Water Workshop 2025

Microplastic pollution: Environmental pathways, human health risks, and the role of legislation

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Microplastics

Plasic particles with size < 5 mm

Microplastic

PRIMARY MICROPLASTIC

Factory-produced plastic smaller than 5 mm

SECONDARY MICROPLASTIC

Microplastics that are formed by the degradation of large plastic debris under the influence of various physical, chemical, and biological processes

Environmental pathways

Direct Deposition from Consumer /Industrial Activities

- Manufacturing
- Abrasion (e.g. tire wear)
- Use of synthetic textiles shed fibres
- These can deposit locally or be carried off
- Use of plastic mulches in agriculture, plastic films

Environmental pathways

Sewage & Wastewater Systems

Wastewater treatment plants often receive microplastics from homes (laundry, personal care products), industries, stormwater.
Many particles are not completely retained and are discharged with effluent.
Sludge from treatment plants is often used as fertilizer in agriculture;
This can introduce microplastics back into soils.

Environmental pathways

Landfill Leachate & Disposal Sites

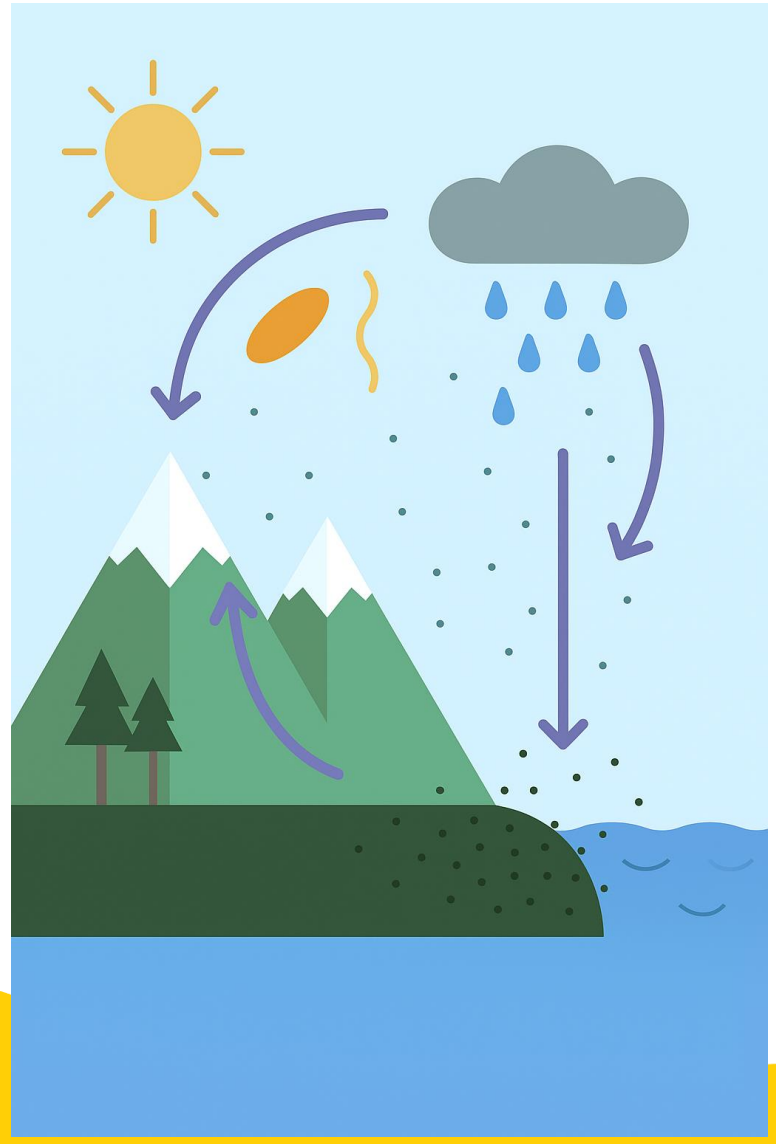
Plastic waste in landfills breaks down

Microplastics (or smaller fragments) can be leached out, transported by water, or escape via improper waste handling.

