Understanding the Macro Problem that is Microplastics

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Tina Liu

MECC Kansas City | September 14, 2022

Image Source: David Liitschwager/National Geographic

This morning, did you…?

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Image Sources: Nature, L'Oreal Paris, Overstock, BBC, Adobe Stock

Microplastics are trending

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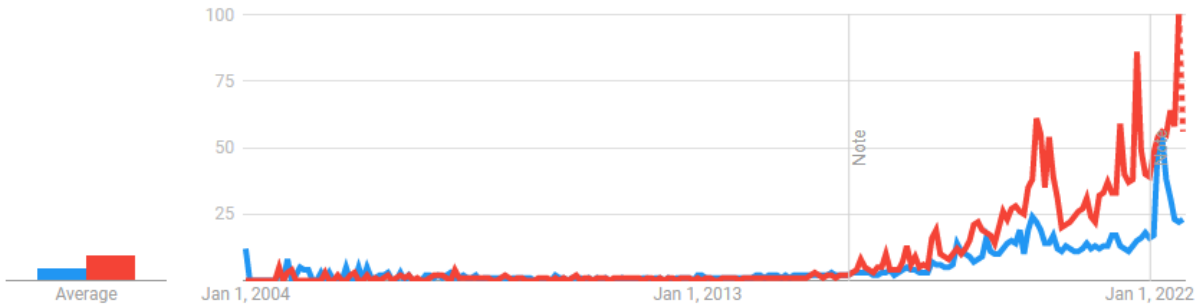
microplastics
Search term

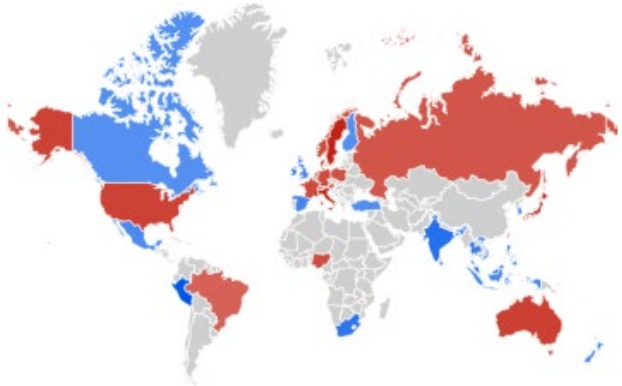
pfas
Search term

+ Add comparison

Worldwide | 2004 - present | All categories | Web Search

Interest over time





Source: Google Trends

Agenda

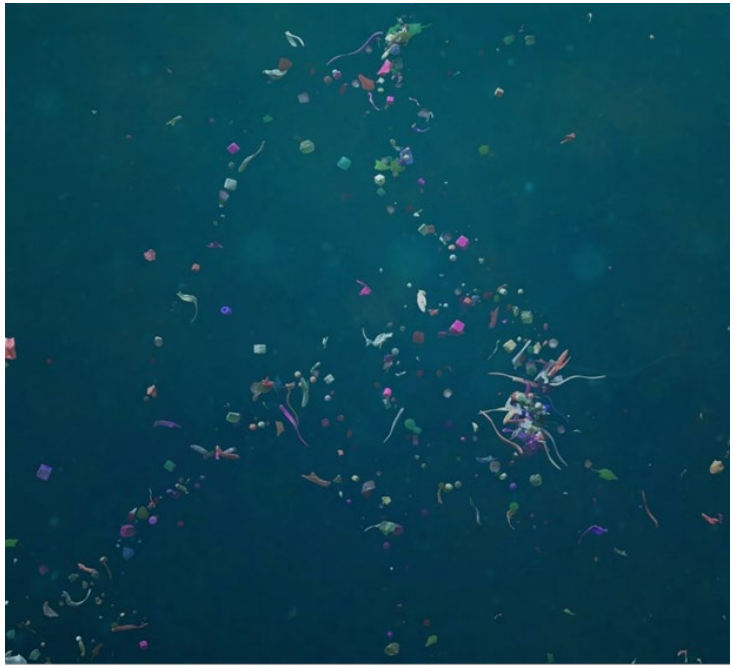


Image Source: Quench Water

01 **Microplastics 101**
History, characteristics, sources, pathways

02 **State of Science**
Toxicity & risk assessment, sampling & analysis, comparison to PFAS

