Simulated leaching and photodegradation of tire tread particle-derived compounds in natural water

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Tire wear particles (TWP)

- Microplastics found in stormwater and roadway runoff leads to surface water pollution

Pristine, cryomilled tire tread particles
32.2 um ± 25.5 um

Tires and road surface interaction

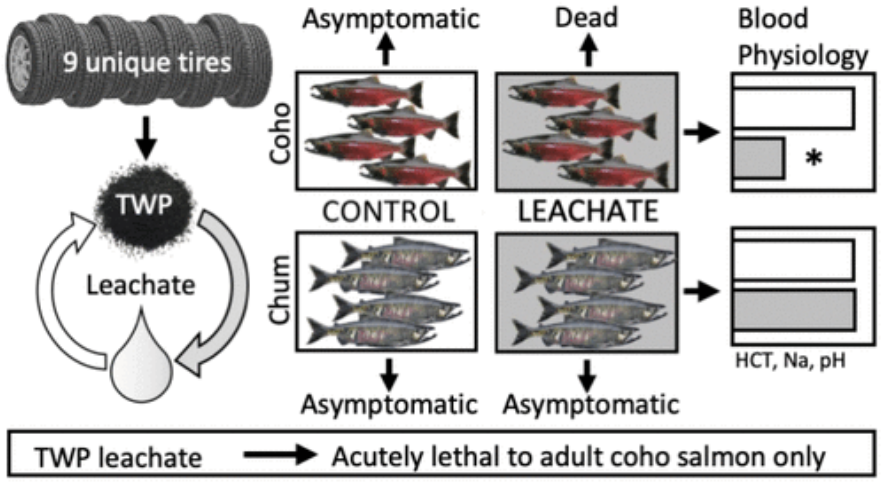
Shear force → Release of **coarser** particles (PM10)

Evaporation of volatile content → Release of **finer** particles (PM2.5, PM 0.1)

Kim & Lee, 2018; Wagner et al., 2018

TWP-derived compounds

- Leachate resulted in coho salmon death (McIntyre et al., 2021)
- **6PPD-Quinone** associated with mortality



McIntyre et al., 2021

NOAA

TWP-derived compounds

- Which chemicals leach from TWP?
- How rapidly do chemicals leach under sunlight? What is their persistence?

Oregon Department of Forestry

TWP suspended in water

Methods

❖ TOC Analysis

- Dissolved organic carbon (DOC) and total dissolved nitrogen (TDN)

TOC Analyzer

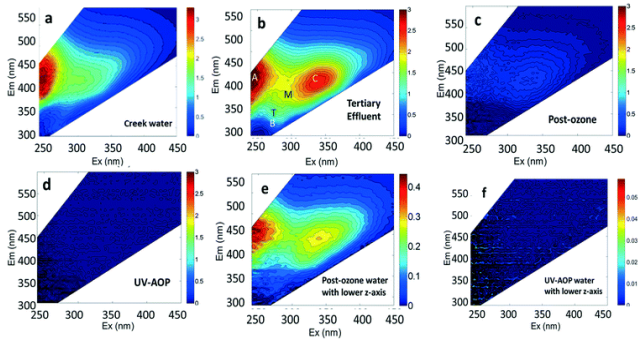
❖ Experimental Setup

- TWP
- Lab-created freshwater (low DOC)
- Sunlight or dark conditions

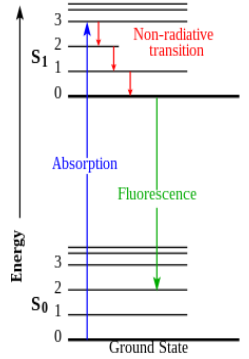
Solar Simulator

❖ Fluorescence spectroscopy

- Many trace organics are fluorescent
- Technique: 4 mL sample in cuvette; non-destructive

