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College of Engineering

Microplastic & Nanoplastic Pollution: From Sources to Solutions

SMART Management of Microplastic Pollution in the Great Lakes, Wayne State University Civil and Environmental Engineering

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Current Research: Microplastics Detection, Fate & Transport



Enwave Optronics, Inc



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NIEHS P30 ES020957



CONTRACT NO. 1904710



GLPF 1151



What most people want to know about microplastic pollution

- What are the sources and causes?
- What are its effects?
- What is being done about it?
- What can we, as individuals, do?



Photo credit - <https://inhabitat.com/nyc/state-senate-attempts-roadblock-to-derail-nycs-plastic-bag-fee/>

Microplastics: what are they?

Micro: small plastic pieces less than five millimeters, created either intentionally (microbeads, pellets) or unintentionally (degradation, break-down)

Nano: size 1 – 1000 nm, unintentionally produced, with colloidal behavior (binds with other particles; biologically active)



Photo credit - <https://www.independent.co.uk/topic/microplastics>

Where do microplastics come from?

Primary microplastics: manufactured for a purpose

- Health & beauty products
- Glitter & crafts
- Paintings / coatings / inks
- Product manufacturing feedstock
- Industrial abrasives



Secondary microplastics: degraded from plastic debris or fragmented during wear (clothes, tires, litter)



Photo credit - Ocean Voyages Institute/
Greg Yoder, AP



Photo credit – Wayne State University,
Yongli Zhang



Diagram of microfibers –
Wayne State University



Why are we concerned?

- Plastic pollution is everywhere
- Fragmentation continues to molecular size
- Plastic is not inert... toxins are attracted to and transported by it
- Plastic interacts with biology at all levels
 - Internally (organisms of all sizes)
 - Food webs



Where are they found?

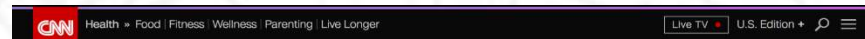


Photo credit - Law and Thompson, 2014.



It's not just the oceans: Microplastic pollution is all around us

By Mark Tutton, CNN
Updated 4:51 AM ET, Sun April 22, 2018



Microplastics found in human stools, research finds

By Rob Picheta, CNN
Updated 8:34 AM ET, Tue October 23, 2018



- Ocean, surface & ground water
- Drinking water (tap & bottled)
- Food & Beverages
- Air & soil
- Bodies of humans & animals