Environmental pathways

Runoff and Water Flow

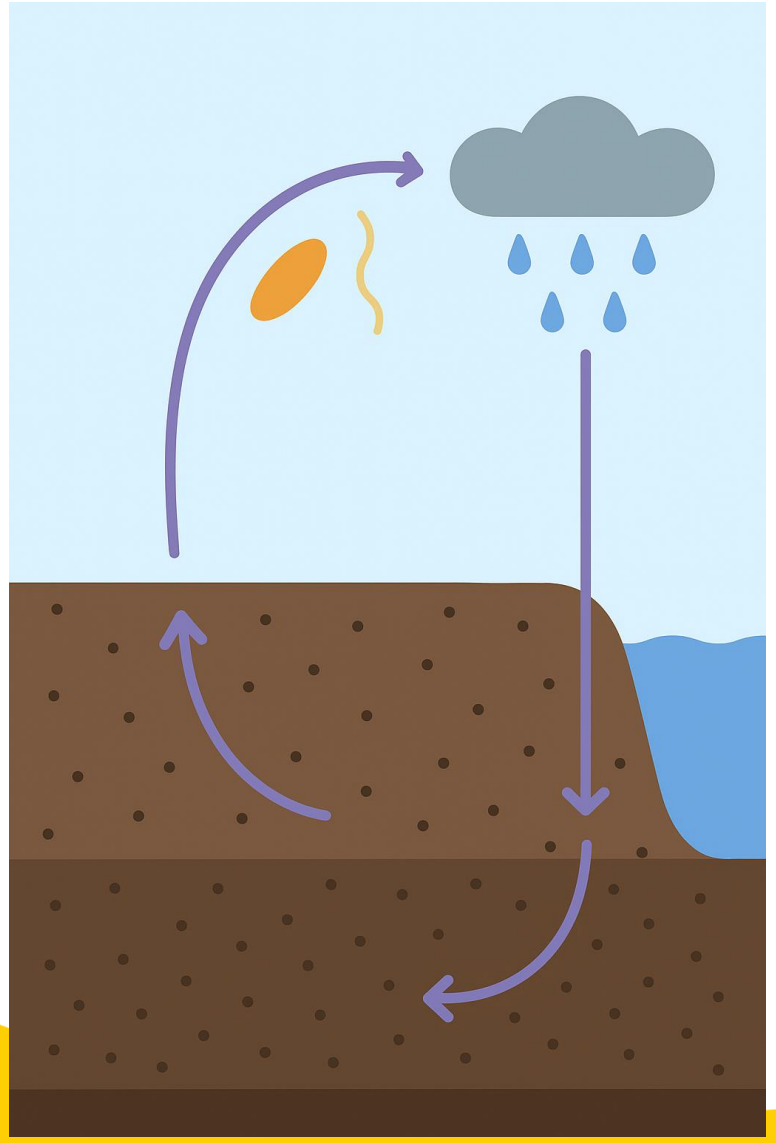
Rainfall and stormwater wash microplastics from land surfaces (urban areas, roads, agriculture) into rivers, lakes and ultimately oceans.
Surface water flow—including small streams—can carry particles downstream, sometimes depositing them in sediments or moving them out to sea



Environmental pathways

Atmospheric Transport & Deposition

Microplastics (especially light fibres or small fragments) can become airborne via wind, dust/resuspension, or being lifted from surfaces
After being airborne, they can settle out (“atmospheric fallout”) onto land or water surfaces via precipitation, gravity, or air currents



