Exploratory assessment of microplastic from arable soils during wind erosion in the dry steppe of Kazakhstan

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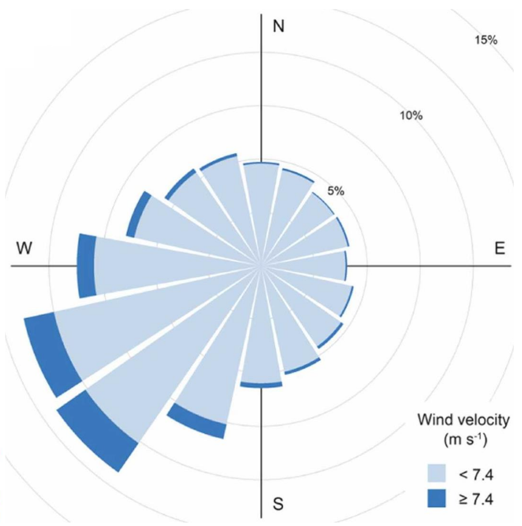
Background

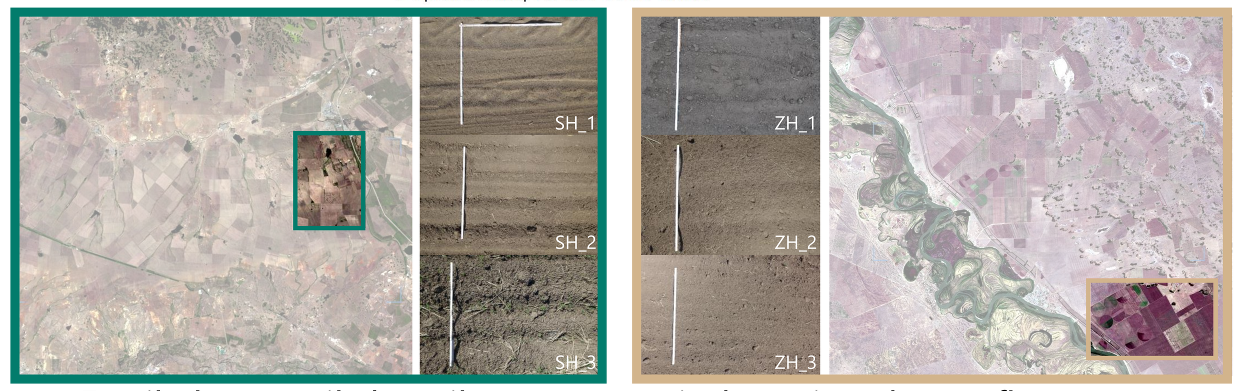
- Global microplastic (MP) contamination in agricultural soils has been documented [4, 11, 13]
- Agricultural intensification increases the risk of microplastic pollution [6, 14, 15]
- Potential for aeolian microplastic mobilisation, transport and deposition from arable soils [1, 3, 12]
- Risk of wind-driven microplastic contamination on a local and regional scale [2]
- In-situ studies on the aeolian dynamics of microplastic on arable soils have so far been scarcely conducted

Research aims

- Assessing microplastic variety in abundance (including shape and type) in soils and in wind tunnel-driven erosions on fallow steppe
- Studying the potential flux of microplastic and enrichment ratio (ER) for both study sites
- Exploring links between microplastic detections and potential sources

