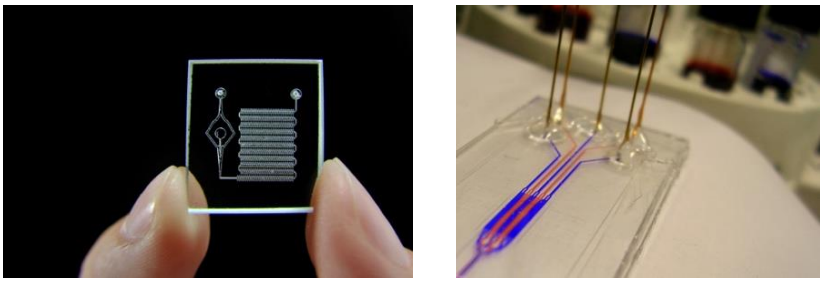
Sensing greenhouse gas emissions from weathering plastics using lab-on-the-sea technology

Nicole Pamme (UoH, Lab-on-a-Chip), Mike Rogerson & Bryony Caswell (SES Hull)
Contact email: n.pamme@hull.ac.uk

Once plastics are disposed of they become part of the Earth System and so they begin to weather. As the polymers are gradually oxidised, they lose mass producing methane, ethane, ethene and associated gasses. These reactions are well-known, but the fluxes produced by plastics in the environment and the changes in gas production rates at the different stages of weathering for the different polymers is not well-known. These emissions are greenhouse gases and thus can be major contributors to climate change, further exacerbating the enormous problems associated with the inappropriate disposal of plastic litter. The capture of gaseous fluxes is presently limited by the analytical approaches used to measure them, which require manual handling, storage, transport and off-site mass spectrometry. This is expensive, time consuming and cannot be implemented as a monitoring array at useful spatial or temporal scales.

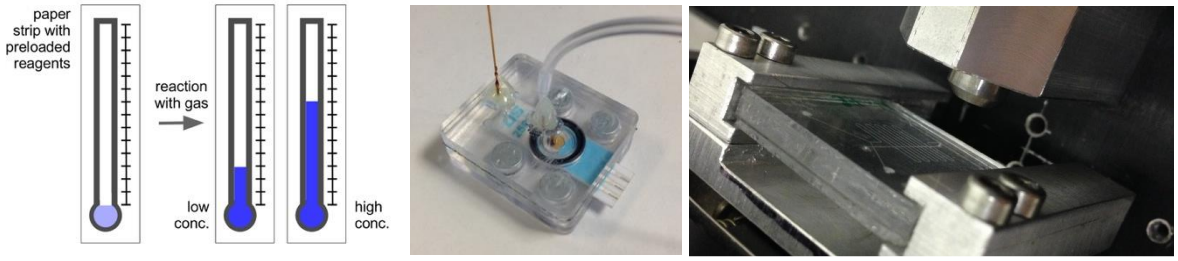
The aim of this project is to develop new technologies that can be implemented as autonomous monitoring arrays within the natural environment. The student will build on the leading expertise of Prof. Pamme in developing analytical measurement systems based on microfluidic lab-on-a-chip technology, to invent gas sensing systems that can operate in an automated fashion on a deployable buoy and transmit data at regular intervals, a lab-on-the-sea. Prof. Rogerson will assist with geochemistry and experimental design elements, and Dr. Caswell will assist with implementation, and support investigation into the implications for marine pollution.



Lab-on-Chip devices as miniaturised analysis platforms.

Objectives

- The PhD student will carry research into the rates, temporal patterns and polymer-specific differences of methane, ethane and ethene emission by weathering plastic in the natural environment, and in analogous experiments in the laboratory.
- Once the production of these gasses is properly characterised, they will scope colourimetric systems (similar to gas detection tubes) based on porous paper matrices for pre-concentration and sampling as well as small format optical spectroscopy systems.
- This will involve lab-based optimisation studies followed by in-situ studies using in situ floating experiments installed at the University of Hull Marine Science Field Centre at Spurn Head.



(a) Colourimetric sensors, (b) electrochemical flow cell, (c) spectroscopic flow cell.

Potential for high impact outcome

Effective monitoring of greenhouse gas emission from weathering plastics with low-cost and deployable sensors will enable us to characterise and capture real-world diurnal and seasonal variability. This will transform our understanding of this process, taking us from an awareness that it might be a problem to a full understanding of how much plastics release methane depending on their environmental context, through diurnal and seasonal cycles and through the aging of the plastic itself. Only then will we be in a position to appreciate how much influence this is having on marine methane budgets, and greenhouse gas emission.

Training

The student will join an exciting research and training environment and will be embedded within our wider team addressing challenges in Sensing the Water Environment. The student will have access to our Lab-on-a-Chip Fabrication Facility, our Fab Lab for 3D printing and additive manufacturing and our Nanofabrication & Nanopatterning Facilities. Our University has invested heavily in High Performance Computing with VIPER as the highest-rated academic HPC in the North of England. Through our Environmental Scientists we have access to the Marine Science Field Centre and the NERC/UoH-funded Transportable Environmental Analytical Laboratory (TEAL), plus a wide range of sample sites including estuarine and oceanic sites. We have excellent links to industry and stakeholders which we will involve as advisors. This will provide an opportunity to engage across sectors and provide access to additional training that will greatly enhance PhD employability and also create KTPs and spin-out opportunities. The PhD student immersed in this environment will develop responsible citizenship and be empowered to take on the next step in their career, be it as PostDoc, employee or running their own spin-out company.

Student profile

The project would be suited to a candidate with an interest in multi-disciplinary research and a background in Geochemistry, Chemical Sciences, Physics, Engineering or related disciplines.

References

(1) Adrian M. Nightingale, Alexander D. Beaton, Matthew C. Mowlem, *Trends inmicrofluidicsystems for in situ chemical analysis of natural waters*. Sens Actuat B, 2015, 221, 1398.
(2) Ke Yang, Hagit Peretz-Soroka, Yong Liu, Francis Lin, *Novel developments in mobile sensing based on the integration of microfluidic devices and smartphones*, Lab Chip, 2016 , 16 , 943.
(3) Kershaw, P., Katsuhiko, S., Lee, S., and Woodring, D.: *Plastic debris in the ocean*, in, United Nations Environment Programme, 2011.
(4) Tosin, M., Weber, M., Siotto, M., Lott, C., and Degli-Innocenti, F.: Laboratory Test Methods to Determine the Degradation of Plastics in Marine Environmental Conditions, Frontiers in Microbiology, 3, 10.3389/fmicb.2012.00225, 2012.

Related UG subjects

- Geochemistry
- Chemistry
- Physics
- Chemical Engineering
- Atmospheric science