Micro-plastics in the Solent estuarine complex, UK: An initial assessment

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Plastics and global production

Synthetic or semi-synthetic organic polymers, largely derived from petrochemicals

Versatile, inexpensive, lightweight, strong, durable, resistant to corrosion, with high insulation properties

Increasing variety offering a broadening range of technical solutions

**Global production:**
- Accounts for 8-10% of global oil production
- Predicted growth of 4% pa to 2016
Typology and application of plastics

Six plastics types account for about 70% of the total demand
Waste and plastic pollution

*Increasing consumption = increasing levels of waste*

Estimates: 75 to 80 tonnes of packaging end up in the oceans each year (Andrady, 2011)

*Vectors to the marine environment:* industrial discharge, littering and terrestrial run-off (Ng and Obbard, 2006)

18% of plastics in the marine environment is associated with the fishing industry (Andrady 2011: Thompson *et al.*, 2004; Frias *et al.*, 2010).
Micro-plastics

Pieces of plastic *less than 5 mm in size*, which can normally pass through a 500 µm sieve (Thompson *et al.*, 2004), resulting from:

- **In situ degradation of plastic objects** through photo chemical action or physical breakdown (including that by marine animals)
- **Direct input** by industrial processes and domestic uses

**Generic typology:**

1. **Particulates** - significant proportion are *micro beads* from raw material production and product ingredients

2. **Fibres** - facial cleaners, cigarette butts and fibres from clothes
Impact mechanisms of micro-plastics?

1. **Ingestion:** block intestines; lower steroid hormone levels; effect reproduction; prevent growth; and, reduce organism’s utilisation of nutrients (Murray and Cowie, 2011: Wright et al., 2013)

2. **Release of Persistent Organic Pollutants (POPs),** such as polyaromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) (Noren, 2010)
   
   – Transporting persistent, bio accumulating toxic substances into ecosystems?
   
   – Human health issues include cancer, immune system suppression, endocrine disruption and developmental abnormalities in children?

........ Is this a significant eco toxicological problem?
An initial assessment of micro-plastics in the Solent

Few studies have focused on estuaries; and most of those on sediments.

This study surveyed the levels of micro-plastics found within the water column of the Solent estuarine complex, UK.

Focussing on the Rivers Hamble, Itchen, and Test, and Southampton Water.

Problem: replicability and comparability

• Relatively recent research area
• No standardised methodology or protocol
• GESAMP Working Group 40 TOR
Methodology: data gathering

The survey utilised a plankton net with a 0.3mm mesh.

Four sample points identified in each of the Estuaries.

Each sample involved a 5 minute trawl downstream and 5 minute trawl upstream at 3 knots to counter effects of the tide.

Trawl 1 per estuary was furthest upstream.

Plankton trawl locations in the estuarine complex.
**Methodology: sample analysis**

- **Sample preparation:** Super-saline solution was applied to help separate high organic content from the plastics

- **Visual analysis:** samples were filtered through Whatman GF/A filter paper; and classified for size, shape and colour using light microscopy

- **Polymer analysis:** A representative sample was removed and polymer analysis performed using a Thermo Fisher Nicolet iS10 **Fourier Transform Infrared Spectrometer (FT-IR)** by the Clinical Biochemistry Laboratory at Southampton General Hospital

- Micro-plastic particles were *matched with the spectra of 53 polymers* in the Hummel polymer sample library, using a spectrum correlation search algorithm
### Results: total counts

<table>
<thead>
<tr>
<th>River</th>
<th>Trawl 1</th>
<th>Trawl 2</th>
<th>Trawl 3</th>
<th>Trawl 4</th>
<th>Total micro-plastics found</th>
</tr>
</thead>
<tbody>
<tr>
<td>Itchen</td>
<td>12</td>
<td>33</td>
<td>173</td>
<td>937</td>
<td>1155</td>
</tr>
<tr>
<td>Test</td>
<td>41</td>
<td>3</td>
<td>10</td>
<td>294</td>
<td>348</td>
</tr>
<tr>
<td>Hamble</td>
<td>17</td>
<td>22</td>
<td>148</td>
<td>109</td>
<td>296</td>
</tr>
<tr>
<td>Southampton water</td>
<td>489</td>
<td>45</td>
<td>334</td>
<td>92</td>
<td>960</td>
</tr>
<tr>
<td>Total all estuaries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2759</td>
</tr>
</tbody>
</table>

