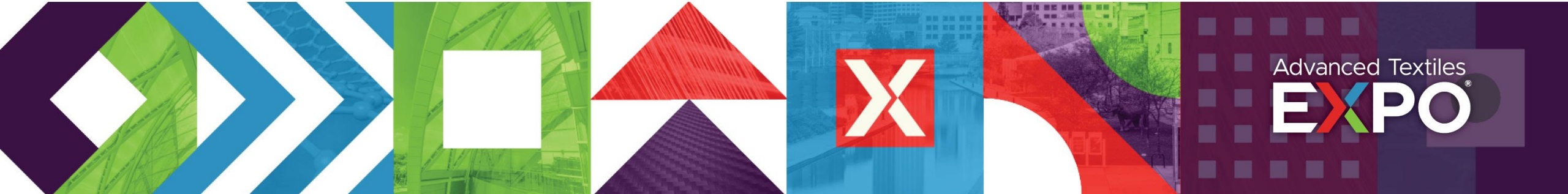
Microplastics in Textiles:
Contributors, Challenges, and the Path Forward

November 6, 2025

Danielle Harrier, Ph.D., Brian Jing, Ph.D., Sadella Santos, Ph.D.,
Erin Kirkpatrick, Ph.D., Soshana Smith, Ph.D.



Overview

- About Exponent
- What is a Microplastic?
  - Definition(s)
  - Presence in the Environment
  - Major Contributors
- Current Regulations
- Testing Standards and Analysis Toolkit
- Case Study
- Future Outlook
- Summary
- Q & A

About Exponent

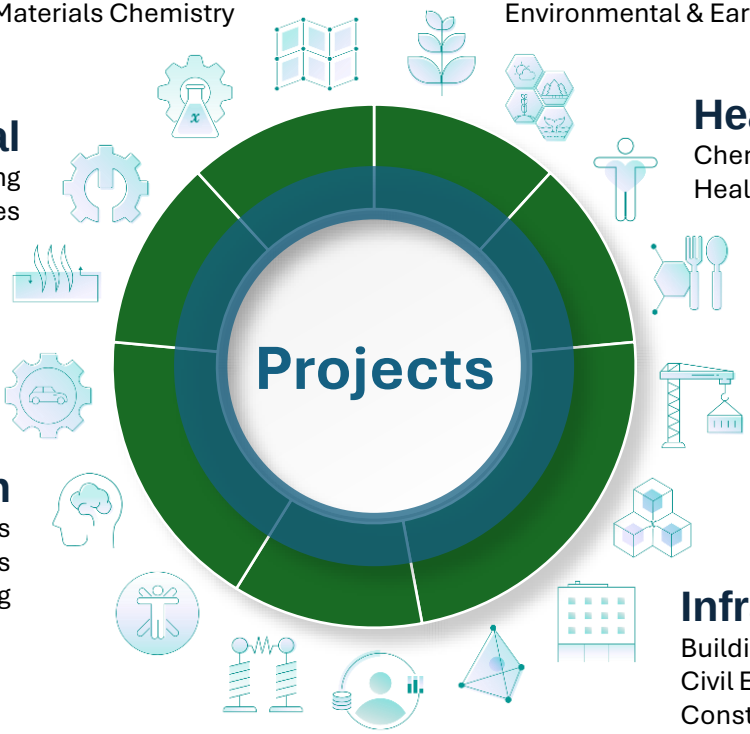
Exponent is the only premium engineering and scientific consulting firm with the depth and breadth of expertise to solve our clients' most profoundly unique and urgent challenges.

1967
50+ Years of Scientific Excellence

950+
Consulting Staff

90+
Technical Disciplines

30+
Offices Across North America, Europe & Asia



Polymers & Biomedical
Biomedical Engineering & Sciences
Polymer Science & Materials Chemistry

Environmental Sciences
Ecological & Biological Sciences
Environmental & Earth Sciences

Mechanical & Thermal
Mechanical Engineering
Thermal Sciences

Health Science
Chemical Regulation & Food Safety
Health Sciences

Transportation
Biomechanics
Human Factors
Vehicle Engineering

Infrastructure & Materials
Buildings & Structures
Civil Engineering
Construction Consulting
Materials & Corrosion Engineering

Electrical & Data Sciences
Data Sciences
Electrical Engineering & Computer Science

Advanced Textiles EXPO®

Exponent Offices

North America

Atlanta

Austin

Boston
Maynard
Natick

Chicago
Chicago
Warrenville

Denver

Detroit

Houston

Miami

New York

Philadelphia

Phoenix

Sacramento

Seattle
Bellevue
Seattle

San Francisco Bay Area
Menlo Park
Oakland

Southern California
Irvine
Los Angeles
Pasadena

Tampa

Washington DC
Washington DC
Alexandria
Bowie

Canada

Europe

Edinburgh

Germany

Harrogate

Ireland

London

Nottingham

Switzerland

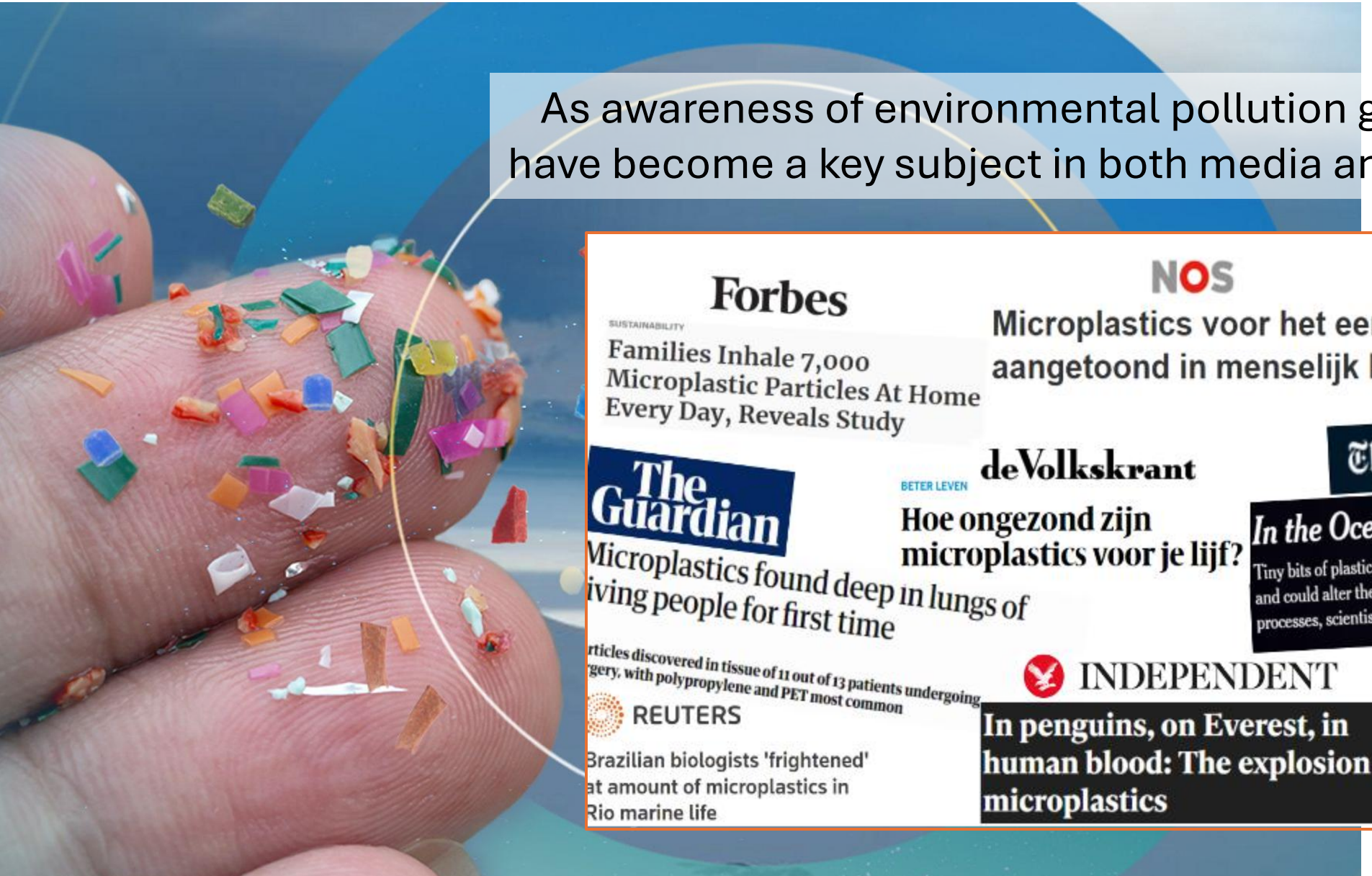
Asia

Hong Kong

Shanghai

Singapore

Microplastic Spotlight: Science, Media, and Public Awareness



As awareness of environmental pollution grows, microplastics have become a key subject in both media and scientific literature.