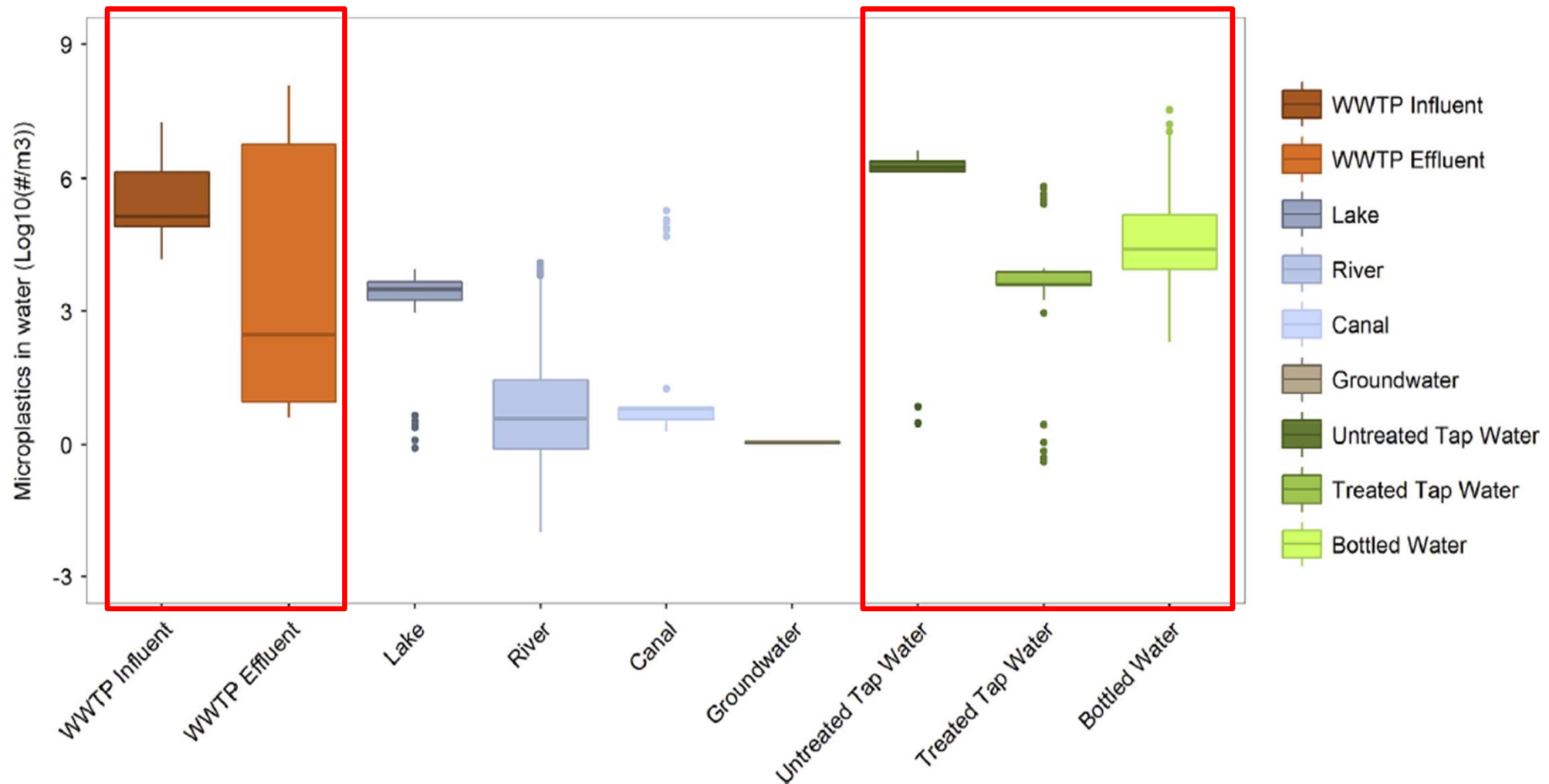


Pathways into the environment





Quantity of Microplastics in Water

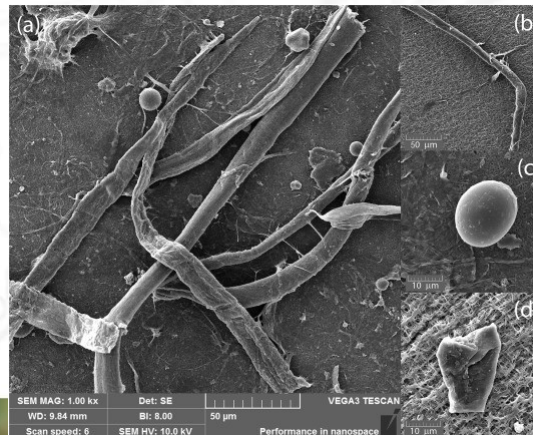


Most Observed in H₂O by Plastic Type: PE ~ PP > PS > PVC > PET

Source: "Microplastics in freshwaters and drinking water: Critical review and assessment of data quality" Koelmans et al. 2019 *Water Research*. <https://www.sciencedirect.com/science/article/pii/S0043135419301794?via%3Dihub>

How do we ingest microplastics?

