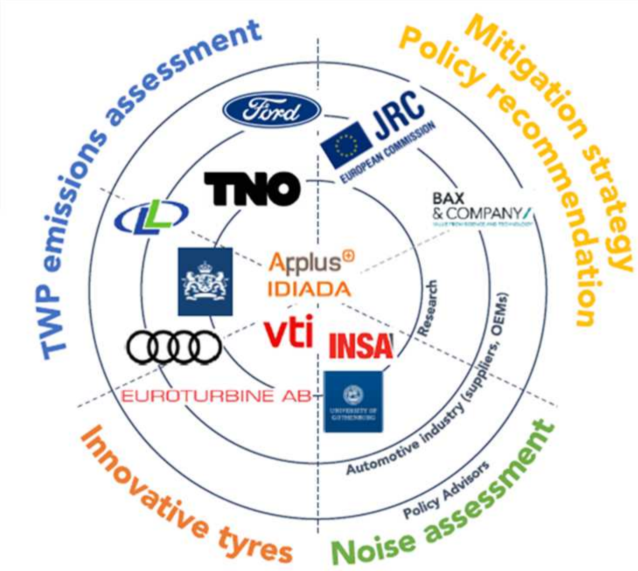
Reduction of tyre emissions for a better quality of life: LEON-T perspective.

nPETS Final Event

Brussels, November 12, 2024

J.J García

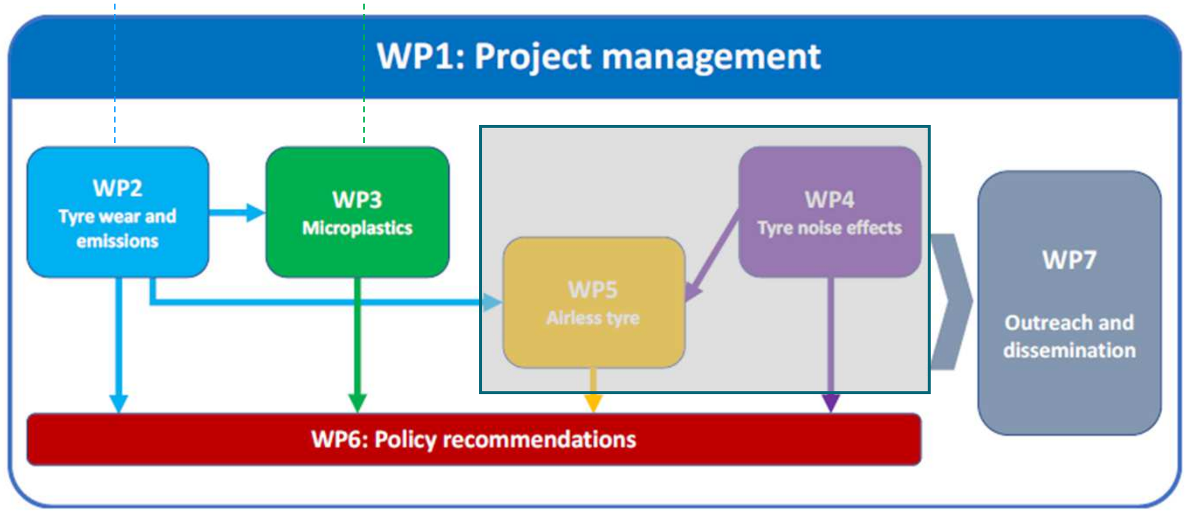
Low particle Emissions and lOw Noise Tyres



- Call / Topic / Project:
  H2020-MG-2020-TwoStages / LC-MG-1-14-2020 / 955387 (LEON-T)
- Duration: June 2021 until June 2024 (extension until Nov 2024)
- www.leont-Project.eu/the-Project/
- WP1: Project management
- **WP2: Tyre wear and emissions**
- **WP3: Microplastics**
- **WP4: Tyre noise effects**
- **WP5: Airless tyre**
- **WP6: Policy recommendations**
- WP7: Outreach and dissemination

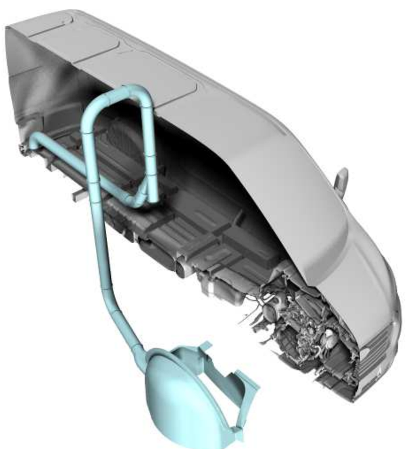
Lab & on road
Measurement
Chemical transf.