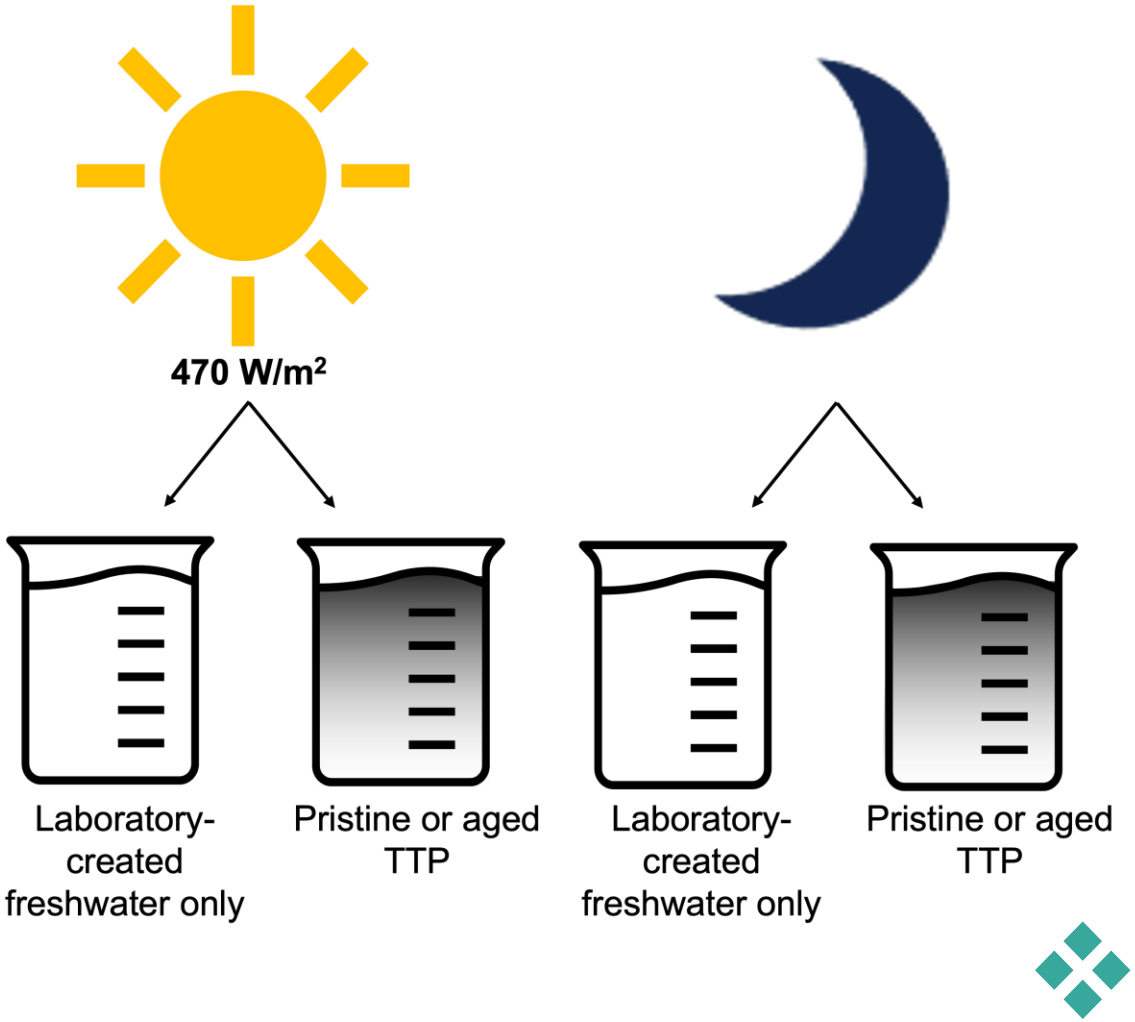


Three-dimensional excitation emission matrices (3D EEMs) of different water types (Wasswa et al., 2019)