03 **Regulatory Update**
Federal, state, international, other drivers

04 **What's Next?**
Data gaps & challenges, potential compliance issues

History of Plastics & Microplastics

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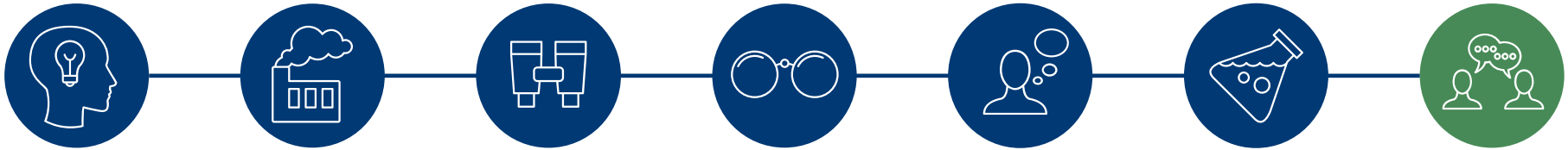


Early 20th century

First synthetic plastic produced

Mass production of plastics

1950s

1960s – 1970s

Observations of small pieces of plastic debris in surface water and stomachs of birds/fish described in scientific papers

Monitoring of plastic debris begins

1990s

2004

Term “microplastics” introduced

Scientific research and increased attention of the impact of plastics on the environment

2010s – ongoing

2022

Nearly 10,000 articles on microplastics have been published

What are Microplastics?

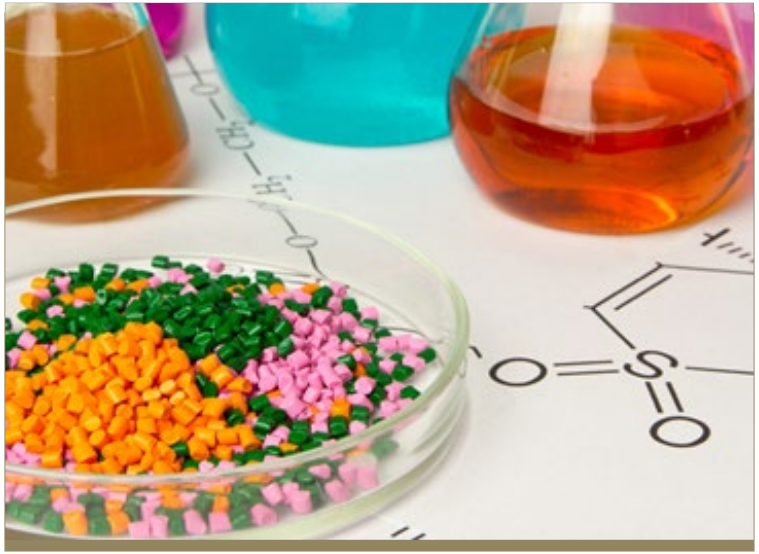
films
fibers
spheres
fragments
pellets

nanoplastics
microplastics

Small pieces of plastic that are less than 5 mm

PET
LDPE
HDPE
PS
PVC
PP

Chemical Characteristics



Polymer & Product Type

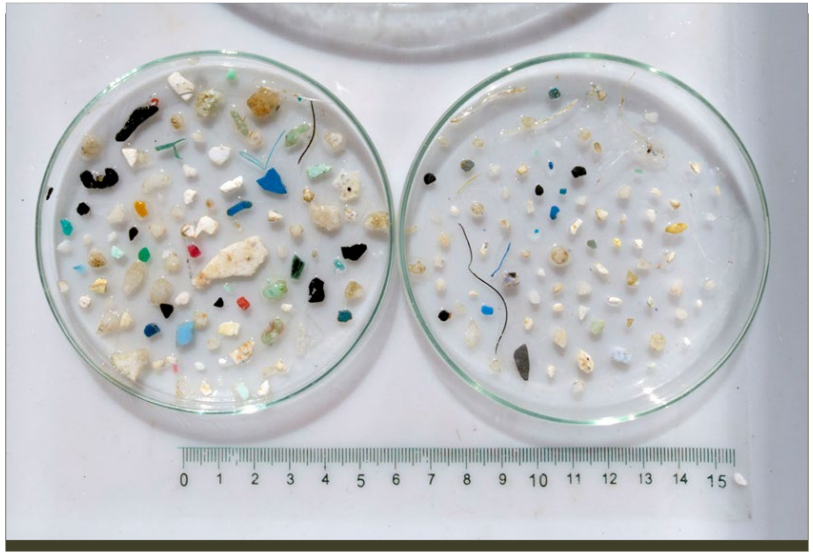
- Proprietary chemical “cocktail”
- Product purpose

