Microplastics:

“*The New PFAS?*”

From the American Bar Association…

July 29, 2022

Beyond PFAS to Plastics: The Emerging Contaminant that Lies Ahead

Mark McDaniel and Thomas Redick

What are microplastics?

- According to World Health Organization “the definition of **microplastics** is not completely straightforward. Microplastics represent a diverse range of material types, shapes, colours and sizes (Thompson, 2015).”

ITRC: Microplastics are small three-dimensional pieces of human-made plastic that are man-made solid polymeric materials greater than one nanometer and less than five millimeters in length which may contain other substances or chemical additives.

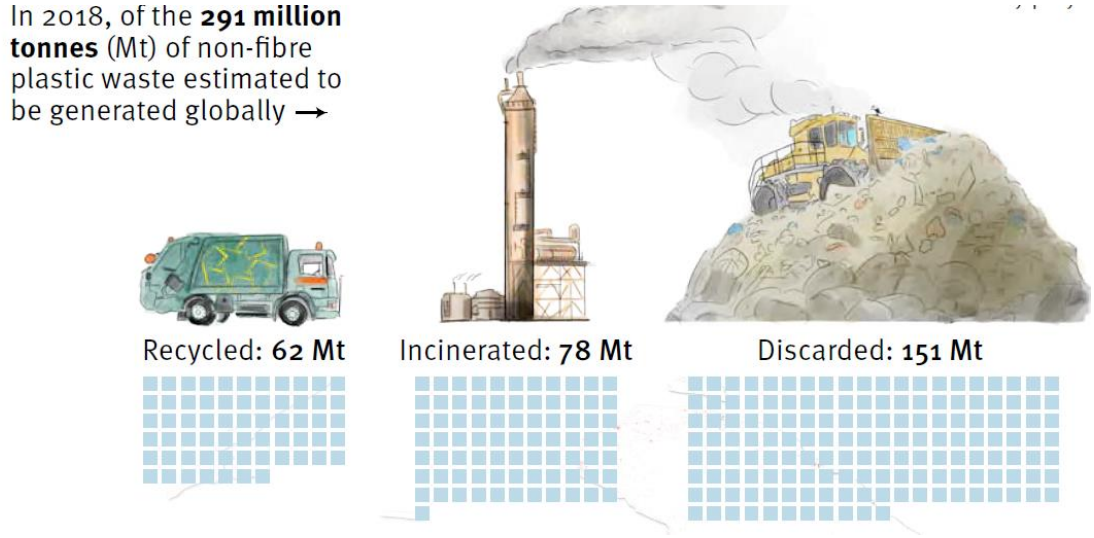
Also, included are “non-traditional” plastics commonly derived from petrochemicals that may be partially natural, called semi-synthetic plastics (synthetic rubber, synthetic fibers, silicones, bio-based polymers, biodegradable polymers, cellulose acetate, etc.) commonly derived from petrochemicals and may be partially natural, called semi-synthetic plastics.

California Water Board: Microplastics in Drinking Water’ are defined as solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least three dimensions that are greater than 1nm and less than 5,000 micrometers (µm).

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

Most marine litter (including plastics) is derived from land

- Plastic production has reached approx. **400 million tonnes** annually, it will be **600 million** tonnes by 2025, and exceed **1 billion tonnes** by 2050
- Estimations: 19-23 million tonnes of plastic waste enter the oceans annually



- Tire and road wear particles are one of the largest sources of microplastics entering the aquatic

Sources: They are everywhere

Primary: Manufactured as microbeads, other applications. Relatively easy to regulate at source

Secondary: Breakdown of larger plastic products

- Multiple domestic and industrial sources
- Fibers from clothing
- Motor vehicle tires and brakes

The weathering of particles, diffusiveness and variety of sources makes the tracking and control of microplastics very challenging

Why are we so concerned about microplastics?

Nature

NEWS FEATURE | 11 February 2025

Your brain is full of microplastics: are they harming you?

Plastics have infiltrated every recess of the planet, including your lungs, kidneys and other sensitive organs. Scientists are scrambling to understand their effects on health.

