Application of novel field sensors for tracking pathogens in drinking water supplies in Africa

Lead Supervisor: Dan Lapworth, British Geological Survey, Wallingford
Email: djla@bgs.ac.uk

Co-supervisors: Steve Pedley, University of Surrey**; Dan Read,** Centre for Ecology & Hydrology, Wallingford

Sub-Saharan Africa is experiencing unprecedented changes. Rapid projected population growth, pressures on land-use, growing climate variability, and often poor environmental hygiene are threatening the long-term sustainability of clean sources of water. The problem is particularly acute in heavily populated low-income peri-urban areas of major cities where faecal contamination of water supplies can be widespread. Bacteria and viruses found in wastewater and sewage cause diarrheal diseases, such as cholera, which kill 1.8 million people every year, 90% of whom are children under 5 years[1]. Here, poor health from drinking contaminated water has a huge impact on the livelihoods of millions of people, reducing life expectancy, their ability to generate income and ultimately their ability to improve their economic prospects. Sustainable Development Goal 6 sets a challenge to eliminate these conditions by 2030 by "[achieving] universal and equitable access to safe and affordable drinking water for all[2]." Monitoring water to confirm safety is going to be an important task. Waterborne pathogens are typically inferred from the presence of surrogate indicator organisms such as thermo-tolerant coliforms. However, analysis requires access to suitable laboratories, specialist trained personnel, and is time-consuming: typically 24 - 48 hours to get a result. This can limit sampling resolution, particularly during critical pollution events or for intervention monitoring. Given the limited capability of many laboratories in Sub-Saharan Africa and the growing pressure on water resources, it is vital to research the potential for quick, cheap, accurate ways of measuring faecal pollution in the field to guide efforts to provide safe and affordable drinking water for all.

This research project will focus on the application of novel field-based sensors for tracking faecal contamination in drinking water supplies (e.g. Sorensen et al 2015) in East Africa (Kenya and Uganda). These methods will be reviewed and tested alongside a suite of tools, which will include: molecular DNA (qPCR, High throughput sequencing) techniques to quantify pathogenic strains of bacteria and viruses; mapping, characterizing and quantifying the risks posed by water-borne pathogens in both urban and rural communities. In partnership with NGOs (including Oxfam and Practical Action) and local ministries, the project will generate much-needed process understanding about the fate a dispersal of pathogens in shallow groundwater in Africa. Equally important, it will increase the capacity of local actors to collect real-time information about the quality of sources and the need for interventions.

Training opportunities:
In the first year, you will be trained as a part of a single cohort on research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to the student's projects and themes. Specifically they will be able to attend modules on the University of Surrey's renowned MSc in Water and Environmental Health Engineering. Specific training in fieldwork skills, hydrogeology, analytical and geospatial data analysis will also be given by the NERC research partner centres (BGS and CEH). The

[1] WHO (2004) http://www.who.int/water_sanitation_health/publications/factsfigures04/en/ [accessed July 2015]
[2] https://sustainabledevelopment.un.org/?menu=1300 [accessed October 2015]

project will include a substantial placement at NERC research center; at BGS Wallingford. In-kind assistance and hands on experience in field and analytical methods needed to undertake the research will be provided by BGS, CEH and Surrey.

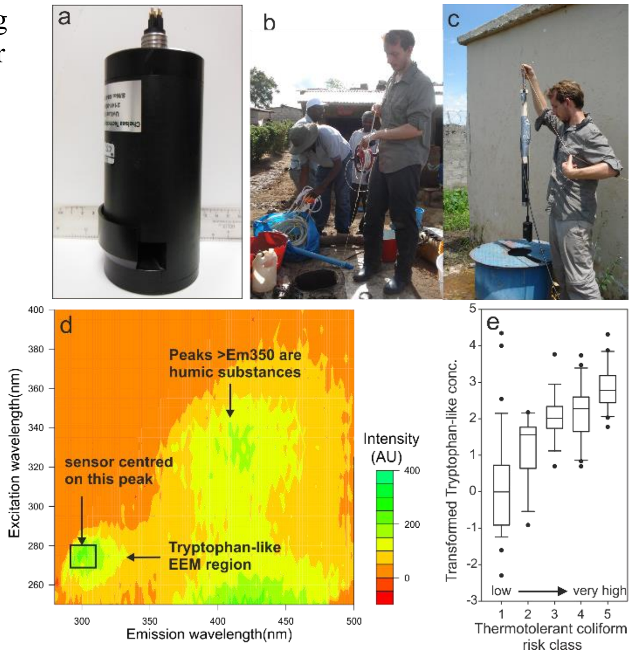

Figure: a) Example of tryptophan sensor used for carrying out in-situ quantification of fecal bacteria, **b)** Groundwater sampling from shallow wells in Africa, **c)** Deploying a combined tryptophan, turbidity and water level logger to undertake a borehole water quality profile at a municipal monitoring site in Africa, **d)** Excitation-Emission Matrix (EEM) spectra from bench top fluorescence spectra of groundwater showing tryptophan-like peak as well as peaks from humic substances in groundwater, **e)** Relationship between sensor (centred on tryptophan peak) tryptophan-like concentration and thermo-tolerant coliform risk class (TTC): WHO risk classes are defined using thermo-tolerant colony forming unit counts/100mLas <2 (class 1, no risk), 2 to <10 (class 2, low risk), 10 to <100 (class 3, intermediate risk), 100 to <1000 (class 4, high risk), >1000 (class 5, very high risk).

Student profile:
This project would be suitable for students with a good degree in a range of environmental or physical sciences (including but not limited to chemistry, biology, biochemistry, geography or engineering) and/or students with a relevant MSc (e.g. engineering, hydrogeology, hydrology, public health).

Partners and collaboration:

You will gain unique experience of working with various International NGO partners (e.g. Oxfam, Practical Action) in Africa as part of this project.

Funding particulars:
This studentship will be hosted by BGS, where the student will spend at least half of the PhD. This includes £3500 for mobility costs, £1000 (p.a.) additional stipend, and additional funds for fieldwork and experimental work.

Further details:
Further project details may be obtained from the lead supervisors at the research institutions involved:

- **Dan Lapworth**, British Geological Survey (BGS), djla@bgs.ac.uk +44(0)1491 692327
- **Steve Pedley**, University of Surrey, s.pedley@surrey.ac.uk +44 (0)1483 689209

References and relevant background reading:
Including a sample of relevant publications by the PhD supervisors:

- Lapworth, DJ, Carter, RC, Pedley, S, MacDonald, AM, 2015. Threats to groundwater supplies from contamination in Sierra Leone, with special reference to Ebola care facilities. Nottingham, UK, British Geological Survey, 87pp. (OR/15/009)
- Sorensen, JPR, Lapworth, DJ, Marchant, BP, Nkhuwa, DCW, Pedley, S, Stuart, ME, Bell, RA, Chirwa, M, Kabika, J, Liemisa, M, Chibesa, M, 2015. In-situ tryptophan-like fluorescence: a real-time indicator of faecal contamination in drinking water supplies. Water Research, 81. 38-46

- Further information: http://www.reading.ac.uk/nercdtp