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### ► **To cite this version:**

Marie-France Dignac, Melissa Bakhos, Susanne Brander, Gabin Colombini, Megan Deeney, et al.. Why a strong global plastics treaty is essential for agricultural systems, food safety, food security and human health. Cambridge Prisms: Plastics, 2025, 3, pp.1-13,e18. <10.1017/plc.2025.10006>. <halshs-05137035>

**HAL Id: halshs-05137035**

**<https://shs.hal.science/halshs-05137035v1>**

Submitted on 5 Sep 2025

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## Letter to the Editor

**Cite this article:** Dignac M-F, Bakhos M, Brander S, Colombini G, Deeney M, Dufour E, Geissen V, Hooge A, Huerta Lwanga E, Monsaingeon B, Syberg K and Yates J (2025). Why a strong global plastics treaty is essential for agricultural systems, food safety, food security and human health. *Cambridge Prisms: Plastics*, 3, e18, 1–5  
<https://doi.org/10.1017/plc.2025.10006>

Received: 29 May 2025

Revised: 04 June 2025

Accepted: 08 June 2025

### Keywords:

agriculture; food; plastic pollution; soil health; human health; soil

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# Why a strong global plastics treaty is essential for agricultural systems, food safety, food security and human health

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## Abstract

An ambitious global plastics treaty is urgently needed to decrease soil pollution from microplastics and nanoplastics (MNPs), originating both from intentional uses of agricultural plastics and from composts and sludges applied to soils, contaminated due to the increasing plastic production and use. The current narrative, biased by vested interests, overemphasizes short-term benefits of agricultural plastics, while ignoring their adverse effects. MNPs disturb invertebrate and pollinator behavior, affect nutrient cycling and carbon sequestration, decrease photosynthesis and plant growth, contribute to water and air pollution and may contaminate plants, crops and livestock. The thousands of chemicals contained in conventional and biodegradable or biobased plastics can leach into soil. By threatening ecosystem functioning and terrestrial food production, plastic pollution represents a challenge for food safety and human health and is a long-term threat to food security. To protect soils from plastic pollution, a strong global treaty is needed, with provisions on plastic production reduction, product design and regulation of plastic chemicals. Plastics' essentiality, sustainability and safety criteria are needed in the agriculture sector – where plastics are used unsustainably and not all are essential – and in all sectors along the food production value chain (food processing, packaging).

## Abstrait

Un traité mondial ambitieux sur les plastiques est nécessaire de toute urgence pour réduire la pollution des sols par les micro et nanoplastiques (MNP), provenant à la fois de l'utilisation intentionnelle de plastiques agricoles, et des composts et boues appliqués aux sols, contaminés en raison de l'augmentation de la production et de l'utilisation des plastiques. Le récit actuel, biaisé par des intérêts commerciaux, met l'accent sur les avantages à court terme des plastiques agricoles et ignore leurs effets néfastes à long terme. Les MNP perturbent les invertébrés et les pollinisateurs, affectent les cycles des nutriments et le stockage de carbone, diminuent la photosynthèse et la croissance des plantes, contaminent l'eau et l'air, et peuvent contaminer les plantes, les cultures et le bétail. Les milliers de substances chimiques présentes dans les plastiques conventionnels et biodégradables ou biosourcés peuvent s'infiltrer dans le sol. En menaçant le fonctionnement des écosystèmes et la production alimentaire, la pollution plastique représente un défi pour la sûreté des aliments et la santé humaine et, à long terme, un défi pour la sécurité alimentaire. Pour protéger les sols de la pollution plastique, un traité mondial ambitieux est nécessaire, avec des dispositions pour la réduction de la production de plastiques, la conception des produits et la réglementation des substances chimiques des plastiques. Des critères d'évaluation de l'essentialité, durabilité et sécurité des plastiques sont nécessaires dans le secteur agricole, où les plastiques sont utilisés de manière non durable et ne sont pas tous essentiels, ainsi que dans tous les secteurs de la production alimentaire (transformation des aliments, emballage).

## Impact statement

Before the next session of the negotiation of the Global Plastics Treaty (INC5.2), we draw attention to the independent scientific knowledge on the negative impacts of plastics on soil health, food safety in the short term, food security in the long term and on human health. Taking into account the long-term adverse impacts of plastics in agricultural systems and in food supply is essential to make informed decisions.