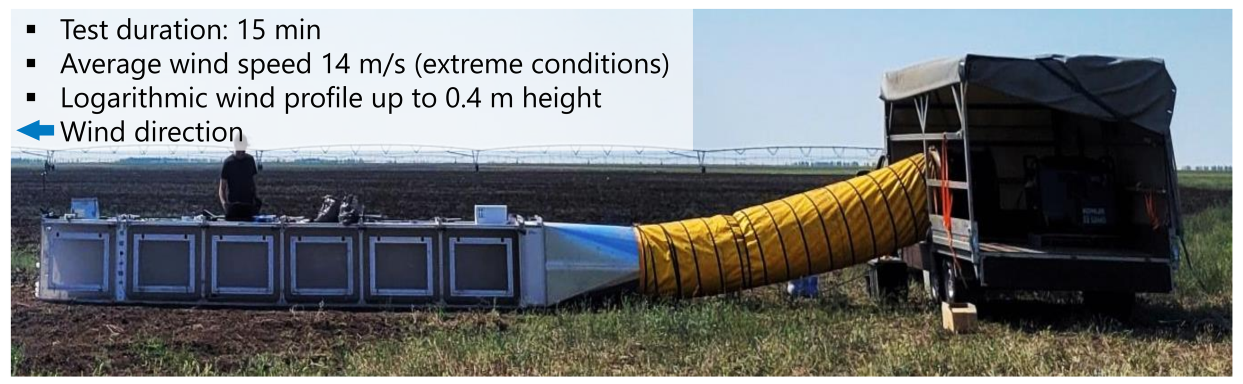
Study sites



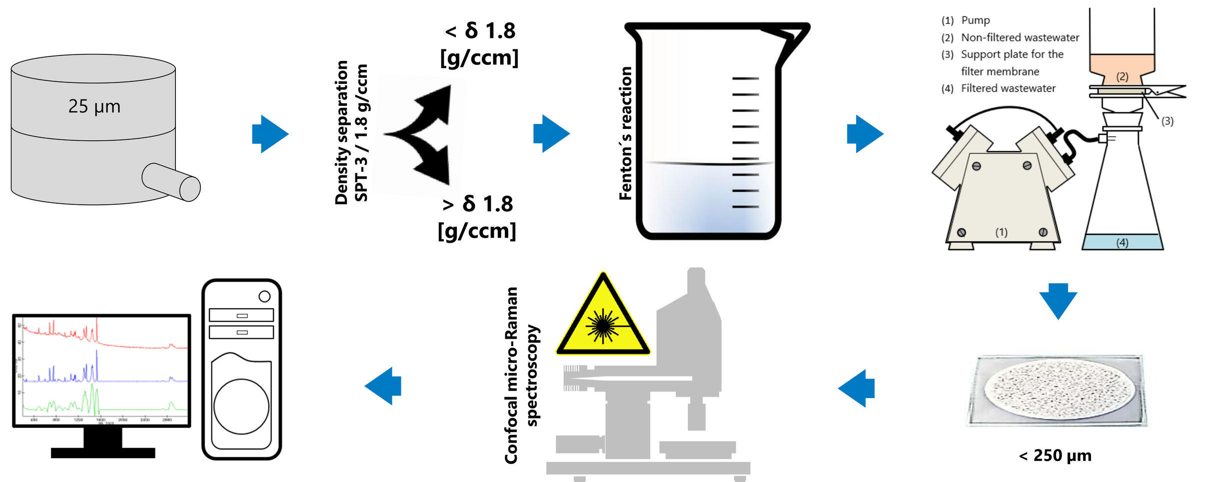


- Fertile loess soils heavily prone to wind erosion due to flat topography, semi-arid climate and agricultural management

Wind tunnel (push-type) [9]



