Do microplastics cause harm in the Marine Environment?
ME5416 Potential for microplastics to cause “harm” in the marine environment

What’s the problem?

Plastics bring many societal benefits, providing important components for a multitude of applications. Annual global production is around 300 million tonnes. However, if not disposed of properly, plastic waste causes a variety of environmental problems. Discarded plastics can fragment in the environment, resulting in the formation of microplastics. Microplastic particles are also used in a variety of cleaning products as well as in cosmetics; these particles may then enter the environment via wastewater. Microplastics have been reported on shorelines, at the sea surface and even in the deep sea. They can be ingested by a wide range of organisms and concerns have arisen that this might cause ‘harm’; but the facts are poorly understood. Some plastics contain additive chemicals incorporated during manufacture and some also have the potential to concentrate organic chemical pollutants onto their surfaces from seawater. These pollutants can become very concentrated on microplastics. Hence the presence of microplastics in the environment could influence the transport of chemicals to marine life.

What are the aims of the project?

This research aims to establish the extent to which microplastic debris might cause harm to organisms in the marine environment. The plan of work and the objectives have been tailored to inform UK policy on marine litter. The project has five specific objectives:

1. To establish whether microplastic particles sorb contaminants present in the marine environment, which contaminants (if any) are of concern, and are they made bioavailable at concentrations which may cause ‘harm’ above background concentrations.

2. To establish whether common chemical additives in plastics persist after ageing in the marine environment and whether they are made bioavailable on ingestion and as such have the potential to cause ‘harm’.

3. To establish whether and how, microplastics are passed on through food web interactions and what the implications are for populations and ecosystems.

4. To determine the extent to which the physical presence of microplastics can cause ‘harm’ and in what quantities.

5. To establish whether ‘degradable plastic’ differs from conventional plastic in its potential to cause ‘harm’ impacts.

Which policy areas will the research inform?

Understanding whether microplastics cause harm in the environment will help UK policymakers assess how microplastics could impact the UK Government aim for oceans and seas to be clean, healthy, safe, productive and biologically diverse. The project outcomes may also inform waste management strategies. Hence the project is of direct relevance to UK policy, as well as being of broad international interest.

Figure 1: Schematic diagram illustrating how microplastic might transfer chemicals to marine life. A) Floating microplastic (yellow spheres) can contain additive chemicals (black diamonds) it can also adsorb and chemical pollutants (red circles) from sea water. B) Upon ingestion by marine organisms, chemicals desorb and this process is facilitated by natural detergents (surfactants) in the digestive tract (green symbols).
Source: Thompson, Plymouth University
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What are the results from the project and how will they be used?

Objective 1: Our experiments showed that microplastics rapidly took up organic pollutants from seawater (adsorption). Adsorption was plastic and pollutant specific, for example, being greater onto polyethylene than onto polyvinylchloride for some pollutants and vice versa for others. When present in mixtures, pollutants competed for adsorption onto plastics, with some chemicals suppressing others. It would therefore be necessary to assess specific combinations in any environmental risk assessment. The release of individual pollutants from plastics, (desorption), under conditions simulating those in the guts of marine organisms was evaluated. Gut conditions facilitated desorption and desorption rates increased with temperature, possibly indicating greater bioavailability for warm blooded creatures.

To estimate the relative importance of microplastics in transporting chemicals from seawater adsorption and desorption data were used in computerised programmes to simulate bioaccumulation in a deposit feeding invertebrate, a fish and a seabird. These scenarios considered either 1% or 5% plastic being present in the material that would normally be ingested during feeding. While there may be scenarios in which the presence of plastic makes a more important contribution, our modelling indicated that ingestion of microplastic does not provide an important additional pathway for the transfer of adsorbed chemicals from seawater to biota via the gut.

These predictions assumed microplastics are excreted at the same rate as natural food. However, subsequent experiments and some previous work, indicate microplastics can be retained by some organisms and this could increase chemical transfer, so we do not exclude the possibility that, for some organisms, transport of pollutants by microplastics could be more important.

Objective 2: Concentrations of chemical additives incorporated into plastics during manufacture can be higher than the concentrations of adsorbed pollutants. Experiments using plastics manufactured in the laboratory showed that transfer of additives from microplastics to marine life could be important. These conclusions were supported by toxicological experiments using invertebrates. Further work to quantify release of additive chemicals in the environment, prior to ingestion, is however needed to establish the full environmental relevance of these findings.

Figure 2: Microplastics a) particles from a cosmetic product (Source: Napper and Thompson, Plymouth University Electron Microscopy Suite), b) fragments of microplastics collected from a shoreline near to Plymouth, UK (Source: Thompson, Plymouth University). Scale bar applies to both pictures.

Objective 3: Our laboratory experiments showed that microplastics can transfer along a simple food chain from the common mussel to the shore crab.

We also demonstrated (Objective 4) that ingestion of microplastics in the absence of any additional chemical contaminants could cause ‘harm’, reducing the ability of a marine invertebrate to process food, but only at concentrations comparable to heavily contaminated shorelines.

Desorption of organic pollutants from one degradable polyethylene-based polymer was tested and was similar to that from conventional plastic (Objective 5).

In conclusion, this project advances our understanding about the transfer of organic pollutants and chemical additives from microplastics to marine life and demonstrates there can be adverse physical effects from ingesting microplastics.

Where can I find further information about this and related research?

Contact the project lead, Professor Richard Thompson, Plymouth University: r.c.thompson@plymouth.ac.uk

Alternatively, please contact Defra’s Marine and Fisheries Science Unit: marinescience@defra.gsi.gov.uk

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