

Some facts about Plastics submitted by Dr. Randi Pokladnik

1. Plastic packaging accounts for half the plastic wastes in the world
2. America, Japan and the European Union are the world's largest producers of plastic per capita
3. By 2050 there will be 12 billion tons of plastic litter in landfills and the environment
4. By 2050, plastic may account for 20% of the world's total oil consumption
5. If tied together, the five trillion plastic bags used worldwide each year could be wrapped around the world seven times every hour!
6. More than half of all the plastic made was produced in the last 15 years
7. 99 percent of all the plastic made is derived from fossil fuels
8. In 1978, Coca Cola replaced glass with plastic
9. In 2018, 1.13 million items of packaging (mostly plastics) used for food and drinks in European Union alone
10. Plastics found in soils are 4 to 23 times higher than plastics in the sea
11. Making a polyester shirt may emit between 3.8 to 7.1 kg of Carbon dioxide
12. In 2018, China banned the import of plastic wastes
13. The four biggest exporters of plastics are: USA, Japan, Germany and UK
14. We have a ton of plastic for every person alive on the planet
15. Coca cola uses 88 billion single use bottles a year
16. Sachets, one single use of a single serving size are used extensively in poor countries (50% end up as wastes in a month)
17. USA uses 21% of single use packaging
18. Most common single use plastics are: Cig butts, drinking bottles, bottle caps, food wrappers, plastic grocery bags, plastic cup lids, straws, stirrers, foam take-out containers (ALL UNNECESSARY USES)
19. Of the 400 million tons of plastic made each year (158 million tons is for packaging) (62 for fabrics) (45 for consumer products) (71 for building and construction- this sector wouldn't be single use)
20. If you drink bottled water, you consume an average of 130,000 microplastics a year (Canadian study)
21. We eat on average the weight of one credit card a week of plastic (Australian study)
22. Food packaging industry market value in 2017 was \$277.9 billion
23. Women who handle plastics in the car industry are 5 X as likely to develop breast cancer
24. Plastic additives contribute to : obesity, diabetes, neurological diseases, premature onset of puberty, hypospadias
25. Bio-degradable plastic requires 12 weeks at 60 C to de-grade
26. Only 24 % of the 9.2 billion tons of plastics made since the 1950s are still in use

27. By 2021 Thailand and Malaysia will ban imported plastic scrap
28. Britain and USA are among the world's top plastic exporters and Malaysia is one of the top importers of wastes
29. Incinerators are expensive and when plastic is burned it creates dioxins and furans as well as carbon dioxide and other toxic emissions
30. Price paid for plastic wastes is much lower than what us paid for cardboard and metals
31. End of the waste stream solutions like recycling and incineration absolve the manufacturers of their responsibility. We need to make less plastics.
32. ORB found approximately 16 fibers in the tap water at the visitor's center in US Capital, home to both houses of Congress.
33. 95 % of the world's tap water now contains microplastics
34. 10 Rivers are carrying 90% of the plastic wastes to oceans. Two of them are in Africa - the Nile and the Niger - while the others are in Asia: the Indus, Ganges, Amur, Mekong, Pearl, Hai he, Yellow and Yangtze.
35. By 2050, an estimated 99% of seabirds will have ingested plastics
36. Plastic bags can increase the risk of transmission of vector- borne diseases such as malaria (blocking sewer systems and holding water.
37. The world produces over 400 million tons of plastic a year.
38. Only 2 percent of plastic packaging is effectively recycled.
39. Many of our food containers contain styrene and benzene which are carcinogens.
40. North America is the only continent without any policy on plastic bags.
41. The combined mass of just the three most-littered plastics (polyethylene, polypropylene, and polystyrene) of 32–651  $\mu\text{m}$  size-class suspended in the top 200 meters of the Atlantic Ocean is 11.6–21.1 Million Tonnes. (<https://www.nature.com/articles/s41467-020-17932-9>)
42. Sunlight can completely oxidize Polystyrene to  $\text{CO}_2$  and partially oxidize PS to dissolved organic carbon (DOC). Time scales of these photo-oxidation pathways are orders of magnitude faster (decadal to centennial) than microbial respiration (millennia), indicating that sunlight exposure is likely a governing factor for the environmental fate of PS. (<https://pubs.acs.org/doi/10.1021/acs.estlett.9b00532>)
43. Styrene remains in polystyrene and has been found in 100% of adipose (fatty tissue) samples, meaning it is widespread and prevalent in all of us. It even crosses the placenta barrier. According to a 2000 World Health Organization report, "The ability of styrene monomer to migrate from polystyrene packaging to food has been reported in a number of publications and probably accounts for the greatest contamination of foods by styrene monomer." (<https://ilsr.org/health-implications-polystyrene/>)
44. Yearly, approximately 500 billion plastic bags are used out of which an estimated 13 million tonnes ends up in the ocean, killing approximately 100,000 marine lives [18]. <https://www.clinmedjournals.org/articles/ijtra/international-journal-of-toxicology-and-risk-assessment-ijtra-5-021.php?jid=ijtra#>

