

A survey on the effect of plastic pollution in the Great Lakes

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ABSTRACT

Plastic pollution is one of the most important subjects of water contaminations in the world. Plastic pollutions not only threats locally, but also, they are widespread, posing broader risks to the world and environment. Plastics which act as pollutants are categorized by size into micro-, meso-, or macro debris. The micro plastics move through oceans from one region to another region. Today, there are several evidence of micro plastics in south pole where we believe it as a clean area. This paper surveys the effects of micro plastics on the Great Lakes.

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1. Introduction

The Great Lakes are a series of relatively big interconnected freshwater lakes with certain sea-like characteristics in Canada which connect to the Atlantic Ocean. The Great Lakes consist of five lakes: namely Lakes Superior, Michigan, Huron, Erie, and Ontario (See Fig. 1). The Great Lakes maintain the biggest group of freshwater lakes on our planet by total area and they are the second largest in terms of the total volume, or about 21% of the world's surface fresh water in terms of volume (Ghassemi, 2007). The lakes have been used primarily for different purposes such as transportation, migration, trade, and fishing. Moreover, the lakes serve many aquatic species in a region (Likens, 2010).

During the past few decades, the Great Lakes have been under severe pollution by many issues. Many industries across the board empty their switches in the Lakes, which contaminate the water significantly. Many civilians leave their unused belongings to the lakes and such contamination influences residents of Ontario. One survey estimates that nearly 10,000 metric tons of plastic debris enter the Great Lakes every year from the United States and Canada (Rochester Institute of Technology, 2016; Durnford et al., 2018). These plastic substances penetrate to wild inhabitants in the region and through a long cycle will end in the body of civilians. The immediate consequence of having such unwelcome materials in our body is the presence of different diseases. Contamination of food supply is not even restricted to residents since the lakes are connected to oceans and over a long period of time, the lives of the people all-around of the world will be threatened.

This paper presents a survey on recent advances on scientific achievements of the effects of plastic pollution on the Great Lakes.

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Fig. 1. The Great Lakes (Source: Wikipedia)

2. Plastic pollutant

According to Cable et al. (2017), most plastic pollution is originally generated on land and freshwater bodies transport the plastic litter to the ocean. Thus, it is important to learn more about the effects of plastic litter in freshwater ecosystems. Rainey (1967) is believed to be the first one who raised concerns over the Great Lakes plastic contamination. He showed through a mathematical model that “if the pollution of the Great Lakes were discontinued, the natural flow through the lower Great Lakes would be sufficient to remove about 90 percent of the waste in about 20 years. On the other hand, hundreds of years would be required to displace the pollution from Lake Michigan and Lake Superior” (Rainey, 1967). Garcia-Hernandez et al. (2022) presented a model for estimating the total economic costs of nutrient emission reduction policies to halt eutrophication in the Great Lakes. The results indicated the least cost-way to reach various TP emission reduction targets. The estimated cost to reduce TP emissions by 40% in all GL amounts to a total annual cost of 3 billion Canadian dollars or 0.15% of Canada's GDP.

Sonzogni et al. (1983) further emphasized the irreversible pollution impacts of chloride on the Great Lakes. Hoh et al. (2006) also reported a significant amount of chloride substances in creatures living in the lakes. According to Eriksen et al. (2013), Plastic pollution accumulates in the Laurentian Great Lakes of the United States and Canada. Boulanger et al. (2004) also reported a significant amount of perfluorooctane surfactants in Great Lakes water.

During the past years, due to the widespread event of dissemination of contaminants in Great Lakes tributaries, a vulnerability index (VI) has been developed to evaluate the potential exposure of aquatic communities to chemicals of emerging concern (CEC) in the Great Lakes basin. Kiesling et al. (2022) examined the robust nature of the VI to assess the underlying statistical model and expanded the spatial domain of the index. Zaporski and Yang (2022) the impacts of magnetite on phosphorus storage and carbon cycling in Lake Michigan shoreline sediments. Microcosm incubations with native sediments demonstrated that “the addition of P substantially increased microbial decomposition of labile organic carbon, whereas the added synthetic magnetite did not significantly reduce the P bioavailability or decrease the carbon degradation”.

Through the Great Lakes, CECs have been discovered in urban water resources. Baker et al. (2022) collected surface water and a limited number of sediment samples from Spring to Fall 2018–2019 at different locations in the Lake Huron to Lake Erie corridor to study more than 150 CECs. Surface water was carefully considered for pharmaceutical and personal care products (PPCPs), pesticides, and per- and polyfluoroalkyl substances (PFAS). Sediment was also studied for PFAS. The results indicated that compound mixtures became increasingly complex downstream and showed that the downstream Lake Huron to Erie corridor was wastewater effluent-dominated, but the aquatic environment related to Lake St. Clair was influenced by a mixed urban, suburban, and agricultural landscape.

