PLASTIC POLLUTION IN THE GREAT LAKES

Queen's University | BlueGreen Innovation Group

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"[I] would put plastic pollution and the associated chemicals second to climate change, in terms of our species survival."

– Dr. Sherri Mason

Sustainability Coordinator, Penn State Behrend

THE GREAT LAKES

- Contain 18% of the world's total freshwater[1].
- Abundance of natural resources, efficient transportation systems, and long-standing binational economic integration.
- Economic capacity comparable to some of the largest industrialized economies in the world.

PLASTIC PRODUCTION AND INDUSTRY

- Plastics are ubiquitous in modern life, with wide-ranging applications in manufacturing, technology, and consumer products.
- World plastic production was 348 M Tonnes in 2017, with 2% of industry being in Canada[2,3].
- Plastics adsorb harmful chemicals.

OVERVIEW OF PUBLISHED LITERATURE

Tributaries | Sediments | Shorelines | Surface Waters

Plastic Debris in 29 Great Lakes Tributaries: Relations to Watershed Attributes and Hydrology
Baldwin et al., 2016

Microplastics in the Great Lakes
Various authors, International Joint Commission, 2016

Plastic debris in the Laurentian Great lakes: a review
Driedger et al., 2015

Sources and sinks of microplastics in Canadian Lake Ontario nearshore, tributary, and beach sediments
Ballent et al., 2016

Hidden plastics of Lake Ontario, Canada, and their potential preservation in the sediment record
Corcoran et al., 2015

Comparison of the distribution and degradation of plastic debris along shorelines of the Great Lakes, North America
Zbyszewski et al., 2014

Assessing and Mitigating Plastic Pollution in Lake Huron
Hydra Horizons Consulting, 2013

Distribution and degradation of fresh water plastic particles along the beaches of Lake Huron, Canada
Zbyszewski et al., 2011

Microplastic pollution in the surface waters of the Laurentian Great Lakes
Eriksen et al., 2013

Microplastic Abundance and Composition in Western Lake Superior As Determined via Microscopy, Pyr-GC/MS, and FTIR
Hendrickson et al., 2018

Pelagic plastic pollution within the surface waters of Lake Michigan, USA
Mason et al., 2016

The academic discourse identifies the following knowledge gaps:

- Spatial and temporal distribution of plastic debris
- Microplastics' physiological impact on the aquatic organisms
- Microplastics' impact on sediments
- Sources and compositions of plastic pollution, and
- The presence and impact of macroplastics

MAJOR SOURCES OF PLASTIC POLLUTION

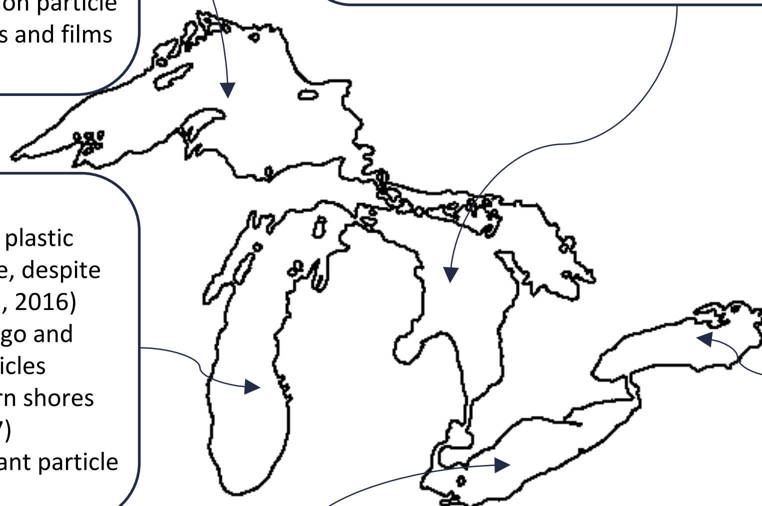
Population - Most intact plastic waste found on beaches of the Great Lakes comes from urban waste, particularly driven by the high number of residents and visitors around Lake Erie and the GTA. The high number of microbeads found is likely due in large part to abrasive agents used in cosmetic products. Consumer products such as clothing, packaging, and Styrofoam are also likely sources.

Industry – The largest contributor is spillage of pre-production plastic pellets ("nurdles") during transportation and in factories.

SUMMARY OF RESEARCH FINDINGS

Lake Superior
- Predictive model projects lowest number of plastic particles of any of the lakes (Driedger et al., 2015)
- Nearshore sites have the lowest concentration of microplastics with offshore open-water sites having the highest (Hendrickson et al., 2018)
- Fibers are the most common particle type, followed by fragments and films (Hendrickson et al., 2018)

Lake Huron
- Found to have the lowest concentration of plastics (Eriksen et al.)
- Gradual decrease in plastic volume from Sarnia towards Kingcardine, suggesting that most debris originates from the industrial area surrounding Sarnia, Ontario (Zbyszewski et al., 2014)
- Beach samples yielded high volumes of pellets, plastic fiber fragments, and Styrofoam (Zbyszewski & Corcoran, 2011)