## Introduction

Soils are a fragile, thin fertile layer on the Earth's surface. While soils form the foundation of our society by providing food and are fundamental for environmental sustainability and human health and well-being, intensified agricultural practices have exhausted and polluted soils at an accelerating pace. Soils are threatened by plastic pollution, including microplastics and nanoplastics (MNPs) and the thousands of chemicals they leach. Soils are nonrenewable resources at the scale of a human lifetime; they take hundreds to thousands of years to form. Global rules, as expected in the Global Plastics Treaty, are needed to end plastic pollution in soils.

## Direct and indirect sources of plastics in soils

Plastics are increasingly used in agriculture (greenhouses, nets, haylage covers, mulching, irrigation pipes, coated fertilizers, etc.), representing 7.4 million tons of plastic per year (FAO, 2021). They release MNPs and chemicals during their use and disposal. Mulching films fragment during use and are not completely recovered after the growing season, leaving up to 25–33% of the film in the field (Yang *et al.*, 2022). Polyethylene films, as used in greenhouses, are known to release MNPs when exposed to UV light (Masry *et al.*, 2021).

Land application of compost and sludge (biosolids from wastewater treatment) is another major source of MNPs (e.g., Colombini *et al.*, 2022; Lofty *et al.*, 2022; Hooge *et al.*, 2023). In some countries, over 50% of biosolids, which retain more than 90% of the MNPs and microfiber from wastewater, are applied agriculturally, and often near marginalized communities (Geyer *et al.*, 2022).

Due to the MNPs' persistence in soils (Chamas *et al.*, 2020; Liu *et al.*, 2022), current plastic use, both on and off-farm, is driving unsustainable accumulation in soils (Colombini *et al.*, 2024; Cusworth *et al.*, 2024). Terrestrial reservoirs of macroplastics and MNPs represent 97% of total plastic pollution that can be transferred to aquatic ecosystems (groundwater, lakes, rivers and ultimately the oceans) through infiltration and erosion, or to the air through wind remobilization (Sonke *et al.*, 2022; Morales-Caselles *et al.*, 2025).

## Impacts of plastics on soil functions

MNPs pollution has adverse effects on soil health (including soil properties, biodiversity, fertility) and on agricultural yields (Gao *et al.*, 2019; Zhu *et al.*, 2025) and may contaminate the edible parts of plants (Conti *et al.*, 2020; Li *et al.*, 2025). MNPs have direct and indirect effects on soil biota, through their impacts on soil properties – particularly critical for the microbiome, which is a key driver for nutrient cycles, carbon sequestration and soil structure (Seeley *et al.*, 2020; Joos and De Tender, 2022; Li and Xiao, 2023; Sun *et al.*, 2023), and thus for soil resilience. MNPs affect soil fauna (Selonen *et al.*, 2020; Guo *et al.*, 2023), notably earthworms (Huerta Lwanga *et al.*, 2016), and even pollinators (Sheng *et al.*, 2024).

Effects of MNPs on soil health depend on their contents and properties (composition, shape, size, surface, additives), which are

highly variable due to the large combination of sources, particularly from composts and biosolids. Recycling organic matter in soils is crucial for many soil properties and functions, but due to excessive use of plastics, the increasing share of plastics in waste (US-EPA, 2021) and few controls on microplastics in composts and biosolids, they are a key vector of MNPs, undermining soil functions. If we do not want the incentives to sequester soil carbon to end up paradoxically promoting plastic carbon storage in soils, it is crucial to improve compost quality by limiting plastic waste at source. To enable the essential circularity of organic matter, we urgently need to reduce plastic production (Baztan *et al.*, 2024) to decrease plastics in waste and wastewater.

## Ending soil plastic pollution to strengthen food safety and food security and protect human health

As populations worldwide become increasingly disconnected from the means of food production, the accumulation of plastic pollution in soils goes largely unseen. However, mounting evidence from fields and farms worldwide suggests its impacts on soil health, food safety and human health are already here. From invertebrate behavior to nutrient cycling and carbon sequestration (Rillig *et al.*, 2021; Joos and De Tender, 2022), from pollinator disturbance to decrease in photosynthesis and plant growth (Jia *et al.*, 2023; Sheng *et al.*, 2024; Zhu *et al.*, 2025), plastic pollution is undermining the fundamental role of healthy soils in ecosystem functioning and terrestrial food production. Projected plastic pollution growth represents an alarming threat to food production and food security (Gao *et al.*, 2019; Zhu *et al.*, 2025), especially critical for already malnourished populations (FAO, IFAD, UNICEF, WFP and WHO, 2022).

