Assessment of airborne emissions from tire wear: Insights into ultrafine particle distribution

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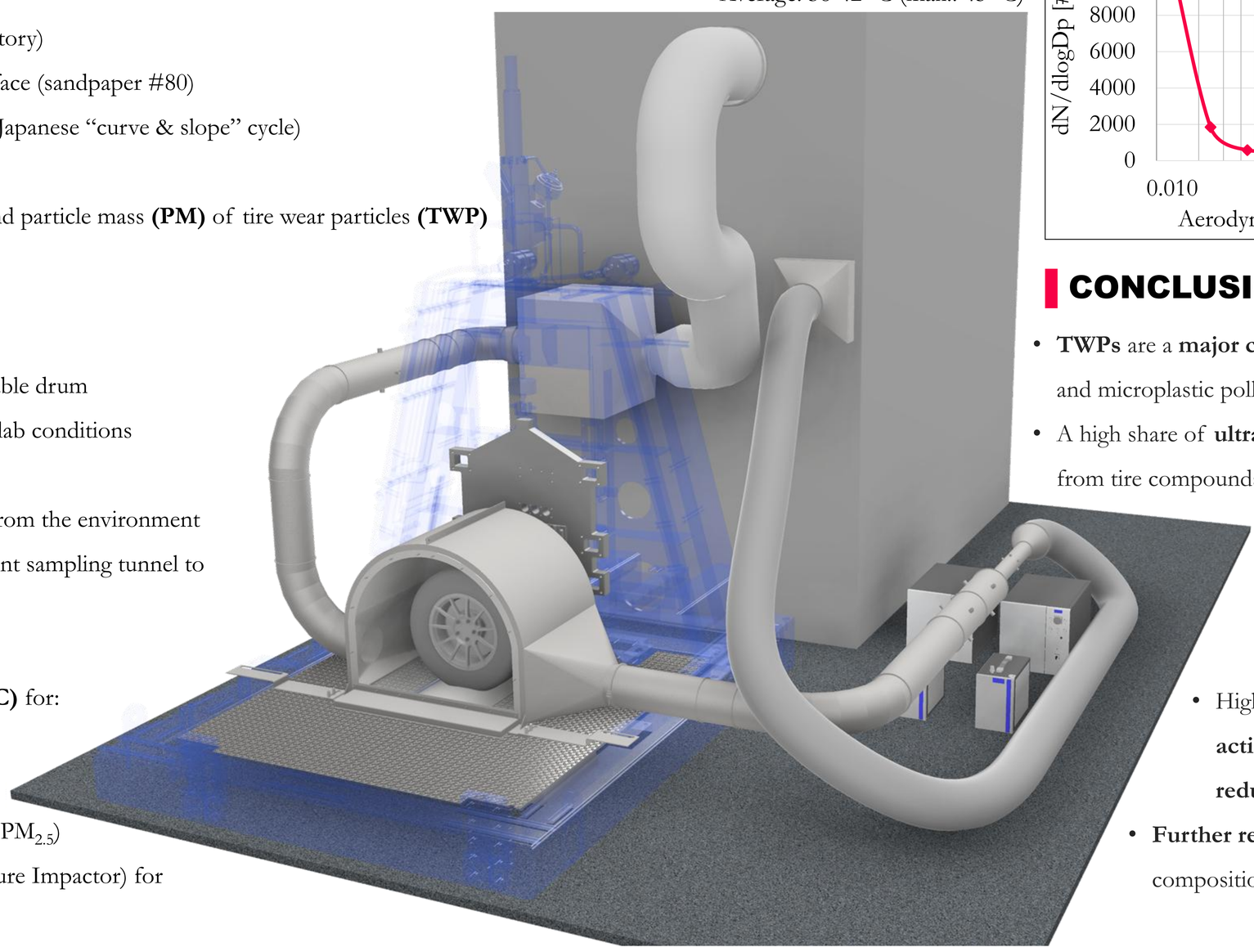
INTRODUCTION

