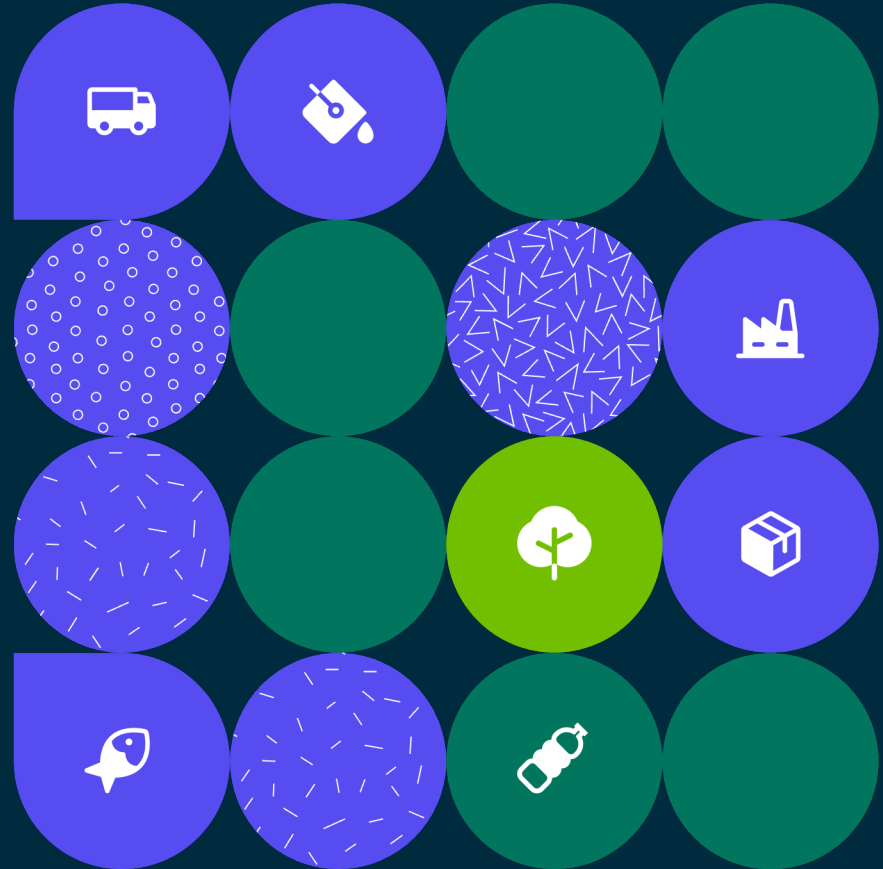


Module on microplastic from tires

Version 2 – March 2026

Micro Tire and Roar Wear particles (TRWP)



Introduction to the Plastic Footprint Network

Leading organizations have united within the Plastic Footprint Network to chart a new, more effective path toward plastic pollution mitigation.

The network's first priority was unifying the framework for measuring plastic leakage into a single, science-based methodology for organizations to accurately assess the environmental impact of their plastic use. Over 100 professionals from 35 organizations worked to establish the resulting methodology, which consists of 11 modules, all optimized for usability and delivery of actionable results.



Objectives

Unifying the methodologies and perspectives of leading scientists, experts, and global practitioners, PFN enables organizations to understand the full impact, or footprint, from the use of plastic in their companies, products, and services.

1

Update and unify plastic footprinting methodologies

2

Ensure the methodology is used consistently by practitioners

3

Disseminate and scale the use of plastic footprinting

4

Explore link with plastic credit schemes, and how to prevent greenwashing claims

What are the objectives of this module?

The goal of this module is to establish a standardized approach for evaluating the impact of microplastics derived from tire particles within the broader context of a plastic footprint. To achieve this, we will address the following key questions:

1

What defines the significance of tire-derived microplastics within the overall plastic footprint?

2

How can an effective methodology be employed to quantify microplastics from tire particles accurately?

3

What specific data is crucial for precise calculations, and how can it be seamlessly integrated into the assessment process?

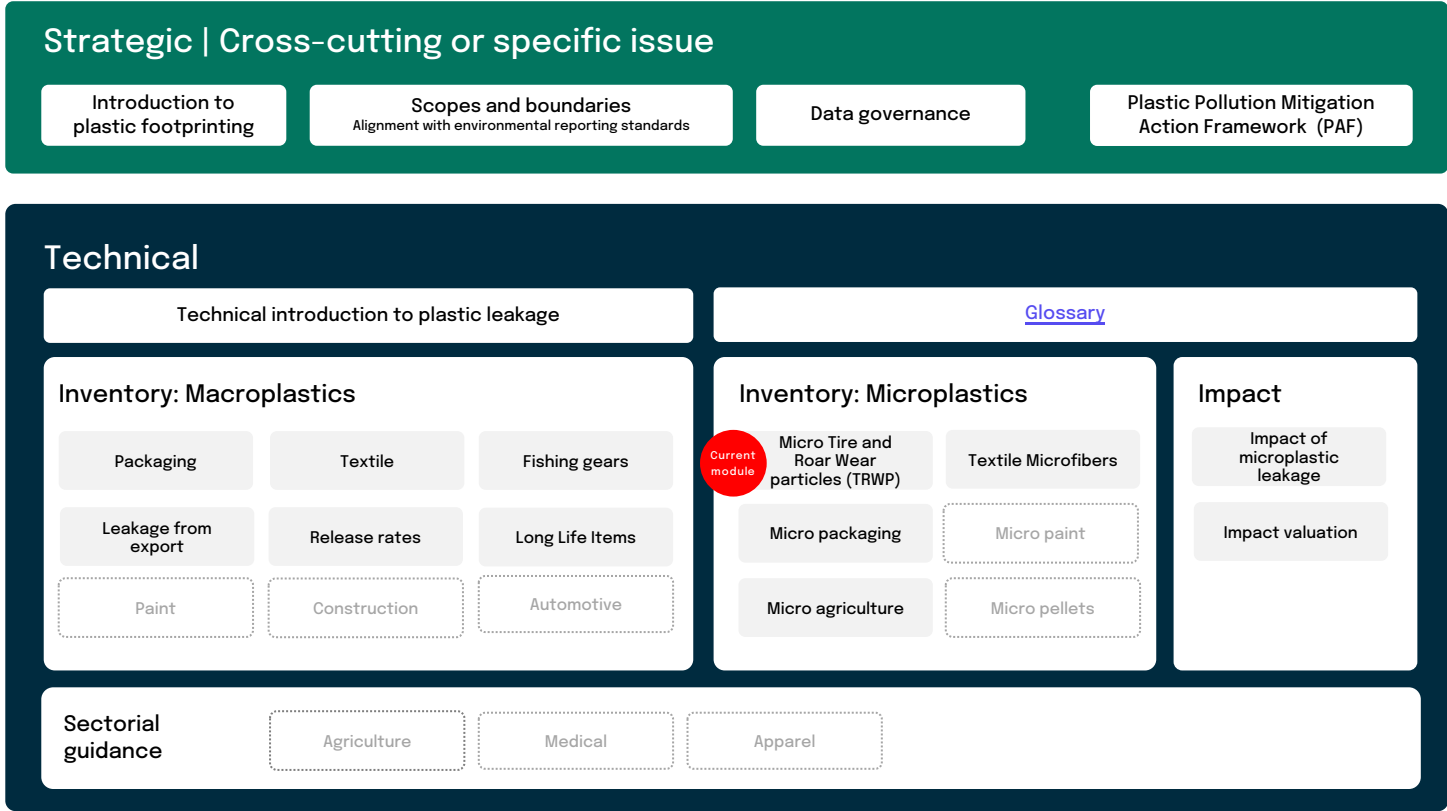
This module aims to offer a comprehensive and contemporary methodology, based on a meticulous analysis of existing approaches and real-world scenarios, while highlighting the necessity for users to gather primary data to ensure a thorough evaluation of the impact of tire-derived microplastics within their plastic footprint analyses.



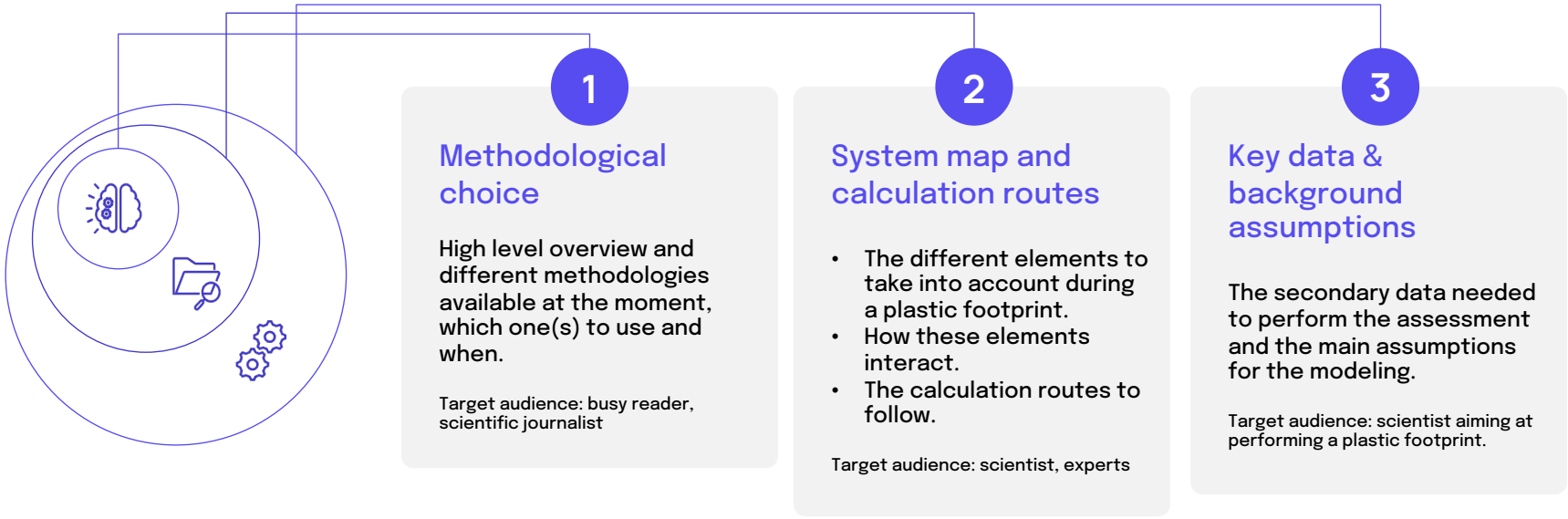
At the end of this module, the users should know how to include Tire and Roar Wear particles (TRWP) in their plastic footprint assessment.

Where does this module fit in the PFN landscape?

Guidance



Structure of each technical module

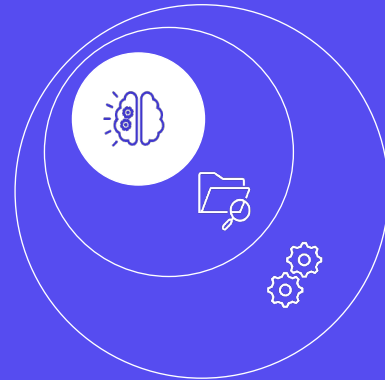


Reading keys: Main take away Supporting information Key warning

Part. 1

Methodological choice

The different methodologies available at the moment, which one(s) to use and when.



Useful definitions

EF = Emission factor

MP = Microplastic

PM = airborne particulate matter,

- **PM₁₀** = PM with aerodynamic diameter below 10 μm (include **PM_{2.5}**)
- **PM_{2.5}** = PM with aerodynamic diameter below 2.5 μm

TRWP = Tire and Road Wear Particles, “a complex mixture of tire tread fragment, pavement released due to tire during use on the road surface and road surface elements such as minerals and road dust” (Jekel 2019) (Baensch-Baltruschat et al. 2020)

WWTP = Wastewater Treatment Plant

Light Duty Vehicles (LDV) = Vehicles used for the carriage of goods and having a maximum weight of 3.5 tonnes.

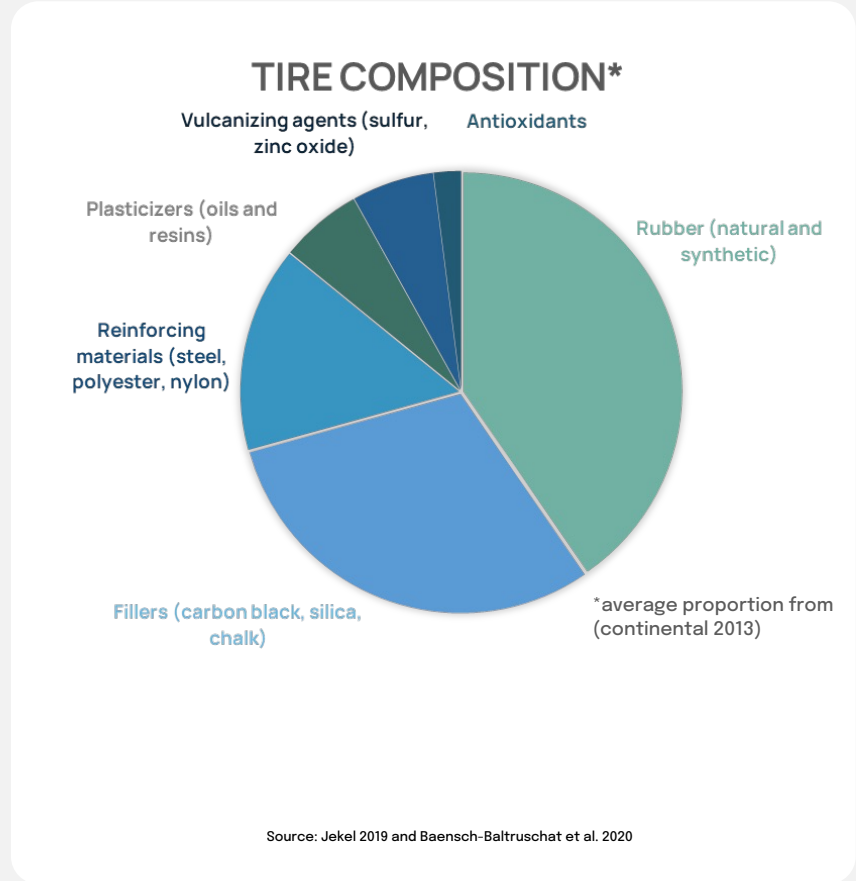
Medium Duty Vehicles (MDV) = Vehicles used for the carriage of goods and having a maximum weight exceeding 3.5 tonnes but not exceeding 12 tonnes.

Heavy Duty Vehicles (HDV) = Vehicles used for the carriage of goods and having a maximum weight exceeding 12 tonnes.

An overview of micro tire particles

- Friction at the interface between the road pavement and the tire tread causes abrasion of the latter.
- When rolling, temperature increases and the elastic and deformable rubber becomes sticky; thus minerals, road and other traffic-related particles may attach to it.
- With further wear and abrasion Tire and Road Wear Particles - a hetero-aggregate composed of particles from the tread and particles and dust from the road - are emitted to the environment.
- When abrasion of the tread mainly generates particles of coarse size (10 to 500 μm), volatilization of fine particulates (mainly PM₁₀ and PM_{2.5}) is also possible on local hotspots on the tire.

The proportion of natural and synthetic rubber varies with the type of vehicle. For example, in truck tires 34% of the rubber is natural and 11% synthetic while in passenger cars, 19% is natural rubber and 24% is synthetic rubber (U.S. Tire Manufacturers Association 2020).



What are TRWPs

Properties of TRWPs:

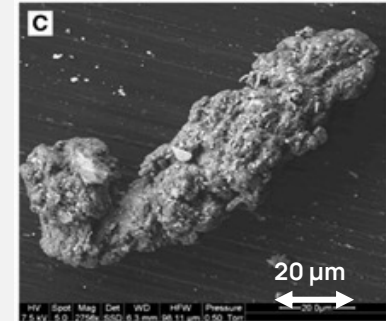
- Cigar-shaped particles
- About 90% of coarse particles (10 – 500 µm); less than 10% of particulate matter (PM_{2.5} and PM₁₀)
- Ratio of 50% tread wear – 50% road wear
- Density ~ 1.8 g/cm³
- Composed of synthetic and natural rubber residues but also chemical additives, heavy metals

Are TRWPs microplastics?

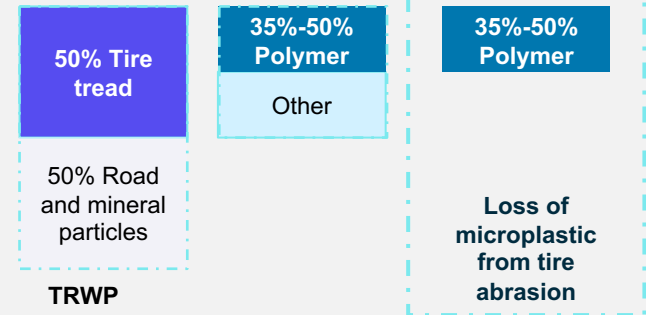
- TRWP “consists of tyre tread enriched with mineral encrustations from the roadway surface.” (ISO/TS, 2018).
- Microparticles with a polymer (rubber) matrix → microplastics



However, when assessing the microplastic leakage from tires, the focus is on the polymer share of the TRWPs (which represents 17.5 to 25% in mass of the TRWP) according to the assumed mass distribution.



Elongated "cigar-shaped" TRWP;
source: Kreider et al., 2010



How do microplastics from tires pollute the environment



Leakage of microparticles during rolling

- From the road where they are emitted, tire microparticles may disperse and distribute into environmental compartments through different pathways including road runoffs, precipitation and wind circulation.
- Although partly treated in the wastewater treatment plants within urban areas, a large proportion of particles ultimately end up in natural media, namely the soil near roads, other terrestrial environments, freshwater (and eventually groundwater), sediments and the ocean.
- Hence, TRWPs as microplastics are ubiquitous in the environment and potentially induce adverse effects on natural organisms. For that reason, they have to be properly accounted for and we have to consider their contribution to the total environmental pollution caused by plastic materials.

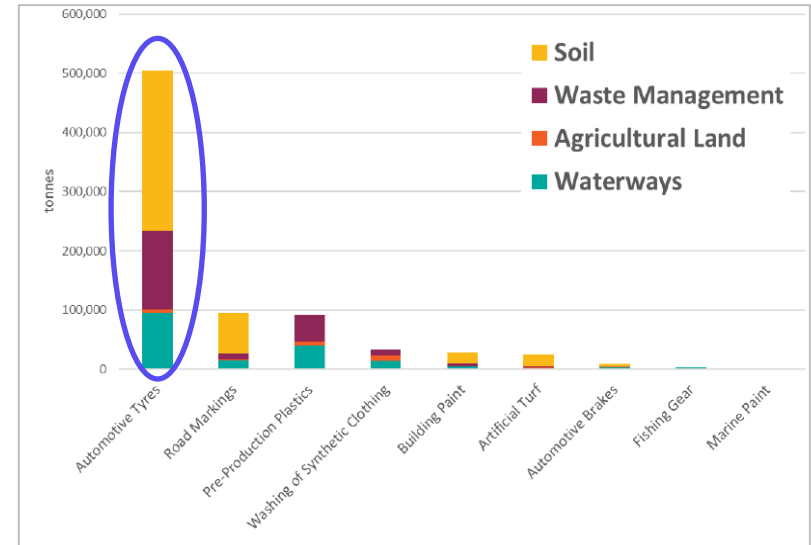
How big is the microplastic leakage from tires?

Among all the sources of microplastics in Europe, automotive tires are the biggest contributor with more than 500 000 tones generated per year.

- Tire abrasion is a major source of MPs emitted to the environment

The assessment of the microplastic leakage from tire particles is relevant in the context of the environmental impact assessment of road transport, especially the:

- Transport of passengers
- Transport of goods



Source: Annual generation and fate of microplastics from automotive tires compared to other microplastic sources from wear and tear in EU28; from Eunomia report (2017)

Useful definitions

Activity/Mass

We identify the quantity of plastic of interest through an activity or a mass.

- For microplastics from tires, the tire abrasion rate is the relevant indicator. It refers to the mass of tread lost during the tire use phase.
- The **emission factor (EF)** is defined after this abrasion rate and is given in mg/km.
- The **loss rate** from tires is defined as the mass of the tire lost which is microplastic. It is therefore calculated by multiplying the EF by the share of polymer in the tire.

Release

Fraction of the plastic transferred from the loss to the environmental compartment. In this case, fraction of lost tire microparticles that are not captured by a WWTP and end into the oceans, or tire microparticles that are captured but ultimately released to soil.

Loss

Fraction of the plastic leaving the well managed system. In this case fraction of tire tread lost during rolling (use phase).

Plastic leakage to the environment

Plastic leakage is defined as the plastic potentially leaving the technosphere (human environment) and accumulating in the natural environment.



The term "emission factor" is widely used to describe a vehicle's emission performance which includes the exhaust and non-exhaust emissions. Still, here we only refer to microparticle emissions due to tire abrasion.

Inspiration: Methodology from Plastic Leak Project

Inventory of emissions for transport of goods and passengers:

- Based on tire wear abrasion rate
- For several vehicle classes: Passenger cars and light trucks, Medium/heavy trucks, Bus/coach, Motorcycle, Aircraft
- Two calculation routes are proposed: for “tire-related studies” and for “non-tire-related studies”

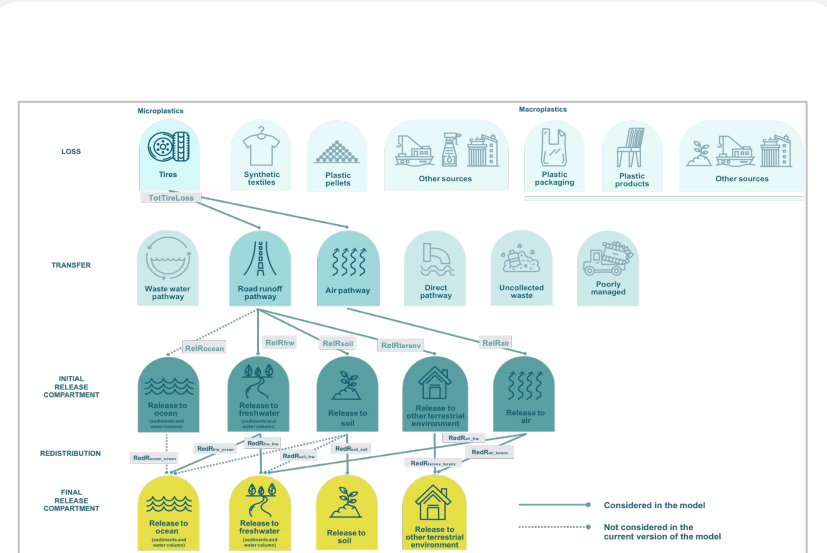
The PLP model is based on four phases:

- Loss – first release (to initial environmental compartments) – redistribution – final release (to final release compartments)
- First release and redistribution rates are based on (Unice et al. 2019) which represent the European context.
- ⊗ Redistribution: Because our compartments are already ocean and freshwater altogether, and soil and other terrestrial compartments altogether, we don't model the redistribution and we give release rates directly to the final compartments.

Improvements:

- ✓ We update the data collection for tire abrasion rate by reviewing new data sources.
- ✓ We propose specific EFs according to the type of road (urban, rural or highway), to take into account parameters that influence the tire abrasion rate (combination of the nature of the pavement, road profile and driving speed).

Source: Peano et al. 2020



Source: PLP – Section 8 – Inventory of microplastic leakage from tire abrasion - page 113, 114

Methodology for Microplastic Leakage

Primary data needed:

- Number of vehicles per type N_{type}
- Distance travelled per vehicle and type $D_{vehicle,type}$
- OPTIONAL: Number of passengers, $Nb_{pass,type}$, or transported load, $M_{good,type}$, per vehicle type.

Secondary data provided in the Excel spreadsheet:

- Microplastic loss rate for each vehicle type $LR_{vehicle,type}$
- Parameter-specific multiplier factors f_p
- Release rates by compartment $RR_{compartment}$
- OPTIONAL: Average number of passengers, $Pass_{av,type}$, or transported load, $Load_{av,type}$, per vehicle type



Two methods for calculating the Loss Rates are proposed: a **generic** approach that uses emission factors for each vehicle type, and a **parametrized** approach that takes into account external factors influencing these emission factors. The second method allows for emissions quantification that is specific to different driving contexts (see slide 22).



The category or type of vehicle can be a passenger car, light-duty vehicle, etc.



The loss rate represents the mass lost by the tire that is microplastic.



It is important to look both at ocean and land for a full comprehension of the leakage.

Steps:

1. Collect **primary data**: the number of vehicles per type, and the distance travelled per vehicle and type.
 2. Compute **activity rate (AR)**: function of the number of vehicles and distance travelled for each vehicle type.
 3. Compute **tire mass loss**: Calculate the mass of microplastic lost by tires for each vehicle type.
 4. Compute **leakage**: multiply the lost mass by the release rates for the compartments of interest.
- OPTIONAL STEP: calculate leakage per passenger*km or per ton*km.

$$\text{STEP 2: } AR_{type}[vch * km] = N_{type}[\#vch] * D_{vch,type}[km]$$

$$\text{STEP 3: } TireLoss [kg \text{ of microplastics}] = AR_{type}[vch * km] * LR_{type} \left[\frac{kg}{vch * km} \right]$$

$$\text{STEP 4: } Leak_{compartment} = \underbrace{\sum_{country} \sum_{vehicle \ type} (TireLoss_{type}^{passengers} + TireLoss_{type}^{goods})(kg)}_{\text{Mass loss}} * \underbrace{RR_{compartment}(\%)}_{\text{Release}}$$

With compartment = ocean, land

$$\text{OPTIONAL STEP: } TireLoss [kg \text{ of microplastics}/pass] = \frac{TireLoss [kg \text{ of microplastics}]}{Occupancy_{type}[pass] \text{ OR } Load_{type}[ton]}$$

