Plastic Pollution in the Environment:
Insights from Lake Superior

Elizabeth Minor, UMD Large Lakes Observatory
Kathryn Schreiner, UMD Large Lakes Observatory
Introduction: some definitions

- Plastic: a synthetic organic polymer that exhibits plasticity (the ability to deform under stress) at some point in its life cycle and that can be molded.
  - Many different polymers fit this definition and they are often mixed with additives to adjust their properties.

Polyester

Polypropylene

PVC
Introduction: some definitions

- Plastic: a synthetic organic polymer that exhibits plasticity (the ability to deform under stress) at some point in its life cycle and that can be molded.
  - Many different polymers fit this definition and they are often mixed with additives to adjust their properties.

- Plastic size ranges
  - **Microplastics** usually defined as <5 mm in size with lower size cut-off determined by analytical limitations (>300 um usual for microscopy, >20 um for microFTIR - explained later)
  - **Nanoplastics** have a range of definitions, but are generally smaller than microplastics (< 300 um or < 20 um)
Introduction
Introduction
Estimates of microplastic consumption by humans (from Cox et al, 2019). Caveat: based upon 15% of US caloric consumption. No data on fish, chicken, vegetable microplastic contents…
But the collection & analysis of environmental microplastics is a science that is still being developed.

There are many challenges, including:

- Field collection: time intensive and need enough sample for good counting statistics
- Sample preparation: time intensive and requires many human hours
- Sample analysis: difficult and requires specialized equipment
Our studies

Three views of plastics in the environment:

- From water in Lake Superior
- From beach sands in Lake Superior
- From fish from the Texas Gulf Coast

- Current work investigating water, sediment, and fish in 4 MN lakes.
Sample Collection: Water

**Water:** Net tows (~30 min): lots of water (one 600 m tow filters ~50,000 L), but nets are larger mesh size (typically 300 um).

For smaller size particles like nanoplastics, which may have more particles/L, 100 to 1000L of water may be enough with an in-situ oceanographic pumped filter system, 1000 L takes ~ 6 hours.
Sample Collection: Sand

- **Beach sand**: easy to collect (<30 minutes) but time consuming to process
Sample preparation & analysis

1. Sieving/filtering and drying
2. Removal of natural OM if necessary
3. Density separation
4. Microscopy: melt testing, particle picking
5. Chemical identification (PyGCMS, FTIR, or SEM)
6. Data analysis

Photo: E. Minor
Photo: E. Hendrickson
Photo: E. Hendrickson

Microplastic Abundance and Composition in Western Lake Superior
As Determined via Microscopy, Pyr-GC/MS, and FTIR

Erik Hendrickson, Elizabeth C. Minor, and Kathryn Schreiner
Results: Water
- Particles obtained from site C
- Microscopic identification with pressure test only.

- Particles chosen for chemical analysis.
- Slightly disproportional because:
  - Wanted morphology from at least 1 in all categories.
  - Challenges in identification:
    - E.g., Non-plastic fragments found, analyzed in replicate.
Results: Water (Lake Superior)

PVC, PP, PE, and PET most dominant plastics identified.
Beach sand study in national parks (samples collected in 2015, 2016)

• APIS: 221 ± 29 microplastic particles/kg (all fibers)...

Figure 2: Mean abundance of microplastics per kg of sand for thirty-seven NPS units sampled during 2015 and 2016. Colors represent the region the park is located. Error bars represent standard error.
We even more fibers 330/kg (blank corrected)

But via melt test: 0 to 35 plastic particles/kg

blank-corrected values have no measurable plastics

What are these fibers that don’t melt (either burn or are inert to flame)?

No signal via pyGCMs.

Tried scanning electron microscopy instead…

Results: Beach sand
Results: Beach sand

**SEM data**

Al1_2a (plastics) > 0.45μm Location 1

<table>
<thead>
<tr>
<th>Spectrum</th>
<th>In stats</th>
<th>C</th>
<th>O</th>
<th>Al</th>
<th>Si</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrum 1</td>
<td>Yes</td>
<td>85.5</td>
<td>12.9</td>
<td>0.3</td>
<td>1.07</td>
<td>100.0</td>
</tr>
<tr>
<td>Spectrum 2</td>
<td>Yes</td>
<td>33.3</td>
<td>3.38</td>
<td></td>
<td></td>
<td>63.2</td>
</tr>
</tbody>
</table>

Particle is C rich but doesn’t have much O, organic?
Particle floated in density separation, did not melt, appears mineral (high Si, Al, and O levels) via SEM. Aluminosilicate (natural or fiberglass?)
Results: Fish (Gulf Coast)

Ingested microplastics by morphology (from Peters et al., 2017)

- Fiber
- Bead
- Fragment
Current work

- Water
- Sediment
- Fish

Sentinel lakes

Click on a lake for more information

- White Iron
- Elk
- Ten Mile
- Peitler

Sentinel lake type:
- Cold Water (Cisco or Trout)
- Deep
- Shallow
- Super sentinel

Major land type:
- Canadian Shield
- Transition Forest
- Glacial Drift Northern Forest
- Prairie and Cornbelt
Questions?

Elizabeth Minor: eminor@d.umn.edu
Kathryn Schreiner: kschrein@d.umn.edu