Plastics Pollution in the Laurentian Great Lakes

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Scope

Plastic debris is pervasive and persistent pollutants in the world’s aquatic environments, with significant economic, ecological, human health, and aesthetic impacts. We are exploring the feasibility of using spectroscopic techniques to detect plastic debris in rivers, lakes, beaches and sediments, while also using existing data sets to help characterize and map the distribution of plastic debris in the Great Lakes. Our research aims to advance the identification, tracking, mapping, and reporting of plastic debris in the Great Lakes to support public awareness, industries at risk, regulation of plastic waste disposal and treatment, and to expedite cleanup efforts. Our recent publication (Driedger et al., 2015) provides the first comprehensive review of plastic pollution research in the Great Lakes.

Background

Microscopic Plastic Debris

- Size (diameter): < 2.5 mm
- Sources: fibers from synthetic fabrics, breakdown of larger plastics
- Due to size and buoyancy, microscopic plastics are not retained by wastewater treatment plants.
- Impacts: transport of debris (including POPs and heavy metals), accumulation in the food chain, transfer of toxins from plastic to wildlife (via ingestion)

Macroplastic Debris

- Size (diameter): >5 mm
- Sources: litter from beach-goers, fishing materials (e.g. nets, lines), stormwater discharge, human littering, illegal offshore dumping, lost during shipping
- Impacts: wildlife entanglement and ingestion, transport of toxins including POPs and heavy metals, impact of invasive species, reduced fishing catch, beach and harbor cleaning costs

Cost of Combating Plastics Pollution in the Great Lakes

Stickel et al. (2012) estimated that $13 per resident annually is spent on the following activities:

- Beach and waterway cleanups
- Street sweeping
- Installation of storm-water capture devices
- Storm drain cleaning and maintenance
- Manual cleanup of litter
- Public anti-littering campaigns

By extrapolation, given that the Great Lakes region houses 36 million people within 50 km of its shoreline, we estimate that the direct cost of combating plastic pollution in the Great Lakes is:

US $468,000,000

Spectral Identification

We conducted a feasibility study on the use of near infrared reflectance (NIR) and Raman spectroscopy for detecting plastic debris in aquatic environments. In collaboration with P&P Optica, a spectrometer manufacturer in Waterloo, we conducted two experiments to determine the effects of mechanical weathering and biofilm growth on the NIR and Raman spectra of plastic debris. The experiments intend to simulate the fate of plastic debris in lake environments. The results obtained so far indicate little changes in the diagnostic spectral characteristics of the plastics upon mechanical weathering and colonization by microorganisms. The intensities of the NIR spectra for the debris covered by biofilms, however, are attenuated relative to the naked plastic surfaces. Raman spectroscopy may help overcome this limitation of NIR.

We found that the NIR spectra of the weathered plastics show minimal changes in the spectral features of weathered plastics when compared with the initial, unworn plastic.

BIOFILM FORMATION

NIR spectra of the weathered plastic debris: preliminary results show minimal change in the spectral features of weathered plastics when compared with the initial, unworn plastic.

Conclusions and Future Research

- NIR has the ideal spectral range for in situ identification of plastic debris. Due to significant attenuation in water, NIR sensing technology is most promising for plastics detection in filtered water samples and solid-phase samples (sediments, soils, beach sand). Raman suffers less from attenuation in water than NIR and will be used to develop in situ sensors for monitoring plastics within the water column.
- Weathering of plastics does not significantly alter their spectral features; current NIR spectral libraries are sufficient to identify weathered plastics. Biofilms diminish NIR spectral peaks but spectra can still be identified.
- Volunteer beach cleanups show that typically more than 80% of litter along the shorelines of the Great Lakes is comprised of plastics. Because intact or near-intact debris, such as cigarette filters and food related items, mostly represent in-situ litter, beach-goers appear to be a major source of plastic debris.
- Population density (and by extension, number of beach-goers) was found to be a significant driver of litter density on Great Lakes shorelines. The strong correlation between macroplastic and tiny plastic debris indicates their sources are likely related.
- Future research will include field deployment of NIR spectrometer, continued analysis of shoreline litter data, and application of Raman spectroscopy.

Shoreline Litter Analysis

To date, few scientific articles have been published that include quantitative data describing the distribution of plastic debris on Great Lakes shorelines. Data characterizing the spatial and temporal distribution of plastic debris is important for developing waste reduction and management strategies. Volunteer-led beach cleanups provide a valuable, alternative source of data about shoreline plastics. We are using litter survey data generated during cleanups between 2008 and 2013 by volunteers of the Adopt-a-Beach (AAB) and Great Canadian Shoreline Cleanup (GCSC) programs to delineate the abundance, sources, and distribution of plastic debris on Great Lakes shorelines.

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Contributors

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References:


