# EU Directive on Soil Monitoring and Resilience

## Nordic Agrifoodplast Network policy and stakeholder forum "The Challenge of Soil Plastic Pollution for the Nordic Environment, Agriculture, and Society"

Mirco Barbero
D1 Land Use & Management
DG ENV – European Commission

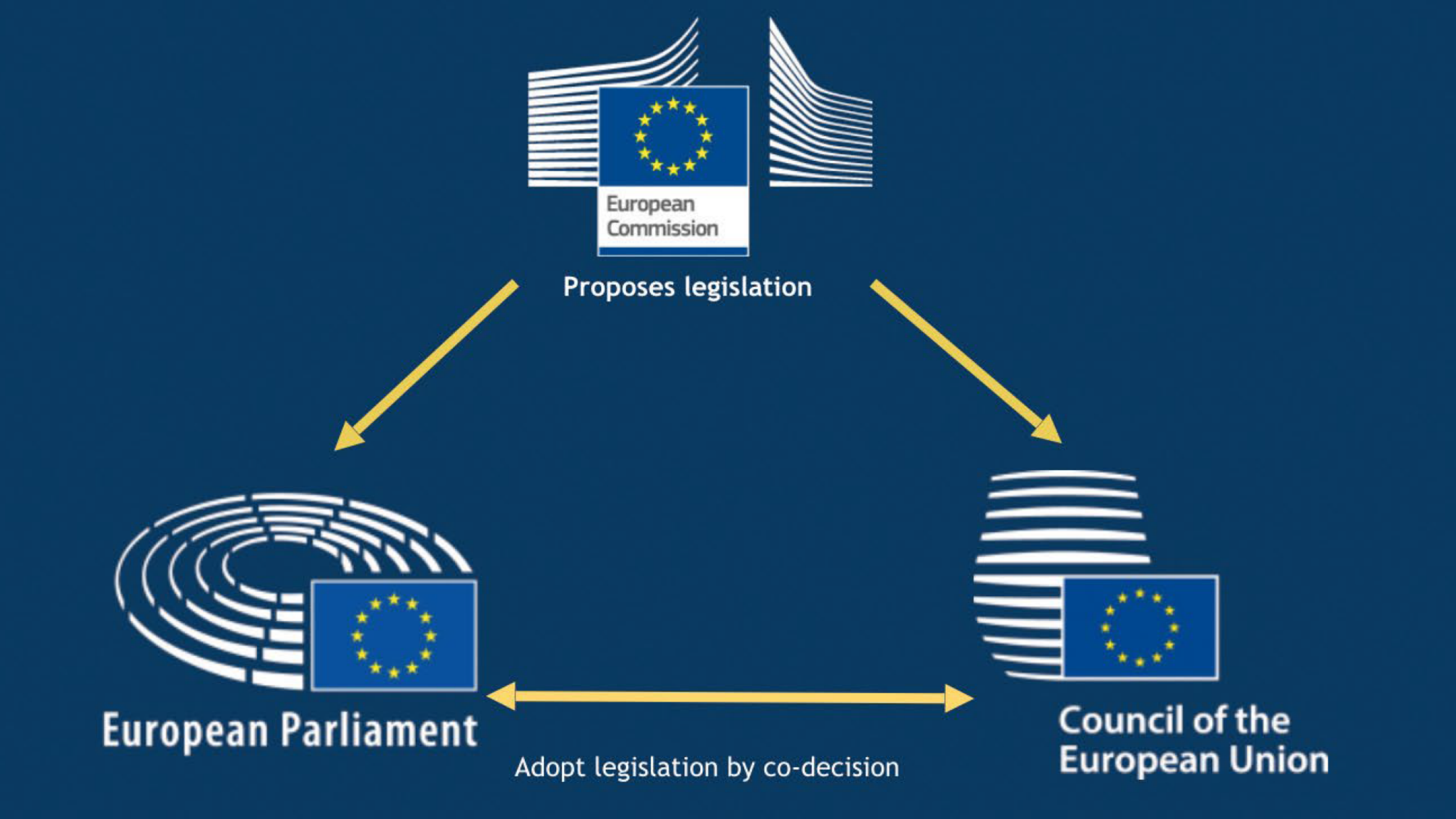
# Healthy soils as key contribution to **challenges**

Healthy soils for achieving the Union's overarching objectives concerning **climate change mitigation and adaptation** and **biodiversity**

Healthy soils for preventing and mitigating the impacts of **natural disasters** and increasing the **drought resilience**

Healthy soils for increasing/ensuring the EU's **long term capacity** to produce **sufficient, safe and nutritious food**

Healthy soils for protecting the **health** of EU citizens


European Commission
Proposes legislation
European Parliament
Council of the European Union
Adopt legislation by co-decision

# Soil Monitoring Law – key features

# Soil descriptors

| Aspect of soil degradation | Soil descriptor (mandatory) | Soil descriptor (optional) |
|---|---|---|
| Salinisation | Electrical conductivity | |
| Loss of Soil Organic Carbon | SOC concentration | soil organic carbon content |
| | SOC stocks | |
| Soil compaction | Bulk density in topsoil | saturated hydraulic conductivity (top-and sub-soil) |
| | Bulkdensity in subsoil | air capacity (top-and sub-soil) |
| Excess nutrient content in soil | Extractable phosphorus | |
| | Total nitrogen content in soil | |
| | SOC to nitrogen ratio | |
| Soil erosion | Soil erosion rate | |
| Soil contamination | concentration of heavy metals | |
| | concentration of a selection of organic contaminants | |
| | Concentrations of selected PFAS | Concentrations or presence of a selection of other emerging soil contaminants |
| | Concentrations of selected active substances in pesticides and their metabolites | |
| Reduction of soil water retention and infiltration | soil water holding capacity | |
| | saturated hydraulic conductivity | |
| | air capacity | |
| Acidification | Soil acidity (pH) | base saturation /effective cation exchange capacity |
| Loss of soil biodiversity | DNA metabarcoding for fungi and bacteria | metabarcoding of archaea, protists and animals |
| | | phospholipid fatty acid analysis (PLFA) |
| | | abundance and diversity of nematodes |
| | | abundance and diversity of earthworms |
| | | abundance and diversity of springtails |
| | | abundance and diversity of native ants |
| | | soil biological quality based on arthropods (QBS-ar) |
| | | presence of invasive alien species and plant pests |
| | | soil basal respiration |
| Soil sealing and soil removal | Total sealed soils and areas that underwent soil removal ($km^2$ and % of Member State surface) | soil artificialisation |
| | Soil sealing and soil removal, de-sealing and net-sealing (average per year–- in $km^2$ and % of Member State surface) | land fragmentation |
| | Total settlement area ($km^2$ and % of Member State surface) | land recycling rate |
| | Land use change to and from settlement area (average per year–- in $km^2$ and % of Member State surface) | land taken for commercial activities, logistic hubs, renewable energies, surfaces such as airports, roads, mines |
| | | consequences of soil sealing and soil removal, such as quantification of loss of ecosystem services, change in the intensity of floods |

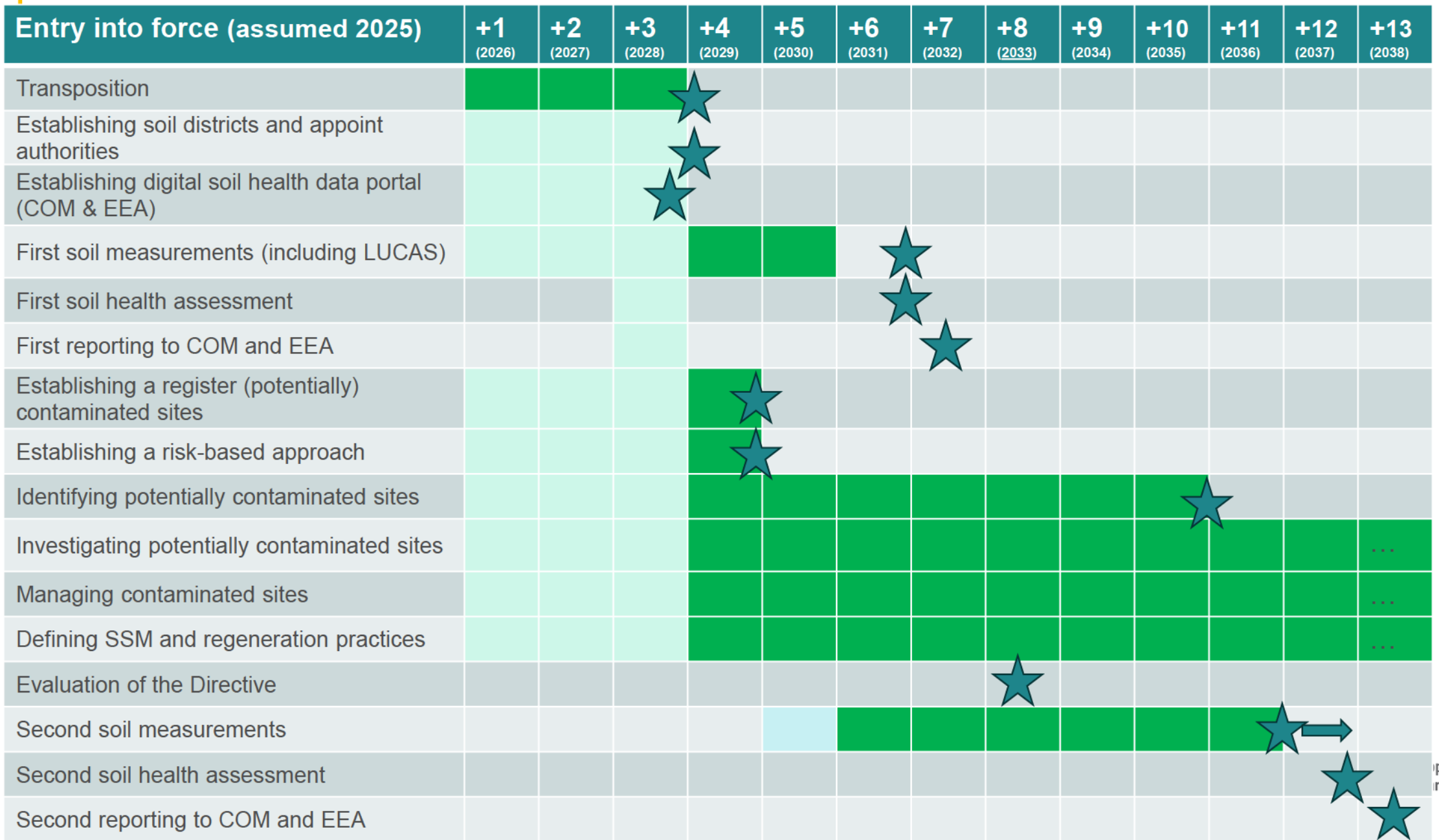
# SML recital 52

- (52) Microplastics and nanoplastics are substances that can pose a risk to soil health and also to essential activities such as agricultural production. Their presence in soils can have implications for soil fertility, thereby compromising the health and healthy development of crops. It is therefore essential that this Directive allow the inclusion of microplastics and nanoplastics in the monitoring of soil contaminants.