45. Marine food web has been continuously polluted with polychlorinated biphenyls (PCBs) for the last 70 years, particularly in seabirds [104]. PCBs ingestion may cause reproductive disorders, enhance disease proliferation, alters hormone levels and death [104,105]. PCBs can contaminate marine food web through the plastic bits and it has been shown that PCB is detrimental to marine life even at very low concentrations [106]. The study of Ryan, et al. [107] showed the presence of PCBs in the tissue of great shearwaters (*Puffinus gravis*) after ingestion of plastic particles. <https://scinapse.io/papers/2024428269>
46. Polystyrene, a type of petroleum-based plastic, contains benzene which is carcinogenic to humans [1]. Polystyrene is commonly used in the production of insulators and packaging materials. Products from styrene are hazardous to health. Report of Dowty, et al. [22] showed that a long-term exposure to small quantity of styrene can be neurotoxic and causing cytogenetic, carcinogenic and hematological effects. The International Agency for Research on Cancer (IARC) has categorized styrene as a human carcinogen [1].

47. **Table 4:**

Different additives used in plastic production, their effects and the plastic types.

Toxic Additives	Uses	Public health effect(S)	Plastic types
Bisphenol A	Plasticizers, can liner	Mimics oestrogen, Ovarian disorder	Polyvinyl chloride (PVC), Polycarbonate (PC)
Phthalates	Plasticizers, artificial fragrances	Interference with testosterone, sperm motility	Polystyrene (PS), Polyvinyl chloride (PVC)
Persistent Organic Pollutants (POPs)	Pesticides, flame retardants, etc.	Possible neurological and reproductive damage	All plastics
Dioxins	Formed during low temperature combustion of PVC	Carcinogen, interferes with testosterone	All plastics
Polycyclic aromatic hydrocarbon (PAHs)	Use in making pesticides	Developmental and reproductive toxicity	All plastics

Polychlorinated biphenyls (PCBs)	Dielectrics in electrical equipment	Interferes with thyroid hormone	All plastics
Styrene monomer	Breakdown product	Carcinogen, can form DNA adducts	Polystyrene
Nonylphenol	Anti-static, anti-fog, surfactant (in detergents)	Mimics oestrogen	PVC

**Source:** [76].

48. More than 25 different phthalate esters exist. Phthalates are incorporated into plastics as plasticizers to impart flexibility, pliability, and elasticity to otherwise rigid polymers, such as PVC (**18**). Phthalates comprise ~70% of the U.S. plasticizer market (**104**). Unlike BPA monomers in polycarbonate plastics, phthalates are by design not covalently bound to the polymer matrix, which makes them highly susceptible to leaching. Phthalates are contained in plastics at surprisingly high percentages. For example, they can contribute up to 40% by weight to intravenous medical bags and up to 80% by weight in medical tubing (**13**).

49. Excellent article on plasticizers

<https://www.annualreviews.org/doi/10.1146/annurev.publhealth.012809.103714>

50. <https://www.sciencedirect.com/science/article/pii/S0304389420314199>

Excellent sources as PDF microplastics

### Sources:

Break Free from Plastics (Atlas)

Single Use Plastics – A roadmap for Sustainability UN Report

Plastics and Health- The Hidden Costs of a Plastic Planet CIEL Report

[https://orbmedia.org/stories/Invisibles\\_plastics/](https://orbmedia.org/stories/Invisibles_plastics/)

The Helmholtz Centre for Environmental Research in Leipzig, Germany

### List of Plastics Curriculum Materials:

From CLEAR: 7-12 outcome lists

<http://explorecuriosity.org/Portals/4/Images/article%20images/5934/Monitoring-Marine-Plastics-Curriculum-connection-NL.pdf>