Jablonski diagram

Leaching TWP under photoirradiation

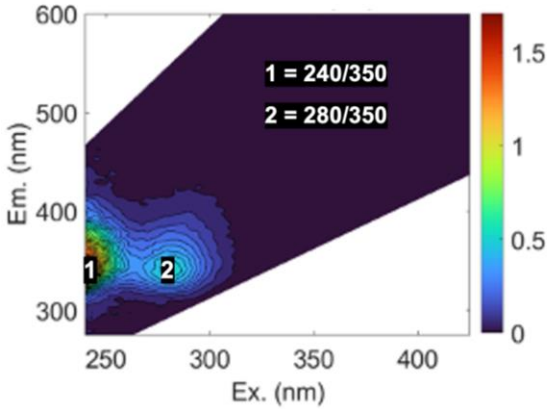


Samples (10 g/L) and controls inside the Solar Simulator

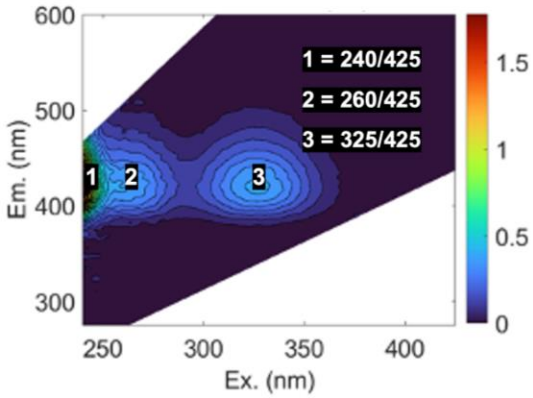
TWP-specific compounds

- **Cyclohexanamines** = used in rubber manufacturing
- **Quinolines** = nitrogenous heterocyclic aromatic compounds

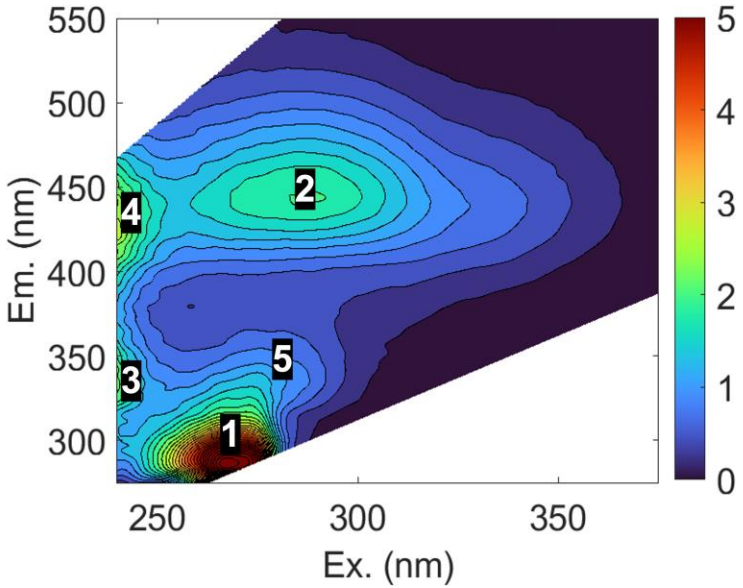
Cyclohexanamine, N-cyclohexyl-



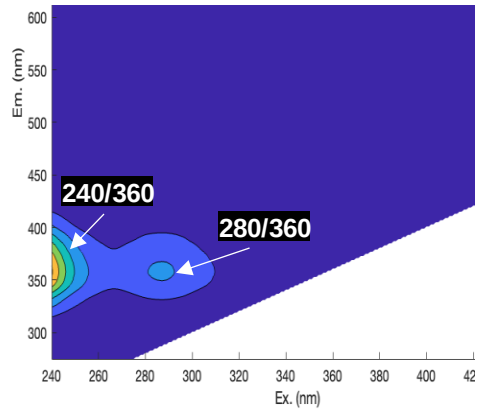
Quinoline, 1,2-dihydro-2,2,4,-trimethyl-



