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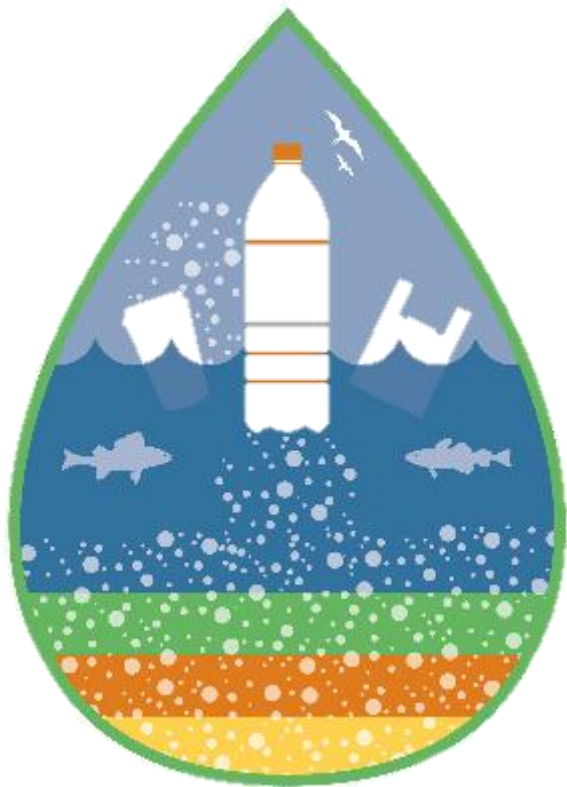
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Welcome!

Microplastics (MP-1) ITRC Guidance Document



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Sponsored by: Interstate Technology and Regulatory Council (www.itrcweb.org)
Hosted by: US EPA Clean Up Information Network (www.cluin.org)

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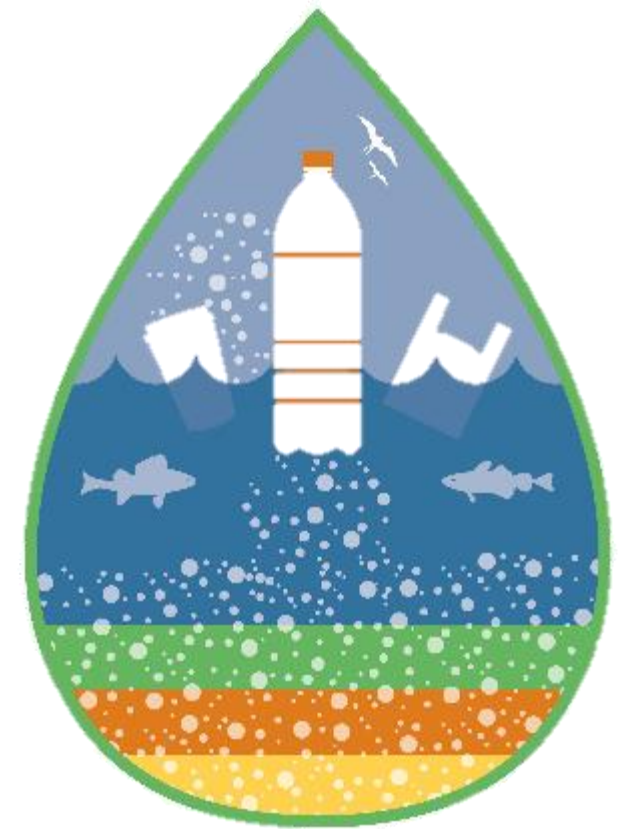
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Read trainer bios at <https://clu-in.org/conf/itrc/Microplastics/>

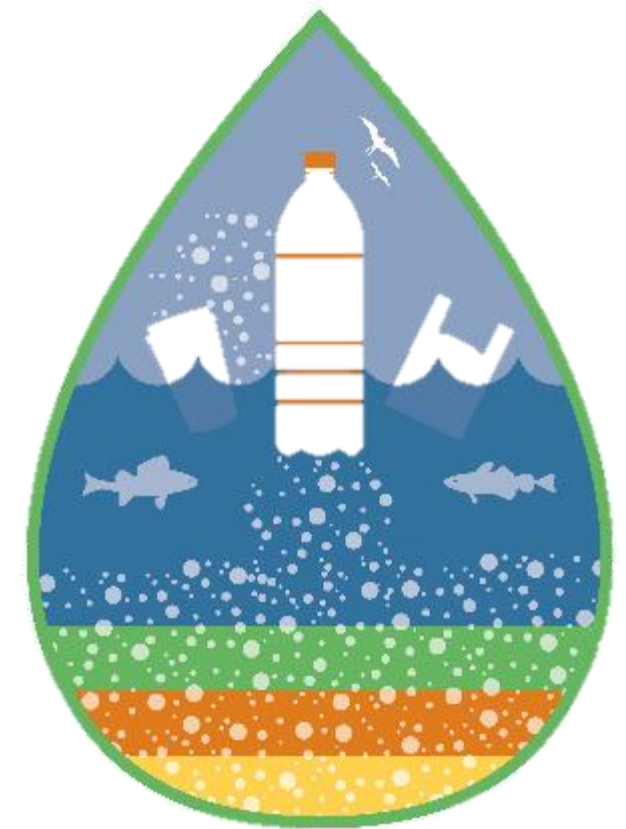
Today's Training Road Map



Microplastics Guidance Document

Overarching Goal:

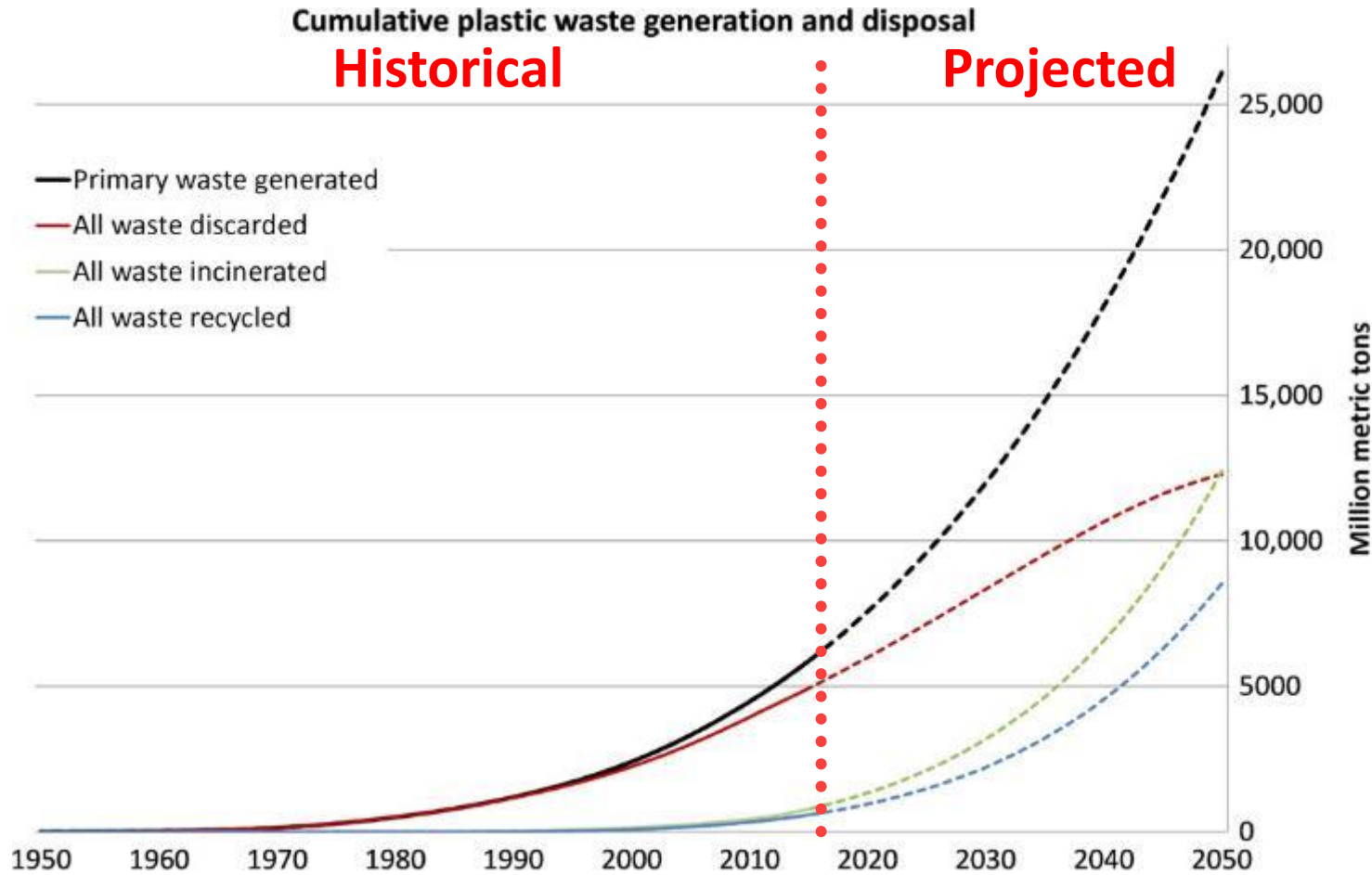
The guidance will provide an understanding of microplastics and the state of the applied science without having to go to the scientific literature.



Topics Covered

- Introduction to Microplastics and their Sources
- Environmental Distribution, Fate & Transport
- Sampling and Analysis Techniques
- Human Health and Ecological Effects
- Current Regulations
- Mitigation and Abatement

Global Plastic Production



Invention of first synthetic plastic	Innovation of variety of plastics	Growth of plastic industry	Innovation of biobased and biodegradable plastics
1907	1933-1945	1950	1970s and beyond

Source: D. Yardimci
 Data sourced from
<https://www.plasticsindustry.org/history-plastics>

Source: Geyer *et al.* (2017). *Science Advances*. [Open Access]

Global Plastic Waste

The pathway by which plastic enters the world's oceans



Estimates of global plastics entering the oceans from land-based sources in 2010 based on the pathway from primary production through to marine plastic inputs.

Global primary plastic production:
270 million tonnes per year

Global plastic waste:
275 million tonnes per year
It can exceed primary production in a given year since it can incorporate production from previous years.

Coastal plastic waste:
99.5 million tonnes per year
This is the total of plastic waste generated by all populations within 50 kilometres of a coastline (therefore at risk of entering the ocean).

Mismanaged coastal plastic waste:
31.9 million tonnes per year
This is the annual sum of inadequately managed and littered plastic waste from coastal populations. Inadequately managed waste is that which is stored in open or insecure landfills (and therefore at risk of leakage or loss).

Plastic inputs to the oceans:
8 million tonnes per year

Plastic in surface waters:
10,000s to 100,000s tonnes
There is a wide range of estimates of the quantity of plastics in surface waters. It remains unclear where the majority of plastic inputs end up — a large quantity might accumulate at greater depths or on the seafloor.

2 billion people living within 50km of coastline

Source: [OurWorldData](https://ourworldindata.org/), CC-BY-SA

Why Do We Care About Microplastics?

- Ubiquitous in the environment
- Accumulate and persist long time in the environment
- Contain harmful chemical contaminants and additives
- Consumed by humans and other organisms
- Cause adverse health impacts on humans and other organisms



Source Top: Flickr, Global Water Forum

Source Bottom: Oregon State University, : [CC-BY-SA-2.0](#)

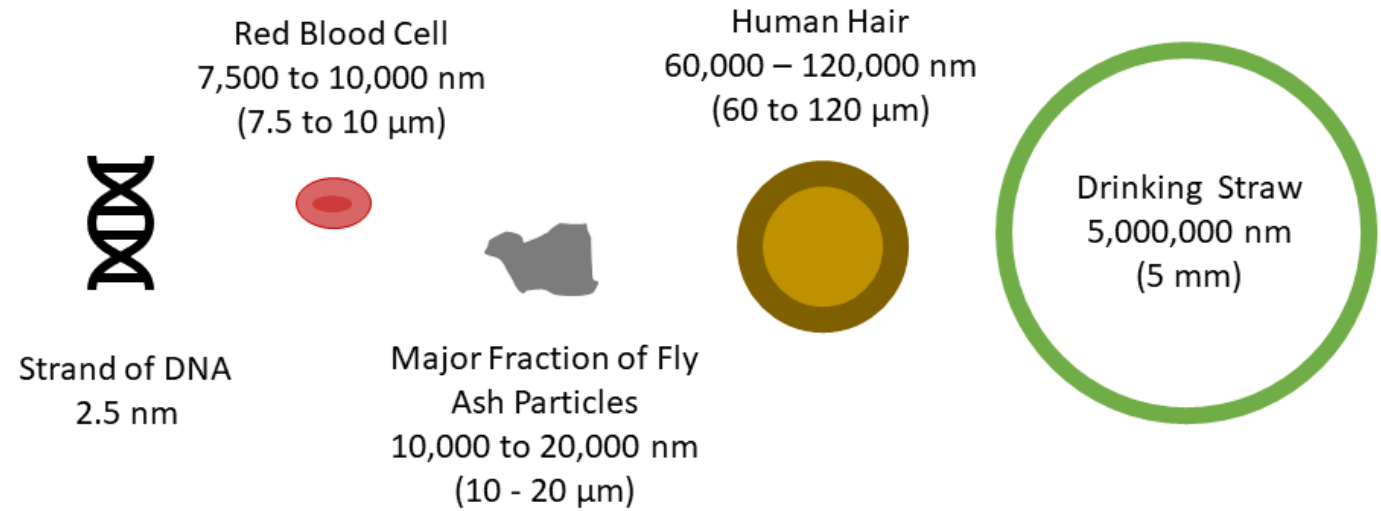
Microplastics Definition

Particles that are ***greater than 1 nanometer (nm)*** and ***less than 5 millimeters (mm)*** in their longest dimension and comprised of solid polymeric materials to which chemical additives or other substances may have been added.

Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded

Microplastic Size

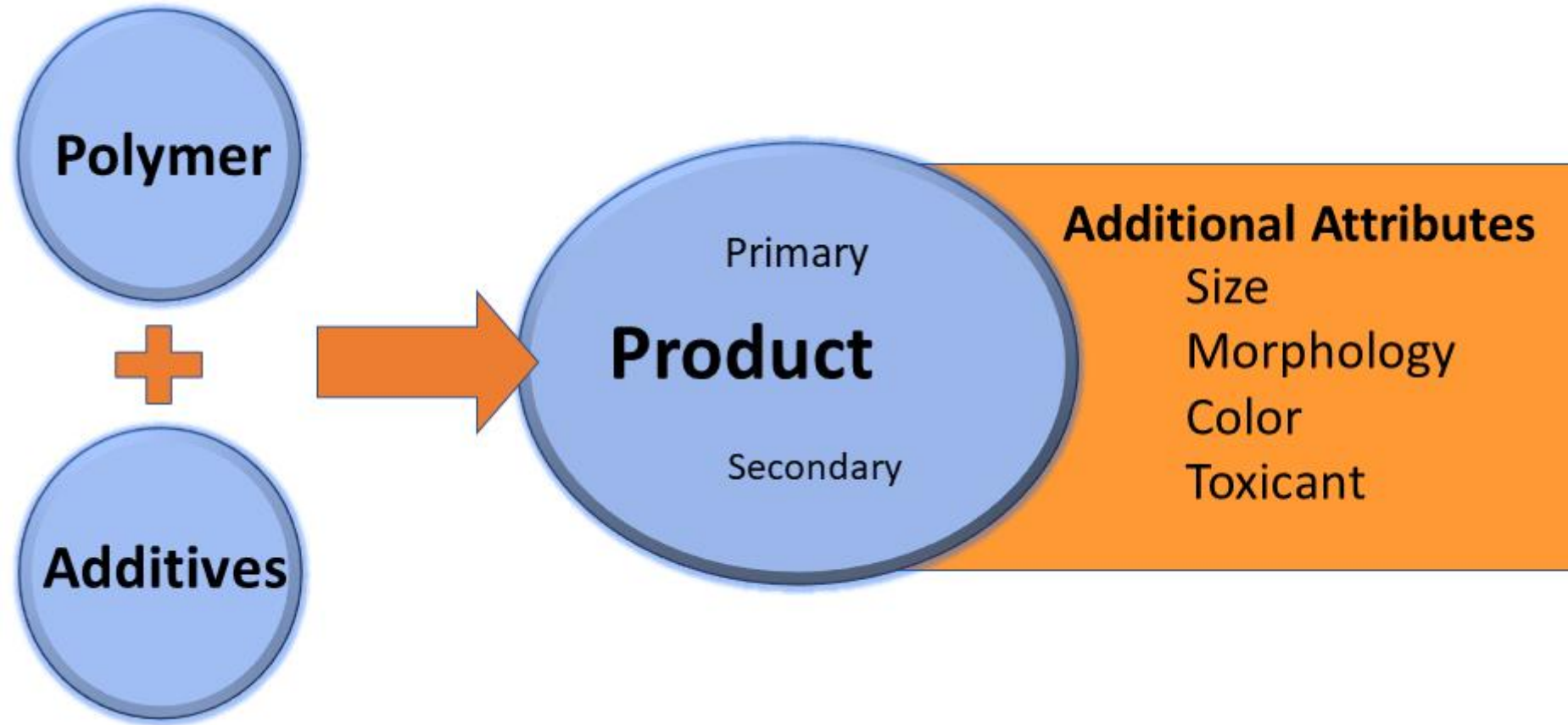
Items Comparable in Size to Microplastics (between 1 nm and 5 mm)