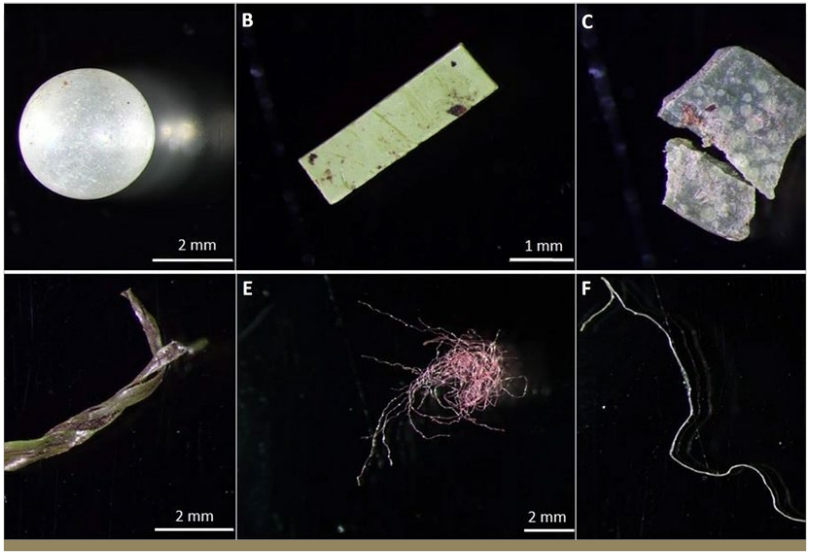
Additive & Eco-toxin

- Stabilizers, colorants, flame retardants, fillers, etc.
- Heavy metals, DDT, PAHs, PCBs, etc.

Image Sources: Samuel Bollendorff/Fondation Tara Océan, Phoenix Plastics

Physical Characteristics





Size

- Microplastics vs. nanoplastics
- What can we measure with current technology?

Morphology (Shape)

- Fragments, spheres, fibers, films, pellets, etc.
- Most of the existing data is for polystyrene spheres and virgin material

Image Sources: Samuel Bollendorff/Fondation Tara Océan, Weithmann et. al 2018

A Diverse Suite of Contaminants

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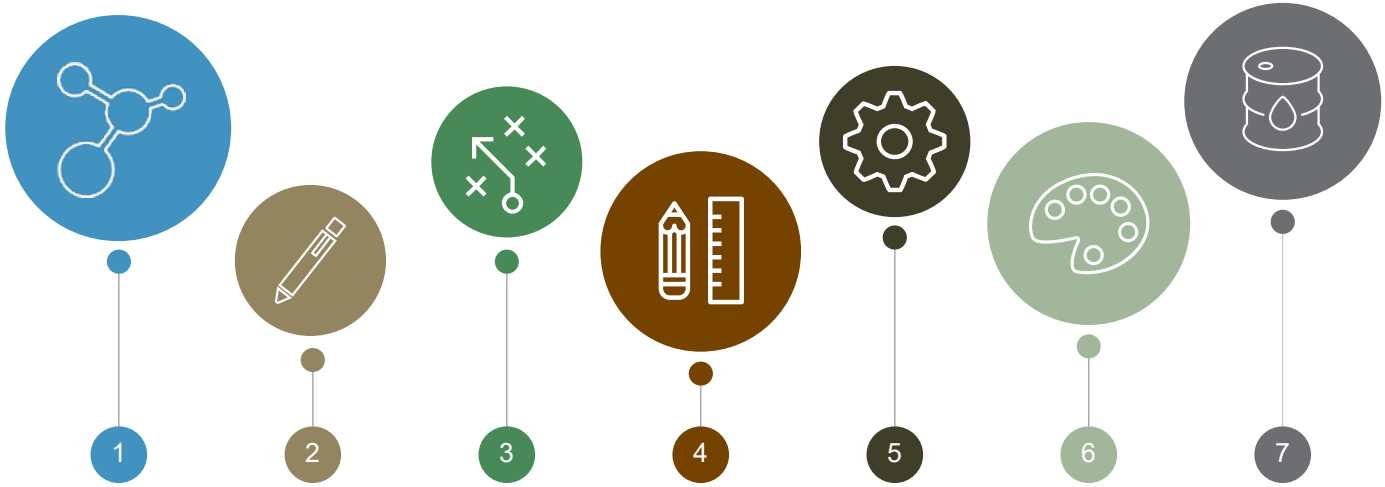