Laboratory analytics

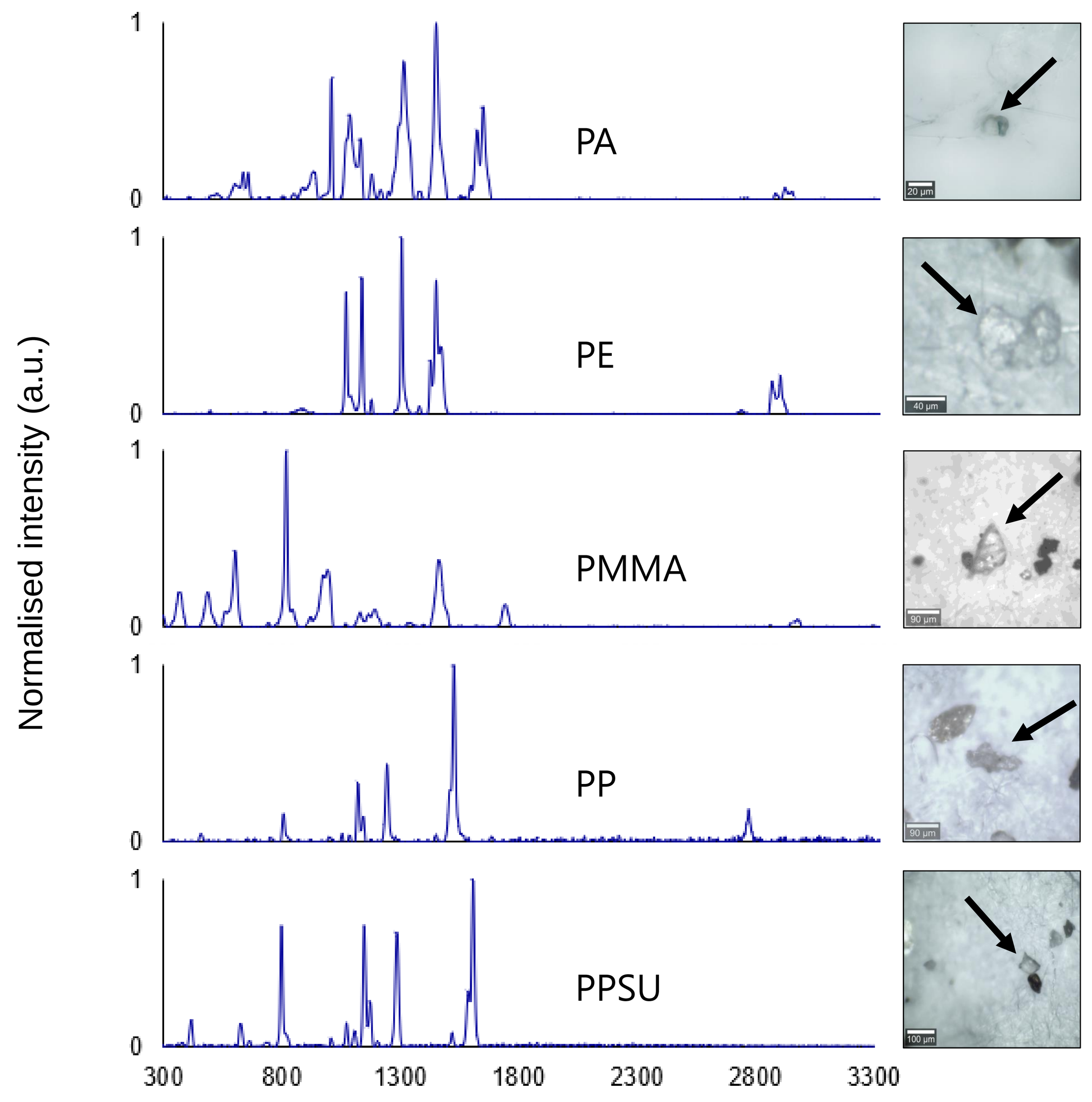


Results

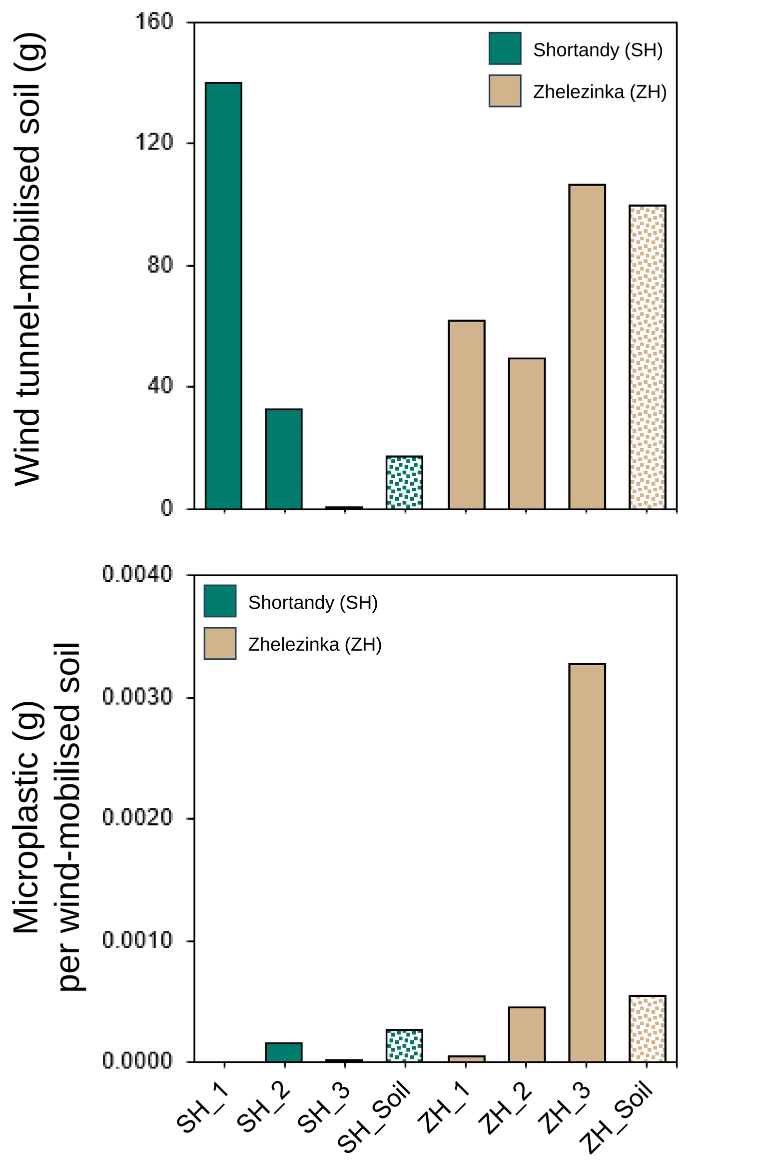
Table 1: Summary of wind tunnel–mobilised sediment and detected microplastics in Shortandy and Zhelezinka, including polymer shapes, types and percentage distribution. *Abbreviations: PP – polypropylene; PPSU – polyphenylsulfone; PE – polyethylene; PA – polyamide; PMMA – polymethylmethacrylate.*

	Sediment (g)	Microplastic (g)	Fragments (g)	Fibres (g)	PP (g)	PPSU (g)	PE (g)	PA (g)	PMMA (g)
∑ Shortandy (SH)	190.77	0.00041	0.00015	0.00026	0	0	0	0.00041	0
∑ Zhelezinka (ZH)	317.74	0.00433	0.00420	0.00013	0.00076	0.00327	0.00016	0	0.00013
∑ Total$_{SH + ZH}$	508.51	0.00474	0.00435	0.00039	0.00076	0.00327	0.00016	0.00041	0.00013
Percentage		0.00093 %	92 %	8 %	16 %	69 %	3 %	9 %	3 %

