Project Title	The fate of microplastics in aquatic environments : Effect of Size, Shape, and Density
University (where student will register)	University of Warwick
Which institution will the student be based at?	As above
Theme (Max. 2 selections)	Climate & Environmental Sustainability ☒ Organisms & Ecosystems ☐ Dynamic Earth ☐
Supervisory team (including institution & email address	PI: Jonathan Pearson, School of Engineering, University of Warwick; j.m.pearson@warwick.ac.uk Co-I: Gary Bending, School of Life Sciences, University of Warwick; Gary.Bending@warwick.ac.uk Soroush Abolfathi, School of Engineering, University of Warwick; soroush.abolfathi@warwick.ac.uk

Project Highlights:

- **Refining a brand new novel method, developed by the applicants to track and analyse microplastics (Cook et al., 2020)**
- **Mesocosms studies to track behaviour of microplastics in aquatic flow domains (Rivers, Coastal, Ponds & Wetlands)**
- **Training in a wide range of ecological methods using state-of-the-art technology**

Overview:

Microplastics (MPs) are an emerging contaminant of increasing concern that are ubiquitous within freshwater and marine ecosystems. Rivers are recognised as a fundamental transport pathway for MPs; connecting terrestrial plastic sources to marine ecosystems, as well as an area where high levels of biological activity and modification can occur. However, there is little consideration as to the sources and fate of plastics within these freshwater ecosystems. Rivers are subject to plastic pollution from both point (i.e. sewage systems) and diffuse (i.e. agricultural and urban runoff) sources. It is expected that riverbed sediments act as a sink for microplastic debris (1). However, the extent to which riverbeds interact with MPs and their entrapment rates will be governed by many physical, biological and chemical factors. Colonisation studies of plastic debris by microbial biofilms have shown to cause buoyant polymers to sink (2,3). Equally, microbial biofilms over riverbed sediment will influence MP infiltration and settling rates. Nevertheless, the relative importance of these processes remains largely unclear with empirical data urgently needed to parametrise models. In this project you will investigate the interactions and feedbacks between riverbed dynamics and MPs. The research will build on a brand new novel tracking methodology developed by the applicants (Cook et al., 2020), which allows real time tracking of microplastics in purpose built experimental flumes.

The main aim will be to determine the key variables which contribute to the entrapment and resuspension of MPs within this freshwater ecotone. Different types of plastic particles with different size, shape & densities will be considered and analysed using novel state-of the-art technology and innovative methods. The release rate and sources of MPs is vital for a more complete understanding and assessment of the hazards posed by these contaminants. As such, the new insights offered by the project have the potential to contribute directly towards new policies relating to water management and environmental conservation.

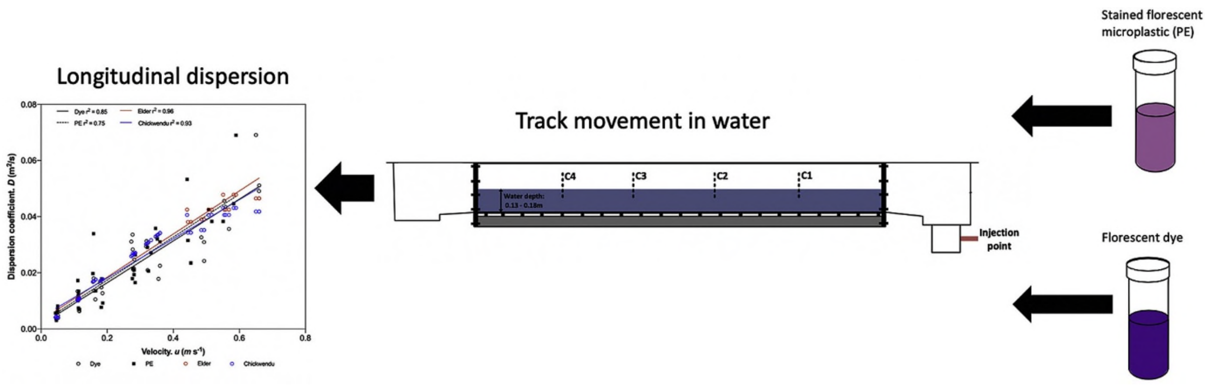
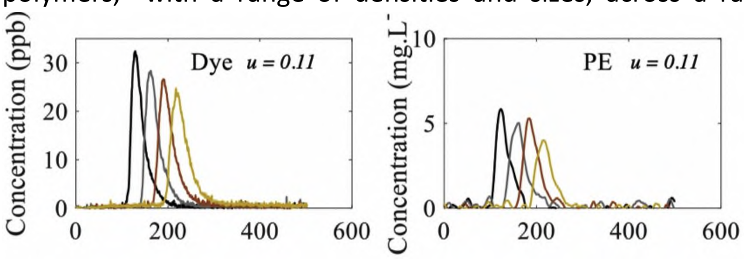


