Sub-cellular localisation and functional effects of micro/nanoplastics on aquaculture fish with coherent Raman microscopy

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Project description:
Plastic pollution is a major challenge threatening the future sustainability of fish aquaculture. Petrochemical plastics are a modern commodity, deliberately designed to be resistant to degradation. As only 9% of plastics are recycled, the remaining 91% are left to pollute environments worldwide. Aquaculture is the fastest growing food producing sector. Fish provide 3.3 billion humans with over 20% of their average per capita animal protein intake, increasing to 50% in some Asian countries. Despite this, the effects of plastic pollutants on aquaculture fish welfare and on fish food products are largely unknown. Petrochemical plastics predominantly break down through hydrolytic cleavage and photo-oxidation with UV light. This causes embrittlement and subsequent fragmentation of larger plastic particles into micro (<1mm) and nanoplastics (<1µm). The accumulation of these micro/nanoplastics in wild and cultured fish raises major concerns about the health impacts on the fish and humans consuming them. Notably, small nanoparticles can cross biological barriers, e.g. the blood-brain-barrier and the gut, and elicit harmful responses. Yet, the extent and effects of plastic particle pollution in farmed fish stocks destined for human consumption are largely unknown. In addition, biobased polymers, commonly termed bioplastics, are being heralded as a sustainable solution to the plastic crisis, but our understanding of bioplastic degradation and biological impacts is extremely limited.

The aim of this project is to address micro/nanoplastic pollution on fish aquaculture, by using a novel optical micro-spectroscopy technique able to reveal the spatial location/accumulation of micro/nanoplastics particles directly inside cells and tissues. Both petrochemical plastics and bioplastics will be investigated. Juvenile rainbow trout will be studied, as they are the predominant freshwater fish for UK aquaculture and easy to maintain under laboratory conditions. They will be exposed to micro/nanoplastics with compositions and concentrations representative of current values in the environment.

A unique in-house developed Coherent Raman scattering multiphoton microscope will be used[1] to examine the amount, chemical composition and location of micro/nano plastics in tissue sections extracted from parts of the fish, including the gut (where microplastics will likely accumulate) and the fillet (important for human consumption). These microscopy studies will be combined with state-of-the-art bioassays of fish growth, metabolic rate, and transcriptomic analysis in response to treatments, available in the supervisory team[2]. This project will be important to assess the biological effects of plastic pollution on aquaculture fish, producing data that will help informing government policies, industry practice and consumer behaviour.
[1]DOI:10.1063/1.5027256; 10.1039/D0AN02381G, [2]DOI:10.1016/bs.apar.2017.07.001

Our aim as the SWBio DTP is to support students from a range of backgrounds and circumstances. Where needed, we will work with you to take into consideration reasonable project adaptations (for example to support caring responsibilities, disabilities, other significant personal circumstances) as well as flexible working and part-time study requests, to enable greater access to a PhD. All our supervisors support us with this aim, so please feel comfortable in discussing further with the listed PhD project supervisor to see what is feasible.