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Letter to the Editor

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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 (Geueke 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

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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.

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