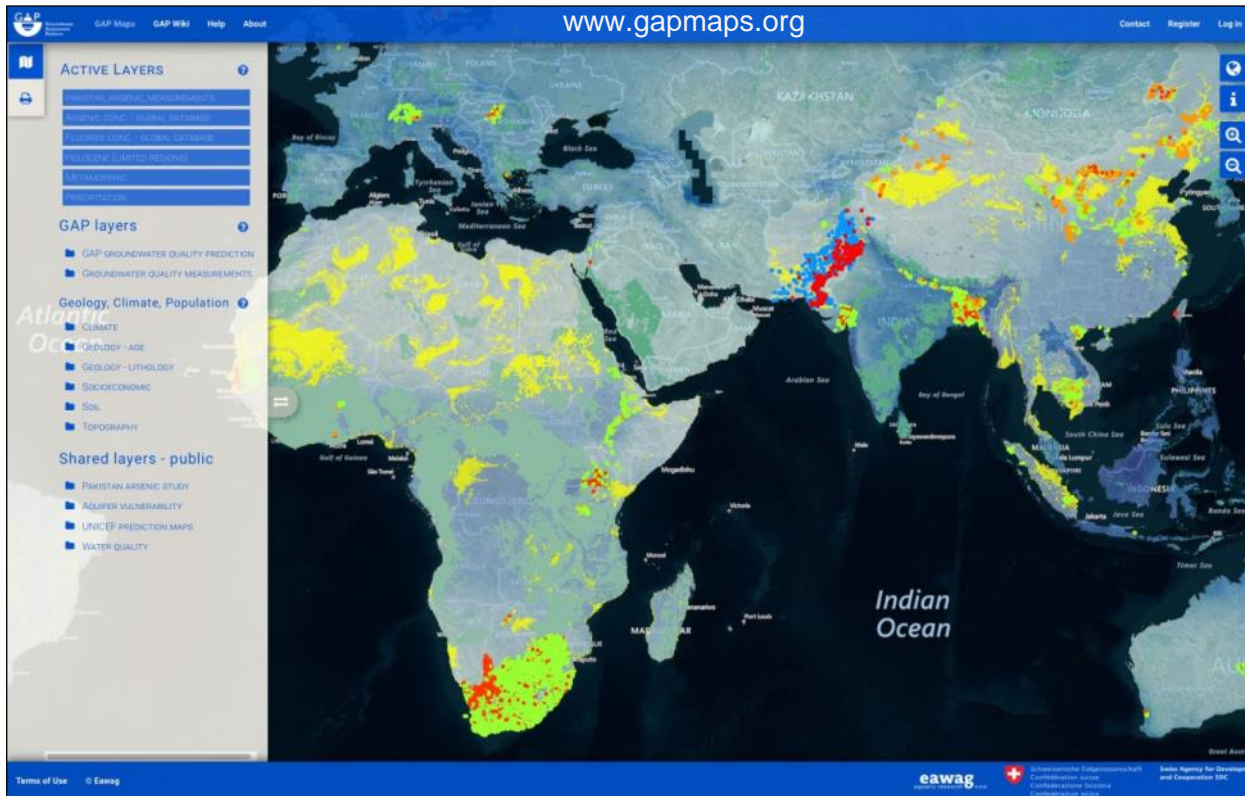


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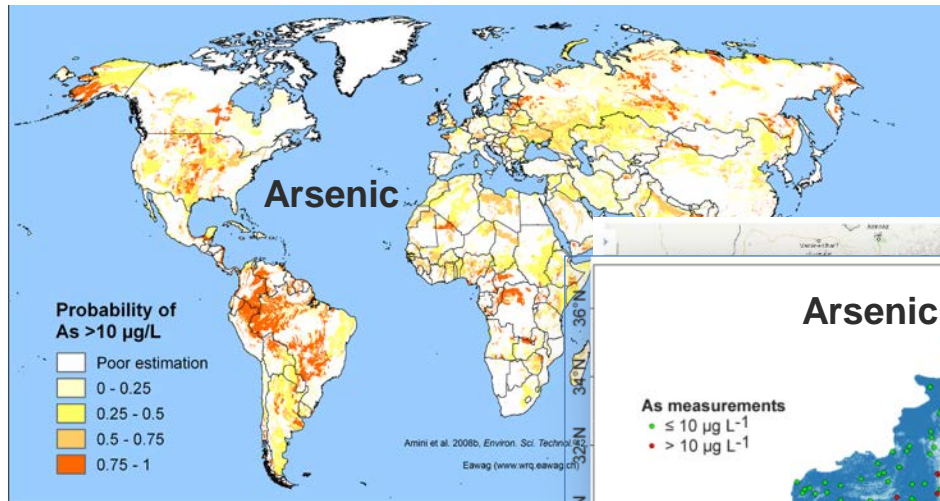