Lists of outcomes for grades 7-12

Marine Debris Tracker APP

<http://marinedebris.engr.uga.edu/>

Tells how to use and get app and photos of plastics as well as schools participating

HOW TO GUIDES from CLEAR LAB

#### “HOW TO” GUIDES

1. Spotters guide to plastic pollution

<http://explorecuriocity.org/Portals/4/Images/article%20images/5934/3-Spotters-Guide-to-Plastic-Pollution-trawls.pdf>

2. How to build the Ice Cream Scoop

<http://explorecuriocity.org/Portals/4/Images/article%20images/5934/5-Instruction-Manual-Scoop.pdf>

3. How to build Babylegs

<http://explorecuriocity.org/Portals/4/Images/article%20images/5934/6-BabyLegs-Guide.pdf>

4. How to remove samples from Babylegs trawl

<http://explorecuriocity.org/Portals/4/Images/article%20images/5934/8-DIY-lab-work-for-trawls.pdf>

5. How to sample for Plastics on Land

<http://explorecuriocity.org/Portals/4/Images/article%20images/5934/7-2-Land-survey-Guide-CS-for-schools.pdf>

Articles with many different references about plastics

<http://explorecuriocity.org/Explore/ArticleId/6730/we-use-a-lot-of-plastic.aspx>

Microplastics (embedded video)

<https://oceanservice.noaa.gov/facts/microplastics.html>

Plastics in bottled water

<https://www.cbc.ca/news/technology/marketplace-canadian-bottled-water-microplastics-1.4606182>

Plastics in Oceans National Geographic

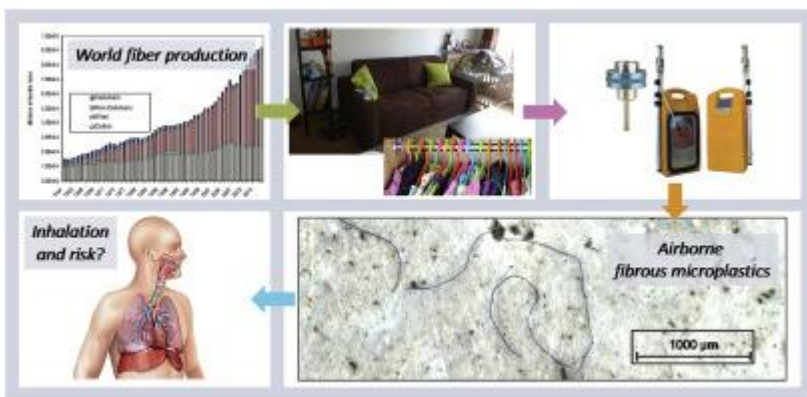
<https://news.nationalgeographic.com/news/2015/02/150212-ocean-debris-plastic-garbage-patches-science/>

Plastics in Oceans by 2050 with photos

[https://www.washingtonpost.com/news/morning-mix/wp/2016/01/20/by-2050-there-will-be-more-plastic-than-fish-in-the-worlds-oceans-study-says/?noredirect=on&utm\\_term=.474542f6ef49](https://www.washingtonpost.com/news/morning-mix/wp/2016/01/20/by-2050-there-will-be-more-plastic-than-fish-in-the-worlds-oceans-study-says/?noredirect=on&utm_term=.474542f6ef49)

Microplastics in the air (we are breathing them)

<https://www.sciencedirect.com/science/article/pii/S2468584417300119#!>



Plastics report from industry (see pages 10-16) for impacts

[http://www3.weforum.org/docs/WEF\\_The\\_New\\_Plastics\\_Economy.pdf](http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf)

Plastic fibers found in tap water around the world (Guardian Report)

<https://www.theguardian.com/environment/2017/sep/06/plastic-fibres-found-tap-water-around-world-study-reveals>

Formosa Plastics article

<https://publicintegrity.org/environment/pollution/pushing-plastic/as-the-world-grapples-with-plastic-the-u-s-makes-more-of-it-a-lot-more>

Deep State article for Canada

<https://www.macleans.ca/opinion/is-there-a-deep-state-in-albertas-oil-industry/>

waste to Energy Peer reviewed abstract

<https://www.deepdyve.com/lp/elsevier/the-evolution-of-waste-to-energy-incineration-a-review-IOMAPrgXVI>