1,000 nm = 1 μm
1,000,000 nm = 1 mm
1,000 μm = 1 mm

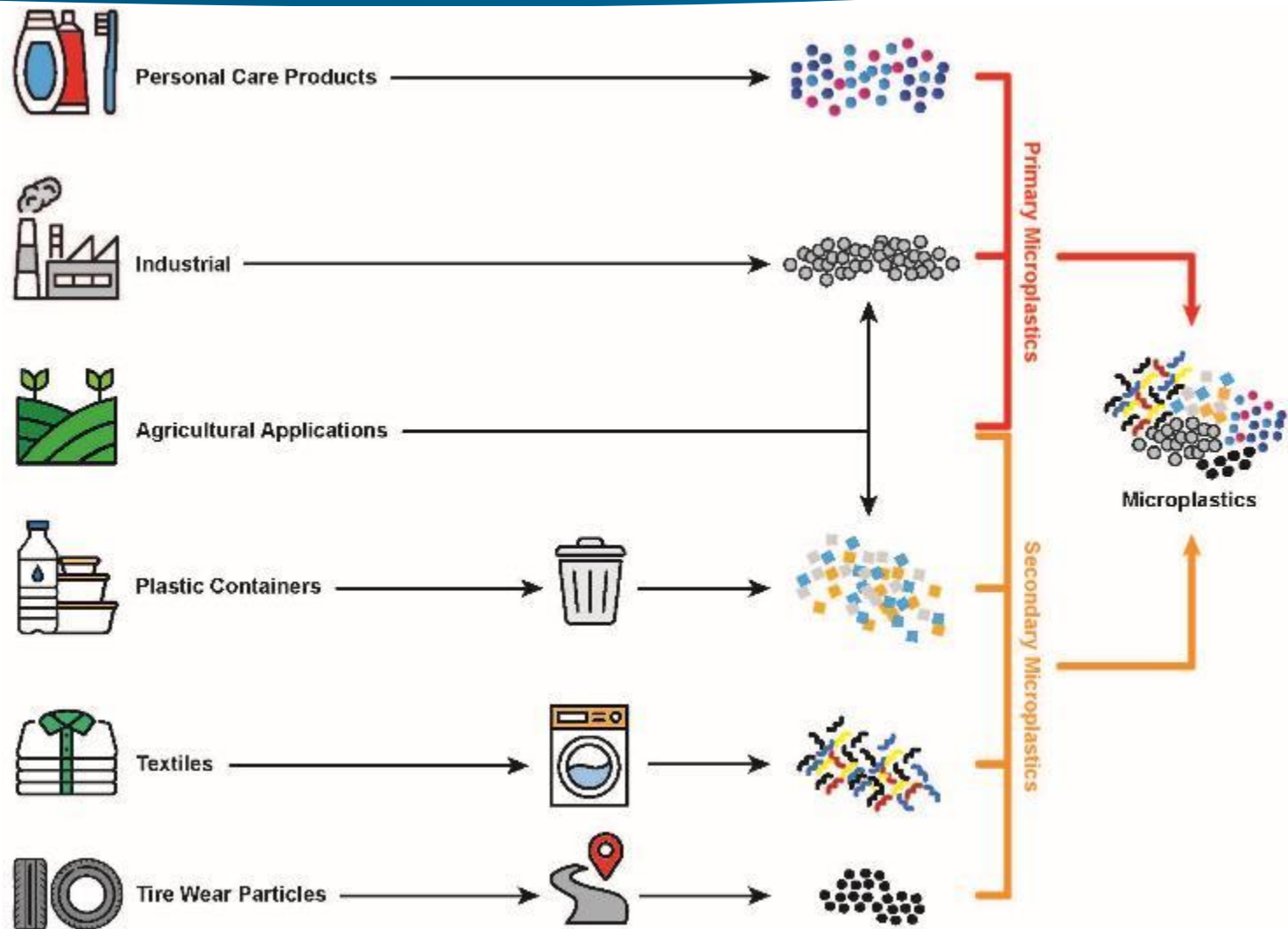
ITRC MP Figure 1-2
Source: V. Hanley

Variety of Microplastics



Source: C. Baysinger

Primary vs. Secondary Microplastics



ITRC MP Figure 2-1
Source: J. McDonald

Primary Microplastics

Intentionally manufactured for specific applications or products

microbeads in personal care products



Source: S. Ehardt / CC0-1.0

pre-production pellets (nurdles)



Source: gentlemanrook / CC-BY-2.0

Case Study: Appendix A.4: Nurdles Along the Gulf Coast



ITRC MP Figure A.4- 2

Source: Tunnell et al. 2020

Highlights how citizen science can play a significant role in understanding and evaluating emerging contaminants, as well as drive litigation, which can ultimately impact policy

Secondary Microplastics

Originate from larger plastics that fragment into smaller pieces



wear and tear of car
tires



fragmentation of consumer
products



fibers/filaments
from synthetic
textiles

Sources: S. Viinamäki/ CC-04, Streetwise Cycle /CC-04, B. Schumin/ CC-03, B. Spragg/CCO-1.0

Case Study: Appendix A.3: Impact of Disposable PPE and Single Use Plastic Items During the COVID-19 Pandemic



ITRC MP Figure A.3- 1.

Source: C. Huang

Microplastic Shape

- Fragments
- Beads
- Pellets
- Foams
- Films
- Sheets
- Filaments
- Fibers



ITRC MP Figure 1-4
Source: Martindale et al, 2020

Microplastics Adsorb Harmful Chemicals

Enhance sorption of heavy metals (e.g., lead, cadmium)

Enhance sorption of persistent organic pollutants (POPs)

- Polycyclic aromatic hydrocarbons (PAHs)
- Polychlorinated biphenyls (PCBs)
- Per- and polyfluoroalkyl substances (PFAs)
- Organochlorine pesticides (dichlorodiphenyltrichloroethane, DDT)

Factors Enhance Chemical Adsorption Capacity of Microplastics

High hydrophobicity

High surface area to volume ratio

- Smaller size
- Rougher shapes
- Weathered and aged

Polymer type

- Low-density plastics (PE, PP) > High-density plastics (PET, PVC)
- Rubbery plastics (PE, PP) > Glassy plastics (PET, PVC)

Microplastics as Vectors

Allow formation of biofilms -> vector for bacterial pathogens

Spread of antibiotic-resistant bacteria (ARB)

Long-distance transport of chemical contaminants

Source of contaminants in aquatic environments, sediments, and biota

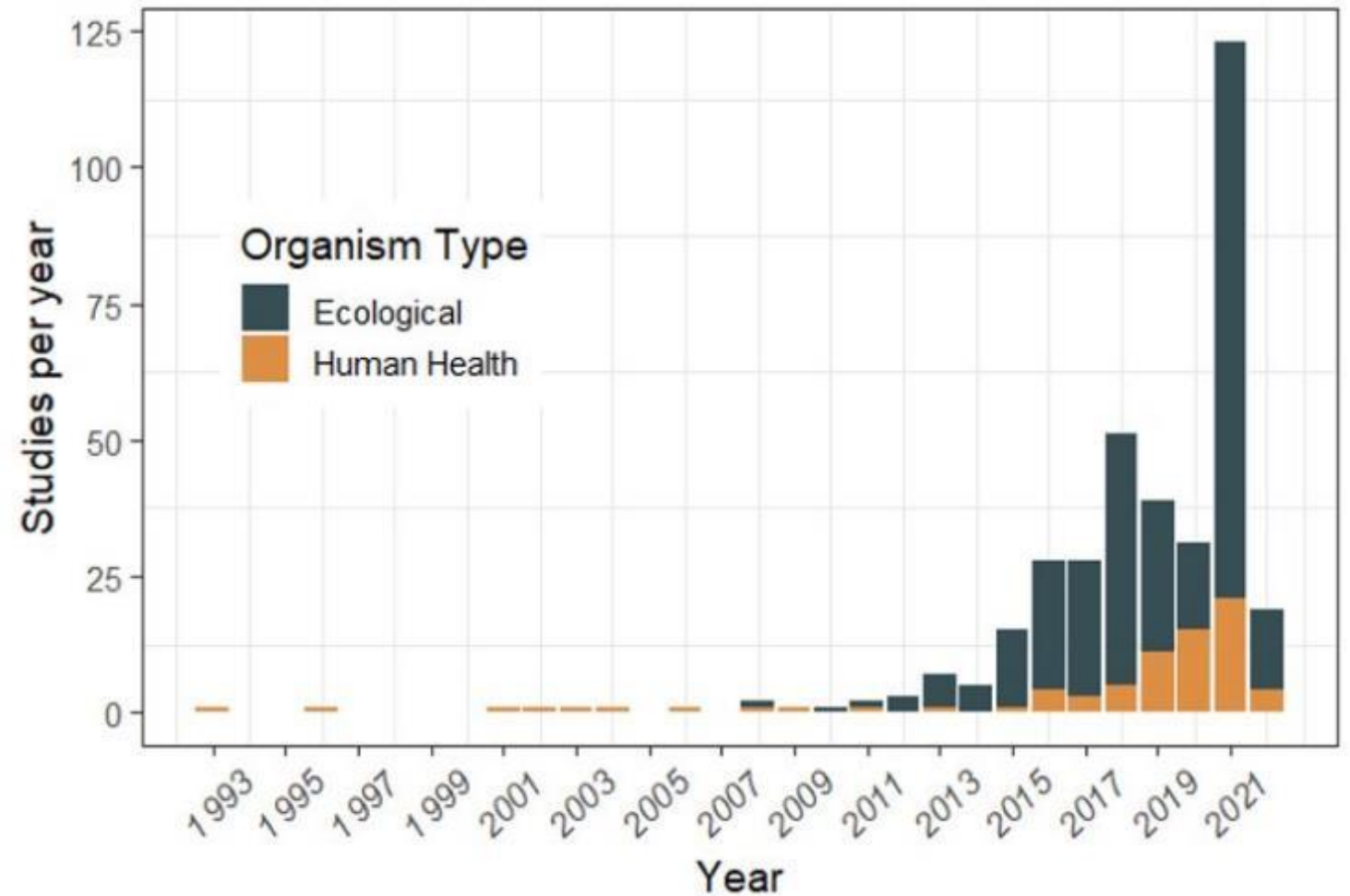
More studies needed to understand vector effects of microplastics

Evolving State of Science of Microplastics

Emerging contaminant of concern

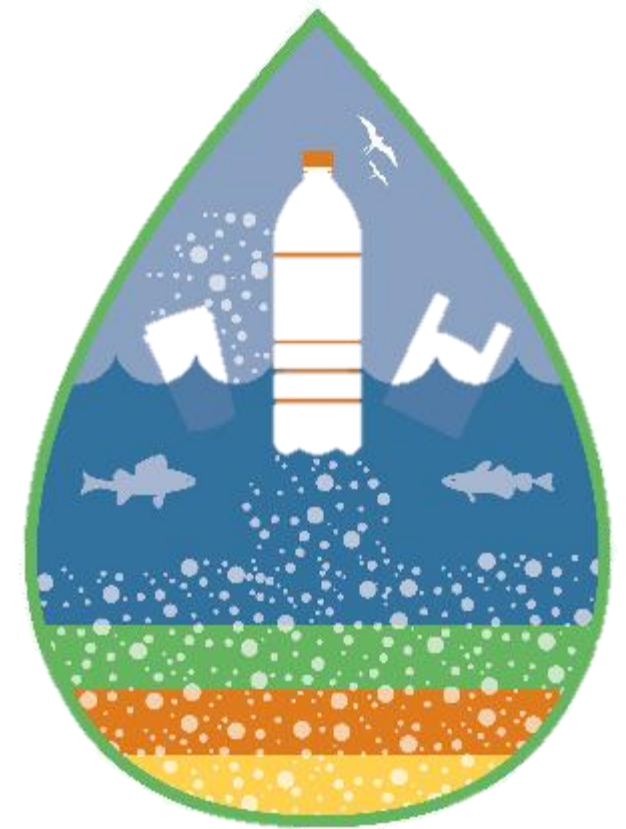
Rapidly evolving state of science

Increase in number of microplastics toxicity studies



Source: S. Coffin 2021 (unpublished, used with permission)

Today's Training Road Map



Interactive Case Study - Objectives



Source: A. MacDonald

Start with hypothetical environment

Identify sources, pathways, receptors

Develop recommendations for investigation and evaluation

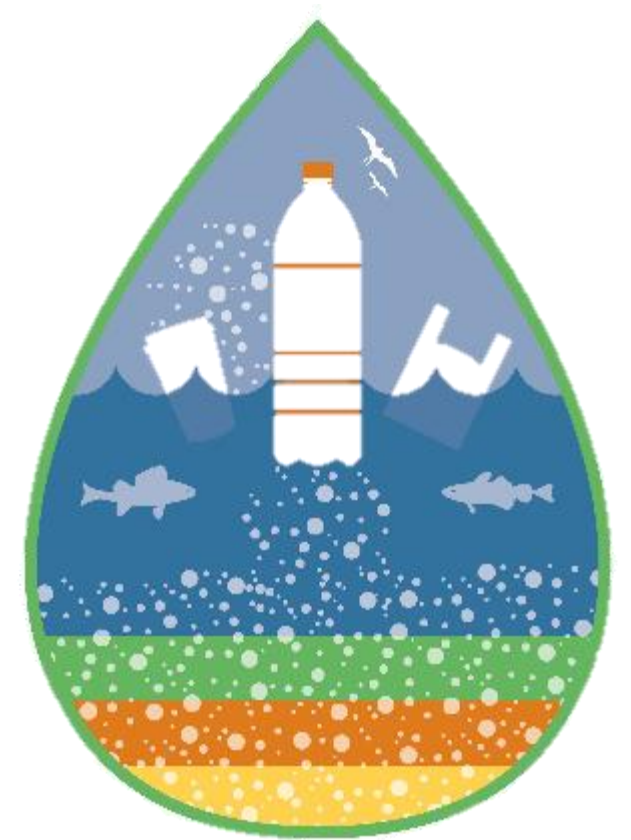
Case Study – Step 1 – MP Sources



Identify the MP Sources:

Please use the chat function to type in your answers

Today's Training Road Map



Conceptual Site Model (CSM)

Multifunctional Tool

- Overview Information
- Document Navigation



Source: J. McDonald

CSM: Point Sources

Marine Point Sources:
Materials lost or discarded from vessels

Stormwater Outfalls

Industrial Smokestacks

Wastewater Outfalls



CSM: Non-Point Sources

Microplastics can be transported through the atmosphere and deposited far away from the source

(Macro)Plastic trash washes into the ocean, then breaks down into smaller and smaller pieces, eventually becoming microplastics

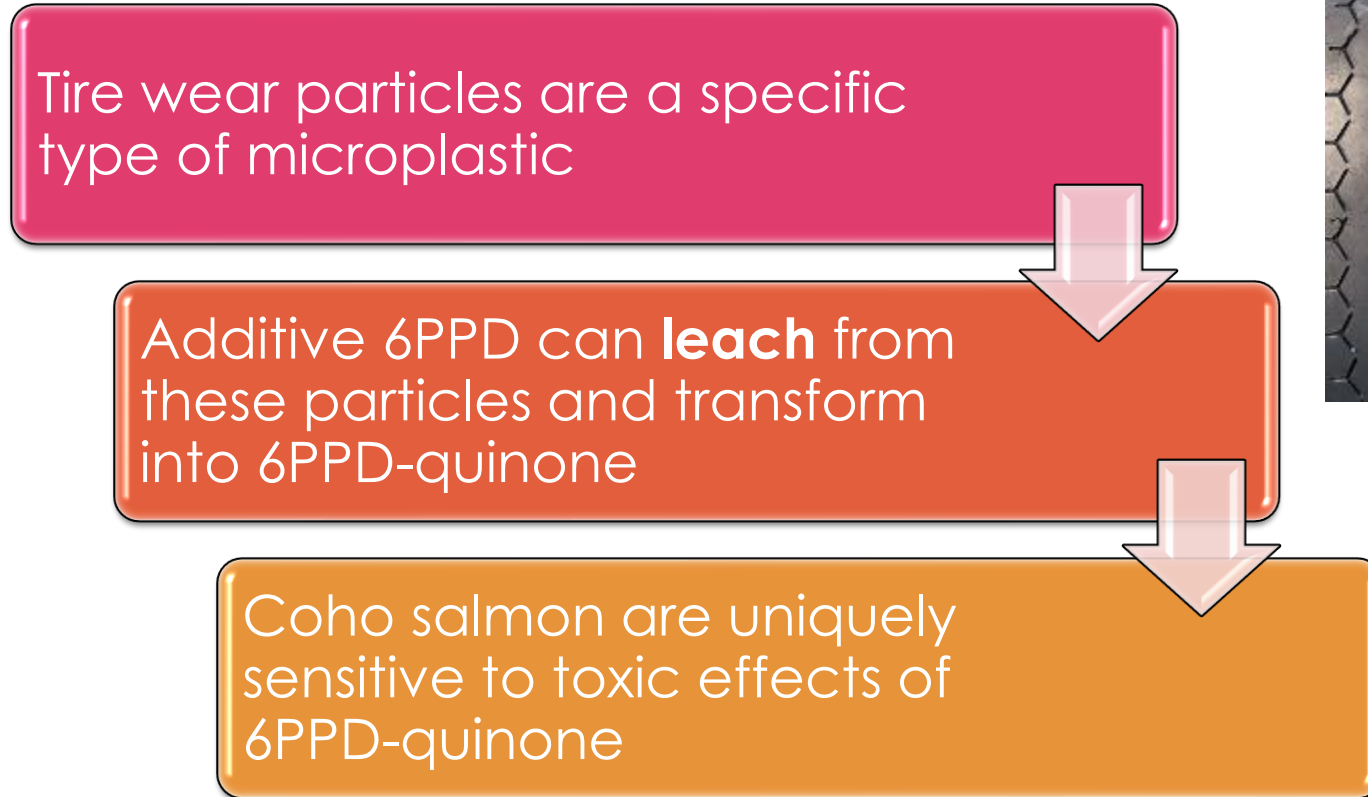
Microplastics generated through typical tire wear and breakdown of roadway materials



Microplastics may be present in household products such as toothpaste or facial cleaners. Microplastics can be generated through household activities such as laundering of clothing

Microplastics may be present in agricultural lands due to direct application of fertilizer pellets, biosolids from wastewater treatment plants, or due to breakdown of plastic sheeting

Case Study: Appendix A.5: Tire Wear Particles and Coho Salmon



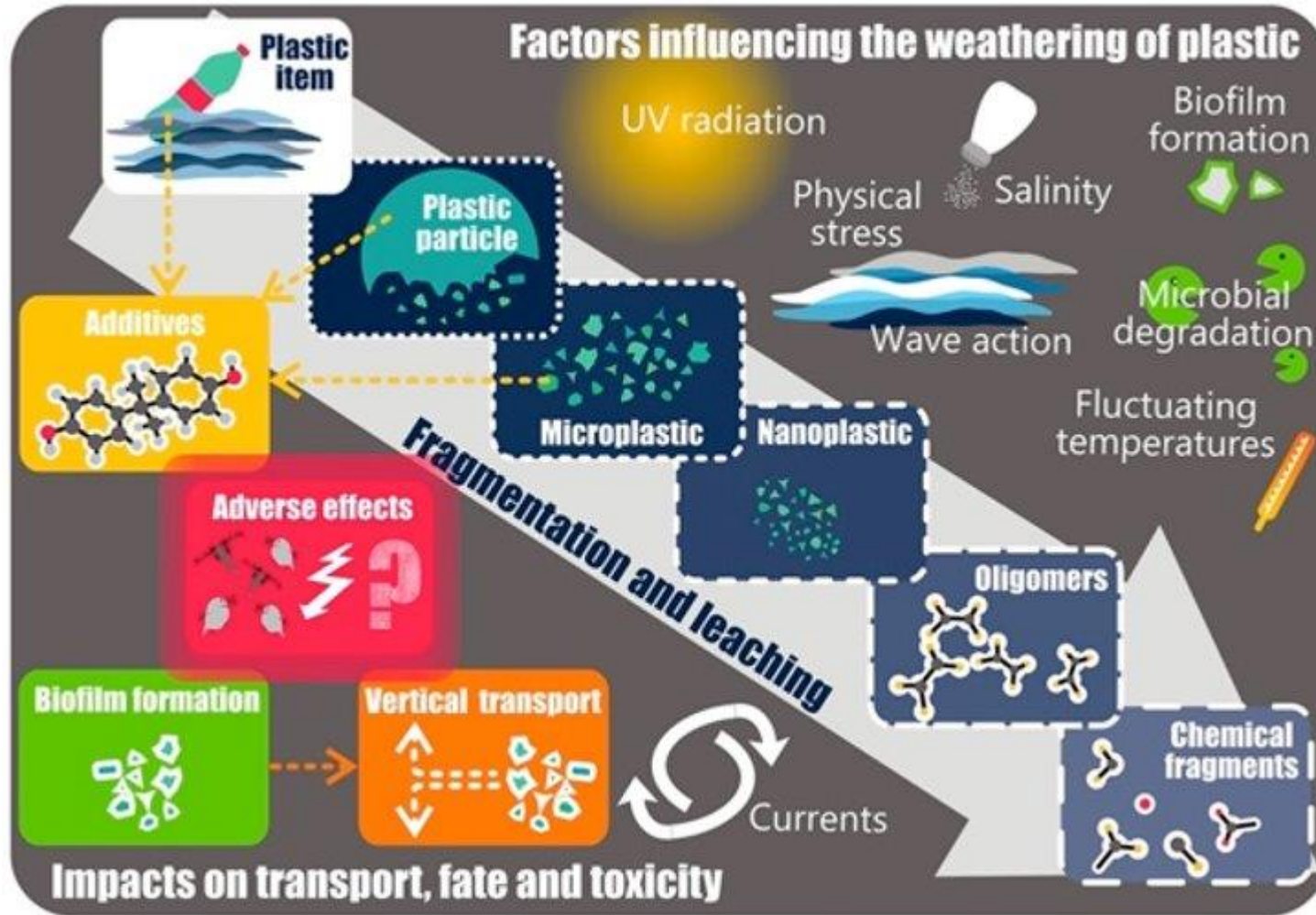
Source:
Kalernna/
CC 3.0



ITRC MP Figure A.5- 1

Source: Bureau of Land Management

How Microplastics are Generated



Environmental Distribution – MP in the Fluvial Environment



ITRC MP Figure 2-3, Source: J. McDonald and T. Miller

MP transport – rivers and streams
Prevalent at surface, throughout water column, and in sediments