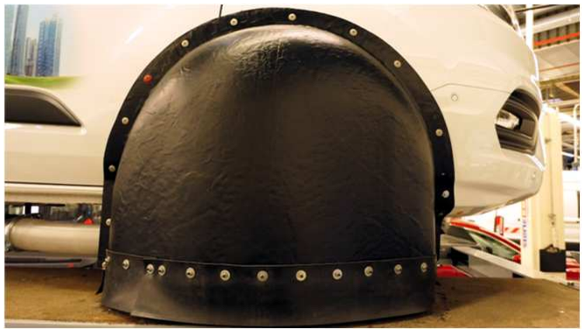
Tyres in
environmental
compartments

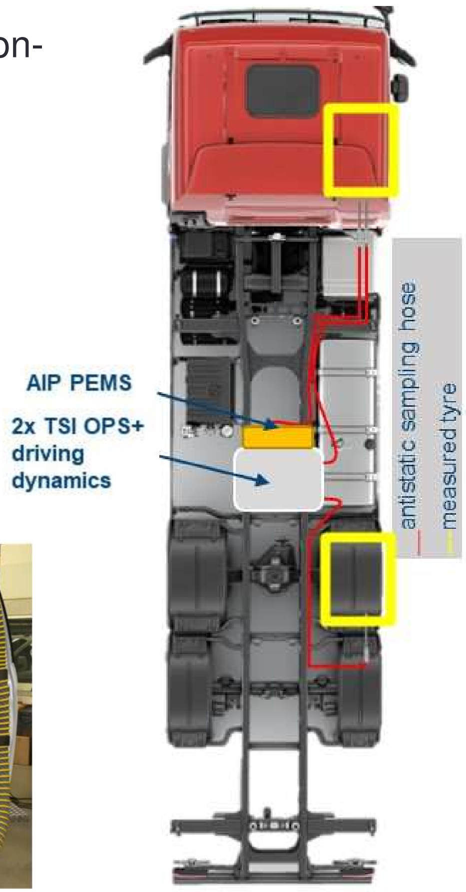


In-service tyre emissions measurement

- *Measurement concept:* Enclosed wheel housing with constant volume sampling and on-line measurement of PN/PM emissions. Characterization/optimization of sampling efficiency based on tracer gas measurements
- Investigation relationship between particle size and PN vs. driving severity
- Many issues and uncertainties. Influencing factors: background concentration, traffic congestion, construction sites, agricultural activities.
- **The concept cannot be used for regulatory purposes yet**







Tyre mass loss increases with temperature
PM10 and PN emission increases with decreasing rubber hardness

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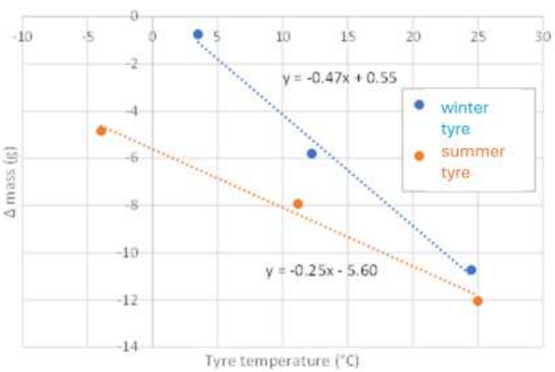
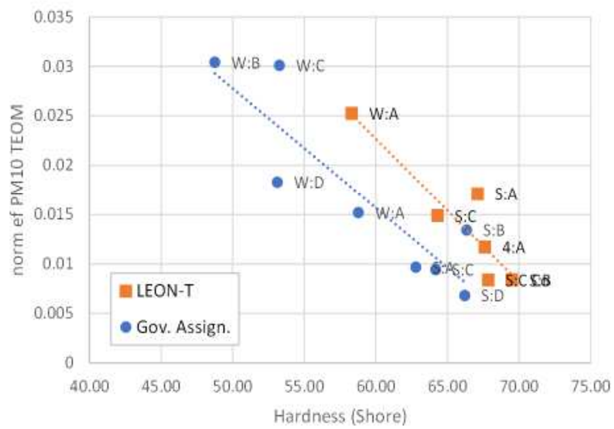
Higher temperature – softer tyre – higher mass loss