Soil plastic pollution is not just a medium-term problem for food security; it is an immediate challenge for food safety and health. MNPs, and the thousands of chemicals they leach, may enter plants and crops (Conti *et al.*, 2020; Li *et al.*, 2025), now even appearing in the livestock we raise for meat (Huerta Lwanga *et al.*, 2017; Bahrani *et al.*, 2024). Off-site transport by wind erosion contaminates the air and indoor dust. Soil plastic pollution reaches humans via dietary and non-dietary exposure (Geeke *et al.*, 2024). While the exact effects of MNPs across human bodies are yet to be fully understood (Xu *et al.*, 2025), plastic chemicals have well-established hazards (Wagner *et al.*, 2024) – contributing to a wide range of adverse health outcomes related to childbirth, endocrine function, neurodevelopment, nutrition, circulatory and respiratory systems and cancers (Symeonides *et al.*, 2024). Over 300,000 annual deaths from cardiovascular disease have been associated with exposure to di-2-ethylhexylphthalate (DEHP), just one of the chemicals that leach from plastics (Hyman *et al.*, 2025), including agricultural plastics (Ramanayaka *et al.*, 2024).

The chronic and growing exposure of global populations to MNPs across the food chain and via non-dietary routes is therefore an unprecedented risk to global food safety and public health. Food insecurity already affects a third of the world (FAO, IFAD, UNICEF, WFP and WHO, 2024). More than 11 million people die each year from dietary risk (Afshin *et al.*, 2019) and almost half

of the deaths in children under five are due to undernourishment. In the context of global health crises and with increasing threats to global food production and supply chains amidst the volatility of geopolitics, conflict and climate change, we cannot afford to further undermine food systems and risk health. And yet, plastic pollution in agriculture continues to rise.

### Avoiding regrettable substitutions and alternatives

The so-called “biodegradable” plastics, a promise proposed since the 1970s to replace conventional plastics, have not been proven to be less harmful to the environment (de Sadeleer and Woodhouse, 2024) or human health. Adverse health effects of starch-based microplastics (PLA) have been evidenced in mouse models (Liu et al., 2025b). The industrial facilities necessary to effectively biodegrade biodegradable plastics – whose end-of-life is planned in composting or methanization – are limited, and the produced compost and digestates may be enriched in plastic particles and chemicals, which are further applied to soils (Afshar et al., 2024). Additives can sum up to 50% of the plastic mulch, but there is no regulation on the declaration of chemicals used in mulching films.

Although some studies have reported short-term benefits of biodegradable mulch films, including improved crop yields, regulation of soil moisture and temperature (Iacuzzi et al., 2024; Ramadhani et al., 2024), these advantages depend on agricultural practices, climatic conditions and the physicochemical properties of the materials used (Renumala et al., 2025). In contrast, many studies highlight long-term adverse effects, such as microplastic fragmentation, disturbance of soil microbiome and altered nutrient cycling (Campanale et al., 2024; Dewi et al., 2024). Notably, long-term exposure to (poly(butylene adipate terephthalate)) PBAT-based biodegradable plastics altered soil microbial composition and functions, particularly those related to carbon, nitrogen and sulfur cycling, while also potentially increasing the relative abundance of plant pathogenic fungi (Liu et al., 2025a). Biodegradable mulch films could be more harmful than nonbiodegradable plastics by releasing microplastics and toxic chemicals when used and disposed of directly into the soil (Tartiu et al., 2025).

The precautionary principle should apply to avoid regrettable substitutions that create unknown long-term consequences and future problems. It is imperative to test all new materials on soil biota under a range of realistic environmental conditions before those materials are introduced to the market.

### Are agricultural plastics essential?

Since their introduction in the 1950s and their exponential increase since the 1990s, first in China and then in the rest of the world, plastics have become widespread in conventional agriculture (Orzolek, 2017). These materials, now deemed indispensable, are closely tied to the petrochemical industry’s efforts to create new markets. In France, for instance, by 1961, an engineer from the *Ethylène-Plastique* company believed that their nascent use constituted a revolution and that everyone should be “well imbued with its inevitability” (Duranel, 1961). “Whether we like it or not,” (Duranel, 1961) plastics would intensify global agricultural production and address the scarcity of arable land needed to feed a growing world population.

This narrative, though biased by commercial interests, highlighted the benefits of plastics while marginalizing traditional techniques and competing materials. It led to adopting methods that

were not essential and overlooked long-term risks, such as the degradation and accumulation of plastics in soils through the many residues left by their use. These issues, identified early on, were initially seen as technical challenges that progress would solve.