Part. 2

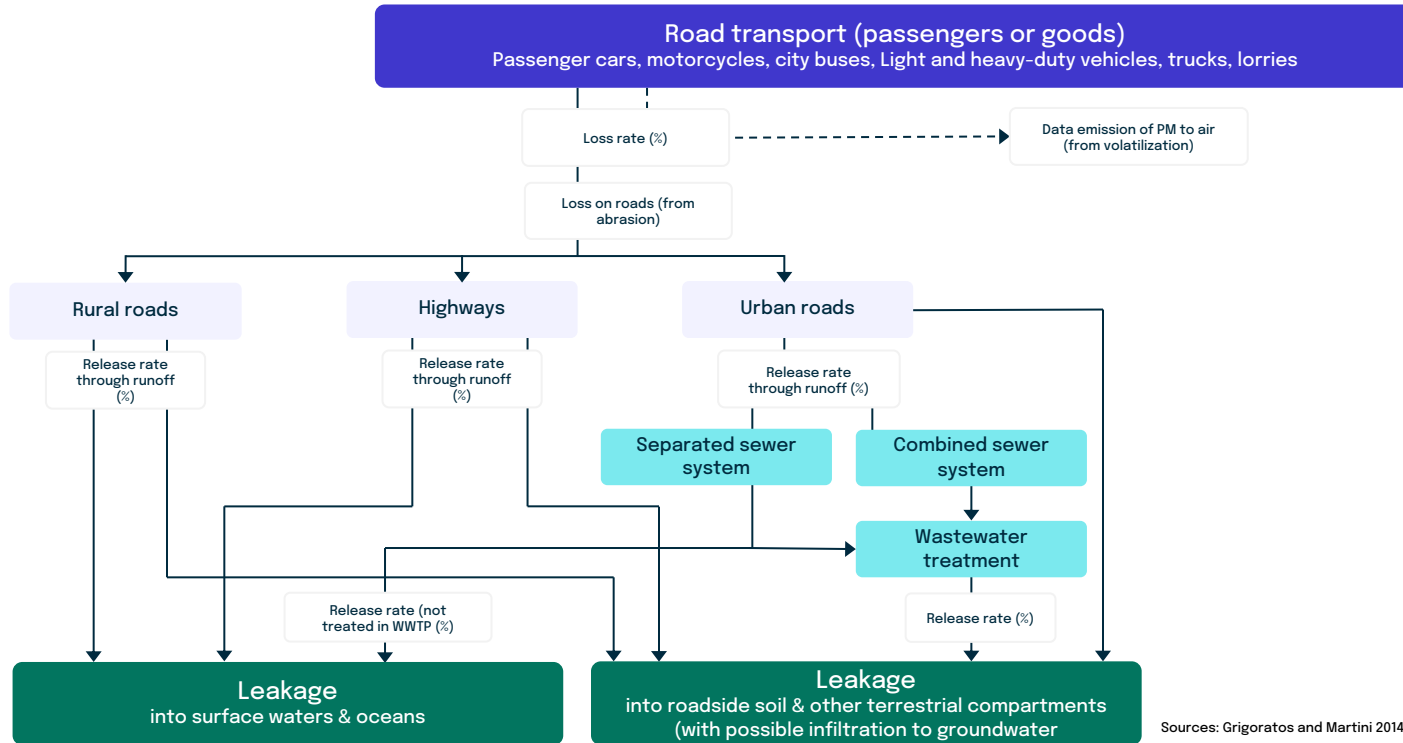
System map & calculation routes

The different elements to take into account during a plastic footprint. How these elements interact? Which calculation routes to follow?



System map

The path of tire microparticles, from emission to final release:



Sources: Grigoratos and Martini 2014 and Peano, Kounina et al. 2020

Calculation routes for tire microplastics

$$Leak_{compartment} = \sum_{country} \sum_{vehicle\ type} \underbrace{\left(N_{type}[\#vhc] * D_{vhc,type}[km] * 1/(Occupancy\ OR\ Load_{type})[-] * LR_{type} \left[\frac{mg}{vhc * km} \right] \right)}_{Mass\ loss} * \underbrace{RR_{compartment}(\%)}_{Release}$$

With compartment = ocean, land



Symbol	Description	Unit	Value	Reference	Additional comments
N_{type}	Number of vehicle of a given category	# vhc	From primary data	n/a	
$D_{vhc,type}$	Distance travelled on the road by a vehicle of a given category	km / vhc	From primary data	n/a	
$Occupancy_{type}$	Number of passenger transported over the distance D	# pers	From primary data (optional)	n/a	If data is unavailable, an average value is provided in the Excel spreadsheet as secondary data.
$Load_{type}$	Mass of good (products) transported over the distance D	kg	From primary data (optional)	n/a	If data is unavailable, an average value is provided in the Excel spreadsheet as secondary data.
LR_{type}^*	Loss of microplastic from a tire of the vehicle type	mg / (vhc*km)	To be calculated	n/a	The loss rates are calculated for each vehicle category from emission factors and the share of polymer in tires.
p_j^*	Multiplier factor associated with the influencing parameter j	(-)	To be calculated (if applicable)	Ospital et al. 2025	Applicable when the parametrized Loss Rates are utilized.
$RR_{compartment}^{**}$	Release rate to environmental compartments	%	From secondary data	Values from the PLP Guidelines results	



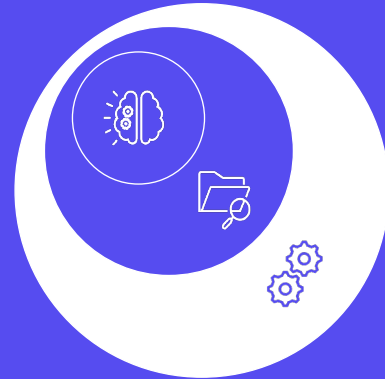
* Loss rates can be calculated using either a generic model or a parameterized model, which takes into account the influence of external factors through specific multiplier factors (see Loss Rates calculation using the parametrized model).