1	2	3	4	5	6	7
Polymer	**Product Type**	**Morphology**	**Size**	**Additive**	**Color**	**Eco-toxin**
PET	Bottles	Pellets	< 5 mm	Stabilizers	Dark	Heavy metals
LDPE	Bags	Fragments	< 1 µm	Colorants	Light	DDT
HDPE	Containers	Spheres		Flame retardants		PAHs
PV	Nurdles	Fibers		Fillers		PCBs
PS	Microbeads	Films				

Information Source: Rochman et al. 2019

Types of Microplastics

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PRIMARY MICROPLASTICS

Small pieces of plastics that are purposely created by manufacturers to be smaller than 5 mm and enter the environment as such

SECONDARY MICROPLASTICS

Plastic fragments derived from the breakdown of larger plastic debris due to natural degradation

Image Sources: Bioplastic News, Earth911, Spoon University, One Green Planet

Entry Points for Microplastics

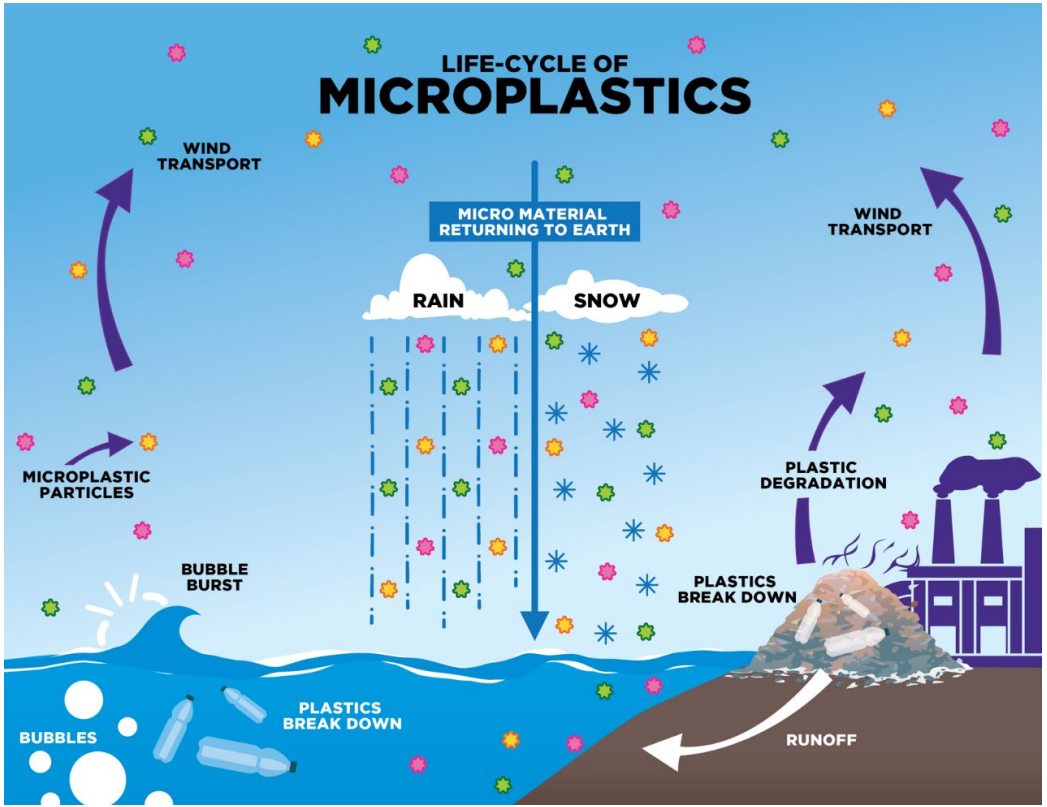

Image Source: Andrea Steffen

Atmospheric Fallout or Precipitation

Direct Release

Stormwater

Landfill Leachate

Wastewater & Biosolids

Microplastics in the Environment

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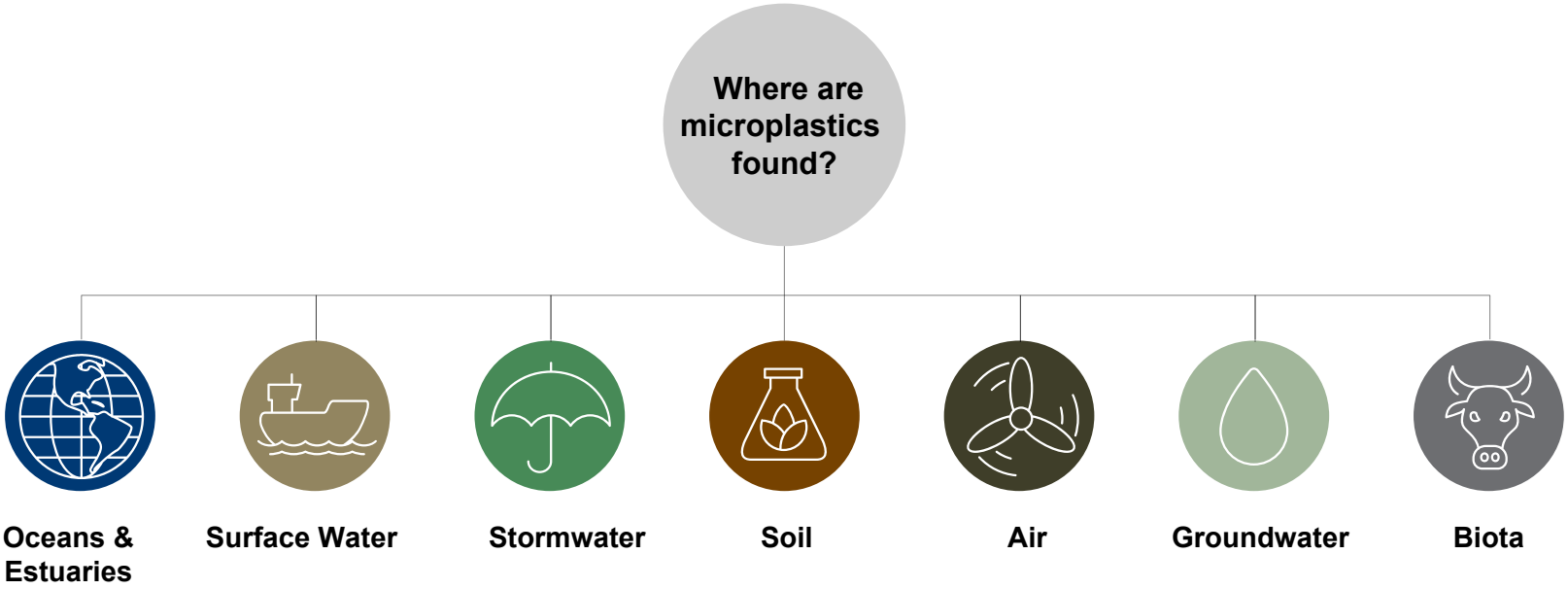

Microplastics in the Environment

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Where are microplastics found?

Oceans & Estuaries
Surface water
Stormwater
Marine debris
Plastics pollution
Discharges/spills

Surface Water
Textile laundering