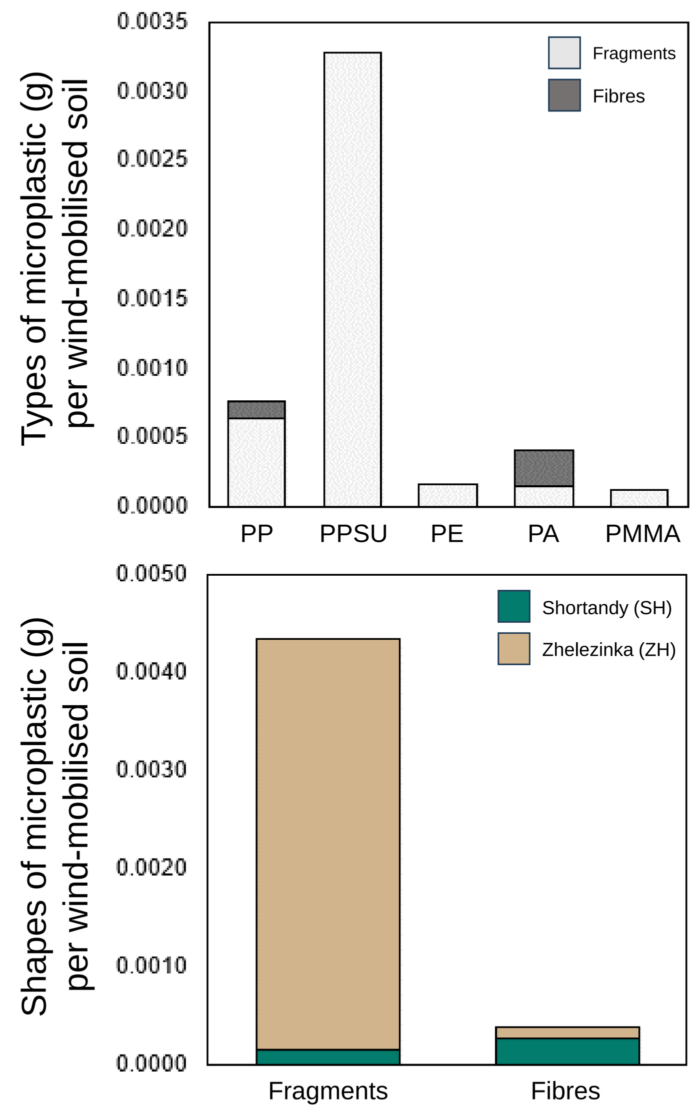
Enrichment ratio (ER) = Microplastic$_{wind\text{-}driven}$ / Microplastic$_{soil}$ = 1.63



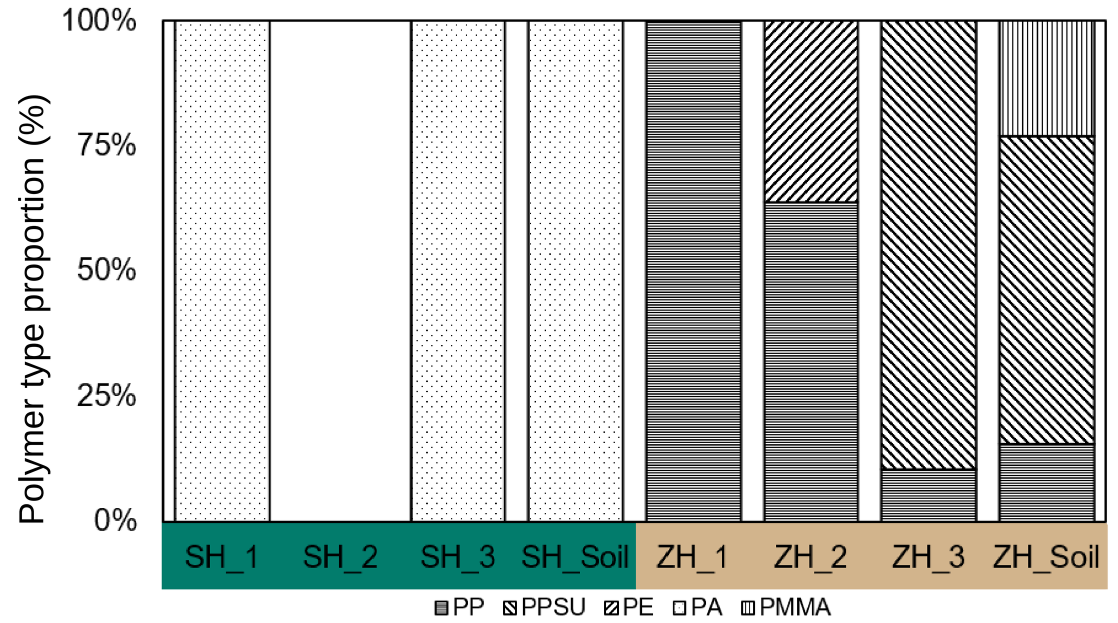
Raman shift (rel. 1/cm)