Environmental pathways

Soil Mobilization & Leaching

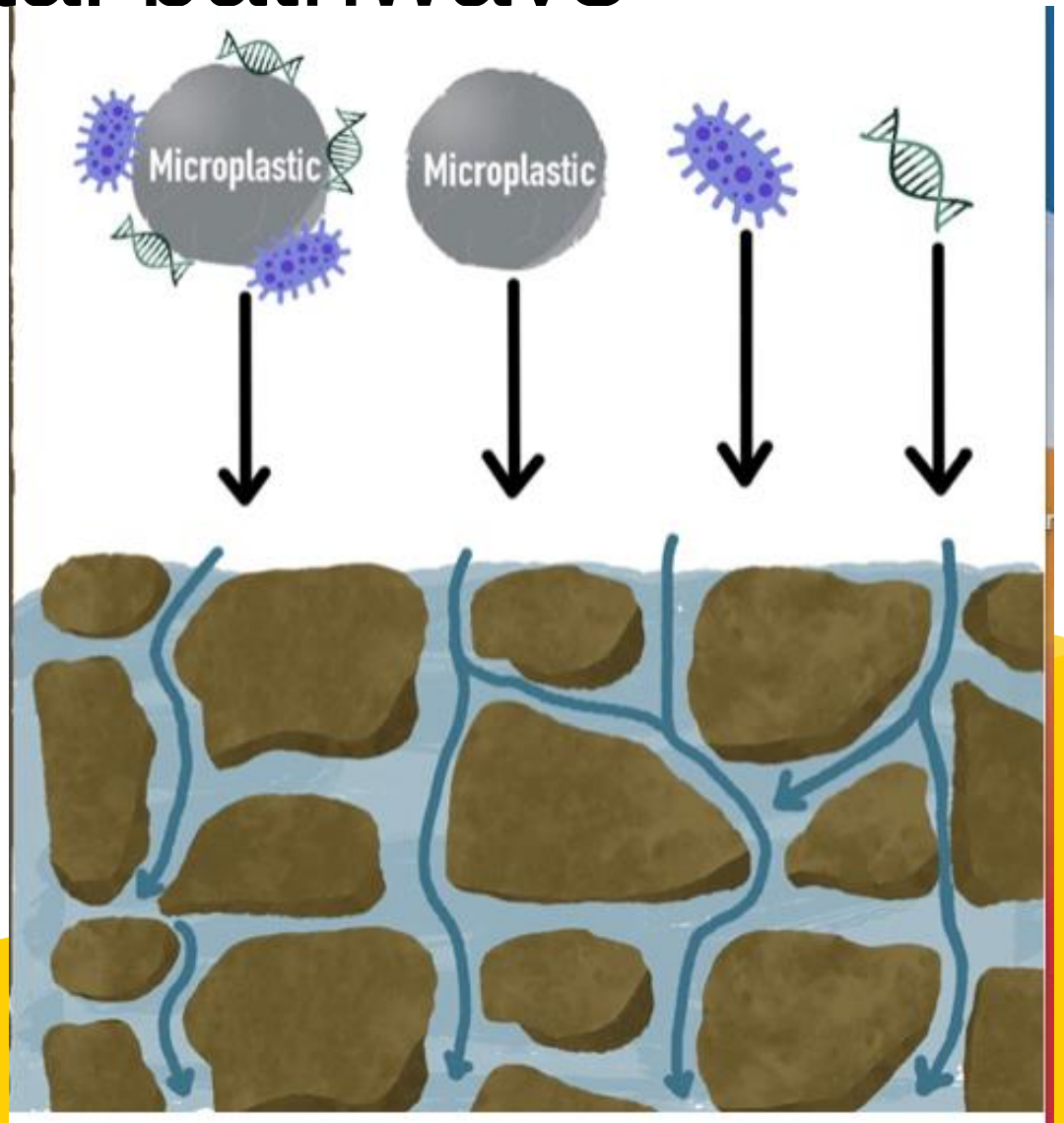
Soil disturbances (tillage, erosion, heavy rainfall) cause microplastics to move within soils, down the soil profile, or into adjacent water bodies via runoff

In some cases, microplastics can percolate into groundwater, especially in permeable soils, shallow water tables

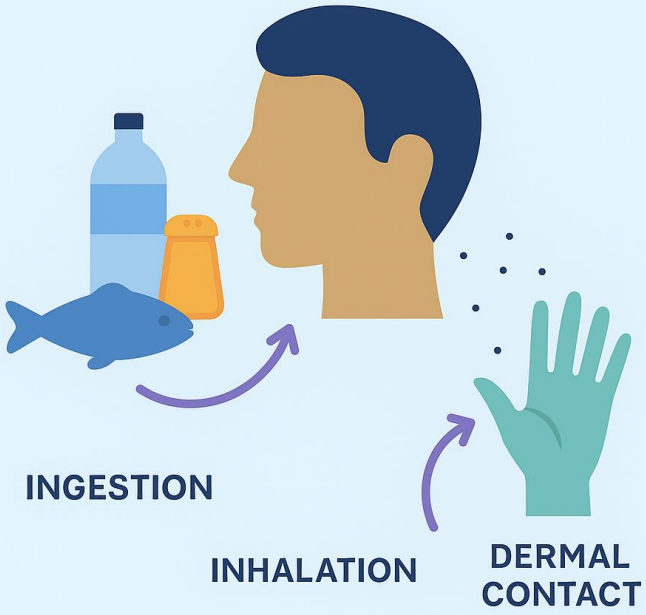
Environmental pathways

Biotic Transport

Organisms (e.g. earthworms, insects) ingest microplastics and move them through the soil profile.
Plants might take up tiny particles via roots and move them internally (this pathway is less well-characterized).