WWTP
Plastics pollution
Discharges/spills

Stormwater
Urban runoff
Tires/roads
Plastics pollution
Discharges/spills

Soil

Air

Groundwater

Biota

Microplastics in the Environment

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Where are microplastics found?

Oceans & Estuaries

Surface Water

Stormwater

Soil
Agricultural fields
Biosolids/WWTP
Landfill leachate
Plastics pollution
Discharges/spills

Air

Groundwater

Biota
Plants/crops
Animals
Humans

Microplastics in the Environment

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Where are microplastics found?

Oceans & Estuaries

Surface Water

Stormwater

Soil

Air
Textile laundering
Incineration
City dust

Groundwater
Infiltration

Biota

Toxicity & Risk Assessment

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Ecological
- Uptake, trophic transfer, dermal
- Physical & chemical drivers
- Toxicity studies focused on aquatic

Human Health
- Ingestion, inhalation, dermal
- Physical & chemical drivers
- Uptake, absorption, translocation
- Limited studies

Risk Assessment
- No federal framework for human health and ecological risk assessments
- Academics propose potential frameworks
- Limited dose-response models for humans
- ToMEx database

Image Sources: iStock, Matthew Cole (SCCWRP)

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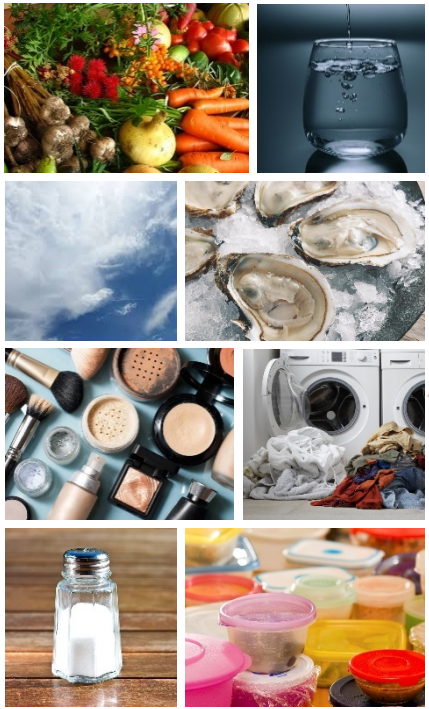