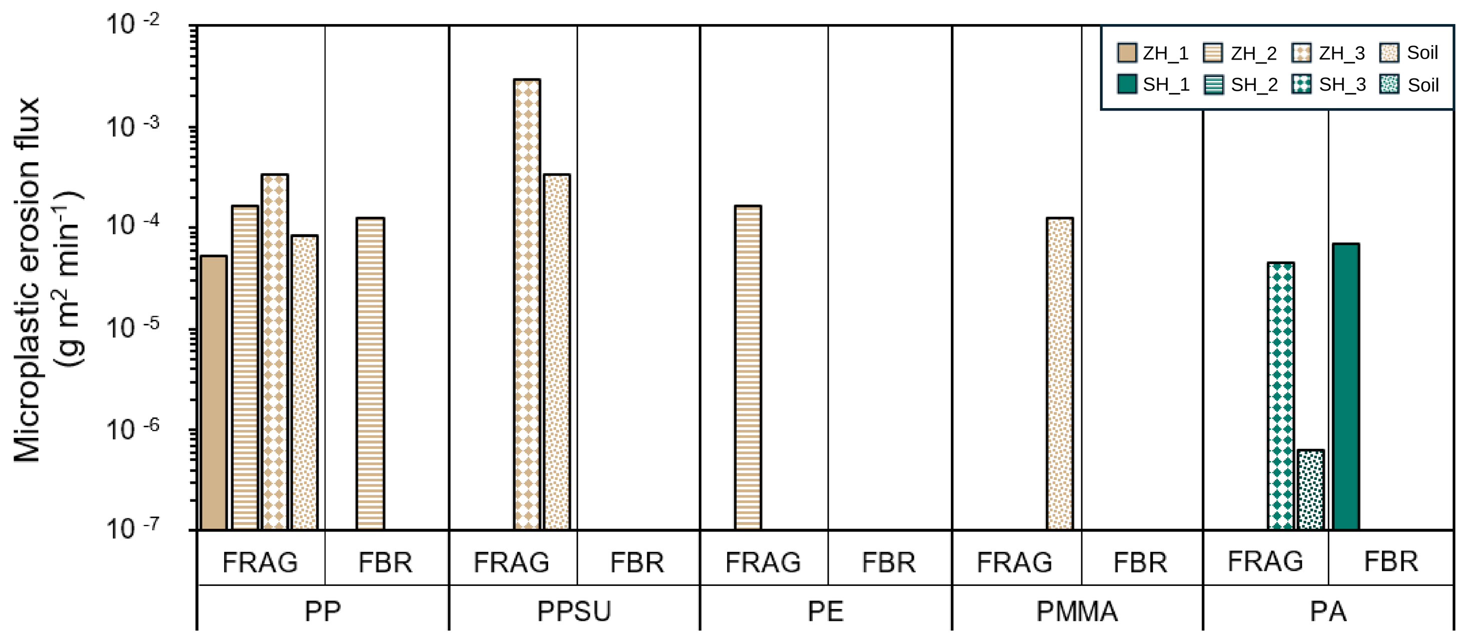
Experiments per study sites



Polymer type (above) and shapes (below)

