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Research insights into how complex mixtures of urban pollutants affect aquatic organisms and ecosystems

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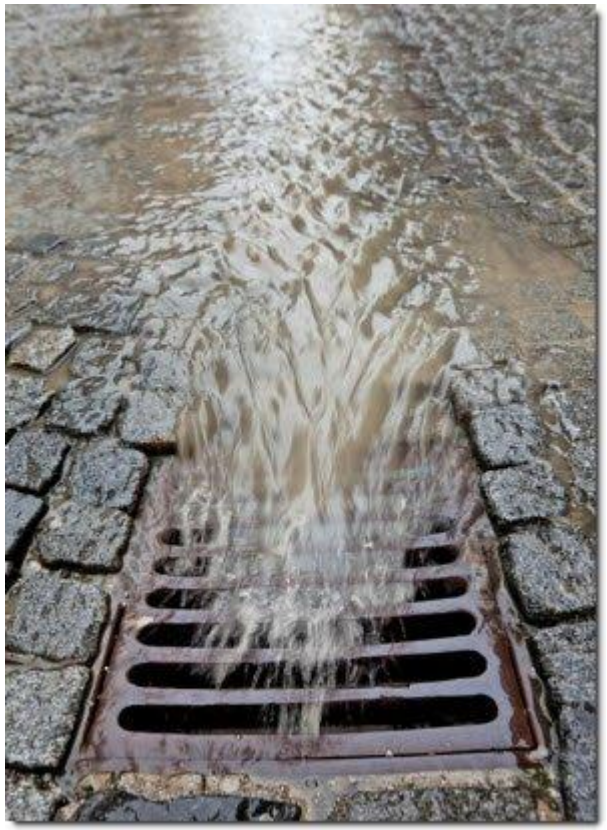
Webinar: PAN Europe – Urban Pollution

Date: 10 December 2025

Why Urban Runoff Matters

- Urban runoff = major source of pollution in rivers and estuaries
- Often *untreated and unregulated*
- Across England, over 18 000 motorway and trunk-road outfalls (Stormwater Shepherds UK & CIWEM, 2024).
- likely over a million local highway drains (Stormwater Shepherds UK & CIWEM, 2024)



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What's in Road Runoff?

Well-known pollutants (WFD regulated):

- Heavy metals (e.g., zinc, lead)
- Hydrocarbons (e.g., oil, fuel)
- Pesticides
- *Polycyclic Aromatic Hydrocarbons (PAHs)*

Pollutants of emerging concerns:

- *Microplastics*
- *Tyre-Derived Pollutants (TDPs)*

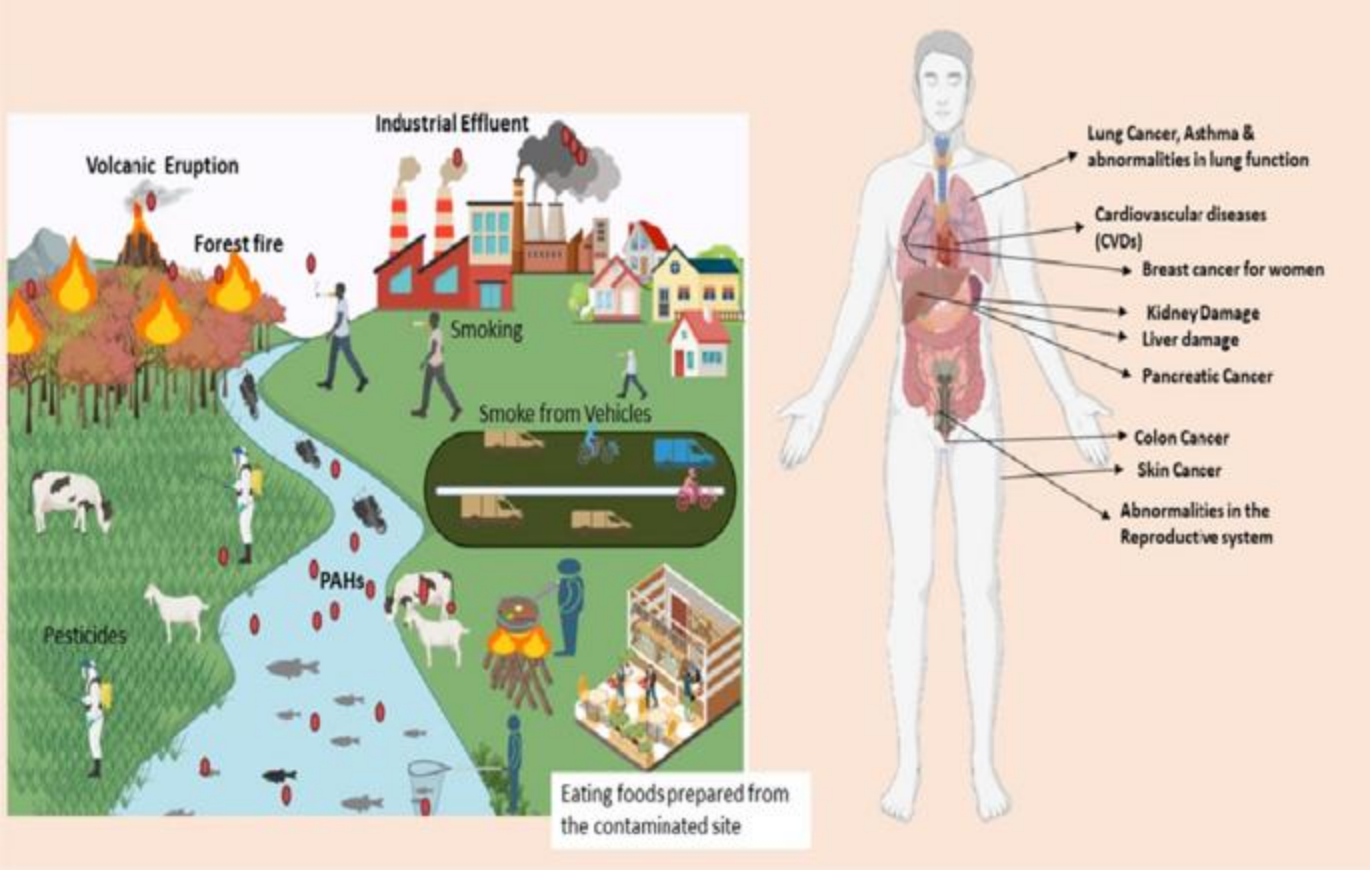

Figure 1: Hazards of PAH Janarthanam, V. A., Issac, P. K., Guru, A., & Arockiaraj, J. (2023). Hazards of polycyclic aromatic hydrocarbons: a review on occurrence, detection, and role of green nanomaterials on the removal of PAH from the water environment. *Environmental Monitoring and Assessment*, *195*(12), 1531.

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Why TDPs Matter

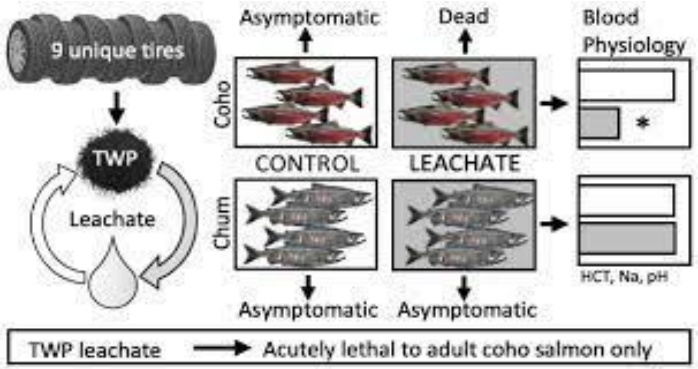

Fig. 1: Toxicity of TWP leachate. (McIntyre *et al.,* 2021)

