**Cascading effects of micro- and nano-plastics on lipid quality and transfer through freshwater planktonic ecosystems**

**Lead Supervisor Name**

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**Lead Supervisor Location/Student Home Institution**

Institution: Cardiff

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**Full Project Description**

Despite growing concern about nano- and micro-plastics (NPs, MPs) in aquatic ecosystems, there is only rudimentary understanding of the pathways through which any adverse effects might occur. Suggestions include physical impact (abrasion, obstruction, surface coating), direct physiological toxicity or toxicity through vectored co-contaminants, but evidence is limited. Investigations of effects transferred through food webs are rare. Our recent laboratory studies with widespread algae (Chlorella sorokiniana) have revealed how exposure to environmentally realistic concentrations of polystyrene microplastics (PS-MPs) significantly modifies the concentrations of several lipid molecules that are essential extracellular compounds, waxes and steryl esters, and chloroplast lipids, while also being involved in the synthesis of essential fatty acids (FAs). As well as revealing a novel mechanism of plastics effects on aquatic organisms, these results have ecological ramifications: the transfer through aquatic food webs of effects on algae lipids might impair food quality, reduce growth or alter resistance to other stressors in zooplankton. We propose to investigate such effects of different microplastics across a range of sizes (nano- to micro), while also assessing the potential for cascading effects between freshwater algae and zooplankton in microcosms, mesocosms and field conditions. Methods. The student will use laboratory and field investigations in an integrated assessment of responses to environmental relevant plastic pollutants to inform risk assessments of their direct (physiological) and indirect (ecological) effects. Laboratory experiments:

1. Algae as primary producers: Contrasting algae (Chlorella sorokiniana and Nannochloropsis limnetica, respectively providers of essential 18:2n-6/18:3n-3 FAs and LCPUFA 20:4n-6) will be exposed to realistic concentrations of PP, PE, PET and PS and analysed for uptake and cell distribution of MPs/NPs; extra- and intracellular lipids; synthesis of essential FAs.
2. Daphnia/Bosmina spp.. Natural populations of zooplankton consumers will be fed control and MP/NP-treated algae, demographic changes recorded and biochemical analysis of potential lipid biomarkers performed.
3. Predators: Different freshwater predators (e.g. Chaoborus) will be fed with zooplankton from control or MP/NP-treated algae. Mesocosms To increase realism, field mesocosms will be deployed in contrasting locations (eg Cardiff Bay, Llangorse Lake, Lake district) to assess how direct and cascading plastic effects on lipids are modified under field conditions, and to assess food-web-transfer of MPs/NPs among algae, primary consumers and predators (eg Chaoborus).
4. Pollution gradients. Should time permit, we will assess lipid biomarker response to plastics among algae and zooplankton along a pollution gradient.

The student will gain experience of experimental design, planktonic ecology, biochemistry, lipidomics, chromatography, molecular biology, microscopy. As well as being part of the FRESH community, the host institutions have strong early-career communities in planktonic ecology, environmental biochemistry and ecology. The project also offers the opportunity for short internships with the stakeholder partners.

**Real Life challenges this project will address**

Appraising and understanding the effects of micro- and nanoplastics on individuals, freshwater ecosystems and ecosystem processes.

**What you should know about this project**

Despite growing global concern about the occurrence of nano- and micro-plastics in aquatic ecosystems, there is only rudimentary understanding of the pathways through which any adverse effects might occur. Investigations of effects that might be transferred through food webs are even rarer in the literature. Recent Cardiff research has shown how common and widespread algae are affected by polystyrene microplastics (PS-MPs), resulting in changes in the concentrations of lipid molecules that are important in extracellular compounds, waxes and steryl esters, chloroplast lipids, and in the synthesis of essential fatty acids (FAs). As well as revealing a little-known mechanism through which plastic could affect aquatic organisms, these observed effects would also have ecological ramifications if they were transferred between algae as primary producers and consumers in aquatic food webs (eg impaired food quality, impaired growth or altered resistance to other stressors). This PhD will investigate such effects further, using different plastics compounds across a range of sizes (nano- to micro), while also assessing the potential for cascading effects between freshwater algae and zooplankton in microcosms, mesocosms and actual field conditions. The supervisory team combines leading expertise in lipid chemistry (Guschina), plastics in freshwaters (Ormerod/Feuchtmayr) and lake planktonic ecology (Thackeray/Feuchtmayr). Several of the supervisors have worked together previously.

**What expertise you will develop**

Skills development will include:

1. The use of scientific literature;
2. Scientific writing, communication and publishing;
3. Laboratory and Field experimental design;
4. Data analysis;
5. Biochemistry, specifically lipids, chromatography and lipidomics;
6. Algal and zooplankton cultivation;
7. Limnology and planktonic studies
8. Imaging.

**Why this project is novel**

Although there is an increasing number of studies revealing the occurrence of micro- and nanoplastics in ecosystems, there is very poor understanding of any adverse effects or the mechanisms involved. This project will help to open two completely new fronts in investigations through i) appraising effects of plastic on ecologically important lipids in aquatic primary producers and ii) assessing whether effects could cascade through food webs.

**Rest of Supervisory Team:**

**Stakeholder Organisation** Cardiff Harbour Authority

**Stakeholder Supervisor** David Hall

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