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**Hochschule
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UNIVERSITY OF APPLIED SCIENCES



“Effects of tire wear on roadside soils and their ecosystems: A review”



Europäische Union

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Europäischer Sozialfonds



Diese Maßnahme wird mitfinanziert
durch Steuermittel auf der Grundlage des
vom Sächsischen Landtag beschlossenen
Haushaltes.

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Hypothesis

“Roadside soils are a long-term sink and source of tire wear particulate matter.”

- Tire wear contribute up to 40% of the total microplastic entry.
- Primary entry paths are rain & surface water on streets and parking lots and atmospheric deposition.
- Most prominent knowledge gap is the transport behaviour of tire wear particles, especially within the soil.
- Tire and road wear particles (**TRWP**): Tire wear particles containing particles from the road or road dust.

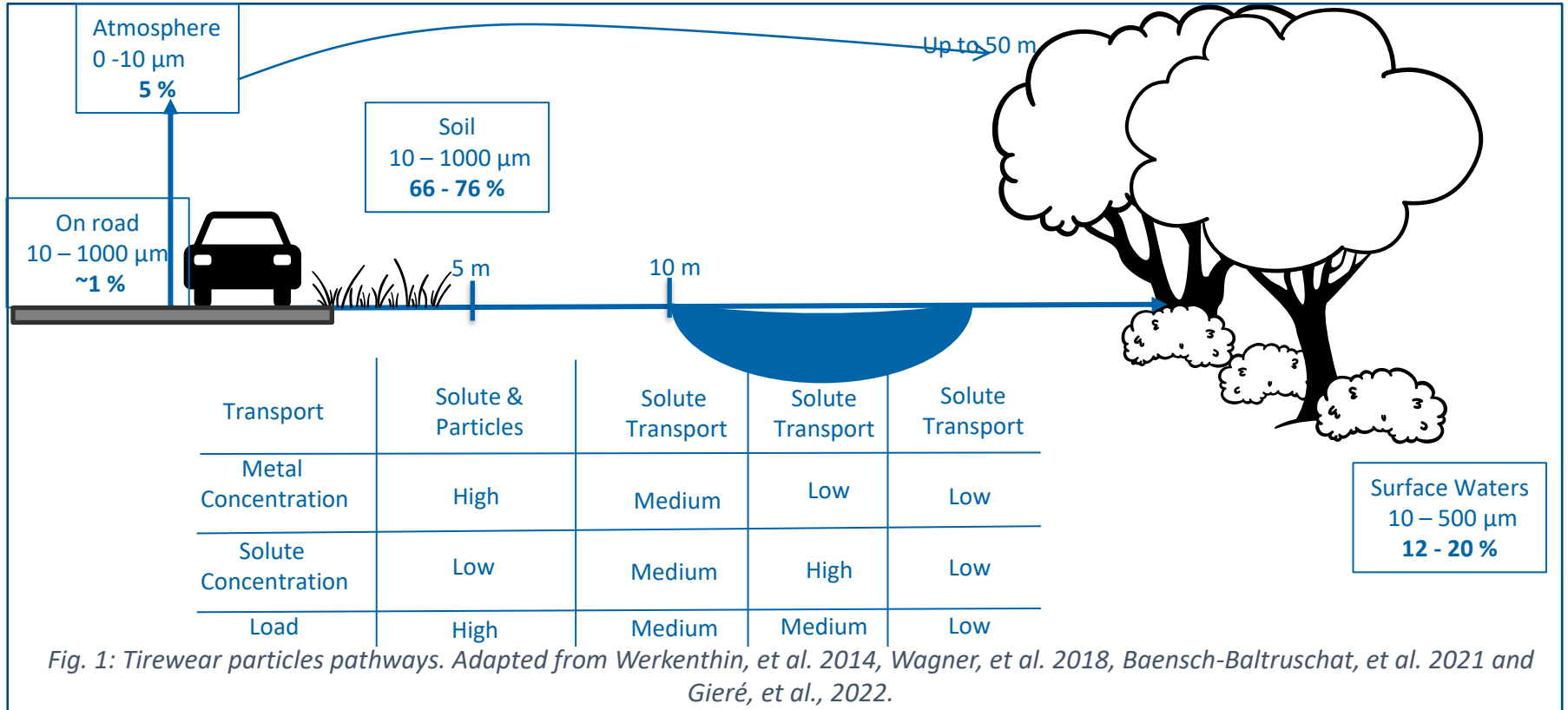


Fig. 1: Tirewear particles pathways. Adapted from Werkenthin, et al. 2014, Wagner, et al. 2018, Baensch-Baltruschat, et al. 2021 and Gieré, et al., 2022.

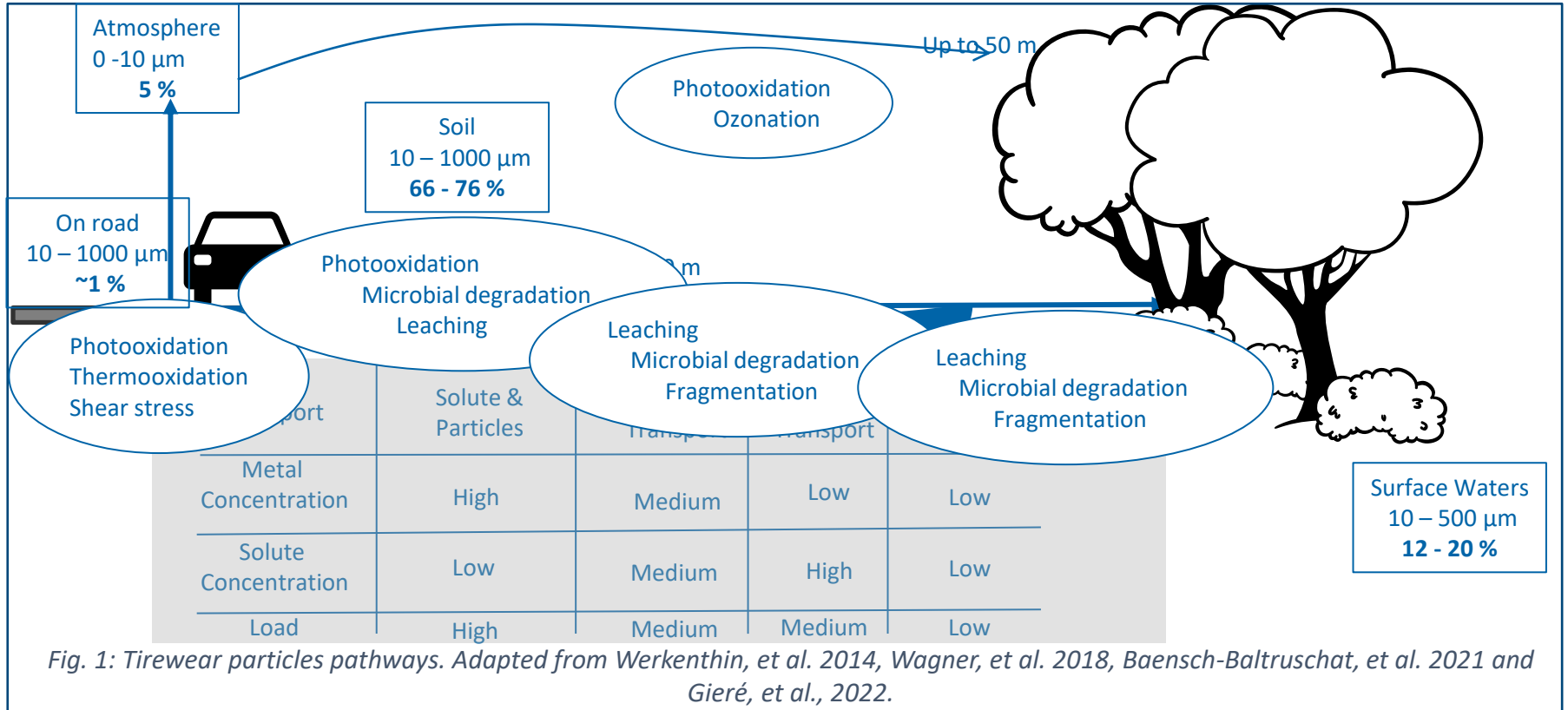


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Research Goal: Transport Processes in Soil

Vertical transportation and infiltration patterns of TRWP in the soil is not experimentally reproducible.

- Fate and degradation rate of TRWP (half-life 500 days, (Wagner et al., 2021)).
- Soils as a sink for TRWP, investigating transport processes and TRWP content.
- TRWP on a road and data on particle sizes and mass flows.
- Integrated mass and particle balance models that can be validated through specific monitoring.
- Standard protocol to quantify and qualify microplastic particles in environmental samples.
- Describe and parameterize the shapes and their effect on transport behaviour.

Factors Influencing TRWP Generation

- **Tire characteristics:** Size, tread depth, construction, tire pressure and temperature, chemical composition, accumulated mileage.
- **Road surface characteristics:** Pavement construction, aggregate rocks, porous asphalt, macro and micro texture, porosity, condition, road surface wetness, road dust loading in surface texture.
- **Driving behaviour/Vehicle operation:** Speed, linear and radial acceleration, frequency and extent of braking and cornering.
- **Vehicle characteristics:** vehicle weight and distribution of loads, wheel alignment, engine power, electronic braking systems, suspension type and condition.

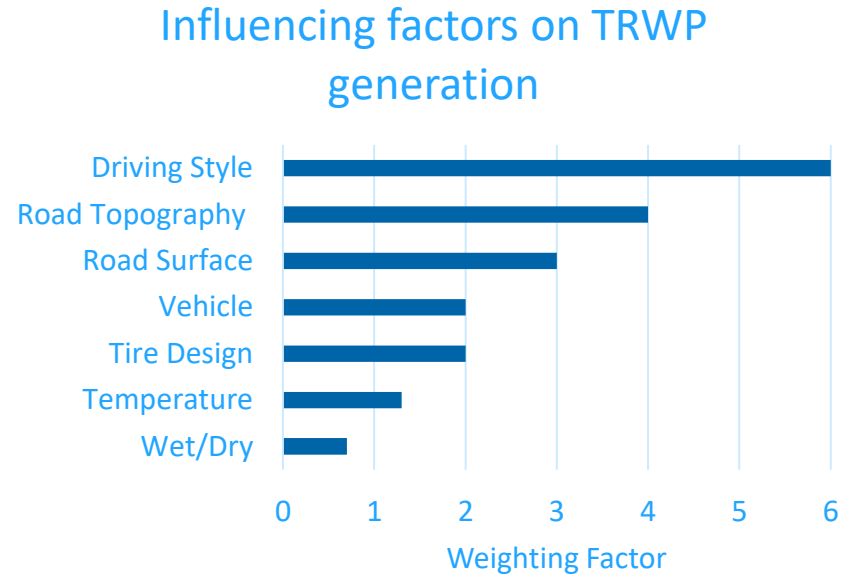


Fig. 2: Ranking of key influencing factors according to their estimated impact on tire wear generation (ETRTO).

Research Study

1. Sampling

Many particles that were not TRWP emitted from the tire were captured.



Fig. 3: Sampling with a vacuum system and a broom.

2. Sample preparation

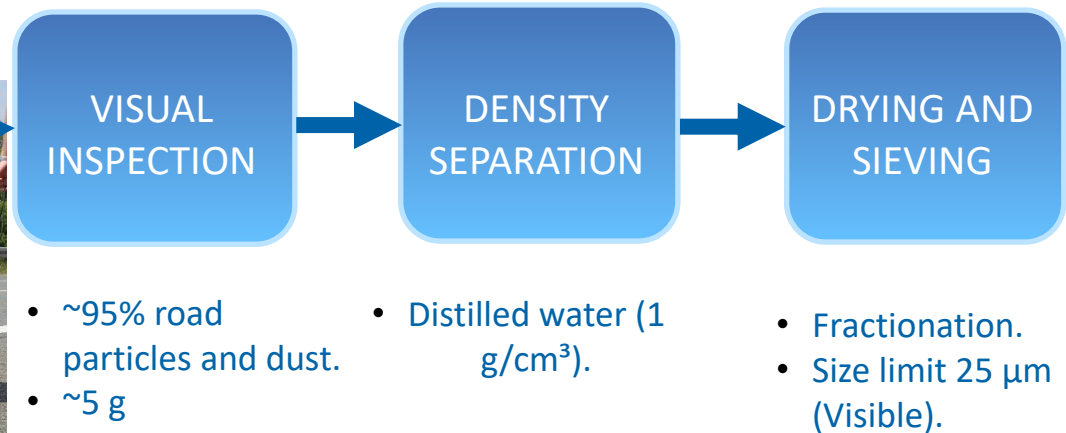


Fig. 4: Workflow for quantifying tire and road wear particles generated on the road.

Study Area



- Gera
- Bundesstrasse 2
- 1.5 km off A4 (Direction Zeitz)
 - 2.2 ° slope
- 400 m between each sampling point
 - No speed limit

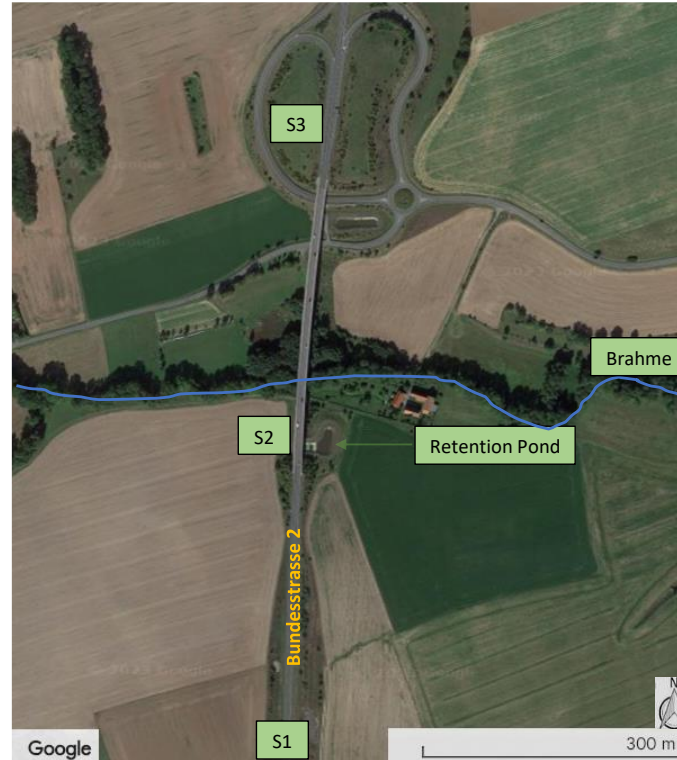


Fig. 5: Sampling locations.

Sampling Location: S1



Fig. 6: Sampling positions (S1) on a road (A-F); (B2 near Gera-Dorna).

Size Fractionation at S1

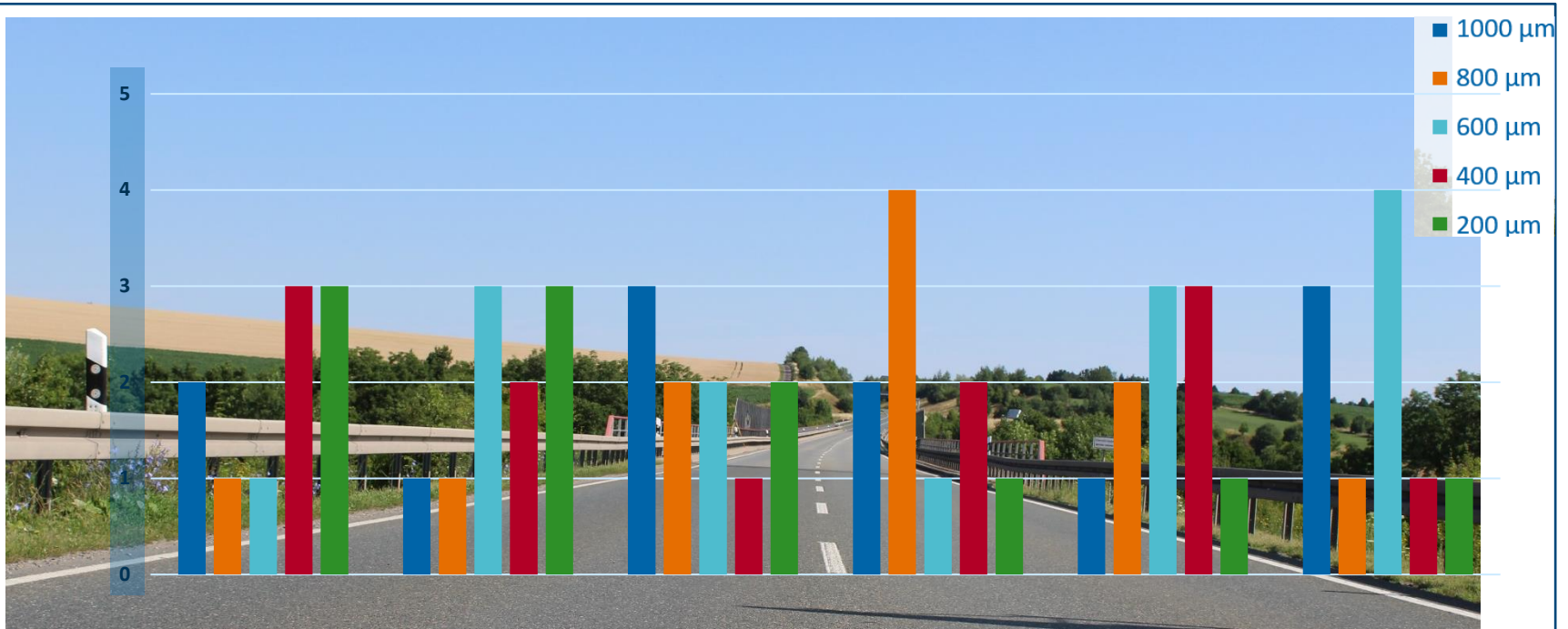


Fig. 6: Sampling positions (S1) on a road (A-F); (B2 near Gera-Dorna).

Sampling Location: S2



Fig. 7: Sampling positions (S2) on a road (A-F); (B2 near Gera-Dorna).