- We find microplastics everywhere we look, from Antarctica to organs
- Brain levels are 50% higher in 2024 than 2016
- Studies show varied effects across multiple organism levels
- Measurement challenges are a major issue, with contamination and lack of standardization

Microplastics and human health

nature › news › article

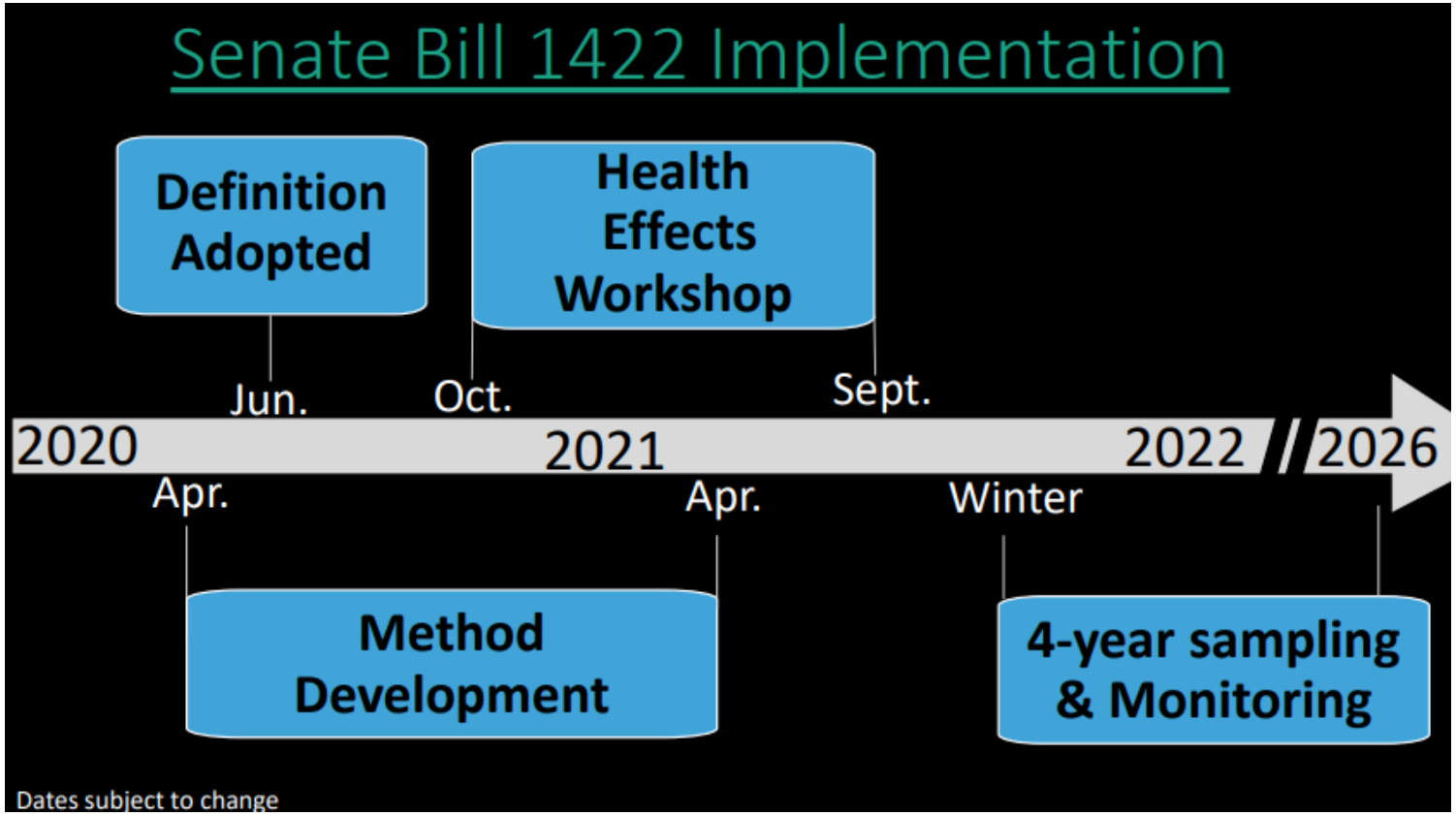
NEWS | 06 March 2024

Landmark study links microplastics to serious health problems

People who had tiny plastic particles lodged in a key blood vessel were more likely to experience heart attack, stroke or death during a three-year study.

https://www.nature.com/articles/d41586-024-00650-3

California leading on Microplastics



Health Effects Report-Out Webinar
September 8th, 2021

Scott Coffin, Ph.D.
California State Water Resources Control Board
@DrSCoffin

- Framework for setting health-based guidance developed
- Quality of toxicological data deemed insufficient to establish a regulatory guidance level
- Non regulatory screening level
  - Reference dose 1.7 ng/kg/day at a source contribution 20%
  - Non-regulatory screening level = 6.4 ng/L or 1.2 particles/L based on 5 um spheres

https://ftp.sccwrp.org/pub/download/DOCUMENTS/Microplastics/HealthEffects/ReportOut_Coffin.pdf

Sampling and analysis of microplastics is a unique challenge

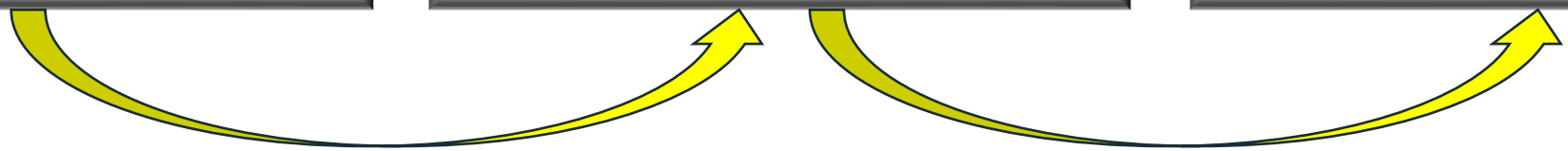
Microplastics are particles	Microplastics come in many shapes, sizes and composition	In order to analyse samples at ultra trace levels, thousand of litres may be required
Is your sample representative?	Increases the complexity of testing	Increases the complexity of testing
Microplastics are ubiquitous.	Unlike bulk analyses, microplastic determinations may require counting, size distribution and characterization	Microplastics include 1 nm – 5 mm particles.
The risk of extraneous contamination or background levels increases	Full characterization can be time-consuming	Current commercial best available technology is not sufficiently sensitive to measure 1 nm – 10 um

Microplastics Measurement: Major Variables to Consider

- Particle size
- Particle shape
  - Fibers
  - Films
  - Foams
  - Beads
  - Spheres
  - Pellets
  - Fragments
  - etc.
- Origin/Source
  - Primary – manufactured product
  - Secondary – degraded or “broken down”
- Composition
  - Polyethylene
  - Polystyrene
  - Polycarbonate
  - and many, many more
- Particle properties
  - Density
  - Crystallinity, etc.
- Additives and Sorbed Contaminants
  - Fillers, colorants and functional chemicals
  - Environmental contaminants
- Weathering and transformation in the environment

Sampling and Sample Preparation

Collect and size separate the sample	Prepare sample by removing interferences	Count – Measure - Characterize
Sieve set-up will be dependent on the particle sizes of interest	Chemically assisted separation to isolate specific plastics. Multiple chemical and enzymatic digestion options are available	Various techniques available to be used alone or in combination depending on project objectives • Microscopy • Fourier Transform Infrared (FTIR) • Laser Direct Infrared Imaging (LDIR) • Raman • Pyrolysis Gas Chromatography Mass Spectrometry (pyr-GC/MS)



Analysis - Many options, no single solution

Microscopy

- Counting technique
- Visible Microscopy – 50 um
  Scanning electron Microscopy (SEM) – 10 um
  Visible Microscopy (with staining) – 3 um
  Differentiation still a challenge (Is it a plastic?)
- Visible microscopy with staining presents potential as a first-pass" screening method
- Analysis time: hours per sample

LDIR (SGS EU)

- Uses laser direct imaging techniques
- Characterizes and counts particles down to 10 um
- Faster than FTIR/Raman
- High instrumentation costs, single vendor → higher price
- Analysis time: hours per sample