MP sinks – lakes and inland areas of decreased flow velocity

Two-way transport affects distribution
water ↔ land ↔ air

Environmental Distribution – Surface Water



Rivers, Lakes, and Streams

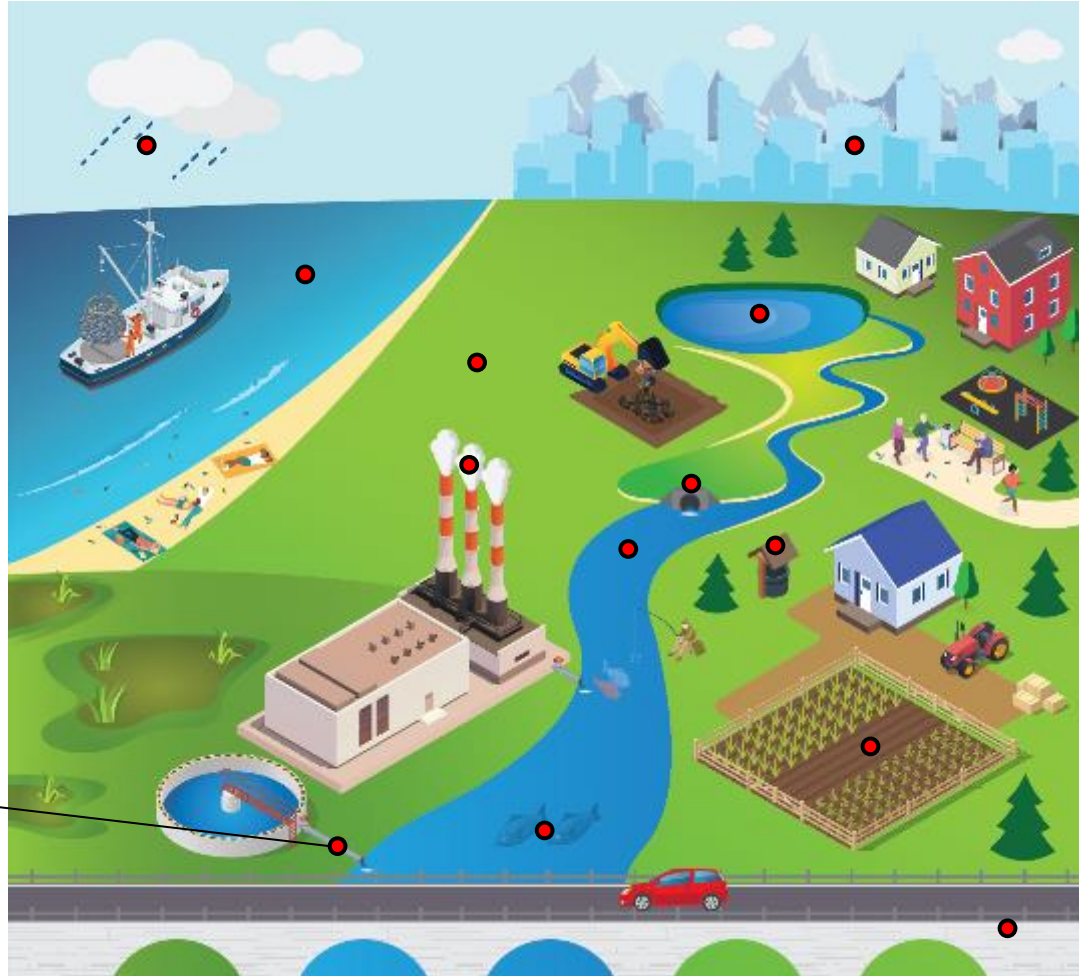
Stormwater

Bays and Estuaries

WWTP as sources

ITRC MP Figure 2-1

Environmental Distribution – Wastewater



Section 2.3.2
MP in Wastewater

ITRC MP Figure 2-1

Industrial and domestic product sources for MP entering WWTPs

WWTP processes remove MP—no standard treatments or analysis methods

Biosolid products, re-release by land application and landfiling

MP in wastewater effluent predominantly smaller than 0.5 mm

Environmental Distribution – Groundwater



Section 2.3.3
MP in
Groundwater

Limited studies indicate lower prevalence of MP than other water types

Current sampling obstacles due to plastic monitoring well construction

Movement affected by particle size, density, soil moisture, pH, salinity, and ionic strength – aided by preferential pathways

Reported presence in Illinois (US), as well as Germany, and South Africa – shallow and deep groundwater

Higher concentrations near WWTP, landfills, and agricultural sites

ITRC MP Figure 2-1

Environmental Distribution – Oceans

Section 2.3.4
MP in Oceans



Enter from estuaries, rivers, outfalls, and the atmosphere – move at surface by currents towards central, slower moving oceanic gyres

Denser MP sink, then distributed by subsurface currents – reported from all ocean depths – highest concentrations at depths 200 m to 600 m

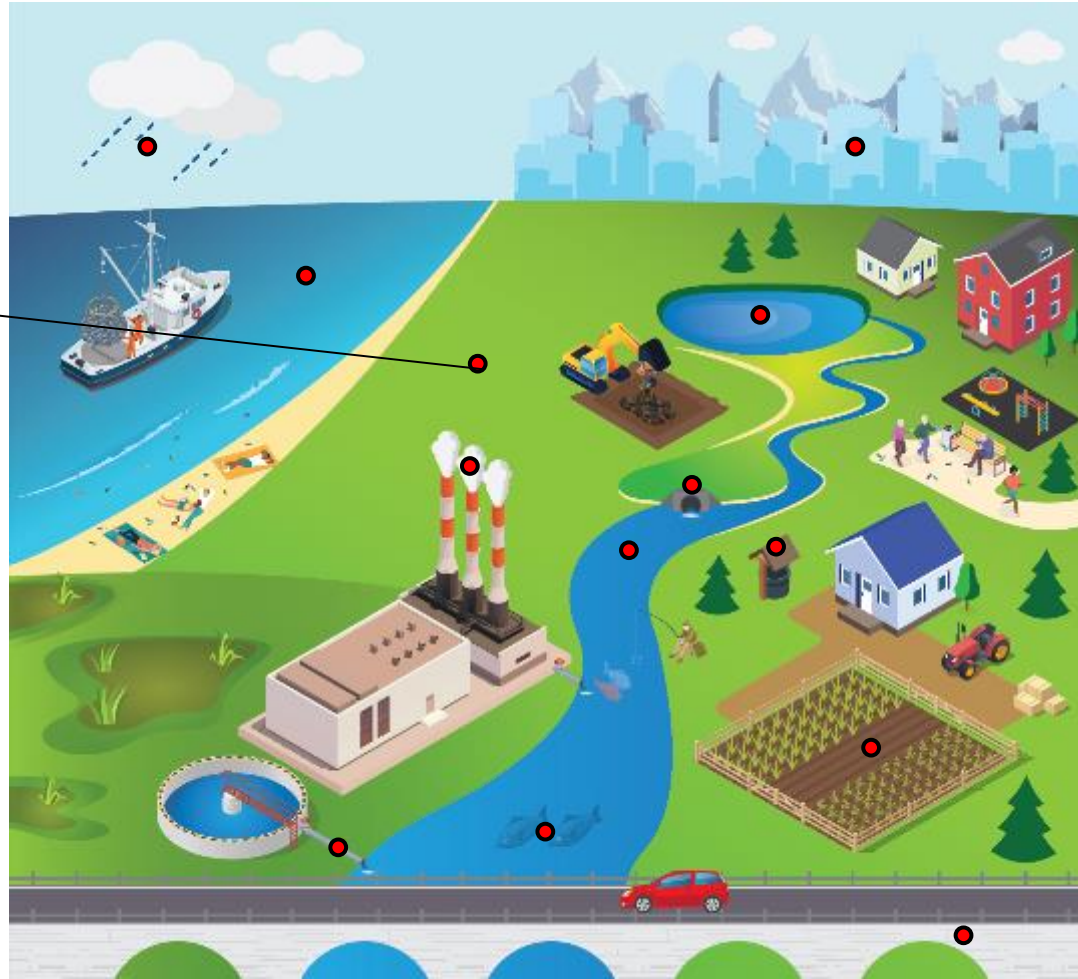
Transport of floating debris – ocean currents, convergence zones, Stokes drift, tides, wind force, Langmuir circulation, ice formation and melt, drift, etc.

Vertical transport – Factors include degradation/aggregation, biofouling; positive, negative, neutral buoyancy

ITRC MP Figure 2-1

Environmental Distribution – Soils

Section 2.4
MP in Soils



Likely to be long term sinks for MP since most plastics are used and disposed of on land.

High MP abundance – Lands close to busy roads, waste management and agricultural areas, and home gardens

Other factors – soil type and management, plastic size and density, and precipitation

Potential to alter soil properties such as bulk density and water retention capacity – vary with type, fibers have distinctly negative impact compared to foams, films, or particles

ITRC MP Figure 2-1

Environmental Distribution- Sediment



Section 2.5
MP in Sediment

Suspended MP settle from the water column to combine with sediments – found in marine and freshwater, flowing and non-flowing systems

Fibers and fragments common – higher density MP more likely to settle, abundance decreases with sediment depth

Research shows sediments higher in total organic carbon (TOC) tend to have more MP

Residence time in river headwaters is high especially in low flow conditions – rivers are a key pathway of transport to other areas

Resuspension and redistribution from sediment is a key process

ITRC MP Figure 2-1

Environmental Distribution – Air

Section 2.6
MP in Air



Increased occurrence and transport of MP in densely populated areas – denser human populations and activities, industrialization

Atmospheric deposition – precipitation events; rain and snow

Emergent component of air pollution due to inhalation and combination with other pollutants (e.g., mercury, PAHs)

Transport – wind speed, up/down drafts, convection lift, and turbulence

Also affects distribution of plastic pollution in terrestrial and marine environments, potential for long-distance transport

Small MP sizes, various shapes; fibers, fragments, and films

ITRC MP Figure 2-1

Environmental Distribution – Urban Litter



Section 2.7
MP in Urban Litter

Macroplastic litter breaks down to MP

Plastic portion of litter can vary dramatically – San Francisco Bay area stormwater study showed plastic items were 2.2% to 15.1% of litter by volume, whereas a Mississippi River basin study showed plastic accounted for 74% of litter

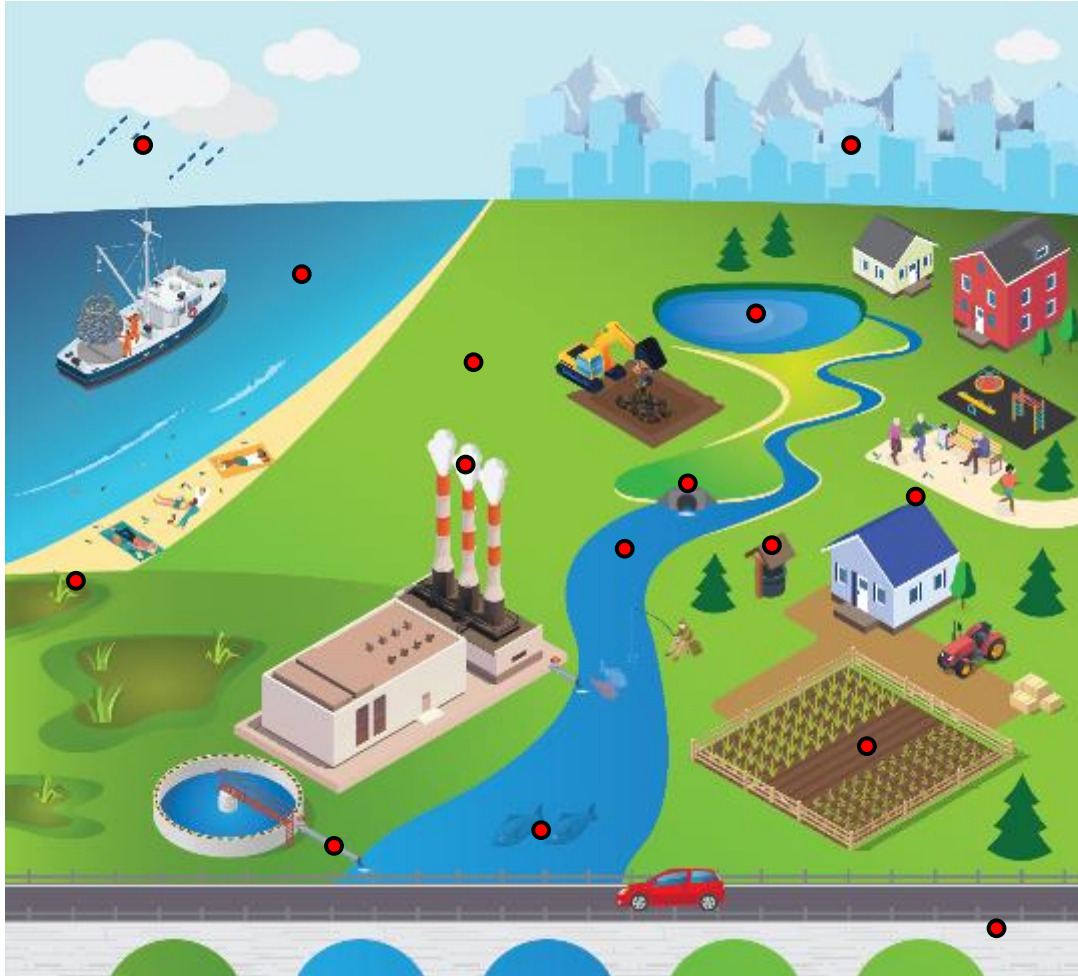
Storm events play important role – Los Angeles River study showed MP increased 7-fold at the coast near Long Beach after a storm

A Great Lakes area study showed fragments, films, foams, and pellets, all found in urban watersheds at higher concentrations as result of rainfall or snowmelt events

ITRC MP Figure 2-1

Environmental Distribution – Biota

Section 2.8
MP in Biota



MP found in plants, invertebrates, birds, mammals, and fish

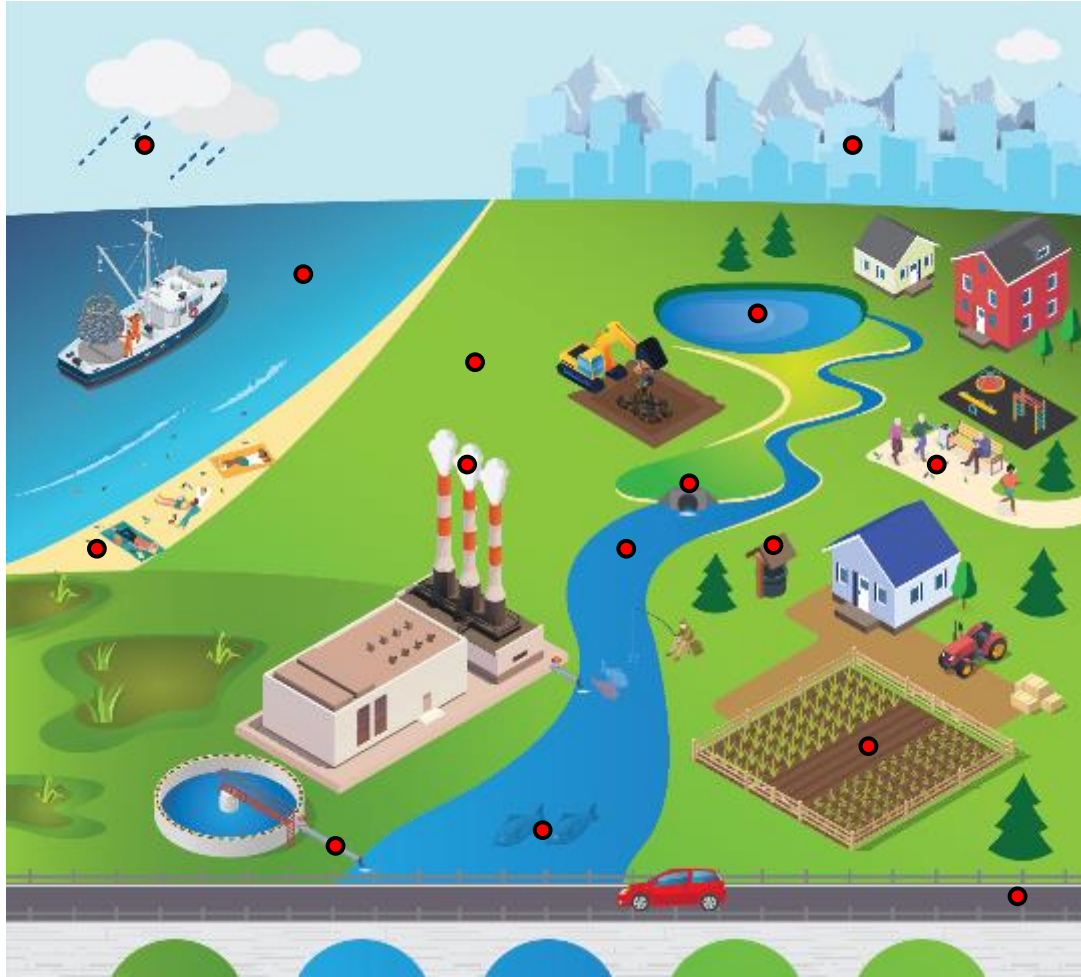
MP are being ingested

Plants – studies show uptake by crop plants through roots and transported to shoots

Marine biota – Filter feeders at greater risk due to suspension feeding

ITRC MP Figure 2-1

Environmental Distribution- Summary



Section 2.3: Fluvial Environment

Surface water

Wastewater

Groundwater

Oceans

Section 2.4: Soils

Section 2.5: Sediments

Section 2.6: Air

Section 2.7: Urban Litter

Section 2.8: Biota

ITRC MP Figure 2-1

Case Study – Step 2 – MP Transport Pathways and Media



Identify the possibly MP-impacted media:

Please use the chat function to type in your answers

Case Study – Step 2 – MP Transport Pathways and Media



Possible MP-impacted media

- Ambient air
- Subsurface Soils
- Surface soils
- Surface water
- Groundwater
- Beach sand
- Crops/Produce

Case Study – Step 2 – MP Transport Pathways and Media



Identify the possibly MP-Transport Pathways:

Please use the chat function to type in your answers

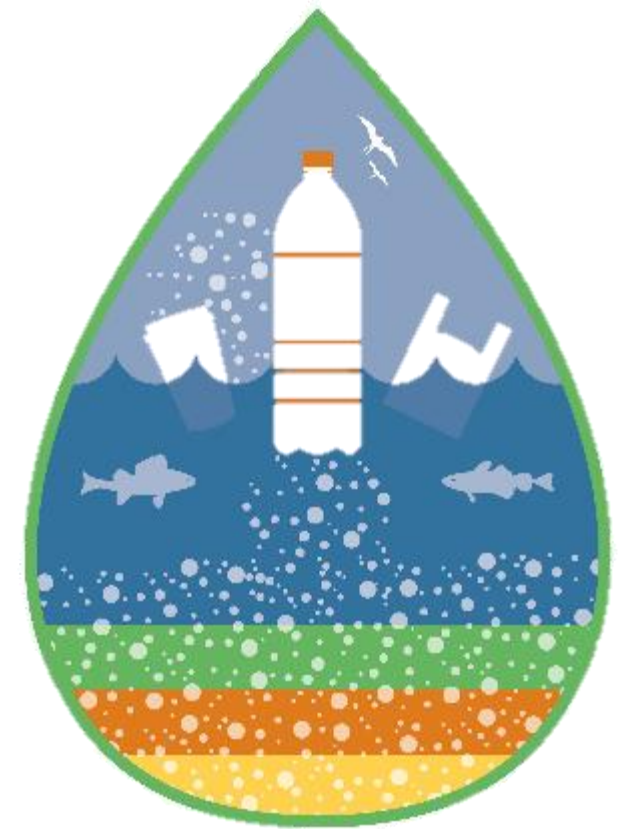
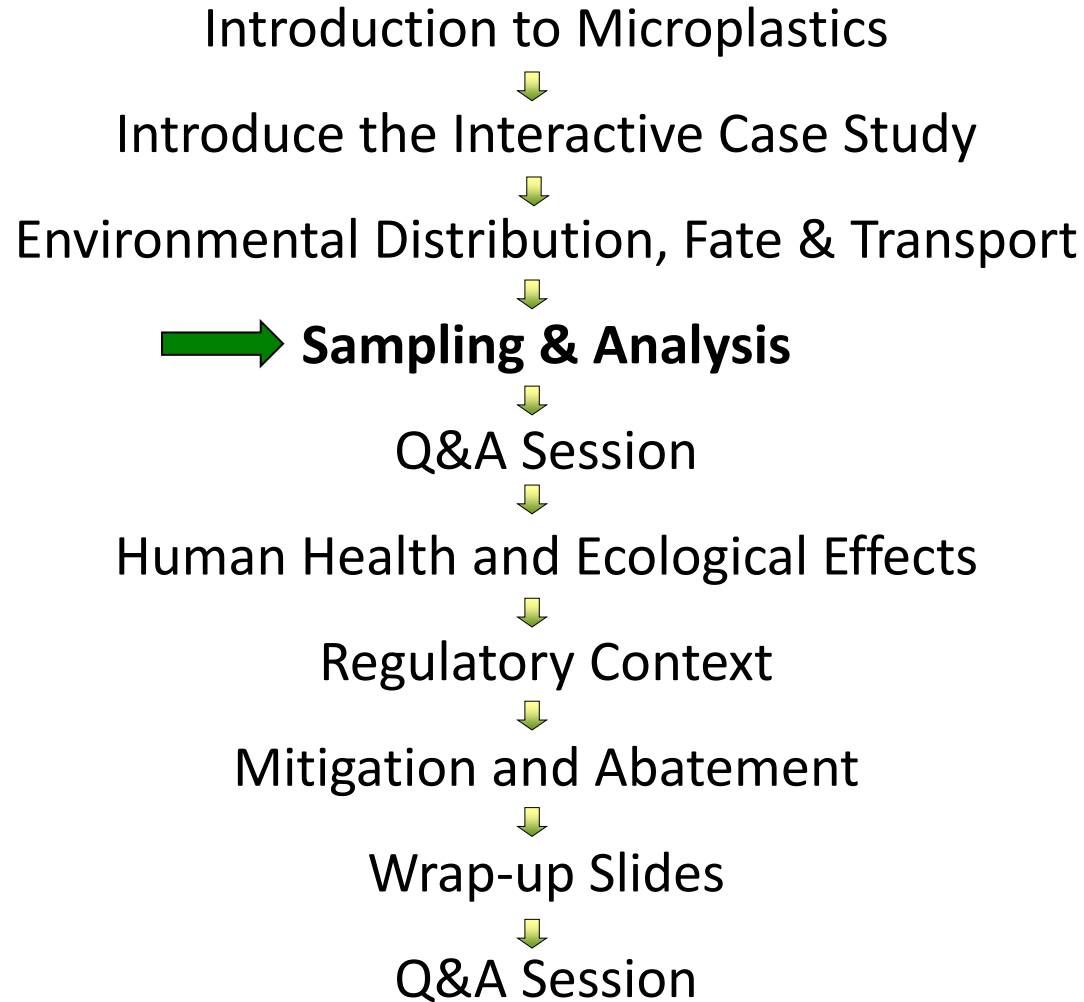
Case Study – Step 2 - MP Transport Pathways and Media



Possible MP transport pathways

- Urban runoff
- Rainfall
- Stormwater discharge
- Factory stack emissions
- Wind-blown wastes
- Wastewater discharge
- Agricultural soil disturbance

Today's Training Road Map



Overview – Sampling & Analysis

Considerations for selecting appropriate methods

ITRC tools to help choose appropriate methods

- Sampling = Sample Collection Tool
- Analysis = Table 4-2. Characterization Techniques Summary

Standard/adopted methods

Minimizing sample contamination

CSM – Sampling & Analysis

Air

Section 3.4.3 sample collection
Section 3.6.3 sample preparation

Soil

Section 3.4.2.1-sample collection
Section 3.6.2 sample preparation



Surface Water - Freshwater

Section 3.4.1.2.1-sample collection
Section 3.6.1.2-sample preparation

Sediment

Section 3.4.2.2-sample collection
Section 3.6.2-sample preparation

ITRC MP Figure 3-1

Selecting Appropriate Methods

What are your data quality objectives?

- sample media
- particle size
- minimum detectable amount
- data needed (size, shape, polymer, units, etc.)
- equipment/cost available

Sample Collection Tool

INTERSTATE TECHNOLOGY COUNCIL ITRC REGULATORY

Microplastics HOME

Welcome Microplastics

Plastics have become pervasive in modern life and are now used in a wide range of commercial and industrial applications. **Microplastics (MP)** are one of the biggest emerging threats to the global environmental community. Recognizing the importance of tackling the global plastics problem, the United Nations convened the **UN** Plastics Summit in Uruguay in 2022 to develop a legally binding instrument on plastic pollution. The Environment Assembly

Select Sampling Methods

ASTM D8332-20 (July 2020)

- Drinking water, surface waters, wastewater influent and effluent (secondary and tertiary), and marine waters
- Pump or existing sample tap + series of sieves
- Large volume (400 – 1,400 gallons)

California Water Boards

- Drinking Water
- In-line sieve filtration (e.g. Yuan et al. 2022, Chemosphere)
- Large volume (1,000 L)

Analytical Methods

Description	Analysis Time/ Sample	Size Detection Limit	Measurement Preparation	Identifies Polymer Types	Detects Additives /Surface Chemicals	Detects Particles or Mass
Visual Methods						
NE Naked eye	Hours	1 mm	None	No	No	Particle
SM Stereo microscopy	Hours	100 µm	On filter	No	No	Particles
FM Fluorescence microscopy	Hours	50 µm (Possibly smaller based on objective lens used)	On filter	No	No	Particles
SEM Scanning electron microscopy	Hours	0.001 µm	On filter	Yes	No	Particles
Spectroscopic Methods						
FPA-FTIR Focal plane array-Fourier transform infrared spectroscopy (in	Hours	20 µm	On special filter	Yes	No	Particles

Excerpt From ITRC MP Table 3-1.
Characterization Techniques Summary

Analytical Methods - California

ITRC MP Table 3-1. Characterization Techniques Summary Excerpt

Description	Analysis Time/ Sample	Size Detection Limit	Measurement Preparation	Identifies Polymer Types	Detects Additives /Surface Chemicals	Detects Particles or Mass
FTIR Fourier transform infrared spectroscopy (in transmission mode)	Days	20 µm	On special filter	Yes	No	Particles
LIDR Laser direct infrared spectroscopy	Minutes particles/ hour	20 µm	Special microscope slide	Yes	No	Particles
NIR, vizNIR Near infrared spectroscopy, visible-near infrared spectroscopy	Hours	Unspecified	On filter	Yes	Surface Chemicals only	Particles
Raman Spectroscopy	Days	1 µm (Theoretically but challenging to achieve)	Extraction and placed on filter	All polymers	Yes	Particles

Recently, the California State Water Resources Control Board adopted FTIR and Raman methods for MP identification in drinking water samples.

Keep it “Clean”

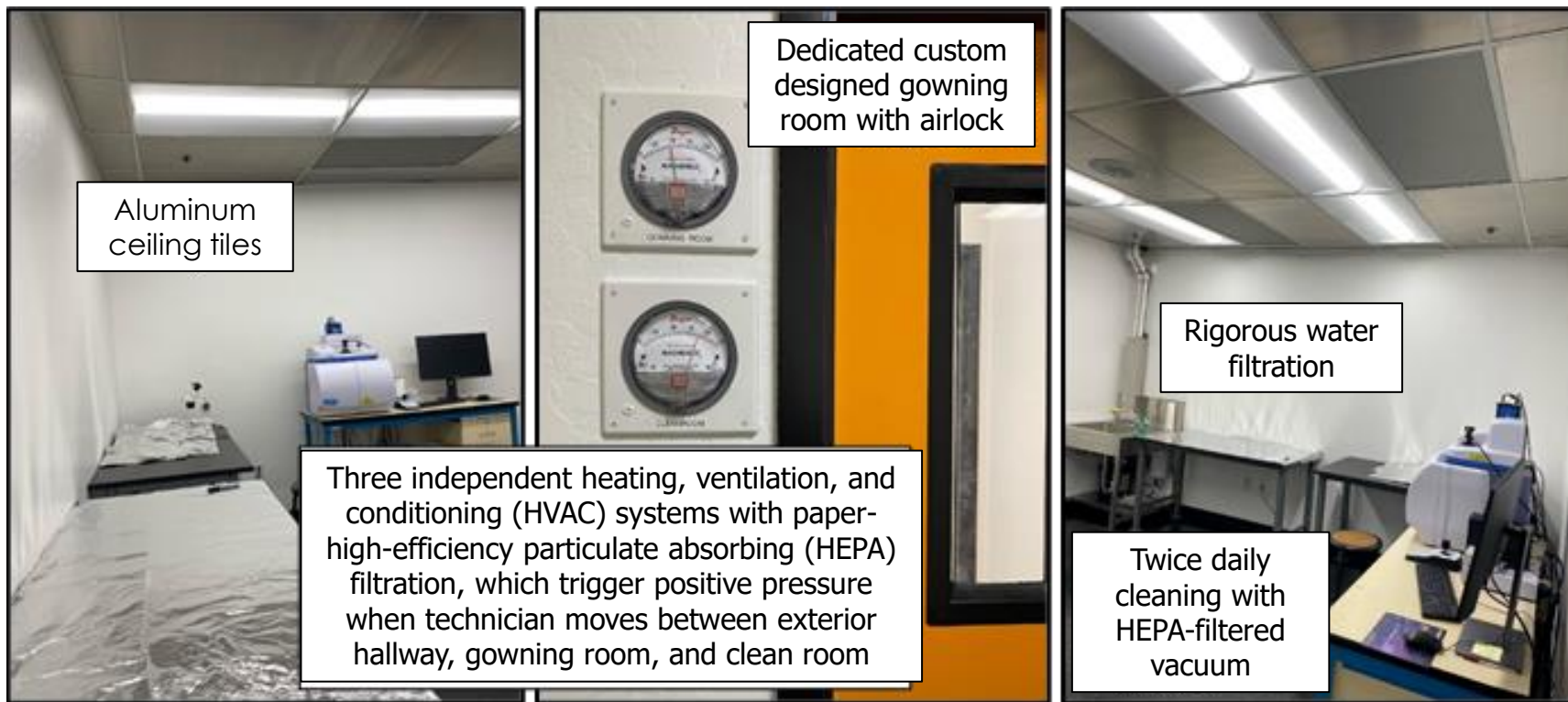
Minimize contamination

- Eliminate or limit plastic products used for sampling/processing
- Set up a clean laboratory

Account for contamination

- Collect air & procedural blanks to measure contamination introduced during processing

Example Laboratory Considerations



ITRC MP- Figure 3-2
Source: A. Enright
Photos: Eurofins

Summary – Sampling & Analysis

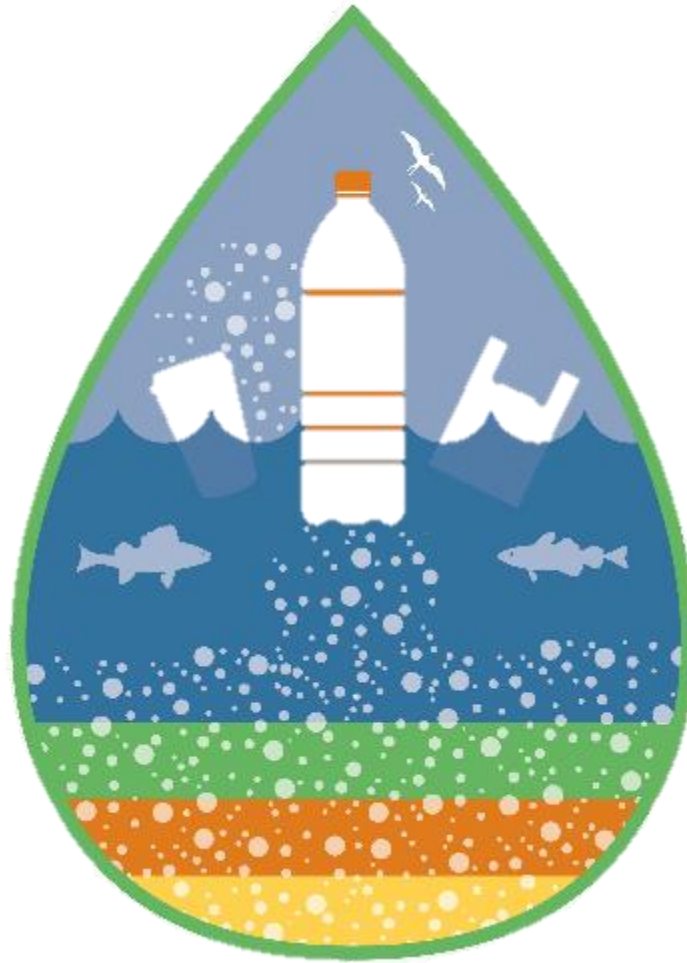
Standardized sampling methods available for water

FTIR & Raman analytical methods adopted for drinking water in CA

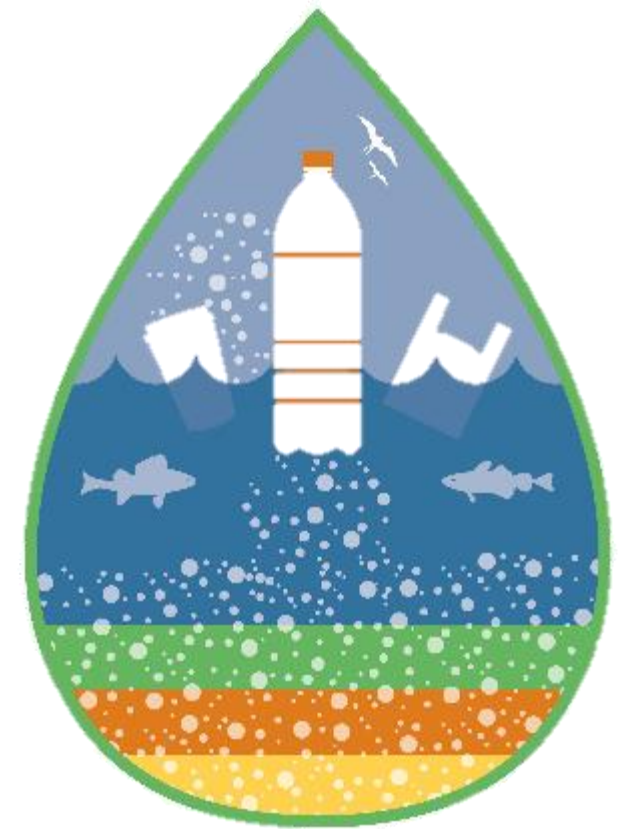
For other media/scenarios, use ITRC tools to select methods