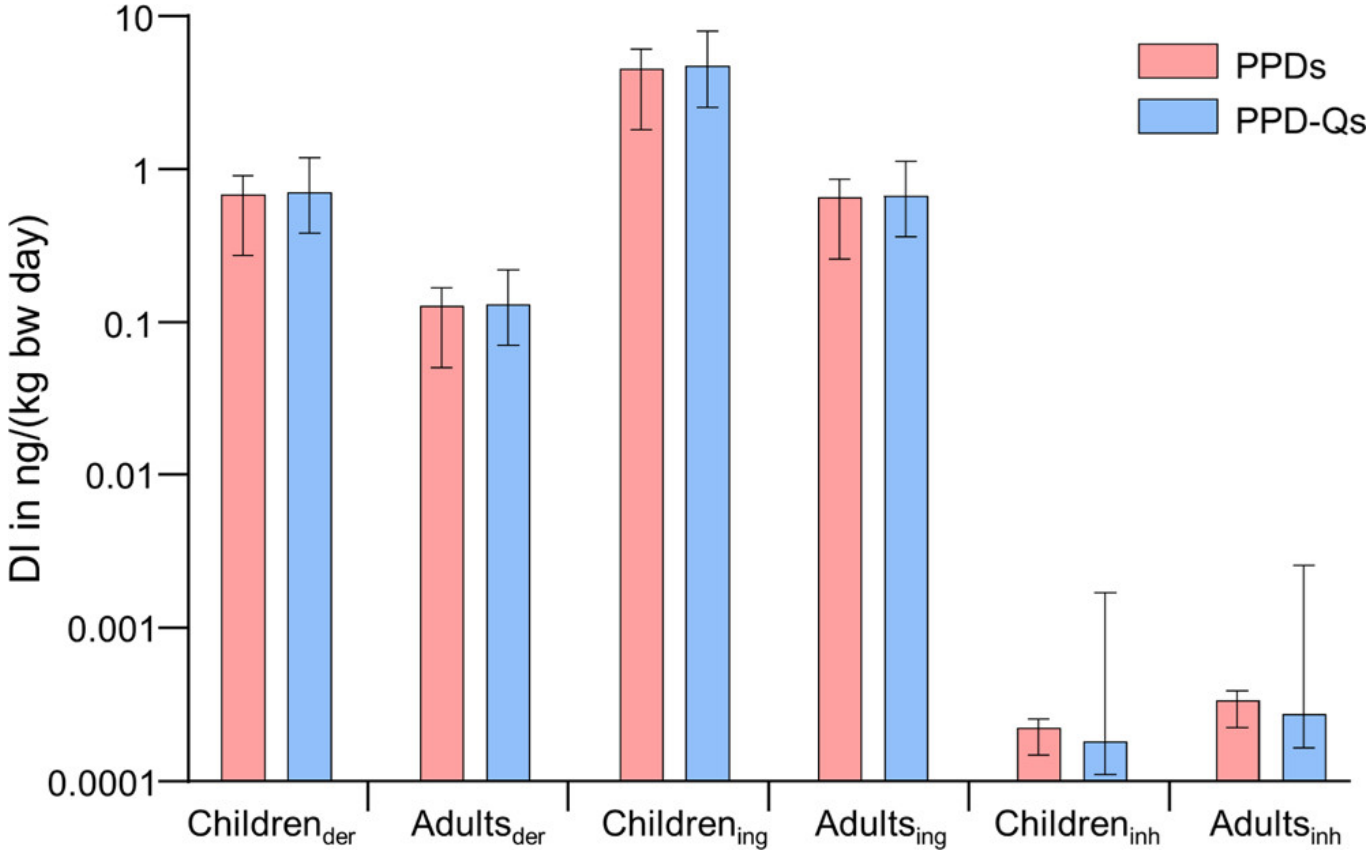

Figure 3. Daily intake rates of PPD antioxidants and PPD-Qs *via* dermal absorption, oral ingestion of roadside soils, and inhalation of outdoor air for adults and children in Hong Kong. (Guodong Cao et al., 2022).

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Understanding the issues

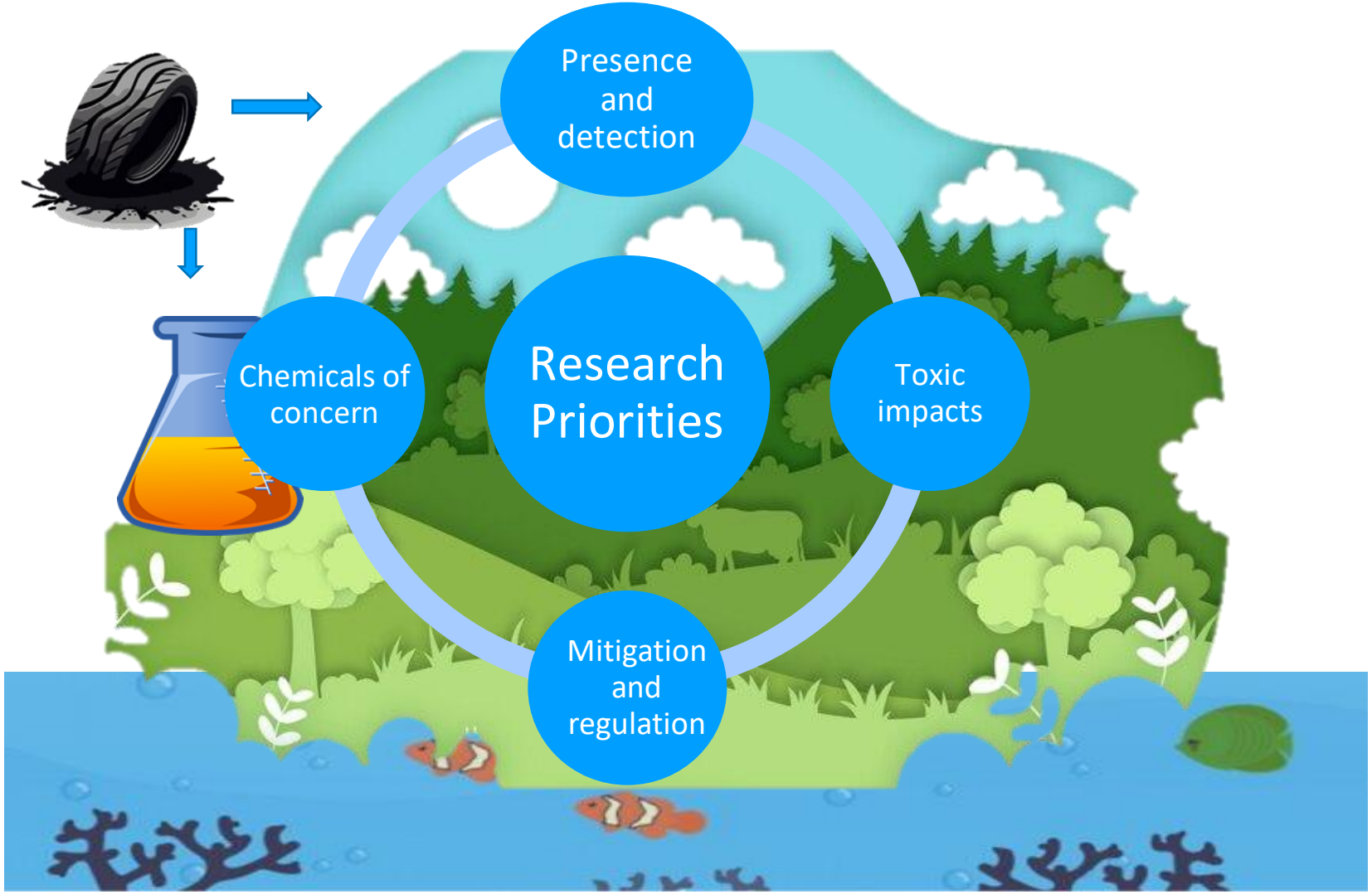

Fig: Output of scoping workshop

International Effort: Multidisciplinary team of experts from the UK, Norway, USA, Australia, South Korea, and more.

Impact: Research priorities aim to reduce uncertainty, inform policy, and establish sustainable regulations

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Note: You may wish to refer to item 9 and item 10 on the UPRBA.