- **Shift in emission sources:**
  - Exhaust emissions have decreased significantly due to regulations
  - **Non-exhaust** sources now make up **>85%** of vehicle emissions [1]
- **Tire particle characteristics:**
  - Larger fragments (> 10 µm) → environmental **microplastics** [2]
  - Airborne fractions (PM_{10}) → **inhalable, health-relevant** [3-5]
    - < 400 nm particles → enter bloodstream
    - < 100 nm particles → may reach the brain
- **Regulatory response:**
  - UNECE Task Force on Tyre Abrasion **(TFTA)** standardized procedure for **tire abrasion** measurement [6]
    - Convoy method (on-road)
    - **Indoor drum method** (laboratory)
      - 5,000 km test on rough surface (sandpaper #80)
      - **"JASIC-Cycle"** (WLTC + Japanese "curve & slope" cycle)
- **Objective of our study:**
  - Quantify particle number **(PN)** and particle mass **(PM)** of tire wear particles **(TWP)**

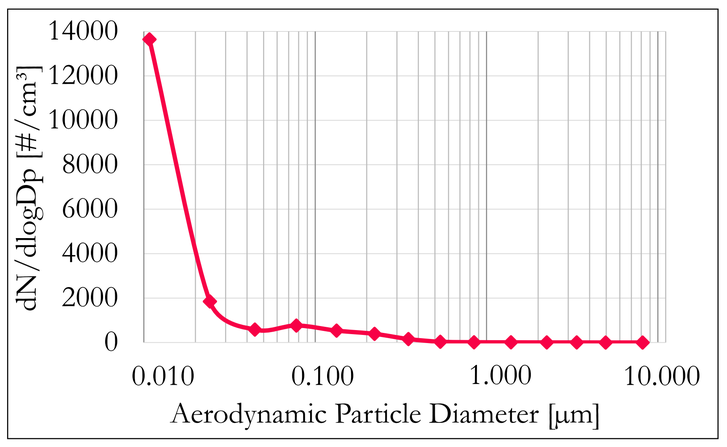
METHODS

- **Test setup:**
  - Outer drum test bench with steerable drum
  - **"JASIC-Cycle"** under controlled lab conditions
- **Enclosure system:**
  - **Tire enclosure** to isolate TWPs from the environment
  - **GTR-24** (brake emission) compliant sampling tunnel to measure airborne particles
- **Measurement instruments:**
  - **2 × AVL Particle Counters (APC)** for:
    - Total Particle Number (TPN)
    - Solid Particle Number (SPN)
  - **2 × AVL PM Samplers (**PM_{10} & $PM_{2.5}$)
  - **1 × ELPI+** (Electrical Low-Pressure Impactor) for particle size distribution



