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MICROPLASTICS IN PLASTICULTURE : CURRENT KNOWLEDGE, CHALLENGES AND PERSPECTIVES

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INTERNATIONAL COMMITTEE FOR AGRICULTURAL PLASTICS

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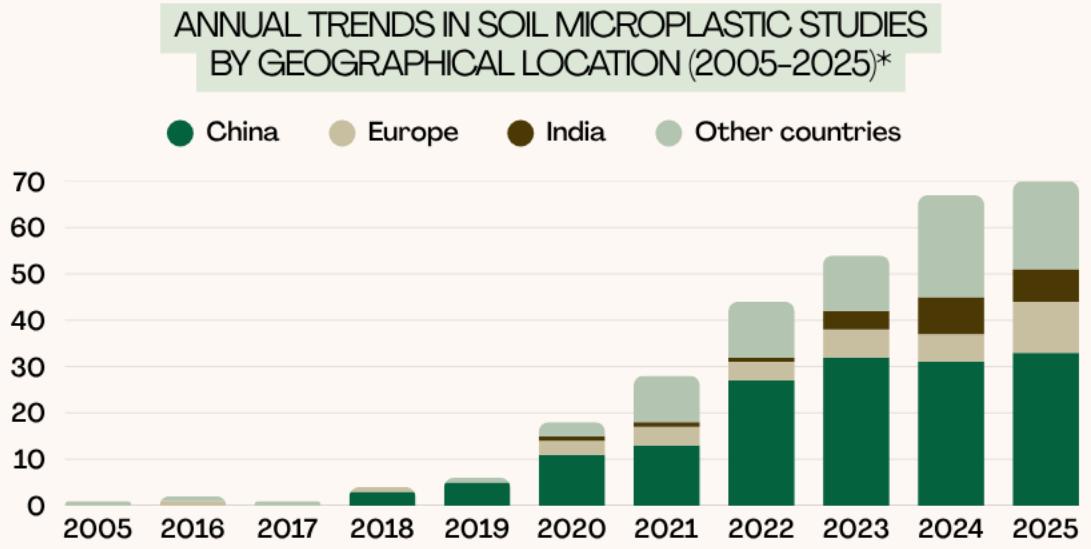
SCIENTIFIC RESEARCH ON MPs ↗

Rilling, M.C. (2012) - *"Microplastic in terrestrial ecosystems and the soil?"* Environmental Science & Technology, 46, 6453–6454	Early scientific recognition of MP as an emerging issue in terrestrial ecosystems and soils
First scientific papper : Zhang & Liu (2018) - *"The distribution of microplastics in soil aggregate fractions in southwestern China Science of the Total Environment"*, 642, 12–20	Early quantitative evidence of MP Abundance and Distribution in Agricultural Soils
First German scientific papper : Piehl S. et al. (2018) - *"Identification and quantification of macro- and microplastics on an agricultural farmland"* Scientific Reports, 8, 17950	Quantification of MP in an agricultural field (without apparent direct agri-plastics inputs)

Research scope	Publications	Source
All environments (Air, Water, Soil)	11784	Wang et al. (2026)
Atmospheric MPs	1385	Wang et al. (2026)
Soil MPs	2210	Pan et al. (2024)
Agroecosystems	1636	Jamil et al. (2024)



* ***Source:*** *Wu et al. (2026) — 297 publications, 6,197 records. Countries based on study locations*

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MEASURING MPs IN AGRI-SOIL

1 Sampling

- Sampling depth
- Sampling mass/volume
- Number & spatial distribution of subsamples
- Composite vs Individual Contamination control

2 Extraction

- Size fractionation/sieving
- Organic matter digestion
- Density separation
- Filtration
- Recovery efficiency

3 Quantification

- Particles abundance
- Mass concentration

4 Identification & Characterisation

- µFTIR / ATR-FTIR
- Raman
- LDIR
- Polymer identification
- Size distribution
- Shape (fragments, fiber, films, ...)
- Py-GC/MS