Forbes

SUSTAINABILITY

Families Inhale 7,000 Microplastic Particles At Home Every Day, Reveals Study

NOS

Microplastics voor het eerst aangetoond in menselijk bloed

Daily Mail

Microplastics can cause cell death and allergic reactions in humans — at levels known to be eaten by people via their food, scientists warn

The Guardian

Microplastics found deep in lungs of iving people for first time

rticles discovered in tissue of 11 out of 13 patients undergoing gery, with polypropylene and PET most common

deVolkskrant

BETER LEVEN

Hoe ongezond zijn microplastics voor je lijf?

The New York Times

In the Ocean, It's Snowing Microplastics

Tiny bits of plastic have infiltrated the deep sea's main food source and could alter the ocean's role in one of Earth's ancient cooling processes, scientists say.

REUTERS

Brazilian biologists 'frightened' at amount of microplastics in Rio marine life

INDEPENDENT

In penguins, on Everest, in human blood: The explosion of microplastics

Trouw

Bloedsomloop

Voor het eerst plasticdeeltjes aangetoond in menselijk bloed

What is a “Microplastic”?

- Currently, there is no unified definition of a microplastic, but most definitions of microplastics are plastic particles smaller than 5 mm.
  - **Lower size limits vary:** some definitions consider microplastic particles as small as 1 nm or 1 µm, while others do not set a lower boundary.
  - **Composition varies:** Definitions often specify **solid, synthetic polymers**; many exclude natural, biodegradable, or soluble materials.
  - **Microfibers may be defined separately** from other microplastic particles.

Microplastic Definition Overview

Regulatory Body	Reference	Lower Limit on Size	Upper Limit on Size	Material
ASTM	(D8402 and D8489)	1 µm	5 mm	Solid, synthetic organic polymeric material
California	Water Resources Control Board Resolution No. 2020-0021	1 nm	5 mm	Solid polymeric materials Non-chemically modified natural polymer are excluded
EU	EU Commission Regulation 2023/2025 amendment to Annex XVII to Regulation (EC) No 1907/2006	Not listed	5 mm	Synthetic polymer; solid Non-chemically modified natural polymers, Biodegradable, soluble substances, Carbon-free polymers are excluded
Proposed NJ	NJ S3619	Not listed	5 mm	Piece of plastic; Separate definition of microfiber
Federal Agencies	EPA and NOAA; Interagency Marine Debris Coordinating Committee (IMDCC), Report on Microfiber Pollution*	1 nm	5 mm	Piece of plastic; Separate definition of microfiber

Representative list of current definitions, not a comprehensive list.

Types of Microplastics

Primary Microplastics

- Microplastics that are intentionally manufactured at small sizes (typically less than 5 mm) for commercial use
- Enter the environment directly as small particles

  Common Sources:

  - **Personal care and cosmetic products:** e.g., microbeads in facial scrubs, toothpaste, exfoliants
  - **Industrial abrasives:** used in sandblasting or as scrubbers
  - **Pre-production pellets:** “nurdles” used in plastic manufacturing

Key Points:

- Designed for specific uses requiring tiny plastic particles
- Can bypass wastewater treatment and enter aquatic systems directly

https://thegreatbubblebarrier.com/what-are-microplastics/

Types of Microplastics

Secondary Microplastics

- Microplastics that are formed from the breakdown of larger plastic items
- Result from physical, chemical, and biological degradation and weathering processes in the environment

  Common Sources:

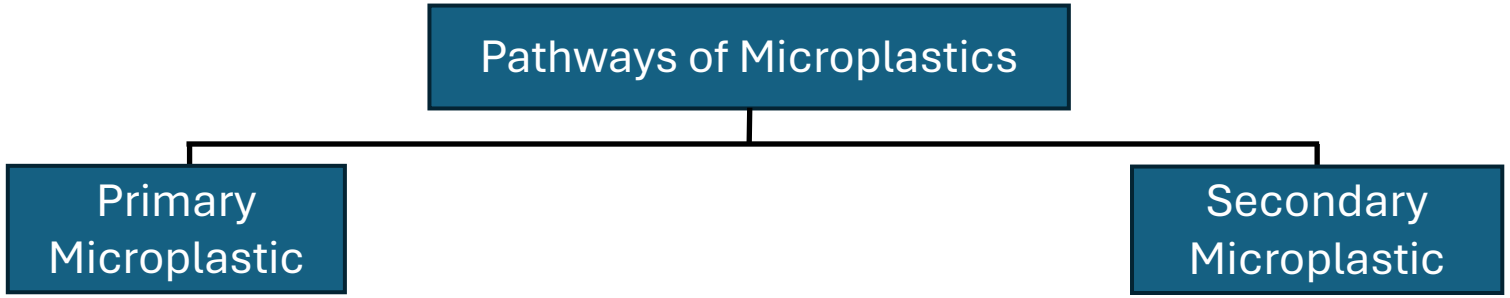
  - **Plastic debris:** bottles, bags, packaging breaking down in sunlight and weather
  - **Textiles:** synthetic fibers released from washing clothes
  - **Tire wear particles:** produced as tires roll and degrade on roads

Key Points:

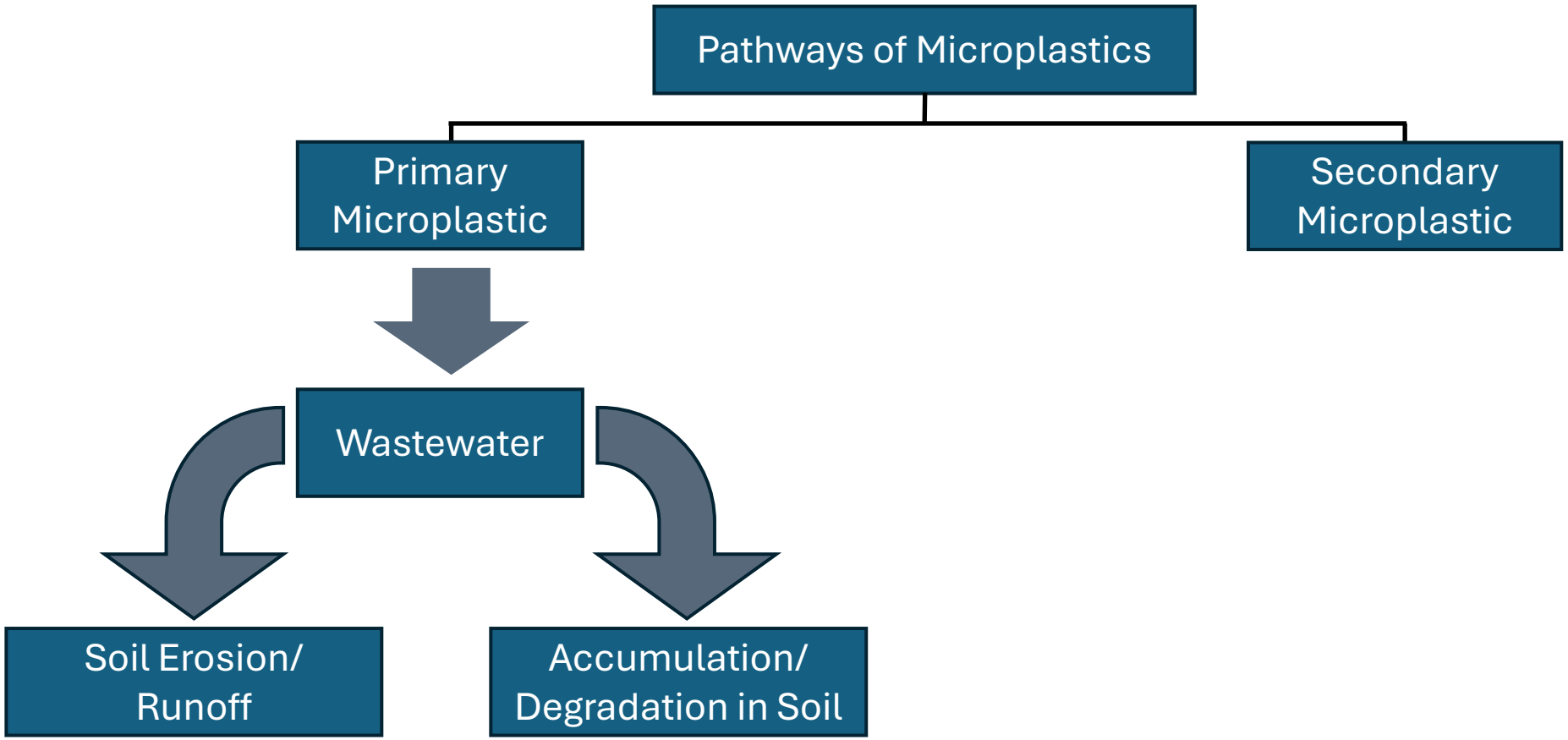
- Not originally manufactured in microscopic form
- Breakdown accelerated by UV exposure, abrasion, and natural elements