Today, this progressivist and biased narrative persists. However, given the multiple environmental threats posed by plastics, it is urgent to question the agricultural model that relies on them and to develop practices that lessen the dependence on plastics by integrating seasonality, diversification and reduction of the distance between consumers and producers (Duquesne et al., 2025).

Plastic use in agriculture is expected to increase in response to the growing population and to rising temperatures and extreme weather events due to climate change (FAO, 2021). However, plastic production and the incineration and open burning of agricultural plastics also emit significant quantities of greenhouse gases, exacerbating the climate crisis (Karali et al., 2024). While plastics may support climate adaptation and food production in the short term, the manifold direct and indirect implications for health, now and in the future, cannot be ignored (Hofmann et al., 2023). Financial mechanisms to support countries grappling with the most severe effects of climate change are needed, within a framework of globally coordinated, science-based, sustainable strategy development for plastics in agriculture.

### Ending the toxic legacy of plastics in agriculture through a strong global plastics treaty

The UN Treaty is essential to facilitate a shift in the way we use and assess plastics, both on and off-farm, to avoid the unsustainable accumulation of plastic pollution in soil. The agricultural system is a typical example of how a system has been created that produces high yields, but at the expense of both natural systems and human and environmental health. In addition to damaging soil conditions, plastics are made from fossil fuels (including half of biodegradable plastics), which greatly exacerbates the climate crisis (Villarrubia-Gómez et al., 2024). The positive short-term effects of agricultural plastics are offset by the pollution increase and their negative long-term invisible effects. The narrative that presents agricultural plastics as necessary is no longer acceptable if we take into account the knowledge produced by independent scientists with no conflicts of interest, which shows the strong adverse effects of plastics, that release greenhouse gases, decrease soil quality and health and contribute to the loss of biodiversity (a pillar of soil productivity), the decline of agricultural yields and to numerous human health issues. To produce quality food without destroying the soil resource for future generations and ultimately reducing the quality of crops and livestock, other paths are possible. For example, agroecology can help mitigate climate change and adapt to its effects without compromising food security (Dittmer et al., 2023) by developing a holistic vision that improves both yields and soil quality, using principles that have been practiced for thousands of years.

A strong global plastics treaty is needed to end plastic pollution threatening food safety now and food security in the long-term, taking into consideration decreasing soil health. Reduction of plastic production with global targets, improvement of product conception and regulation of harmful plastic chemicals are needed in the agriculture sector, where plastics are used unsustainably and are not all essential, as well as in all sectors along the food production value chain (food processing, food packaging, etc.).

Global, harmonized and science-based criteria and standards for evaluating plastics’ essentiality, sustainability and safety for the

environment and human health would benefit the evaluation of plastics used in agriculture and their alternatives. Monitoring existing plastic pollution is crucial to avoid food production on highly polluted soils and to minimize transfers to other environmental compartments. A decrease in plastic consumption will reduce pollution of the first receptors of plastic pollution, the soils.

**Open peer review.** To view the open peer review materials for this article, please visit <http://doi.org/10.1017/plc.2025.10006>.

**Author contribution.** Conceptualization: MFD; writing original draft: MFD; writing, review and editing: all authors. All authors have read and agreed to the published version of the article.

**Financial support.** This research did not benefit from any specific grant.

**Competing interests.** The authors declare none.

In agreement with the Editor, a French version of this article has been published: Dignac M-F, Bakhos M., Brander S., Colombini G., Deeney M., Dufour E., Geissen V., Hooge A., Huerta Lwanga E., Monsaingeon B., Syberg K. et Yates J., 2025 - Pourquoi un traité mondial ambitieux sur les plastiques est essentiel pour les systèmes agricoles, la sécurité alimentaire et la santé humaine. *Étude et Gestion des Sols*, 32, 85-93