FRACKING Resources:

<https://www.psr.org/wp-content/uploads/2019/06/compendium-6.pdf>

NEW YORK STATE Physicians Social Responsibility

Fact Sheets from PSR site (excellent)

[https://www.psr.org/resources/?sft\\_resource\\_category=environment-health](https://www.psr.org/resources/?sft_resource_category=environment-health)

## **VIDEOS**

A Plastic Ocean: Excellent 1 hour 42 minutes

Worksheet on TES site ( Password protected using last name)

Handouts:

List of plastics types and products and names

[https://www.bing.com/images/search?view=detailV2&id=A5E5404EF942B92CA0B030DFE47B26795CD854DB&thid=OIP.wdpFFI3bTxph9XGAr5Xz0AHaJ1&mediurl=http%3A%2F%2F3.bp.blogspot.com%2F-kf5FL\\_PYZkQ%2FVC5r3z2rKzI%2FAAAAAAAAAAKk%2FEExbmxFGIU8%2Fs1600%2FUntitled.png&exph=776&expw=584&q=what+types+of+plastics+are+there&selectedindex=23&ajaxhist=0&vt=0&eim=1&ccid=wdpFFI3b&simid=608039000131829842](https://www.bing.com/images/search?view=detailV2&id=A5E5404EF942B92CA0B030DFE47B26795CD854DB&thid=OIP.wdpFFI3bTxph9XGAr5Xz0AHaJ1&mediurl=http%3A%2F%2F3.bp.blogspot.com%2F-kf5FL_PYZkQ%2FVC5r3z2rKzI%2FAAAAAAAAAAKk%2FEExbmxFGIU8%2Fs1600%2FUntitled.png&exph=776&expw=584&q=what+types+of+plastics+are+there&selectedindex=23&ajaxhist=0&vt=0&eim=1&ccid=wdpFFI3b&simid=608039000131829842)

[https://www.bing.com/images/search?view=detailV2&id=7CF467DB0E4A1C73645683B080F684D1D18A9C0A&thid=OIP.HDOEX1\\_5i5JAxK8myk53-gHaFj&exph=480&expw=640&q=what+types+of+plastics+are+there&selectedindex=19&ajaxhist=0&vt=0&eim=1&ccid=zmQMZi2B&simid=608015704234789574&mediurl=https%3A%2F%2Fs-media-cache-ak0.pinimg.com%2F736x%2F2b%2F71%2F3f%2F2b713fc3e0831f65dea6e3083068ab49.jpg](https://www.bing.com/images/search?view=detailV2&id=7CF467DB0E4A1C73645683B080F684D1D18A9C0A&thid=OIP.HDOEX1_5i5JAxK8myk53-gHaFj&exph=480&expw=640&q=what+types+of+plastics+are+there&selectedindex=19&ajaxhist=0&vt=0&eim=1&ccid=zmQMZi2B&simid=608015704234789574&mediurl=https%3A%2F%2Fs-media-cache-ak0.pinimg.com%2F736x%2F2b%2F71%2F3f%2F2b713fc3e0831f65dea6e3083068ab49.jpg)

## **Earthday Network**

Percentage of single use plastics

<https://www.earthday.org/2018/03/29/fact-sheet-single-use-plastics/>

PLASTIC POLLUTION PRIMER AND TOOLKIT (53 pages) download

<https://160g7a3snaig2i1r662yjd5r-wpengine.netdna-ssl.com/wp-content/uploads/Plastic-Pollution-Primer-and-Action-Toolkit.pdf>

Page 24 has a how to calculate your plastic consumption

Action Toolkit for Community event on plastics (14 pages)

<https://160g7a3snaig2i1r662yjd5r-wpengine.netdna-ssl.com/wp-content/uploads/Earth-Day-Action-Toolkit-2018.pdf>

Organizing a Campus Teach-in (12 pages)

<https://160g7a3snaig2i1r662yjd5r-wpengine.netdna-ssl.com/wp-content/uploads/MobilizeU-Campus-Teach-In-Toolkit-2.pdf>

<http://oceanrusaders.org/plastic-crusades/plastic-statistics/>excellent chart of all the wastes one person makes in a year!