https://thegreatbubblebarrier.com/what-are-microplastics/

How Are Microplastics Introduced Into The Environment?

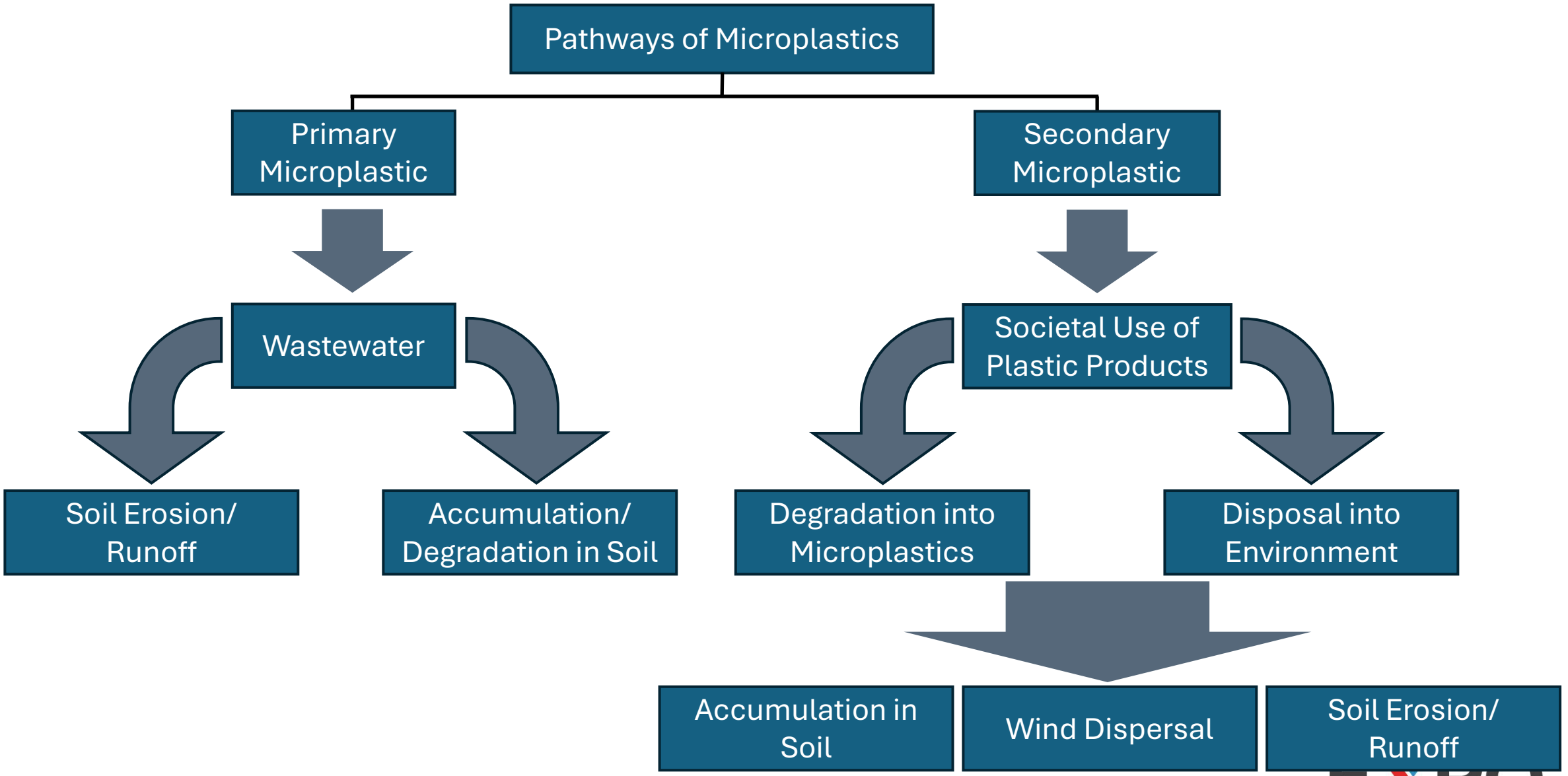


How Are Microplastics Introduced Into The Environment?