## References

- Afshar SV, Boldrin A, Astrup TF, Daugaard AE and Hartmann NB (2024) Degradation of biodegradable plastics in waste management systems and the open environment: A critical review. *Journal of Cleaner Production* **434**, 140000. <https://doi.org/10.1016/j.jclepro.2023.140000>.
- Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, Mullany EC, Abate KH, Abbafati C, Abebe Z and Afarideh M (2019) Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the global burden of disease study 2017. *The Lancet* **393**, 1958–1972. [https://doi.org/10.1016/S0140-6736\(19\)30041-8](https://doi.org/10.1016/S0140-6736(19)30041-8).
- Bahrani F, Mohammadi A, Dobaradaran S, De-la-Torre GE, Arfaeinia H, Ramavandi B, Saeedi R and Tekle-Röttering A (2024) Occurrence of microplastics in edible tissues of livestock (cow and sheep). *Environmental Science and Pollution Research* **31**, 22145–22157. <https://doi.org/10.1007/s11356-024-32424-9>.
- Baztan J, Jorgensen B, Almroth BC, Bergmann M, Farrelly T, Muncke J, Syberg K, Thompson R, Boucher J, Olsen T and Álava JJ (2024) Primary plastic polymers: Urgently needed upstream reduction. *Cambridge Prisms: Plastics* **2**, e7. <https://doi.org/10.1017/plc.2024.8>.
- Campanale C, Galafassi S, Di Pippo F, Pojar I, Massarelli C and Uricchio VF (2024) A critical review of biodegradable plastic mulch films in agriculture: Definitions, scientific background and potential impacts. *TrAC Trends in Analytical Chemistry* **170**, 117391. <https://doi.org/10.1016/j.trac.2023.117391>.
- Chamas A, Moon H, Zheng J, Qiu Y, Tabassum T, Jang JH, Abu-Omar M, Scott SL and Suh S (2020) Degradation rates of plastics in the environment. *ACS Sustainable Chemistry & Engineering* **8**, 3494–3511. <https://doi.org/10.1021/acssuschemeng.9b06635>.
- Colombini G, Rumpel C, Houot S, Biron P and Dignac MF (2022) A long-term field experiment confirms the necessity of improving biowaste sorting to decrease coarse microplastic inputs in compost amended soils. *Environmental Pollution* **315**, 120369. <https://doi.org/10.1016/j.envpol.2022.120369>.
- Colombini G, Senouci F, Rumpel C, Houot S, Biron P, Felbacq A and Dignac MF (2024) Coarse microplastic accumulation patterns in agricultural soils during two decades of different urban composts application. *Environmental Pollution* **363**, 125076. <https://doi.org/10.1016/j.envpol.2024.125076>.
- Conti GO, Ferrante M, Banni M, Favara C, Nicolosi I, Cristaldi A, Fiore M and Zuccarello P (2020) Micro- and nano-plastics in edible fruit and vegetables. The first diet risks assessment for the general population. *Environmental Research* **187**, 109677. <https://doi.org/10.1016/j.envres.2020.109677>.
- Cusworth SJ, Davies WJ, McAinsh MR, Gregory AS, Storkey J and Stevens CJ (2024) Agricultural fertilisers contribute substantially to microplastic concentrations in UK soils. *Communications Earth & Environment* **5**, 7. <https://doi.org/10.1038/s43247-023-01172-y>.
- de Sadeleer I and Woodhouse A (2024) Environmental impact of biodegradable and non-biodegradable agricultural mulch film: A case study for Nordic conditions. *The International Journal of Life Cycle Assessment* **29**, 275–290. <https://doi.org/10.1007/s11367-023-02253-y>.
- Dewi SK, Bhat SA, Wei Y and Li F (2024) Impacts of biodegradable mulch: Benefits, degradation, and residue effects on soil properties and plant growth. *Reviews in Agricultural Science* **12**, 262–280. [https://doi.org/10.7831/ras.12.0\\_262](https://doi.org/10.7831/ras.12.0_262).
- Dittmer KM, Rose S, Snapp SS, Kebede Y, Brickman S, Shelton S, Egler C, Stier M and Wollenberg E (2023) Agroecology can promote climate change adaptation outcomes without compromising yield in smallholder systems. *Environmental Management* **72**, 333–342. <https://doi.org/10.1007/s00267-023-01816-x>.