# Diffuse soil contamination in Annex I

| Aspect of soil degradation | Soil descriptor (1) | Criteria for healthy soil condition – non-binding sustainable target values (2) | Land areas exempted from meeting the related criterion |
|---|---|---|---|
| Soil contamination | — concentration of heavy metals in soil: As, Sb, Cd, Co, Cr (total), Cu, Hg, Pb, Ni, Tl, V, Zn (mg per kg)<br>— concentration of a selection of organic contaminants established by Member States and taking into account existing concentration limits in Union law, e.g. for water quality and air emissions | Reasonable assurance, obtained from soil point sampling, identification and investigation of potentially contaminated sites and any other relevant information, that an unacceptable risk to human health and the environment from soil contamination does not exist<br>Natural and anthropogenic background levels shall be taken into account in the risk assessment<br>If natural background is the only reason leading to unacceptable risks, then the relevant soil shall be deemed to meet the healthy soil criteria provided that it is managed in such a way that an unacceptable risk to human health does not exist<br>Habitats with a naturally high concentration of heavy metals that are included in Annex I to Directive 92/43/EEC shall remain protected | No exemption |
| Part C: soil descriptors without criteria | | | |
| Soil contamination (8) | Concentrations of PFAS-21 (9) or concentrations of PFAS-43 (10) or selected PFAS set by Member States in accordance with Article 7(4)<br>Concentrations of selected active substances in pesticides and their metabolites set by Member States in accordance with Article 7(4)<br>Optional:<br>— concentrations or presence of a selection of other emerging soil contaminants set by Member States in accordance with Article 7(4) | | |

# Timeline


Entry into force (assumed 2025)
+1 (2026)
+2 (2027)
+3 (2028)
+4 (2029)
+5 (2030)
+6 (2031)
+7 (2032)
+8 (2033)
+9 (2034)
+10 (2035)
+11 (2036)
+12 (2037)
+13 (2038)
Transposition
Establishing soil districts and appoint authorities
Establishing digital soil health data portal (COM & EEA)
First soil measurements (including LUCAS)
First soil health assessment
First reporting to COM and EEA
Establishing a register (potentially) contaminated sites
Establishing a risk-based approach
Identifying potentially contaminated sites
Investigating potentially contaminated sites
Managing contaminated sites
Defining SSM and regeneration practices
Evaluation of the Directive
Second soil measurements
Second soil health assessment
Second reporting to COM and EEA

# Thank you! Questions?

Env-soil@ec.europa.eu



European Commission

Presentation of the FAO's report

# State of research on the impacts of plastic pollution on soil health and crops


**Luca Nizzetto, Rachel Hurley, France Collard**

Norwegian Institute for Water Research (NIVA)

**Richard H. Thompson**

Thompson Environmental Consulting Ltd

**Giulia Carcasci**

FAO


# Agricultural plastics

- 10.2 million tonnes used in crop and livestock production;
- 2.1 million tonnes in fisheries and aquaculture;
- 0.2 million tonnes in forestry.
- 40% of the total are films (Mulch, greenhouse, covers)

*Scan the QR code to access the publication*


# Specific objectives

To review and summarize all available scientific evidence on the occurrence and impacts of plastic pollution on soil and crop health

(in particular microplastics from Agricultural Plastics)



TABLE A1. Boolean search strings used in the systematic review

| Systematic literature review | Boolean search strings | Date of search | Total number of search results | Number of eligible studies |
|---|---|---|---|---|
| Inventories of agricultural plastic use | Topic: "agricultural plastic*" OR Agriplastic* OR "agricultural plastic waste" AND inventor* OR generation OR Assessment OR survey OR map* | 01.04.2024 | 73 | 22 |
| Occurrence in soils | Title: soil; Topic: microplastic* OR "plastic residue" or "plastic litter" OR "plastic debris"; agricult* OR agriplastic* OR mulch OR mulching film* OR film* OR greenhouse OR encapsulated OR slow-release OR waste; monitor* OR occurrence OR source* | 02.04.2024 | 529 | 67 |
| Microplastic generation mechanisms in soils | Title: soil; Topic: microplastic* OR "plastic residue" or "plastic litter" OR "plastic debris"; agricult* OR agriplastic* OR mulch OR mulching film* OR film* OR greenhouse OR encapsulated OR slow-release OR waste; generation OR source* OR fragment* | 04.04.2024 | 295 | 8 |
| Fate processes in soils | Title: soil; Topic: microplastic* OR "plastic residue" or "plastic litter" OR "plastic debris"; fate OR transport* OR transfer* OR mobilis* OR retain* OR retention OR export OR runoff OR accumul* | 08.04.2024 | 408 | 27 |
| Effects on soil properties | Title: soil; Topic: microplastic* OR "plastic residue" or "plastic litter" OR "plastic debris"; agricult* OR agriplastic* OR mulch OR mulching film* OR film* OR greenhouse OR encapsulated OR slow-release OR waste; effect* AND soil properties OR microbio* OR bacteria | 13.03.2024 | 619 | 231 |
| Effects on plants | Topic: microplastic* OR "plastic residue" or "plastic litter" OR "plastic debris"; agricult* OR agriplastic* OR mulch OR mulching film* OR film* OR greenhouse OR encapsulated OR slow-release OR waste; effect* AND soil properties OR microbio* OR bacteria | 13.03.2024 | 265 | 114 |
| Long-term effect of AP use in soil | Topic: Mulch* AND plastic* AND effect AND crop AND yield AND "long-term"; Residue* OR microplastic* OR pollut* | 28.04.2024 | 20 | 4 |
| Plant uptake and transfer | Topic: microplast* uptake OR microplast* transfer OR nanoplast* uptake; vegetables OR maize OR corn OR pea* OR carrot OR soybean OR bean* OR wheat OR rice OR potato* OR fruit* OR peanut OR crop OR cabbage OR lettuce OR tomato; plastic related chemical OR additive* OR plasticizer OR flame retardant OR phthalate* | 13.03.2024 | 74 | 32 |

# Methodology

## A systematic review of the scientific literature

**(January 2014- April 2024)**

- Use of main-stream scientific literature search engines (WoS)
- Only primary research paper included (excluded review papers)
- Focus on effect of plastic on soil health and not on the agricultural performance of plasticulture

