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WATER, SANITATION AND HYGIENE: CHALLENGES OF THE MILLENNIUM

The groundwater arsenic problem in Bangladesh

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A SYSTEMATIC NATIONWIDE survey funded by DFID has shown that (excluding the Chittagong Hill Tracts):

- 27% of shallow tubewells exceed 50µg L^{-1}; 1% of deep (>150 m depth) tube wells do;
- 46% of shallow tubewells exceed 10µg L^{-1}; 5% of deep (>150 m depth) tube wells do;
- approximately 35 million people drinking water above 50µg L^{-1} (56 million above 10µg L^{-1});
- worst in south and south-east Bangladesh especially districts of Chandpur, Gopalganj, Madaripur, Munchiganj, Lakshmipur and Comilla;
- occassional arsenic 'hotspots' in northern Bangladesh;
- problem is greatest in young sediments (Holocene alluvium) and least in old sediments (uplifted Barind and Madhupur Tract Pleistocene sediments, and old alluvium);
- 6-11 million handpump tubewells now in Bangladesh, mostly private;
- large degree of variation found within affected villages;
- 35% of well waters exceed the WHO guideline value for manganese;
- water from dugwells usually have arsenic concentrations of less 10µg L^{-1} even in heavily contaminated areas;
- we could not identify.

Source of the problem

- natural, geological source of arsenic;
- scientists disagree about why it is high and when it formed, and present-day changes with time;
  We do not understand the process completely, but believe that:
  - small aouts of arsenic (As (V)) were strongly absorbed by river and deltaic sediments (espe cially iron oxides) during deposition;
  - once buried, these sediments rapidly became anaerobic (reducing) and released arsenic by reductive desorption (As (V) to As(III)), reductive dissolution of iron oxides, diagenesis of iron oxides and competitive desorption (phosphate, bicarbonate);
  - this happened thousands of years ago and is essentially a 'one off' response to a change in the geochemical environment;
  - the low hydraulic gradient in the Bangladesh delta region means that flushing of the released arsenic is slow;
  - with time (tens of thousands of years), it will probably be flushed away to the Bay of Bengal or back to the river to be reabsorbed by the sediments;
  - this flushing was much greater during the last ice age because the sea level was more that 100m lower than at present;
  - this hypothesis (the 'iron oxide reduction hypothesis') contrasts with the 'pyrite oxidation' hypothesis proposed by some which says that the arsenic is a recent phenomenon caused by the widescale abstraction of groundwater for irrigation (and by the building of the Farakah barrage on the river Ganges) - we see no evidence to support that;
  - high arsenic groundwaters can be expected in other similar environments, especially in large deltas and closed, inland basins (may be associated with salinity);
  - all such environments which are exploited for groundwater use should be considered 'at risk' and tested for arsenic;

Key scientific issues

- what is the risk from drinking arsenic-contaminated water and what factors affect it?
- need reliable, sensitive and cheap field-test kits for arsenic (the latest generation are more promising);
- need to understand the Bangladesh aquifiers (shal low and deep) better from a sedimentalogical (dating, minerals, chemistry), hydrogeological (for modelling groundwater flow) and geochemical (comprehensive water quality, interactions of arsenic with the sediments) point of view;
- variations with time - need to monitor carefully and systematically over a long time period.

Mitigation

- What arsenic standard should Bangladesh aspire to? Presently 50µg L^{-1}, WHO guideline value is 10µg L^{-1}; EU (50->10 µg L^{-1} soon); USA (50-> proposed 5 µg L^{-1});
- What about other potential problems with groundwater, particularly manganese (also boron,

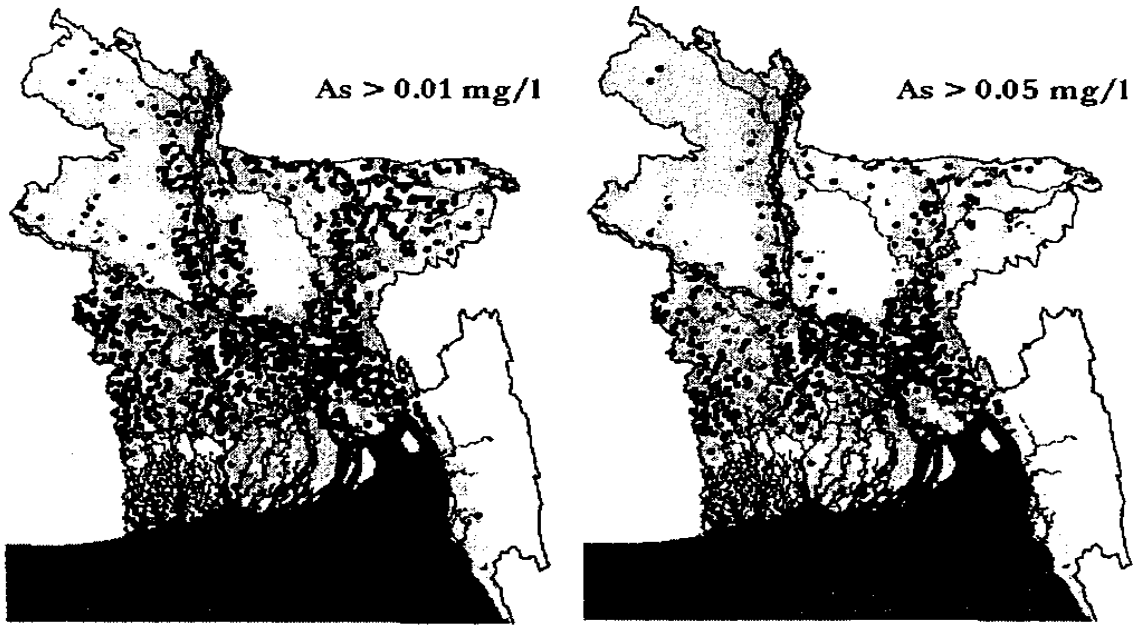

Figure 1.

uranium, iron, ammonium, bactaria)?
- What timescale?
- What strategy (institutional responsibilities - government vs private), priorities, funding?
- Testing verses mitigation;
- Treatment (domestic, community, town) verses low-arsenic source (deep wells, dugwells surface water, rainwater);
- *In situ* remediation?
- Distributed (pumped) water supply - when, what scale, who administers?
- What about existing wells in affected areas? Irrigation?
- Communication of risks, uncertainty, decision-making.

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