3. Pollution survey statistics

We have performed a survey using the Scopus database to see how deep the subject of pollution has been investigated. We used the term The Great Lakes and pollution as two keywords together for the search and realized that 1240 articles have been devoted to study this subject from 1914 to 2022. On average, there have been 31.5 papers published from 2000 to

2022. In our survey, the most influential paper belongs to Daniel et al. (1998) followed by Fry (1995) which focused on reproductive effects in birds exposed to pesticides and industrial chemicals. Blair et al. (2013) presented a controversial survey and reported that pharmaceuticals and personal care products were detected in the Great Lakes and became a basic search for other researchers of environmental concern. This paper has received 346 and 475 records of citations based on Scopus and Scholar databases, respectively.

In terms of fundings, 50 research papers were published by funding provided by Natural Sciences and Engineering Research Council of Canada. In addition, 44 research papers were also financially supported by the government of Canada. There were also 94 research works supported by the U.S. Environmental Protection Agency while 21 works were supported by the U.S. Geological Survey. In terms of the affiliation, 242 studies were affiliated to Environment Canada and 46 research works were affiliated to the Ontario Ministry of the Environment. It is interesting to learn that 162 and 147 papers were published in Journal Of Great Lakes Research and Environmental Science And Technology, respectively. It appears that the subject was so popular that there was one specialized journal dedicated only on the Great Lakes issues. Fig. 2 shows the diversity of the keywords used in our survey.

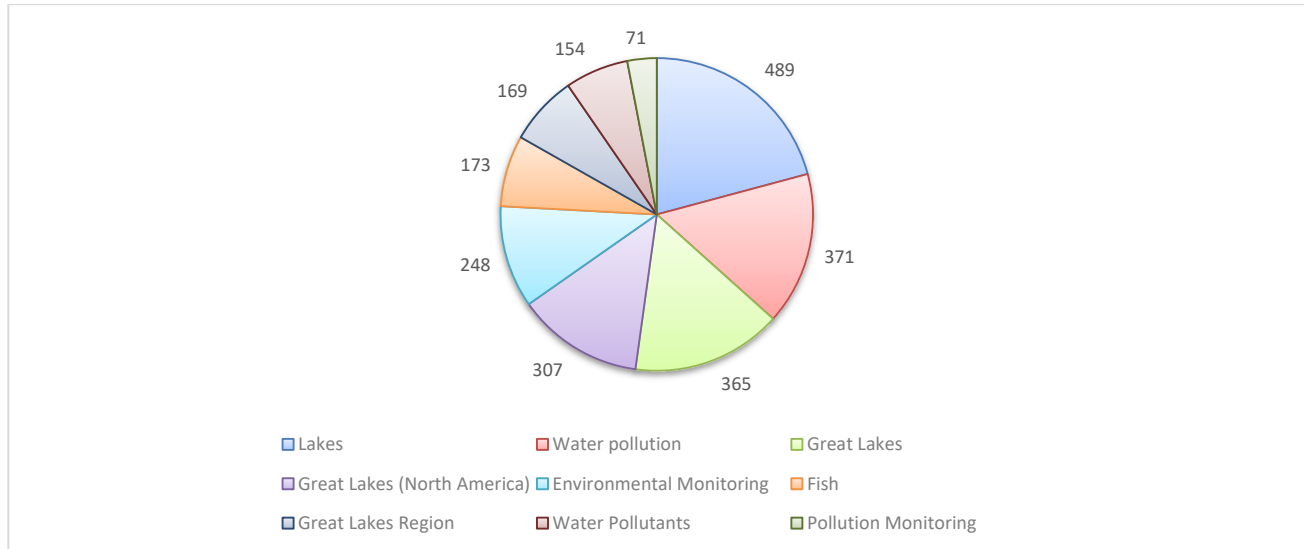


Fig. 2. Distribution of the keywords used in the published papers from 1900 to 2022

As we can observe from Fig. 2, keywords like Great Lakes and Great Lakes Region were the most popular words among 1240 articles in our survey.

3. Summary

This short survey has shown the relative importance of clean water on the lives of the people all over the world. The Great Lakes, as the biggest source of water, must remain clean for the next generations and there must be more attempts to save what mother nature has inherited from us. Government must place more restrictive laws to prevent people and industries from abusing the Great Lakes. There must be more awareness on the relative importance of clean water and the effect of plastic pollution on the human body. Future research studies must continue to find new methods of preventing the lakes from more pollution.

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