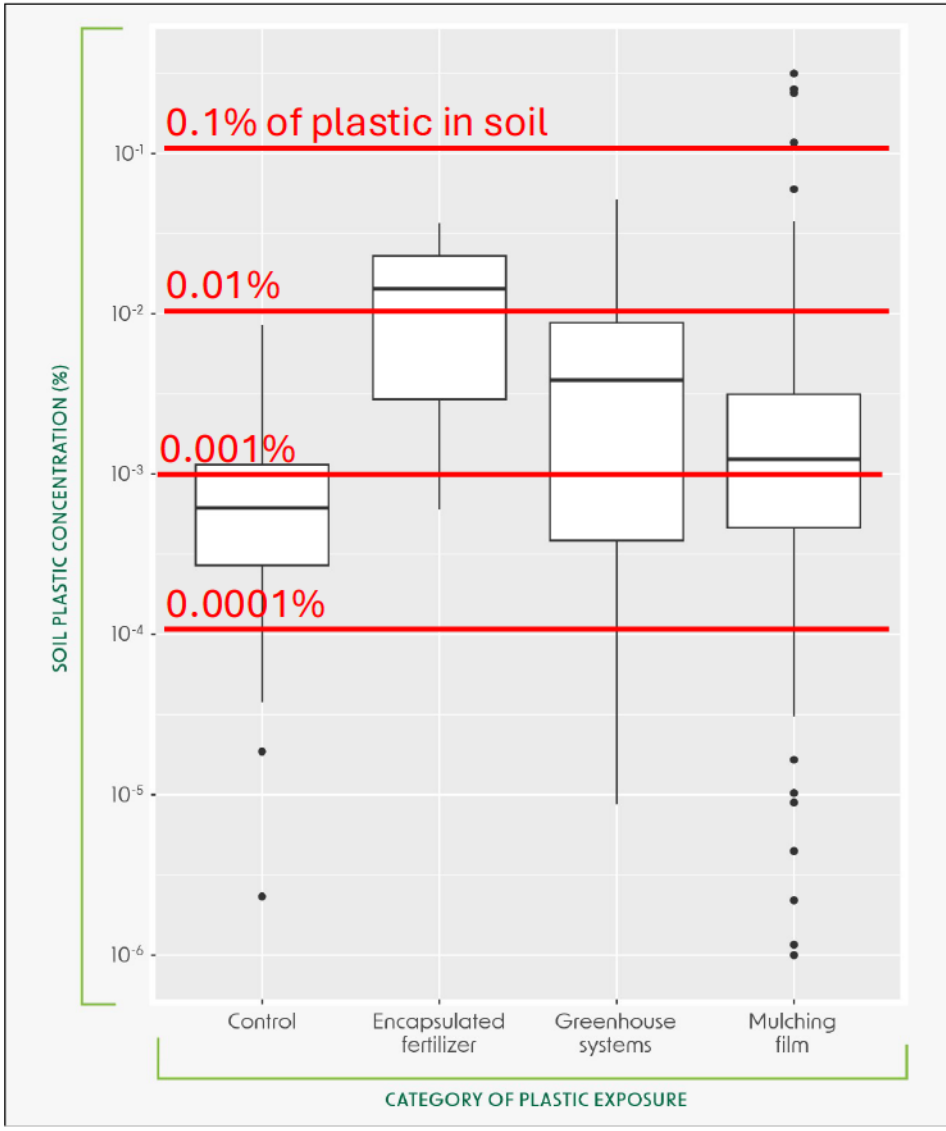
**2,283** documents retrieved

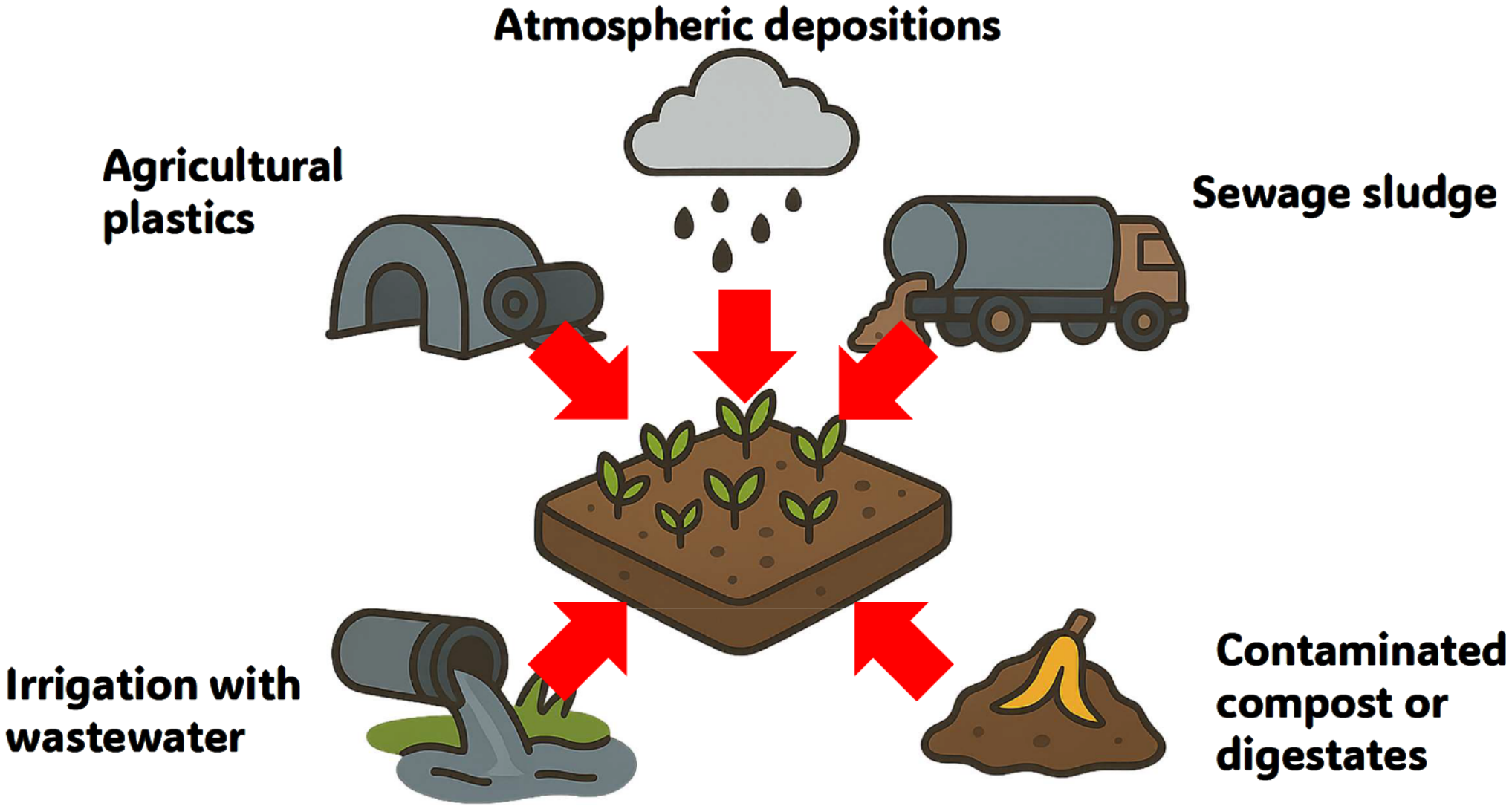
**505** matching inclusion criteria

>80% of available studies were produced after 2022

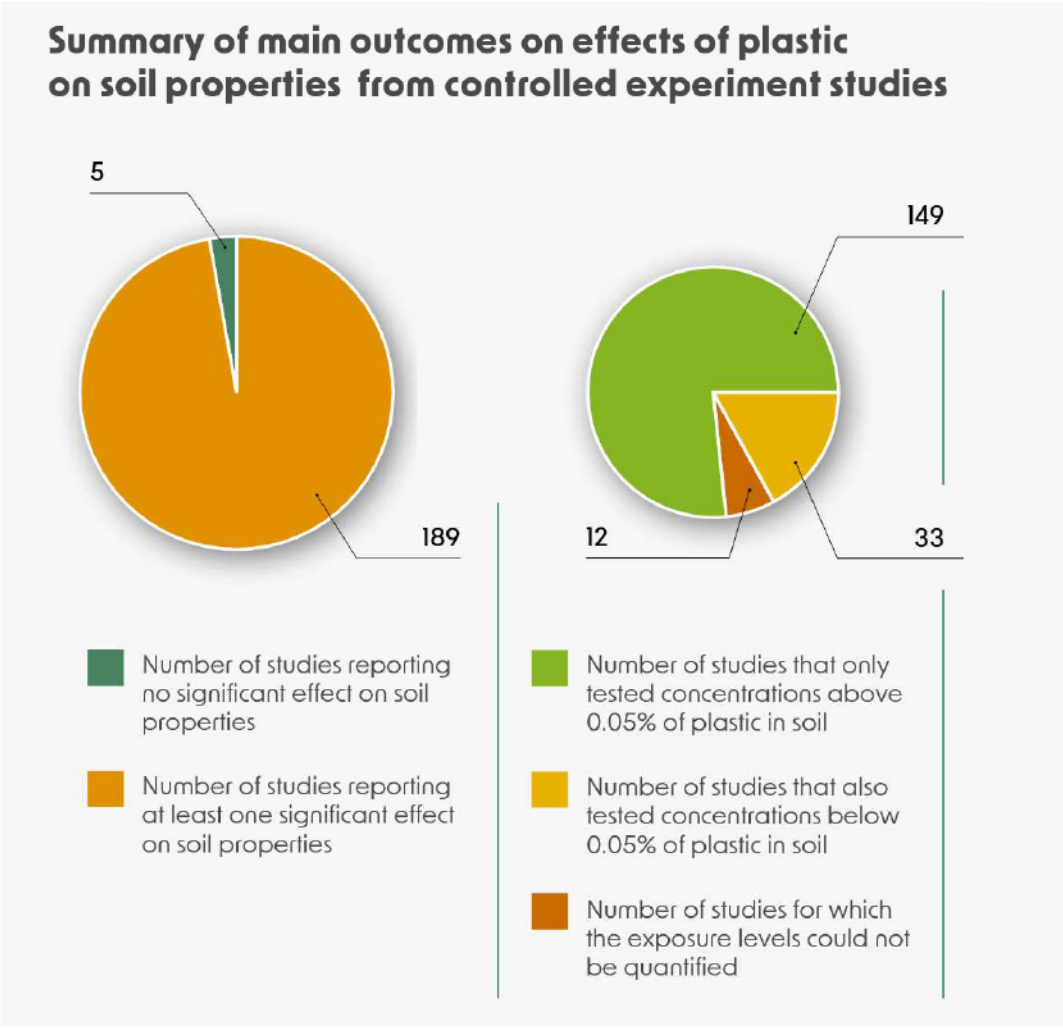
# 1. Is the use of Agricultural Plastics an important source of soil pollution?

- Several studies indicate agricultural plastics as a significant pollution sources
- Plastic residues (microplastics) concentrations in agricultural soils: **0.0001%– 0.3%**


Atmospheric depositions
Agricultural plastics
Sewage sludge
Irrigation with wastewater
Contaminated compost or digestates

# 2. Is plastic pollution a real concern for soil health?




- Altera physical, chemical, and biological soil properties
- Effects occur at <0.05% plastic concentration (within environmental range)
- Independent of plastic type, size, or origin

## 3. What changes can plastic cause in soil chemical and physical properties?

- Most studies focus on plastic residues from mulching films.

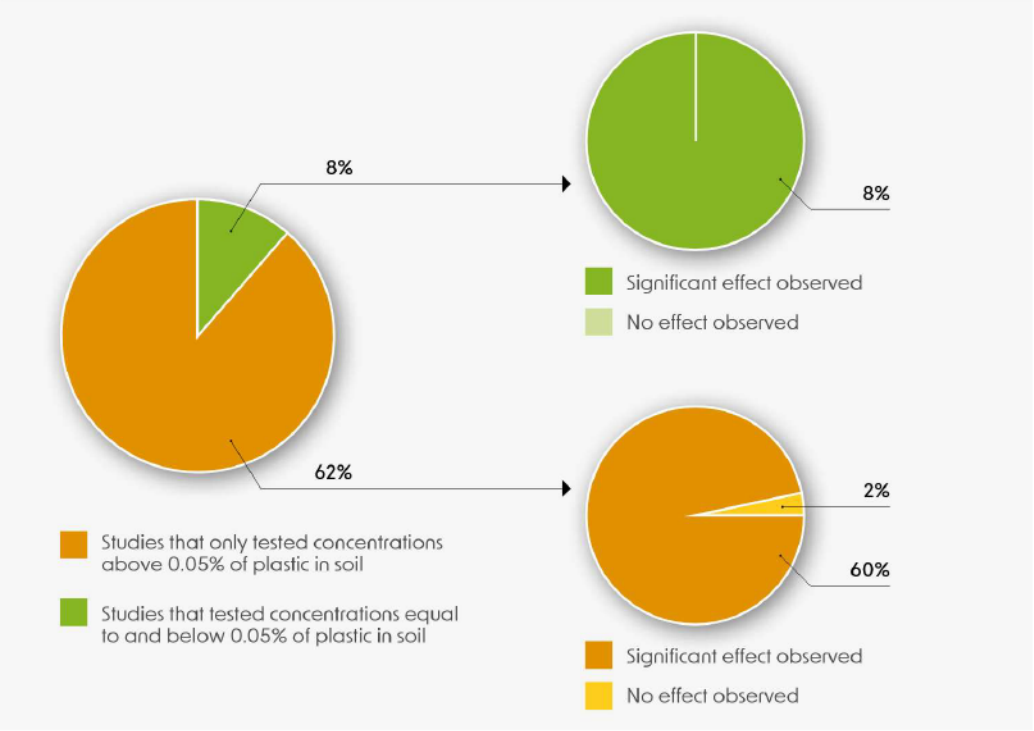


- Changes soil structure, pH, microbial activity
- Affects water retention,
- Nutrient speciation and cycle (especially N)
- Impacts occur at as low as **0.001% plastic**

# 4. Can soil plastic pollution affect plant health and crop production?

- It can inhibits growth, nutrient budgets in plant tissues
- Reduce chlorophyll concentrations
- Alter nutritional balance
- Increase concentration of stress metabolites
- Increases bioavailability of toxins
- Effects on growth mainly observed in pot and mesocosm studies
- Physiological responses observed also in field
- Impacts occur at as low as **0.001% plastic**

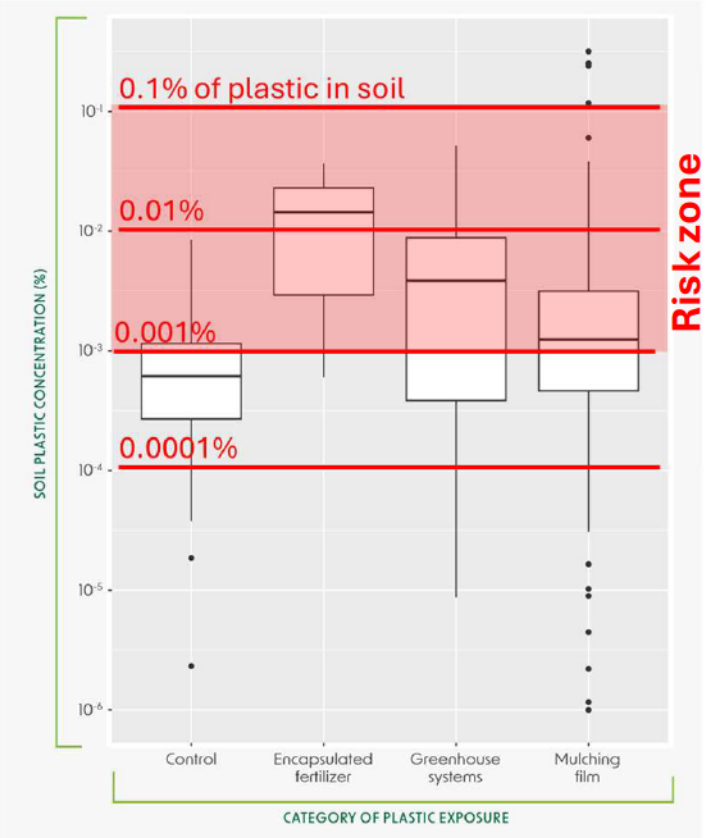
FIGURE 7. Proportion of studies on plant effects conducted in realistic exposure scenarios