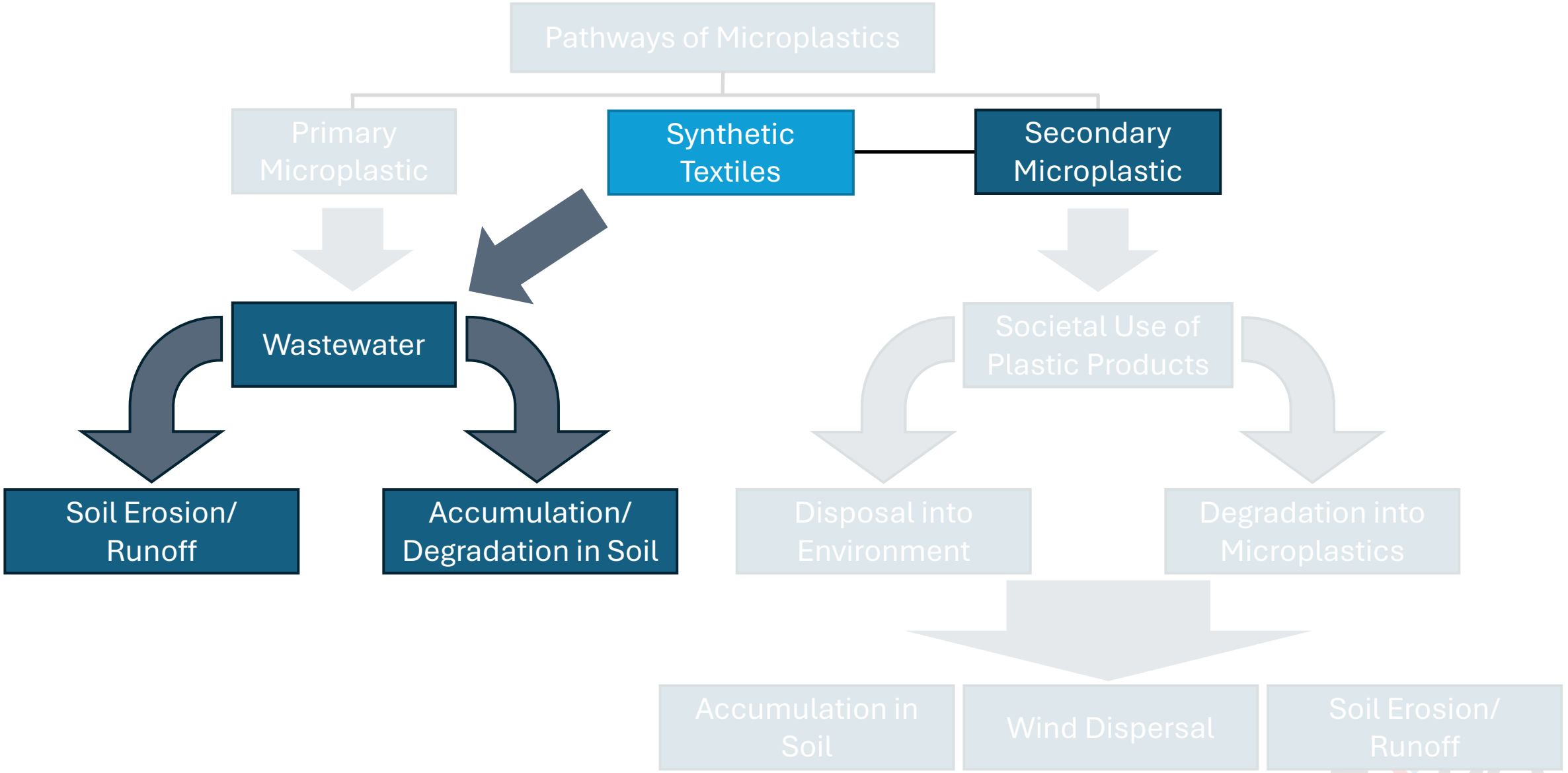


Advanced Textiles EXPO®

How Are Microplastics Introduced Into The Environment?



How Are Microplastics Introduced Into The Environment?



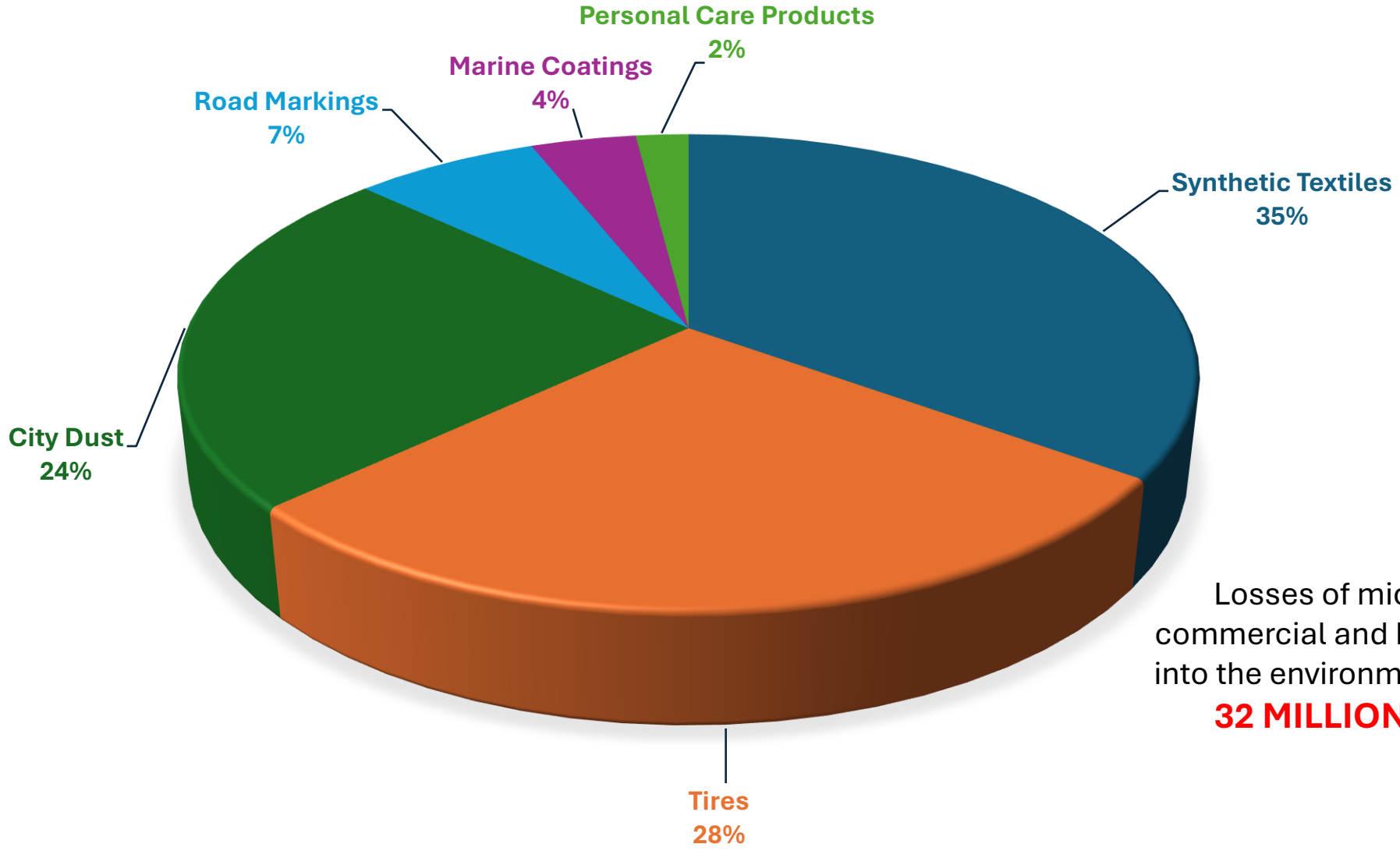
Sources of Microplastics in the Environment

Can you rank the following sources from most to least responsible for contributing to global microplastic pollution?

- **Synthetic tires:*** abrasion while driving
- **City dust and pollution:** weathering and abrasion of objects, infrastructure
- **Road markings:** weathering and abrasion by vehicles
- **Marine coatings (e.g., ship paint):** weathering, maintenance, and disposal
- **Personal care products** (e.g., exfoliating scrubs): product use
- **Synthetic textiles:** abrasion during laundry