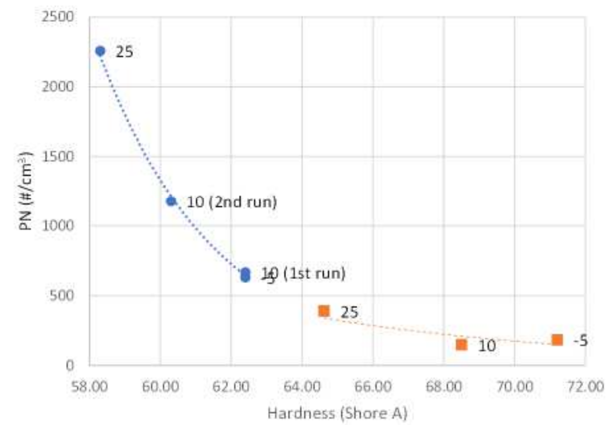


PM10. Different tyres at same temperature



- Lower PM emission correlates to harder rubber mixes
- Winter tyres have softer rubber mixes
- 4-season tyre group with summer tyres

PN. summer & winter tyre at three different temperatures



- Lower PN emission correlates to harder rubber mixes and lower temperatures

Understanding the causes of tyre wear

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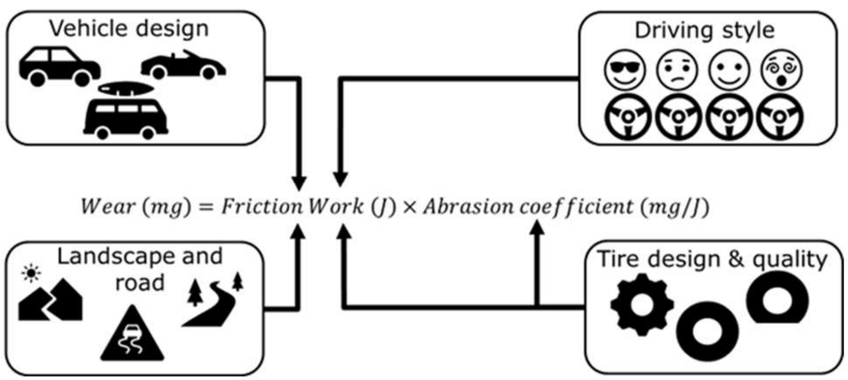
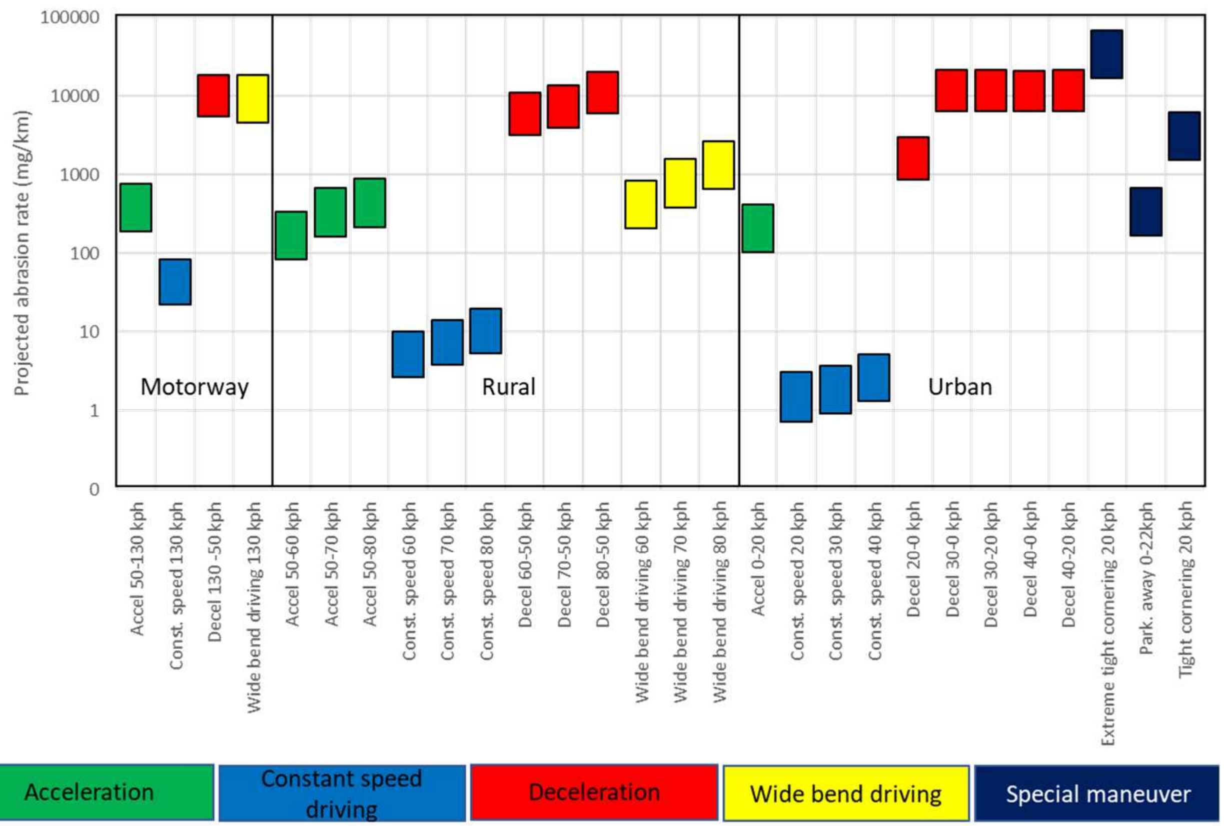
- Braking & extreme tight cornering
- Modelling study based on the IDIADA tyre wear measurements