Microplastics chart

<https://www.bing.com/images/search?q=microplastic+pollution+data&id=DDBB0FE9F63A69424371FE3FBB7D866310D043E9&s=1&view=detailv2&rtpu=%2fsearch%3fq%3dmicroplastic+pollution+data&form=IEQNAI&selectedindex=0&exph=0&expw=0&vt=0&eim=1>

Microplastics report

<https://www.cnn.com/2018/04/22/health/microplastics-land-and-air-pollution-intl/index.html>

Microplastics in our oceans waterways

<https://owi.usgs.gov/vizlab/microplastics/>

<https://www.ellenmacarthurfoundation.org/publications/the-new-plastics-economy-rethinking-the-future-of-plastics> A great report on the issues with plastics.



## ALTERNATIVES TO SINGLE-USE PLASTICS

Single-Use Plastic Option	Alternative
Bin liner (plastic bag)	Line your bin with newspaper or cardboard
Bread	Local bakery in paper bag or reusable cloth bread bag
Deodorant	Solid Deodorant Bar – Lush
Dishwashing liquid - Cleaning products (plastic spray bottles)	Buy from bulk food store in refillable bottle – DIY foamer
Disposable plastic pens	Refillable metal parker pen
Doggy doo bags	Folded up newspaper – steel can to carry
Coffee cup – take away	Take a reusable cup (keep cup) or drink it there and take 5mins to relax / <i>ask for no lid</i>
Glad wrap/cling film	Reusable container / baking paper / <i>wax wraps</i>
Lighter	Matches
Liquid hand/body soap	Solid soap bar or buy from bulk food store in refillable bottle
Magic tape	Masking tape / cloth tape
Plastic carry bags	String / reusable cotton / lunch pack bag
Plastic produce bags	Cotton / <i>mesh (recycled plastic)</i>
Plastic snap lock / freezer bags	Containers / <i>wax wraps</i>
Plastic bottled water / soft drinks	Glass bottle / Aluminium can - Reusable metal / glass / plastic
Plastic cutlery	Metal – wrap it in a cloth napkin / <i>bamboo cutlery</i>
Plastic straw	Say NO and use your lips / reusable metal / <i>bamboo</i>
Plastic sponge / scourer	Natural loofah - natural bristle brush / <i>coconut fiber sponge</i>
Plastic take away containers	Reusable lightweight metal containers or tiffin's
Shampoo/Conditioner	Solid bar shampoo and conditioner – Lush, buy from bulk food store in refillable bottle
Spice packets	Glass jars / bulk buy in reusable container
Toilet paper	Look for toilet paper wrapped in paper - “who gives a crap”
Toothbrush	Look for wooden a toothbrush/Electric heads

**Bathroom:**

Bar shampoo, bar soap, bar body creams “Ethique”

([https://ethique.com/?gclid=CjwKCAjw19z6BRAYEiwAmo64LdFFlrU62ye9nWQfMy1ajNWuEORKNOURleXiuJCZHqazxTkLCy5PGxoCmRQQAvD\\_BwE](https://ethique.com/?gclid=CjwKCAjw19z6BRAYEiwAmo64LdFFlrU62ye9nWQfMy1ajNWuEORKNOURleXiuJCZHqazxTkLCy5PGxoCmRQQAvD_BwE) “The Earthling” (

<https://theearthlingco.com/>) (look for sustainable or palm oil free) \* Cream rinse bar from Ethique lasted me almost a year.

Refillable shampoo, body cream, and conditioner in stainless steel bottles “Plaine” company name (<https://www.plaineproducts.com/ref/TriMax/>) \* GREAT SHAMPOO a bit \$\$\$\$

Metal razor or electric razor rather than plastics

([https://leafshave.com/?gclid=CjwKCAjw19z6BRAYEiwAmo64LT2PIM2wjfPbSbpsX9ON6d8S8AySm\\_vMV1T8d0CDB3aO5h-Ah8xJFRoCEwYQAvD\\_BwE](https://leafshave.com/?gclid=CjwKCAjw19z6BRAYEiwAmo64LT2PIM2wjfPbSbpsX9ON6d8S8AySm_vMV1T8d0CDB3aO5h-Ah8xJFRoCEwYQAvD_BwE)) \*

Zero waste make-up brands (<https://goingzerowaste.com/blog/10-zero-waste-make-up-brands/>)