Figure 1. Experimental results & schematic of the experimental flume setup of novel tracking methodology developed by the applicants (Cook et al., 2020)

Methodology:

We will use our novel mesocosm systems to investigate and isolate the different mechanistic processes governing the interaction between the riverbed and MPs. We will test different plastic polymers, with a range of densities and sizes, across a range of riverbed systems with unique characteristics (i.e. pore size, biofilm coated, bedform shape). Methods will include metagenomics to analyse biofilm community structure and optical spectral imaging to visualise where the biofilm colonises the different plastic polymers. In addition, we will adopt our newly developed method to track the movement of MPs within our laboratory-based system (4) using fluorescence-based technology.



Training and skills:

Training will be provided by the supervisory team in a wide range of environmental science approaches and techniques including environmental river processes, molecular techniques (16S amplicon sequencing), bioinformatics, molecular spectroscopy and multivariate data analysis.

CENTA students are required to complete 50 days training throughout their PhD including a 10-day placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to CENTA research themes.

Partners and collaboration (including CASE):

The student will have a training placement at Thames 21, an environmental NGO operating in London, delivering environmental pollution management with communities and municipal stakeholders. There will be the opportunity to work closely with the Thames 21 team in their river catchment sites around London; collecting river sediment cores and exploring plastic management solutions.

COVID-19 Resilience of the Project:

The project has been designed taking account of COVID-19 mitigation measures. Although the proposed project is predominantly laboratory based in our own dedicated large open lab., which can operate within current social distance guidelines. As long as the building is permitted to open, then no further anticipated problems are envisaged. However if the building is closed for a sustained period, then the project may slightly switch towards numerical modelling, which can be undertaken remotely on our dedicated remote server.

Possible timeline:

Year 1: Mesocosm and biofilm community studies to develop process level understanding of the environmental pathways and interactions of microplastics

Year 2: Targeted extraction and analysis of microplastics from riverbed cores to investigate their environmental fate and temporal / spatial distribution

Year 3: Integration and ecological interpretation

Further reading:

1. Rillig, M.C., 2012. Microplastic in terrestrial ecosystems and the soil? Environmental Science and Technology 46, 6453-6454.
2. Rummel, C.D., Jahnke, A., Gorokhova, E., Kuhnel, D., Schmitt-Jansen, M, 2017. Impacts of biofilm formation on the fate and potential effects of microplastic in the aquatic environment. Environmental Science & Technology Letters, 4, 258-267.
3. Kaiser, D., Kowalski, N., Waniek, J.J, 2017. Effects of biofouling on the sinking behavior of microplastics. Environmental Research Letters, 12, 124003.
4. Cook, S., Chen, H.L., Abolfathi, S., Bending, G.D, Schäfer, H., Pearson, J.M. Quantifying microplastic transport in aquatic flows using fluorometric techniques, Volume 170, 1 March 2020, 115337 https://doi.org/10.1016/j.watres.2019.115337
5. Merel Kooi* and Albert A. Koelmans,2019. Simplifying Microplastic via Continuous Probability Distributions for Size, Shape, and Density. Environ. Sci. Technol. Lett. 2019, 6, https://doi.org/10.1021/acs.estlett.9b00379

Further details:

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