PRAMA: Probabilistic Risk Assessment Modelling to inform mitigation of Arsenic bearing groundwaters

Background: Arsenic in well waters used extensively for drinking, cooking and irrigation in India, Bangladesh, Pakistan and elsewhere in the world are impacting the lives of millions of people, causing massive deleterious health impacts

Aims

Project objectives included:

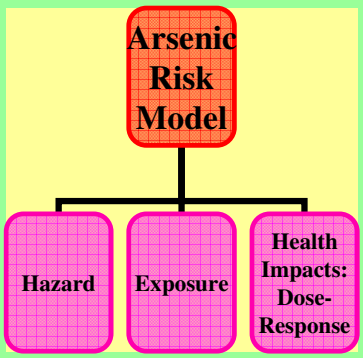
(i) development of a robust model to describe the source, exposure route and response elements of the overall risk to human health from groundwater arsenic in West Bengal;

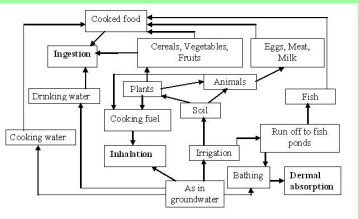
(ii) acquisition of key field data;

(iii) assessing the relative merits of various remediation options

Key Findings – Risk Substitution

The health-protective qualities of supplying pathogen-free well waters for drinking water in at least some parts of India are undermined by both (a) massive groundwater-arsenic attributable detrimental health impacts; & (b) contamination of waters after supply by pathogens;





Key findings – Genetics / Symptoms

(i) Some genetic polymorphisms are associated with significantly increased risk of arsenic-attributable diseases

(ii) Many exposed individuals are externally asymptomatic yet have arsenic-attributable genetic damage, arguably a cancer precursor

Key findings – Arsenic and Rice

(i) As well as water, rice is a major arsenic exposure route for humans

(ii) Thus, remediation of drinking water supplies alone will not massively reduce arsenic exposure from rice

(iii) Current (2010) regulations for arsenic in rice require re-assessment

Implications for UK & Europe –

geogenic arsenic-attributable health risks in the UK & Europe may be substantially under-estimated.

Partners: Indian Institute of Chemical Biology, Kolkata, India; & University of Manchester, UK
Collaborators: University Aberdeen (UK), Calcutta University, Kalyani University (India)
Website: http://www.prama.manchester.ac.uk/

Publications: **[1] Hery**, M., van Dongen, BE, Gill, F., Mondal, D, Lawson, M, Vaughan, DJ, Pancost, RD, Polya, DA & Lloyd, JR (2010) Arsenic release and attenuation in low organic carbon aquifer sediments from West Bengal. ***Geobiology***, 8, 155-168; [2] **Lawson**, M, Ballentine, CJ, Polya, DA, Boyce, A.J, Mondal, D, Chatterjee, D., Majumder, S, & Biswas, A (2008) The geochemical and isotopic composition of ground waters in West Bengal: tracing ground-surface water interaction and its role in arsenic release. ***Mineralogical Magazine***, 72, 441-444. ; [3] **Mondal**, D & Polya, DA (2008) Rice is a major exposure route for arsenic in Chakdha Block, West Bengal: a Probabilistic Risk Assessment. ***Applied Geochemistry***, 23, 2986-2997; [4] **Mondal**, D, Hegan, A, Rodriguez-Lado, L, Bradford, W, Hennermann, K, Banerjee, M, Ganguli, B, Giri, AK & Polya, DA (2008) Multiple regression analysis of arsenic groundwater hazard and assessment of arsenic-attributable human health risks in Chakdha Block, West Bengal. ***Mineralogical Magazine***, 72, 461-465; [5] **Mondal**, D, Banerjee, M, Kundu, M, Banerjee, N, Bhattacharya, U, Giri, AK, Ganguli, B, Sen Roy, S & Polya, DA (2010) Comparison of drinking water, raw rice and cooking of rice as arsenic exposure routes in three contrasting areas of West Bengal, India. ***Environmental Geochemistry and Health***, 32, 463-477; [6] **Mukherjee-Goswami**, A, Nath, B. Jana, J, Sahu, SJ, Sarkar, MJ, Jacks, G, Bhattacharya, P, Mukherjee, A, Polya, DA, Jean, J-S & Chatterjee, D. (2008) Hydrogeochemical behaviour of arsenic-enriched groundwater in the deltaic environment: comparison between two study sites in West Bengal, India. ***Journal of Contaminant Hydrology***, 99, 22-30.; [7] **Polya**, DA & Charlet, L (2009) Rising arsenic risk ?. ***Nature Geoscience***, 2, 383-384; [8] **Polya**, DA, Mondal, D & Giri, AK (2010) Quantification of deaths and DALYs arising from chronic exposure to arsenic in groundwaters utilized for drinking, cooking and irrigation of food crops in Preedy & Watson (Eds) ***Handbook of Disease Burdens and Quality of Life Measures***, Springer-Verlag, ISBN: 978-0-387-78665-0 , pp 702-728 [INVITED]; [9] **Polya**, DA, Polizzotto, ML, Fendorf, S, Rodriguez-Lado, L, Hegan, A, Lawson, M. Rowland, HAL, Giri, AK, Mondal, D, Sovann, C, Al Lawati, WMM, van Dongen, BE, Gilbert, P & Shantz, A (2010) Arsenic in Groundwaters of Cambodia in Irvine, K, Murphy, T, Vanchan, V and Vermette, S (Eds) ***Water Resources and Development in South-East Asia***, SE Asia Centre, New York, pp. 31-56 [INVITED]; See also David Polya: Human Health Risks Attributable to Groundwater Arsenic in Southern Asia; invited lecture at CARSHH Seminar, Cambridge University, March 2010 http://www.crassh.cam.ac.uk/gallery/86