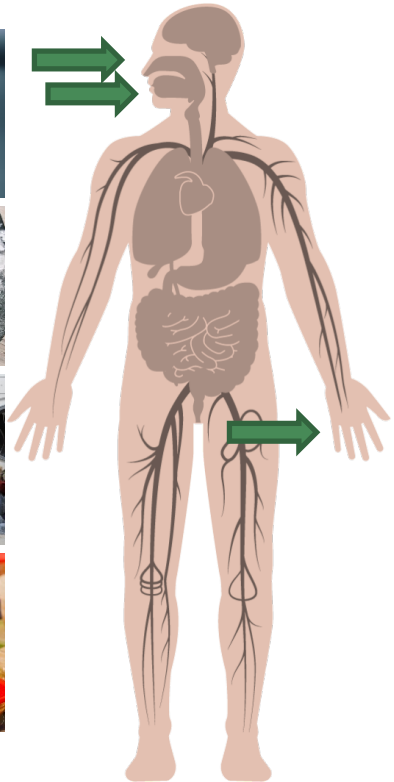

Image Sources: Washington Post, Downy, Agriculture Monthly, Eating Well, Medical Xpress, Unsplash, Healthline, Reader's Digest Canada, American Cleaning Institute

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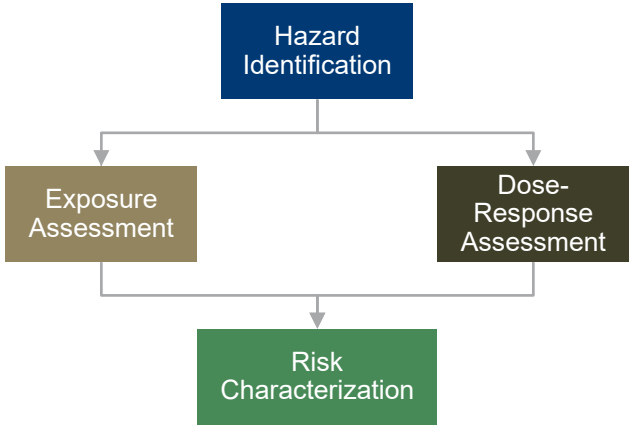

Image Sources: Depositphotos, Megan Lorenz

Toxicity Drivers

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Size

Smaller particles = uptake, translocation

Larger particles = block nutrient uptake in gut

Shape

Fiber, fragment, sphere

Polymer Type

PVC and PS = more hazardous

PE and PP = less hazardous

Microplastics Sampling & Analysis

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Standardized Operating Procedures for Laboratory Analysis

- 2021: California introduced SOPs for infrared (FTIR) and Raman spectroscopy for analysis of microplastics in drinking water
- Interlaboratory study with 22 laboratories from 6 countries participated

Laboratory Accreditation Program

- 2022: California Environmental Laboratory Accreditation Program (ELAP) adds world's first accreditation program for microplastics analysis

Sampling & Analysis Guidance Document

- 2022: California approved the world's first guidance on sampling and analytical protocols
- 2023 (pending): ITRC Microplastics Team currently creating a guidance document with a sampling and analysis chapter

Data Quality

Monitoring microplastics in drinking water: An interlaboratory study to inform effective methods for quantifying and characterizing microplastics

Hannah De Frond [a,*], Leah Thornton Hampton [b], Syd Kotar [b], Kristine Gesulga [b], Cindy Matuch [b], Wenjian Lao [b], Stephen B. Weisberg [b], Charles S. Wong [b], Chelsea M. Rochman [a,**]

CALIFORNIA Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

INTERSTATE COUNCIL ITRC TECHNOLOGY REGULATORY

The Next PFAS?