## 5. Are current level of plastic in soil safely below effect thresholds?

- **NO!** Concentrations measured in soil overlaps with levels that can affect soil properties and plants and crop health

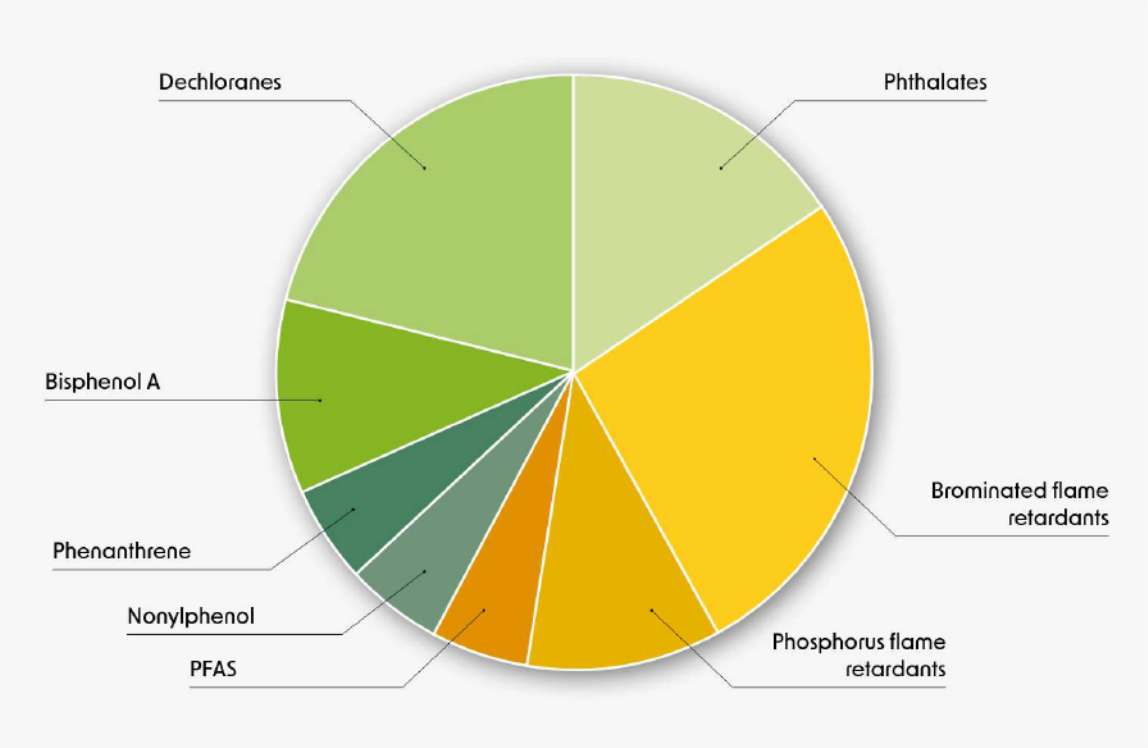
**Overlap occurs in the range:**
**0.001%-0.1% of plastic in soil**



# 6. Can plastic debris and their associated chemicals be transferred to crop?

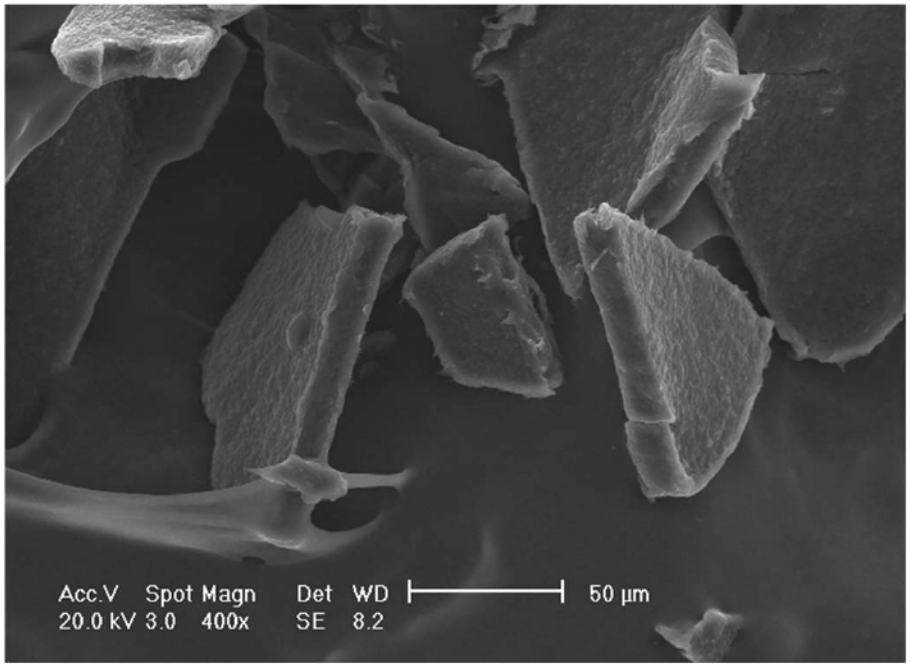
- Up to April 2024 - 33 studies investigated uptake of nano- and microplastics and of plastic-related chemicals by crops.
- Nearly all of them produced evidence that both plastic-related chemicals.
- Plastics & additives can move from soil to crops
- Plants absorb micro/nanoplastics & chemicals via roots
- Some evidence of transfer to edible parts

FIGURE 10. Prevalence of plastic chemical additives in studies on uptake in edible plants



## 7. Are biodegradable plastics safer alternatives?

- In 2024 – 33 studies
- Can still impact soil health & plant growth, similar to conventional plastic
- Effects at as low as **0.02%** plastic in soil
- Risks: incomplete degradation, microplastics, additives




Microfragment of a PBAT mulching film observed at scansion electron mictrosope (image: University of nsubria)

**Need precautionary approach & long-term studies**
**They are not readily degradable in Nordic Conditions**

# In conclusion

- **Strong evidence of potential harm at current environmental exposure**
- Global problem and data gaps
- Important Nordic specificities
    - ➢ Slow degradation of biodegradable plastics,
    - ➢ Circularity in farming adding plastic pollution (sewage sludge, compost digestates)
    - ➢ Expanding use of plastics (self-sufficiency in greens production)
- Food safety concerns from plastic transfer to crops
- Call for precautionary principle and policy action

**Plastic pollution is a concern for soil health and for agricultural sustainability**

## Thanks to:

my co-authors: Rachel Hurley, France Collad, Richard H. Thompson, Giulia Carcasci.

Lev Neretin (for conceiving and mobilizing resources)

FAO production team: Sergejus Ustinov, Marta Arnés García, Carmen Bullón Caro, Alexandre Meybeck, and Huimin Zhang

Reviewers: Defu He, Marie-France Dignac, Richard C. Thompson, and Joe Yates

# Thank you for your attention

**Luca Nizzetto**
Norwegian Institute for Water Research (NIVA)
Luca.Nizzetto@niva.no

Norsk institutt for vannforskning


*Scan the QR code to access the publication*

# Soil microplastics monitoring methods and results from the pilot monitoring study in Europe

Rachel Hurley

*Norwegian Institute for Water Research*

# PAPILLONS

## Plastic in Agricultural Production: Impacts, Lifecycles, and LONg-term Sustainability

Horizon 2020 Research and Innovation Action project
*Funded under the topic: SFS-21-2020 Emerging challenges for soil management [B] Use of plastic in agriculture*

June 2021 – May 2025 (48 months)

20 partners from 12 countries

Total budget: €7.27 million

Coordinated by Norwegian Institute for Water Research (NIVA)

Approach for monitoring microplastics in soils

Summary of results for soil microplastics

## Sampling of **73 agricultural fields** in **7 European countries**

Sampling along gradients of agricultural plastic use, soil management, and biogeography

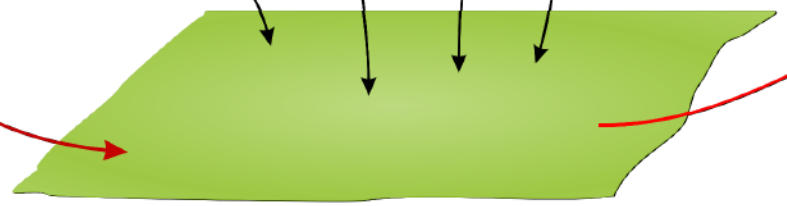
## Selection of fields based on **4 source categories** related to potential microplastic inputs

Use of **agricultural plastics**
Thin films; conventional, non-degradable polymers

Application of **sewage sludge**

Application of **compost/digestate products**
Compost/digestate products suspected to be contaminated by microplastic based on waste streams relevant to the country or region

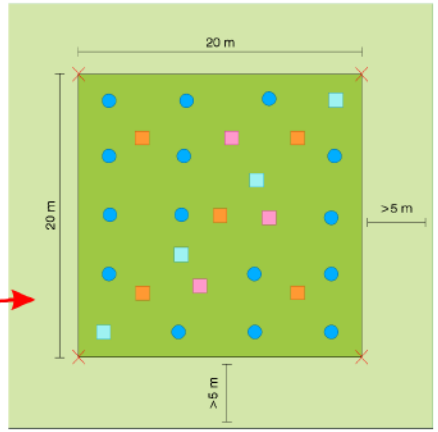
**No history of plastic exposure**
No documented use of agricultural plastics or sludge/compost application, representing inputs from atmospheric deposition



## Fieldwork sampling design

Delineation of a study area within each field and collection of a composite soil samples, as well as spatially representative macroplastic and earthworm sampling

Metadata about each field and information on plastic exposure, practices, behaviours, and perceptions will be obtained from a questionnaire given to the farmers




- Soil sampling point
- Macroplastic sampling quadrat
- Earthworm sampling point for community analysis
- Earthworm sampling point for MP analysis
- Measure GPS coordinates

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Sampling of **73 a**
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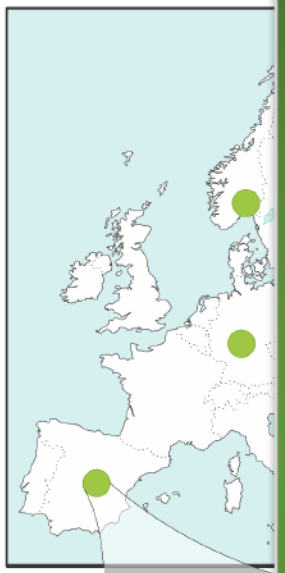