- High totals with significant spatial variation ..... why?
- Hot spots appear around confluence points
## Spatial distribution of activities

<table>
<thead>
<tr>
<th>River Itchen</th>
<th>River Test</th>
<th>River Hamble</th>
<th>Southampton Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 wastewater treatment plants</td>
<td>2 wastewater treatment plants</td>
<td>2 wastewater treatment plants</td>
<td>2 wastewater treatment plants</td>
</tr>
<tr>
<td>Shipping and port activity</td>
<td>Shipping and port activity</td>
<td>Boating and marina activity</td>
<td>Shipping and port activity</td>
</tr>
<tr>
<td>Boating and marina activity</td>
<td>Naval dockyard</td>
<td>Boat yards</td>
<td>Marina</td>
</tr>
<tr>
<td>Debris from roads</td>
<td>Debris from roads</td>
<td>Debris from roads</td>
<td>Debris from roads</td>
</tr>
<tr>
<td>Scrap yard</td>
<td>Scrap yard</td>
<td></td>
<td>Fawley oil terminal</td>
</tr>
<tr>
<td>Industrial estate (including polythene bag and sheet wrapping company)</td>
<td>Industrial estate</td>
<td></td>
<td>Confluence of other rivers and estuaries</td>
</tr>
</tbody>
</table>

**Summary:** Whilst there is similarity of activities the extent of these varies greatly
Results: shapes

**Fibres:** mainly polyester PET (clothes)?

**Rounded beads:** mainly PE and PP (exfoliants and feedstock pellets)?

**Low number of irregular shapes:** implies breakdown of larger plastics is of lesser importance? Why?

**Possible explanation:** The residence T of plastics within water column is relatively short ... *but why?*

**Tidal nature of the estuary?** .... the complex has a double high tide and a *particularly strong ebb*
Qualification: *Only partial results achieved, and not for all trawls*
Problems, problems:

**Sorting process:** efficiency of particle recovery; and possible misidentification of particles

**Poor spectra matching:** very small particles; environmental degradation and weathering of particle surfaces; organic coatings ..... or *just not in the library*
Results: Predominant polymer type by FTIR
Results are far from comprehensive and only act as an indicator

- Predominance of PE (including PET) and to lesser extent PP in all areas

- Particularly close to wastewater treatment works: PE and exfoliant product links (e.g. Fendell and Sewell, 2009)

- Where wastewater inputs are less influential, other plastics dominate

- **Cellophane**: Organic cellulose based polymer and therefore subject to biodegradation .... *Why is it there? Does it coat other plastics?*

...... *More research needed to answer the increasing number of questions!*
Management implications?

Managing the sources of micro-plastics:

- **Wastewater treatment plants** – difficult to foresee viable technical solutions
- **Industry** – the enhancement of waste management; and the development of improved assessment and auditing procedures for the plastics industry

**Education and campaigning:** *best short-term option*

- Encourage enlightened consumerism and corporate altruism
Conclusions

“I have not failed, I have found 100 ways that do not work”

Benjamin Franklin

..... Initial results raise more questions than answers .... a precursor for further work !
Conclusions and further work

- Count data suggests that the estuarine waters carry substantial amounts of plastic – *mostly fibres and rounded micro-beads*

- Polymer analysis suggests a *predominance of polyethylene (PE)*, associated with exfoliant products, and a likely sewage related debris vector …..

- However the picture lacks clarity ….

- Need for *a standardised methodology*

- *Further research* is required to better understand the polymer mix, residence times (oceanographic conditions); and the levels of risk associated with the pollution

….. *As well as how best to tackle the problem*
Many thanks ..... 

..... Any questions?