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- 9,000+ compounds with unique characteristics (hydrophobic, hydrophilic)
- Soluble
- Novel approaches have been developed to assess risk and exposure
- Only a subset of compounds can be analyzed using current methods

PFAS

- Diverse suite of contaminants
- Traditional fate and transport models inadequate
- Potential to bioaccumulate
- Persistent
- Ubiquitous nature requires specific procedures when sampling
- Risks to ecological and human health
- Implications for many industries

Both

- Extreme diversity in polymer type, size, shape, etc.
- Insoluble
- Uncertainty on toxicity drivers (physical vs. chemical)
- Additives/other environmental chemicals may add another layer of complexity
- Lack of standardized analysis methods

Microplastics

Federal Regulatory Update

Microplastics

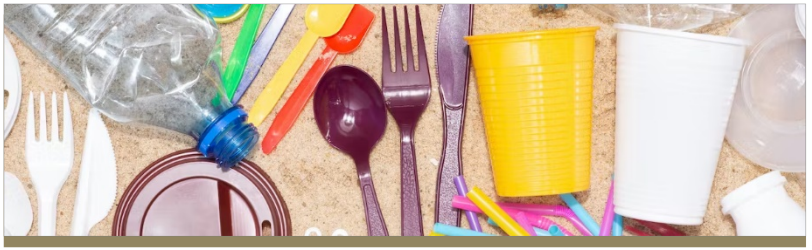
- **2015: Microbead-Free Waters Act**
  - Prohibits addition of plastic microbeads in certain personal care products

Macroplastics

- **2020: Save Our Seas 2.0 Act**
  - Aimed at reducing, removing, and preventing plastic waste in the environment
- **Proposed 2021: Break Free from Plastic Pollution Act**
  - Proposing amendments to the Solid Waste Disposal Act including reducing the production/use of certain single-use plastic products
  - Proposing a microplastics pilot program
- **Proposed 2021: Plastic Pellet Free Waters Act**
  - Proposing that the EPA set limitations to pre-production pellet pollution

Image Sources: BBC, NPS

State Regulatory Update



California

- **2018: California Safe Drinking Water Act: Microplastics**
  - ✓ Adopted first definition for microplastics in drinking water in 2020
  - ✓ Adopted standardized methods for testing microplastics in drinking water in 2021
  - ✓ Set up first accreditation program for microplastics analysis
  - ✓ Approved a policy handbook for testing microplastics in drinking water sources in 2022
  - ✓ Approved to test water supplies for microplastics over 4 years
  - ❑ Issue notification level to aid in results interpretation
- **2018: California Ocean Protection Council: Statewide Microplastics Strategy**
  - ✓ Published Statewide Microplastics Strategy in 2022

Other States

- Bans on single-use bags, utensils, and containers in 9 states (California, Connecticut, Delaware, Hawaii, Maine, New Jersey, New York, Oregon, and Vermont)
- Regulations on microbeads in personal care products and storage and handling of plastic resin pellets/nurdles

Image Sources: California Water Board, SCCWRP, California OPC, Shutterstock

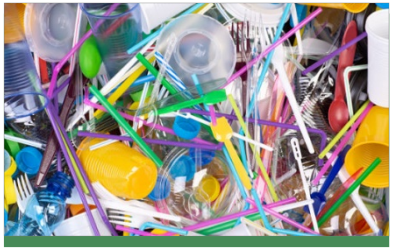
International Regulatory Update

2018

- Similar microbead bans in Canada, EU (Belgium, France, Ireland, Italy, Sweden), and UK
- 127 countries have adopted some form of legislation to regulate plastic bags

2019

- Basel Convention is modified to include plastic waste
- At the UN Environmental Assembly in Nairobi, 170 countries pledged to reduce use of plastics by 2030



2021

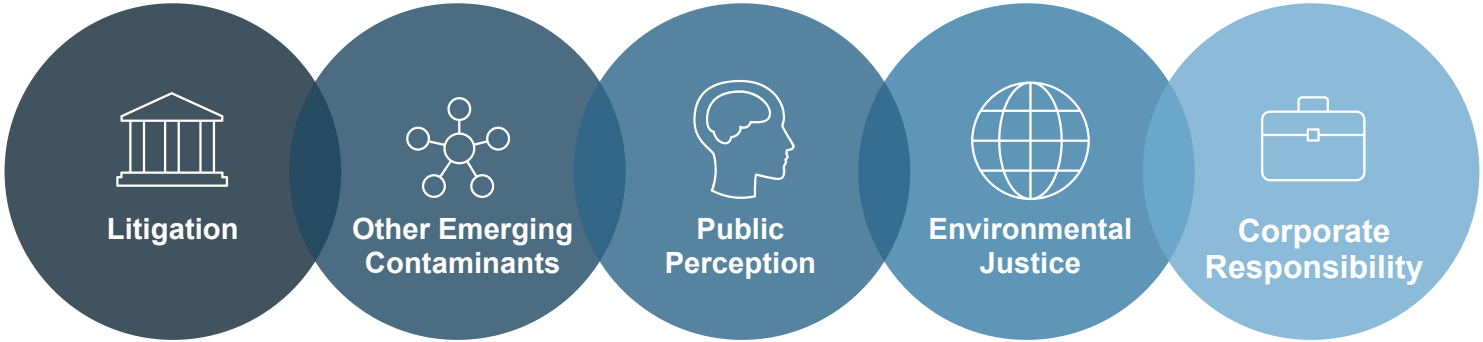
- Canadian EPA adds plastic manufactured items added to the List of Toxic Substances