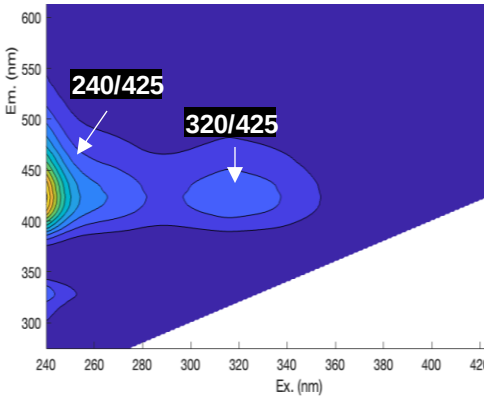
TWP Leachate



Peaks 3 and 5



Peak 4



TWP leachate photodegradation

Step 1

Leach TWP in laboratory-made freshwater (low DOC) for 1 and 6 days in dark conditions

Step 2

Filter TWP suspensions to remove particles

Step 3

Combine leachates (dissolved compounds in water) without particles

Step 4

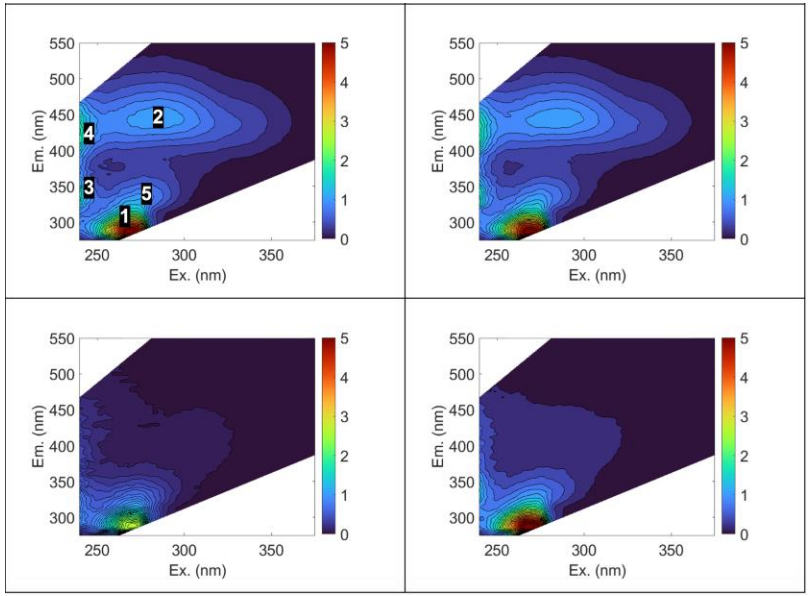
Track degradation of compounds using fluorescence spectroscopy