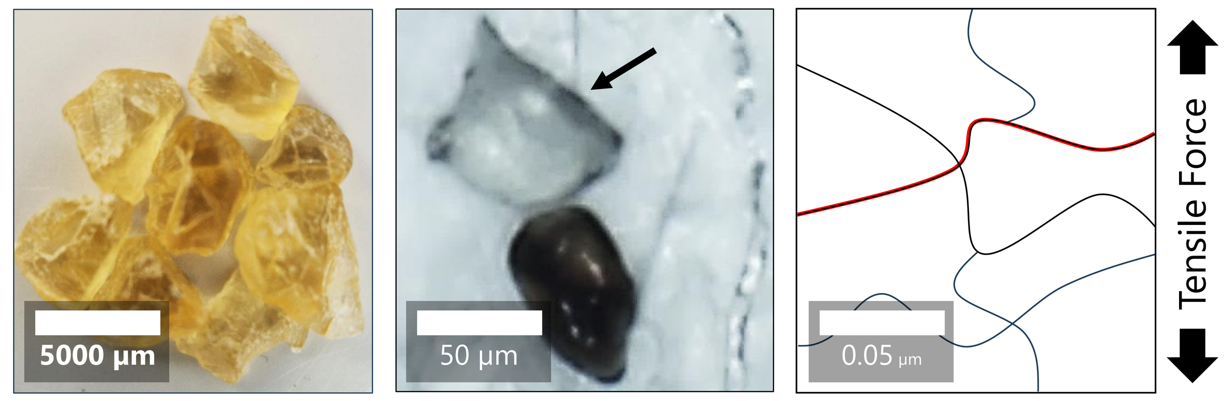


Microplastic detections per study sites and soil



Microplastic fragments (FRAG) and fibres (FBR) per polymer type and study site

Discussion



Pristine PPSU granules from the laboratory

PPSU detection confirmed by the confocal micro-Raman spectroscopy

Amorphous structure of PPSU with fracture (red) along the grain boundaries

→ Indication for irrigation systems as a source for PPSU [5, 7, 8, 10]

- ✓ PPSU is commonly used in irrigation systems (e.g., fittings, connectors and pipes)
- ✓ Regular use of irrigation systems in the study region was confirmed by local farmers
- ✓ River water pumping carrying fine sediments potentially causes abrasion and of PPSU
- ✓ Due to low ductility, PPSU fractures easily under stress
- ✓ Crystallographic bond failures promote micro-fragment release (embrittlement)
- ✓ Fine PPSU particles were found in irrigated field soils
- ✓ Findings suggest links between agricultural irrigation and microplastic pollution

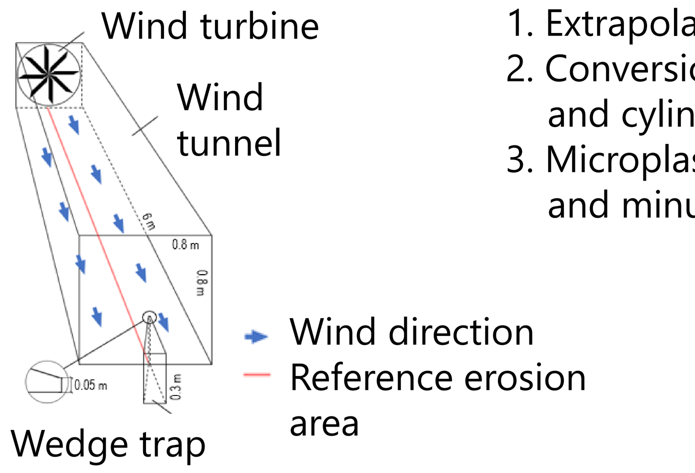
Conclusion

- Detection of microplastic (maximum size 150 µm) in both wind tunnel-driven erosion and soil
- Variation in microplastic abundance, shape and polymer type related to agricultural management
- PPSU contamination potentially originate from irrigation systems
- Fragments were the dominant microplastic shape
- Microplastics were more abundant in wind-driven erosion compared to soil
- The procedure has been proven to be adequate for assessing microplastic erosion in semi-arid steppe

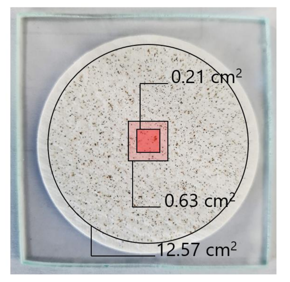
Next steps

- ➢ Further studies including varying wind speeds and diverse surfaces are needed to assess potential microplastic mobilisation
- ➢ Additional soil samples are needed to spatially scale microplastic abundance

Assumptions and calculations



1. Extrapolation to filter membrane and total wind-mobilised soil
2. Conversion of microplastic items to mass (g) based on spherical and cylindrical shapes
3. Microplastic results were normalised to square meter (x 3.33) and minute



Mean Raman-measured filter membrane

Mean Raman-recorded filter membrane

Total filter membrane area

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