Treated drinking water:
300 – 500 particles/L



Source: "Occurrence of microplastics in raw and treated drinking water" Pivokonsky et al. 2018 *Sci. Total Environ.*
<https://pubmed.ncbi.nlm.nih.gov/30104017/>

Salt



Photo credit - <https://www.globalcitizen.org/en/content/microplastic-in-table-salt/>

Seafood

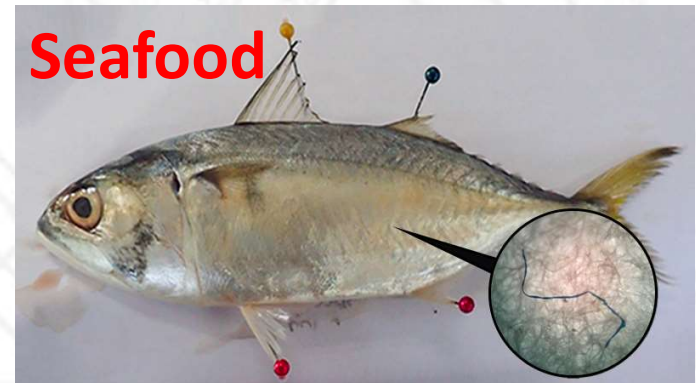


Photo credit - Marine National Park Operation Center Trang 3/ Facebook <https://coconuts.co/bangkok/news/thai-fish-now-available-with-78-types-of-plastic-inside/>

Global study of particles in tap water & sea salt found majority are fibers (99%)

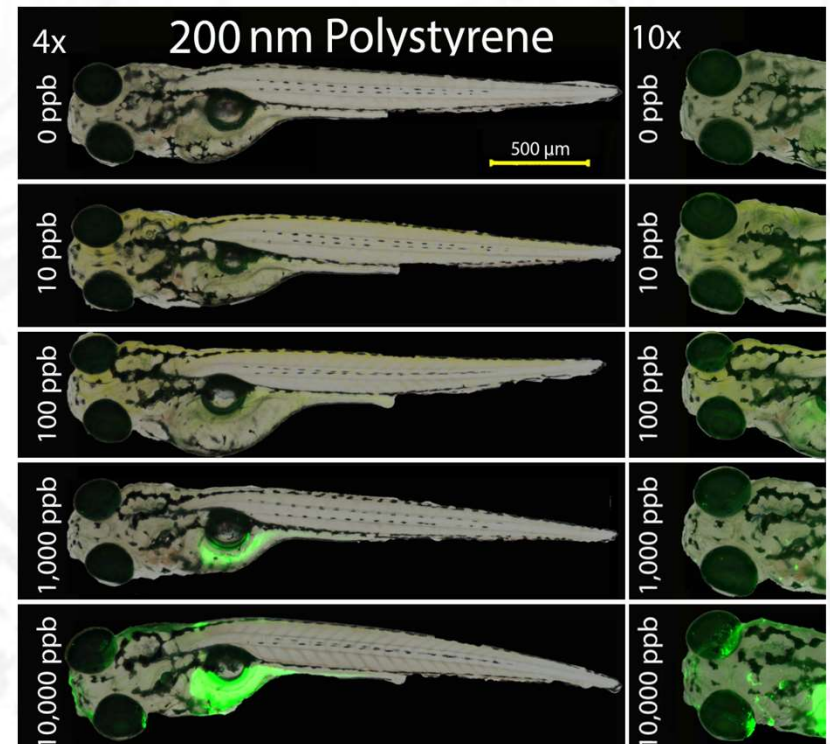
- European food safety authority - panel on contaminants in the food chain 2016 - statement on the presence of microplastics and nanoplastics in food, with particular focus on seafood. EFSA Journal 14 (6), 4501, 2016, (6), 30. <https://efsa.onlinelibrary.wiley.com/doi/pdfdirect/10.2903/j.efsa.2016.4501>
- Anthropogenic contamination of tap water, beer, and sea salt 2018 Kosuth et al <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0194970>



What are the effects of ingestion?

In experimental studies, microplastics:

- Cross the gut barrier into tissue
- Accumulate in tissues & organs (in humans: lungs)
- Perturb gut microbiome
- Induce inflammation, neurodegeneration, motor dysfunction, behavioral hyperactivity
- Carry other contaminants into tissue, where they may be absorbed (persistent organic pollutants, heavy metals, antibiotics, synthetic toxins)



“Nanoplastics impact the zebrafish (*Danio rerio*) transcriptome: Associated developmental and neurobehavioral consequences”
Pedersen et al 2020 *Environmental Pollution*
<https://doi.org/10.1016/j.envpol.2020.115090>

American adults consume & inhale 94,000 – 113,000 particles/year



What testing is being done?

**Develop
Test Methods**



Detect



**Evaluate
Removal
Efficiency**

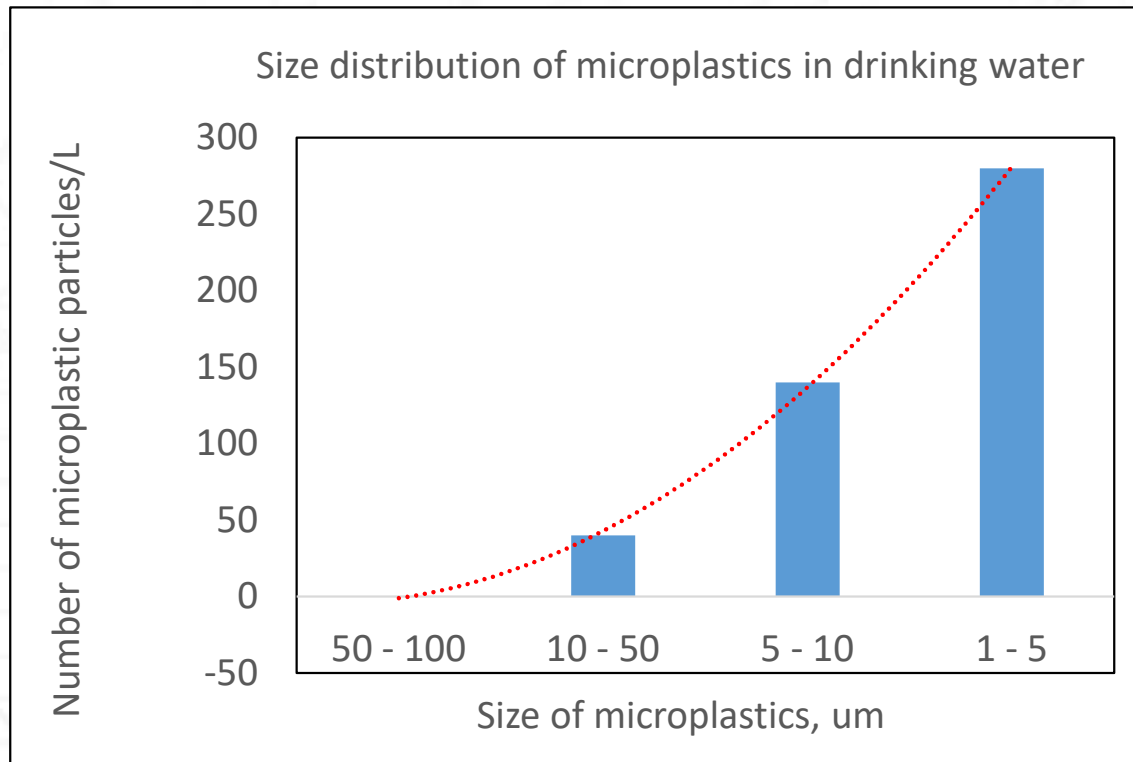
- NOAA, EPA, ASTM Sampling, Processing, Testing & Data Standards
- Experimental Comparisons & Combinations of results:
 - Fourier-transform infrared spectroscopy (FTIR) (> 20 μm)
 - Micro Raman spectroscopy (> 1 μm ; pigments interfere)
 - X-ray photoelectron spectroscopy (XPS; mixtures uncertain)
 - Pyrolysis gas chromatography mass spectrometry (Py-gc/ms)
- Wayne State & University of Alabama real-time sensor development for drinking water utility operators
- Wastewater Treatment Plant treatment train analysis

