Removing microplastics in sewage treatment plants

Julia Talvitie
Aalto University, Finnish Environment Institute

Microplastics in wastewater treatment,
Skanderborg, September 26th
Introduction; Marine litter, microlitter and microplastics

- **Marine litter** is a human-created waste accidentally or deliberately released in the aquatic environments.

- Marine litter includes materials like glass, metals, rubber, wood, paper, textiles, **plastics**.

- **Microplastics** (< 5 mm) are of particular concern:
  - durability
  - potential to be transferred within food webs
  - causing mechanical stress
  - expose animals to hazardous substances
  - function as artificial “microbial reefs”

- Also non-synthetic **microlitter** has been proposed to have potential to transport chemical pollutants.
Microplastics - Where does it come from?

- Land-based sources of microplastics:
  - cosmetics and personal care products
  - textiles and clothing (synthetic fibres)
  - stormwater runoff (dust from tyres, synthetic fibers)
  - plastic industry and fabricators (plastic resin pellets)

- Proportion of microplastics will end up in WWTPs

- Aquatic-based sources include fisheries and shipping sectors

- Relative contribution of different sources to the total concentration of microplastics in the aquatic environment is poorly understood
Introduction: Wastewater treatment plants (WWTPs) as points source of microplastics

- First studies show that MPs can be efficiently (up to 99%) removed from the wastewater during the conventional treatment processes (e.g. CAS)

- Effluents still contain microplastics
  → Large amounts of effluents are discharged into aquatic environments continuously
  → Role of WWTPs as an entrance route of MPs to aquatic environments?

- WWTPs can offer solutions to reduce the input of MPs into the environment
Removing microplastics in sewage treatment plants

- Removal of microplastics during conventional activated sludge (CAS) process
- Microplastic balance in WWTP
- Effect of size and shape of microplastics on their removal in different treatment steps
- Common materials of effluent microlitter and microplastics
- Microlitter and microplastic load discharged into the aquatic environment with effluents
- “Effluent polishing”
Selected WWTP – Process Scheme

- Samples from influent (1), primary effluent (2), secondary effluent (3), final effluent(s) (4), excess sludge (5), reject water (6) and dried sludge (7)
Removal of microlitter during different treatment steps

- Influent: 567.8 ML L\(^{-1}\)
- Primary effluent: 11.6 ML L\(^{-1}\)
- Secondary effluent: 1.4 ML L\(^{-1}\)
Effect of particle size and shape on their removal in different treatment steps

**Size Fractions**

- Influent
- Primary effluent
- Secondary effluent

**Shapes**

- Influent
- Primary effluent
- Secondary effluent
The microlitter balance in WWTP

- Influent: ~80%
- Pre-treatment
- AS: ~1%
- Effluent
- Raw + Excess sludge: ~99%
- RAS
- Reject water: ~20%
- Digestion
- Dewatering: ~79%
- Dry sludge
Materials of microlitter detected in effluent
### Microlitter and microplastic discharged with secondary effluents

<table>
<thead>
<tr>
<th>Date</th>
<th>Monday 14.9</th>
<th>Wednesday 16.9</th>
<th>Saturday 19.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate (m³/d)</td>
<td>219024</td>
<td>281750</td>
<td>224294</td>
</tr>
<tr>
<td>ML concentration (ML/m³)</td>
<td>3200</td>
<td>700</td>
<td>3500</td>
</tr>
<tr>
<td>ML outflow (ML/d)</td>
<td>~ 7,0×10⁸</td>
<td>~ 2,0×10⁸</td>
<td>~ 7,9×10⁸</td>
</tr>
<tr>
<td>MP concentration (MP/m³)</td>
<td>651</td>
<td>6</td>
<td>161</td>
</tr>
<tr>
<td>MP outflow (MP/d)</td>
<td>~ 1,4×10⁸</td>
<td>~ 1,7×10⁶</td>
<td>~ 2,0×10⁷</td>
</tr>
</tbody>
</table>
Solutions to microplastic pollution

- 0.5 – 2.0 MP/L (secondary effluent)
  - Discfilter
  - 0.03 – 0.3 MP/L (final effluent)

- 0.7 MP/L (secondary effluent)
  - Rapid sandfilter
  - 0.02 MP/L (final effluent)

- 2.0 MP/L (secondary effluent)
  - Dissolved air flotation
  - 0.1 MP/L (final effluent)

- 6.9 MP/L (primary effluent)
  - Membrane bioreactor
  - 0.005 MP/L (final effluent)
For future recommendation

- Common methods (monitoring tools) → improving comparability of the results
- Composite sampling, flow-based measurements → better loading estimations
- Supporting parameters (SS, nutrients, bacteria, etc) from wastewater from the time of MP sampling → interpretation of the results
- Method development for influent (and sludge) sampling
- Fate and transportation of microplastics with sewage sludge
- Data from other sources!
Ongoing research in Finland

- Estimating the total MP load from Finnish WWTPs (part my PhD Thesis)

- Mussels (Mytilus trossulus) as indicators for point source discharge of microlitter

- Microplastics as vectors for bacteria from wastewater into the aquatic environment

- The role of stormwaters to MP load into the environment (Part of MIF (*Microplastics in Finnish Waters*) project)
Thanks 😊