Tracking Pollution in Urban Estuaries: The Solent Case Study

- Real-world complexity: runoff + tidal mixing + legacy pollution
- Mixture exposure via sediments, water, biota
- Risk assessments often focus on single substances but aquatic life is exposed to cocktails of contaminants

Fig: Satellite image of Solent

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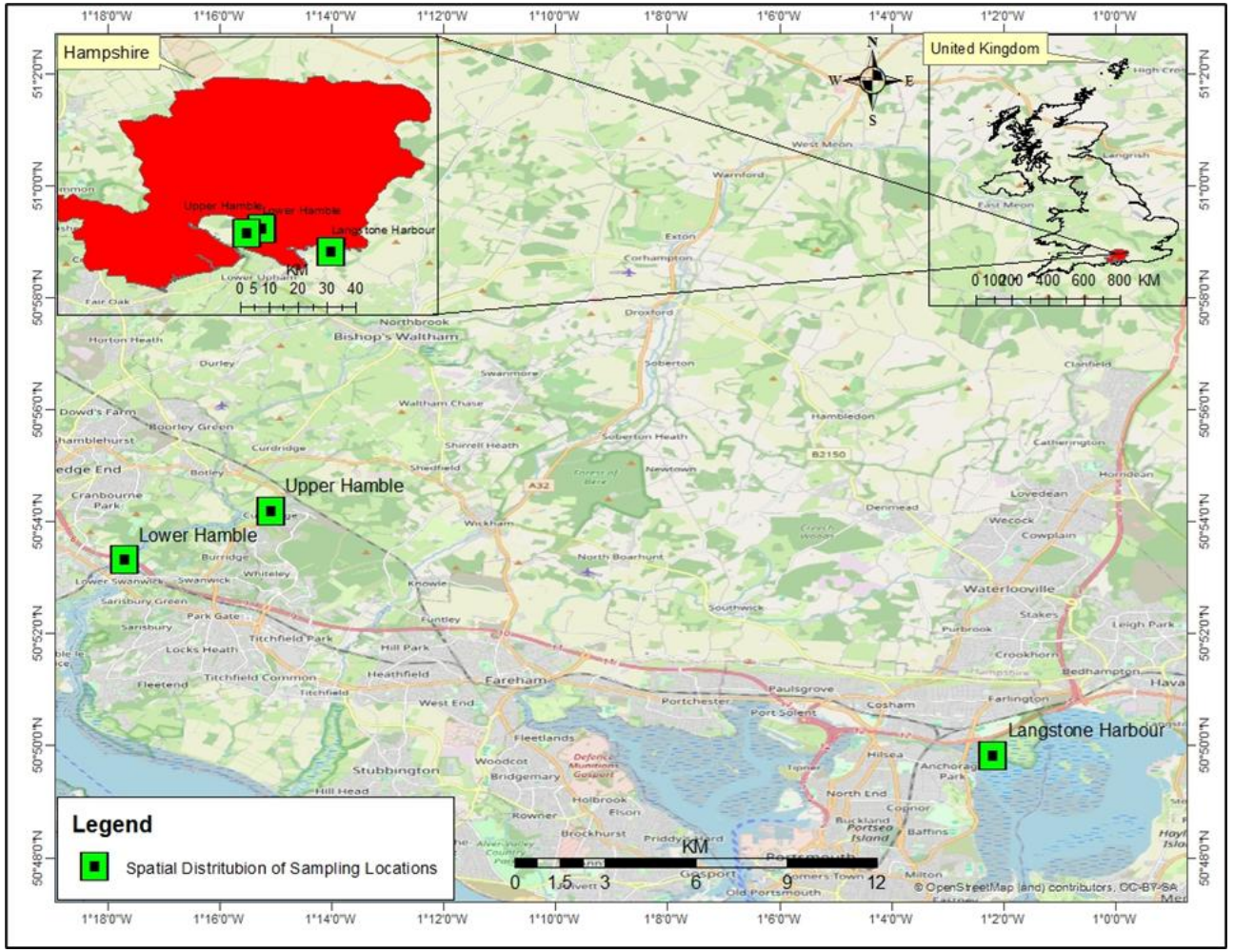
Sampling locations



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Non-Target Analysis Results For Tire compounds

