Hydrochemistry and Human Health

Thursday 29th November 2018

Geological Society, Burlington House, London

A joint meeting of the British Chapter of the International Association of Hydrogeologists (IAH) and the Hydrogeological Group of the Geological Society, including the 2018 Ineson Lecture.

The **2018 Ineson Lecture** will be presented by **Dr Pauline Smedley,** Principal Hydrogeochemist at the British Geological Survey.

Dr Smedley is a world renowned Hydrogeochemist with an extensive publication history. She will be supported by leading UK speakers addressing the geochemical issues we face today with our potable groundwater supplies and potential impacts on human health.

- **Full day meeting including lunch and drinks reception**
- **Six supporting speakers**
- **Poster session**
- **IAH John Day Bursary Award (Early Career Hydrogeologist)**
- **Geological Society Whitaker Medal Award**
- **IAH Applied Hydrogeology Award**
- **AGM of Geological Society Hydrogeological Group held at lunchtime**

To register for the meeting please use the link below

https://www.hydrogroup.org.uk/hydrogeology-and-health-a-one-day-meeting-including-the-ineson-lecture/

The final day for registration is 21st November

Please note unlike previous years there will be no registration on the door

Programme

09:30	Registration - with refreshments
10:30	Welcome
10:40	Dr Adrian Butler (Imperial College London) and Dr Mohammad Hoque (University of Portsmouth) *Medical Hydrogeology of Asian Deltas - Do We Need an Holistic Approach to Water Quality?*
11:10	Marianne Stuart (British Geological Survey) *Emerging contaminants in groundwater: a health risk?*
11:40	Peter Ravenscroft (National Hydrology Project, India) *Mitigating Groundwater Arsenic Poisoning in the Bengal Basin*
12:10	Award of the John Day Bursary to Sean Watson (University of Glasgow)
12:20	Lunch - including Posters & the Hydrogeological Group AGM
13:20	Jane Dottridge to present the IAH 2018 Applied Hydrogeology Award to Peter Ravenscroft (National Hydrology Project, India)
13:30	Mike Packman (Southern Water) *Forty four years of groundwater quality risk management with Southern Water*
14:00	Prof John Tellam and Michael Riley (University of Birmingham) *Hazard and Risk Associated with Manufactured Nanoparticle Release into Matrix-Flow Dominated UK Aquifer Systems*
14:30	Award of the 2018 Whitaker medal posthumously to Prof Paul Younger. The presentation will be made by Mike Packman (Southern Water) and the medal will be received by Prof Younger's family.
14:50	Tea
15:20	Prof David Polya (University of Manchester) *Arsenic hazard in public water supplies in England and Wales: implications for exposure, health and regulation*
15:50	Introduction to the Ineson lecture by Marianne Stuart (British Geological Survey)
16:00	Ineson lecture, Dr Pauline Smedley (British Geological Survey) *Hydrogeochemistry of trace elements and human health: from the water table to the kitchen table*
17:00	Drinks reception in the Lower Library

Medical Hydrogeology of Asian Deltas - Do We Need an Holistic Approach to Water Quality?

A. P. Butler[1]* and M. A. Hoque[2]*

[1]Department of Civil and Environmental Engineering, Imperial College London, South Kensington, London SW7 2AZ, UK;

[2]School of Earth & Environmental Sciences, University of Portsmouth, Portsmouth PO1 3QL, UK;

* Correspondence: a.butler@imperial.ac.uk and o.hoque@port.ac.uk

Groundwater, a drinking water source for more than 70% of inhabitants living in Asian deltas, has received much attention because of its naturally occurring arsenic, but the coupling or decoupling of arsenic toxicity with other water constituents remains unexplored. In addition, although nutrients are generally provided by food, in under developed rural settings, where people subsist on low nutrient diets, drinking-water-nutrients may supply quantities vital to human health thereby preventing disease. Using Bangladesh as a case study, we show that the chemical content of groundwater is such that in some areas individuals obtain up to 50% or more of the recommended daily intake (RDI) of some nutrients (e.g., calcium, magnesium, iron) from just two litres of drinking water. We therefore suggest that an understanding of the association of non-communicable disease and poor nutrition cannot be developed, particularly in areas with high levels of dissolved solids in water sources, without considering the contribution of drinking water to nutrient and mineral supply.

Emerging contaminants in groundwater: a health risk?