METHODOLOGICAL HETEROGENEITY → LIMITED COMPARISON AND ROBUST DATA AGGREGATION →

Different choices at each step

Need for harmonisation - but not necessarily for a single analytical protocol :
Decision-tree approach

- Objective
- Particle size
- Data output
- Analytical tools

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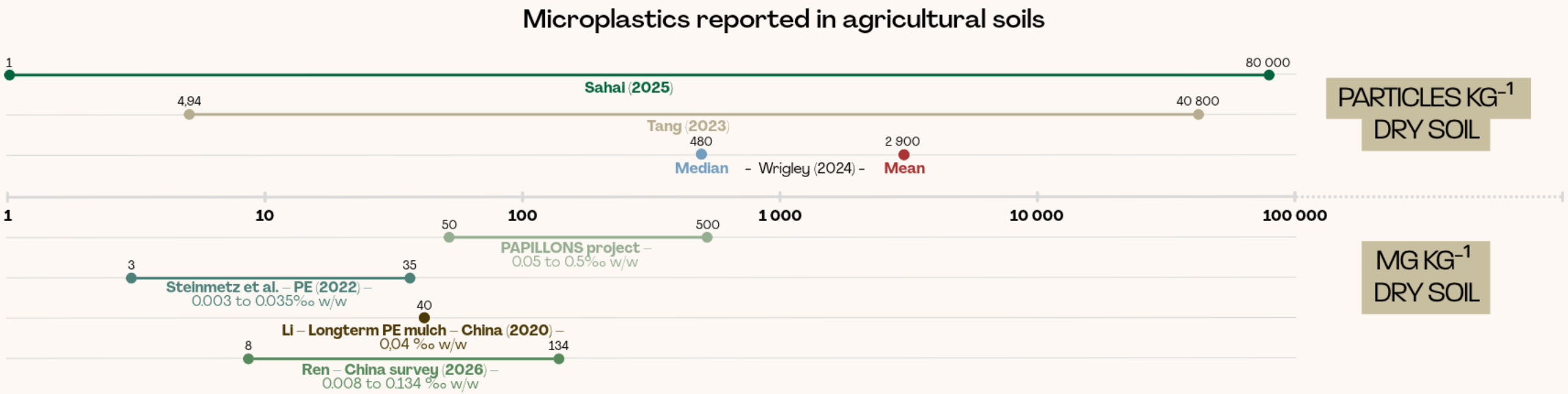
MEASURING MPs IN AGRI–SOIL



MOST FREQUENTLY REPORTED POLYMERS IN SOILS

PE > PP > PS, PVC, PET and other polymers*

**Kubayi et al. (2026)*

PE AND PP ARE ALSO THE MOST WIDELY USED POLYMERS GLOBALLY

↘ Polymer identity alone is therefore not sufficient for source attribution

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IMPACTS OF MPs ON AGRICULTURAL SOIL

Type of impact	Demonstrated effects	Polymer(s) tested	MP concentration (% w/w dry soil)	Scientific reference	Comments
Soil physicochemical properties	Decreased soil pH; changes in soil aggregate stability	PE, PBAT/starch	0.005–0.05%	Šmídová et al. (2025)	Significant pH reductions in specific field treatments. Aggregate responses varied across sites and seasons.
Soil microbial communities and functions	Reduced fungal biomass and microbial respiration	PE, PBAT/starch	0.005–0.05%	Šmídová et al. (2025)	Two-year European field study. Significant reductions observed under specific soil and exposure conditions.
Soil enzymatic activity	Reduced phytase activity; increased dehydrogenase activity	PE, PP, PS	0.01–0.1%	Lian et al. (2024)	Experimental study using 5–10 µm particles. Enzyme responses indicate altered soil biochemical functioning.
Nutrient cycling	Reduced available phosphorus; reduced total nitrogen and ammonium	PE	0.01–0.06%	Xu et al. (2024)	Two-year rice–wheat field trial. Phosphorus decreased during both seasons; nitrogen reductions were observed during the rice season.
Soil organic carbon dynamics	Reduced particulate organic carbon (31.8–41.6%) and microbial biomass carbon (39.7–63.0%)	PE, PPC/PBAT	0.3%	Zhang et al. (2024)	Eight-week incubation study. Quantified reductions concern grassland soils; farmland-specific responses are not established here.
Soil fauna	Reduced reproduction of soil invertebrates	PP agricultural plastics	0.005–5%	van Loon et al. (2025)	Species-dependent reproductive effects, mainly at ≥1% MP concentrations.