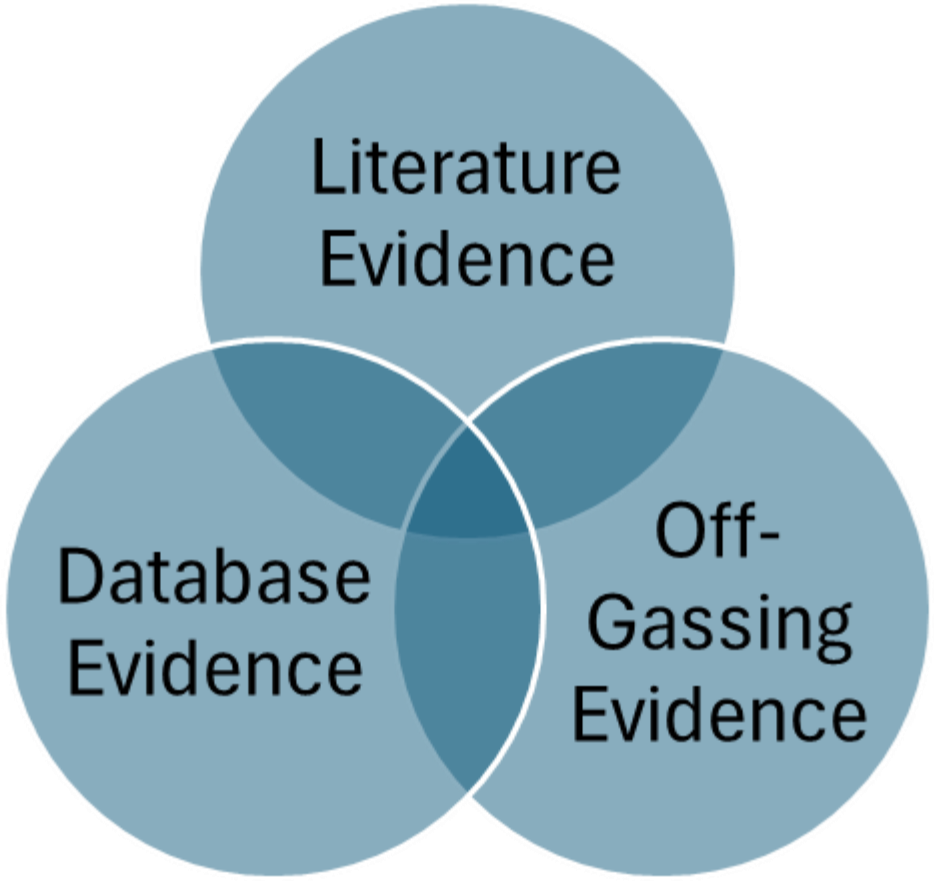

Figure: Integrating Multiple Sources to Identify Tyre-Related Chemicals

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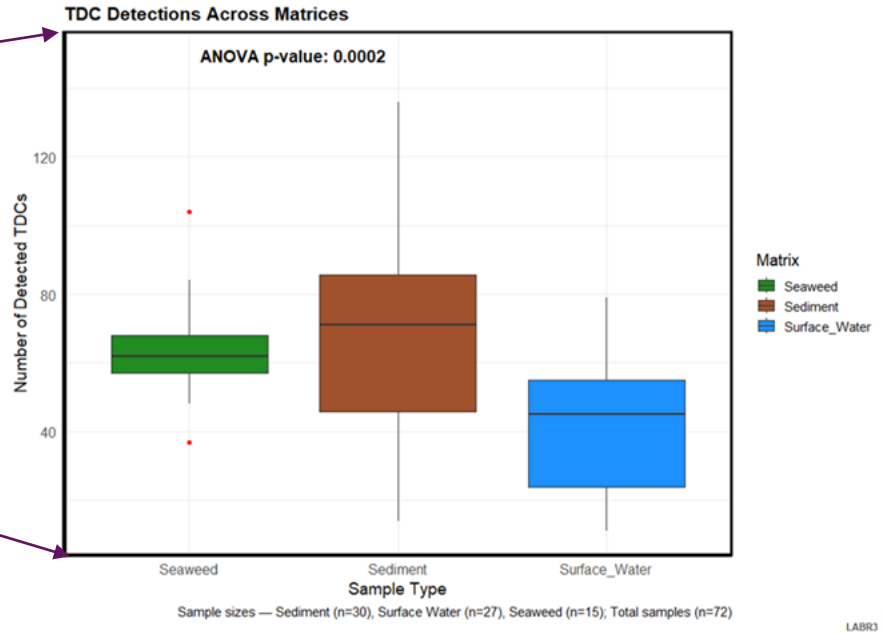
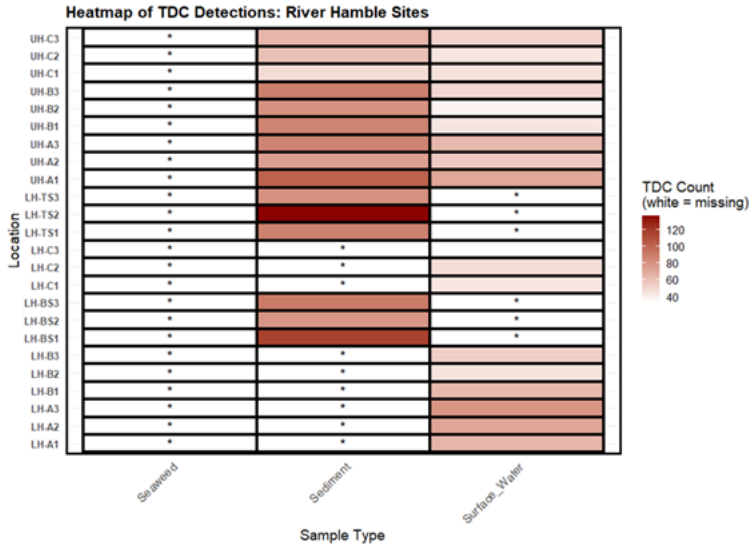
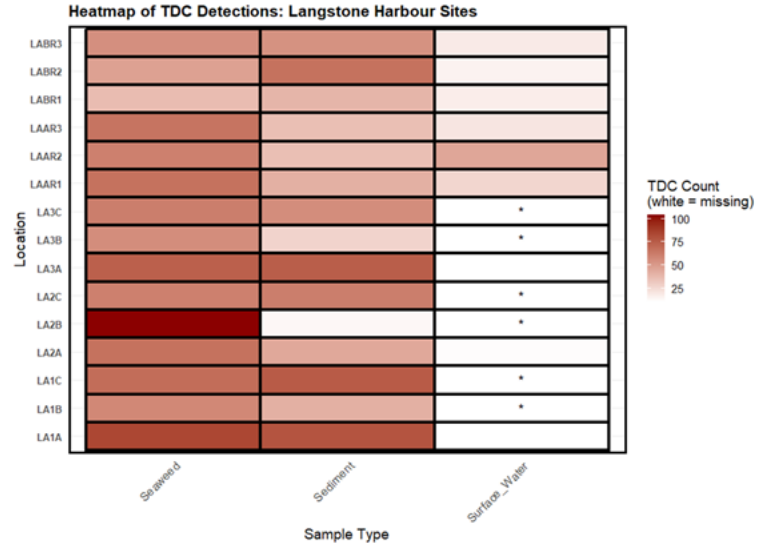
Non-Target Analysis Results For Tire compounds







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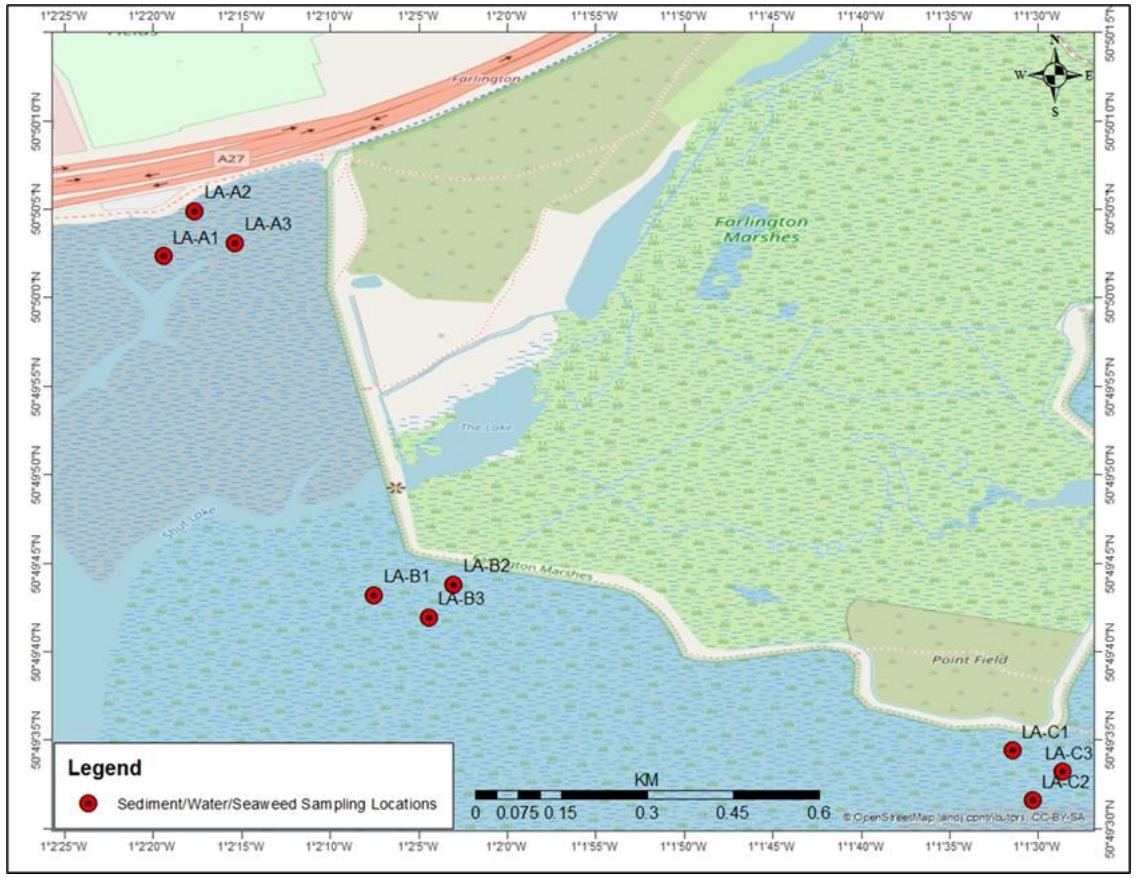
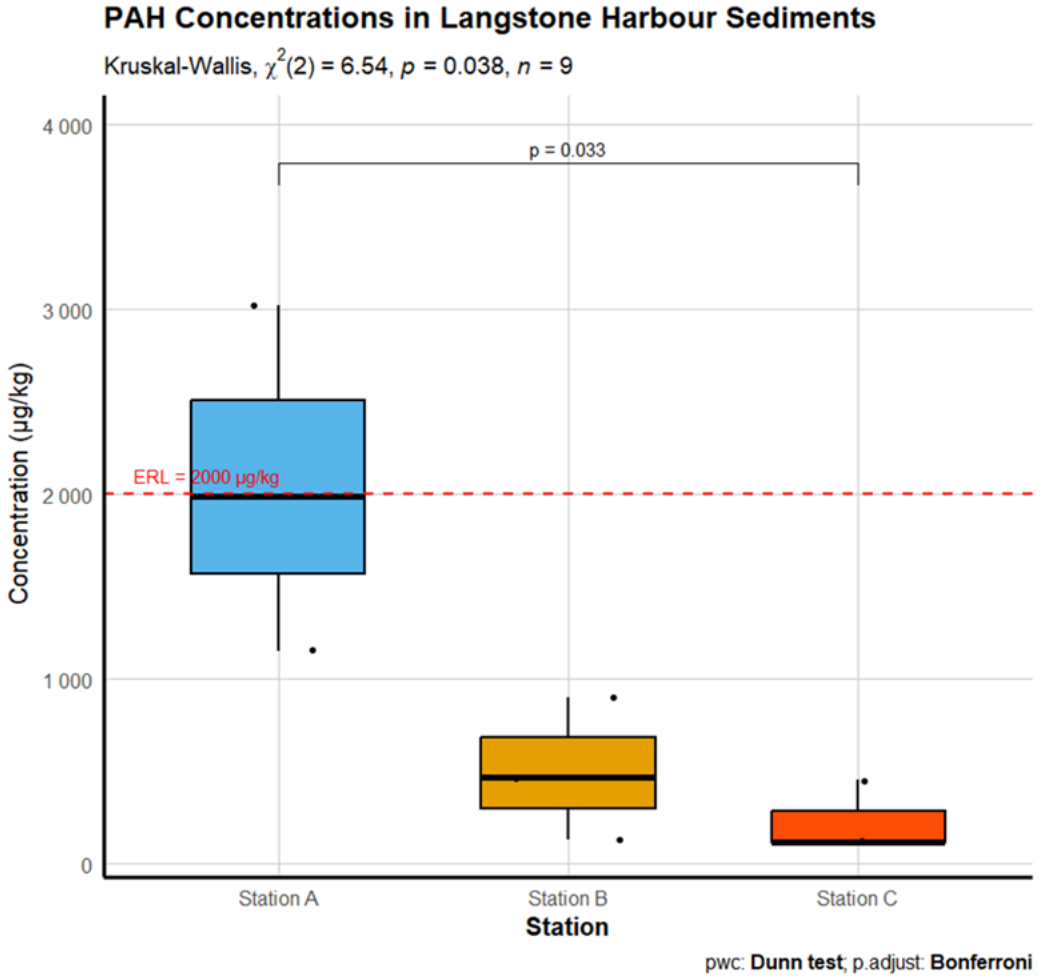
TARGET ANALYSIS RESULTS FOR PAHs (Sediment)