Size Fractionation at S2

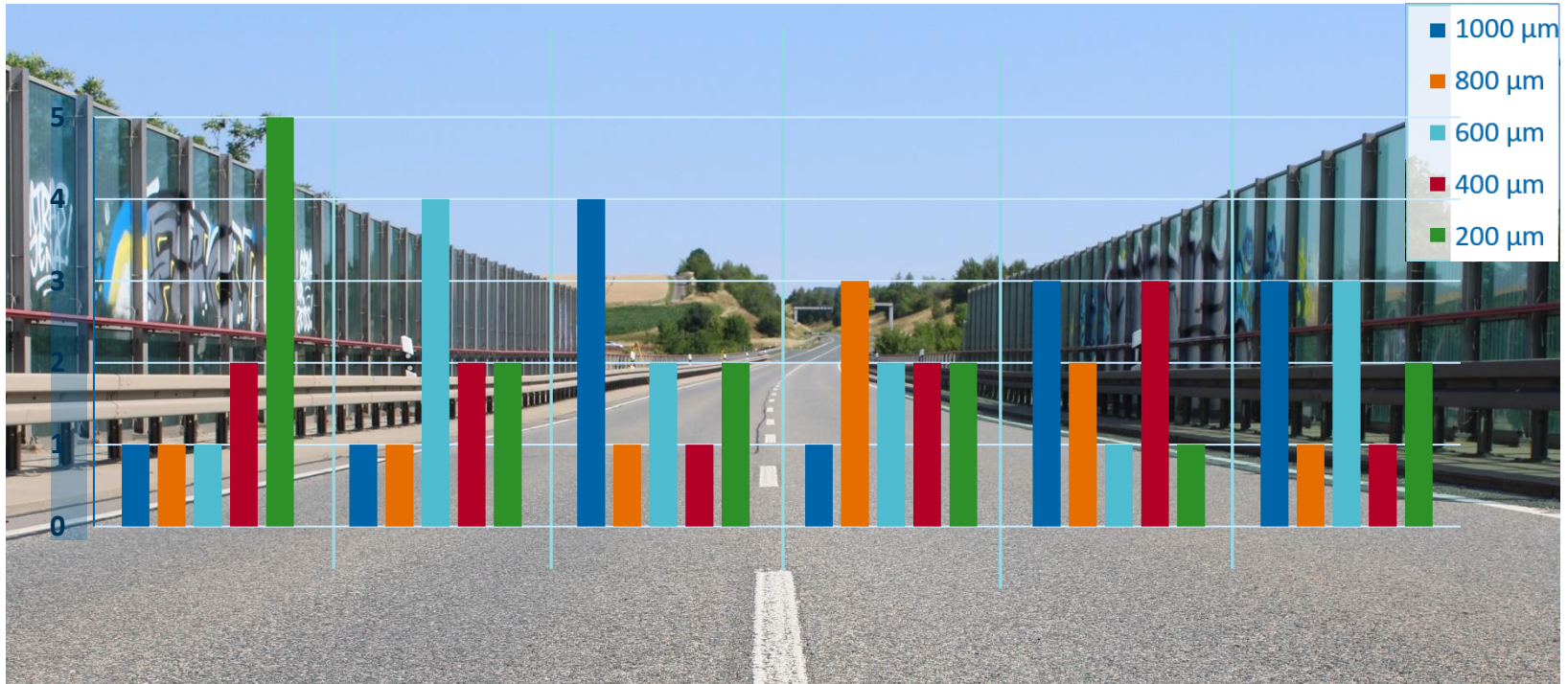


Fig. 7: Sampling positions (S2) on a road (A-F); (B2 near Gera-Dorna).

Sampling Location: S3



Fig. 8: Sampling positions (S3) on a road (A-J), points A and B in the acceleration track and I and J in the deceleration track (B2 near Gera-Dorna).