Experimental or field studies report effects on soil properties , microbial communities, carbon and nutrient cycling, and soil fauna. Some effects have been observed at environmentally relevant concentrations – although their ecological significance remains uncertain.

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IMPACTS OF MPs ON PLANTS & YIELDS

Impact category	Demonstrated effects	Crop / polymer	MP concentration (% w/w soil)	Reference
Vegetative growth	Shoot length reduced by 18.0–44.4% ($p < 0.05$)	Lettuce / PE, PP, PS	0.01–0.1%	Lian et al. (2024)
Plant biomass	Mean reduction of 13% (95% CI: 7–19%)	Multiple species / various MPs	Variable	Shi et al. (2024), meta-analysis
Photosynthetic pigments	Mean chlorophyll reduction of 28% (95% CI: 23–34%)	Multiple species / various MPs	Variable	Shi et al. (2024), meta-analysis
Oxidative stress	Mean oxidative damage increased by 20% (95% CI: 15–25%)	Multiple species / various MPs	Variable	Shi et al. (2024), meta-analysis
Root development	Mean root length reduction of 14.3%	Multiple species / various MPs	Variable	H. Xu et al. (2024), meta-analysis

Crop	Demonstrated effects	Polymer	MP concentration (% w/w soil)	Reference	Experimental conditions
Rice (hybrid cultivar)	Grain yield −23%	PE	0.15%	Yi et al. (2023)	Pot experiment; cultivar-dependent effect
Tomato	Fruit yield −19.6% (PET) and −37.5% (PVC)	PET, PVC	0.5%	Dainelli et al. (2023)	Controlled pot experiment; 15 weeks
Maize	Strongest productivity decline with 75 µm PE particles (approximately twofold)	PE	0.2%	Iqbal et al. (2025)	Pots inserted into an agricultural field; 120 days
Rice	Grain weight +42.5%	PE	0.06%	M. Xu et al. (2024)	Field lysimeters; first-year result
Wheat	No significant effect on grain biomass	PE	0.01–0.06%	M. Xu et al. (2024)	Field lysimeters; rice–wheat rotation

MPs can significantly affect plant growth and physiology, with highly variable effects on crop yields depending on species, polymer characteristics and exposure conditions

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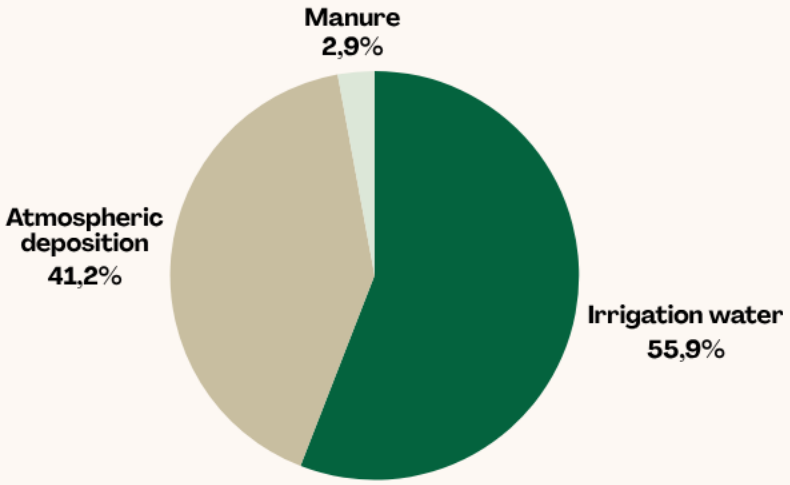
ORIGINS OF MPs IN AGRI–SOIL