- Duquesne S (coord.), Mercier-Bonin M (coord.), Monsaingeon B (coord.), Paresys L (coord.), Akoueson F, Baudrin M, Bensaude-Vincent B, Beriot N, Body-Malapel M, Bouillot PE, Camargo-Pardo M, Cordier M, Corvellec H, Da Costa J, Dabert P, Dashkina R, Debeaufort F, Dedieu F, Desvaux P, Duflos G, Duval H, Ferlay A, Gontard N, Grassl B, Lampi E, Le Tilly V, Le Perchec S, Mougin C, Munhoz D, Nerin C, Notelet D, Ovlaque O, Picuno P, Rayns F, Siracusa V, Soulestin J and Tassin B (2025) *Plastics Used in Agriculture and for Food: Uses, Properties and Impacts*. Extended Report. INRAE, CNRS (France). <https://esco-plastiques-agri-alim.colloque.inrae.fr/>
- Duranel J (1961) Les polyéthylènes en horticulture. In *Pépiniéristes, horticulteurs, maraichers: revue française du maraichage, de l'horticulture et de la pépinière*, n°21, novembre 1961 (pp. 614–625).
- FAO (2021) Assessment of agricultural plastics and their sustainability: a call for action. <https://doi.org/10.4060/cb7856en>.
- FAO, IFAD, UNICEF, WFP and WHO (2022) *The State of Food Security and Nutrition in the World 2022. Repurposing Food and Agricultural Policies to Make Healthy Diets more Affordable*. Rome: FAO.
- FAO, IFAD, UNICEF, WFP and WHO (2024) *The State of Food Security and Nutrition in the World 2024 – Financing to End Hunger, Food Insecurity and Malnutrition in all its Forms*. Rome: FAO. <https://doi.org/10.4060/cd1254en>
- Gao H, Yan C, Liu Q, Ding W, Chen B and Li Z (2019) Effects of plastic mulching and plastic residue on agricultural production: A meta-analysis. *Science of the Total Environment* **651**, 484–492. <https://doi.org/10.1016/j.scitotenv.2018.09.105>.
- Geueke B, Parkinson LV, Groh KJ, Kassotis CD, Maffini MV, Martin OV, Zimmermann L, Scheringer M and Muncke J (2024) Evidence for widespread human exposure to food contact chemicals. *Journal of Exposure Science & Environmental Epidemiology* **17**, 1–2.
- Geyer R, Gavigan J, Jackson AM, Saccomanno VR, Suh S and Gleason MG (2022) Quantity and fate of synthetic microfiber emissions from apparel washing in California and strategies for their reduction. *Environmental Pollution* **298**, 118835. <https://doi.org/10.1016/j.envpol.2022.118835>.
- Guo S, Wang Q, Li Z, Chen Y, Li H, Zhang J, Wang X, Liu J, Cao B, Zou G and Zhang B (2023) Ecological risk of microplastic toxicity to earthworms in soil: A bibliometric analysis. *Frontiers in Environmental Science* **11**, 1126847. <https://doi.org/10.3389/fenvs.2023.1126847>.
- Hofmann T, Ghoshal S, Tufenkji N, Adamowski JF, Bayen S, Chen Q, Demokritou P, Flury M, Hüffer T, Ivelva NP and Ji R (2023) Plastics can be used more sustainably in agriculture. *Communications Earth & Environment* **4**, 332. <https://doi.org/10.1038/s43247-023-00982-4>.
- Hooge A, Hauggaard-Nielsen H, Heinze WM, Lyngsie G, Ramos TM, Sandgaard MH, Vollertsen J and Syberg K (2023) Fate of microplastics in sewage sludge and in agricultural soils. *TrAC Trends in Analytical Chemistry* **166**, 117184. <https://doi.org/10.1016/j.trac.2023.117184>.
- Huerta Lwanga E, Gertsen H, Gooren H, Peters P, Salánki T, Van Der Ploeg M, Besseling E, Koelmans AA and Geissen V (2016) Microplastics in the terrestrial ecosystem: Implications for *Lumbricus terrestris* (Oligochaeta, lumbricidae). *Environmental Science and Technology* **50**, 2685–2691. <https://doi.org/10.1021/acs.est.5b05478>.
- Huerta Lwanga E, Mendoza Vega J, Ku Quej V, Chi JDLA, del Cid L S, Chi C, Escalona Segura G, Gertsen H, Salánki T, van der Ploeg M and Koelmans AA (2017) Field evidence for transfer of plastic debris along a terrestrial food chain. *Scientific Reports* **7**, 14071. <https://doi.org/10.1038/s41598-017-14588-2>.