* ***Note:*** Not all definitions of microplastics include rubber

Sources of Microplastics in the Environment

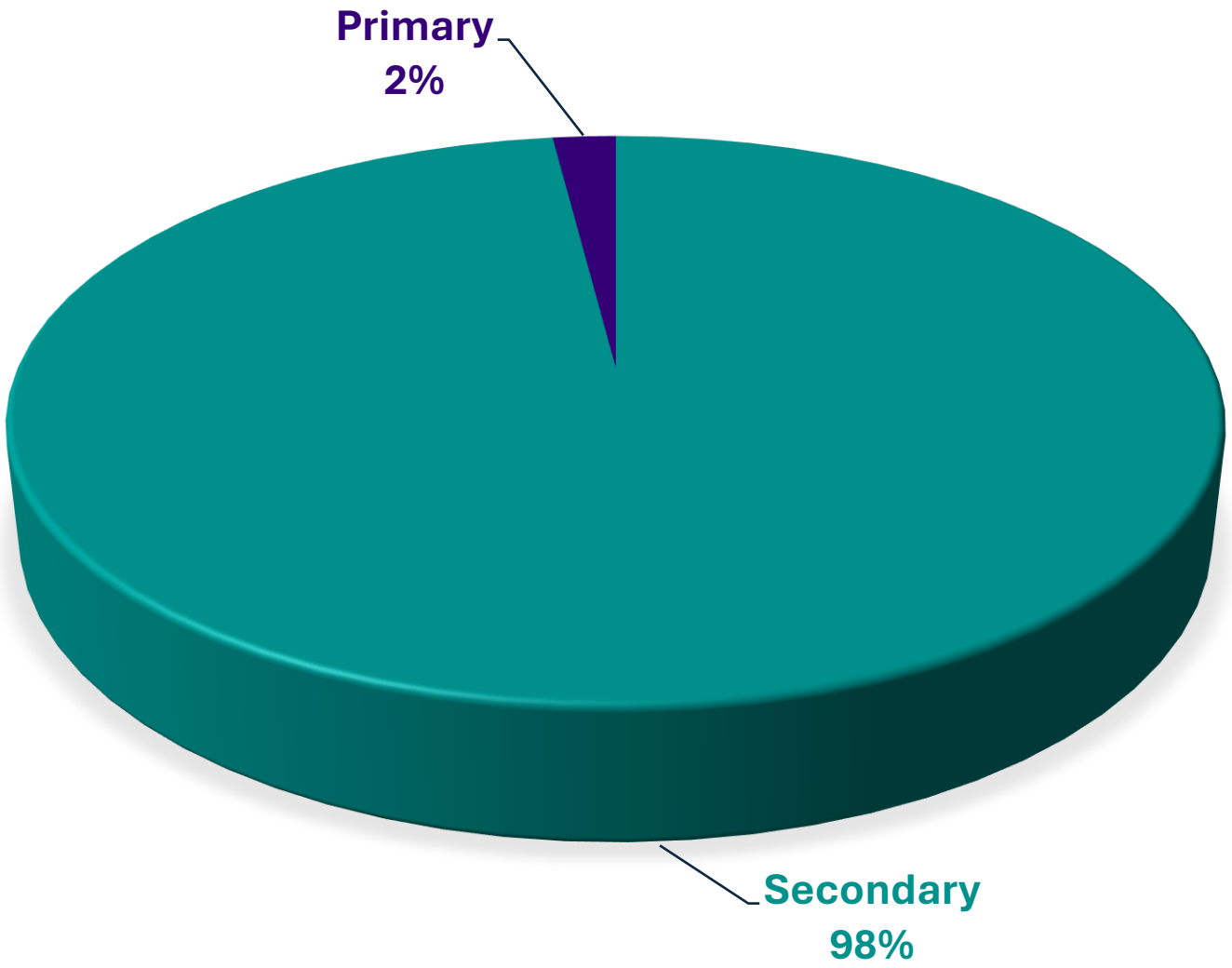


Losses of microplastics from commercial and household activities into the environment is in the order of **32 MILLION TONS/YEAR***

Advanced Textiles EXPO®

* Boucher, J. "Primary microplastics in the oceans: a global evaluation of sources." (2017)

Sources of Microplastics in the Environment



Primary Microplastics (2%)

- Personal care products

Secondary Microplastics (98%)

- Synthetic tires
- City dust and pollution
- Road markings
- Marine coatings
- Synthetic textiles

Advanced Textiles EXPO 15

* Boucher, J. "Primary microplastics in the oceans: a global evaluation of sources," (2017).

Microplastic Regulations

- The US EPA defines primary and secondary microplastics; however, it has not proposed a regulation specifically targeting microplastics.
- Current microplastic regulation has an emphasis on primary microplastics, more specifically, microbeads.[1]
  - To date, the Microbead-Free Waters Act of 2015 is the only federal legislation explicitly aimed at microplastics (in the form of microbeads) in consumer goods.
  - Several state regulations also exist that specifically target either the manufacture, importation, sale or use of microbeads in personal care products are combination thereof.
- In other regions, restrictions have been adopted to regulate microplastics intentionally added to products.
  - For example, in 2023, the European Commission adopted measures to restrict intentionally added microplastics (REACH restrictions).[2]
  - Additionally, the commission presented a brochure to provide an overview of EU policies and initiatives to promote research and ensure integrated monitoring of microplastics.

1. **HR 1321 – Microbead Free Waters Act of 2015**
2. **ECHA News Microplastics**

Development Of Regulations And Standards

US Microbead-free Waters Act of 2015

CT Public Act 15-5 Sec. 50 Microbead ban

Illinois SB 2727

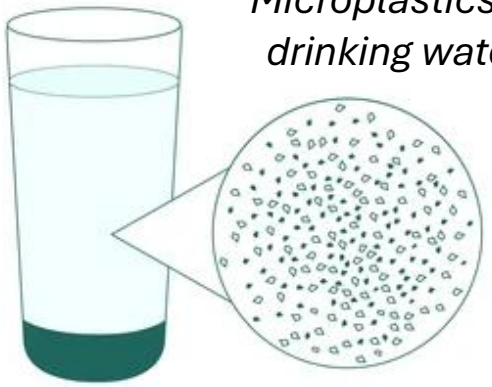
Colorado HB 15-1144

CA SB 1422

CA SB 1263

2018 2019 2020 2021 2022 2023 2024 ……

Targeted Concern:
Microbeads used as exfoliants in personal care products



Targeted Concern:
Microplastics in drinking water

CA adopts a **state-wide** approach to reducing microplastics.

CALIFORNIANS AGAINST WASTE

Summary of Current Federal And State Regulations

Federal/ State	Name	Effective Date	Primary/Secondary Microplastics?	Products of Concern	Notes
General Regulations on Microbead[1]					
Federal	US Microbead-free Waters Act of 2015	2018	Primary	Cosmetics	Act allows state or local authorities to enact laws restricting the manufacture or delivery of microbead-containing rinse-off cosmetics
State	CT Public Act 15-5 Sec. 50 Microbead ban	2018	Primary	Personal care products	Bans the use, sale, import or manufacture of synthetic microbeads for personal care products in the state of CT
State	Illinois SB 2727	2018	Primary	Personal care products	Prohibits the manufacture or sale of personal care products with plastic microbeads
State	Wisconsin SB 15	Proposed- Not Passed	Primary	Personal care products	Prohibits manufacture and acceptance for sale of products containing microbeads
State	Colorado HB 15-1144	2018	Primary	Personal care products/ over-the-counter drugs	Prohibits production, sale, manufacturing, or promotion of personal care products or over-the-counter drugs that contain synthetic plastic microbeads
Textile Specific Regulations on Microfibers					
State	Illinois SB 2727/HB3816	In Progress	Secondary	Textiles (Laundering)	Prohibits the sale of a washing machine without a ≤100 µm microfiber filtration system
State	New Jersey S3619	Introduced	Secondary	Textiles (Laundering)	Washer microfiber filter requirement

General survey of current regulations, not a comprehensive list.

1. Interstate Technology Regulatory Council

NJS3619: Microplastic/ Microfiber Policy

Synopsis

- Requires **microfiber filtration system** to capture microfibers and microplastics on washing machines sold on or after January 1, 2030.

Proposed Definition:

- **Microplastic:** means a piece of plastic that is ≤ 5 millimeters (mm) in diameter.
- **Microfiber:** synthetic fiber intentionally woven or imbedded into a textile that is shed when the textile is washed.
- **Microfiber filtration system:** filtering system that is active across all washing cycles, is integrated into the washing machine … designed to capture microfibers and microplastics from the water used in the washing process before the water is released from the washing machine into the wastewater system.

Proposed Washing Machine Regulation:

- Microfiber filtration system with a mesh size of not greater than 100 micrometers (μm)
- Bears a conspicuous label …that includes the following statement:
  - "NOTICE: THIS WASHING MACHINE CONTAINS A FILTER TO CAPTURE MICROFIBERS. CHECK THE FILTER REGULARLY AND DISPOSE OF CAPTURED LINT IN A WASTE BIN."

SENATE, No. 3619
STATE OF NEW JERSEY
221st LEGISLATURE

INTRODUCED SEPTEMBER 19, 2024

Recap: Current Federal and State Regulations

Federal Landscape:

- Only **1 federal law** directly targets microplastics: *The Microbead-Free Waters Act (2015)*
  - No federal limits yet for microplastics in drinking water, food, textiles, or packaging.
  - Agencies (EPA, CDC, ATSDR) are conducting risk assessments and method development, but no enforceable standards exist.
- **Textiles identified as an emerging priority** in federal research agendas (EPA, NOAA).