Human health risks



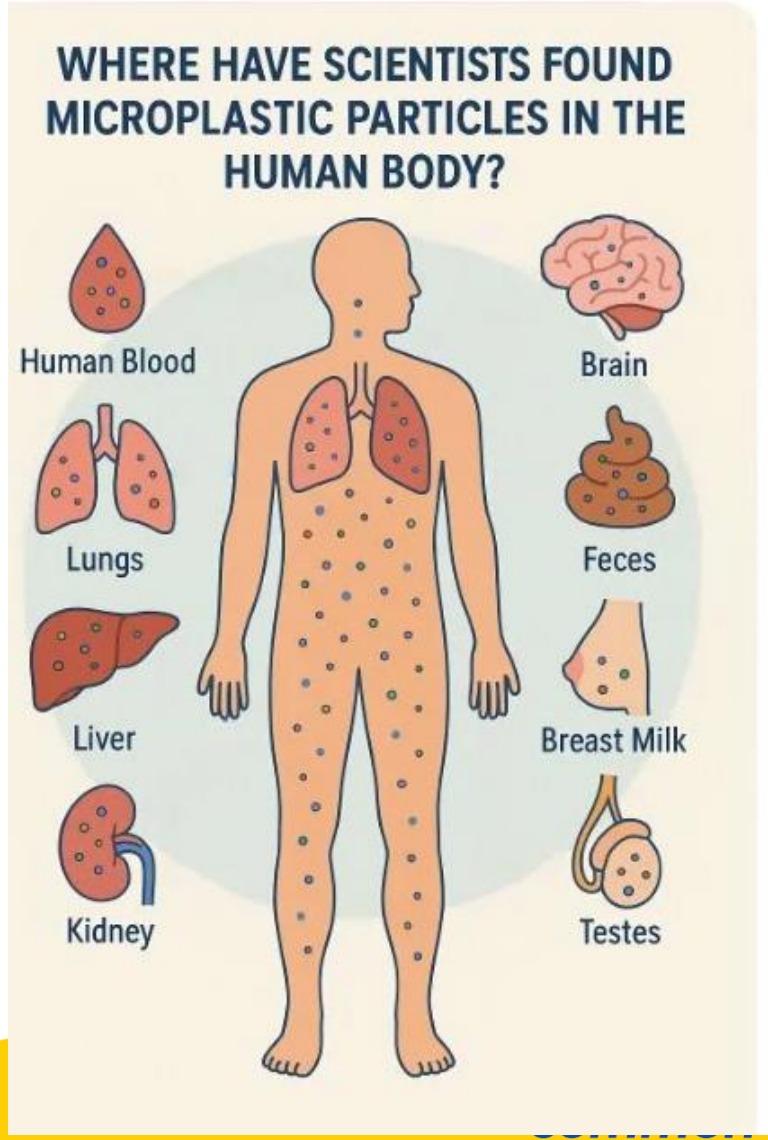
Routes of exposure

Ingestion: via contaminated food and drinking water. MPs are found in seafood, salt, bottled water, etc.
Inhalation: airborne microplastics (dust, synthetic fibers indoors, particles from tire wear, etc.) can be inhaled.
Dermal contact: skin contact is possible (especially with small particles, damaged skin, wounds), but less studied.

Human health risks

Presence in human tissues

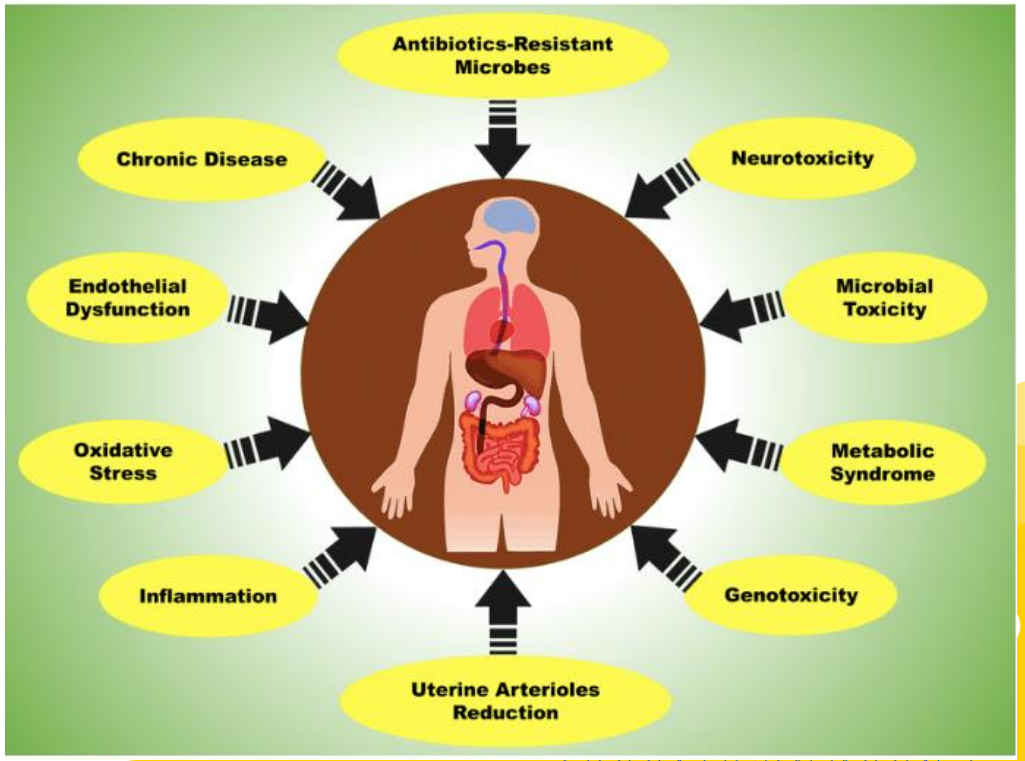
Microplastics have been detected in human excrement, biofluids, tissues (including lung tissue)
Indoor air often has higher microplastic content than outdoor