- Hyman S, Acevedo J, Giannarelli C and Trasande L** (2025) Phthalate exposure from plastics and cardiovascular disease: Global estimates of attributable mortality and years life lost. *eBioMedicine*, **117**, 105730. <https://doi.org/10.1016/j.ebiom.2025.105730>.
- Iacuzzi N, Tortorici N, Ida DM, Alaimo F, Cozzolino E, Sarno M, Mori M and Tuttolomondo T** (2024) Biodegradable mulching films affect soil temperature and agronomic performance of open field eggplant in hot-arid environments. *Italian Journal of Agronomy* **19**, 100025. <https://doi.org/10.1016/j.ijagro.2024.100025>.
- Jia L, Liu L, Zhang Y, Fu W, Liu X, Wang Q, Tanveer M and Huang L** (2023) Microplastic stress in plants: Effects on plant growth and their remediations. *Frontiers in Plant Science* **14**, 1226484.
- Joos L and De Tender C** (2022) Soil under stress: The importance of soil life and how it is influenced by (micro) plastic pollution. *Computational and Structural Biotechnology Journal* **20**, 1554–1566. <https://doi.org/10.1016/j.csbj.2022.03.041>.
- Karali N, Khanna Nand Shah N** (2024) *Climate impact of primary plastic production*. Lawrence Berkeley National Laboratory LBNL-2001585. <https://energyanalysis.lbl.gov/publications/climate-impact-primary-plastic>
- Li W and Xiao Y** (2023) Microplastics increase soil microbial network complexity and trigger diversity-driven community assembly. *Environmental Pollution* **333**, 122095. <https://doi.org/10.1016/j.envpol.2023.122095>.
- Li Y, Zhang J, Xu L, Li R, Zhang R, Li M, Ran C, Rao Z, Wei X, Chen M and Wang L** (2025) Leaf absorption contributes to accumulation of microplastics in plants. *Nature* **641**, 1–8. <https://doi.org/10.1038/s41586-025-08831-4>.
- Liu X, Wen Z, Zhou W, Dong W, Ren H, Liang G and Gong W** (2025a) Effect of multiyear biodegradable plastic mulch on soil microbial community, assembly, and functioning. *Microorganisms* **13**, 2. <https://doi.org/10.3390/microorganisms13020259>.
- Liu J, Xia P, Qu Y, Zhang X, Shen R, Yang P, Tan H, Chen H and Deng Y** (2025b) Long-term exposure to environmentally realistic doses of starch-based microplastics suggests widespread health effects. *Journal of Agricultural and Food Chemistry* **73**, 9867–9878. <https://doi.org/10.1021/acs.jafc.4c10855>.
- Liu L, Xu M, Ye Y and Zhang B** (2022) On the degradation of (micro) plastics: Degradation methods, influencing factors, environmental impacts. *Science of the Total Environment* **806**, 151312. <https://doi.org/10.1016/j.scitotenv.2021.151312>.
- Lofty J, Muhawenimana V, Wilson CAME and Ouro P** (2022) Microplastics removal from a primary settler tank in a wastewater treatment plant and estimations of contamination onto European agricultural land via sewage sludge recycling. *Environmental Pollution* **304**, 119198. <https://doi.org/10.1016/j.envpol.2022.119198>.
- Masry M, Rossignol S, Gardette JL, Therias S, Bussi ere PO and Wong-Wah-Chung P** (2021) Characteristics, fate, and impact of marine plastic debris exposed to sunlight: A review. *Marine Pollution Bulletin* **171**, 112701. <https://doi.org/10.1016/j.marpolbul.2021.112701>.
- Morales-Caselles C, Viejo J, Montero E and C ozar A** (2025) Agricultural plastics as marine pollutants: Empirical evidence from inland and coastal field surveys. *iScience* **28**, 6112701. <https://doi.org/10.1016/j.isci.2025.112701>.
- Orzolek M** (2017) A guide to the manufacture, performance, and potential of plastics in agriculture. In William Andrew (ed.). *Plastics Design Library*. Oxford: Elsevier Science & Technology Books.
- Ramadhani AM, Nassary EK, Rwehumbiza FB, Massawe BHJ and Nchimbi-Msolla S** (2024) Potentials of synthetic biodegradable mulch for improved livelihoods on smallholder farmers: A systematic review. *Frontiers in Agronomy* **6**, 1454060. <https://doi.org/10.3389/fagro.2024.1454060>.
- Ramanayaka S, Zhang H and Semple KT** (2024) Environmental fate of microplastics and common polymer additives in non-biodegradable plastic mulch applied agricultural soils. *Environmental Pollution* **6**, 125249. <https://doi.org/10.1016/j.envpol.2024.125249>.