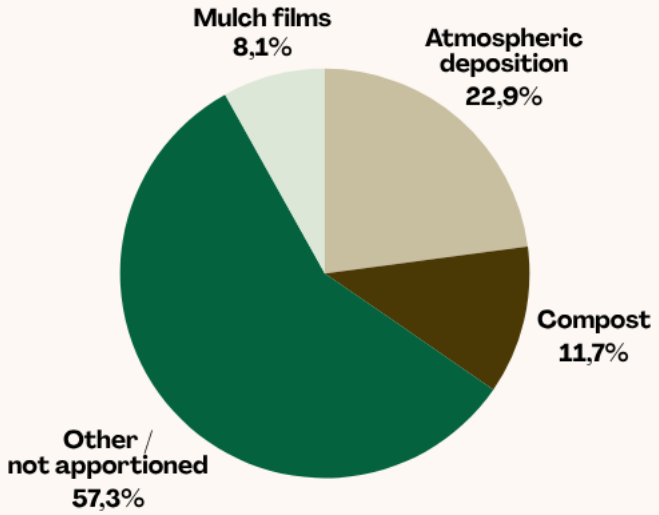
PORTUGAL — ORCHARDS (2025)



Field sampling + input flux estimates

Relative contributions of three investigated input pathways, normalized to 100%.

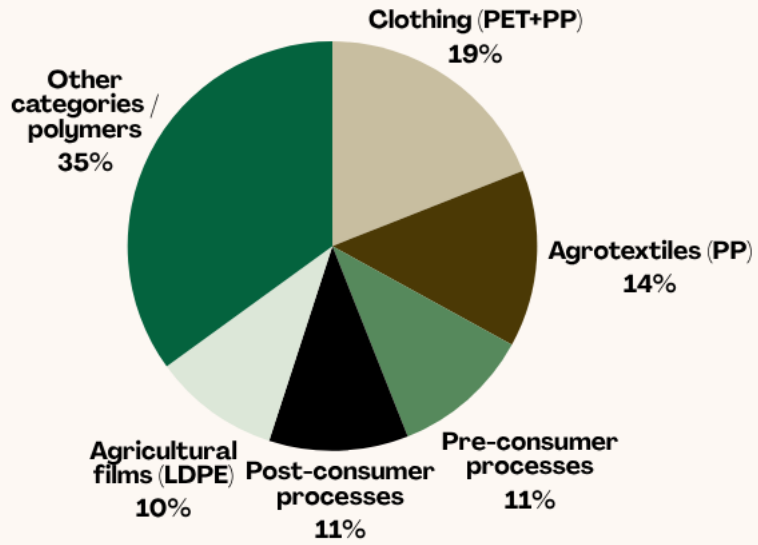
CHINA — REN ET AL (2026)



Field sampling + MFA

Estimated contributions of different sources to soil MPs contamination, without an exhaustive 100% source apportionment.

SWITZERLAND — JIANG & NOWACK (2025)



Probabilistic MFA — all soils, excluding tyre wear (960 ± 350 g/habitant/year)

Distribution of modelled MPs emissions to Swiss soils, based on Probabilistic Material Flow Analysis (PMFA)

↘ **Agricultural plastics are not necessarily the dominant source of MPs in agricultural soils.**
Multiple pathways contribute, with highly context-dependent relative importance.
Robust source attribution remains a major scientific challenge.

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FROM SCIENTIFIC EVIDENCE TO ENVIRONMENTAL ASSESSMENT ↗

Source attribution

MPs detected in agricultural soil
→ MPs attributed to agri-plastics
Are the sources reliably identified?

Experimental representativeness

Effects observed with selected particles and doses
→ Effects of weathered agricultural plastics fragments at field-relevant concentrations
Do the experiments reflect realistic exposure ?

Ecological significance

Changes in biological or physiological indicators
→ Measurable impairement of soil functions or crop productivity
Are the effects persistent and ecologically meaningful?

