Uptake and Impact of Microplastic on Aquatic Macroinvertebrates in Morecambe Bay

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- Microplastic uptake by macroinvertebrates in Morecambe bay
- Impacts of microplastics on invertebrates health
- Other research going on
Plastics
Plastics - Production

- 400 million tonnes of plastic produced yearly (globally)
- 50% of manufactured plastics are for single use
- Globally 32% of plastic is recycled

(Plastics Europe, 2020)
Plastics - Microplastics

- Mechanical breakdown
- UV radiation (Photo-oxidation)
- Microfibres from clothing
- Degraded tyre and road markings
- Primary microplastics (Banned)
Plastics - Size

Macroplastics
≥ 5 mm and <2.5 cm

Mesoplastics
5–10 mm

Microplastics
less than 5 mm

Nanoplastics
1-100nm
Microplastics - Transport

- Manufacture of synthetic textiles
- Manufacture of macroplastics
- Manufacture of microplastics

(Horton et al., 2017)
80%–99% of plastics entering sewage treatment are stored in sludge

(Horton et al., 2017)
Atmosphere

lower atmosphere (0.3–1.5 MPs/m³)

Indoor Air (30-60 MPs/m³)

Domestic

Industrial

WWTW

Sewage Sludge

Agriculture

(Horton et al., 2017)
high concentrations of plastic debris (40–250 MP/L melted ice) stored in Arctic sea ice (Horton et al., 2017)
50% of human population live less than 19 miles from the coast

4.8-12.7 MT of plastic pollution to marine environments

(Horton et al., 2017)
Domestic
Industrial
Agriculture
WWTW
Sewage Sludge

River characteristics
Microplastic characteristics

(Horton et al., 2017)
Fluxes of microplastics in the environment

(Windsor, 2020)
Biota Interactions with microplastics

Interactions with Biota
Microplastic Uptake

- Microplastic ubiquitous in freshwater and marine habitats
- Plastic uptake mainly governed by particle size and morphology
- Depends upon animal feeding type
  - Selective uptake by biota (mistaking plastics for food), due to microorganisms colonizing plastic
  - Aging of microplastics promotes ingestion

(Windsor et al., 2019).
(Setala et al., 2015)
Life History Impacts

- Negative impacts of growth, survival, reproduction and generational for some organisms
- But for most organisms the impacts are unknown
Additives

Endocrine Disrupting Chemicals

- Plasticizers - Phthalates
- Hardeners – Bisphenol A (BPA) & Bisphenol F (BPF) & Bisphenol S (BPS)
- Flame Retardants – Polybrominated diphenyl ethers (PBDE)

Other Additives

- Surfactants
- Synthetic Dyes
Environmentally relevant concentrations of polyethylene microplastics negatively impact the survival, growth and emergence of sediment-dwelling invertebrate

(Windsor et al., 2017).
Scale
- Ecosystem
- Community
- Population
- Individual
- Cellular
- Sub-cellular

Processes
- Colonisation
- Entanglement
- Physical blockage
- Abrasive damage
- Uptake across membranes
- Chemical Leaching

Ecosystem Structure (diversity and composition)
- Population demography (growth and decline)
- Mortality
- Growth
- Immune Response
- Oxidative stress
- Enzymatic process

(Windsor et al., 2017).
Uncertainty in the science?
## Part 2 – Morecambe bay project

1. Investigate the uptake of microplastics by aquatic macro-invertebrates across a salinity gradient in Morecambe Bay

2. Investigate the interactions between microplastic biofilms and aquatic macro-invertebrates in Morecambe Bay

3. Investigate the ‘Life History’ impacts of environmentally relevant microplastics on aquatic macro-invertebrates
Objective 1 – Microplastic uptake in Morecambe Bay

Location of Study Area and Sample Sites In Morecambe Bay

- 4 Rivers/Estuaries:
  - Leven river/estuary (LE)
  - Kent river/estuary (K)
  - Lune river/estuary (L)
  - Wyre river/estuary (W)

- 765 individual Macro-Invertebrates
- 11 different families of Macro-Invertebrates
- Marine/Brackish/Freshwater sites
Method

Sampling

Dissection

Digestion

Gut Clearance

Staining

Inspection

Kick Sample

Prep for digestion

KOH including heating

24 hrs in filtered water

Nile red

Fluorescent microscope

Identification

FT-IR
Field Study

- **Chironomidae** had a significantly higher concentration of MP than all other organisms.
- All sampled **organisms** contained plastic particles.

### Freshwater Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Concentration (MP/mg⁻¹ tissue)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wyre River (W1)</td>
<td>12</td>
</tr>
<tr>
<td>Wyre River (W2)</td>
<td>8</td>
</tr>
<tr>
<td>Lune River (L1)</td>
<td>4</td>
</tr>
<tr>
<td>Kent River (K1)</td>
<td>2</td>
</tr>
</tbody>
</table>

- **Stonefly larvae**
- **Amphipod**
- **Mayfly larvae**

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Field Study

![Bar chart showing MP:mg tissue⁻¹ for different sites and families of mussels and mud scuds.](chart.png)

- **Mussels**
  - Site W3
  - Site W4
  - Site L2
  - Site L3
  - Site K2
  - Site K3

- **Mud Scud**: Image of a mud scud on a sandy background.
Site differences

Concentration (particles mg⁻¹ tissue)

River/Estuary:
- Lune
- Leven
- Wyre
- Kent

Water types:
- bw
- fw
- mw
Exploring objective 2 - Microorganism colonization

Investigate the interactions between microplastic biofilms and aquatic macro-invertebrates in Morecambe Bay

1. Ecocorona
2. Microorganisms
3. EPS
Exploring objective 2 - Microplastic Uptake
method: exploring objective 2

biofilm

three polymers PET, PLA & Nylon, with variation in biofilm and UV aging

compare biofilms of different UV aged and non-UV aged polymers by 16s & 18s rRNA sequencing & analysis using a microvolume spectrophotometer

examine the polymer surface chemistry
Using X-Ray Photoelectron Spectroscopy (XPS)

determine if all plastics are equally ingested

investigate effects on macroinvertebrate growth
PhytoPlastic Project

Quantify the **microalgae biomass** developed on microplastics with different polymeric composition and determine whether biomass vary significantly among substrates across a variety of aquatic systems.

Identify the **microalgae species** that are able to develop on different substrates and understand whether plastics exert a strong enough selection to drive species sorting.

Evaluate the **temporal and seasonal evolution** of the epilastic community of microalgae in relation to several environmental variables.
PhytoPlastic Project

"Life in plastic, it’s fantastic: unravelling the microalgal community of plastisphere across European lentic systems" - funded by @EFFS_EFYR
Summary

Part 1 – Plastics & Microplastics
- Sources – mass production since the 1950’s
- Transport – move throughout all spheres in the environment
- Fate – ubiquitous in nature, organisms at the base of aquatic Food webs interact with them

Part 2 – Macroinvertebrates & Microplastics interactions in Morecambe Bay
- All macroinvertebrates investigated ingested Microplastic in Morecambe bay
- Impacts on palatability and impacts on growth and survival
- PhytoPlastic project
Thankyou for listening

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