Challenges

- Time consuming
- Labor intensive
- Difficult to detect small microplastics
- Very easy to underestimate small particle quantities
- Uncertainties if particles are mixed & aggregated



No Standardized System of Measurement (Yet)



The number of observed microplastics particles increases as particle size decreases.

What about nanoplastics?
» Doubled (>500 particles/L)

Source: "Occurrence of microplastics in raw and treated drinking water" Pivokonsky et al.
2018 *Sci.Total Environ.* <https://pubmed.ncbi.nlm.nih.gov/30104017/>

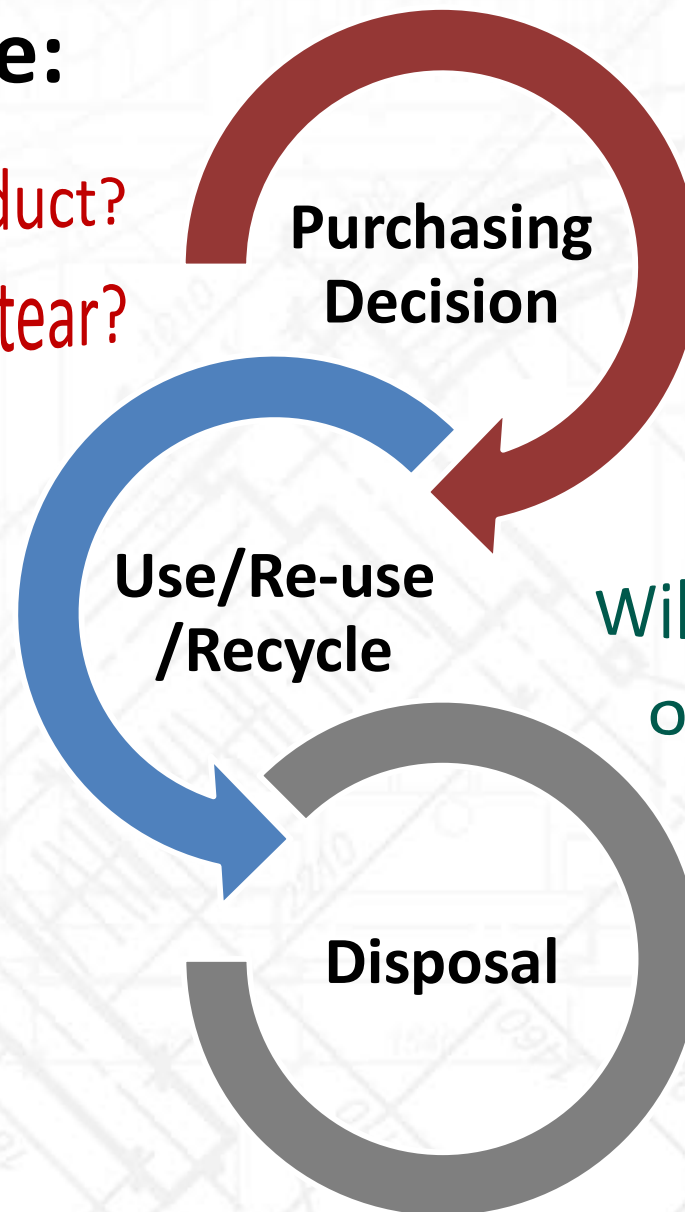


What can we do together?

Break the Cycle:

Expected Life of Product?
Outcomes of wear & tear?

How to reduce wear?
Extend useful life?
Repair?
Repurpose & re-use?
sell or Freecycle?