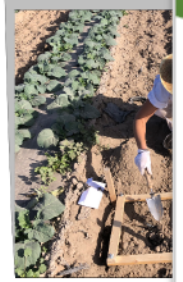

# Protocol for European spatial survey (ESS) sampling in Finland, Germany, Spain, Greece, Italy, Norway, and the Czech Republic

**HORIZON 2020 of European Union**

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000210

Contents





## sampling design

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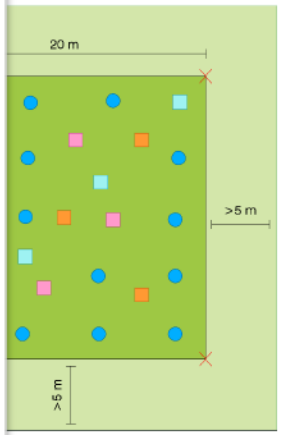


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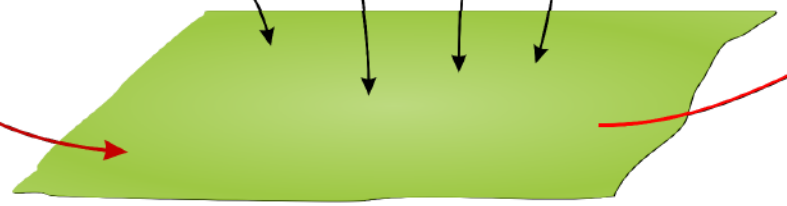

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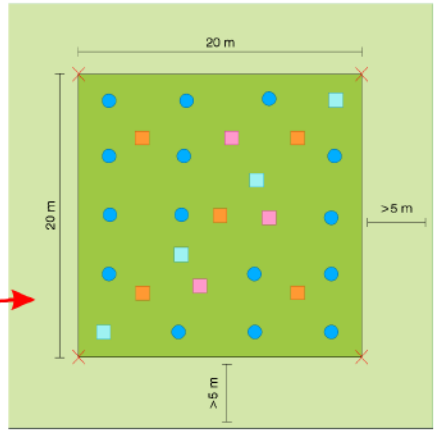


- Soil sampling point
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- Measure GPS coordinates

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**Well-developed protocol** for harmonised sampling across different countries and sampling teams

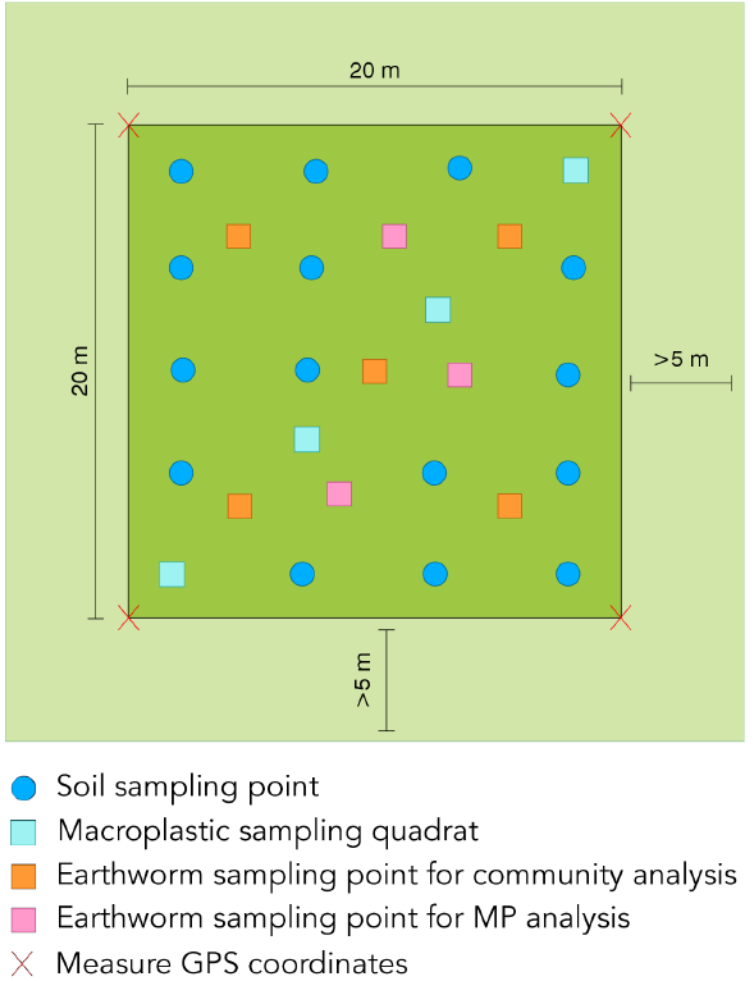
Maximising sampling effort to obtain corresponding information about several parameters

Delineated plot within fields, avoiding field margins. Guidelines for selecting the plot. 20 x 20 m size selected within the field.

15 soil sampling points to create a **composite** that aims to account for spatial heterogeneity in the field

Sampling depth of 10 cm – within the ploughing depth for all fields

Metal tools: **soil auger** with same diameter used for all sampling

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# Contamination control


Natural fibre clothing where possible, and cotton overalls

Precleaned glass containers for all soil samples

Metal equipment for homogenising and subsampling

Extra glass jar kept open for duration of subsampling to track background contamination: *field blanks*

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Sampling of **73 agricultural fields** in **7 European countries**

Sampling along gradients of agricultural plastic use, soil management, and biogeography

Thank you for taking part in the research project

**"PAPILLONS Spatial sampling & questionnaire on the use of Plastic Films, Biosolids and Composts among European Farmers"**

**Purpose of the project**

You are invited to participate in a research project where the main purpose is to assess the of plastic in soils and the impact of plastic debris on soil properties and biodiversity in fiel Europe. We will undertake this survey in 100 fields in total across 7 countries. This data w to establish baseline levels of plastic debris in soils, to better understand some of the m controls on plastic inputs to soils, and the potential impacts of plastic debris on soil he

This survey is part of a wider project funded by the European Union: PAPILLONS (Pl Agricultural Production: Impact, Lifecycles and LONg-term Sustainability). The goal PAPILLONS project is better understand the sources, behaviour and long-term ec socioeconomic effects of plastic debris from different agricultural practices in Eur the data from our research to provide recommendations on how plastics can be in agriculture to ensure functional soils that can support agricultural productio future.

**Why are you being asked to participate?**

You have been invited to participate in this survey because you are a farm selected case study countries (Norway) and you use:

either conventional, non-degradable (e.g. polyethylene) plastic films,

or biosolids derived from sewage sludge,

or composts derived from relevant waste streams

in at least one of your fields,

or you have no history of plastic film or organic fertilizer ( one of your fields.

You may be asked if we can sample more than one field in fit into the criteria identified above.

**What does participation involve for you?**

Participation in the PAPILLONS Spatial sampling & q researchers from your country to sample soils and e and completing a questionnaire. The questionnair (including at farm level), volumes of agricultural plastics us

**PAPILLONS**

**Survey on the use of Plastic Films, Biosolids, and Composts among European Farmers**

This survey is part of the research project PAPILLONS (Plastic in Agricultural Production: Impact, Lifecycles and LONg-term Sustainability) funded by the European Union. In this survey, we will assess levels of plastic in soils and the impact of plastic debris on biodiversity in 100 fields in 7 countries across Europe, including in Norway. This will allow us to better understand the major controls on plastic inputs to soils and the potentially harmful impacts of plastic debris to soil ecosystem health. We will use this research to provide recommendations for the sustainable use of plastics in agriculture.

In each country, we will be working with farmers that use either conventional, non-degradable (e.g. polyethylene) plastic mulching films, or biosolids derived from sewage sludge, or composts derived from relevant waste streams (hereafter, simply referred to as compost), or that have no history of the use of plastic films, biosolids, or compost. Some farms may provide more than one field relevant to the survey.

You can find more information about the research project here: https://www.papillons-h2020.eu/ or by contacting your country contact point or the PAPILLONS coordination team using the contact details at the end of this document.

This survey is designed to provide important ancillary data for interpreting the results from our sample analysis. It consists of five parts, of which the minimal requirement is for you to answer at least:

either Part 1 (Application of plastic mulch films)

or Part 2 (Application of biosolids)

or Part 3 (Application of compost types described above)

or Part 4 (Control field) where you provide information on a field with no known history of plastic mulch or biosolid/compost application.

In addition, there is an optional Part 5 (Additional details). This information will be used to contextualise the use of plastic mulch and biosolids/compost in a larger societal context. You may choose to either complete or overlook Part 4. Only Parts 1 to 3, based on the nature of the field(s) you provide for sampling is required.

Please fill out a questionnaire (Part 1, 2, 3 or 4 and optionally Part 5) for each field that you provide.

The survey will take approximately 20 minutes. You may complete this survey on paper and return it to the researchers when they visit your farm to take samples. Alternatively, you may fill out the survey online using an electronic form or within this word document and return via email. The researchers will be able to answer questions regarding the survey you may have upon sample collection.

## sampling design

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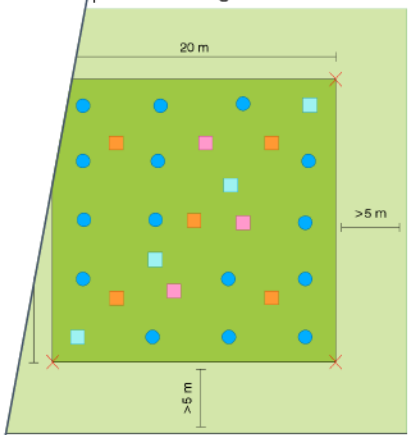