Size Fractionation at S3

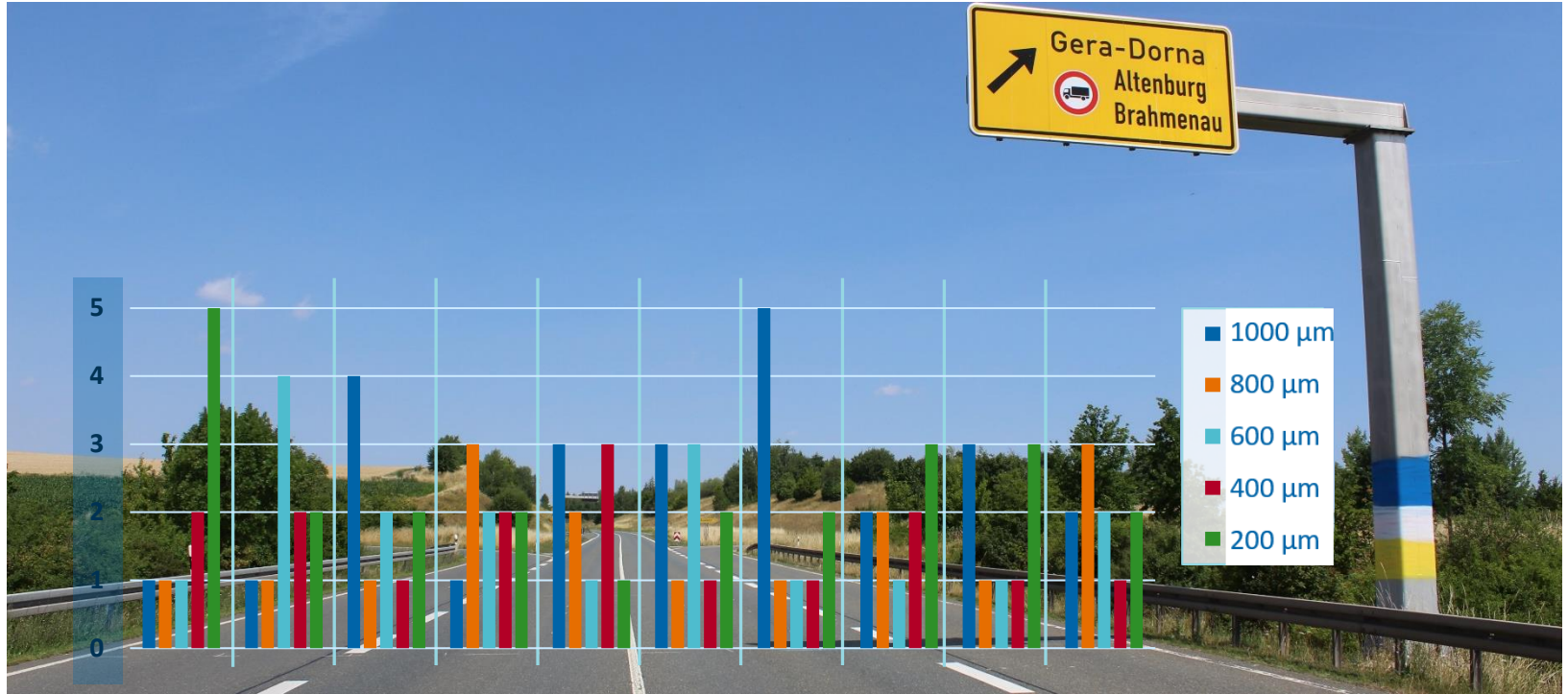


Fig. 8: Sampling positions (S3) on a road (A-J), points A and B in the acceleration track and I and J in the deceleration track (B2 near Gera-Dorna).

Retention pond and drainage system

- Artificial lakes to manage stormwater runoff.
- Can remove particulate pollution and improve the quality of surface runoff due to sedimentation.
- Sediments need to be removed on a regular basis and disposed in an appropriate way.
- Possible leaching of pollutants linked to TRWP.



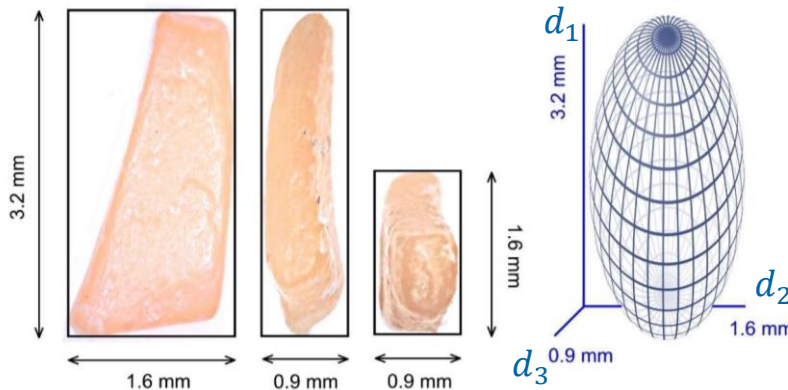
Fig. 9: Water drain on road (A), drainage system (B), and retention pond (C).

Laboratory Experiment

Hypothesis: The particle's morphological shape is directly related to its fate in the environment.

Aim:

- Catalogue fragments based on three-dimensional shape descriptors.
- Investigate morphology-dependent transport and retention of TRWP in saturated quartz sand columns.



➤ Equancy = $\frac{d_3}{d_1}$

➤ Platiness = $\frac{d_2 - d_3}{d_1}$

➤ Elongation = $1 - \frac{d_3}{d_1}$

Fig. 11: Parametrization of a microplastic fragment (Rosal 2021).

Degradation and Fragmentation

Does TRWP follow similar transport patterns to PVC?

	PVC	TRWP
Size:	125 – 200 μm	10 – 1000 μm (median 100 μm)
Density:	2.65 g/cm^3	1.7 g/cm^3
Shape:	Rod-like fragments	Rod-like elongated

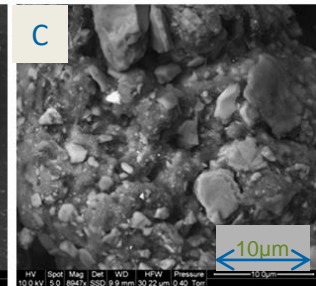
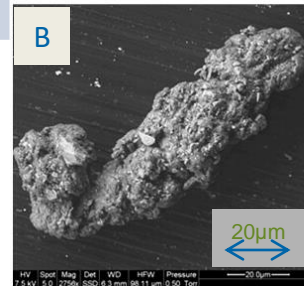


Fig. 12: Light microscope image of PVC particles (A), scanning electron microscope image of TRWP (B), and incrustations magnified (C) (Kreider, et al. 2021).

Outcome

- Feasible tire abrasion rate test method that is repeatable, reproducible, cost efficient and practicable.
- Less time-consuming sample collection.
- Link fragment shape to potential transport in soil.



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Effect of fragmentation on the transport of polyvinyl chloride and low-density polyethylene in saturated quartz sand

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