Necessary?
Elective?
Sustainable Options?
Hidden Waste?

will it be recycled?
or “downcycled”?

Use it up. Wear it out.
Make it do. Or do without.
Alternatives to disposal?



What can we each do individually?

- **Reduce microfibers:** wash synthetic clothes in a filtering bag, drip dry or dry a small load to reduce friction; switch to cotton, wool, bamboo or other natural fibers
- **Shopping:** take cloth bags; buy in bulk; re-use containers; avoid excessive packaging
- **On-the-go:** refill metal or glass water bottles; pack a lunch; select low-packaging food





What Collective Actions Have Been Proposed?

- State Plastic Bag Bans (NY, HI, CA)
- Federal Break Free from Plastic Act (introduced)
<https://www.congress.gov/bill/116th-congress/house-bill/5845/text>
- Expansion of Michigan bottle return law (introduced)
<http://legislature.mi.gov/doc.aspx?2021-SB-0167>
- 2022 CA Ballot Initiative to shift clean-up costs to producers, reduce waste, improve recycling, and expand industries that use recycled materials
<https://oag.ca.gov/system/files/initiatives/pdfs/19-0028A1%20%28Recycling%20Products%20%29.pdf>
- Global Plastics Treaty Dialogues <https://opln.org/>
- Product Stewardship Institute for producers
<https://www.productstewardship.us/page/WhoWeAre>



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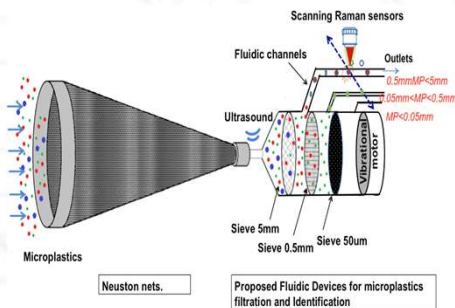
Smart Management of Microplastics

Ongoing research at Wayne State University

Collaboration

- Multi-disciplinary investigators
- Water Industry and Water Authority Representatives
- Business Partners
- Communities
- Non-profit Organizations
- Universities
- 3rd - 12th grades

Reroot
Pontiac



**Detection
technology
development**

Enwave Optronics, Inc



Community engagement

- A community-based web-based assessment tool for estimating micro- and macro-plastic emissions
- Targeted mitigation: Green Stormwater Infrastructure as a pollution interception device
- Laundry filtering bag distribution, "Take the Microplastic Pledge" & river clean-up campaign



Public education



Microplastics in Water

Funded Research at Wayne State University

Objectives

- Understand the source, fate and transport of emerging contaminants in natural and engineered water systems and impacts on ecological and human health.
- Develop technologies for high throughput detection of small biologically-active environmental microplastics (1 nm to 100 μm)
- Develop methods for reducing microplastic pollution sources through public engagement: microplastic reduction campaign, green stormwater infrastructure mitigation initiative, web-based tools for community leaders to examine and communicate about microplastic and plastic problems.

Funded Research Projects

- *Smart Management of Microplastic Pollution in the Great Lakes (funded by Great Lakes Protection Fund #1151)*
- *The Occurrence and Fate of Microplastics in Water and Wastewater Treatment Systems (funded by Great Lakes Water Authority, CONTRACT NO. 1904710)*
- *The Occurrence of Microplastics in Drinking Water and the Consequential Impact on Human Health (funded by WSU CURE Center, NIEHS P30 ES020957)*



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Microplastics

Ongoing research at Wayne State University



Wayne State University
Department of Civil and
Environmental Engineering

Smart Management of
Microplastic Pollution in the
Great Lakes

5050 Anthony Wayne
Detroit, MI 48202

We are developing **WEB-BASED TOOL KITS** that can be used by communities to tackle microplastic & plastic problems to keep our water clean

If you are interested in learning more about our projects, please contact Dr. Yongli Wager zhangyl@wayne.edu or visit our project website microplastics.wayne.edu