Soil sampling point
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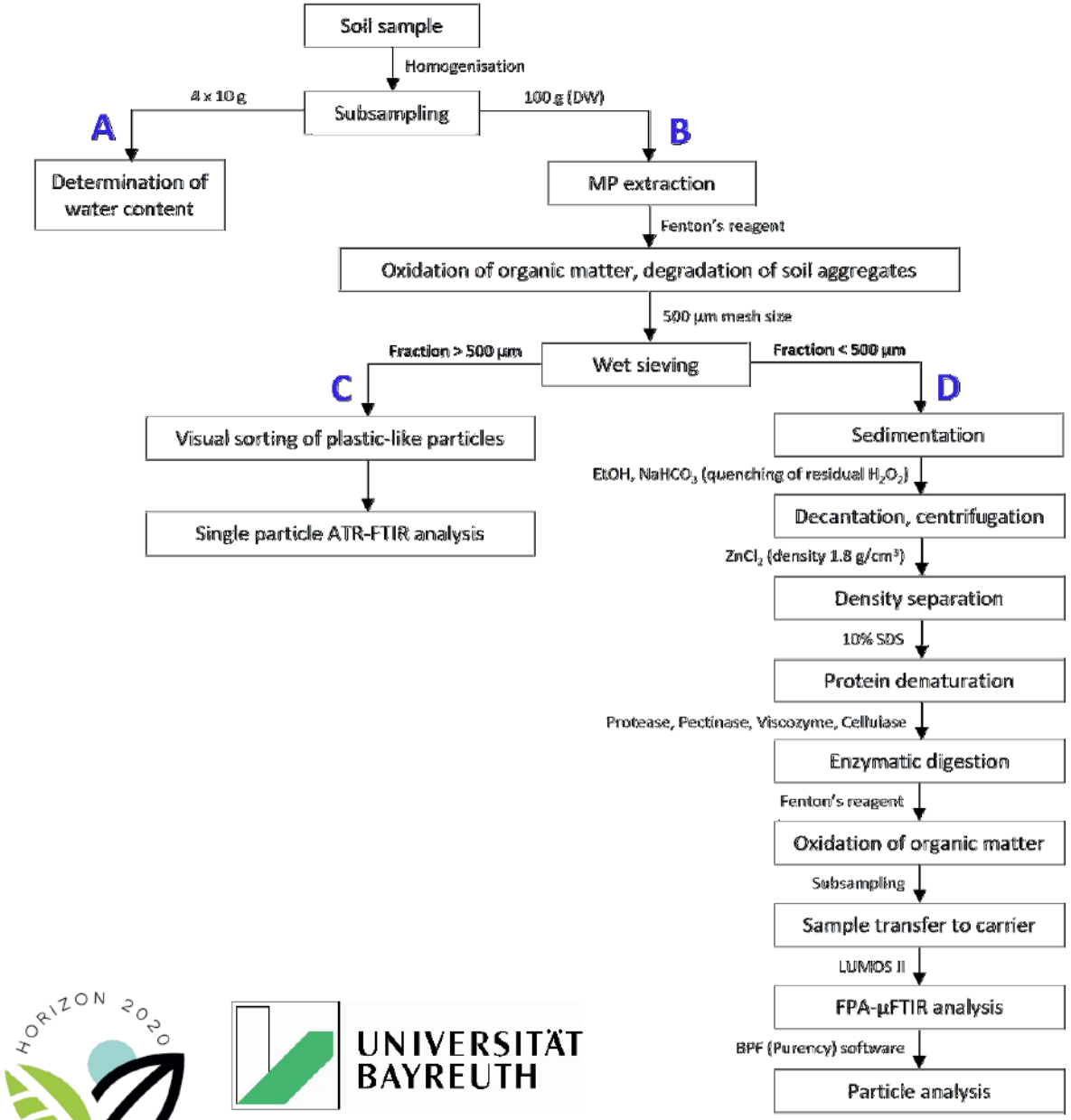
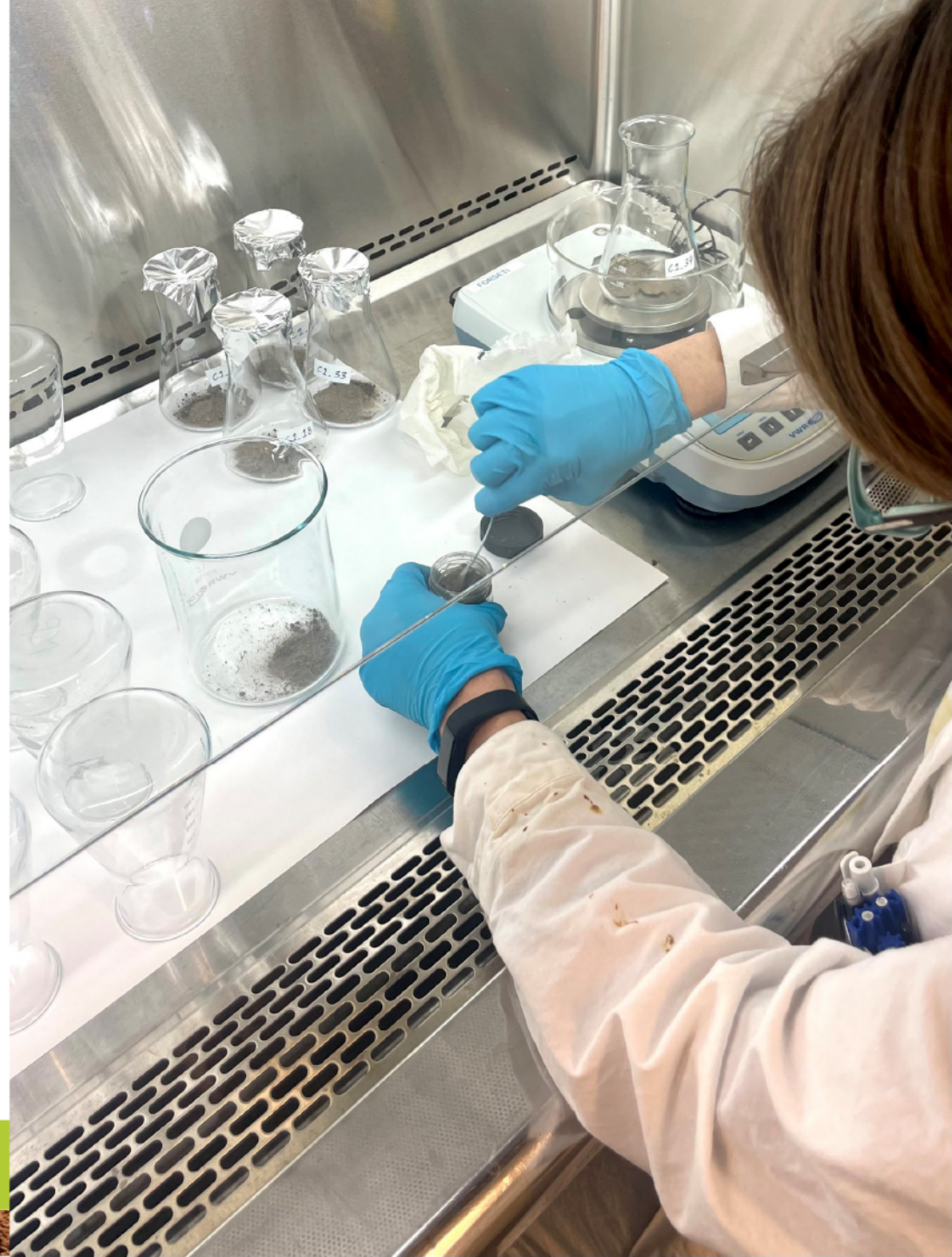
Earthworm sampling point for community analysis
Earthworm sampling point for MP analysis
Measure GPS coordinates


Soil sample
Homogenisation
Subsampling
4 x 10 g
100 g (DW)
A
B
Determination of water content
MP extraction
Fenton's reagent
Oxidation of organic matter, degradation of soil aggregates
500 µm mesh size
Wet sieving
Fraction > 500 µm
Fraction < 500 µm
C
D
Visual sorting of plastic-like particles
Single particle ATR-FTIR analysis
Sedimentation
EtOH, NaHCO3 (quenching of residual H2O2)
Decantation, centrifugation
ZnCl2 (density 1.8 g/cm³)
Density separation
10% SDS
Protein denaturation
Protease, Pectinase, Viscozyme, Cellulase
Enzymatic digestion
Fenton's reagent
Oxidation of organic matter
Subsampling
Sample transfer to carrier
LUMOS II
FPA-µFTIR analysis
BPF (Purency) software
Particle analysis

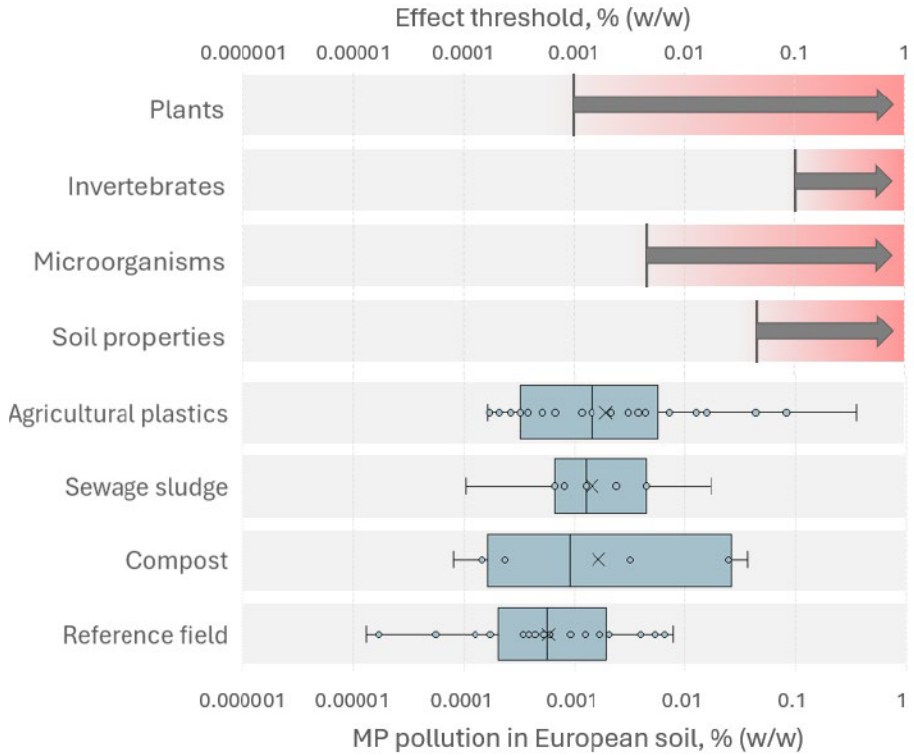


No clear dominant input from the 3 source categories

Agricultural plastics contributed between 18-40% of MP in the corresponding fields, and levels from all source categories overlapped with control fields

Atmospheric deposition, amongst other potential inputs, may represent an important contribution to soil MP levels.

Examining levels observed in control fields revealed a North-South gradient in concentrations.




Effect threshold values for at least plants have already been reached in most fields in all management categories.

The highest concentration observed in this European survey exceeds the effect threshold value for all four endpoints.

This emphasises the urgent need for immediate action to safeguard agricultural soils in Europe, and beyond.