Marianne Stuart[1]*

[1]British Geological Survey, Maclean Building, Wallingford, Benson Ln, Crowmarsh Gifford, Wallingford OX10 8ED

* Correspondence: mest@bgs.ac.uk

The investigation of emerging organic contaminants in groundwater has expanded rapidly over the last two decades. Earlier studies highlighted the wide distribution of compounds such as pesticides, chlorinated solvents, polyaromatic hydrocarbons and phthalate plasticisers and many of these have now been regulated. Additionally, surfactants such as alkyl ethoxylates and linear alkyl sulfonates have been implicated as endocrine disruptors. However, the continued development of analytical methods has meant we can now detect thousands of other microorganic compounds. In England and Wales, we have seen the widespread detection of pesticide metabolites, and emerging contaminants, such as caffeine, DEET and bisphenol A, personal care products and industrial precursors. More recent work on polar compounds has shown a wide range of pharmaceuticals e.g. carbamazepine, clopidol and sulfamethoxazole also to be present, albeit at typically very low concentrations. Like many contaminants, concentrations are controlled by both the source term and seasonal attenuation processes and concentrations can be variable. It remains unclear what the risk to human health from drinking water, and also to the environment, from the very low concentrations detected in groundwater. There are as yet few methodologies which assess compounds both in terms of persistence and mobility in the environment and in health risks in order to set health limits or threshold concentrations in groundwater.

Mitigating Groundwater Arsenic Poisoning in the Bengal Basin

Peter Ravenscroft[1]*

[1]National Hydrology Project, India

* Correspondence: ravenscroftp@aol.com

Since the discovery of arsenic contamination of groundwater in in Bangladesh in the mid-1990s and quickly recognised as the world worst case of mass chemical poisoning, great strides have been in scientific understanding of the causes and controls of arsenic contamination; surveying its extent; its impact on health, agriculture, and the economy; and knowledge of which mitigation technologies do and don't work well. Although there are significant uncertainties concerning *inter alia* the sustainability of potable abstraction from deep aquifers and irrigation from shallow aquifers, the greatest current concern is, 20 years after its discovery, the downward trend in the population exposed to arsenic in drinking water is flat-lining while exposure via the food-chain is increasing. Nevertheless, if the lessons learned to date are applied in practice, there is good reason to expect that unacceptable levels of arsenic exposure from drinking groundwater could be eliminated within a decade and exposure from groundwater irrigated crops significantly reduced. Further the risks of arsenic migration within and between shallow and deep aquifers can be mitigated through innovative monitoring and adaptive management.

Forty four years of groundwater quality risk management with Southern Water

Mike Packman[1]*

[1]Southern Water, Worthing, West Sussex, BN13 3NX, UK

* Correspondence: mike.packman@southernwater.co.uk

Has groundwater quality deteriorated in the last 44 years, or has monitoring just got better and regulation much stricter? Throughout that time over 70 per cent of the water supplied by Southern Water, (SW), has come from groundwater, with over 95 per cent from the Chalk aquifer. In 1974 just two per cent of the Chalk sources had treatment other than disinfection, however now it is nearly 50 per cent, ignoring phosphate dosing for plumbo-solvency. Hundreds of millions of pounds have been spent on nitrate contamination of groundwater, yet the main reason for source outages in SW is turbidity, as it compromises disinfection. In 1977 SW developed their Aquifer Protection Policy, to provide clear statements on the response to potentially polluting development proposals. This new constructive approach, rather than the often inflexible attitude of continually rejecting proposals, plus good liaison with Local Government, (LG), planning and waste disposal staff, proved successful and no appeals were lodged against aquifer protection decisions and no public enquiries held. This, together with Seven Trent's Policy, formed the basis of the National River Authority's, (NRA), Groundwater Protection Policy, (GPP), in 1992. Over one thousand NRA and LG Planning staff were trained in the GPP by myself and two other staff from Southern Science, the SW environmental consultancy. This was followed by a contract to delineate source protection zones, (SPZs), mostly using steady state FLOWPATH models. Many SPZs have not been updated since the mid-1990s, until the recent Water Framework Directive Drinking Water Protection Area work using improved groundwater models and tools to track flow through each cell. This will hopefully assist truly integrated catchment management, which we are starting a pilot

scheme on the IOW, involving water, wastewater, regulators, agriculture, environmental groups, waste disposal, industry and local government at all levels.