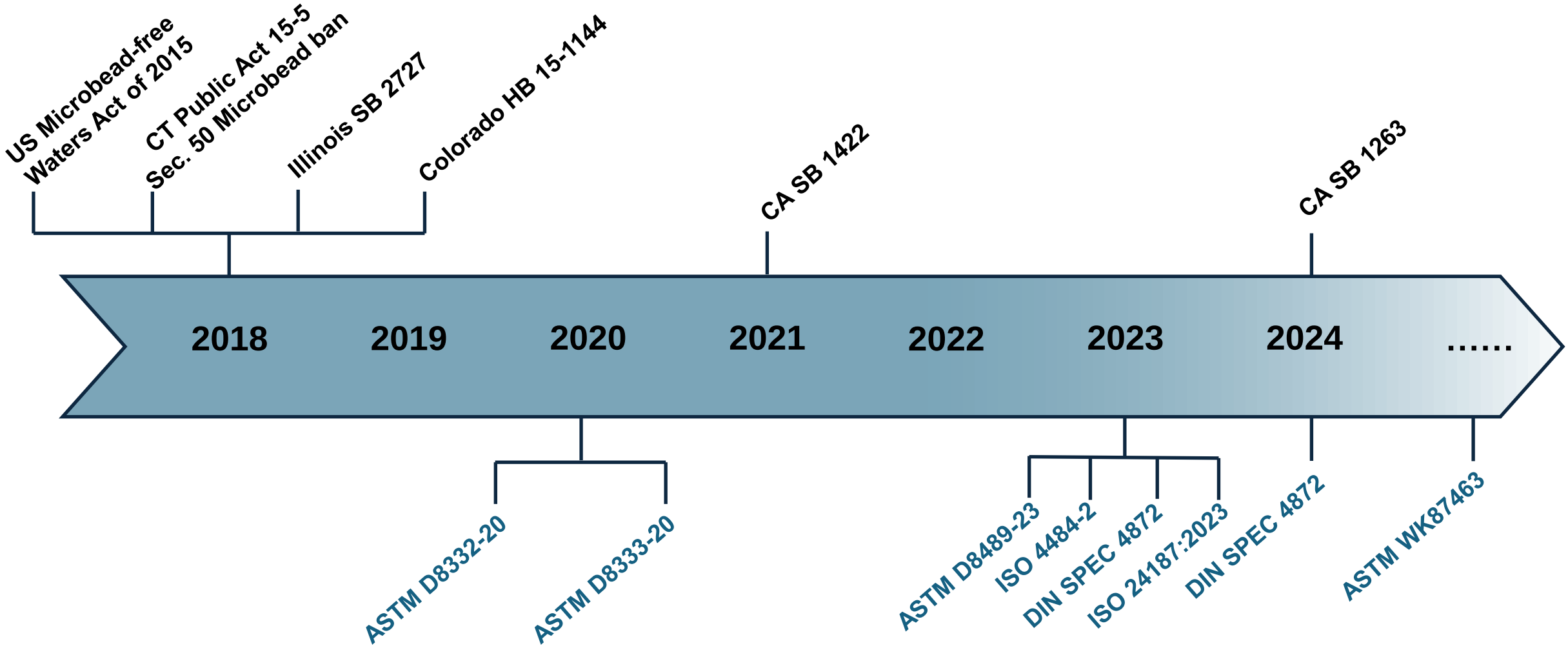
State Leadership & Emerging Microfiber Policy:

- States are stepping in where federal rules lag, but policy momentum is decentralized and inconsistent (different timelines, definitions, and enforcement).
  - **California:** First state to mandate monitoring of microplastics in drinking water (2022–2026) and adopt a Statewide Microplastics Strategy (due 2025).
  - **New Jersey** (S3619, 2024): Requires washing machine microfiber filters by 2030.
  - **New York, Illinois, and Oregon** are considering similar filter mandates.
- **Textiles are the next regulatory frontier** — 5+ (CA, NY, NJ, IL, OR) states with proposed or active microfiber bills.
  - California, New York, and Washington are evaluating microfiber release from textiles under extended producer responsibility (EPR) and textile labeling frameworks.

Key Takeaways:

- U.S. microplastics policy is evolving from microbeads → to microfibers.
- With limited federal oversight, states are driving early regulatory action and shaping analytical standards, research, and product requirements.

Development Of Testing Standards



Advanced Textiles EXPO®

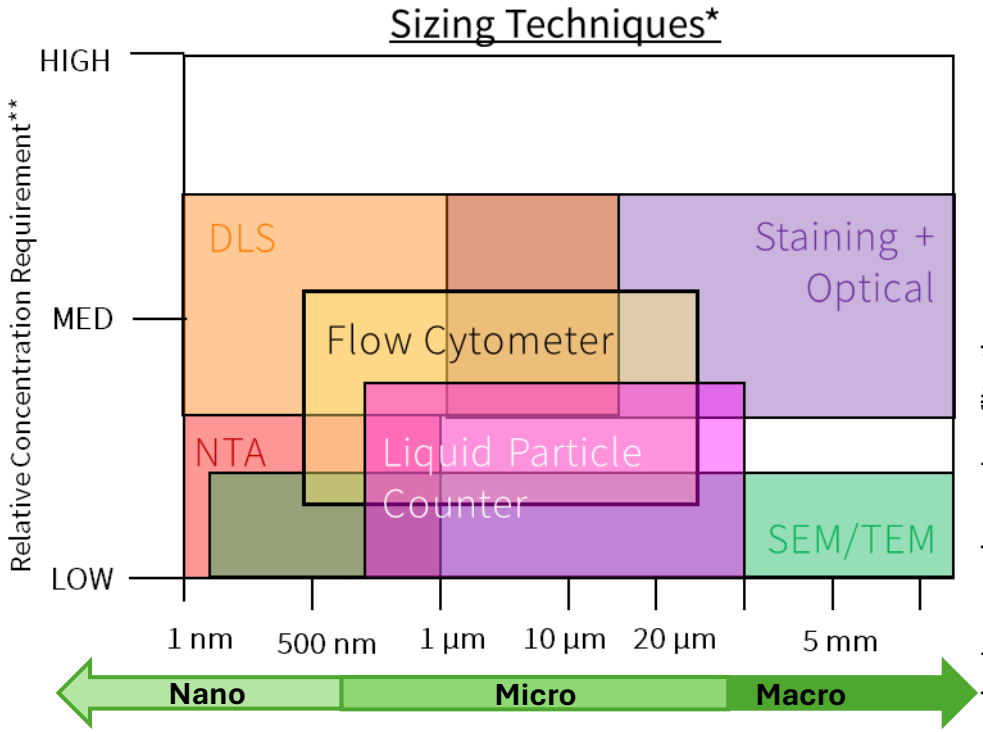
Summary Of Current Testing Standards

Standard	Year Established	Purpose	Methods Implemented
General Standards on Microplastics			
ASTM D8332-20	2020	Proper procedure for collecting samples	N/A
ASTM D8333-20	2020	Identification and quantification	Raman Spectroscopy, IR Spectroscopy, Pyrolysis GC-MS
ASTM D8489-23	2023	Qualitative characterization	Dynamic Image Analysis
ISO 24187:2023	2023	Proper procedure for collecting samples	N/A
ASTM D8401-24	2024	Identification and quantification	Pyrolysis GC-MS
ASTM WK87463	TBD	Identification and quantification	IR Spectroscopy
Textile Specific Standards on Microplastics			
ISO 4484-2	2023	Quantification	Image Analysis, Optical Microscopy coupled with IR/Raman Spectroscopy
DIN SPEC 4872	2023	Quantification	Dynamic Image Analysis

General survey of current standards, not a comprehensive list.

Analysis Toolkit: Particle Counting

Method	Size Range	Advantages	Disadvantages
Dynamic Light Scattering (DLS)	~1 nm – 15 µm	• Fast, minimal prep, ideal for nanoscale to lower micron	• Polydisperse/irregular shapes may cause difficulty in accuracy of detection • No morphology info
Liquid Particle Counting (Flow-based)	~0.5 µm – 100 µm	• High throughput • Volume-based detection	• Limited chemical info • May miss translucent particles
Raman Microscopy	~1 µm and up	• Polymer-specific ID • Individual particle analysis	• Slow • Fluorescence interference • Expensive
Staining + Optical Imaging (e.g. Nile Red)	~1 µm and up	• Inexpensive • Simple staining • Image analysis possible	• Non-specific binding possible • Manual validation often needed
Nanoparticle Tracking Analysis (NTA)	~10 nm – 1 µm	• Real-time tracking • Size distribution • Video output	• Needs dilution • No chemistry info
FTIR Microscopy	~10 µm and up	• Polymer ID • Filter scanning >10um	• Low resolution • Long analysis times
SEM / TEM	<10 nm – µm+	• High-res images • Shape/morphology	• No polymer ID (unless with EDS) • Labor-intensive
Flow Cytometry (with labeling)	~0.5 µm – 50 µm	• High throughput • Tagged detection	• Requires fluorescent labeling; not universal absorption.

