PROJECT TITLE: Self-powered sensing of water quality for remote locations

DTP Research Theme: Changing Planet

Lead Institution: University of Bath

CASE Partner: EMD (Electro-Mechanical Developments Ltd.)

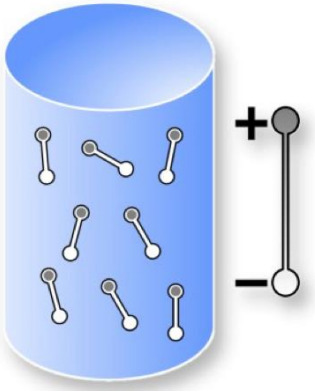
Lead Supervisor: Prof. Chris Bowen, University of Bath, Department of Mechanical Engineering

Co-Supervisor: Dr. Mirella Di Lorenzo, University of Bath, Department of Chemical Engineerinng
Co-Supervisor: Prof. Meiling Zhu, University of Exeter, College of Engineering, Mathematics and Physical Sciences

Project Enquiries: c.r.bowen@bath.ac.uk

Project keywords: Environmental Engineering, Environmental Science, Chemical Engineering, Materials Science

Water



Energy harvesting and sensing

Project Background

There is a need to monitor the quality of drinking water in pipelines or rivers, and this is often achieved using a variety of sensors. The deployment of a wide range of sensors to form a sensor network often needs the provision of electrical power for data transmission and sensors that are able to operate continuously for long periods. This often makes it difficult to deploy such systems in remote locations, since batteries need to be replaced or sensors need to be recalibrated. The PhD will involve the development of a 'battery free' and low maintenance system to provide a self-powered water quality monitoring tool that harvests kinetic energy from water flow. The harvested energy will be used to to support the transmission of water sensor data transmission via LoRa (Long Range) digital wireless data communication technology. The water sensors that are coupled to the energy harvesting power supply will be explored since they often require regular re-calibration to remain accurate, and new approaches to ensure that the water sensor can remain functional for longer periods will be examined; chlorine sensing will be initially considered but this can be extended to the presence of chemicals (e.g. pharmaceuticals) or microbial contamination depending on student interest. A demonstrator system that combines the harvesting mechanism, sensors and data transmission will be produced.

Project Aims and Methods

Approaches to harvesting energy to be examined will be electro-magnetic (e.g. micro-turbines), piezoelectric (e.g. vibrations induced by water flow) or microbial fuel cells. The optimum approaches to use the harvested power to operation existing long-range data transmission methods will be examined.

The water quality sensors that are coupled to the energy harvesting power supply will be explored. As an example, existing chlorine sensors require regular re-calibration to remain accurate, and new approaches to ensure that the water sensor can remain functional for longer periods will be examined. Current chlorine

sensors separate the sensing electrodes from the water sample using a membrane and understanding the role of this membrane and how it can be improved will be one aim of the project.

The PhD will involve manufacture and testing of prototype self-powered long-range water quality monitoring system for deployment in rivers or water network. The balance of the activities (harvesting/sensing/transmission) can be changed to reflect the interests of the student.

Candidate Requirements

The ideal candidate should be interested in water and new methods to assess the quality of water. The project will involve energy harvesting and sensors and therefore some familiarity of the use of sensors, or instrumentation such as background in sensing, electronics, materials or energy harvesting. For example, degrees in Chemical Engineering, Electrical Engineering, Physics etc.

Opportunities for overseas travel exist based on ongoing collaborations (e.g Colombia, Brazil or Vietnam for collaboration on water sensing/treatment) and visits to collaborating company.

CASE or Collaborative Partner

The partner, EMD Ltd., has over 20 years of experience in energy harvesting, ultra low power electronics and data transmission; with a particular interest in working with the water industry to deploy self-powered systems for monitoring water quality. This provides a good synergy with the energy harvesting /systems and sensor expertise of the academic partners of Bath and Exeter. The partner will enhance the knowledge of power requirement for data transmission and the required sensor durability.

Training

Training would be multi-disciplinary and involve: (i) energy harvesting materials, systems (ii) water sensors and lifetime, and (iii) wireless transmission of data.

References / Background reading list

Piezoelectric and ferroelectric materials and structures for energy harvesting applications
CR Bowen, HA Kim, PM Weaver, S Dunn
Energy & Environmental Science 7 (1), 25-44 (2014)

Water quality monitoring in developing countries; can microbial fuel cells be the answer?
J Chouler, M Di Lorenzo
Biosensors 5 (3), 450-470 (2015)

Energy-aware approaches for energy harvesting powered wireless sensor nodes
T Ruan, ZJ Chew, M Zhu
IEEE Sensors J 17 (7), 2165-2173 (2017)

Useful links

Enquiries relating to the project should be directed to the lead supervisor (see email address above for Project Enquiries). Enquiries relating to the application process should be directed to doctoraladmissions@bath.ac.uk

In order to apply, you should select the relevant University of Bath PhD online application form found here: https://www.bath.ac.uk/study/pg/applications.pl. When completing the form, please state in the 'Finance' section that you wish to be considered for GW4+ DTP funding and quote the project title and lead supervisor's name in the 'Your research interests' section.

Further information about the application process may be found here: http://www.bath.ac.uk/topics/postgraduate-research/

The application deadline is 1600 hours GMT Monday 7 January 2019 and interviews will take place between 4 and 15 February 2019. For more information about the NERC GW4+ DTP, please visit https://nercgw4plus.ac.uk.