FTIR/Raman (SGS NA)

- Characterize plastics by size and provenance
- FTIR (20 um) and Raman (1 um) methods available, but time consuming
- ASTM.SCCWRP methods are being developed
- Automated approaches are being developed to support large-scale studies
- Analysis time : days pre sample

Pyrolysis GC/MS (SGS EU)

- Measures total plastic concentration by plastic "type"
- Does not count, but measures the mass of a particular plastic type
- Not limited by particle size
- May be more amenable to regulation due to ease of use
- Specialized techniques may be required to lower reporting limits
- Analysis time: hours per sample

Measuring Microplastics: Advantages and Limitations

Attribute of the Method	Optical Methods (FTIR, Raman, LDIR)	Bulk Methods (pyr-GC/MS)
Particle size, shape and number	Yes (to a limit)	No
Particle mass (amount)	Partly, through area-to-mass conversion	Yes
Plastics type (characterization)	Yes	Yes
Size limit	10 um (practical limit)	No limit (based on filter size)
Data processing time	Higher	Potentially lower
Nanoparticle measurement?	No	Yes (at a bulk level depending on ability to filter particles)
Does the method provide health exposure information?	Yes (particle size, number and depending on the technology, type)	Not quite (bulk measurement only)

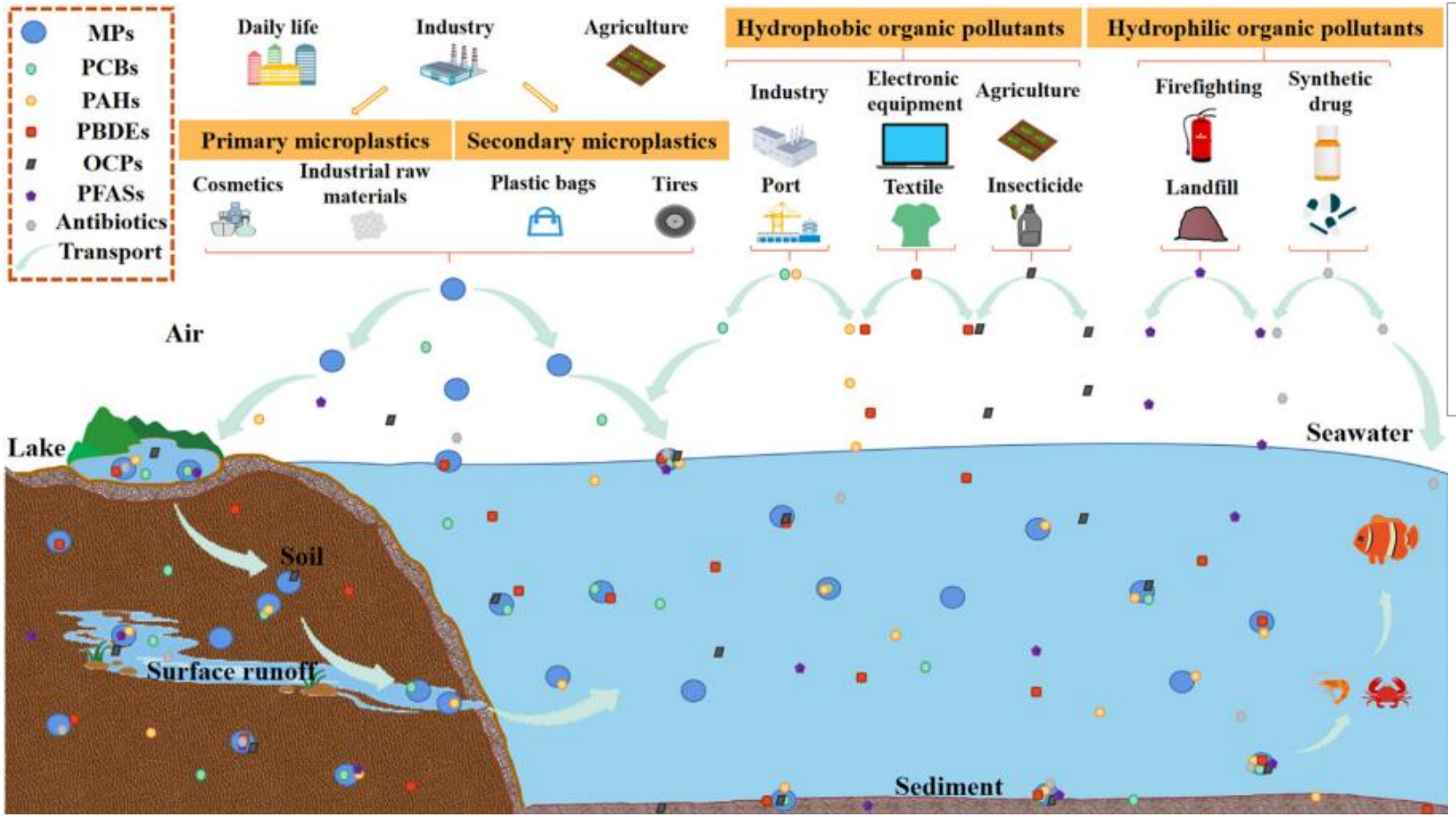
Available and upcoming standard methods

Agency	Technique	ID	Matrix	Particle sizes	Status
CA Waterboards	IR (FTIR/LDIR etc.)	?	Drinking water	> 50 um	Published and seeking accredited labs
CA Waterboards	Raman	?	Drinking water	> 20 um	Published and seeking accredited labs
ASTM	Sampling/collection	D8332-20	Aqueous	< 5 mm	Published
ASTM	Sample Preparation	D8333-20	Aqueous		Published
ASTM	IR FTIR/LDIR etc.)	WK87463	Aqueous	>10 um?	Initiated
ASTM	Pyrolysis	D8401-24	Aqueous	Bulk	Published
ASTM	Dynamic image particle size and shape analyzer	D8489-23e1	Aqueous	5-100 um	Published

Sampling and Analysis Challenges to Solve

- Beyond water, all methods are academic, no standardization on collection, preparation or analysis
- Representative sampling, avoiding background, building plastics-light labs etc.
- Scale and cost: Counting is time consuming, automation/AI still early, costs are high $$$-$$$$
- Commercial labs still hesitant to build due to lack of familiarity, labor intensiveness and investment needed in plastics-free spaces

Microplastics as “Carriers” of Organic Contaminants



- Microplastics are known to sorb organic contaminants such as PCBs, PAHs and more from the aqueous phase
- This sorption can facilitate the delivery of contaminants into vulnerable organs