Human health risks

Health effects observed / suspected

Respiratory effects: inhalation may lead to irritation, inflammation, oxidative stress in the lungs; could worsen asthma, COPD, possibly lead to pulmonary fibrosis.
Digestive / gastrointestinal effects: MPs may cause changes in gut barrier, inflammation, histological (tissue) changes, possibly alter gut microbiota



Human health risks

Health effects observed / suspected

Reproductive/developmental effects: Animal studies show effects on sperm, ovarian follicles, hormonal changes, growth / birth outcomes

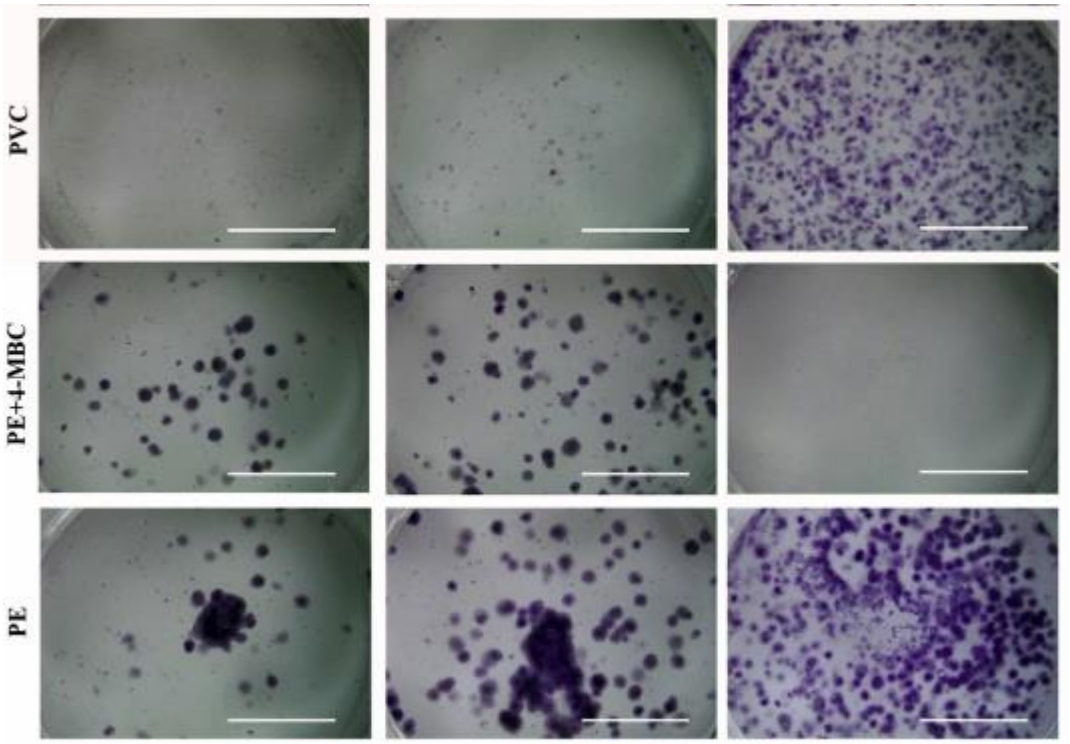
Immune system effects: Exposure may dysregulate immune responses, cause oxidative stress, perhaps increase inflammation

