· Microplastics in freshwater systems – presence, origins and ecological effects

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· Microplastics – what are they?

Plastic fragments/pellets/fibres/films <5mm

Sources:
- **Primary**: polyethylene/polypropylene ‘microbeads’ from personal care products and cosmetics, industrial pellets
- **Secondary**: Breakdown of large litter, shedding of nylon/polyester fibres (laundry)
• Microplastics are everywhere!

• Rivers and land recognised as sources but little studied

• Sewage treatment works do not capture these small particles

• Can be ingested by organisms

• Act as vectors for transport of persistent organic pollutants (POPs)
• Inputs to rivers in the UK

• Storm drain input

• Effluent input (‘grey water’)

• Combined Sewage Overflows (raw sewage)

• Land runoff

• Drainage ditches (agricultural)

• Litter
Microplastics in wastewater and sewage sludge

Removal efficiency of microplastics following wastewater treatment processes:

- 99% (Magnusson and Norén 2014)
- 98% (Murphy et al, 2016)
- 95% (Talvitie et al, 2017)
- 97% (Mintenig et al, 2017)

However due to large volumes processed, one large STW could still release approx. 900,000 – 800,000,000 MPs per day!
Microplastics in the Thames river basin, UK – a study

- 4 sites chosen: 2 dirty (> 25% effluent on average) and 2 clean (< 4% effluent on average)
- 4 replicate sediment samples
- Size fractions 1-2mm and 2-4mm
- Sorted visually and by density separation to ensure all particles were encountered.

Microplastics: sample sorting and analysis

Microplastics – Raman spectroscopy
Depending on the environment and organisms, exposure will occur in different ways.

Numerous variables influence organisms’ exposure, including:
- Proximity to source
- Habitat
- Behaviour
- Feeding habits

In addition to polymer characteristics including:
- Polymer type
- Particle size
- Biofouling

Effects fall into 2 main categories:
**Physical damage & chemical damage**

These can occur in combination.
Our approach to fish sampling:

The UK National Fish Tissue Archive

In 2007, CEH and the UK Environment Agency (EA) began to build an archive of fish tissue samples from a selection of English rivers.

- EA monitor fish stocks annually
- normally: throw all back
- now: give us 10 roach (10 cm+) from selected sites

Size, weight and gender recorded

Frozen on site (liquid N2)

Vacuum packed and stored at -80°C

Fish dissected and gut removed

Gut contents analysed for microplastics

Slide adapted from an original by Monika Juergens
Common roach in the Thames - fish gut analysis

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cricklade</td>
<td>36.047</td>
</tr>
<tr>
<td>Castle Eaton</td>
<td>42.619</td>
</tr>
<tr>
<td>Sandford-Abingdon</td>
<td>105.915</td>
</tr>
<tr>
<td>Caversham-Sonning</td>
<td>161.511</td>
</tr>
<tr>
<td>Temple-Marlow</td>
<td>186.949</td>
</tr>
<tr>
<td>Shepperton-Sunbury</td>
<td>234.155</td>
</tr>
<tr>
<td>Sunbury-Molesey</td>
<td>238.729</td>
</tr>
</tbody>
</table>

- Thames basin
- Urban areas
- River Thames
- Tributaries
- Main STWs
- Sampling sites
Roach gut analysis - results

Polymers identified as:
- Polyethylene
- Polypropylene
- Polyester

Microplastics are ingested!

Average plastics in gut vs distance from source

Differences in ingestion based on:
1. Gender
2. Size of fish
Ingestion of microplastics and chemical bioaccumulation

- Freshwater midge larvae – *Chironomus sancticaroli*
- 1% by mass nylon, 13-18 µm
- PBDEs: 47, 99, 100, 153

Images showing ingestion of microplastics by freshwater midge larvae *(Alice Horton)*

**Graph**

- **Chironomid PBDE body concentration (µg/g)**
- **Sediment PBDE concentration (µg/kg)**

- With microplastics
- Without microplastics

*R² = 0.9603*
Microplastics in terrestrial environments

- No known studies quantifying microplastics in the terrestrial environment
- Plastic litter breaks down in the environment
- Microplastics (beads and fibres) enter terrestrial environment via sewage sludge application to land
- High potential for retention
Difficulties in microplastics research

- Definition of ‘microplastics’ – very broad!
  - What is a plastic? A ‘pure’ polymer? Any composite containing plastic?

- Different polymers, sizes, shapes, ages will behave differently and have different effects.

- Environment will determine ecological interactions

- Comparability between studies: different methods
  - Sampling
  - Particle extraction
  - Minimum and maximum size counted
  - Particle identification

- Many studies rely on visual identification – very subjective

- Environmental studies are time-consuming!
Thank you

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References


Additional reading:

