Tracking Tyre Pollution: Detecting and Mitigating Rubber Microplastics and Tyre Anti-Degradants in Stormwater

Dr Julia Jaeger

Technical Specialist

October 2025

www.eurofins.com

eurofins
Testing for Life

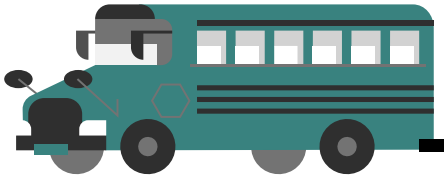
Tyre Pollution

~~Riding the Wave of Resilience~~

Driving the Road of Resilience

Tyre Pollution

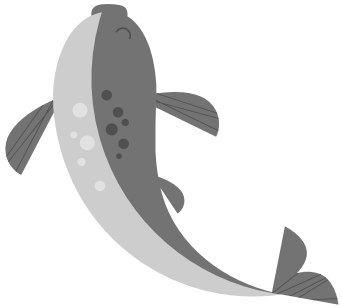
Primary Products



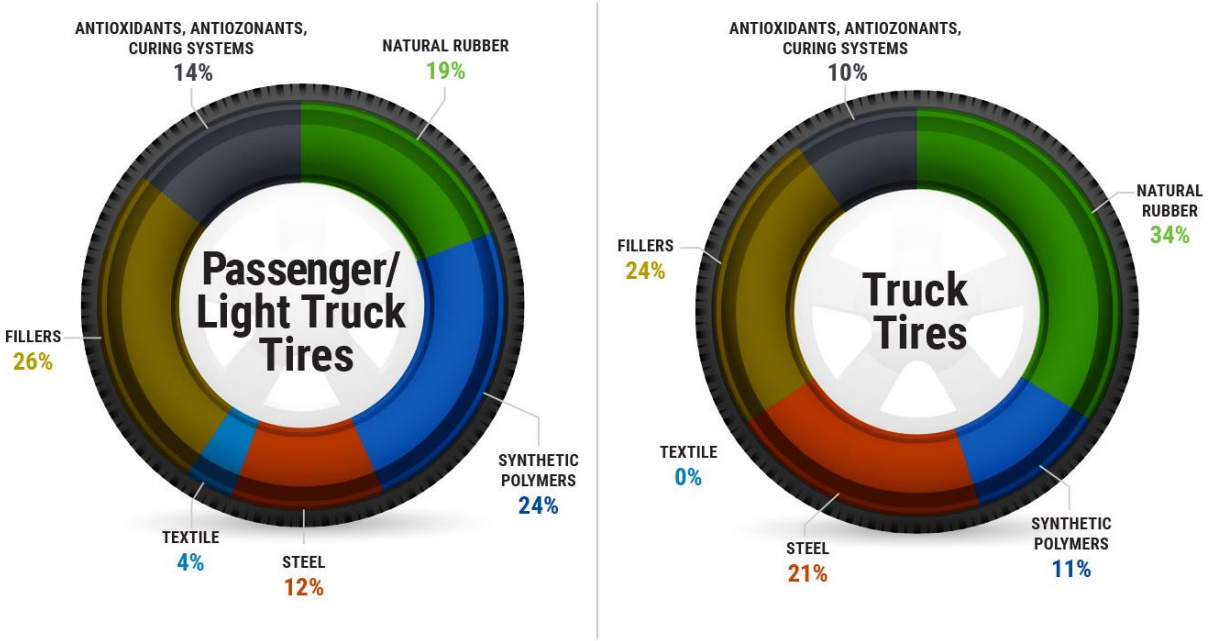
Secondary Products

Tyre Wear Particles (TWPs)

