Microplastic Pollution: A Survey of Wastewater Effluent in the Lake Champlain Basin

Student Researchers: Sadie Brown, Erin Lee, Brandon Buksa and Thomas Nikewicz

Faculty Mentor: Dr. Danielle Garneau

Center for Earth and Environmental Science & Dept. of Biology
SUNY Plattsburgh, Plattsburgh, NY 12901

Abstract

Microplastic pollution in freshwater ecosystems is an emerging topic in aquatic pollution science. Origin of microplastics are typically associated with consumer use of personal care products or the laundring of synthetic fabrics which are unable to be removed with current wastewater treatment plant (WWTP) technologies. Beginning in Fall 2015, we surveyed WWTP post-treatment effluent from the city of Plattsburgh, NY (N = 31). Effluent collection from St Albans, VT (N = 11), Ticonderoga, NY (N = 4), and Burlington, VT (N = 3) began fall 2016. Samples were processed using wet peroxide digestion methods, followed by classification based on type. Across the four WWTPs the majority of plastics found were fragments. Proportions between fragments and fibers were the following; Plattsburgh (51:23), St Albans (44:12), Ticonderoga (44:9), and Burlington (95:5). The high and low flow days, the majority of plastics found were between St Albans and Ticonderoga. Proportions between fragments and fibers were the following; Plattsburgh (51:23), St Albans (44:12), Ticonderoga (44:9), and Burlington (95:5). The high and low flow days, the majority of plastics found were between St Albans and Ticonderoga. Proportions between fragments and fibers were the following; Plattsburgh (51:23), St Albans (44:12), Ticonderoga (44:9), and Burlington (95:5).

Results

Wastewater Treatment Plant (WWTP)

Table 1. WWTP specifications in Lake Champlain Watershed

<table>
<thead>
<tr>
<th>WWTP</th>
<th>Plattsburgh</th>
<th>Ticonderoga</th>
<th>St Albans</th>
<th>Burlington</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max QMGD</td>
<td>16</td>
<td>3</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Population</td>
<td>28,298</td>
<td>6,691</td>
<td>4,600</td>
<td>12,550</td>
</tr>
<tr>
<td>BiAs</td>
<td>1973</td>
<td>1979</td>
<td>1609</td>
<td>1982</td>
</tr>
<tr>
<td>Last Updated</td>
<td>2012</td>
<td>2018</td>
<td>2016</td>
<td>2016</td>
</tr>
<tr>
<td>Discharge Per Capita</td>
<td>2,495</td>
<td>3,574</td>
<td>3,668</td>
<td>2,636</td>
</tr>
<tr>
<td>Influent</td>
<td>1,515</td>
<td>1,515</td>
<td>1,515</td>
<td>1,515</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>4,964</td>
<td>4,964</td>
<td>4,964</td>
<td>4,964</td>
</tr>
<tr>
<td>pH</td>
<td>7.49</td>
<td>7.49</td>
<td>7.49</td>
<td>7.49</td>
</tr>
<tr>
<td>Temperature</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
</tr>
<tr>
<td>N Treatment</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No Treatment</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Water Treatment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Water Treatment</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Methods

• Microplastics are characterized as films (A), pellets/balls (B), fibers (C), fragments (D), and foams (E) and are <5 mm in size (Fig. 2).
• Microplastics derive from personal care products, marine debris (e.g., fishing line, plastic lures, rope), pre-production plastic nurdles, and photo- and mechanical degradation of larger plastics, and/or from clothing, in the form of polyester and acrylic fibers (Thompson et al. 2011).
• More recent findings have suggested >1000 fibers are emitted from washing of one item of fleece clothing (Brown and others 2011).
• Less than 6% of wastewater treatment plants in the Great Lakes basin have tertiary treatment filtration capabilities, which might have reduced microplastic loads (Ondrager et al. 2015).
• Federal legislation (Microbead Free Waters Act) was passed to ban cosmetics containing intentionally-added plastic microbeads beginning on January 1, 2019, and their manufacturing beginning on July 1, 2017.

Hypothesis

• The most common type of WWTP microplastic would be pellets/balls.
• Larger particles would be more common during higher flow events.
• WWTPs serving smaller populations would yield fewer particles per day.

Laboratory analysis of samples:

• Contents of vials were placed in beakers.
• 30 ml of 4M KOH was pipetted into samples and stirred. Contents were sieved into the 125 um sieve and rinsed with DI water and placed into a new beaker.
• 20 ml FeSO4 and 20 ml of H2O2 were added to beakers and post-treatment effluent were heated and stirred at 79°C on a heated stir plate (Figs. 4A, 4D).
• 20 ml of H2O2 were added as needed until all organic material was dissolved.
• Samples were filtered through a stack of sieves 1 mm, 355 µm, 125 µm, for size separation, washed with DI water, and stored in shell vials (Figs. 4E).
• All samples underwent microplastic characterization (e.g., fragment, fiber, film, foam, pellet, under a Leica dissecting microscope (Fig. 4F).

• Fourier transform infrared microscopy (FTIR) will be used for further classification to polymer type.

• Sieve samples received wet peroxide oxidation digests to remove particulate type in WWTP post-treatment effluent.

• All samples underwent microplastic characterization (e.g., fragment, fiber, film, foam, pellet, under a Leica dissecting microscope (Fig. 4F).

• Fourier transform infrared microscopy (FTIR) will be used for further classification to polymer type.

• From the four WWTPs included in this study an estimated total of 28,833 plastic particles per day were entering the Lake Champlain Watershed.

Discussion

• Fragments and fibers were the most common microplastic particulate in WWTP effluent across the four sampling sites. Plattsburgh, Ticonderoga, St Albans, and Burlington. Plants with tertiary treatment had a smaller amount of microplastics compared to those without. 32 particles/sample (St Albans) vs 49 particles/sample (Ticonderoga).

• Plants in the Lake Champlain basin are emitting between 5-11,000,000 particles/day across the four WWTPs. St Albans > Burlington > Plattsburgh > Ticonderoga.

• Higher values in Plattsburgh and Burlington may result from increased population impacts as well as their proximity to Lake Champlain.

• Microplastics typically were small (125 µm) to medium (355 µm)-sized, as compared to larger (1 mm) fibers.

• Fewer small pellets would be expected in tertiary treated effluent, which would result in higher detection of microbeads.

• Microbeads, microfibers, and microplastics are present in the effluent of all four WWTPs with tertiary treatment.

• Microplastics are often associated with consumer use of personal care products or the laundring of synthetic fabrics which are unable to be removed with current wastewater treatment plant (WWTP) technologies.

• Mason et al. (2016) supports that flow rate was not associated with microplastic particulate type in WWTP post-treatment effluent.

• Polystyrene and polypropylene plastics float on the water surface.

• Studies have shown both water transfer from algae (Gutknecht et al. 2016) zooplankton (Frias et al. 2014), to fish (Hesse et al. 2015), and waterfowl (Xu and others 2016), humans (Vanschoonbeek and Joosen 2014-mussels, Lieth and Liebeschuetz 2014, Xu and others 2014) to receive microplastics.