Hazard and Risk Associated with Manufactured Nanoparticle Release into Matrix-Flow Dominated UK Aquifer Systems

John Tellam[1]*and Michael Riley[1]

[1] School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

* Correspondence: J.H.TELLAM@bham.ac.uk

Nanotechnology is advancing at a significant rate resulting in increasing production of nanoparticles (NPs) of a wide range of compositions. Evidence is accumulating of the effects of nanoparticles on organisms, including humans, and in some cases nanoparticles can be viewed as hazardous. Experience indicates that almost invariably industrially-produced chemicals are released into groundwaters, and there is limited evidence of manufactured NP presence in some UK groundwaters. Quantifying the risk, however, is not straightforward. NP mobility is affected by several processes, each of which is affected by the aqueous chemistry, especially pH, ionic strength, presence of organic ligands, the surface properties of the rock mass, and the presence of other particles. Models available are of two main types, process-related and empirical-kinetic: the former often do not match experimental results well and the latter do not take direct account of changing chemical environments. In the UK, field experiments have been banned for many years, and reliance has had to be placed on laboratory experiments. Column experiments have shown the sensitivity of NP mobility to pH and ionic strength, and insights into the importance of rock surface properties have been demonstrated. However, the number of processes is such that interpreting breakthrough curves is hampered by equivalence. To constrain interpretations, a system of magnetic susceptibility monitoring of NP concentrations within columns has been developed and is providing encouraging results. However, despite much investigation, assessment of the risk in groundwaters from NP contamination lags behind NP production: field experiments need to be undertaken in UK aquifers, and many more laboratory studies are required on UK-relevant aquifer materials.

Arsenic hazard in public water supplies in England and Wales: implications for exposure, health and regulation.

David A. Polya[1,*], Lingqian Xu(许伶倩)[1], Yifei Zhang (张艺菲)[1], Qian Li(李芊)[1], Jake Launder[1], Daren C. Gooddy[2] and Matthew Ascott[2]

[1]School of Earth and Environmental Science (SEES) and Williamson Research Centre for Molecular Environmental Science (WRC); University of Manchester, Manchester, M13 9PL, UK

[2]Groundwater Science Directorate, British Geological Survey, Wallingford, OX10 8BB, UK
* Correspondence: david.polya@manchester.ac.uk

Public water supplies in the UK are highly regulated and monitored and have an outstanding compliance with regulatory standards, particularly with respect to the UK PCV (prescribed concentration value) for arsenic of 10 µg/L.

Nevertheless, many UK public water supplies contain arsenic at concentrations within a factor of 10 of the PCV. Given increasing concerns over detrimental health outcomes arising from chronic exposure to drinking water containing arsenic at sub-regulatory concentrations in the 1 – 10 µg/L range, quantifying the distribution of arsenic intake from consumers exposed to arsenic via drinking water in the UK is indicated. In 2015, on the order of 105 consumers in the UK were supplied with drinking water with arsenic concentrations at or above 5 µg/L; 106 at or above 2 µg/L and 107 at or above 1 µg/L. Epidemiological evidence seems currently insufficiently powerful to reliably quantify the detrimental health outcomes arising from such sub-regulatory exposures, but arsenic-attributable premature avoidable deaths in the UK on the order of 100 to 1000 per annum are plausibly estimated here from combined cancer and cardiovascular disease - these values are considerably less than those ascribed to air pollution but are broadly equivalent to the number of annual fatalities of car occupants in road traffic accidents in England and Wales and warrant concern. Uncertainties and limitations of the approach are discussed together with implications for stakeholders.

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Hydrogeochemistry of trace elements and human health: from the water table to the kitchen table

Pauline Smedley[1,*]

[1]British Geological Survey, Environmental Science Centre, Nicker Hill, Keyworth, Nottingham, NG12 5GG

* Correspondence: pls@bgs.ac.uk

Several decades of research have helped to develop an improved understanding of the occurrence of trace elements of health concern in groundwater used for drinking. Progress has been driven by observations of symptoms, advances in analytical capability and developments in drinking-water regulation. Today, fluoride and arsenic remain the most significant recognised health-impacting trace elements in terms of populations exposed. It is estimated that more than 200 million people worldwide are drinking water with fluoride concentrations greater than the internationally accepted standard of 1.5 mg/L, and over 140 million people are exposed to arsenic with concentrations greater than the WHO guideline value of 10 µg/L. Occurrences can be demonstrated from diverse hydrogeological environments, including crystalline bedrock, volcanic terrains and alluvial aquifers, and under varying pH/redox conditions. As new drinking-water guidelines and regulations have developed, other trace elements including molybdenum, uranium, boron and radon have received increasing focus. Exceedances of these elements in groundwater are much less common but do occur, often in similar hydrogeological settings to those affected by arsenic or fluoride. This presentation will consider the different hydrogeological and hydrogeochemical controls on the occurrences of these trace elements and on their implications for water supply and health. Examples are drawn from personal experiences in Africa, south Asia and the UK.