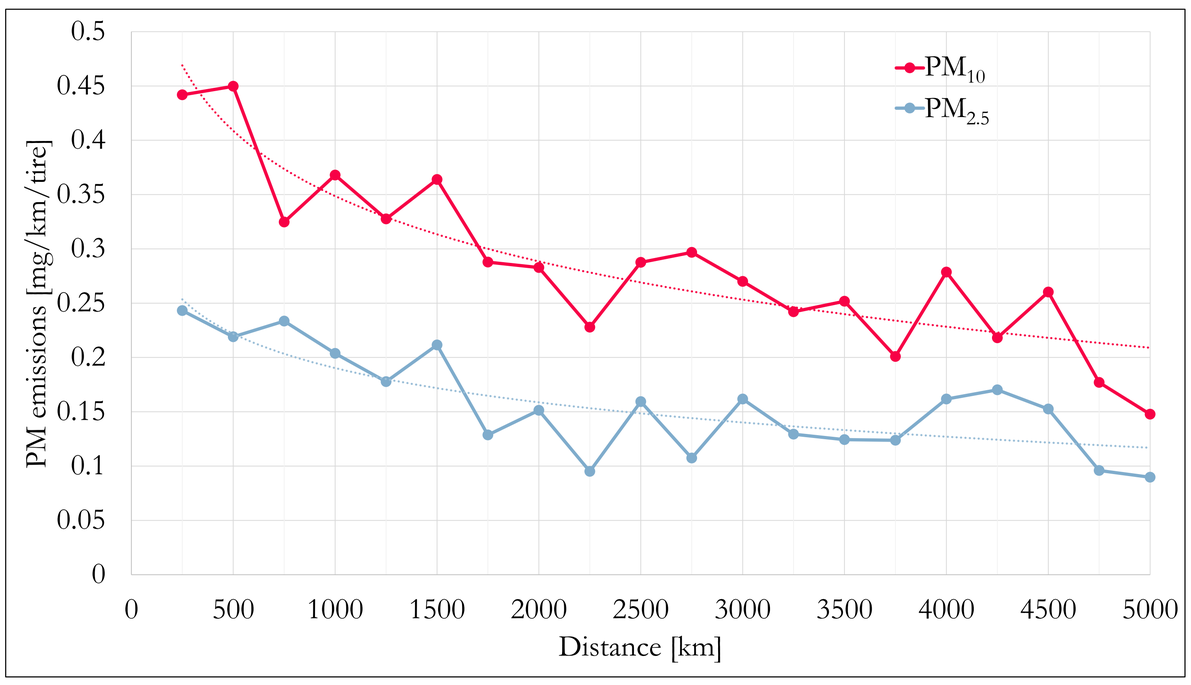
RESULTS

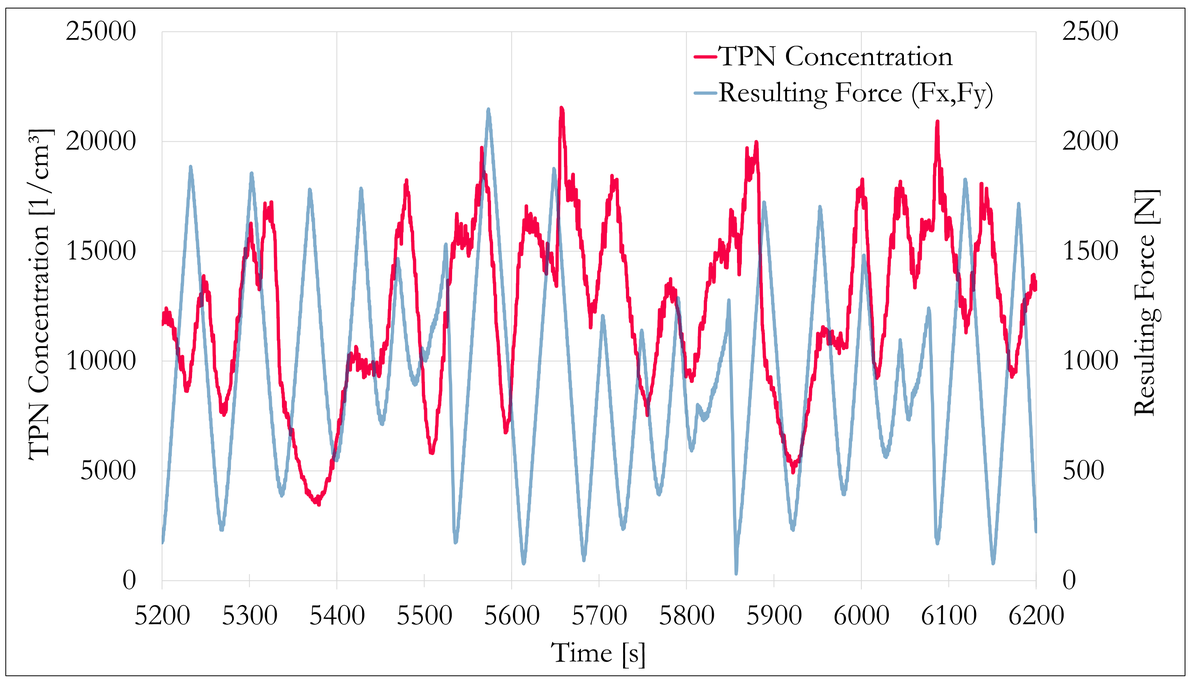
- **TPN vs. SPN:**
  - TPN concentrations over 10× higher than SPN throughout the 5,000 km cycle
    - Indicates a large proportion of **volatile particles**
      - **Evaporation of tire compound material** at elevated temperatures
  - Correlation between PN and force is still under investigation
- **PM10 & PM2.5:**
  - **Running-In phenomenon** similar to tire wear and brake emissions behavior
- **Size distribution:**
  - Majority of particles in the **ultrafine range** (< 100 nm)
  - Minor peak around 100 nm
- **Tire temperature:**
  - Average: 38-42 °C (max.: 45 °C)



CONCLUSION

- **TWPs** are a **major contributor** to non-exhaust emissions and microplastic pollution
- A high share of **ultrafine, volatile particles (< 100 nm)** from tire compounds (e.g., oils, resins) was observed
  - The advanced test setup, aligned with **GTR-24** protocols, enabled accurate PN and PM measurements
  - Highlights the **need for regulatory actions** and innovative tire designs to **reduce TWP emissions**
- **Further research** is essential to understand the composition, behavior, and mitigation of TWPs





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