❑ **Significant impact of road runoff seen**

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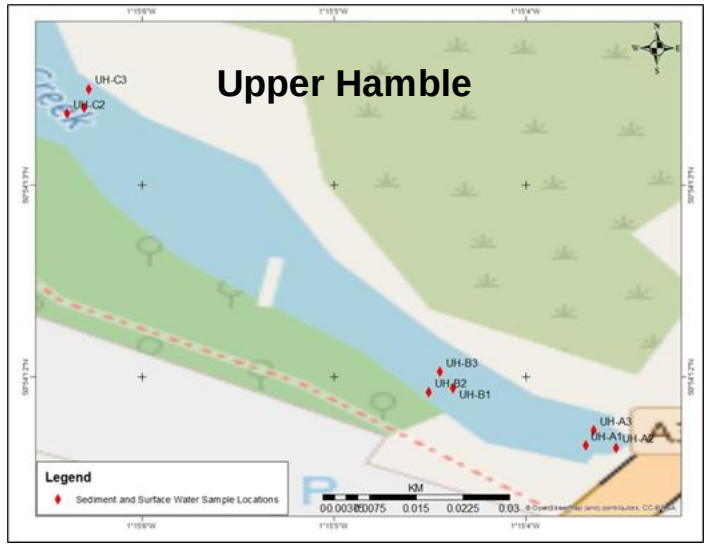
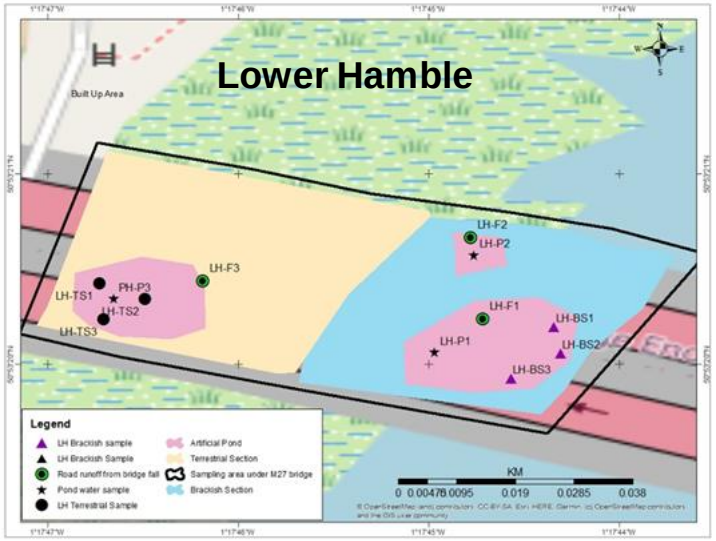
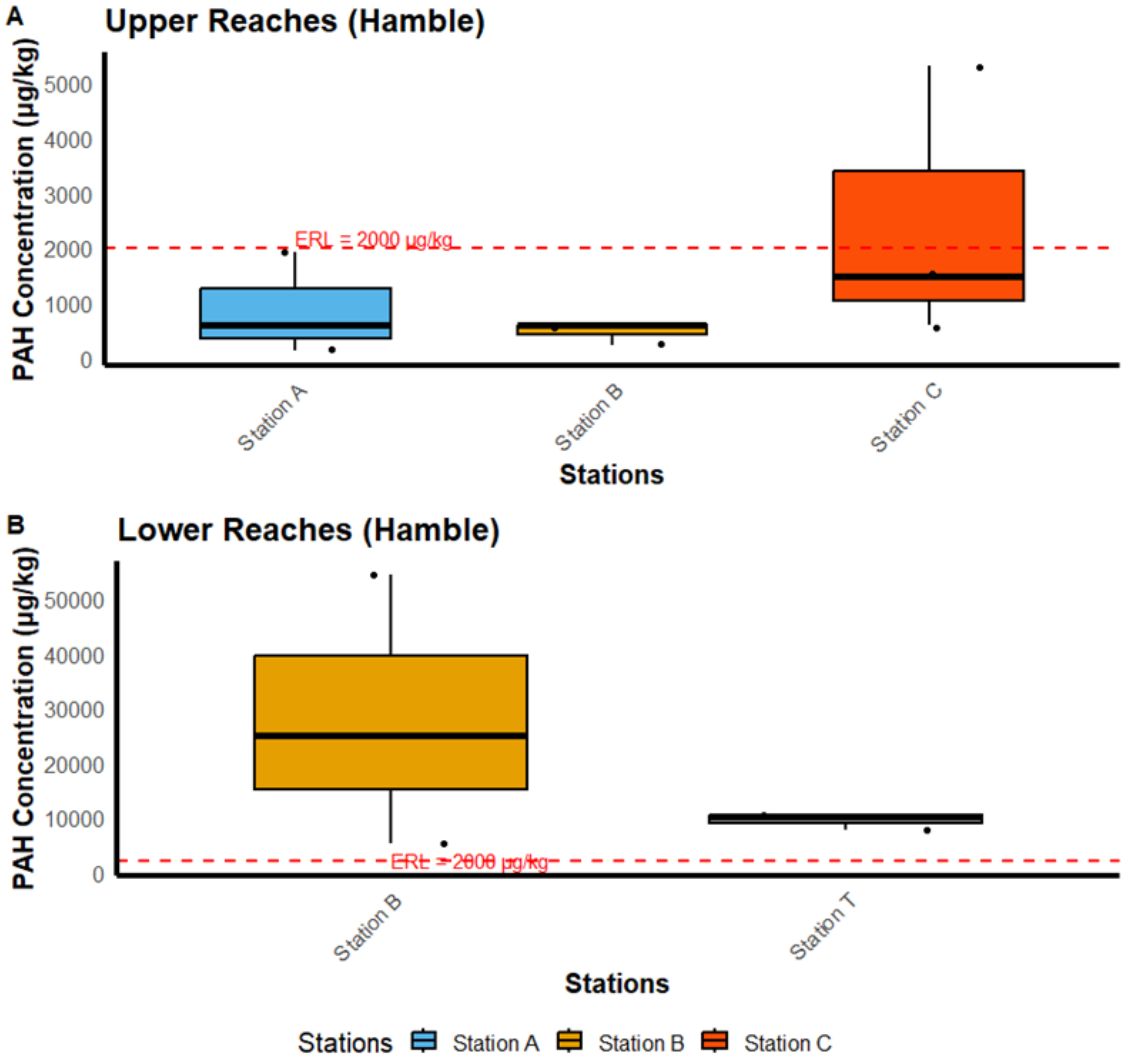
TARGET ANALYSIS RESULTS FOR PAHs (Sediment)