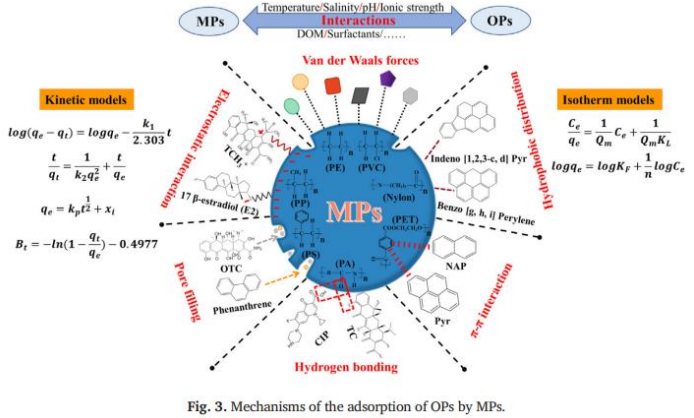


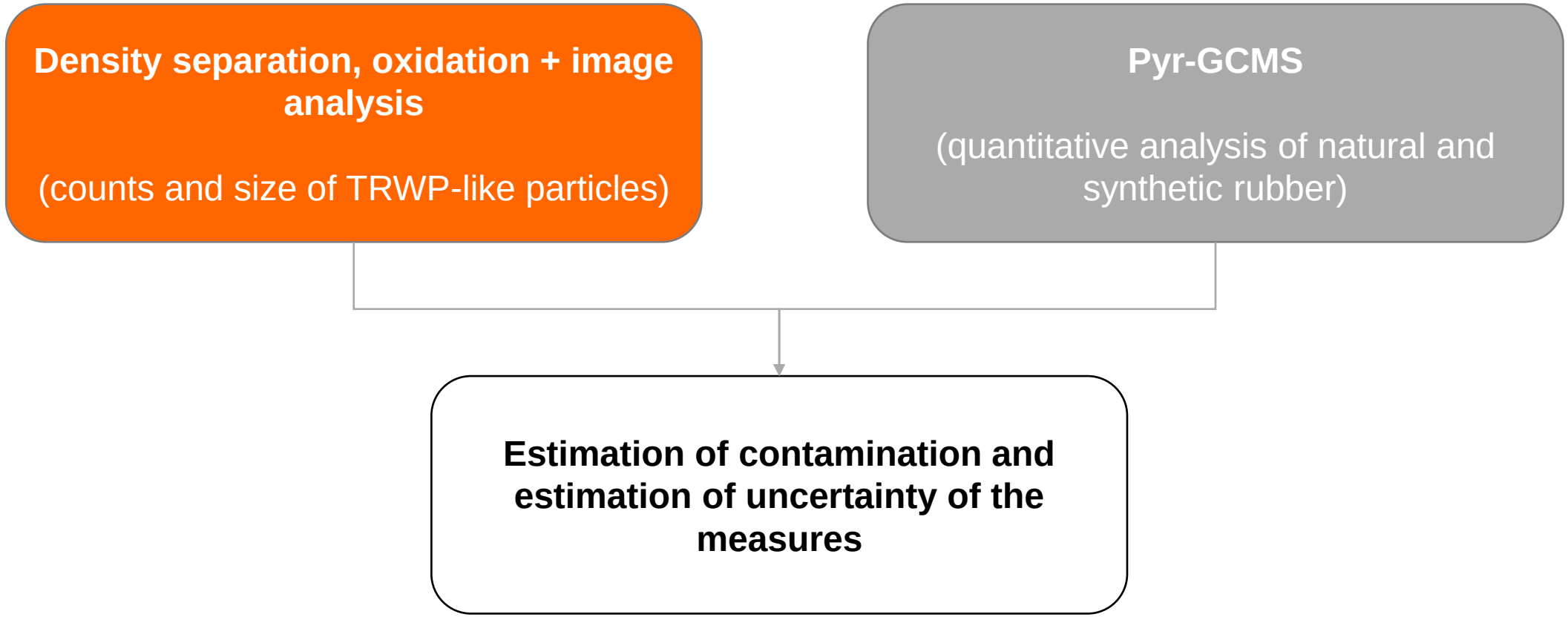
Fig. 3. Mechanisms of the adsorption of OPs by MPs.

Source: Yu *et al*.: *Sci Tot Environ,* **887** (2023) https://doi.org/10.1016/j.scitotenv.2023.164008

Challenges with Tire Wear Particles

- Tire wear particles (TRWP) are present at high levels especially in urban environments
- TRWP can have a density ranging from 1.2 to 2.2g/cm^3
- Density separation is carried out using metatungstate (up to d=2.95/cm^3)
- Difficult to detect using FTIR microscopy, LDIR, Raman…
  - Hard to identify due to mixing of polymers with other substances during abrasion on roads
  - Large under-estimations from most methods and therefore largely ignored in studies

Solutions for TRWP



Resources

- Microplastics - ITRC
- Microplastics Research | US EPA
- Microplastics in drinking-water World Health Organization
- Microplastics Everywhere | Harvard Medicine Magazine
- Microplastics Drinking Water | California State Water Resources Control Board
- Microplastics in Drinking Water: Risks Assessment and Regulations Development, by Scott Coffin

Key Takeaways

- Contamination by microplastics is a global issue
- Microplastics are ubiquitous in all environments
- Often complex steps are required to reduce background from sampling to analysis
- Significant health effects are being observed not only from microplastics themselves, but also their ability to transport organic contaminants directly to sensitive systems
- Measurement of microplastics has advanced in the last 10 years, and with greater commercial availability of testing, SGS is able to support microplastics projects locally and globally

Thank you!

Do you have any questions?

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