2022

- At the UN Environmental Assembly,175 countries agreed to develop a Global Plastics Treaty; have until 2024 to agree on elements of the treaty
- European Commission proposed law to ban intentionally added microplastics

Image Sources: New York Times, Basel Convention, Chemical Watch, UN

Other Drivers



What's the tipping point?

Understanding Data Gaps & Challenges

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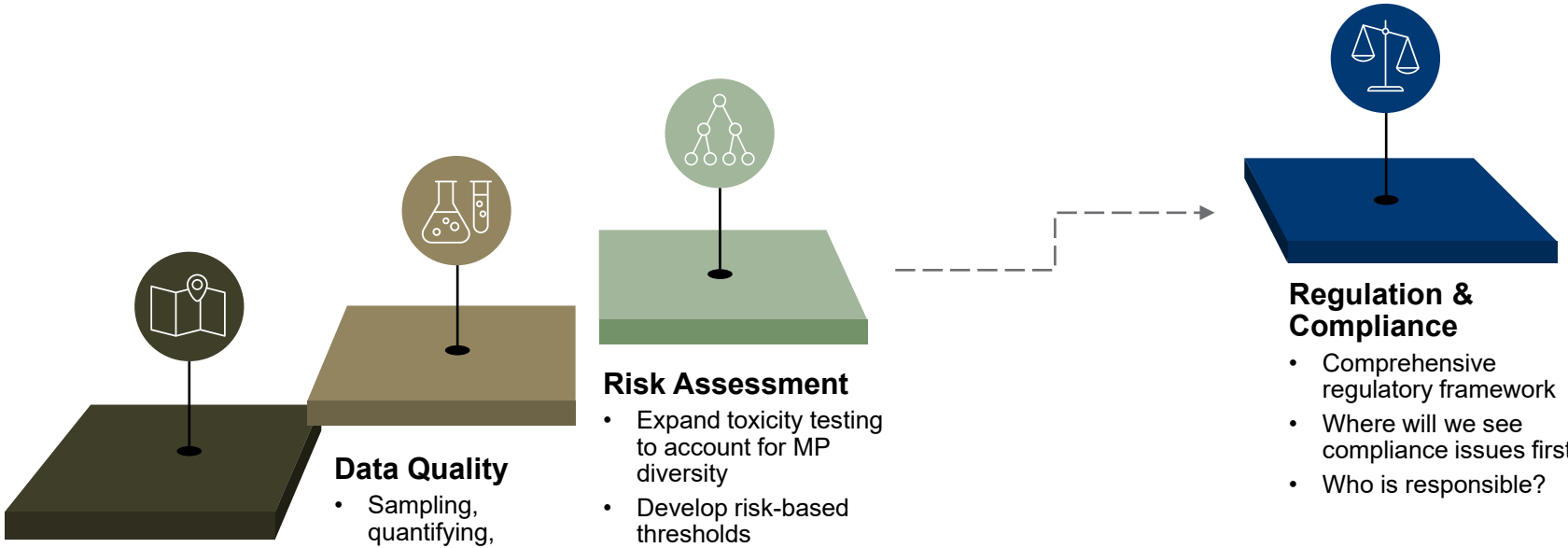

Fate & Transport

- Background/ambient concentrations
- Terrestrial environments and other media

Data Quality

- Sampling, quantifying, characterization
- QA/QC
- Data reporting

Risk Assessment

- Expand toxicity testing to account for MP diversity
- Develop risk-based thresholds
- Risk assessment framework

Regulation & Compliance

- Comprehensive regulatory framework
- Where will we see compliance issues first?
- Who is responsible?

Potential Compliance Issues

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Where might we start seeing compliance issues for microplastics?

Stormwater

Permitting

Best Management Practices

Industrial & Municipal Wastewater

Pretreatment

Discharge requirements

Biosolids

Waste Management

Landfills

Leachate management

Materials Recovery Facilities

Food & Beverage

Drinking water

Bottled water

Food processing & packaging

Agriculture

Manufacturing

Industrial processes

Spill prevention

Product safety

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Thank you!

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