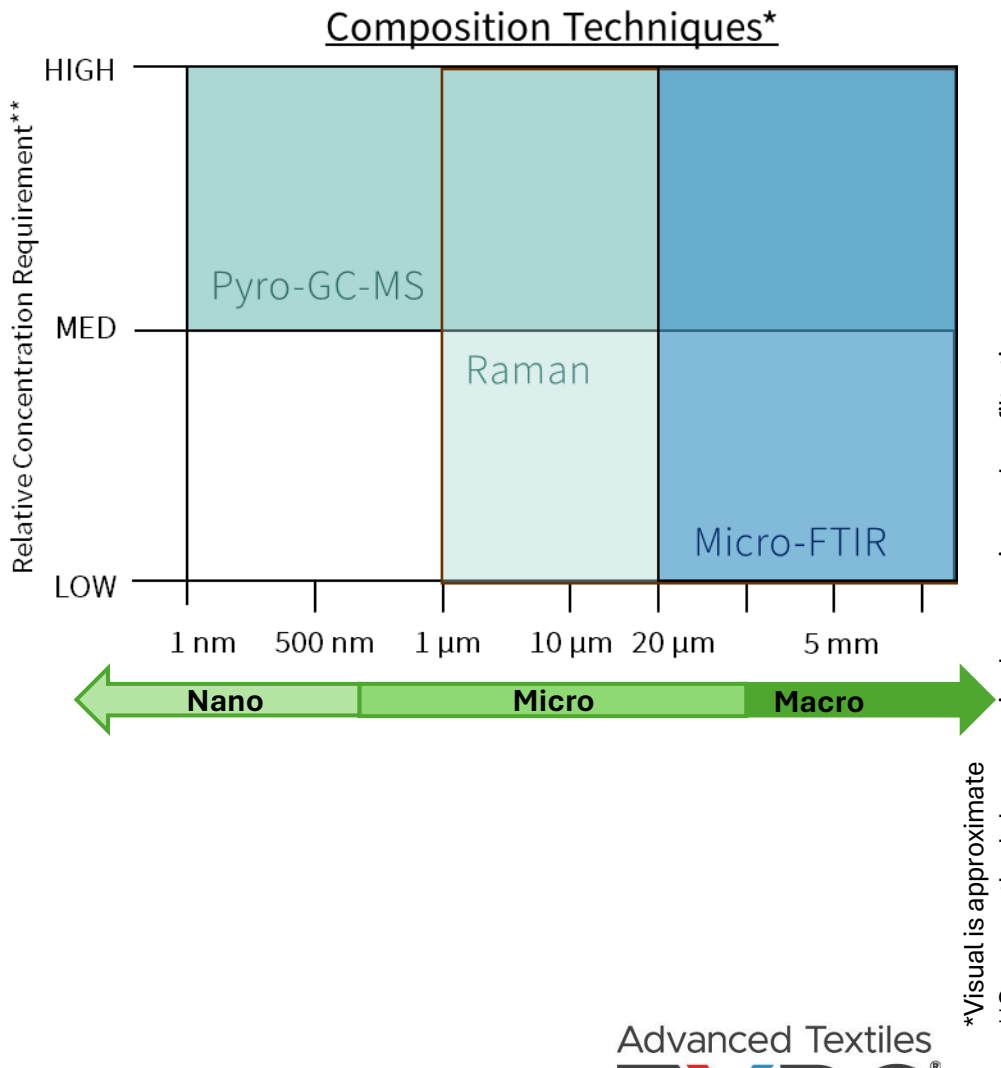


*Visual is approximate
**Some methods have required processing such as filtration

Advanced Textiles EXPO®

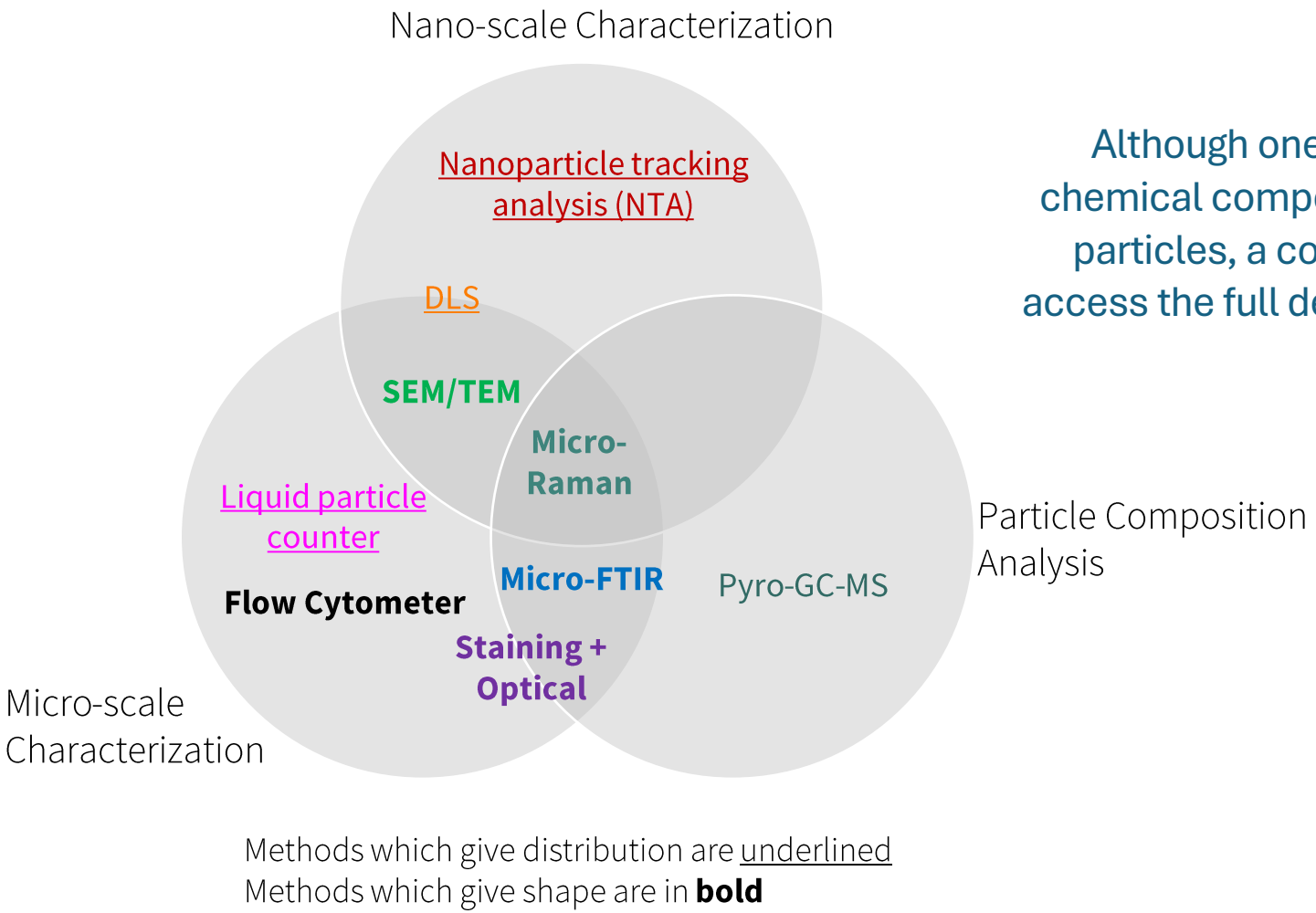
Analysis Toolkit: Particle Composition

Method	Size Range	Advantages	Disadvantages
FTIR (Fourier Transform Infrared Spectroscopy)	~10-25 µm and above (micro-FTIR)	• Widely used, non-destructive • Provides chemical fingerprint • Can analyze many particles at once	• High throughput • Limited sensitivity below ~10 µm • Overlapping signals for some polymers • Surface contamination can interfere • Limited sensitivity with dark samples
Raman Spectroscopy	~1 µm and above	• High spatial resolution (smaller particles than FTIR) • Generally non-destructive	• Best for colorless particles; fluorescence interference • Longer analysis time • Can potentially melt/burn microplastics
Pyrolysis-GC-MS	No size limit, bulk analysis	• High sensitivity • No special resolution for individual particles	• Destructive • No information on particle size, shape, or number • Limited detection on small amounts of material