Bamboo toothbrush (<https://zerowastecalifornia.org/2019/11/10/finally-a-100-biodegradable-toothbrush/>)

Feminine hygiene products (<https://www.vogue.co.uk/article/best-eco-friendly-sustainable-sanitary-brands-products>)

And (<https://www.elle.com/uk/beauty/body-and-physical-health/a28911415/plastic-free-period-products/>)

Clothes soap DROPPS

([https://www.dropps.com/pages/welcome?gclid=CjwKCAjwNf6BRAwEiwAkt6UQs8wuWqX3IArjxgRDTudPsM1EL1GJ8wYzZ-05Wazqgh9r-SPjL14nRoCmMMQAvD\\_BwE](https://www.dropps.com/pages/welcome?gclid=CjwKCAjwNf6BRAwEiwAkt6UQs8wuWqX3IArjxgRDTudPsM1EL1GJ8wYzZ-05Wazqgh9r-SPjL14nRoCmMMQAvD_BwE)) \* LOVE THIS ONE

## KITCHEN:

Who gives a crap bamboo paper towels ( <https://us.whogivesacrap.org/>) They use bamboo or recycled paper and build toilets for third world countries \* LOVE THIS ONE

( or use old sheets that can be cut and washed over)

RE-usable stainless steel straws (<https://nymag.com/strategist/article/best-metal-straws-review.html>) \*

Beeswax wrap for leftovers (<https://www.beeswrap.com/>) \*

Silicon bags ( <https://nymag.com/strategist/article/best-reusable-eco-friendly-food-storage-bags.html>) for cooking storing and containers

([https://ziptop.com/?https://ziptop.com/?utm\\_source=google&utm\\_medium=cpc&utm\\_campaign=acquisition&utm\\_term=broad&gclid=CjwKCAjw19z6BRAYEiwAmo64LbYrPfZomfk7F1irKFHj15I7yAsNQ0qv\\_Ildn5VtkcO48FT7k3tARBoCN8MQAvD\\_BwE](https://ziptop.com/?https://ziptop.com/?utm_source=google&utm_medium=cpc&utm_campaign=acquisition&utm_term=broad&gclid=CjwKCAjw19z6BRAYEiwAmo64LbYrPfZomfk7F1irKFHj15I7yAsNQ0qv_Ildn5VtkcO48FT7k3tARBoCN8MQAvD_BwE))

RE-usable produce bags \*

Stainless steel coffee pot (NO SINGLE CUP COFFEE MAKERS) \*

## Grocery shopping TIPS

- 1) Use your own bags
- 2) Look for produce that is NOT wrapped in plastics
- 3) Buy in cans rather than in plastic bags (frozen foods)
- 4) Buy in glass (mushrooms) instead of Styrofoam containers with plastic wrap
- 5) Stick butter rather than in plastic tubs
- 6) OUI yogurt is in glass
- 7) Beverages in glass bottles/Juice in concentrated form with cardboard containers

**Tested by DR. P \***Annotated Bib on microplastics /freshwater

1. Ability to carry persistent organic compounds (POP). Plastics sink because biofilm coat them and make them sink carry polycyclic aromatic HC PCB Plastic debris in the Laurentian Great Lakes. (organisms colonize plastics)

Plastic amounts as high as those in ocean gyres

Effects of internal plastics on organisms, vector to carry POP and metals, the way it breaks down UV thermal O<sub>2</sub>, only a limited amount of plastics freshwater research, microbeads, solid wastes, debris on shorelines 77-90% is plastic compared to other freshwater lakes in world

<https://www.sciencedirect.com/science/article/pii/S0380133015000064>

2. This study investigates the presence of anthropogenic particles in 159 samples of globally sourced tap water, 12 brands of Laurentian Great Lakes beer, and 12 brands of commercial sea salt. Of the tap water samples analyzed, 81% were found to contain anthropogenic particles. The majority of these particles were fibers (98.3%) between 0.1–5 mm in length. The range was 0 to 61 particles/L, with an overall mean of 5.45 particles/L. Anthropogenic debris was found in each brand of beer and salt. Of the extracted particles, over 99% were fibers. After adjusting for particles found in lab blanks for both salt and beer, the average number of particles found in beer was 4.05 particles/L with a range of 0 to 14.3 particles/L and the average number of particles found in each brand of salt was 212 particles/kg with a range of 46.7 to 806 particles/kg. Based on consumer guidelines, our results indicate the average person ingests over 5,800 particles of synthetic debris from these three sources annually, with the largest contribution coming from tap water (88%).