Tyre Anti-Degradant

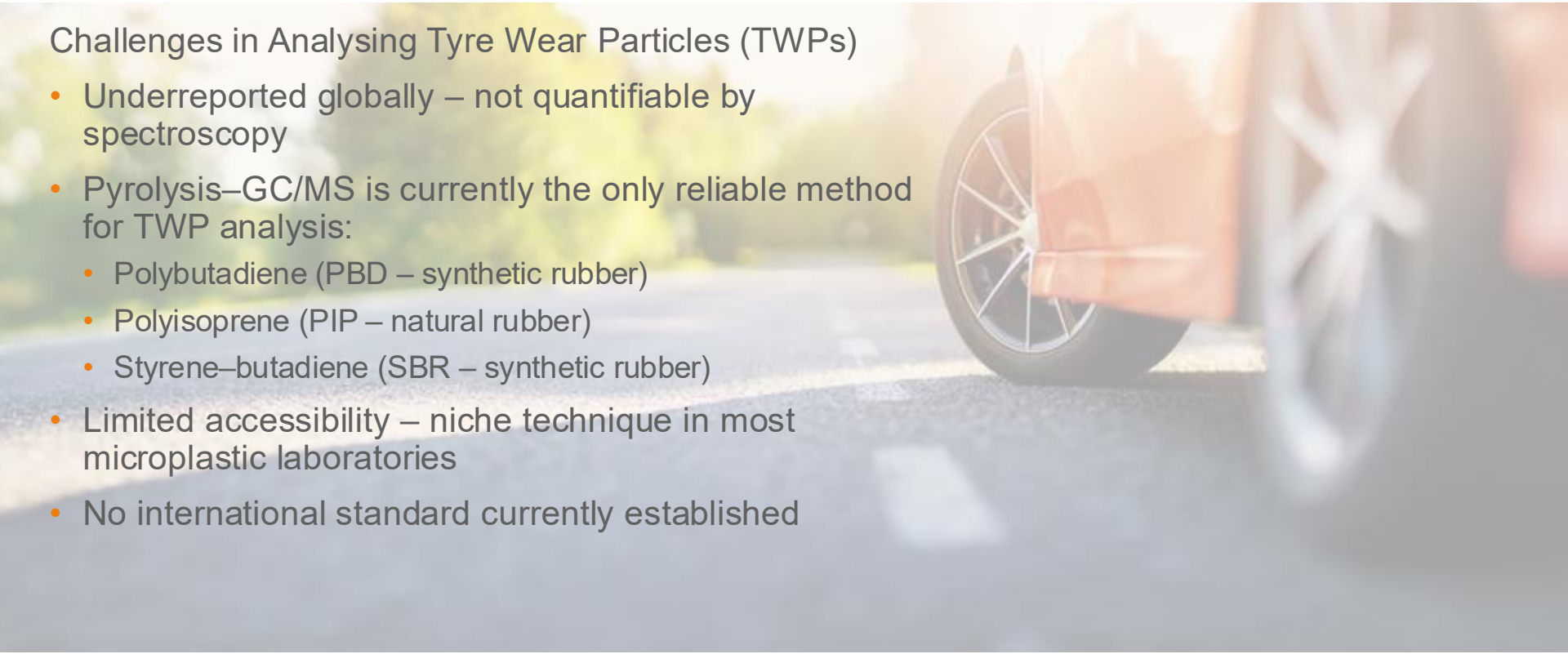


Tyre Pollution



Source: U.S tire manufacturers Association

Tyre Wear Particles (TWPs)

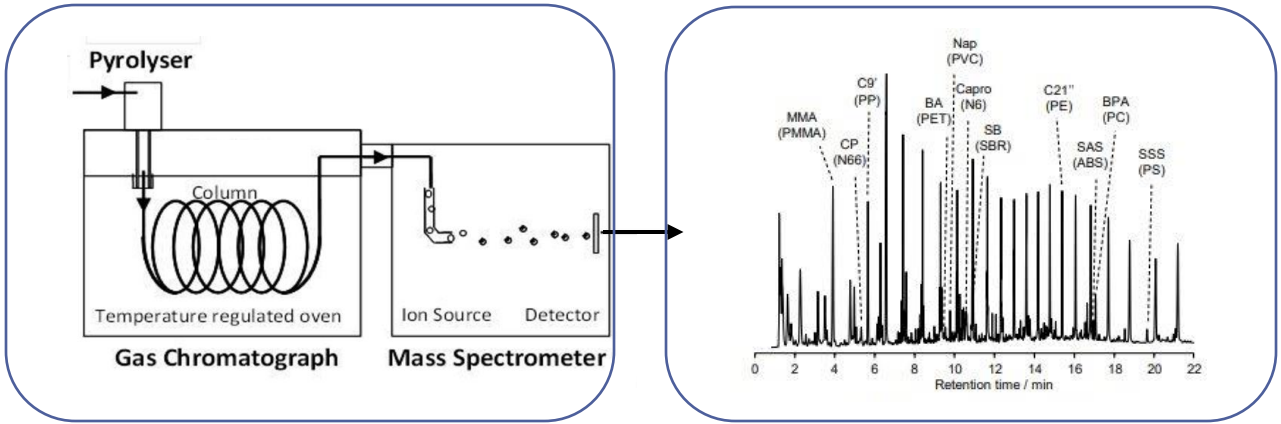


Challenges in Analysing Tyre Wear Particles (TWPs)

- Underreported globally – not quantifiable by spectroscopy
- Pyrolysis–GC/MS is currently the only reliable method for TWP analysis:
  - Polybutadiene (PBD – synthetic rubber)
  - Polyisoprene (PIP – natural rubber)
  - Styrene–butadiene (SBR – synthetic rubber)
- Limited accessibility – niche technique in most microplastic laboratories
- No international standard currently established

Tyre Wear Particles (TWPs) - Analysis

Pyrolysis – GC-MS



Tyre Wear Particles (TWPs) - Analysis

Study	Sample type	Size fraction	Analysis method	TWP concentration
Water samples				
Rødland et al. (2022a)	Untreated tunnel wash water	>1.6 μm	PYR-GC/MS	14.5–47.8 mg/L
Dröge and Tromp (2019)	Runoff from highway road side	No reported size range	TED-GC/MS	51–59 mg/L
Rauert et al. (2022)	Stormwater drain water	>1 μm	PYR-GC/MS	231–665 μg/L[a]
Rauert et al. (2022)	Retention pond water	>1 μm	PYR-GC/MS	72–236 μg/L[a]
Dröge and Tromp (2019)	Surface waters	No reported size range	TED-GC/MS	0.001–0.011 mg/L
Rauert et al. (2022)	Creeks and rivers in urban centres	>1 μm	PYR-GC/MS	<MDL–480 μg/L[a]

Gaggini et al. 2024

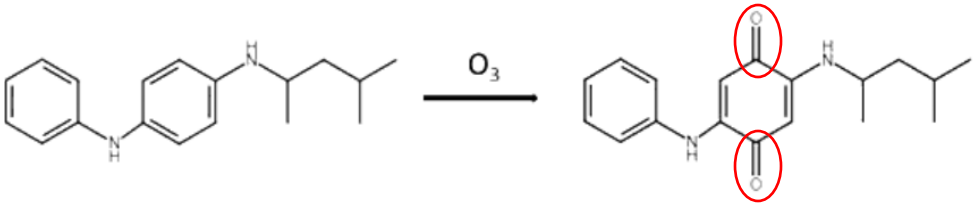
Tyre Anti-Degradants

- Tyre Anti-Degradants
  - Used in manufacturing various rubber types
  - Enhance **material durability** against degradation from heat, oxygen, ozone, UV light, and other environmental and mechanical stresses

Tyre Anti-Degradants

6PPD-Q (N-(1,3-dimethylbutyl)-N'-phenyl-1,4-phenylenediamine quinone)

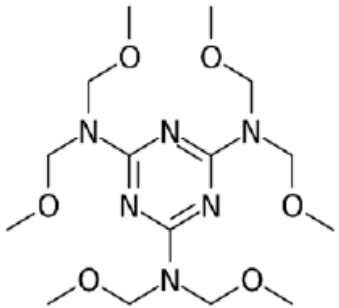
- 6PPD-Q is the ozonation product of 6PPD, an antiozonant used in tyres since the 1960s
- First identified and analysed in 2020
- Highly toxic to aquatic species:
  - Coho salmon: LC_{50} = 95 ng/L (mortality before spawning)
  - Brook trout: LC_{50} = 0.59 µg/L
  - Rainbow trout: LC_{50} = 1.0 µg/L



Tyre Anti-Degradants

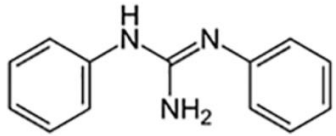
Hexamethoxymethyl melamine (HMMM)

- Used as a **crosslinking agent** in the production of coatings and tyres
- **Enhances adhesion** between rubber and steel reinforcing cords
- **Exhibits acute toxicity** to Daphnia and other aquatic organisms
- **No published acute toxicity thresholds** to date



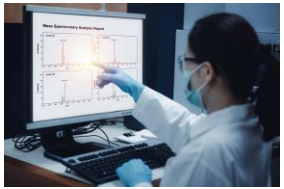
1,3-Diphenylguanidine (DPG)

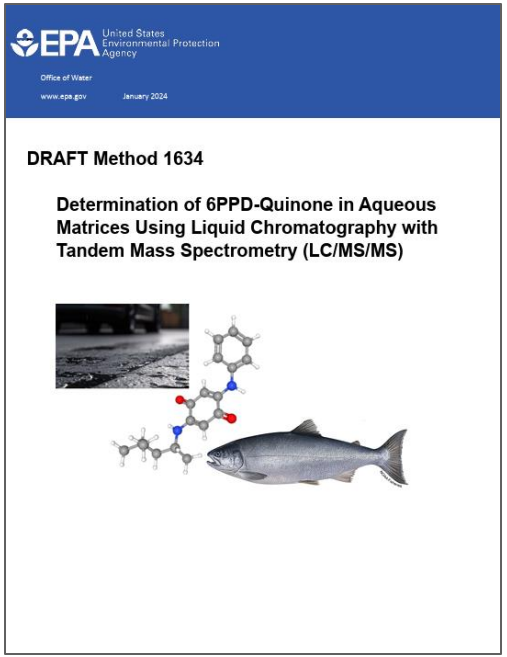
- Used as a **primary and secondary accelerator** in rubber vulcanization
- Enhances the **physical and mechanical properties of tyres**
- **Detected in urban runoff environments**
- **Classified by ECHA** as *toxic to aquatic life with long-lasting effects*



Tyre Anti-Degradants – Analysis

Sample Collection → Extraction → Analysis → Data Analyses and Report





Tyre Anti-Degradants – Results

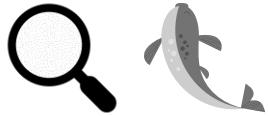
- Range of 6PPD-Q Concentrations in Stormwater, Surface water and wastewater

Type of sample	Range of 6PPD-Q concentrations (µg/L)	Reference
Stormwater runoff		
Seattle, USA	0.80–19.00	Tian et al. (2021)
Los Angeles, USA	4.10–6.10	Tian et al. (2021)
Hong Kong	0.21–2.43	Cao et al. (2022)
Saskatoon, Canada	0.086–1.40	Challis et al. (2021)
Trondelag, Norway	0.11–0.14	Kryuchkov et al. (2023)
Surface water		
Toronto, Canada	0.21–0.72	Johannessen et al. (2021)
Toronto, Canada	2.30	Johannessen et al. (2022)
Brisbane, Australia	<0.00005–0.088	Rauert et al. (2021; 2022)
Seattle, USA	<0.30–3.20	Tian et al. (2021)
San Francisco, USA	1.00–3.50	Tian et al. (2021)
Wastewater		
Leipzig, Germany	0.05–0.11	Seiwert et al. (2022)
Ontario, Canada	<LOD[a]–0.15[b]	Johannessen and Metcalfe (2022)

Acute Toxicity Threshold of 6PPD-Q for Coho Salmon (LC_{50} = 95 ng/L)

Nicomel et al. 2023

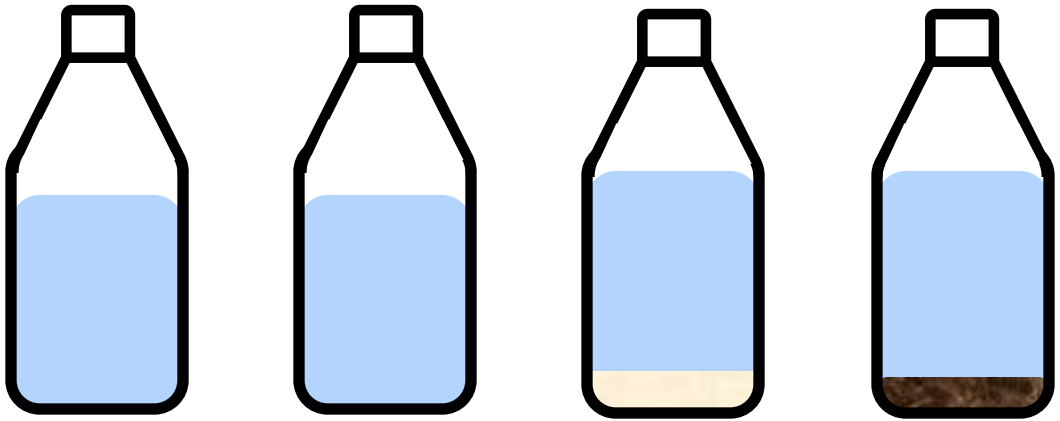
Mitigation Strategies



1. Source Reduction
   - Develop low-abrasion, durable tyre materials
   - Optimise vehicle and tyre design (lighter, better alignment)
2. Driving & Maintenance Practices
   - Promote eco-driving and proper tyre inflation
   - Regular tyre rotation check and maintenance to reduce wear
3. Road & Infrastructure Solutions
   - Use smoother, wear-resistant road surfaces
4. Capture Technologies
   - Efficient street cleaning in urban areas
   - Install filtration and drainage systems to capture TWPs
5. Policy & Research
   - Establish tyre wear emission standards and labelling
   - Support monitoring, innovation, and public awareness
6. Mobility & Urban Planning
   - Encourage public transport, cycling, and walking

Partitioning Experiment for Tyre Anti-Degradants

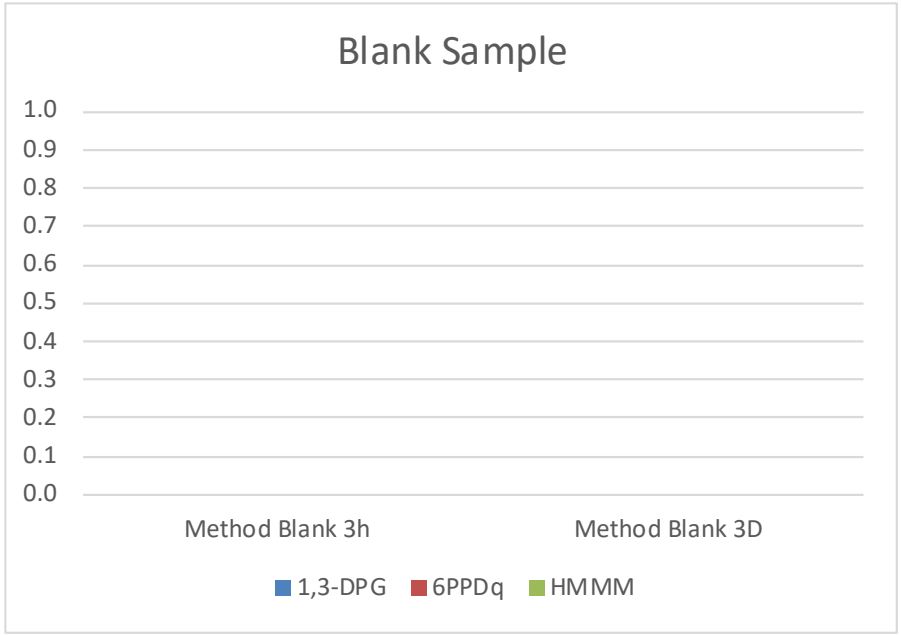
- Experimental Setup: Partitioning of Tyre Anti-Degradants

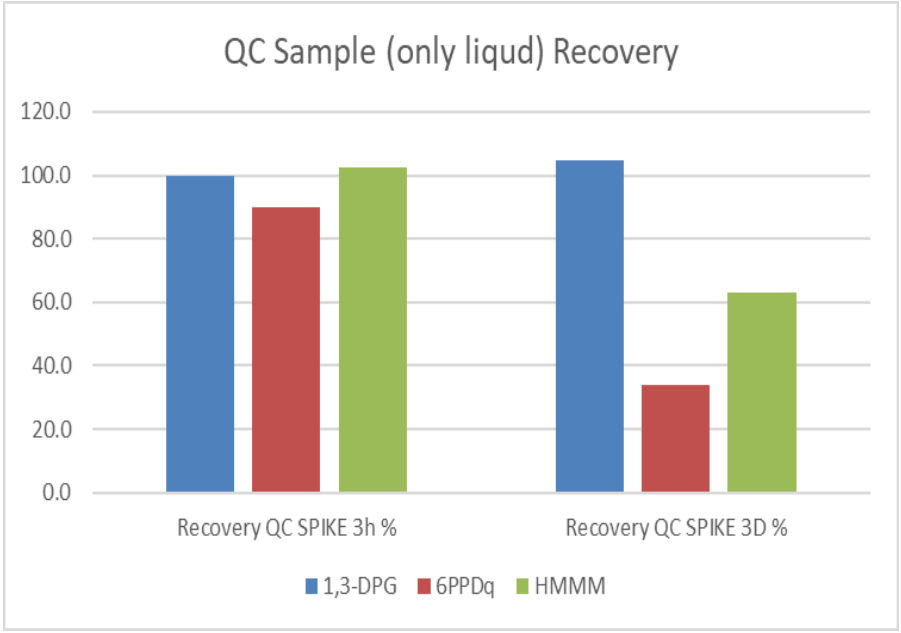


Blank | QC Sample (no solids) | 5 g acid-washed quartz sand | 5 g natural clay

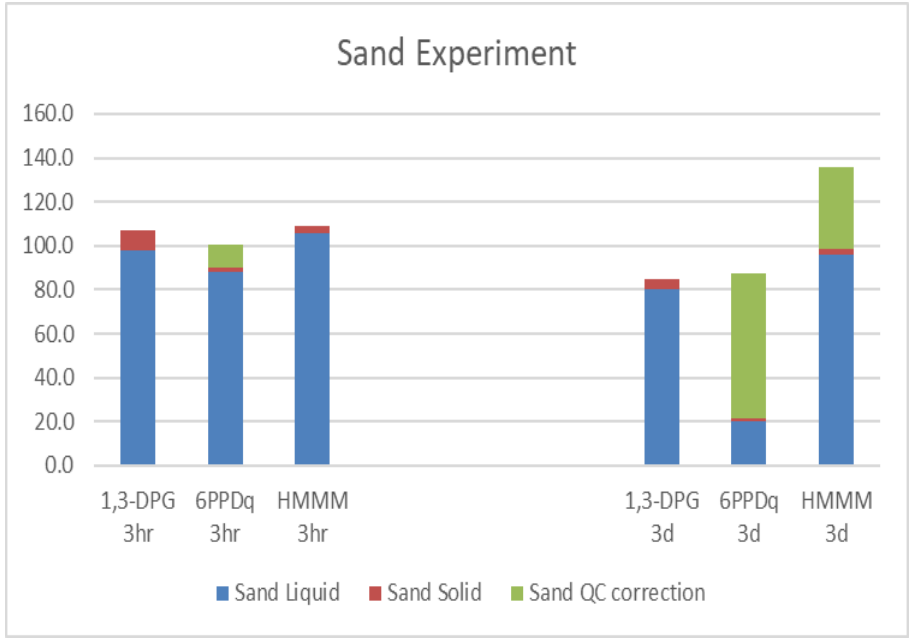
- **Experimental Setup: Sample Preparation:**
  100 mL deionised water spiked with 1,000 ng/L HMMM, 6PPD-Q, and DPG
- **Procedure:**
  - Continuous tumbling at room temperature
  - Sampling after **3 hours** and **3 days**
  - Phase separation
- **Analysis:**
  LC-MS/MS with isotope-dilution for quantification

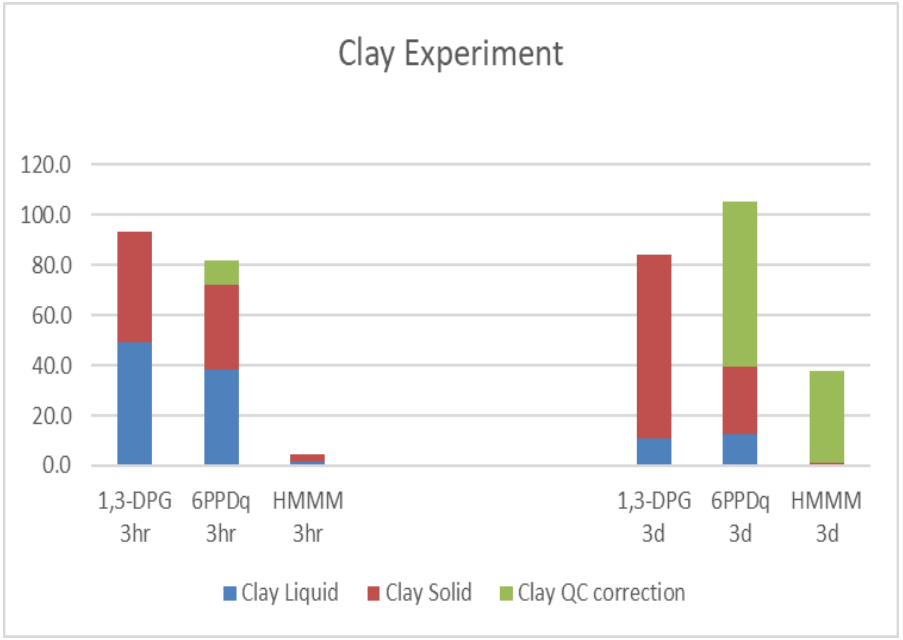
Partitioning Experiment for Tyre Anti-Degradants





Partitioning Experiment for Tyre Anti-Degradants





What's Next – Building Resiliency

- Insights on pollutant-soil interactions guide better stormwater treatment designs
- Clay-rich soils can effectively trap contaminants, reducing their mobility in stormwater
- Future research:
  - Long-term fate of contaminants in real environments
  - Regeneration and disposal of saturated filters
  - Development of more durable tyres with less tyre additives to reduce pollution

Thank you very much for you attention

Julia Jäger
Technical Specialist at Eurofins
Environment Testing - AUS/NZ