** Release rates can be tailored according to the amenities available in the area being studied (see system map).

Part. 3

Data

The secondary data needed to perform the assessment.



Loss rates using the generic model

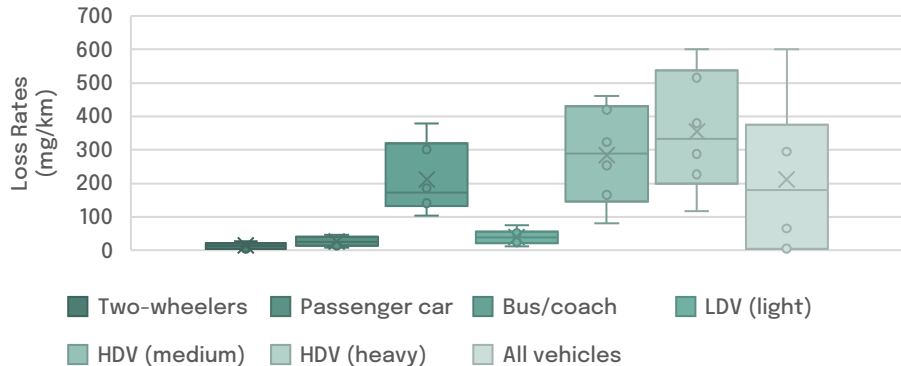
$$Loss\ Rate_{i,j} = EF_{vehicle,i} * ShPolymer_i$$

$i = vehicle\ type$

The loss rates are calculated by multiplying the emission factors of each vehicle type by their respective share of polymer in tires.

Generic LR [mg/(vhc*km)]	Transport of passengers			Transport of goods			All vehicles
	Two-wheelers	Passenger car	Bus/coach	LDV (light) <3.5 tonnes	HDV (medium) >3.5 tonnes, <12 tonnes	HDV (heavy) >12 tonnes	
Lower value (Q1)	6	22	160	38	254	288	6
MEDIAN	13	28	186	40	323	380	66
Upper value (Q3)	20	37	301	51	420	516	301

Computed Loss rates for each vehicle type



Emission factors for tire wear can vary depending on the study conditions and methodologies used. To address this variability, we provide average values for tire wear emissions. These averages were calculated by compiling emission factor values from various sources in the literature, as referenced in Ospital et al. 2025.



For each vehicle category, we provide lower, central, and upper values of LR, allowing users to select the most suitable option for their specific context.



The loss rates are presented in [mg/(vhc*km)] for clarity regarding the orders of magnitude. However, we need to convert these values by multiplying by 10⁻³ when calculating the Tire Loss and the Leak to compartments in kilograms.

Loss rates using the parametrized model

$$Loss\ Rate_{i,j} = \underbrace{EF_{vehicle,i} * ShPolymer_i}_{\text{Generic loss rate}} * \prod_j p_j$$

i = vehicle type
j = influencing parameter



Emission factors for tires can vary depending on external parameters such as road type, driving speed, use of winter tires, specific tire characteristics, etc.

The influence of eight such parameters has been quantified in Ospital et al. 2025 based on experimental studies from the literature.

Default parameters, which were applied when the EF was determined, are set to 1, indicating no influence. Factors greater than 1 increase emissions, while factors less than 1 decrease them.

When multiple parameters are considered, their respective multiplier factors are multiplied together. The resulting product is then applied to the generic loss rate to determine the parametrized Loss Rate (pLR).


Influencing parameter	Multiplier factor, <i>p</i> (from Ospital et al., 2025)	Remark
<i>Rough surface</i>	2.9	based on Lowne 1970 and Le Maitre 1998
<i>Load +20 kg</i>	1.12	based on Yan et al. 2021
<i>Aggressive driving</i>	1.9	based on Le Maitre 1998
<i>Speed +10 km/h (alone)</i>	1.6	based on Kim and Lee 2018, Woo et al. 2022, Kwak et al. 2013
<i>Non-paved road</i>	1.5	based on expert judgment
<i>Wet road</i>	0.7	based on expert judgment
<i>Temperature +10°C</i>	1.01	based on Yan et al. 2021
<i>Urban (default)</i>	1	
<i>Intercity</i>	0.86	Multiplication of curving and speed adjusted to the environment.
<i>Highway</i>	0.74	

Release rates – PLP and aggregation

Final release rates from PLP (2020) based on the results provided by Unice et al. (2019): still used in the current PFN methodology.