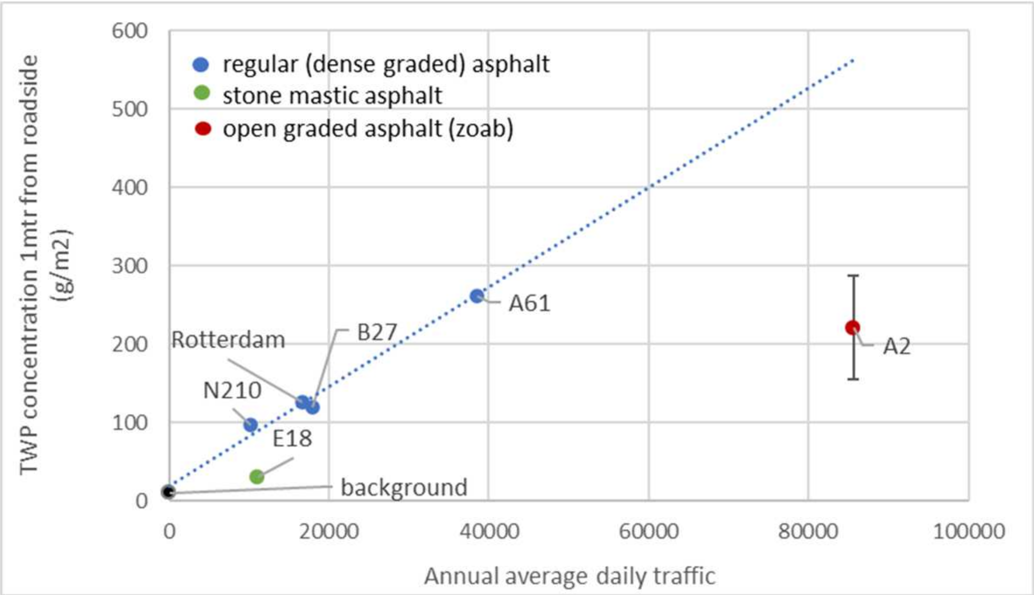




Road surface properties vs TWP concentration

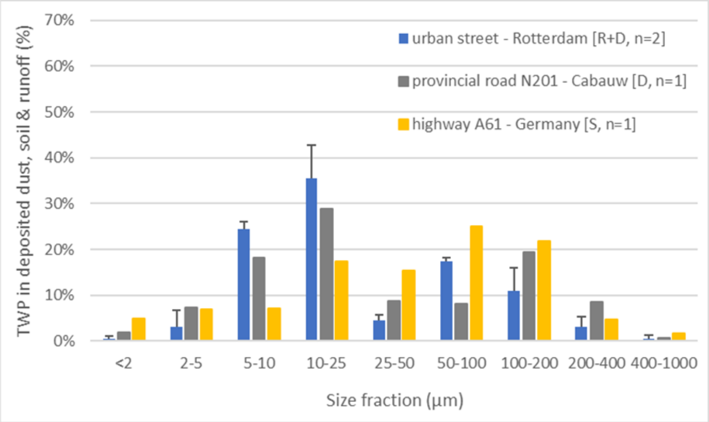
Asphalt surface has an influence on emission rate and particle size distribution of TWP:

- E18: stone mastic asphalt → more fine TWP
- A2: open graded asphalt → more coarse TWP
- E18 & A2 → lower road side soil concentration as regular asphalt

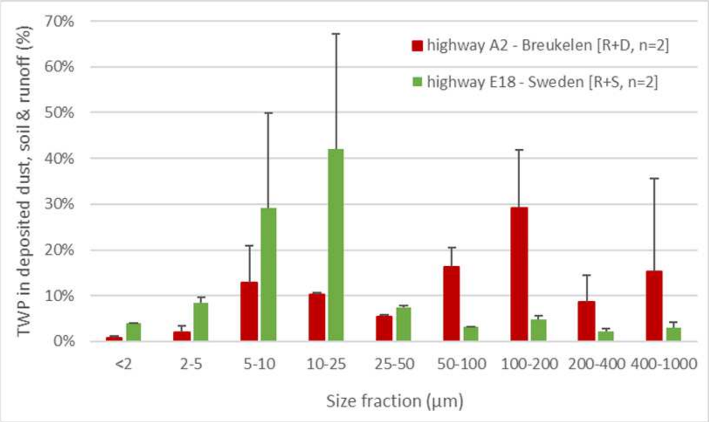


The bimodal size distribution, with peaks 5-25 & 50-200 µm is in agreement with the suggested abrasion mechanisms by Wagner (2018): micro-vibration + stick-slip motion