# Thank you for listening!

rachel.hurley@niva.no

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# Effects of soil microplastics on plants and soil microbial communities

Sannakajsa Velmala

Natural Resources institute Finland – Luke

*In collaboration with Laura Zantis, Sylwia Adamczyk and Klara Šmídová*

Nordic AGRIFOODPLAST Network webinar on soil plastic pollution and policy in the Nordics

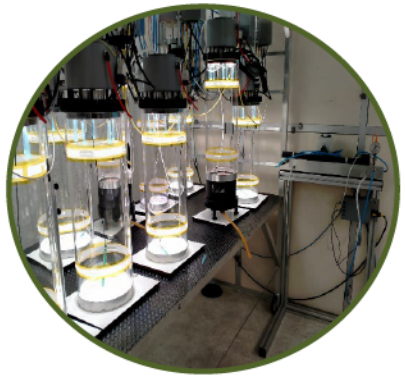
December 8th, 2025

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 101000210.*

sannakajsa.velmala@luke.fi

Plant cell culture

Single species tests



Mesocosm experiments

Field experiments

optimal conditions

realistic conditions

Environmental relevance

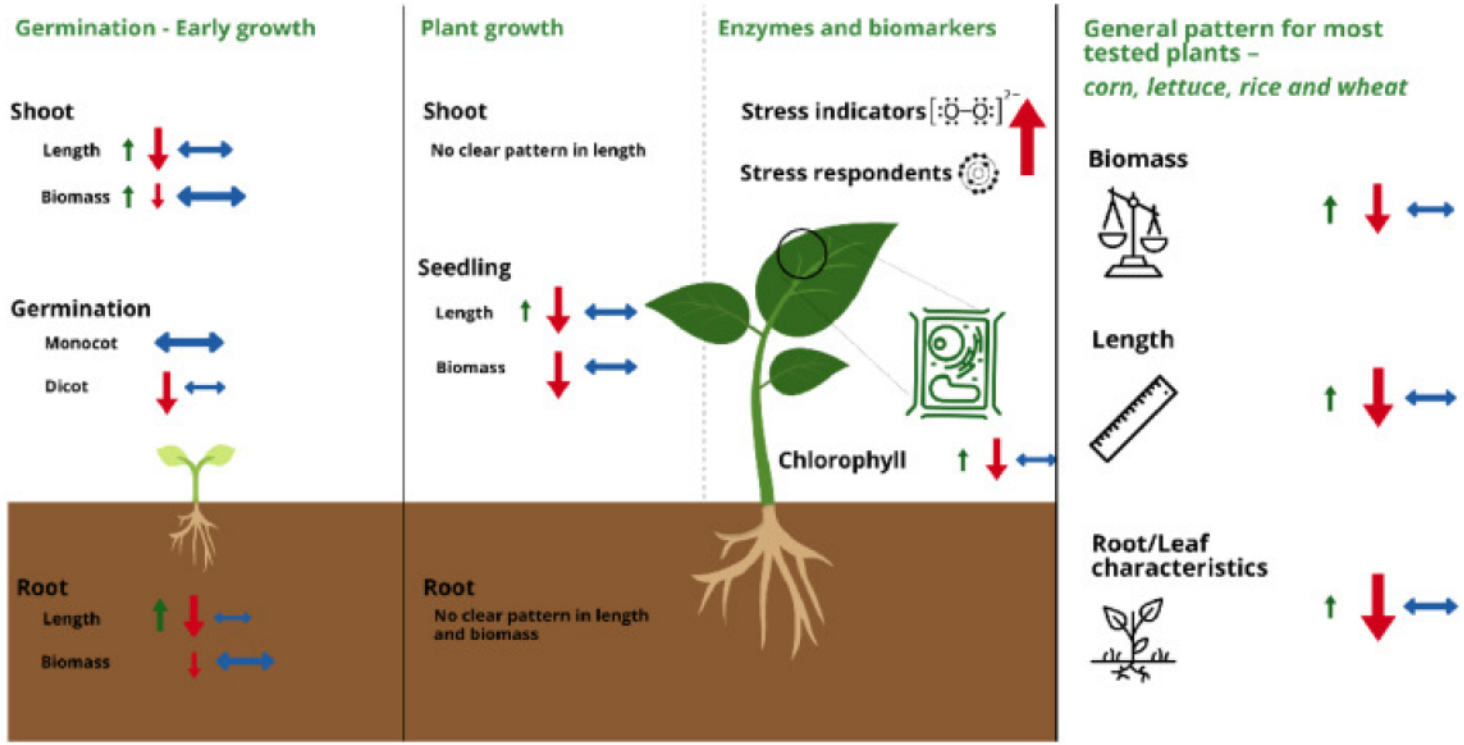
# Systematic literature review: Nano- and microplastics commonly cause adverse impacts on plants at environmentally relevant levels

**Exposure to NMPs**

- various effects on terrestrial plants
- species specific effects on germination and growth
- frequently up-regulated stress levels within plants

➢ trigger plant stress responses, even at environmentally relevant levels

➢ Highlights the need for realistic studies to better understand real-world impacts of NMPs on plant health




## Publication:

**Zantis L. J., Borchi C., Vijver M. G., Peijnenburg W. J. G. M., Di Lonardo S. & Bosker T.** (2023). Nano- and microplastics commonly cause adverse impacts on plants at environmentally relevant levels: A systematic review. Science of the Total Environment, 867: 161211. DOI: 10.1016/j.scitotenv.2022.161211

# Pot-plant experiment: Comparing the impact of microplastics derived from a biodegradable and a conventional plastic mulch on plant performance

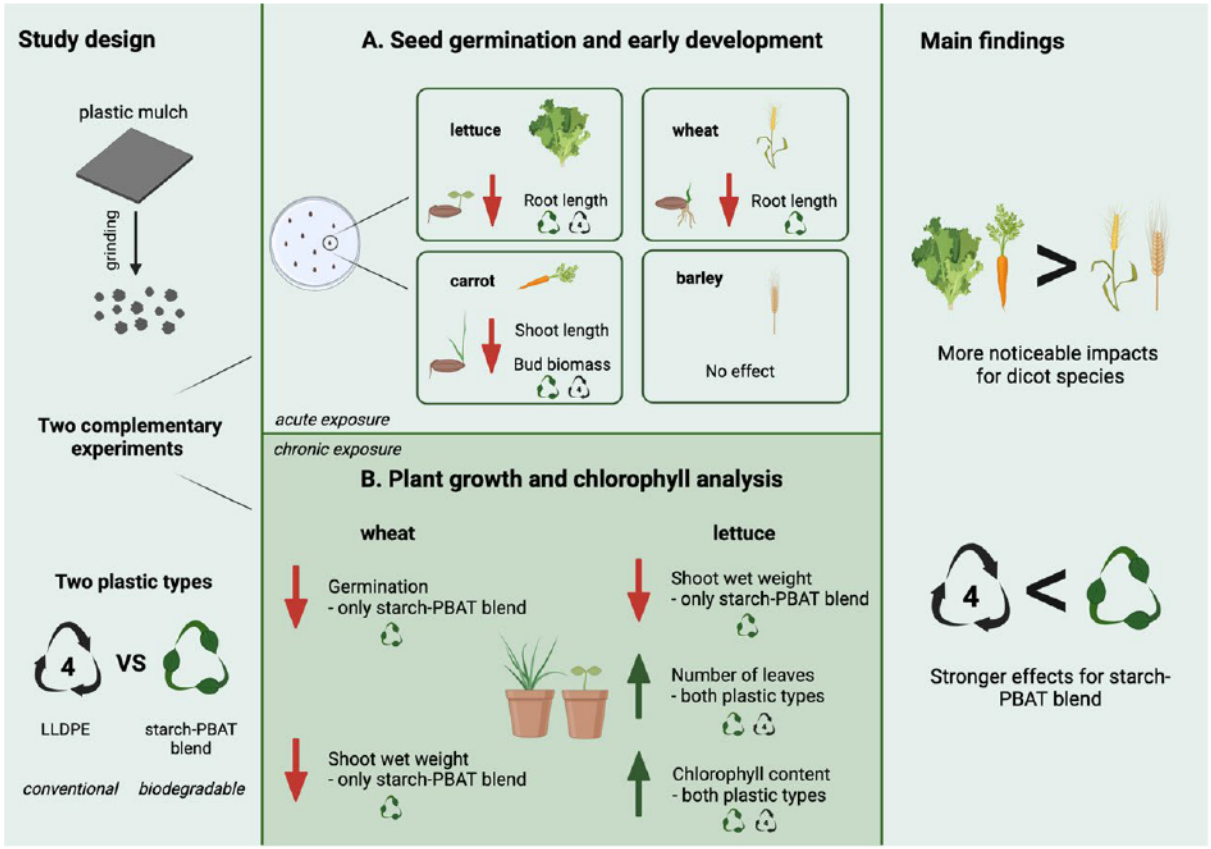
## Conventional and biodegradable MPs

- impact on early development of lettuce and carrot
- only limited chronic effects recorded on plant growth of barley and lettuce
  - chronic exposure resulted in increased chlorophyll content in lettuce

➢ both conventional and biodegradable MPs can affect early plant development, with biodegradable plastics causing stronger adverse effects

## Reference material

- Low linear density polyethylene (LLDPE
- Polybutylene adipate terephthalate (PBAT) starch blend




## Publication

**Zantis L. J., Adamczyk S., Velmala Sannakajsa M., Adamczyk B., Vijver M.G., Peijnenburg W. J. G. M. & Bosker T.** (2024). Comparing the impact of microplastics derived from a biodegradable and a conventional plastic mulch on plant performance. Science of the Total Environment, 935: 173265. DOI: 10.1016/j.scitotenv.2024.173265

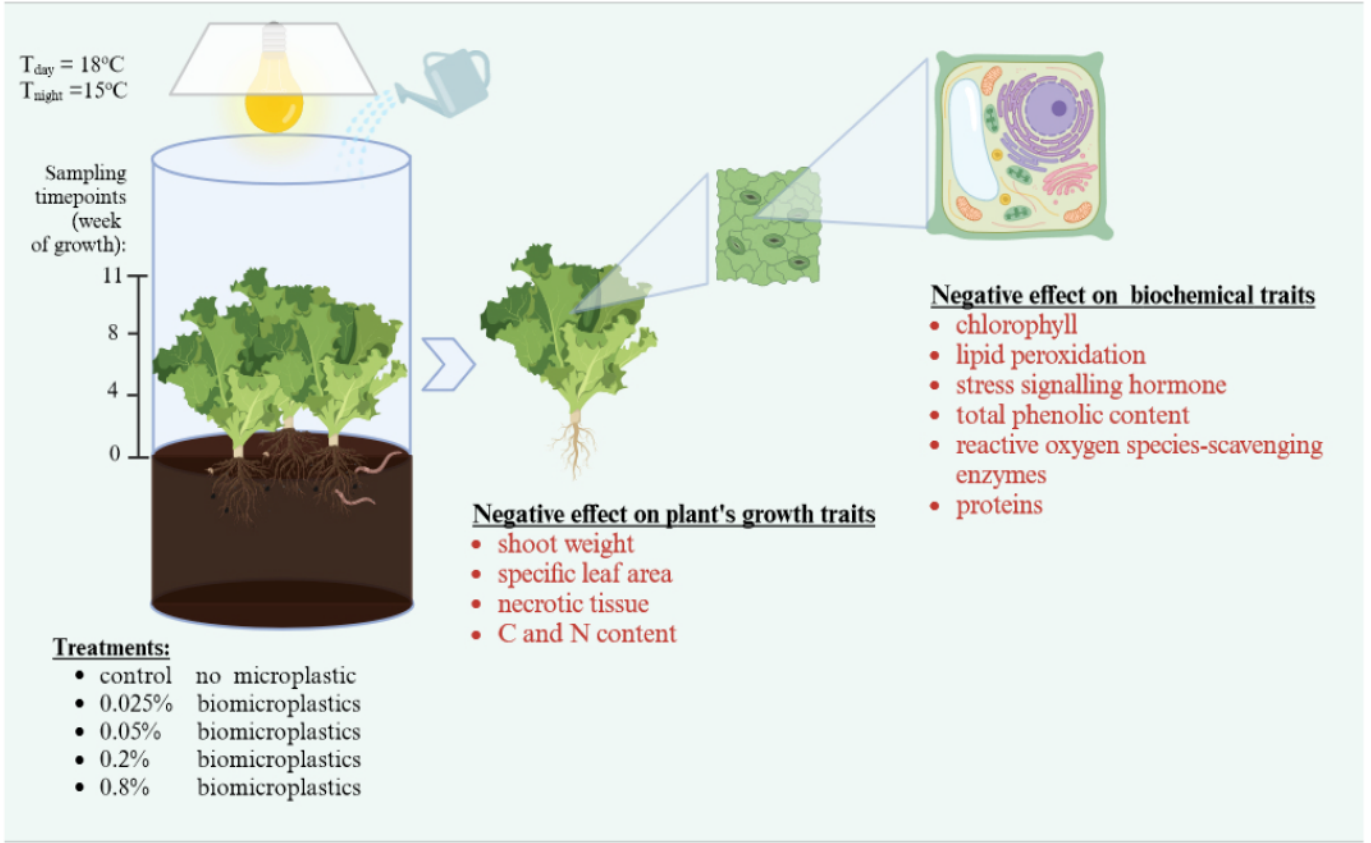
# Mesocosm: Biodegradable microplastics induce profound changes in lettuce (*Lactuca sativa*) defense mechanisms and to some extent deteriorate growth traits