Abreviation	Description	Generic value [% of TRWP emitted], or [% of microplastic from tire abrasion]	Detailed description
FinalRelRocean	Final release rate of TRWP in ocean (sediments and water column) compartment	2%	TRWP emitted in freshwater initial compartment and not deposited into sediments
FinalRelRair	Final release rate of TRWP in air compartment	0%	TRWP redistributed to freshwater and other terrestrial environment compartments
FinalRelRfrw	Final release rate of TRWP in freshwater (sediments and water column) compartment	15%	TRWP deposited in freshwater sediments, coming from: <ul style="list-style-type: none"> • TRWP in runoff water going through separated system and directly released in freshwater • TRWP in runoff water going through CSO of combined system • TRWP in runoff water going through combined system but not retentate in wastewater treatment plant
FinalRelRsoil	Final release rate of TRWP in soil compartment	66%	TRWP captured in soil, coming from: <ul style="list-style-type: none"> • TRWP deposited near road deposition • TRWP in runoff water going through combined system, retentate in wastewater treatment plant and which sludge is spread on fields • TRWP retentate in ditches
FinalRelRterenv	Final release rate of TRWP in other terrestrial compartments	4%	<ul style="list-style-type: none"> • Mismanaged waste from TRWP retentate in WWTP sludge not spread ; Mismanaged waste from TRWP retentate in stormwater management sludge • TRWP initially released into air redistributed between freshwater and other terrestrial compartments
Well managed waste	Part of TRWP that is removed from the environment	14%	<ul style="list-style-type: none"> • TRWP retentate in WWTP sludge not spread that is landfilled or incinerated • TRWP retentate in stormwater management sludge that is landfilled or incinerated

Aggregated release rates used in the current PFN methodology

Final release to land	Sum of release to soil and to terrestrial environment	69%	 <p>These final release are built using the share of rural/urban/highway in the French context. For a more precise assessment these release rates need to be recalculated based on the geography of interest.</p>
Final release to water	Sum of release to freshwater and to ocean	17%	

Limitations of the current methodology and remarks

- The proposed quantification method focuses only on the **polymer component of tire and road wear particles (TRWPs)**. It's important to note that including the mineral and road-based components of these particles would substantially increase the total mass released into the environment. For instance, if TRWPs consist of 50% minerals from the road and 50% tire tread, the total particle mass would double. Consequently, the environmental fate of these particles, including their final release to land and ocean, could differ.
- **Parameters that influence the loss rate:** some of the parameters affecting tire wear and microplastic loss rate have been quantified and integrated into the updated PFN method. However, while the literature cites several other influencing factors, establishing a direct correlation between these factors and emission rates remains challenging, which limits their inclusion in the current calculation model.
- Aircraft are not considered in the current methodology, as the focus is on **road transport**, which is considered to be the major contributor to microplastic pollution from tire abrasion.
- **Emissions to the air compartment:** in the system map, a direct emission flow to the air represents emissions of airborne TRWPs, below 10 μ . These airborne particles account for less than 10% of the total generated. While they are initially transported through the atmosphere, they eventually settle in road, land, or water compartments, following the same pathways as larger particles. However, these airborne particles, primarily consist of **organic materials and heavy metals**. Therefore, they are **not included** in the calculation of microplastic leakage.
- **Scope and application of the methodology:** this methodology for calculating microplastic emissions from vehicle tires is designed to be **adaptable** to different geographic settings. To illustrate its application, we use data from a study in the Seine watershed (Unice et al. 2019). While this data reflects a **French context** the results can serve as a **proxy for Europe**, assuming similar road distributions and water treatment systems. However, caution is advised when applying these values to other regions.
- **Key Considerations:**
 - The **road category** (urban, rural, or highway) influences water runoff treatment systems and their effectiveness, which in turn affects the release rates of tire microplastics.
 - This methodology does not include region-specific data on road type distribution. Instead, it relies on **PLP guidelines**, which are based on a **single freshwater release scenario**.
 - The percentages for road type distribution are **general averages** and can be adjusted to reflect local conditions.

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Our commitment to continuous improvement

The Plastic Footprint Network's successful collaboration is built on pillars of:

- Open
- Non-competitive and productive dialog
- Leveraging science and supporting ongoing research
- Broadly empowering global stakeholders (product manufacturers, brand owners, treaty negotiators, regulators, consultants, NGOs, etc) to effectively do their part to address the plastic pollution crisis.

Given corresponding commitments to transparency and continuous improvement, we welcome and encourage your feedback and input on this document so that the methodology can continue to be enhanced and refined.

Thank you for supporting the work of the Plastic Footprint Network.

Contact us at: contact@plasticfootprint.earth

Our mission is to continuously advance Plastic Footprint Methodology, ensuring it remains at the forefront of sustainable practices and promoting its widespread adoption. By empowering companies to rigorously assess, enhance, and transparently report their plastic footprints, we aim to make significant strides in mitigating the plastic pollution crisis.

Plastic Footprint Network

This working group was created to establish a standardized approach for evaluating the impact of microplastics derived from tire particles. It follows PFN's structured process, ensuring scientific integrity, peer review, and alignment with global standards.

Working group lead
 (Responsible for developing the methodology, ensuring scientific rigor, and managing the working group)



Contributing companies
 (Experts, stakeholders, and industry representatives, who provided insights, data, or case studies to inform the methodology)



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The Plastic Footprint Network is convened by EA for Impact, the non-profit arm of Earth Action.



Illustrations by German Kopytkov



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