Size distribution regular (dense graded) asphalt

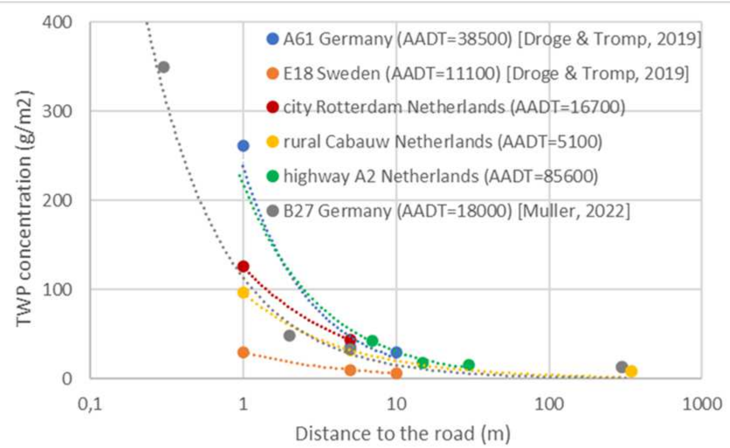


Size distribution Stone mastic & open graded asphalt

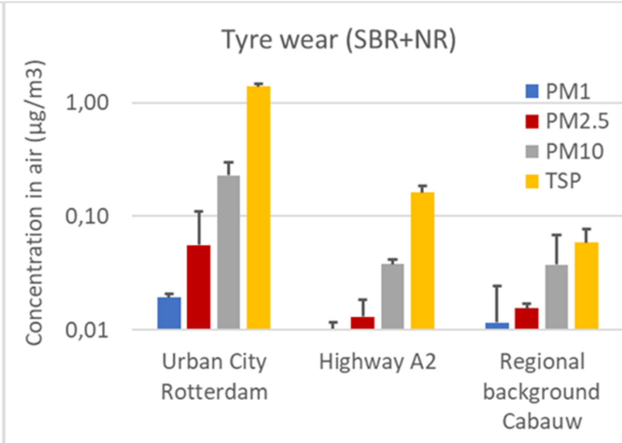


TWP concentrations in ambient air, soil & deposited dust

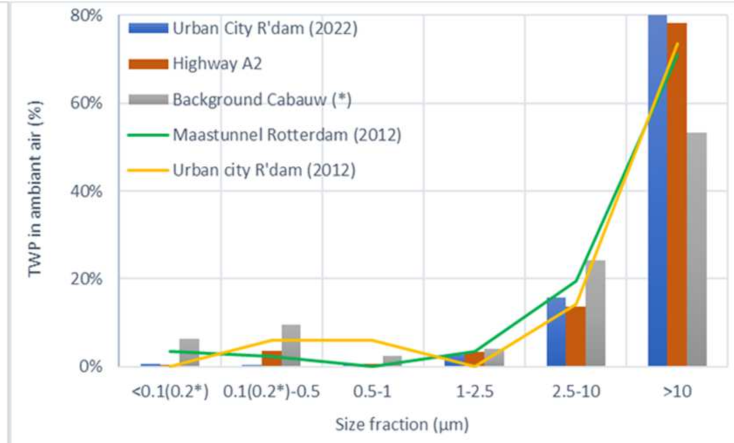
TWP in soil



TWP in ambient air



Particle size distribution TWP in ambient air



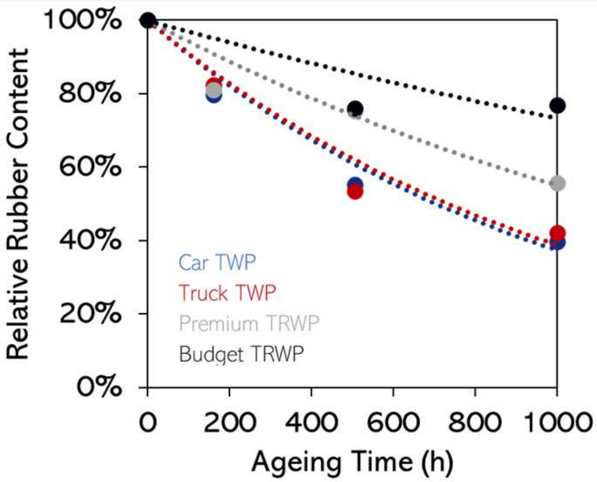
Soil & Deposited dust:

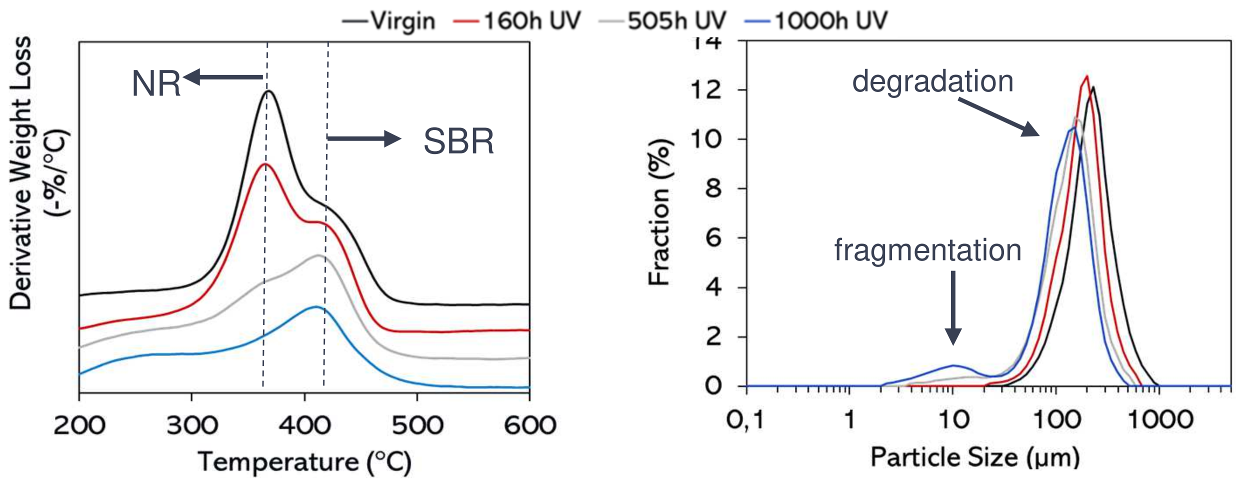
- Highest TWP concentrations nearest to the road, with exponential decrease with increasing distance
- In city higher concentrations due to braking and accelerating
- More traffic (AADT) generates higher TWP concentrations

Ambient air:

- Highest TWP concentrations in Rotterdam (braking & accelerating)
- Highest concentration in coarse fractions (50-80% >10µm)
- Very small amount of TWP in UFP fraction (< 1% by mass)

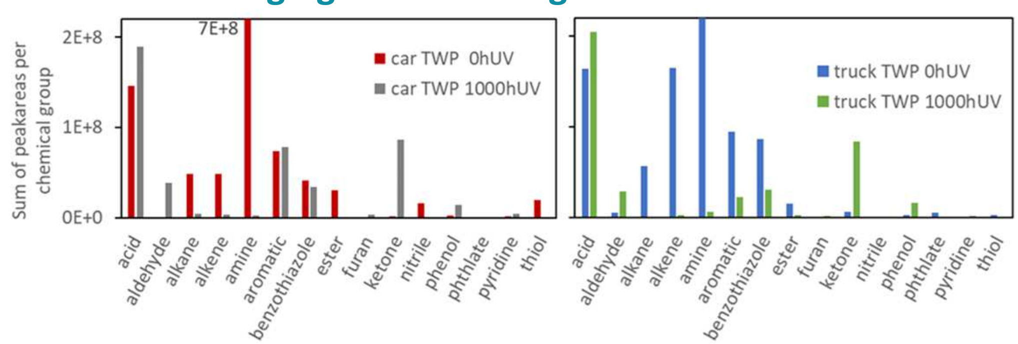
UV-degradation and biodegradation rates of TWP





- UV & biodegradation rates of TWP are in the same order of magnitude, natural rubber degrades faster than SBR
- 1000 h simulates ~8 years of aging in the environment leading to UV degradation rates of 0.011 – 0.033 day^{-1}
- With UV ageing, particles get smaller - environmental equivalent of -0.03 µm day-1
- Second peak <10 µm suggests particle fragmentation
- UV aging results in removal and partial oxidation of organic additives in TWP

aging effects on organic additives



OP vs chemical composition/transformation

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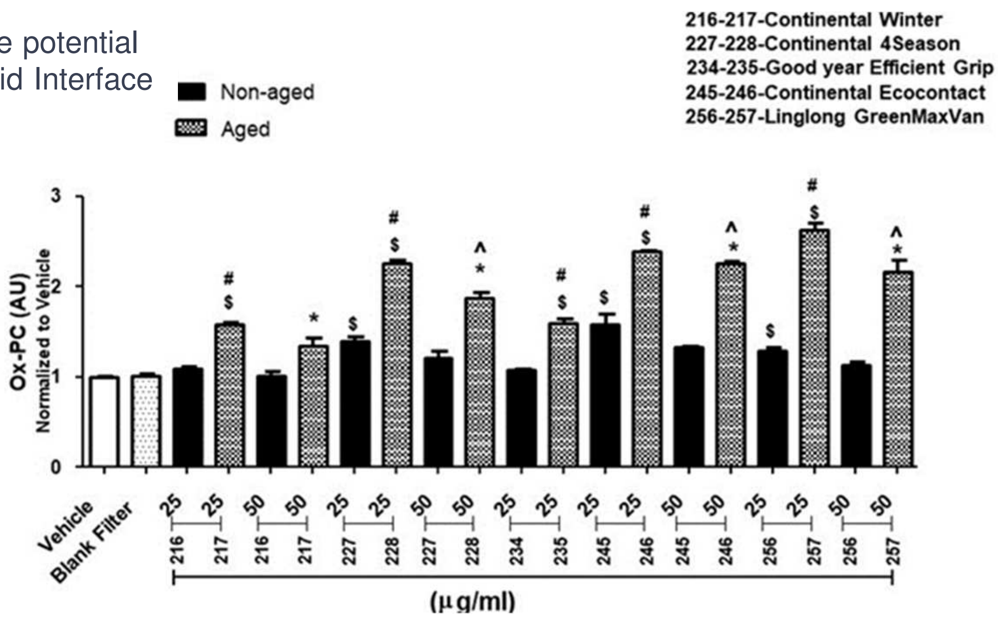
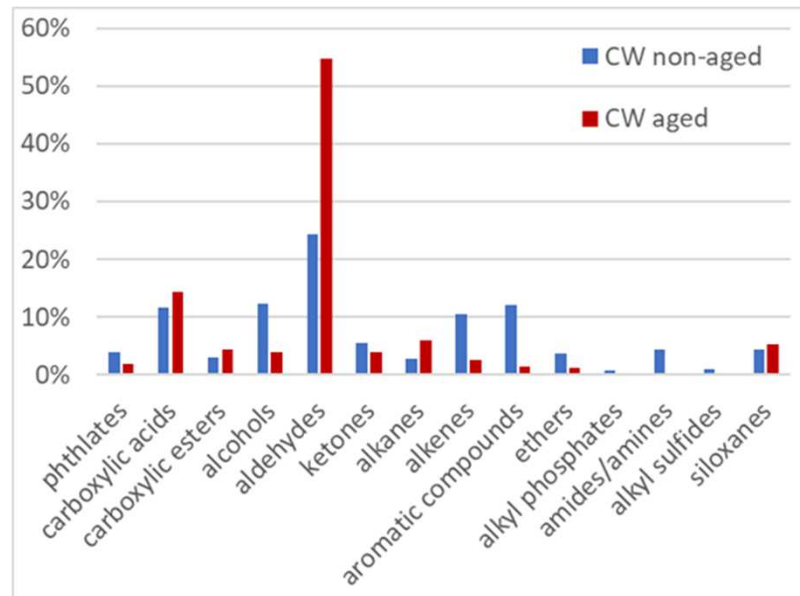
- ALI exposure to PM samples didn't induce cytotoxicity and had **no effect on metabolic activity of A549 cells**.
- **UV aging results in enhanced oxidative potential** (acellulair immuno-assay)
- Findings can be explained by the difference in chemical composition of the non-aged and aged PM samples
- **Aged PM samples contain more oxygenated species** (aldehydes, carboxylic acids), which are more OP-active