- Renumala S, Jolly GE, Singh M, Sri GAU and Sulluru HR** (2025) A comprehensive review of polyethylene and biodegradable plastic mulch films: Impacts on soil health and plant growth. *International Journal of Environment and Climate Change* **15**, 363–378. <https://doi.org/10.9734/ijecc/2025/v15i44817>.
- Rillig MC, Leifheit E and Lehmann J** (2021) Microplastic effects on carbon cycling processes in soils. *PLoS Biology* **19**, e3001130.
- Seeley ME, Song B, Passie R and Hale RC** (2020) Microplastics affect sedimentary microbial communities and nitrogen cycling. *Nature Communications* **11**, 2372. <https://doi.org/10.1021/acs.est.5b05478>.
- Selonen S, Dolar A, Kokalj AJ, Skalar T, Dolcet LP, Hurley R and van Gestel CA** (2020) Exploring the impacts of plastics in soil—the effects of polyester textile fibers on soil invertebrates. *Science of the Total Environment* **700**, 134451. <https://doi.org/10.1016/j.scitotenv.2019.134451>.
- Sheng D, Jing S, He X, Klein AM, K ohler HR and Wanger TC** (2024) Plastic pollution in agricultural landscapes: An overlooked threat to pollination, biocontrol and food security. *Nature Communications* **15**, 8413. <https://doi.org/10.1038/s41467-024-52734-3>.
- Sonke JE, Koenig AM, Yakovenko N, Hagelskj er O, Margenat H, Hansson SV, De Vleeschouwer F, Magand O, Le Roux G and Thomas JL** (2022) A mass budget and box model of global plastics cycling, degradation and dispersal in the land-ocean-atmosphere system. *Microplastics and Nanoplastics* **2**, 28. <https://doi.org/10.1186/s43591-022-00048-w>.
- Sun X, Tao R, Xu D, Qu M, Zheng M, Zhang M and Mei Y** (2023) Role of polyamide microplastic in altering microbial consortium and carbon and nitrogen cycles in a simulated agricultural soil microcosm. *Chemosphere* **312**, 137155. <https://doi.org/10.1016/j.chemosphere.2022.137155>.
- Symeonides C, Aromataris E, Mulders Y, Dizon J, Stern C, Barker TH, Whitehorn A, Pollock D, Marin T and Dunlop S** (2024) An umbrella review of meta-analyses evaluating associations between human health and exposure to major classes of plastic-associated chemicals. *Annals of Global Health* **90**, 1–54. <https://doi.org/10.5334/aogh.4459>.
- Tartiu VE, Hurley R, Baann C, Briassoulis D, Schettini E, Convertino F, Le Moine B, Martinelli A, Vernet L, Ranneklev SB and Geissen V** (2025) Addressing the environmental sustainability of plastics used in agriculture: A multi-actor perspective. *Cambridge Prisms: Plastics* **3**, e5. <https://doi.org/10.1017/plc.2024.34>.
- US-EPA** (2021) Plastic contamination, Emerging issues in food waste management. U.S. Environmental Protection Agency EPA/600/R-21/116. <https://www.epa.gov/system/files/documents/2021-08/emerging-issues-in-food-waste-management-plastic-contamination.pdf>.
- Villarrubia-G omez P, Almroth BC, Eriksen M, Ryberg M and Cornell SE** (2024) Plastics pollution exacerbates the impacts of all planetary boundaries. *One Earth* **7**, 2119–2138. <https://doi.org/10.1016/j.oneear.2024.10.017>.
- Wagner M, Moncl us L, Arp HPH, Groh KJ, L oeth ME, Muncke J, Wang Z, Wolf R and Zimmermann L** (2024) *State of the Science on Plastic Chemicals – Identifying and Addressing Chemicals and Polymers of Concern*. Zenodo. <https://doi.org/10.5281/zenodo.10701706>
- Xu JL, Wright S, Rauert C and Thomas KV** (2025) Are microplastics bad for your health? More rigorous science is needed. *Nature* **639**, 300–302.
- Yang Y, Li Z, Yan C, Chadwick D, Jones DL, Liu E, Liu Q, Bai R and He W** (2022) Kinetics of microplastic generation from different types of mulch films in agricultural soil. *Science of the Total Environment* **814**, 152572. <https://doi.org/10.1016/j.scitotenv.2021.152572>.
- Zhu R, Zhang Z, Zhang N, Zhong H, Zhou F, Zhang X, Liu C, Huang Y, Yuan Y, Wang Y and Li C** (2025) A global estimate of multiccosystem photosynthesis losses under microplastic pollution. *Proceedings of the National Academy of Sciences* **122**, e2423957122. <https://doi.org/10.1073/pnas.2423957122>.