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5895013/>

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0194970>

3. Microplastics in global tap water and bottled water

<https://orbmedia.org/stories/plus-plastic/text>

4. Good for explanation of how we get microplastics and also ingestion and interaction with other pollutants.. and also it is in atmosphere

It lists all the possible places to test for them

<https://hal-enpc.archives-ouvertes.fr/hal-01134553/document>

5. Has a capstone project at Adirondacks about microplastics

<https://www.adkwatershed.org/research>

## 6. **ABSTRACT:**

*Plastic debris is a growing contaminant of concern in freshwater environments, yet sources, transport, and fate remain unclear. This study characterized the quantity and morphology of floating micro- and macroplastics in 29 Great Lakes tributaries in six states under different land covers, wastewater effluent contributions, population densities, and hydrologic conditions. Tributaries were sampled three or four times each using a 333  $\mu\text{m}$  mesh neuston net. Plastic particles were sorted by size, counted, and categorized as fibers/lines, pellets/beads, foams, films, and fragments. Plastics were found in all 107 samples, with a maximum concentration of 32 particles/ $\text{m}^3$  and a median of 1.9 particles/ $\text{m}^3$ . Ninety-eight percent of sampled plastic particles were less than 4.75 mm in diameter and therefore considered microplastics. Fragments, films, foams, and pellets/beads were positively correlated with urban-related watershed attributes and were found at greater concentrations during runoff-event conditions. Fibers, the most frequently detected particle type, were not associated with urban-related watershed attributes, wastewater effluent contribution, or hydrologic condition. Results from this study add to the body of information currently available on microplastics in different environmental compartments, including unique contributions to quantify their occurrence and variability in rivers with a wide variety of different land-use characteristics while highlighting differences between surface samples from rivers compared with lakes.*

### ■ **INTRODUCTION**

*There has been growing concern in recent years surrounding plastics, and especially microplastics, in aquatic environments. Defined as plastic particles less than 5 mm in diameter, microplastics enter aquatic environments in a number of ways. One source is photodegradation and/or mechanical breakdown of larger items, such as Styrofoam, plastic bags, bottles, wrappers, cigarette butts, and tires.<sup>1-3</sup> Spillage of preproduction pellets and powders, beadblasting media, and atmospheric deposition are other potential sources.<sup>4-6</sup> Wastewater treatment plant (WWTP) effluent has also been cited as a source: abrasive microbeads in toilet cleaners, face and hand scrubs, and toothpastes<sup>7</sup> often made from positively buoyant polyethylene<sup>8</sup> may pass through WWTPs and into receiving waters.<sup>1,7</sup> Other more dense particles, such as polyester fibers, are largely captured in WWTP sludge,<sup>8,9</sup> which may subsequently be applied over land<sup>10,11</sup> and remobilized to receiving waters via runoff. Marine organisms, including mammals, birds, fish, turtles, and invertebrates, have been shown to ingest microplastics.<sup>12-15</sup> Physical hazards of ingestion can include obstruction of the digestive system,<sup>13</sup> clogging of feeding appendages,<sup>16</sup> oxidative stress,<sup>17</sup> impaired reproduction,<sup>18</sup> and death.<sup>19,20</sup> In addition, ingestion of microplastics can result in*

**uptake and bioaccumulation of harmful chemicals.<sup>14,19,21</sup> Additives in plastics such as phthalates, brominated flame retardants, nonylphenol, and antimicrobials have been associated with cancer and endocrine disruption.<sup>1,19</sup> The high sorption capacity of plastics enables the accumulation of persistent organic pollutants such as polychlorinated biphenyls, polycyclic aromatic hydrocarbons, and organochlorine pesticides, with concentrations 105–106 times higher than in the surrounding water column.<sup>4,21</sup> Trace metals<sup>14,22</sup> and pathogens<sup>23</sup> have also been shown to accumulate on microplastics. Recent studies on microplastics in lakes and rivers have reported microplastic concentrations to be as high, or higher, than in oceanic gyres.<sup>24–29</sup> The first study of microplastics in the surface waters of the Great Lakes<sup>30</sup> reported a median surface concentration of 5350 microplastic particles/km<sup>2</sup>, with a maximum of greater than 466000 particles/km<sup>2</sup>. Fragments were the most common microplastic particle type in the Great Lakes samples, making up 52% of particles in each sample on average.<sup>30</sup> Pellets/beads made up an average of 16% of particles**