❑ **Significant impact of road runoff seen**

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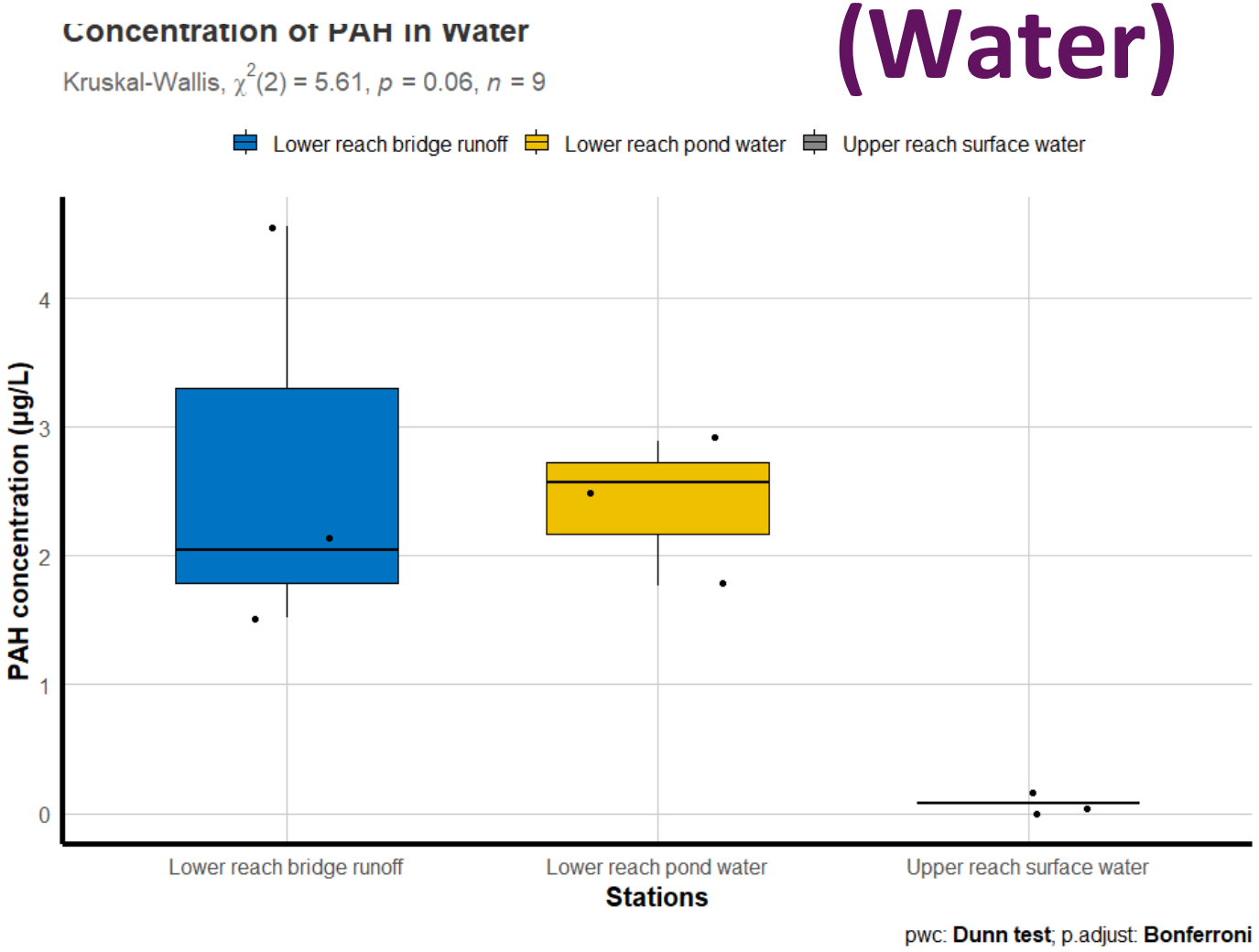
TARGET ANALYSIS RESULTS FOR PAHs (Water)



Components Exceeding Environmental Quality Standards (EQS):

- **Fluoranthene** exceeded the EQS of **0.0120**.
- **Benzo(b)fluoranthene** and **Benzo(k)fluoranthene** exceeded their EQS of **0.0170**.
- **Benzo(a)pyrene** exceeded its EQS of **0.2700**.
- **Benzo(g,h,i)perylene** exceeded the EQS of **0.0082**

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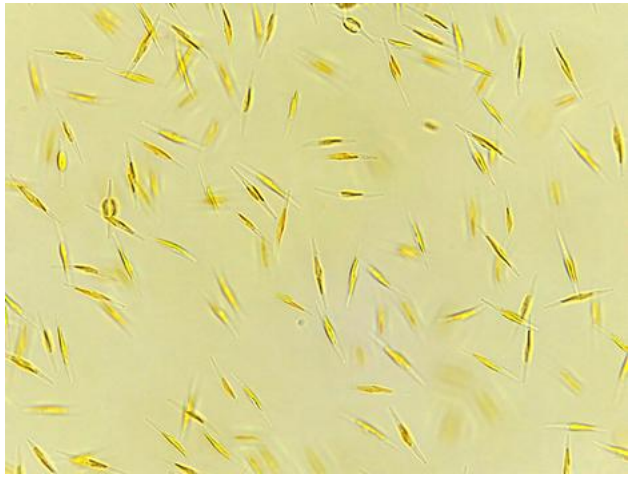
Tire compounds toxicity on Algae

First study to report EC50 for *Phaedactilum Tricornutum (Obanya et al., 2025)*



Toxicity Ranking: DPG (most toxic) > MBT > 6PPD-Q (least toxic)

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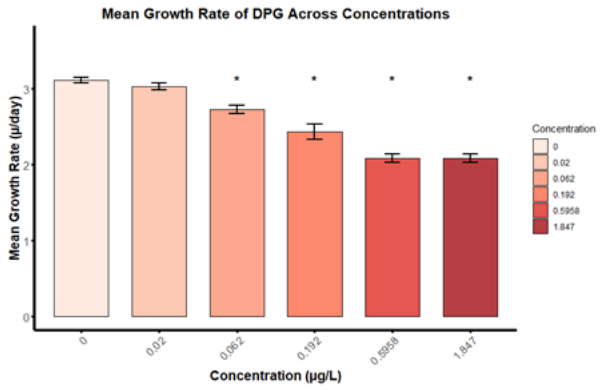