Cardiovascular risks: Some evidence suggests microplastics may contribute to cardiovascular disease via inflammation, oxidative stress, endothelial dysfunction

Human health risks

Levels of evidence and uncertainties

Most *strong* evidence comes from **animal studies** or cell-culture (in vitro) studies. Human epidemiological studies are fewer.
Dose–response relationships (how much MP exposure leads to what effect) are still poorly understood
Long-term chronic exposures, accumulation in organs, translocation (moving from gut/lungs into bloodstream or other tissues), and effects of different particle sizes/types (fibers vs fragments, different plastic polymers) all need more study.



Milić N. et al (2025) Evaluating the in Vitro Toxicity of 4-MBC and Microplastics: The Role of PE and PVC as Carriers, 33(8), 3555-3569

What We Still Don’t Know?

- Exactly how many microplastic particles people are exposed to daily from all sources combined, and how that varies by region, lifestyle, diet.
- Which sizes/shapes/polymers are most harmful, and how they move through the body.
- How particles are cleared (or whether they accumulate) in human tissues.
- Long-term epidemiological data: do microplastics contribute to chronic disease in people, and if so under what exposure levels?

Role of legislation

Prevention measures

Restricting or banning **intentionally added microplastics** in products like cosmetics and detergents, and by tackling the **loss of plastic pellets** and other sources

Role of legislation

Legislation / Regulation	Key Provisions on Microplastics	Effective Dates / Phases
REACH Regulation – Regulation (EU) 2023/2055	**Restricts synthetic polymer microparticles (microplastics) intentionally added to products**. It prohibits placing on the market microplastics on their own or added in mixtures that are released in use. Covers things like glitter, cosmetics, detergents, waxes, polishes, air fresheners, fertilisers, etc.	Came into effect **17 October 2023** for many uses. But there are transitional periods for specific products: e.g. some cosmetics, detergents, and artificial turf infill have deadlines up to **2035**.
Proposal for measures to prevent pellet (nurdle) loss	Aims to reduce unintentional release of plastic pellets throughout the supply chain—storage, transport etc. Because pellets are a major source of microplastic pollution.	Proposal made in **October 2023**. Implementation timeline TBD.
Single-Use Plastics (SUP) Directive – Directive (EU) 2019/904	Bans or restricts certain single-use plastic items (like cutlery, straws, plates, cotton bud sticks), imposes extended producer responsibility (EPR), labelling etc. Aims to reduce plastic waste that can degrade into microplastics	Adopted 2019. Some bans (e.g. certain items) in place since **2021**.

Role of legislation

Country/Region	What Laws / Policies Exist re: Microplastics
Canada	**Single-use Plastics Prohibition Regulations** — prohibits or restricts manufacture/import/sale of several single-use plastic items (checkout bags, cutlery, stir sticks etc.).
China	Ban on producing/selling cosmetics with microbeads. As of end-2020 / end-2022, cosmetics / personal care products with intentionally added plastic microbeads are prohibited.
Australia	National Plastics Plan; state bans; voluntary measures; some regulations on single-use plastics; some states ban microbeads in rinse-off personal care/cleaning products
California	Banned plastic microbeads in *rinse-off* personal care products (e.g. facial/body scrubs, toothpaste)

Uncertainties & Knowledge Gaps

- **Standardization is lacking**: sampling methods, detection limits (especially for very small particles/nano-plastics) vary widely, making comparisons difficult
- Many studies focus only on **larger microplastics** (e.g., >300 µm), while smaller ones (including nano) may be underreported.
- **Health risks**: exposure routes, dose-response relationships, accumulation in human tissues, long-term effects **are still not well quantified.**
- Studies in animals/cell cultures show effects, but the results on human health influence are more limited.

General Trends & Future Directions

- The trend is moving from **banning micro-beads in cosmetics / personal care** → to broader regulation of *all intentionally added microplastics across many product categories*. The EU's REACH restriction is an example.
- There's increasing attention to **unintentional release** (pellets, wear & tear, degradation) though regulation is less advanced for these sources.
- Many laws use *transitional periods* to allow industries to adapt, especially for components like cosmetics etc.
- Gaps remain: airborne microplastics (air quality laws), monitoring and reporting requirements, standard definitions and measurement methods, control of microplastics from wastewater, textiles, agriculture.
- Global Plastics Treaty" for banning plastics

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Microplastics

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Thank you for your attention

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