Minimize & account for contamination

Question and Answer Break



Today's Training Road Map



Overview

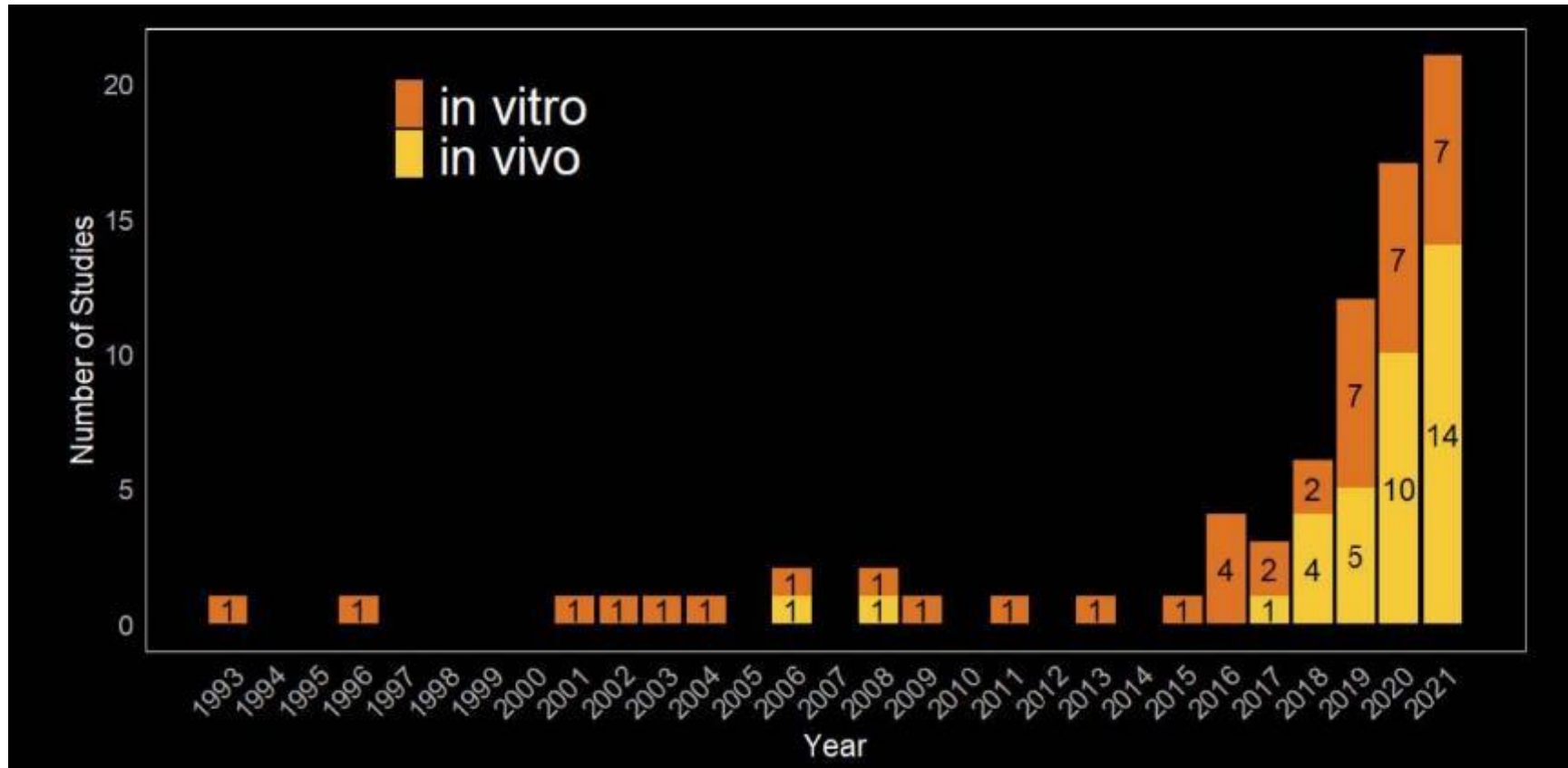
Human Health

- Exposure
- Effects
- Uncertainties

Ecological Receptors

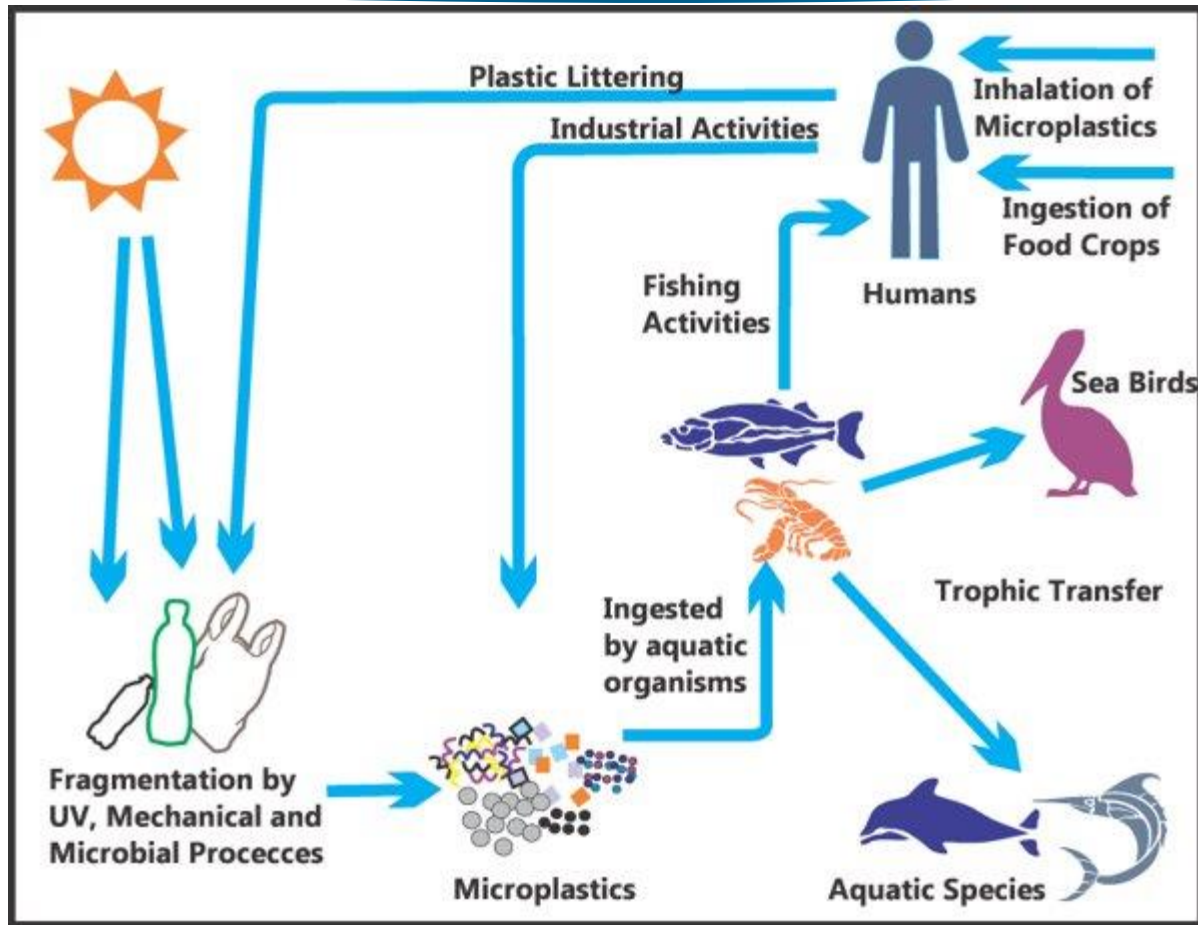
- Effects
- Toxicity tools
- Interpretation

Increase in number of microplastics toxicity studies



ITRC MP Figure 1-4, Source: Coffin (2022)

Human Health – Exposures



ITRC MP Figure 4-2
Source: A. MacDonald

- Multiple media and pathways for human exposure to MP
- Plastics and associated chemicals (MP focus)
- Exposure varies by region and population
- Current estimates: inhalation > dietary ingestion > incidental ingestion > dermal

Challenges in Toxicity Research

Numerous non-human mammalian studies available but usability varies

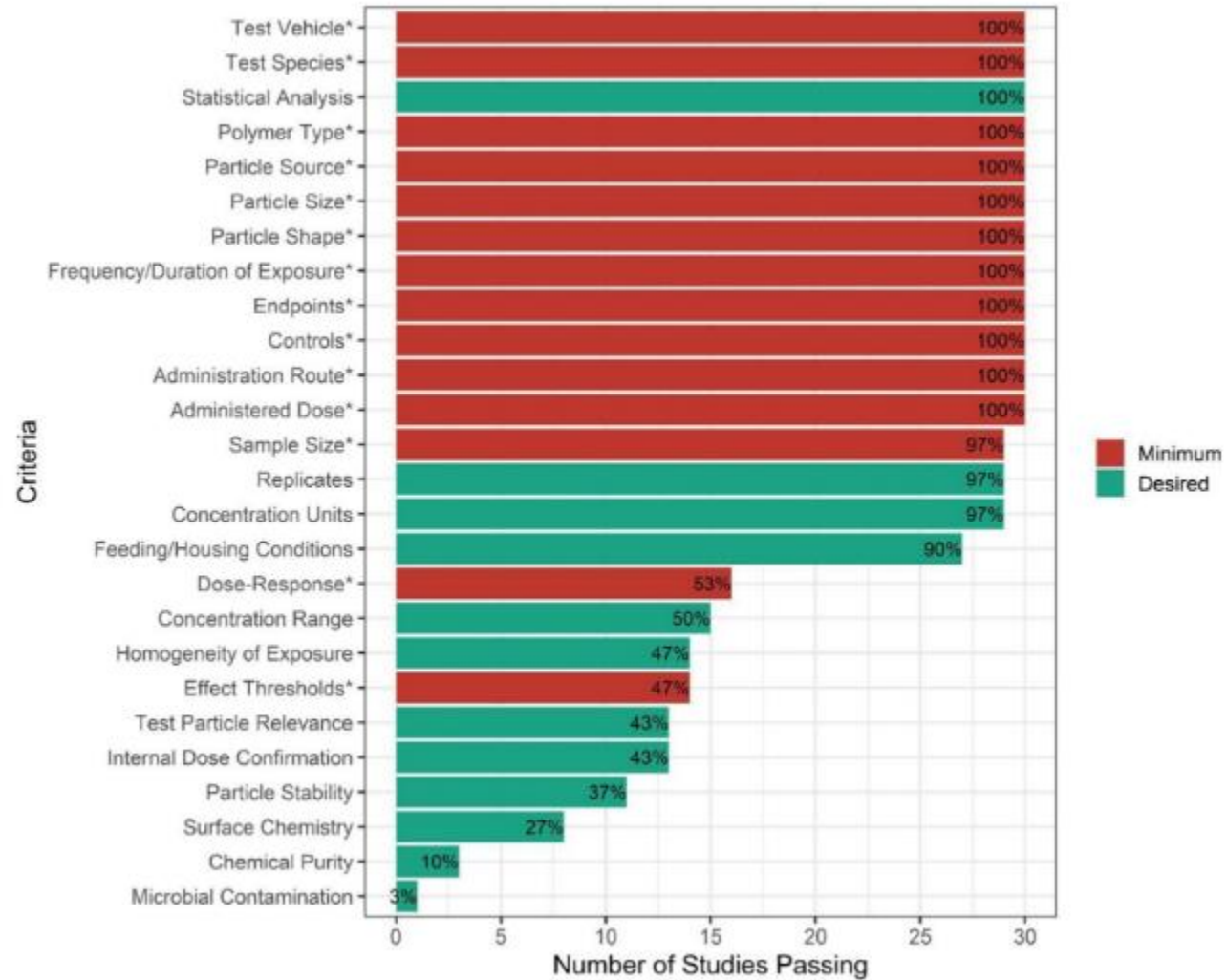
Uncertainties due to study design, exposure concentration, data quality, reporting, data gaps

Exposure \neq Adverse health effect



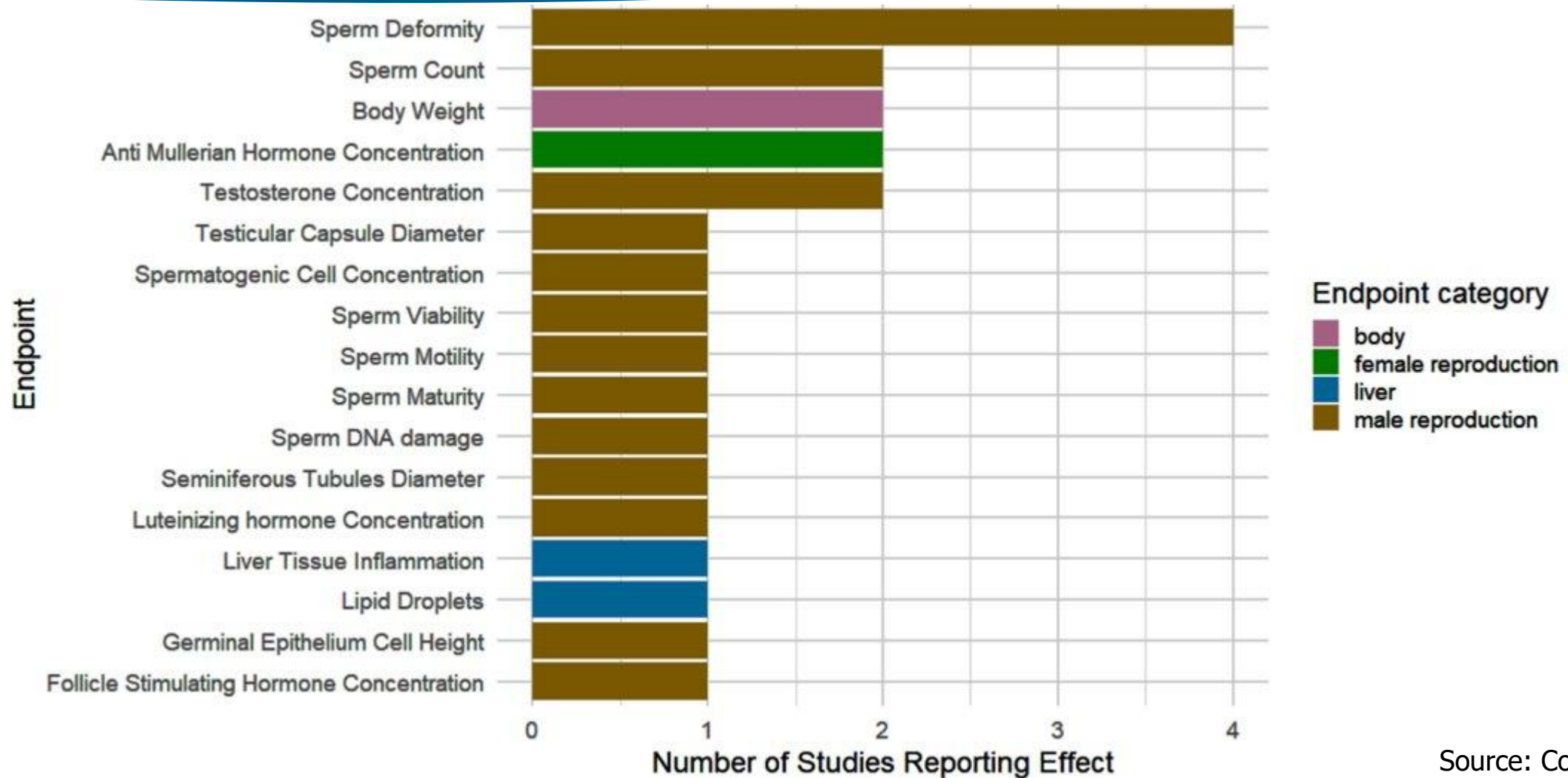
Source: Thornton Hampton et al. 2022

Human Health – Test Quality Criteria



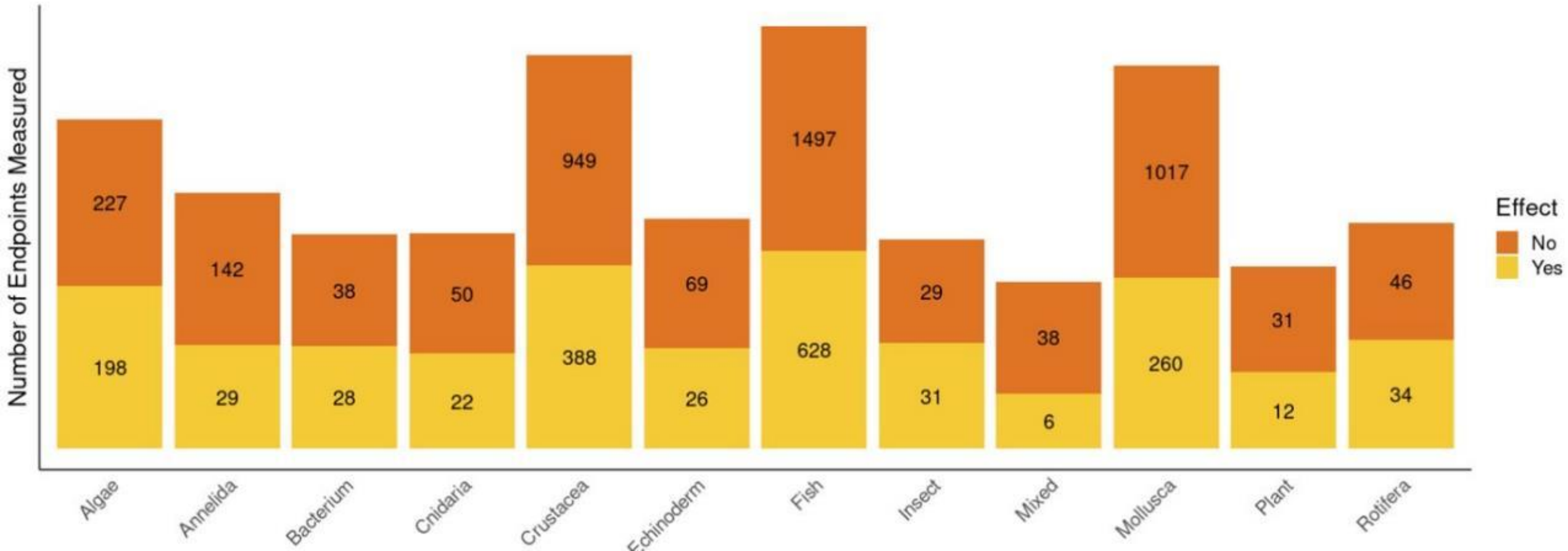
Source: Coffin et al. 2022

Reliable Human Toxicity Endpoints



Source: Coffin et al. 2022

Microplastics Studies By Ecological Group



Influencing Factors

Cellular Damage

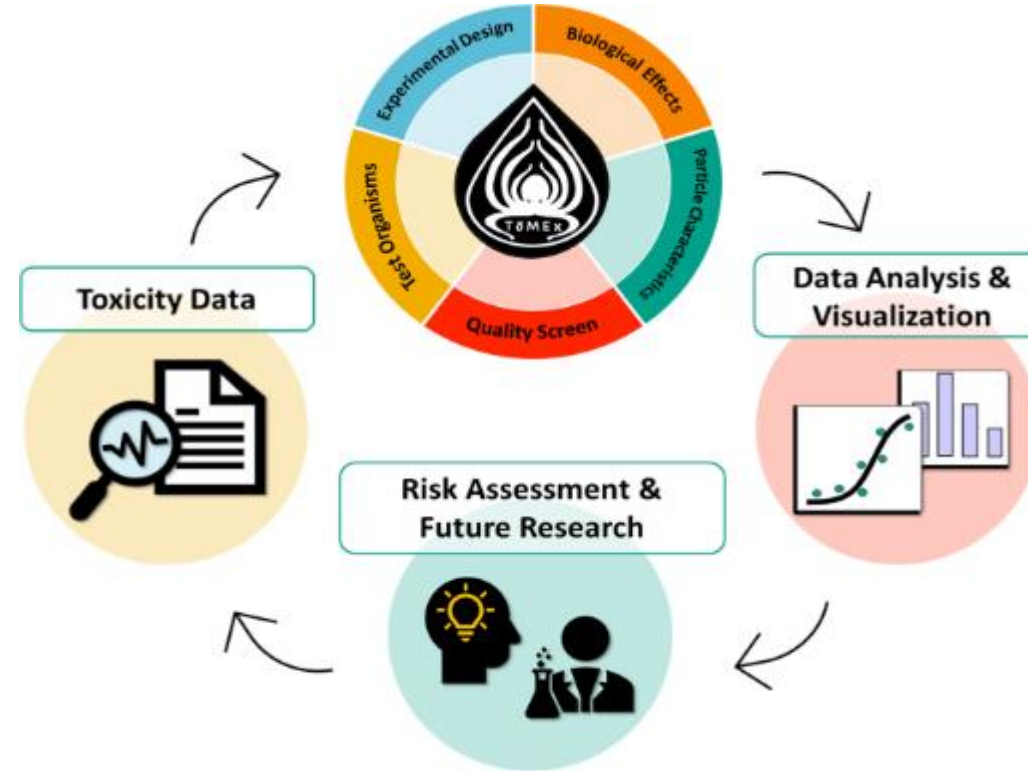
- Size ranges matter
- Particles $<83 \mu\text{m}$ have ability to translocate
 - Fibers are the most commonly found microplastic but are understudied with regards to tissue translocation

Nutritional Deficiencies

- Microplastics mistaken as food can cause nutritional deficiencies due to food dilution
- Preferential consumption of particles by size, shape, color

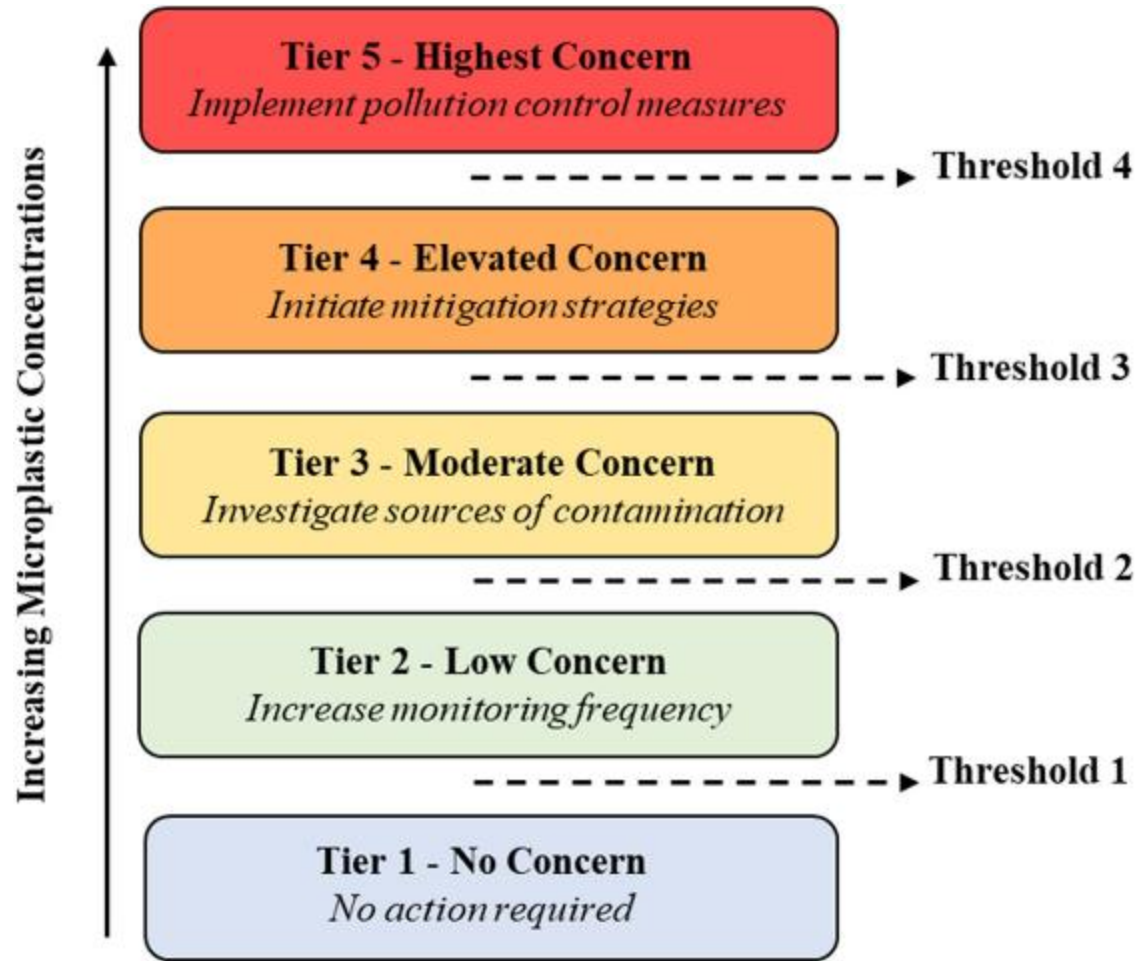
Source: Mehinto et al. 2022

Toxicity Microplastics Explorer (ToMEx) Application

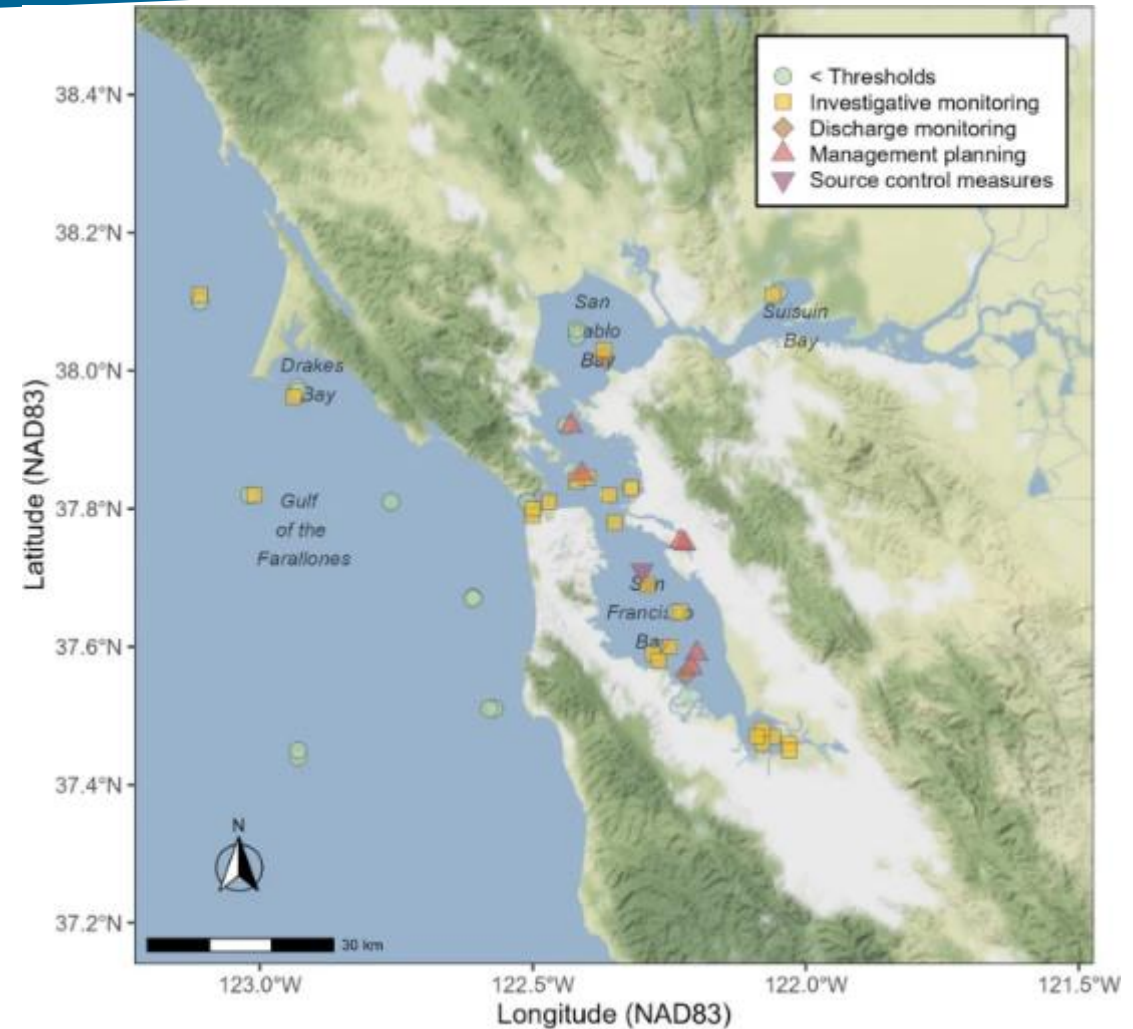


ITRC MP Figure 4-4
Source: Thornton Hampton et al. 2022
<https://microplastics.sccwrp.org/>

Application of Aquatic Risk Threshold to San Francisco Bay, California



ITRC MP Figure A.1- 5 Source: Mehinto et al. 2022



ITRC MP Figure A.1- 6 Source: Coffin et al. 2022

Case Study: Appendix A.2: Consequences of Microplastics on Various Ecological Endpoints in the Chesapeake Bay



ITRC MP Figure A.2-2
Source: NOAA



ITRC MP Figure A.2-1
Source: NASA/USGS Landsat 5



ITRC MP Figure A.2-3
Source: US Fish and Wildlife Service

Health Effects Summary

Physical, Chemical, Biological Hazards

Exposure characterization highly uncertain

Adverse outcome pathways needed

Particle size and shape strongly influence toxicity

We still have a lot more to learn

Case Study – Step 3 – MP Receptors



Identify the possible receptors (human and ecological):

Please use the chat function to type in your answers

Case Study – Step 3 – MP Receptors

Possible Human and Ecological Receptors

- Beach user
- Bay swimmer
- Agricultural worker
- Factory worker
- Urban residents
- Local anglers
- Produce/crop consumers
- Fish
- Aquatic birds
- Aquatic mammals
- Vegetation
- Cattle/herbivores
- Soil invertebrates

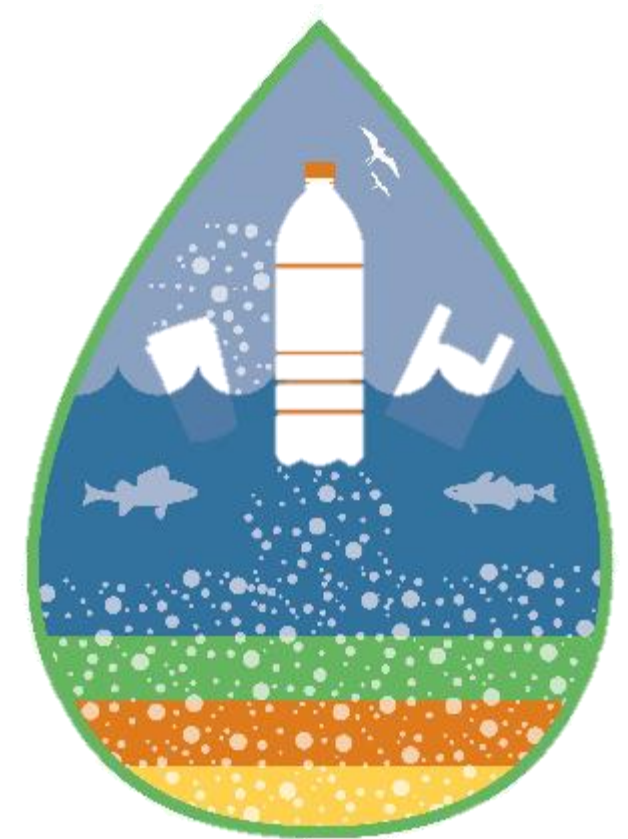
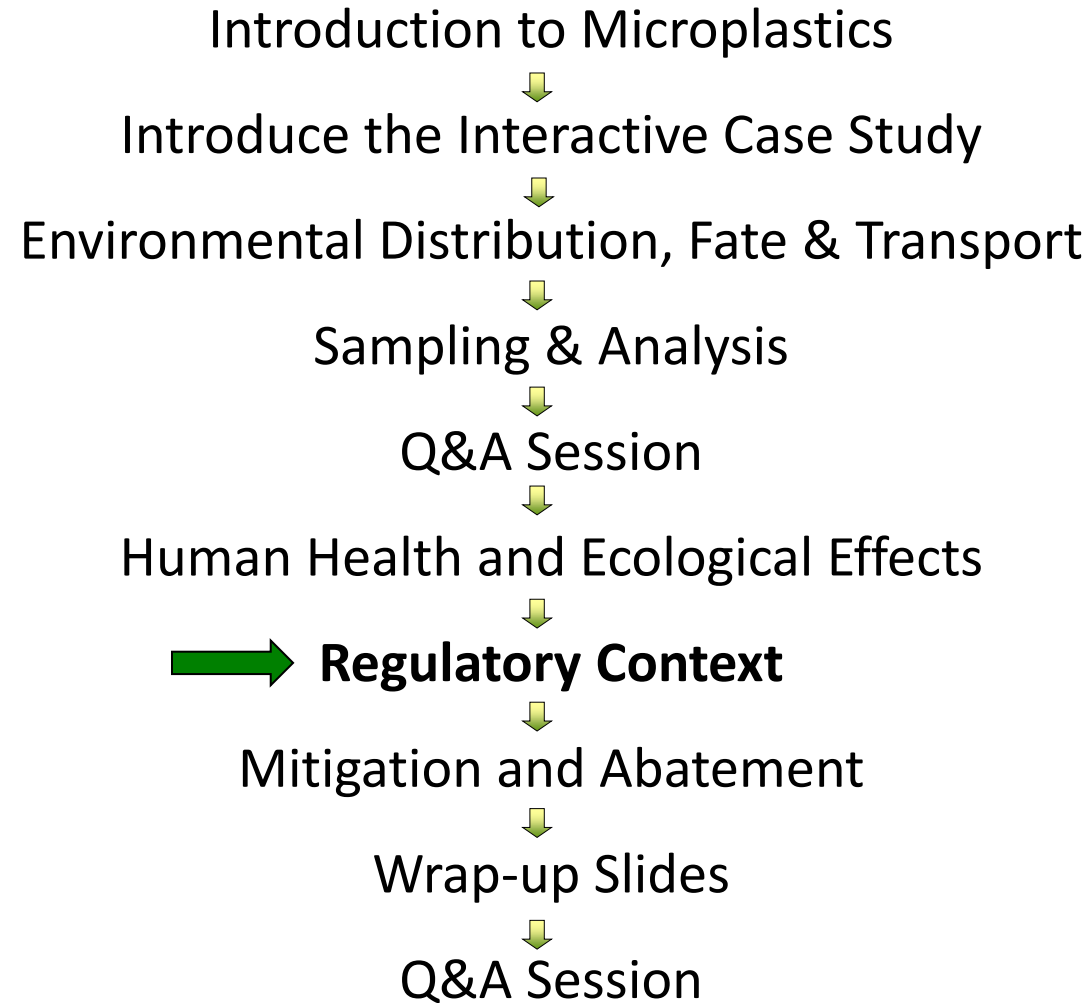


Case Study – Step 4 – Next Steps



Conceptual Site Model Development
Develop Sampling and Analysis Plan

Today's Training Road Map

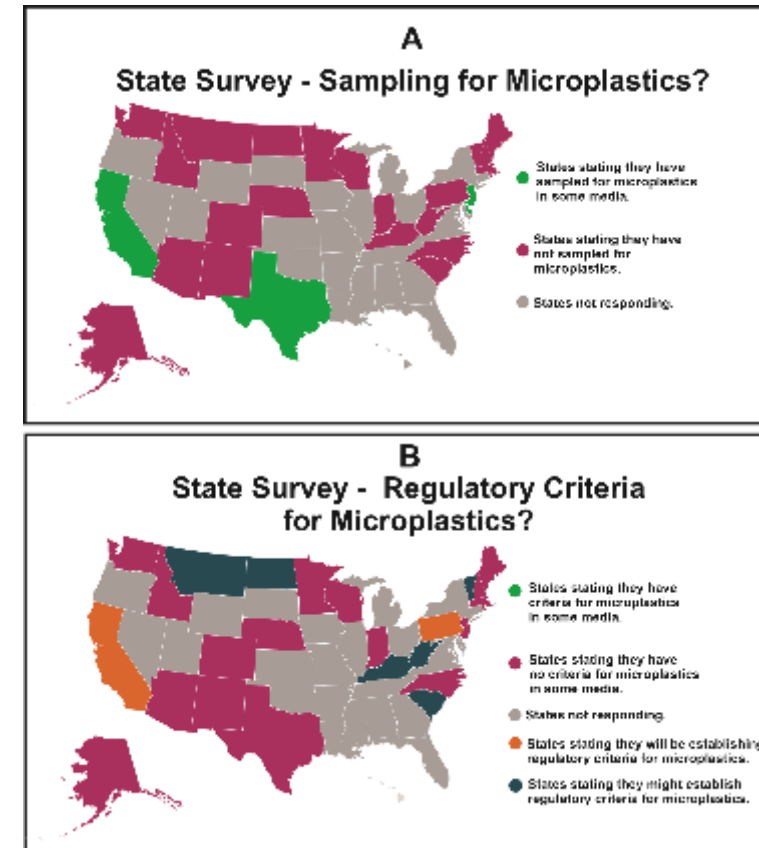


Survey of State Regulatory Efforts

Survey sent to states through ITRC points of contact (June 2021)

Key Results – Responses received from 25 states

- California, Texas, and New Jersey have sampled for microplastics
- No states had regulatory criteria and only two states, California and Pennsylvania, are looking at establishing criteria
- Six states stated that they may establish regulatory criteria



ITRC MP Figure 5-1

Regulatory Efforts - Examples

Most states have focused on plastics in general

Common efforts – recycling mandates; phase-out of plastic single-use bags, restaurant utensils and food packaging (primarily carry-out)

Some states have banned local implementation of these types of restrictions

Appendix C: Regulatory Context Tables

Summary of statutes and regulations

Tables for:

- State
- Federal
- International Regulations
- Macroplastics

Acronyms and Abbreviations

State Programs

Federal Programs

International

Macroplastics, etc.

State Regulatory Context

3	State	Legislation or Executive Order	Program other than Column B	Agency	Program Area	Description	Date Added to the table	Weblinks
19	Connecticut	Senate Bill No. 1502, Public Act 15-5 Sec. 5 (2015)		State Legislature	Consumer Products	Bans the use, sale, import or manufacture of synthetic microbeads for personal care products in the State of Connecticut	7/6/2021	https://www.cga.ct.gov/2015/act/pa/pdf/2015PA-00005-R005B-01502551-PA.pdf
20	Connecticut	Substitute House Bill No. 5360, Public Act 18-181 Sec. 6 (2018)		State Legislature	Consumer Products	Establishes a working group of representatives from both the retail and apparel industry and the environmental community to focus on synthetic microfiber pollution. This working group is meeting to develop consumer awareness and education programs in order to present information regarding synthetic microfibers in clothing to the public.	7/6/2021	https://www.cga.ct.gov/2018/ACT/pa/pdf/2018PA-00181-R00HB-05360-PA.pdf

Navigation: Acronyms and Abbreviations | **State Programs** | Federal Programs | International | Macroplastics, etc. | Sheet1 | ... (+) | ◀

Summarizes state statutes or regulations

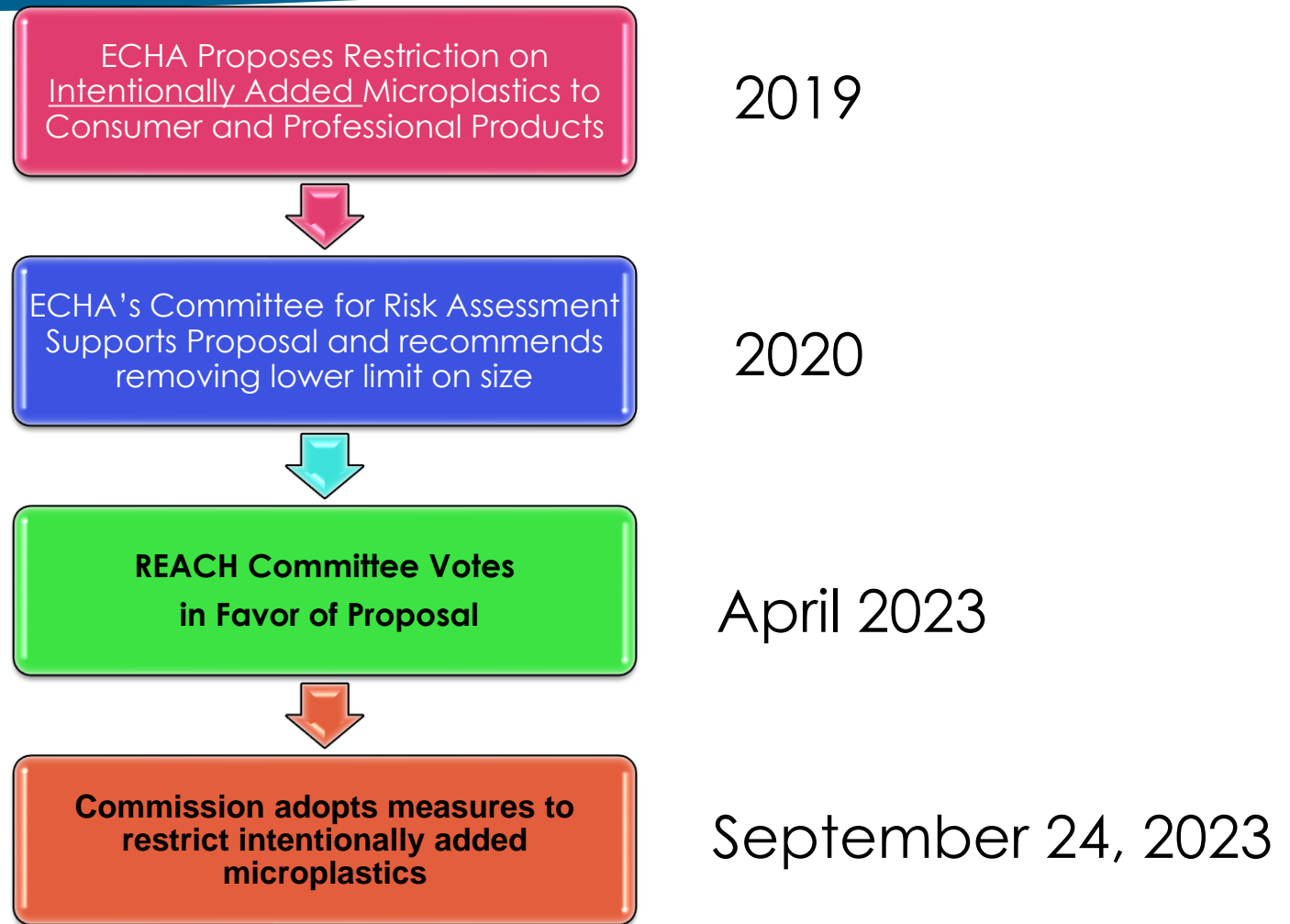
Provides links for more information

International Regulatory Context

Provides information on statutes and regulations from a number of different countries

Location	Legislation or Executive Ord	Agency	Program Area	Description	Date Added to the table	Weblinks
42	Ireland	Microbeads Prohibition Act 2019	Irish Environmental Protection Agency	Consumer Products	Effective February 2020, the Act prohibits the manufacture or sale of cosmetic and cleaning products containing microbeads	12/3/2021 https://www.irishstatutebook.ie/eli/2019/act/52/enacted/en/html
43	Japan	Bill to reduce use of microplastics (2018)	House of Councillors	Consumer products	Urges voluntary action by companies to reduce plastic microbeads in cosmetics, facial cleansers and toothpastes	12/30/2021 https://www.nippon.com/en/news/vj2018061500400/
44	Latin American countries	Plastic litter and microplastics waste management	Varies by country	All plastics	Compendium of national and regional Strategies, Action Plans and Initiatives to monitor and manage plastic wastes and litter	9/14/2022 Marine_EN.pdf (unep.org)
45	Sweden	Roadmap for Sustainable Use of Plastics	Swedish EPA	All plastics	General plan for plastics, including microplastics	12/3/2021 https://visita.se/app/uploads/2021/06/Fardplan-Hallbar-plastanvandning_eng.pdf
46	Sweden	Legislation to prevent the spread of microplastics	Swedish Parliament	Tax	Tax on plastic bags, effective April 2020	12/3/2021 https://www.loc.gov/item/global-legal-monitor/2020-01-31/sweden-parliament-votes-to-adopt-tax-plastic-bags/
		Swedish Medical products		Macroplastics, etc.	Ran on plastic microbeads in cosmetic products, effective	https://www.kemi.se/en/rules-and-regulations/rules-applicable-in-sweden-only/certain-swedish-res

International Actions: European Union

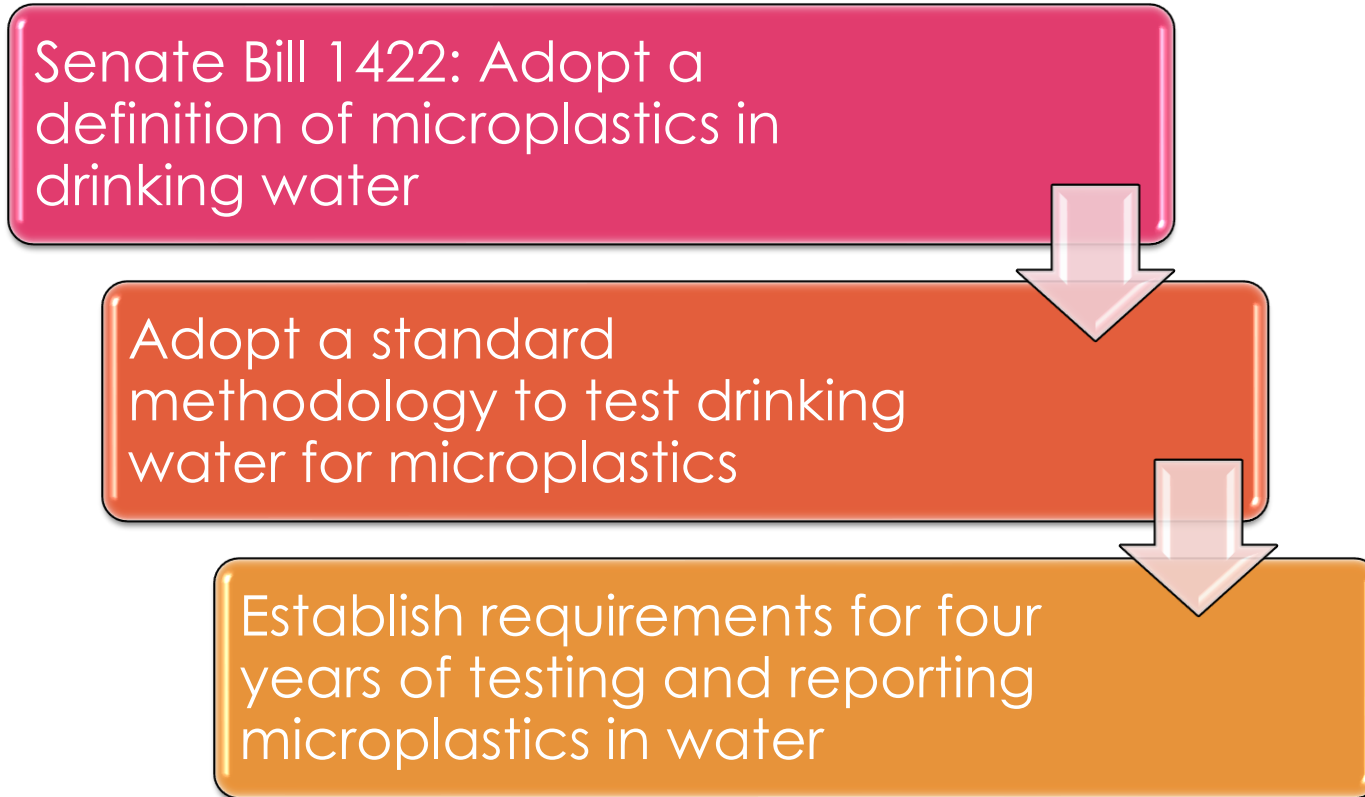


International Actions- UN Plastics Treaty

“Microplastics, mostly from tyres, pellets, textiles, and personal care products, can be addressed by reducing automotive mileage, redesigning tyres and behavioural change, improved design and production of garments, introducing filters on washing machines, improved production and value chains of plastic pellets and facilitating their safe transport, and banning the use of intentionally added microplastics to personal care products.”

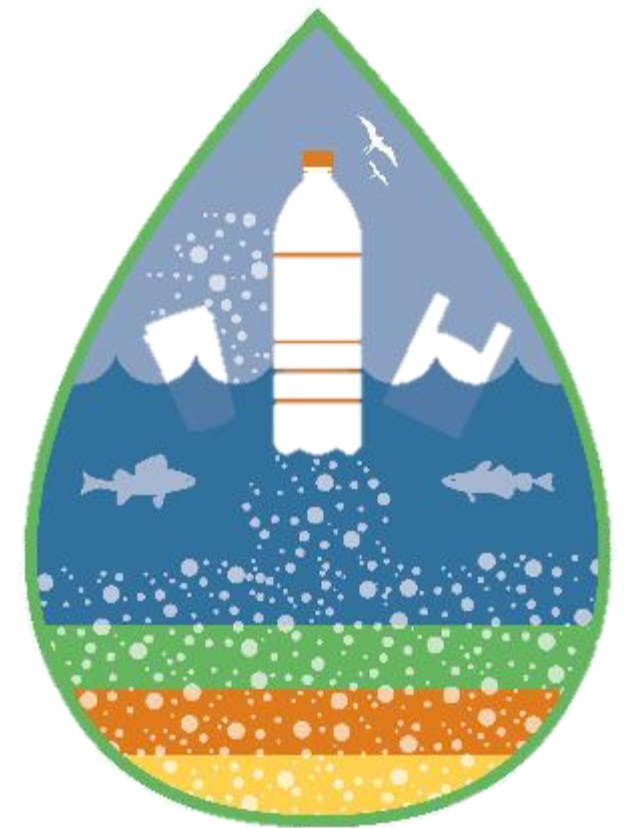


Case Study: Appendix A.1: California Approach for Microplastics



Senate Bill 1263:
Adopt and Implement a
Statewide
Microplastics
Strategy

Today's Training Road Map



Overview: Mitigation and Abatement



Prevention and Mitigation



Remediation Technologies

The Best Defense is Good Offense

Preventing MP from entering the environment

More studies necessary to achieve removal of MP in different media



ITRC MP Figure 6-3
Source: Adapted from USEPA.

Mitigation and Prevention Strategies

Section 6.1.1
Manufacturing &
Packaging
Section 6.1.2
Improving
production
efficiency

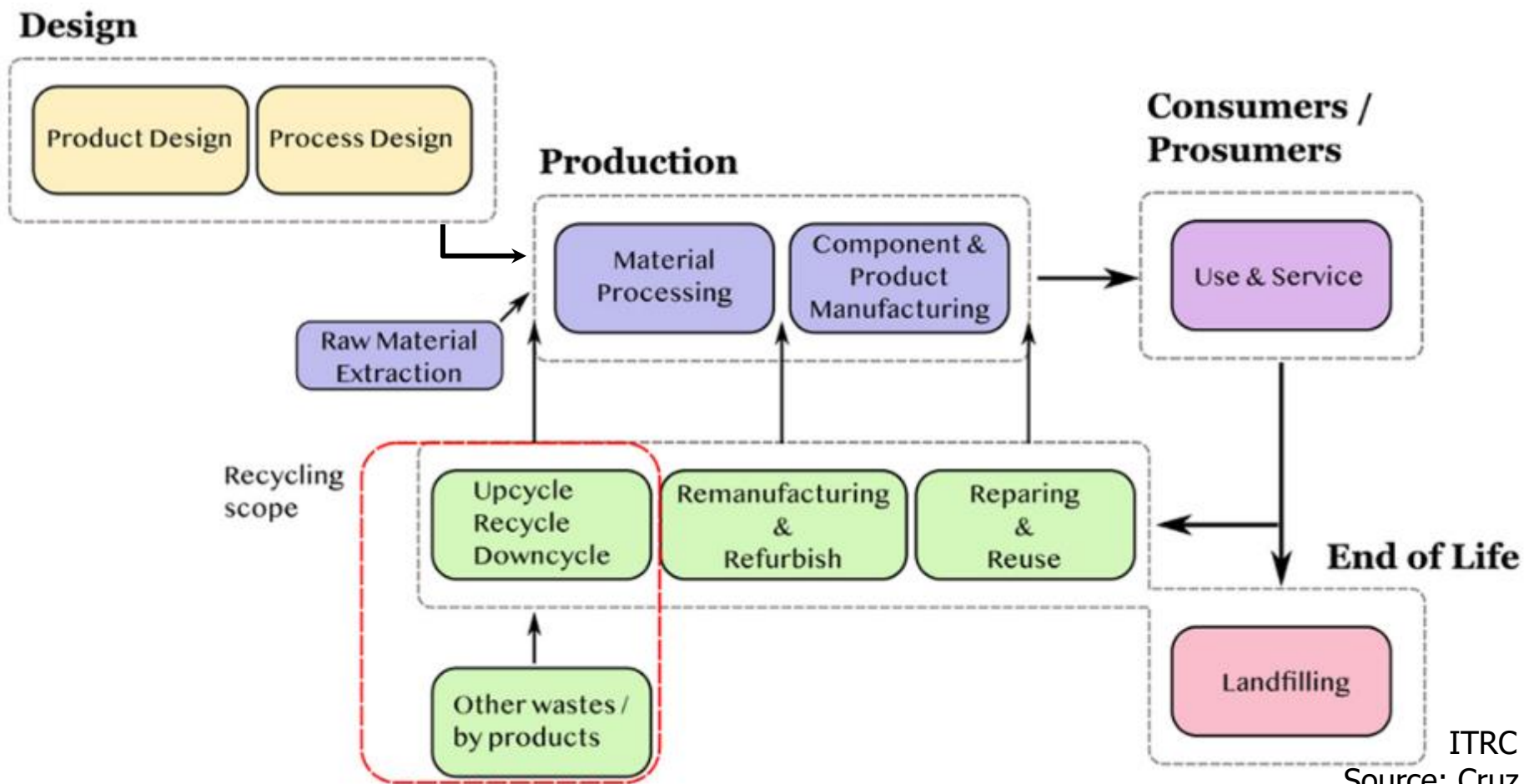


Reduction of plastic packaging and increasing the reuse

Improvements in plastics production at an industrial level including life cycle assessments (LCA)

ITRC MP Figure 6-1

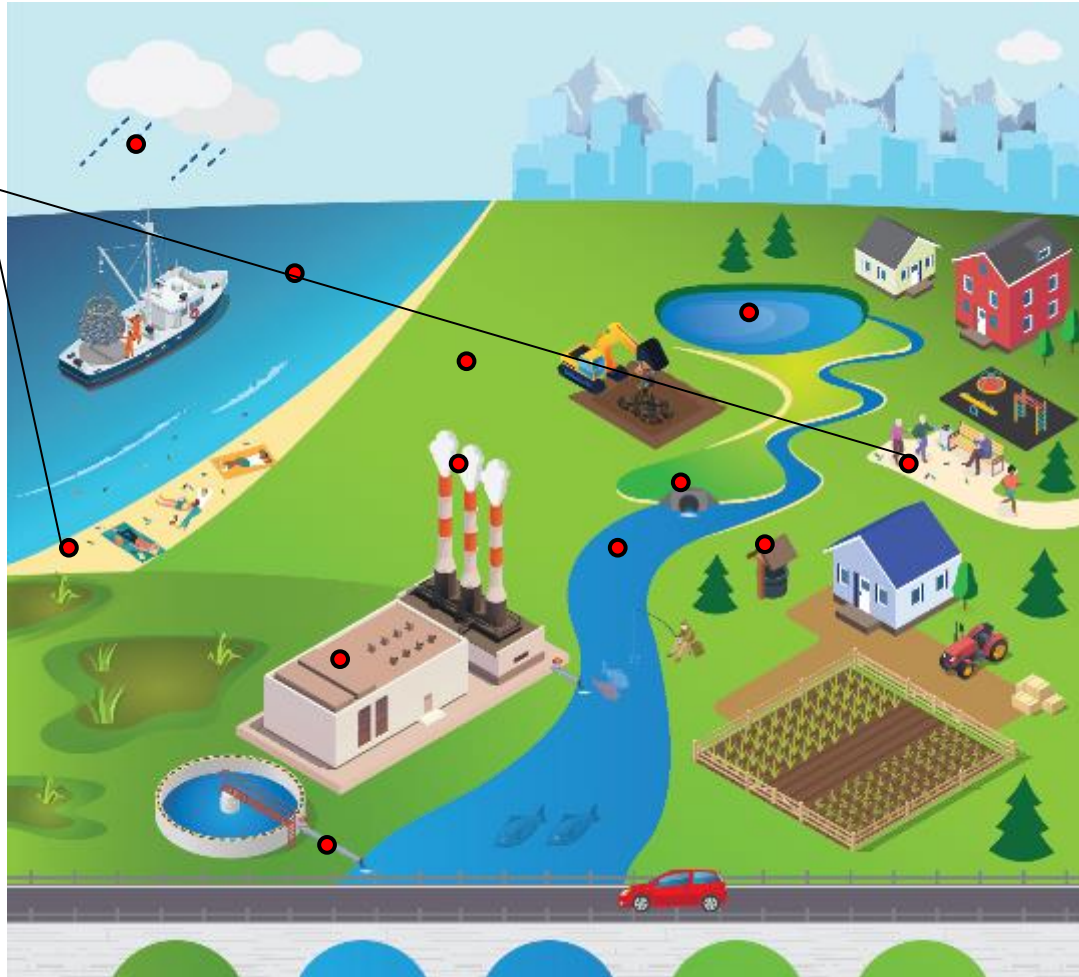
LCAs to Limit Plastics in Use



ITRC MP Figure 6-2
Source: Cruz Sanchez et al. (2020)

Mitigation and Prevention Strategies

Section 6.1.3
Reducing
Consumption



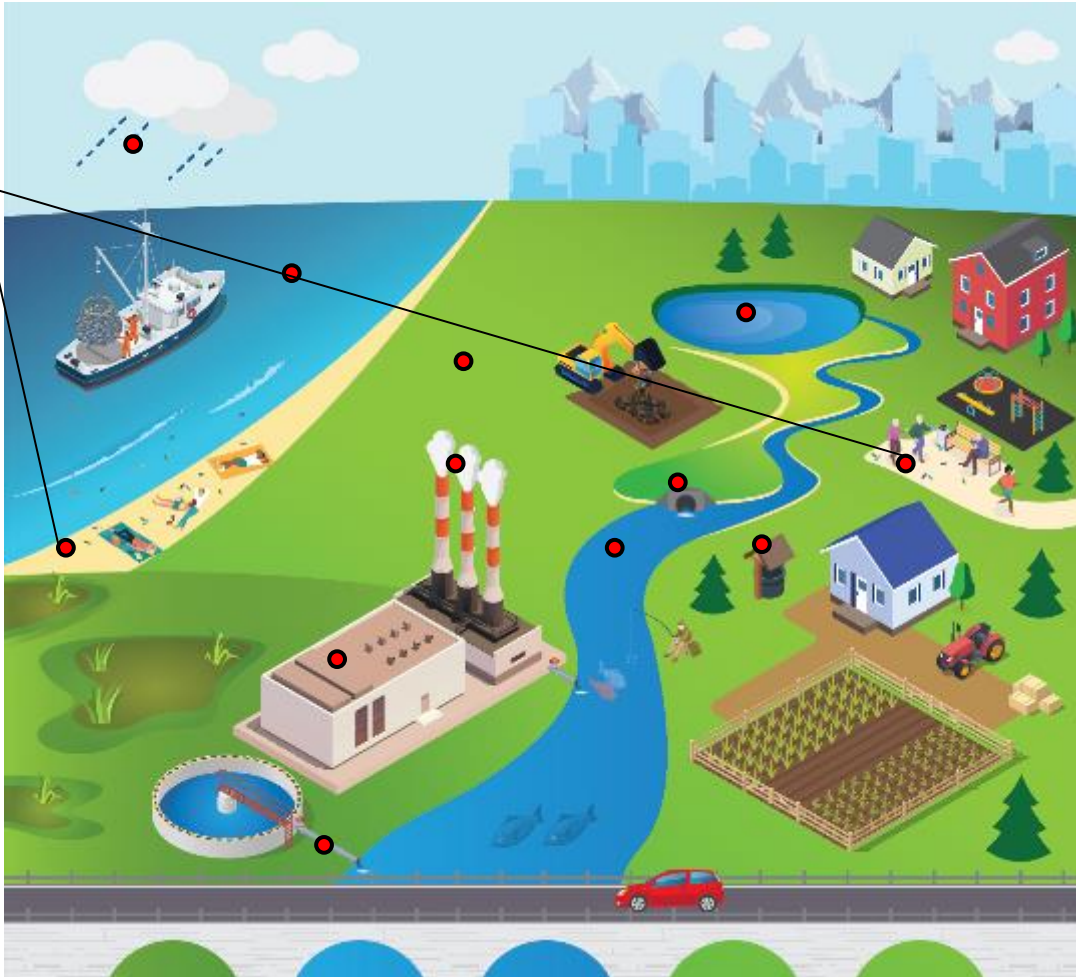
Reduce consumption of plastics

- Product Substitution
- Education & Awareness

ITRC MP Figure 6-1

Mitigation and Prevention Strategies

Section 6.1.4 Improving Disposal of Waste



- Source Collection and Post-Separation Disposal
- Reuse &/or Repurposing
- Waste to Energy and Feedstock
- Landfilling
- Bio-based and Biodegradable Plastic Alternatives
- Electronic Waste Recycling
- Enhancing Distribution/Storage/Transportation
- Stormwater Control

ITRC MP Figure 6-1

Mitigation Wrap-Up



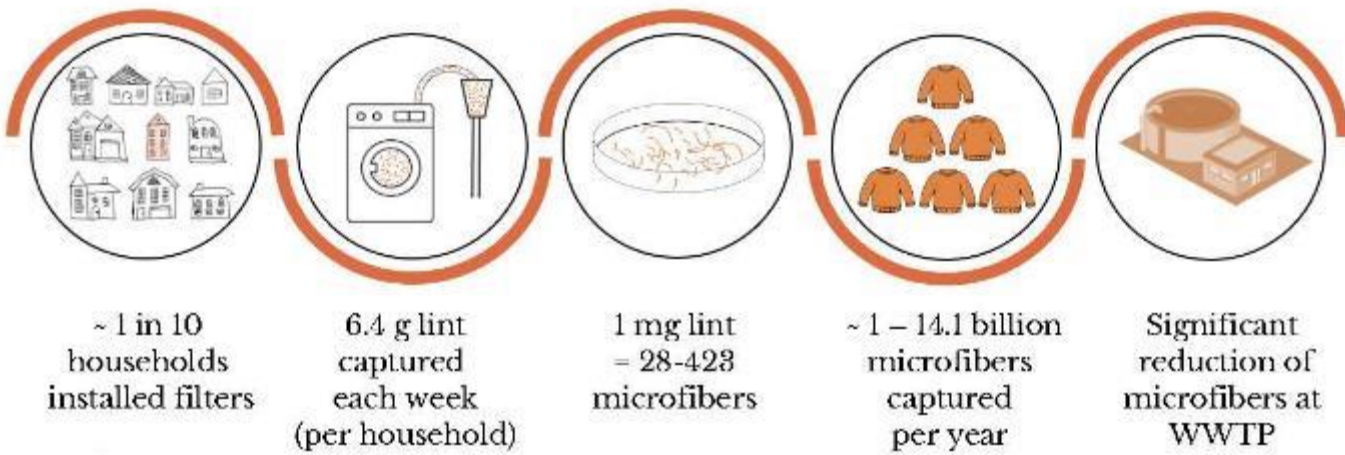
Prevention and Mitigation



Remediation Technologies



Case Study, Appendix A.6: Washing Machine Filters Reduce Microfiber Emissions to Aquatic Ecosystems



Source: Erdle, et al (2021)

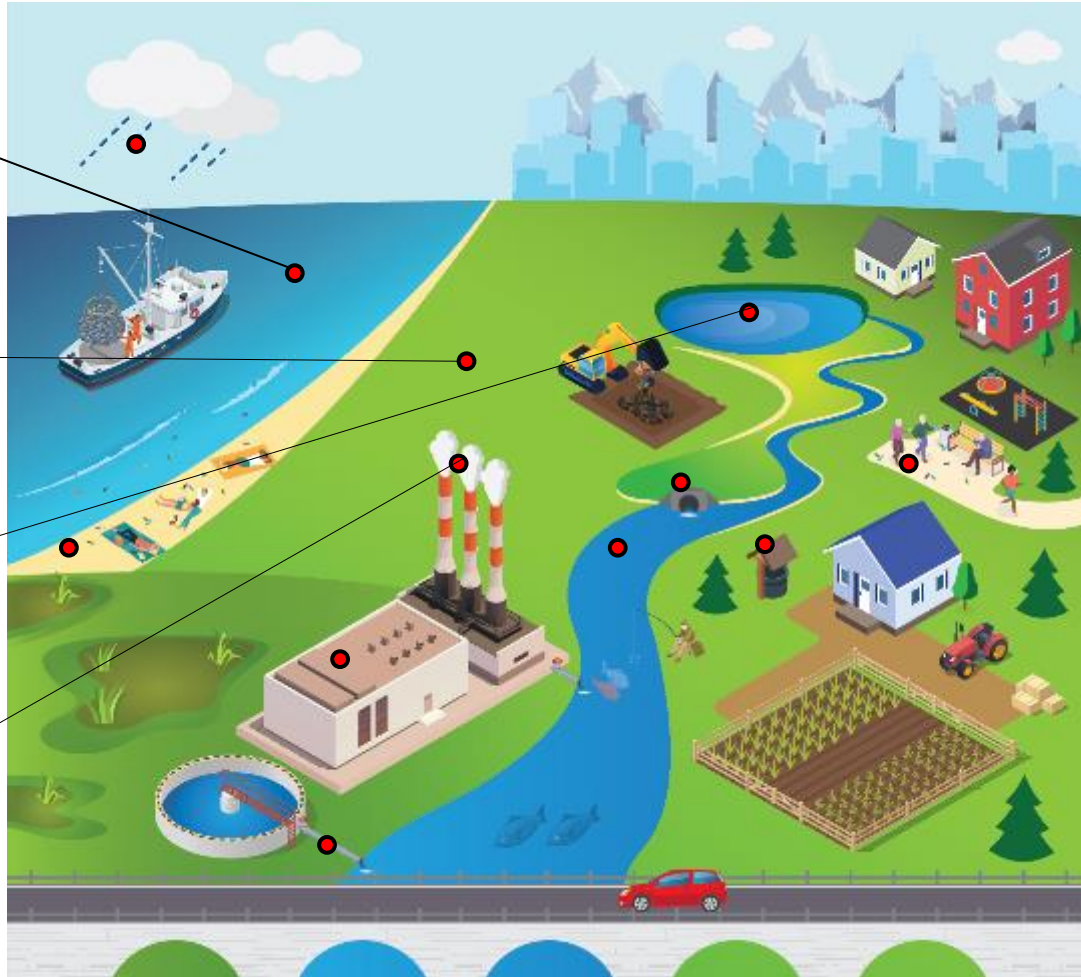
Abatement Strategies

Section 6.2.1:
Water

Section 6.2.2:
Soil

Section 6.2.3:
Sediment

Section 6.2.4:
Air



Field Implemented

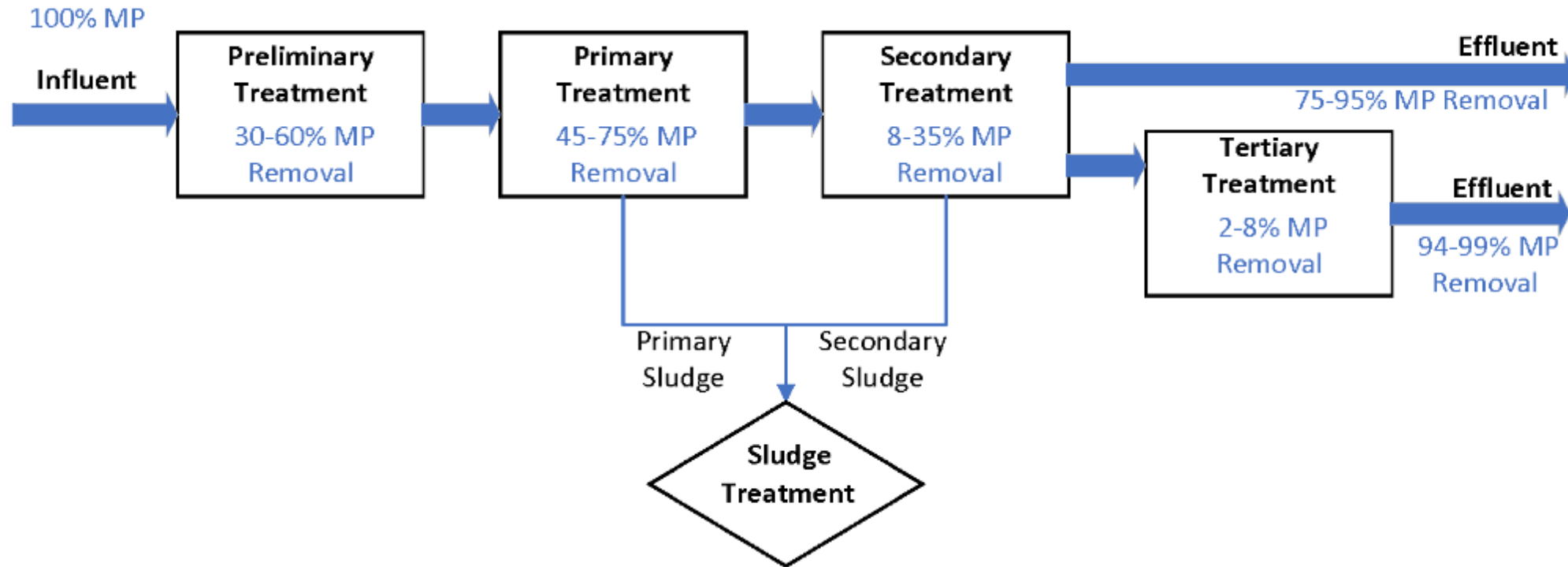
Demonstrated under full-scale conditions at multiple sites, by multiple practitioners and multiple applications, and are well documented in practice or peer-reviewed literature

Developing Technologies

Researched at the laboratory or bench scale, but have not been field demonstrated

ITRC MP Figure 6-1

Estimation of MP Removal in Wastewater Treatment Plants



ITRC MP Figure 6-5 (Modified)

Source: Renee Lu, modified from Ali et al. (2021)

Treatment Technologies by Media – ITRC MP Tables 6-3 and 6-4

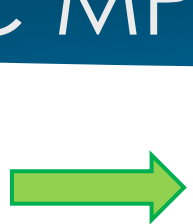
Table 6-3. Treatment technologies for MP in water

Treatment Category	Treatment Technology	Media	Advantages/ Efficiencies	References
Biological	Field Implemented (for Select Media)/General Remediation Technology			
	Rain garden (bioretention cell)	Stormwater	Up to 96% MP removal efficiency	Werbowski et al. (2021) [262] ₆
	Developing Technology or at Lab Scale			
	Biodegradation	Surface water, groundwater, wastewater, marine, soil, sediments	75–99% MP removal efficiency A consortium of organisms can be used as a treatment strategy	Gan and Zhang (2019), Han et al. (2017), Hu et al. (2021), Pathak and Navneet (2017)
Chemical	Developing Technology or at Lab Scale			
	Chemical degradation (oxidation, hydrolysis)	Surface water	Up to 56% MP weight loss for Fenton-like system Builds off treatment technologies used for other contaminants	Hu et al. (2021) [278] ₆
	Electrochemical oxidation	Surface water, groundwater, marine, wastewater, soil	58% MP removal efficiency, and up to 86.8% with an additional oxidant Quick treatment time, particularly effective for MP and NP destruction and effective for reducing MP size and mass and mineralizing NP	Kiendrebeogo et al. (2021) [222] ₆
Field Implemented (for Select Media)/General Remediation Technology				

Table 6-4. Potential treatment technologies for MP in soil

Treatment Category	Treatment Technology	Media	Advantages/ Efficiencies	References
Developing Technology or Lab Scale				
Biological	Biodegradation	Surface water, groundwater, wastewater, marine, soil, sediments	75–99% MP removal efficiency A consortium of organisms can be used as a treatment strategy.	Gan and Zhang (2019), Han et al. (2017), Hu et al. (2021), Pathak and Navneet (2017)
Chemical	Electrochemical oxidation	Surface water, groundwater, marine, wastewater, soil	58% MP removal efficiency, and up to 86.8% with an additional oxidant. Quick treatment time. Particularly effective for MP and NP destruction and effective for reducing MP size and mass and mineralizing NP.	Kiendrebeogo et al. (2021) [222] ₆
Physical	Thermal (that is, pyrolysis and gasification)	Surface water, soil	54% in MP weight loss for catalytic advanced oxidation process with hydrothermal hydrolysis.	Hu et al. (2021) [278] ₆
	General Technology			
	Incineration	Sludge/biosolids, soil, air	Can be used for energy generation.	(Geyer, Jambeck, and Lavender Law 2017)

Treatment Technologies by Media – ITRC MP Table 6-4



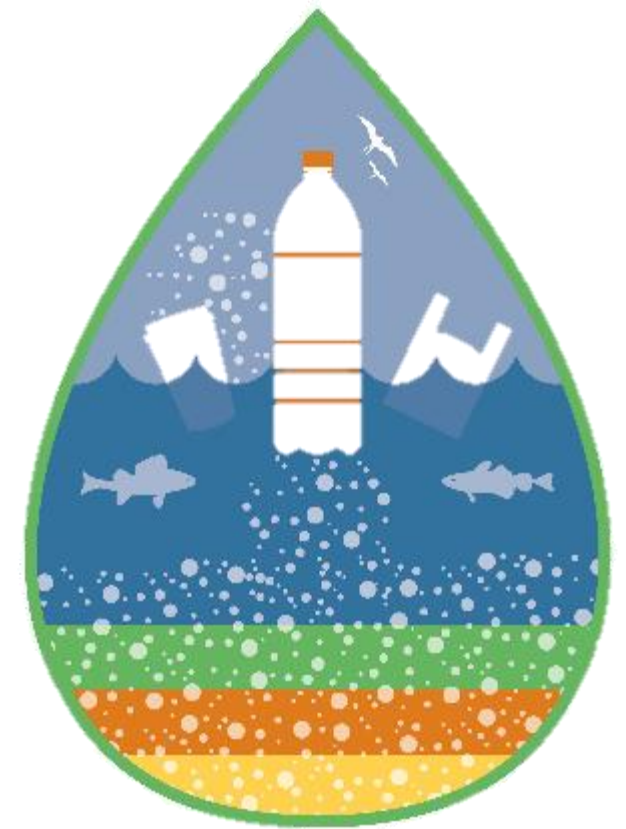
Treatment Category	Treatment Technology	Media	Advantages/ Efficiencies	References
Developing Technology or Lab Scale				
Biological	Biodegradation	Surface water, groundwater, wastewater, marine, soil, sediments	75–99% MP removal efficiency A consortium of organisms can be used as a treatment strategy.	Gan and Zhang (2019), Han et al. (2017), Hu et al. (2021), Pathak and Navneet (2017)
Chemical	Electrochemical oxidation	Surface water, groundwater, marine, wastewater, soil	58% MP removal efficiency, and up to 86.8% with an additional oxidant. Quick treatment time. Particularly effective for MP and NP destruction and effective for reducing MP size and mass and mineralizing NP.	Kjendrebego et al. (2021) [322]▷
Physical	Thermal (that is, pyrolysis and gasification)	Surface water, soil	54% in MP weight loss for catalytic advanced oxidation process with hydrothermal hydrolysis.	Hu et al. (2021) [278]▷
	General Technology ←			
	Incineration	Sludge/biosolids, soil, air	Can be used for energy generation.	(Geyer, Jambeck, and Lavender Law 2017)

**Note:
Removal %
is based on
lab studies**

Summary from Mitigation & Abatement

- Source reduction critical in reducing MP in the environment
- Improve disposal of waste
- Considering different strategies simultaneously
- Existing treatment technologies have varied success
- Management of wastes produced during the treatment of MPs
- Further research on existing and new technologies is necessary

Today's Training Road Map



Web-based Document: ITRC MP-1



Figure 1-1. Microplastics in the environment.


Source: Jonathan McDonald

<https://mp-1.itrcweb.org/>

1.1 What Are Microplastics?

Various organizations, agencies, and researchers have defined MP in different ways. For the purposes of this document, MP are particles that are greater than 1 nanometer (nm) and less than 5,000,000 nm (or 5 millimeters [mm]) in their longest dimension and consist of solid polymeric materials to which chemical additives or other substances may have been added (CA SWRCB 2020^[9]). Polymers that are derived in nature (for example, cellulose, amber, proteins, wool, or silk) that have not been chemically modified (other than by hydrolysis) are excluded from the scope of this document. Plastic particles less than 1,000 nm in their longest dimension are also referred to as nanoplastics (NP); as such, some, but not all, NP fall within the range of MP defined herein. Although the definition of NP is still being debated, it is accepted in scientific literature that they are produced by the fragmentation of MP (or larger particles), measure between 1 nm and 1,000 nm in length, and demonstrate a colloidal behavior. Figure 1-2 shows the sizes of various items that fall within the MP size range, including a strand of DNA (approximately 2.5 nm), a red blood cell (7,500–10,000 nm), a fly ash particle (10,000–20,000 nm), the diameter of a human hair (50,000–120,000 nm), and a drinking straw (approximately 5,000,000 nm). This guidance document is not

Topics Covered



Introduction	>
Environmental distribution, fate, and transport	>
Sampling and analysis	>
Human Health and Ecological Effects	>
Regulatory Context	>
Mitigation, Abatement, and Best Management Practices	>

- Introduction to Microplastics
- Environmental Distribution, Fate & Transport
- Sampling and Analysis
- Human Health and Ecological Effects
- Regulatory Context
- Mitigation and Abatement

Section 7: Data Gaps and Future Research Needs

- Fate and Transport
- Sampling and Analysis
- Health Risks
- Trophic Transfer
- Ecological Exposure
- Mitigation and Abatement

Case Studies: Appendix A

- A.1: California Approach for Microplastics
- A.2: Consequences of Microplastics on Various Ecological Endpoints in the Chesapeake Bay and its Tributary Estuary, the Potomac River
- A.3: Impact of Disposable PPE and Single Use Plastic Items During the Pandemic
- A.4: Nurdles Along the Gulf Coast
- A.5: Effects of 6PPD-quinone on Coho and Chum Salmon
- A.6: Washing Machine Filters Reduce Microfiber Emissions to Aquatic Ecosystems

ITRC Microplastics Outreach Toolkit

General information on outreach



General Audience

- Fact Sheets
- Social Media Materials



Scientific Community

- Fact Sheets
- Social Media Materials
- Presentations



Decision Makers

- Fact Sheets
- Social Media Materials
- Presentations

Question and Answer Session