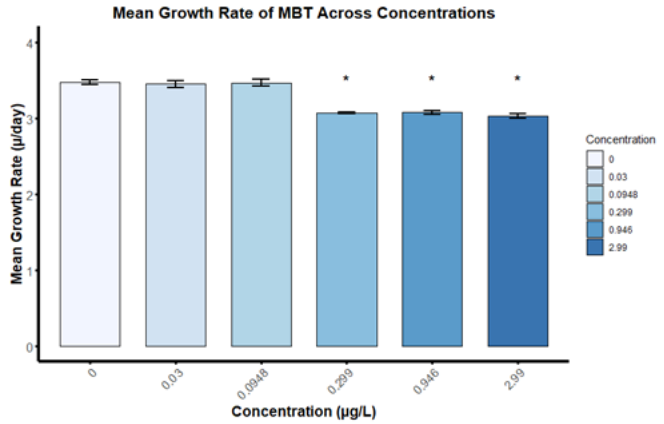

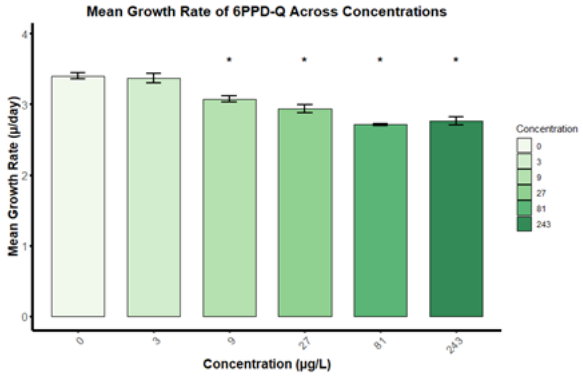

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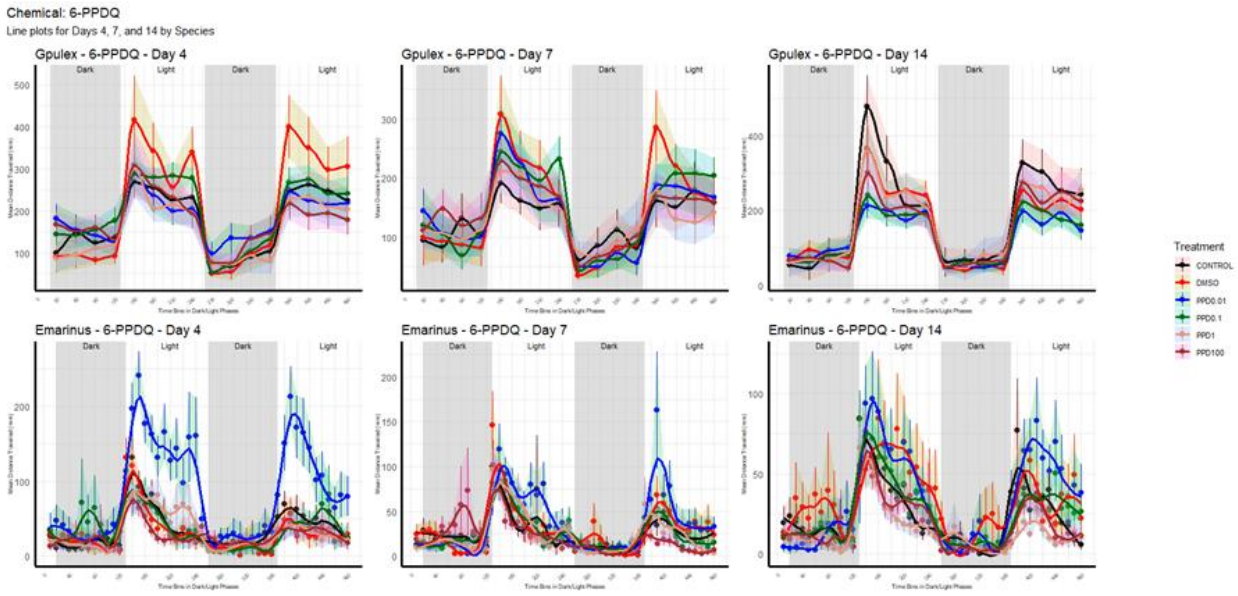
Tire compounds effects on Amphipod

First study to report behavioural effects in Amphipods



Pollutant	PNEC (Freshwater)	PNEC (Marine)	Observed NOEC	Observed LOEC	Species	Effect
DPG	1.05 µg/L	3 µg/L	0.1 µg/L	0.01 µg/L (Day 4 – Second Dark; Day 14 – First Dark)	*G. pulex* (Freshwater)	Inhibition/Hyperactivity
			NA	0.01 µg/L (Day 4 – First Dark and Second Light; Day 7 – First and Second Dark)	*E. marinus* (Marine)	Consistent inhibition
6PPD-quinone	0.000095 µg/L	N/A	NA	NA	*G. pulex* (Freshwater)	Insignificant effect
				0.01 µg/L (Day 4 – First Light)	*E. marinus* (Marine)	Hyperactivity
MBT	4.1 µg/L	0.08 µg/L	NA	0.01 µg/L (Day 14 – First Dark)	*G. pulex* (Freshwater)	Inhibition
			NA	0.01 µg/L (Day 4 – First Dark; Day 7 – Second Dark; Day 14 – First and Second Dark)	*E. marinus* (Marine)	Inhibition (*except Day 14 – First Dark: Hyperactivity*)

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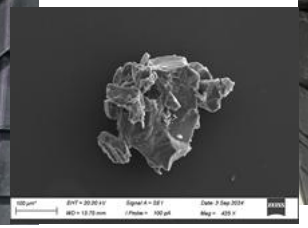
Validating a Tire emissions database through Ecotoxicological testing



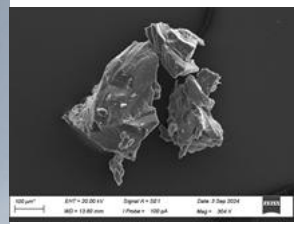


Fig: Contisportcontact (Ctire) and Laufenn (Ltire) before and after micronization

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Methodology

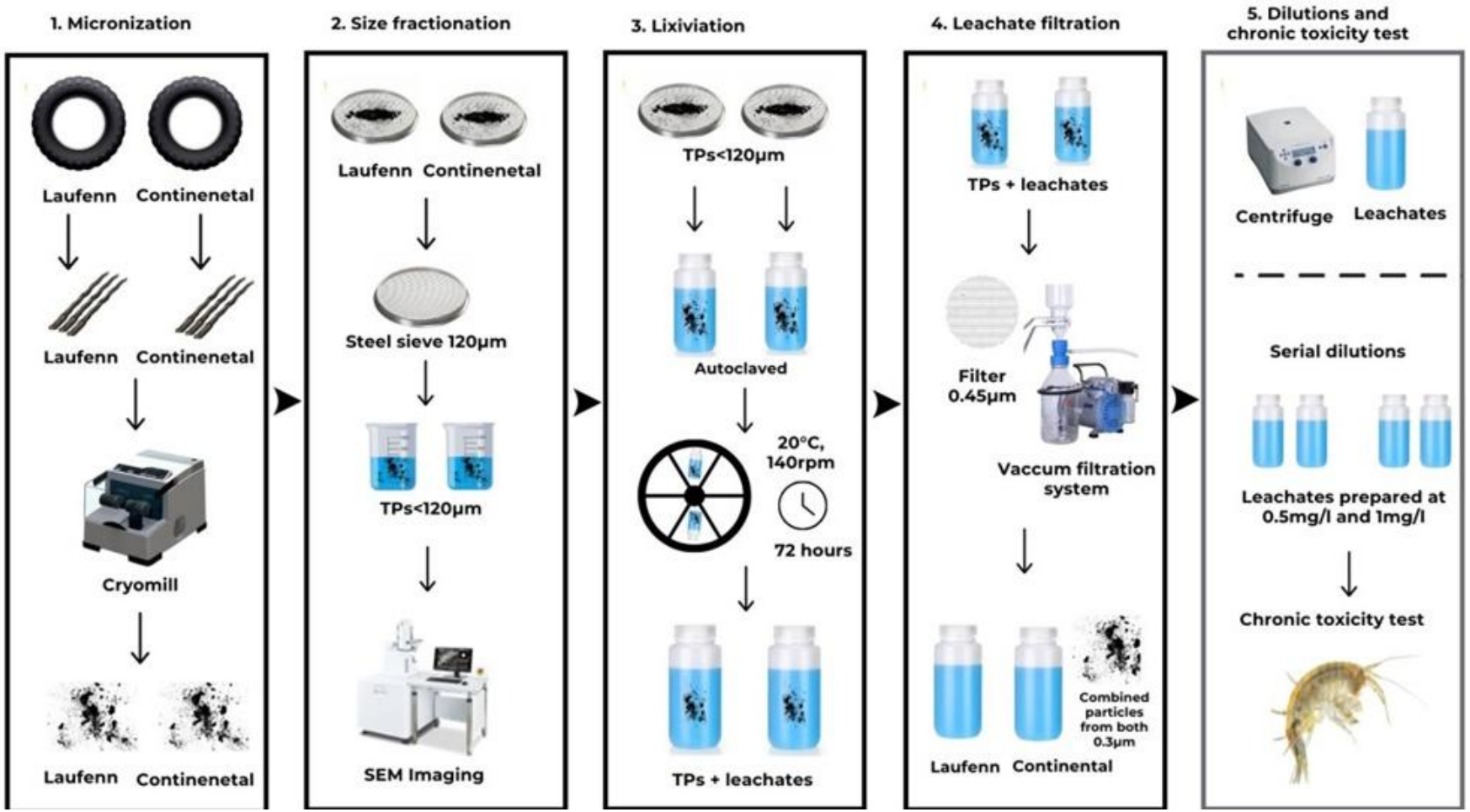

Fig. 1. Overview of leachate generation. Adapted from (Bournaka et al., 2023), based on a protocol by (Almeda et al., 2023). Created and modified using canva,

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Results

Database Predictions vs Observed Toxicity

- **Prediction**:
  - Database ranked L-tire as more toxic based on its higher chemical hazard score.
  - C-tire expected to have lower aquatic impacts.

- **Validation Outcomes** →

- **Mortality and Moulting**:
  - No statistically significant differences across treatments.
  - L-tire trends: Slightly higher mortality (20%) and moulting frequency (40%) at 1 mg/L.

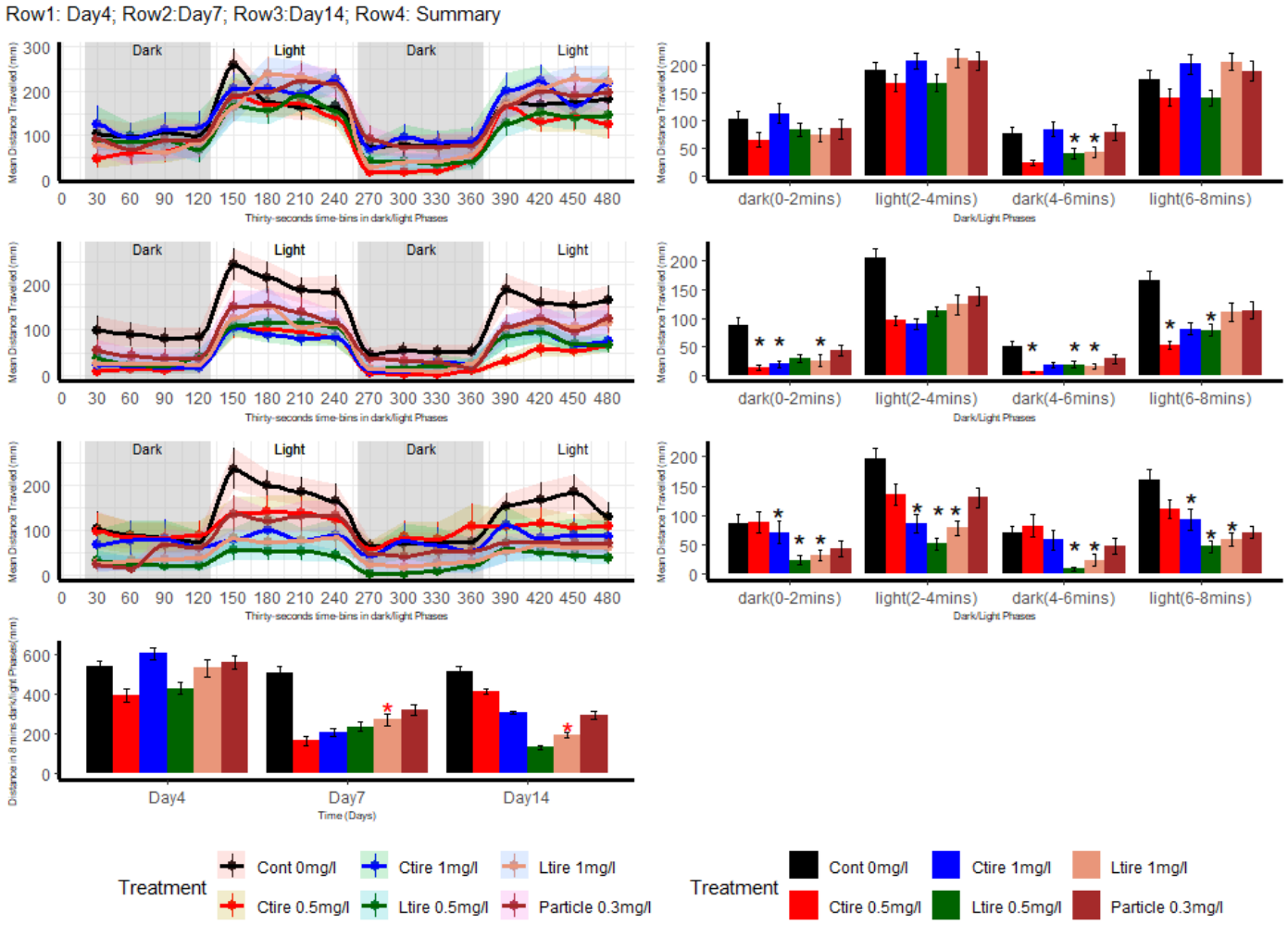

Figure 2: Time-Dependent Behavioural Responses of *Gammarus pulex* to Tire Leachates and Particles Across Light and Dark Phases

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Methodology

Fig: Micronization

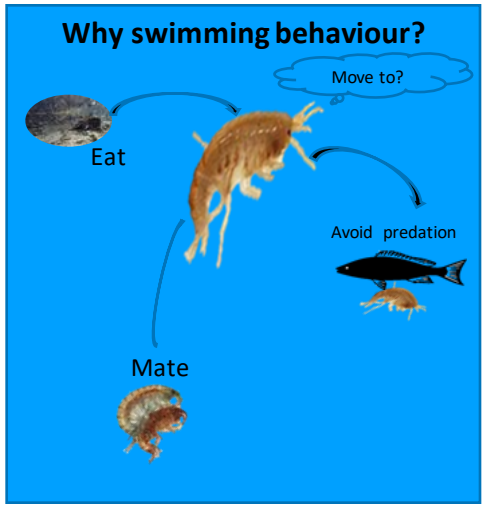

Fig: G. Pulex sampling

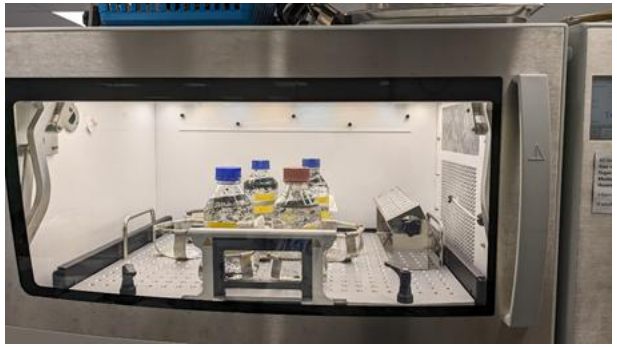

Fig: Lixiviattion and Leachate Filtration

Fig: Exposure experiment to G. pulex completed.

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Discussion

Environmental Monitoring & Contaminant Trends

- PAH analysis showed fluoranthene, benzo(a)pyrene, and other pollutants exceeding EQS limits.
- Seaweed, sediment and water contamination suggest high persistence and bioaccumulation potential.

Toxicity Study on Algae & Amphipods

- First study to report EC50 for *Phaeodactylum tricornutum*, confirming tire leachate toxicity.
- Amphipods exhibited reduced swimming activity indicating sub-lethal behavioral effects.

Key Takeaways

- Changes in behaviour = impacts on food web, reproduction, biodiversity
- “Invisible” sublethal effects can lead to long-term ecosystem decline
- Mixtures may disrupt multiple species at once

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Conclusion - Call to Action

We Need to Manage Urban Runoff as a Complex Hazard

Call for:

- **Mixture-based regulation**
- **Stormwater monitoring frameworks**
- **Inclusion of tyre & road pollutants in EU watchlists**
- **Support for ecotoxicological validation of screening databases**

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THANK YOU FOR YOUR ATTENTION

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