Overall environmental performance

Potential impacts of plastics residues
→ Net environmental impacts of agri-plastics
Are benefits (e.g., improved crop yields, reduced water consumption and reduced use of agricultural chemicals), trade-offs and alternatives considered?

↘ **These uncertainties should not prevent us from taking action to reduce avoidable plastic losses into the environment.**

Scientific evidence of the presence and effects of MPs does not, on its own, establish the environmental impacts attributable to agricultural plastic products.

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ENVIRONMENTAL VULNERABILITY ASSESSMENT — A TOOL FOR PRIORIZING ACTION

1 Accounting-based Approach
→ Input Use Intensity

Volumes placed on the market.

2 Use
→ Environmental Exposure

Potential for microplastic generation and release during agricultural use.
→ Product resistance × Environmental stress

→ Product Resistance

Product standards defining mechanical resistance, ageing and durability requirements of manufacturer guaranty.

→ Environmental Stress

Exposure to weathering, mechanical stresses and physical interactions with soil, vegetation or surrounding materials.

3 Risk of macroplastics loss
→ Residual Removal Difficulty

Difficulty of removing the full plastic material without leaving residual losses.

4 Risk of Improper Management (illegal burial, open burning)
→ Collection Difficulty

Difficulty of capturing the waste stream (within collection schemes).

5 Recycling Difficulty

Technical and operational barriers to recycling, sorting requirements and availability of suitable recycling processes.

→ Effective recycling yield

→ Soilage coefficient

Environmental Vulnerability Profile (EVP)	EVP Score
Low concern	1.0 – 1.8
Limited concern	1.8 – 2.6
Moderate concern	2.6 – 3.4
High concern	3.4 – 4.2
Very high concern	4.2 – 5.0

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ENVIRONMENTAL VULNERABILITY ASSESSMENT — A TOOL FOR PRIORIZING ACTION

Indicator	Coefficient	Score 1	Score 2	Score 3	Score 4	Score 5
1. Input Use Intensity (IUI)	**0,15**	**<2% total market**	**3% - 6%**	**7%-12%**	**13%-20%**	**>20%**
2. Environmental Exposure (EE) = 0,7ES+0,3SP	**0,25**	**Very low exposure potential**	**Low exposure potential**	**Moderate exposure potential**	**High exposure potential**	**Very high exposure potential**
Environmental Stress (ES)	**0,175**	Minimal stress	Limited stress	Moderate stress	High stress	Extreme stress
Product Resistance (PR)	**0,075**	Standard + durability classes	Standard + ageing tests	Guaranteed life + tested strength	Partial manufacturer commitment	No requirements
3. Residual Removal Difficulty (RRD)	**0,2**	**Easy, negligible residues**	**Easy, few residues**	**Specific handling, some residues**	**Difficult, many residues**	**Removal impracticable**
4. Collection Difficulty (CD)	**0,2**	**≥ 85%**	**70% – 84%**	**55% – 69%**	**40% – 54%**	**< 40%**
5. Recycling Difficulty (RD) = (RY + SC) / 2	**0,2**	**≥ 95%**	**85% – 94%**	**70% – 84%**	**55% – 69%**	**< 55%**
Recycling Yield (RY)	**0,1**	≥ 95%	85% – 94%	70% – 84%	55% – 69%	< 55%
Soilage Coefficient (SC)	**0,1**	< 1.20	1.20 – 1.50	1.51 – 2.00	2.01 – 2.50	> 2.50

Preliminary results

Highest EVP scores for FRANCE :
Mulching : 3,25/5
Netwraps : 3,25/5
Twines : 3,15/5

Sensitivity analysis

The samethreeproduct families remain in the top threeunder ±20% variations in weighting factors. Expert-based scores have a greater influence on rankings.

Limitation & next steps

EVP assesses potential environmental vulnerability, not the overall sustainability of agricultural plastics. Agronomic benefits, product essentiality and available alternatives must also be considered.

Work in progress

This exploratory approach needs **inputs from the scientific community, industry and end-users**

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