Lake Michigan
- Fairly even distribution of plastic particles across lake surface, despite seasonal gyre (Mason et al., 2016)
- Primary sources are Chicago and Milwaukee, with most particles accumulating on the eastern shores (Hoffman & Hittinger, 2017)
- Fragments are the dominant particle type (Mason et al., 2016)

Lake Erie
- Average concentration of plastics in its surface waters: 0.1055 plastic items/m^2 (Erikson et al., 2013)
- Converging water currents in its east basin contribute to gathering plastics in high concentration (Beletsky et al., 1999)
- Fragments are the dominant particle type (Zbyszewski et al., 2014)

Lake Ontario
- Average concentration of plastics found to be 700 particles per kg of sediment (Ballent & Corcoran, 2016)
- Proximity to large urban centers such as Toronto correlated with increased amounts of microplastics per kg of sediment (Ballent & Corcoran, 2016)
- Fibers and fragments are the dominant plastic particles across tributaries, beaches, and nearshore sites (Ballent & Corcoran, 2016)

CURRENT PREVENTION MEASURES

RECYCLING	WWTPs
Recycling, often touted as an answer to the environmental crisis, is insufficient. Approximately 6.3B metric tonnes of plastic waste are produced globally, of which nine percent is recycled[4]. The sheer volume of plastics produced and international socioeconomic factors mean that recycling alone cannot address the overproduction of plastic.	Nominally, a mere 1% of microplastics remain in the WWTP effluent after treatment, but this means approximately 30 billion particles can still be released annually in major plants[5]. Without increased tertiary filtration methods, the release of microplastics through WWTP effluents will continue to pose a major hidden source of plastic pollution.

POTENTIAL IMPACT – COMPARISON TO OCEANIC PLASTIC POLLUTION

ENTANGLEMENT	INGESTION	BIOACCUMULATION
• Species most significantly effected include turtles, penguins, and seabirds • Can lead to drowning, starvation, debilitation, or injury	• Can happen when animals mistake plastic for prey • Effects include, but are not limited to choking, wounds, and ulcerating sores	• Persistent organic pollutants adsorbed to plastics can be ingested and accumulate in food webs

Source: 6

THE EVOLUTION OF LEGAL ACTION

1909
Boundary Waters Treaty signed by Canada and the US, establishing the **International Joint Commission**.

1912
International Joint Commission held its first meeting to address more than 100 issues raised by the federal governments.

1978
Great Lakes Water Quality Agreement signed by Canada and the US.

2012
Amendments made to the **Great Lakes Water Quality Agreement**.

2015
Great Lakes Protection Act passed in Ontario.

2018
Charlevoix Blueprint produced at the 44th G7 summit in Québec.
Federal **Ban on Microbeads** commenced.

2019
Ontario released **discussion paper** on reducing waste in communities.

Pollution and management of water resources has long been a concern for governments in Canada and the US.

While lawmakers were initially concerned with the resource, trade, and territorial dimensions of the Great Lakes, focus in the 21st century has gradually shifted to addressing pollution.

The tools for tackling plastic pollution are largely present in existing legislation. Bill C-68, which the government is seeking to pass by June 2019, intends to make "the conservation and protection of fish and fish habitat, including by preventing pollution" one of the two purposes of the Fisheries Act. This would empower the Minister of the Environment to make regulations for the conservation and protection of marine biodiversity, and be a step towards stronger enforcement of the prohibitions in the Act[7].

RECOMMENDATIONS

CONSUMERS should reduce use of plastics. Recycling is a start, but it is not sufficiently effective.

EDUCATORS should integrate environmental awareness into curriculum so everyone is aware of plastic pollution and the impacts.

"There are significant existing regulations on pollution, both at state and provincial levels, as well as international agreements on pollution. The construct already exists to protect the waters; the next step is to increase education on consumer actions"

– Dr. Michael Twiss
Professor, Clarkson University Department of Biology

RESEARCHERS should conduct further research into microplastic's impact on sediments and on biological organisms. Leading academics should also work to develop a uniform sampling methodology and global data sharing platform to harmonize research efforts.

BUSINESS & INDUSTRY LEADERS should stay abreast of changing consumer attitudes towards plastics by developing new innovations that reduce or minimize the impact of plastics. WWTPs should increase tertiary filtration methods to improve clarity of effluent entering the environment.

THE GOVERNMENT OF ONTARIO should gradually phase out Styrofoam and single-use plastics over a multi-year period. Provincial legislature should also strengthen labelling standards on products containing or packaged in plastics and implement incentives for companies that repurpose or reuse plastics for secondary consumption.

THE GOVERNMENT OF CANADA should tax plastic production to ensure recycling remains economically viable. Parliament should clarify the meaning of "deleterious substances" in the *Fisheries Act*, by enumerating categories or listing concentrations of plastics that rise to the level of "deleterious substances."

CANADA AND THE UNITED STATES should work together to increase the independence and adjudicative powers of the International Joint Commission. Both countries should support the development of a universal data sharing network. Federal research grants can incentivize researchers to share data and adopt uniform sampling methodologies.

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