Solar Simulator

TWP leachate photodegradation

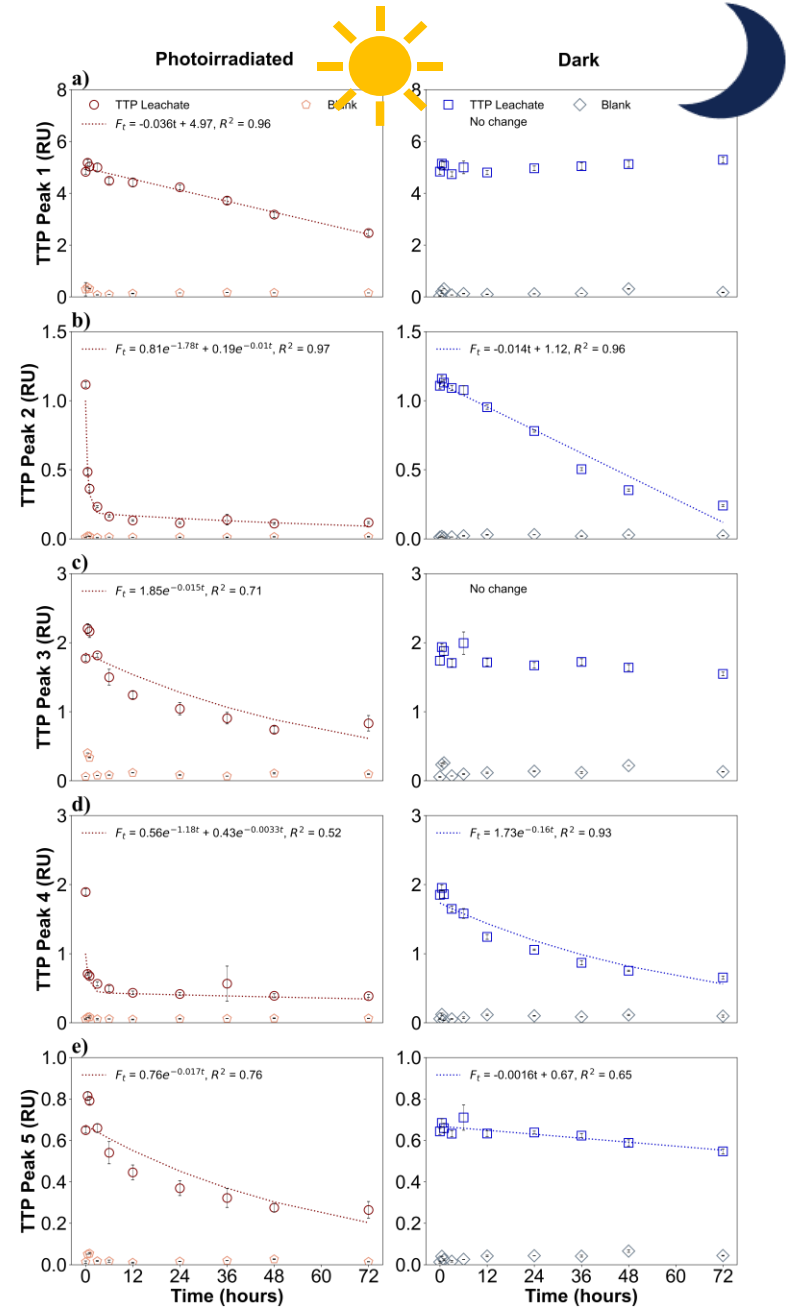
0 hours

3 days



Pristine TWP leachates

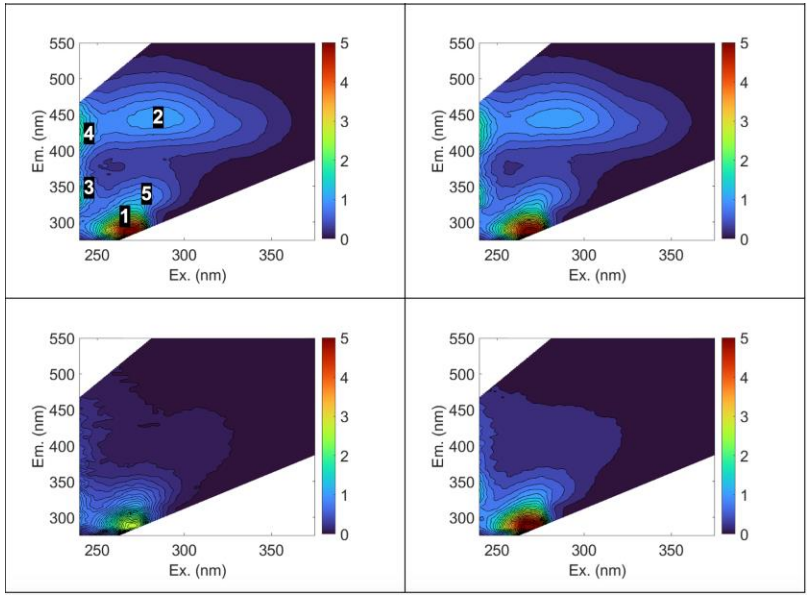
Fastest degradation



TWP leachate photodegradation

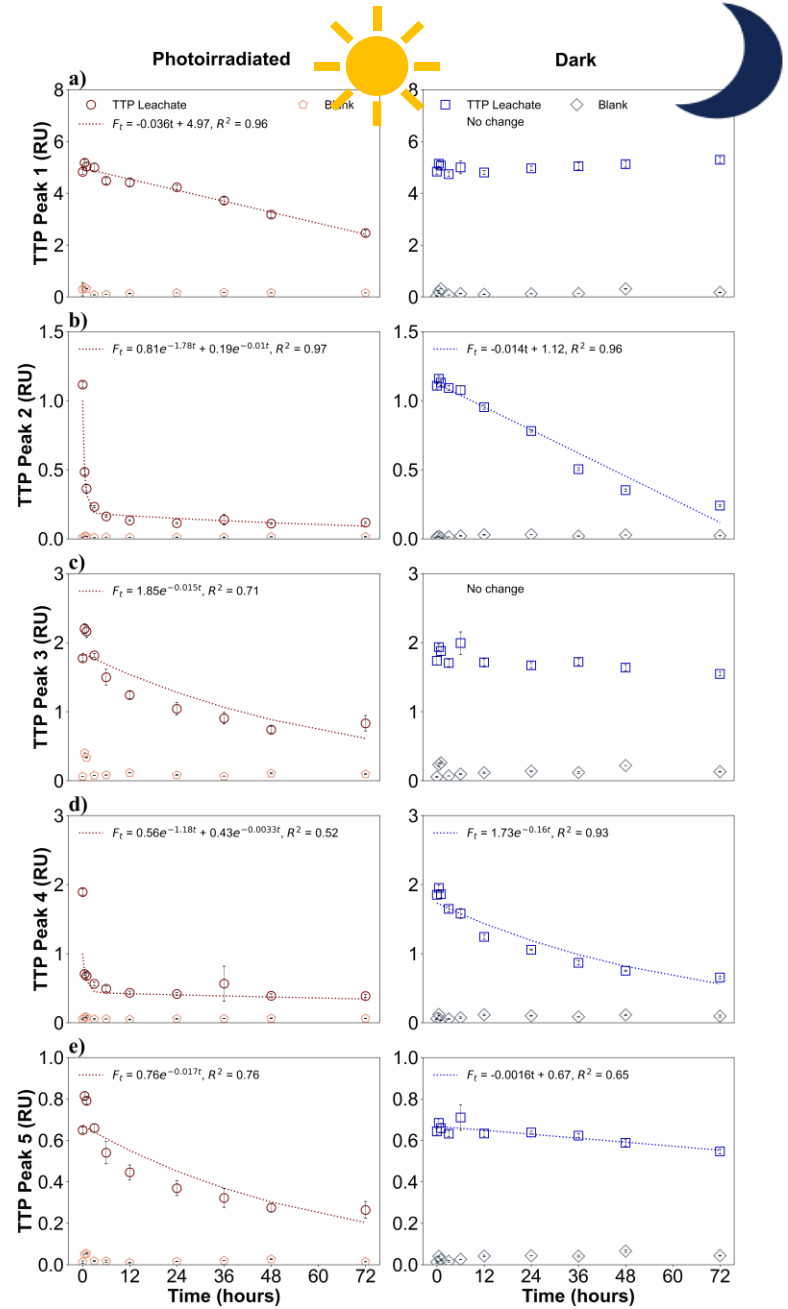
0 hours

3 days



Pristine TWP leachates

Slowest degradation



Conclusions

- In under 24 hours, most compounds leach from TWP in water
- Compounds can be photo-labile, persistent, or volatile
- TWP-specific compounds can be tracked with fluorescence
- *Next steps*: identify additional compounds that were rapidly degraded or persisted under sunlight

Thank You

We thank CSU COAST for funding this research and overall project completed in collaboration with researchers in SDSU School of Public Health.