Advanced Textiles EXPO®

Recap: Microparticle/Microfiber Analysis Toolkit



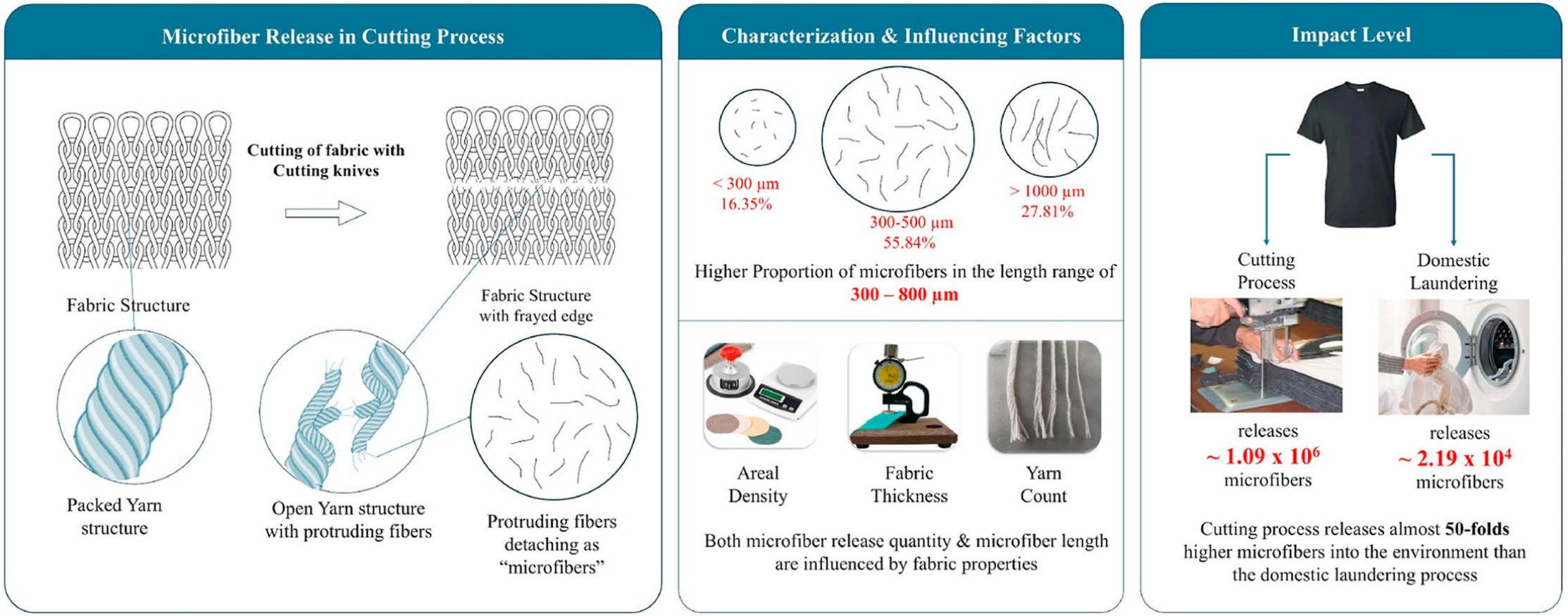
Methods which give distribution are underlined
Methods which give shape are in **bold**

Although one instrument cannot accurately determine the chemical composition as well as size, distribution, and shape of particles, a combination of the techniques should be able to access the full defined range of “microplastics” and “microfibers”.

Note: *size and concentration limits of all the analysis techniques are sample/instrument-dependent.*

Advanced Textiles EXPO®

Case Study: Microfiber release during apparel manufacturing process



- Although domestic laundry has been reported as a major source of microfiber release, researchers stress the potential of the manufacturing stage to contribute equally.
- **Analysis Toolkit Utilized:** Filtration, Optical Microscopy, Quantification and Measurement via ImageJ

Balasaraswathi, S. Raja, and R. Rathinamoorthy. "Microfiber Release during Apparel Manufacturing Process – A Greater Concern than Domestic Laundering." Emerging Contaminants, vol. 11, 2025, p. 100559.

Advanced Textiles EXPO®

Summary

- Microplastics are a complex and evolving challenge due to:
  - Lack of a harmonized definition
  - Originating from multiple sources and pathways
  - Lack of standardized analytical testing methods
- Textiles are the dominant source of microplastics detected in aquatic and terrestrial environments.
- Existing regulations focus narrowly on *primary* microplastics (e.g., microbeads in personal care products), leaving *secondary* sources largely unregulated.
- Current standards rarely trace microplastics to their origin, limiting targeted mitigation strategies.
- New regulations and test methods are emerging, and may impose additional requirements on synthetic textile producers and manufacturers.

Future Outlook

Evolving Understanding

- The “solution” is dynamic, ongoing research continually reshapes what we know.
- Collaboration across disciplines (textiles, water treatment, waste management, policy) is essential.

Source Identification Challenges

- Complex environmental pathways make it difficult to pinpoint microplastic origins.
- Need for improved tracing technologies and standardized sampling methods.

Testing & Standards Gap

- Current standards mainly assess post-use impacts (e.g., laundering, wastewater).
- Shift toward life-cycle-based assessments and real-world emission studies is needed.

Beyond Textiles

- Microfibers from textiles are a current visible focus, but transport, packaging, use/wear, and manufacturing/industrial processes are major contributors.
- Holistic, cross-sector strategies will yield greater reductions.

Regulatory Landscape

- Existing policies primarily target primary microplastics (e.g., microbeads).
- Secondary microplastics (from degradation and abrasion) remain largely unregulated

Literature Recommendation: Luzi, Beatrice, Marco Carnevale Miino, Elena Cristina Rada, Rosa Zullo, Alberto Pietro Damiano Baltrocchi, Vincenzo Torretta, and Silvia Galafassi. “Critical Review of Microfiber Release from Textiles: Results, Comparative Challenges, Mitigation Strategies, and Legislative Perspectives.” Chemosphere, vol. 370, 2025, p. 144394.

Exponent's Insights And Contributions

- **Alerts/Insights @ Exponent.com**
  - Microplastics Testing Explained (**2025**)
  - EFSA Issues New Micro- and Nanoplastics Literature Review **(2025)**
  - California Creates First Statewide EPR Program for Textiles (**2024**)
  - EU Bans Glitter on Ongoing Efforts to Restrict Microplastics (**2023**)
  - Canada Moves to Classify Manufactured Plastics as Toxic Substance (**2021**)
  - California is the First States to Define & Regulate Microplastics (**2020**)
- **Publications/Presentations**
  - Driscoll, S, Pitt JA, White C, Kulacki K, Worthen A. The changing fate of plastics in the environment. Webinar. Washington Defense Trial Lawyers, **2024**
  - Pitt JA, Hahn ME, Aluru N. Implications of exposure route for the bioaccumulation potential of nanopolystyrene particles. Chemosphere **2024**; 141133.
  - Smith, S, Kirkpatrick E. What you need to know about microplastics. Oral Presentation. IFAI International Conference, Charlotte, NC, **2022**.
  - Lee D, Kirkpatrick E, Gladman AS, Ripatti D. Microplastics and the Textile Industry. Textile World **2020**.

Q&A

Learn more about Exponent at
https://www.exponent.com/

Advanced Textiles

EXPO®

See You Next Year

ORLANDO, FL

Nov. 3–5, 2026

JOIN US NEXT YEAR