- Interactive web-GIS platform to assist groundwater management
 - Knowledge hub for global groundwater quality
 - Prediction maps of groundwater contamination

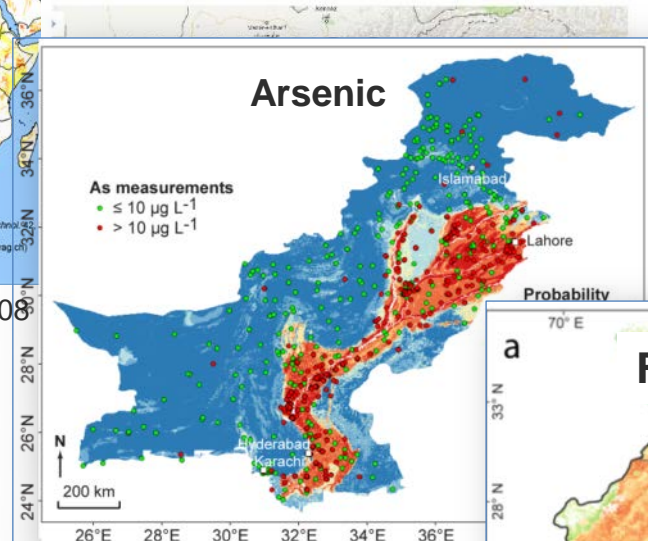


- Visualization of groundwater data
- Upload and view own data
- Create own predictive maps
- Share data and models with other users or publicly

Prediction map examples



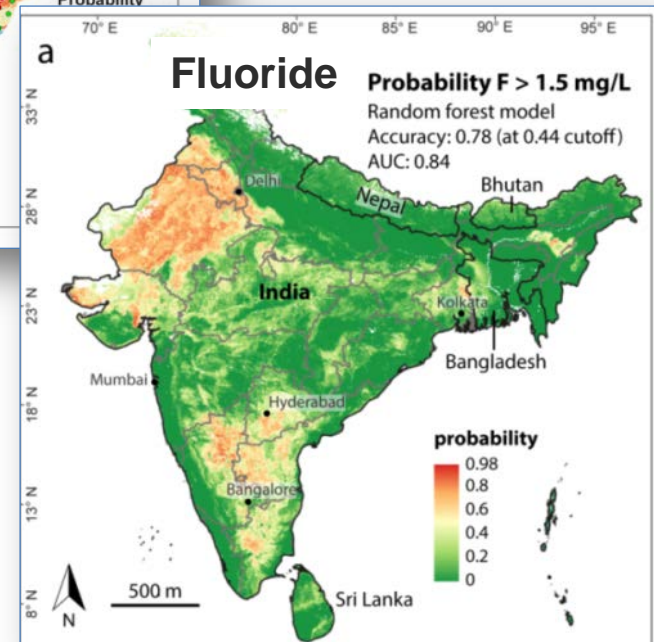
Amini et al. 2008



Podgorski et al. 2017

Predictor variables:

- Geology
- Soil pH
- Soil texture
- Soil type
- Aridity
- Slope
- Cropland
- Irrigation



Impacts:

- Increased awareness
- Political discussions
- Follow-up studies
- Targeted sampling campaigns

Mitigation options



Alternative water resources

- Groundwater: identifying safe wells, deep wells
- Rainwater: mainly at small scale
- Surface water: central treatment facility

Water treatment and safe storage/transport

- Central water utility, piped water
- Household-level (low-cost technology)

Well switching

- Blanket testing of all wells (private and public)
- Communication of results with owners
- Use of water from safe wells of the neighbourhood

Well switching

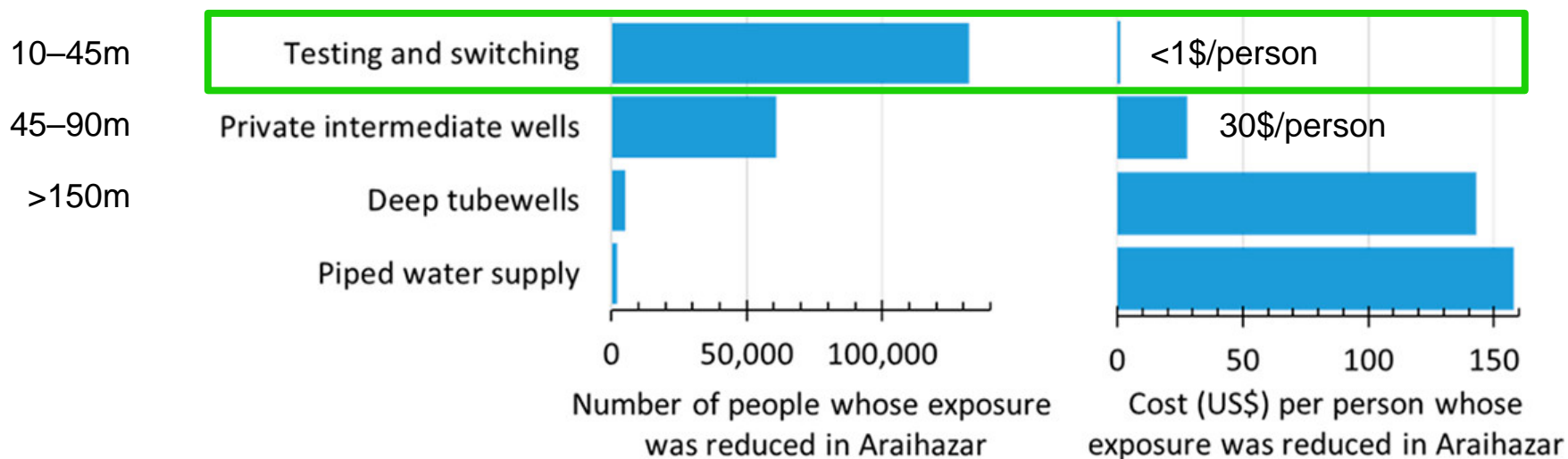
Long-term experience from Araihaazar, Bangladesh (survey of 380'000 people)