PBAT biodegradable microplastics in CLIMECS near-field condition experiment

- BD-MPs affect biochemical traits and to a lesser extent growth of lettuce
- We highlight potentially negative effect of BD-MPs on lettuce health

## Reference material

- Polybutylene adipate terephthalate (PBAT) film fragments




## Publication

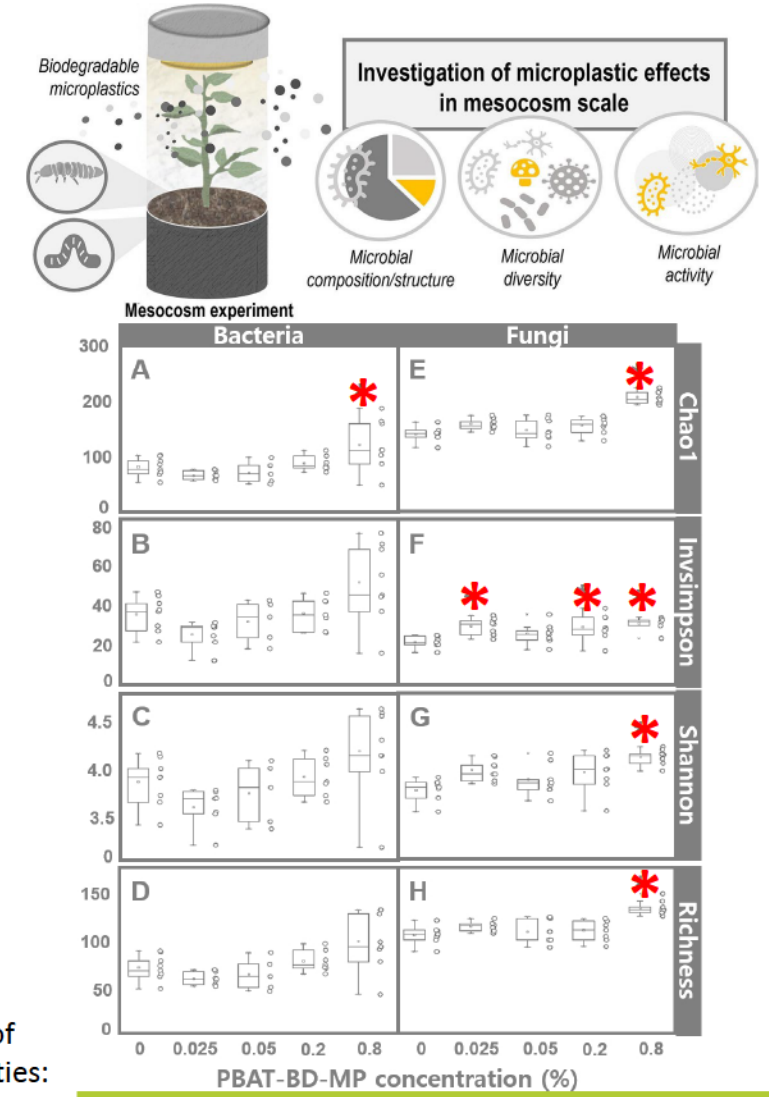
**Adamczyk S., Zantis L. J., Loon S. van, Gestel C. A. M. van, Bosker T., Hurley R., Nizzetto L., Adamczyk B., & Velmala S.** (2024). Biodegradable microplastics induce profound changes in lettuce (Lactuca sativa) defense mechanisms and to some extent deteriorate growth traits. *Environmental Pollution*, *363*, 125307. DOI:10.1016/j.envpol.2024.125307

# Mesocosm: Exposure to PBAT-BD-MPs alter microbiome composition and function

PBAT biodegradable microplastics (BD-MPs) in CLIMECS near-field condition experiment

- slight increase in soil pH
- diversity of soil bacterial and fungal communities increased with increasing PBAT-BD-MP concentrations
  - bacterial and fungal **community composition** differed between the control and 0.8 % PBAT-BD-MP treatment
  - Notable changes included a significant rise in
    - The bacterial phylum *Planctomycetes*
    - The fungal phyla *Ascomycota* and *Mortierellomycota*

- **Carbon mineralization** and **SIR** showed a significant increase at the 0.8 % PBAT-BD-MP



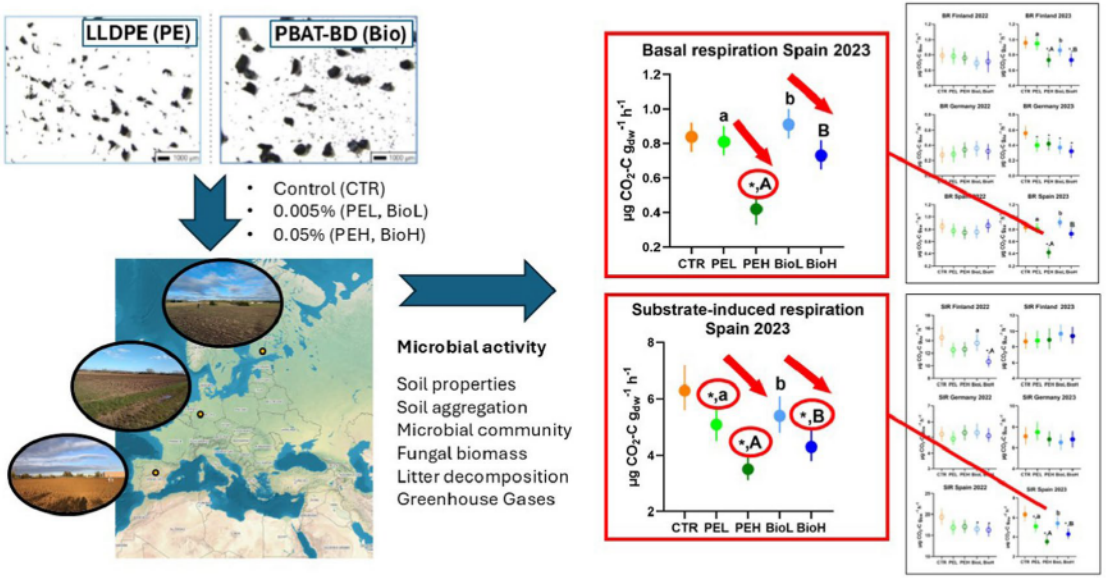

Publication

**Kim, Šmídová, van Loon, van Gestel, Rillig, Fritze, Velmala,** Effects of biodegradable microplastics on soil microbial communities and activities: Insight from an ecological mesocosm experiment, Science of The Total Environment, 2025, https://doi.org/10.1016/j.scitotenv.2025.179288.

# FIELD: Conventional and biodegradable agricultural microplastics: effects on soil properties and microbial functions across a European pedoclimatic gradient

**MP effecst on Soil Microbial Communities**

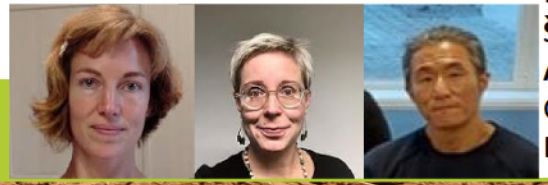
- Microbial activity is a more sensitive indicator of MP effects than diversity metrics
- Microbial activity (BR, SIR) decreased systematically with MP, even without major diversity changes
- C and N mineralization suppressed, especially in Spain
- Likely toxic effects on fungi, not bacterial promotion
  - linked to reduced soil aggregation
  - Germany: Reduced fungal diversity in high PE and PBAT-BD treatments (2022)
  - Spain: Significant fungal biomass decline in 2022 for PE and PBAT-BD treatment
- MPs create microhabitats for plastic-degrading microbes
- Effects are site-specific and may accumulate over time
  - PBAT-BD impacts stronger due to higher degradability




2 Seasons (year **2022** and **2023**)

5 treatments on 25 plots:

- Control (without microplastic)
- PE low 0.005% , PE high 0.05%
- PBAT low 0.005%, PBAT high 0.05%



Publication

**Šmídová K., Soinne H., Kim S.W., Tirronniemi J., Meffe R., Redondo-Hasselerharm P.E., Braun M., Rillig M.C., Fritze H., Adamczyk B., Nikama J., Kaseva J., Saartama V., Amelung W., Hurley R., Hofman J., Nizzetto L., Selonen S., Velmala S.** Conventional and biodegradable agricultural microplastics: effects on soil properties and microbial functions across a European pedoclimatic gradient, Environmental Pollution, 2025, https://doi.org/10.1016/j.envpol.2025.127212.

# Conclusions

- Even at environmentally relevant levels, MNP trigger plant stress responses
- Both conventional and PBAT-BD-MPs can affect early plant development
  - biodegradable plastics causing stronger adverse effects
  - potentially negative effect of PBAT-BD-MP on lettuce health
    - decreased chlorophyll levels (nitrogen deficiency)
    - increased oxidative stress and changes in plant defense mechanisms

- In the field we observed up-regulated stress levels within plants, and only slight effect on plant physiology
  - effects on plants are context-dependent and vary due to soil and atmospheric conditions
  - effects depends on plastic concentration and type

- The increase in soil respiration correlated with increasing PBAT-BD-MP concentration
- Alpha diversity of the bacteria and fungi increased with increasing PBAT-BD-MP concentration

- In the field C and N mineralization is suppressed under MP, especially in Spain
- Microbial activity is a more sensitive indicator of MP effects than diversity metrics
- Microbial activity (BR, SIR) decreased systematically with MP, even without major diversity changes

HORIZON 2020

PAPILLONS

sannakajsa.velmala@luke.fi