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**in each sample, although 97% of all pellets/beads were in only two samples.<sup>30</sup> The least-occurring particle type in the Great Lakes study was fibers/lines, which made up only 2% of the sampled particles on average.<sup>30</sup> The objectives of this study were (1) to determine the occurrence and concentrations of micro- and macroplastics in Great Lakes tributaries, (2) to determine the relations between plastics and watershed attributes such as land cover, population density, and wastewater effluent contribution, and (3) to explore the role of hydrology in the occurrence of plastics. The number and diversity of sampling locations, the regional scale, and the incorporation of varying hydrologic conditions provide a multifaceted study that begins to explore the many factors that may influence the prevalence of plastic debris in rivers. The results will provide a baseline for future studies and will advance our currently limited understanding of the sources, transport, and fate of plastics in fluvial systems. ■ MATERIALS AND METHODS Sample Collection. Samples were collected from**

<https://pubs.acs.org/doi/pdf/10.1021/acs.est.6b02917>

7. Mason was [the first to document the presence of microplastics in the Great Lakes](#) in 2013. She and others later found bits of plastic [in numerous rivers and streams that feed the Great Lakes](#). One of the highest counts was in the Genesee River near downtown Rochester. [Plastic particles common in tap water, beer, and salt](#)

Subsequent research by professors at the Rochester Institute of Technology estimated that 10,900 tons of plastic enter the Great Lakes every year.



They also concluded that the southern shore of Lake Ontario, from which more than a half-million New Yorkers get their drinking water, is among the most plastic-riddled areas in the Great Lakes system.

Plastic material floating in the lakes often washes ashore, fouling beaches with a sad array of detritus. Plastics also may be taken up by fish and wildfowl, potentially accumulating in their bodies and causing them harm.

And, as the newest research demonstrates, they're being consumed daily by people who live on the lakeshore.

That research tested six tap-water samples from Lake Michigan, and one each from the other four Great Lakes. The Lake Ontario sample came from Clayton, a small town

<https://www.democratandchronicle.com/story/news/2018/08/28/plastic-study-finds-tiny-synthetic-bits-great-lakes-tap-water-and-beer/971888002/>

8. As a physical contaminant of organisms, Daley showed a slide that says ingested microplastics could have both behavioral and morphological effects. They could hinder mobility, reduce vigor, block intestines and gastric enzyme secretions, diminish feeding stimulus, hamper breathing and delay ovulation.

Then, there are the chemical contaminants. Some research suggests aquatic organisms also are exposed to the chemicals associated with plastics.

"This is all really early research and we need to do more work," Daley said.

<https://www.plasticsnews.com/article/20150319/NEWS/150319902/researchers-focus-on-great-lakes-pollution>

#### 9. Excellent Report

[https://orbmedia.org/stories/Invisibles\\_plastics?fbclid=IwAR1R4E3QOoOnQWwcRIsTGxYshshuovc9oscRTkqdeiMu88SBlyiqUB4ImN4](https://orbmedia.org/stories/Invisibles_plastics?fbclid=IwAR1R4E3QOoOnQWwcRIsTGxYshshuovc9oscRTkqdeiMu88SBlyiqUB4ImN4)

#### 10. Good article on plastics from National geographic

<https://www.nationalgeographic.com/magazine/2018/06/plastic-planet-waste-pollution-trash-crisis>

<https://www.health.com/home/microplastics-human-poop>  
Plastic in poop and how it affects us

#### 11.

[https://www.biologicaldiversity.org/programs/population\\_and\\_sustainability/sustainability/plastic\\_bag\\_facts.htm](https://www.biologicaldiversity.org/programs/population_and_sustainability/sustainability/plastic_bag_facts.htm)

## **Plastic bags**

[12. Plastic free Great lakes](https://greatlakes.org/plastic-free/)

<https://greatlakes.org/plastic-free/>

<https://qz.com/1689529/nurdles-are-the-biggest-pollution-disaster-youve-never-heard-of/>