Switching to safe wells in the neighbourhood proved to be the most successful option, also in terms of cost

Well depth

Beneficiaries

Cost



Study of N.B. Jamil et al., ES&T, 2019

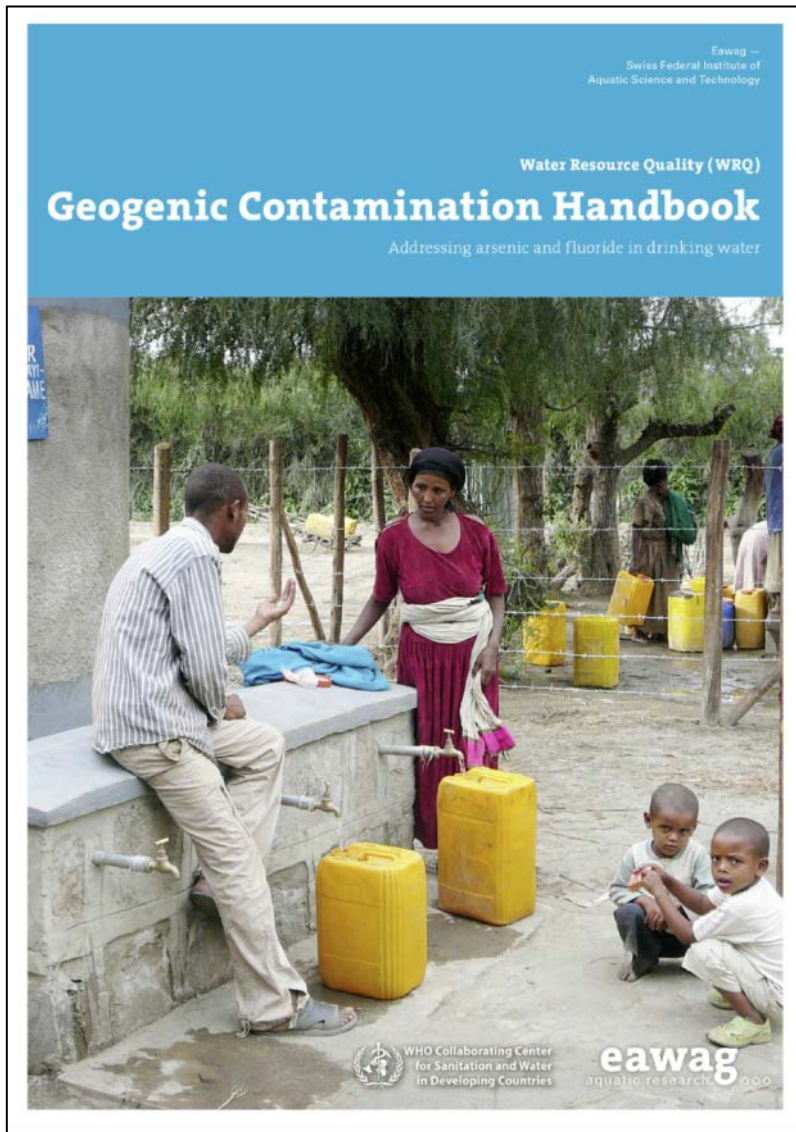
Effectiveness of Different Approaches to Arsenic Mitigation over 18 Years in Araihaazar, Bangladesh: Implications for National Policy

Nadia B. Jamil,[†] Huan Feng,[†] Kazi Matin Ahmed,[‡] Imtiaz Choudhury,[‡] Prabhat Barnwal,[§] and Alexander van Geen^{*||}

Geogenic Contamination Handbook

Comprehensive book for practitioners dealing with arsenic and fluoride in drinking water resources.

Download for free at
www.wrq.eawag.ch





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Thank you

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