OP = oxidative potential
ALI = Air-Liquid Interface





Our every day contribution:

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1 week : 350 gr/car

1 day : 50 gr/ car *

Assume 0.8 gr/km/car; 60 km/day

Tyre emission factors

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Review of tyre emissions before year 2000 in PARTICULATES project
Review years 2000-2024 (around 300 tyre measurements) in LEON-T *
Abrasion level **58 mg/km/t** and abrasion rate (AR) 96 mg/km for Europe

Tyres	Weather	Category	Electrif.	AR	PM_{10}	$PM_{2.5}$
C1	summer	PC	ICE	AR	PM_{10}=0.038×AR	$PM_{2.5}$=0.42× PM_{10}
			xEV	1.25×AR		
C1	winter	PC	ICE	1.10×AR		
			xEV	1.10×1.25×AR		
C2	all	LCV	ICE	2.0×AR		
			xEV	2.0×1.10×AR		
C3	all	HDV	ICE	8.0×AR		
			xEV	8.0×1.10×AR		

Electrified PCs 25% higher AR than ICEs
Winter tyres 10% higher ARs than summer
LCVs 2 times higher ARs than PCs
Electrified LCVs 10% higher AR than ICEs
HDVs 8 times higher ARs than PCs
Electrified HDVs 10% higher AR than ICEs

AR=abrasion rate; HDV=heavy-duty vehicle; ICE=internal combustion engine; LCV=light commercial vehicle; PC=passenger car; xEV=electrified vehicle (BEV or PHEV)

* Sustainability 2024, 16(2), 522; https://doi.org/10.3390/su16020522

Mitigation measures

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- **Reducing particles generation**
  - Technology measures: improved tyres, reduced vehicle weight, speed/acceleration limiters
  - Management: Traffic flow and volume control, maintenance of roads and vehicles, public transport, taxation
- **Collecting particles (vehicle and road)**
  - Tyre dust collectors
  - Asphalt with surfaces that trap particles
- **Reducing exposure and treating particles**
  - Planting vegetation
  - Street cleaning
  - Treating road runoff

Policy recommendations

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- Tyre wear is largest source of microplastics, with at least 35% contribution
- Tyre emission factors were defined. They should be revised when the ongoing market assessment is finalized (at UNECE GRBP/GRPE TFTA level)
- The results of Leon-T support the current regulated (abrasion) methodology with a reference tyre
- The cost benefit analysis shows a clear net benefit of reducing the emission factors of the tyres in the market
- Qualitative analysis is ongoing whether other measures have also a net benefit.

Thank you!

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- www.leont-Project.eu/the-Project/
- with the acknowledgements for the contributions from the entire LEON-T consortium