Microplastics in agroecosystems: research status and future challenges

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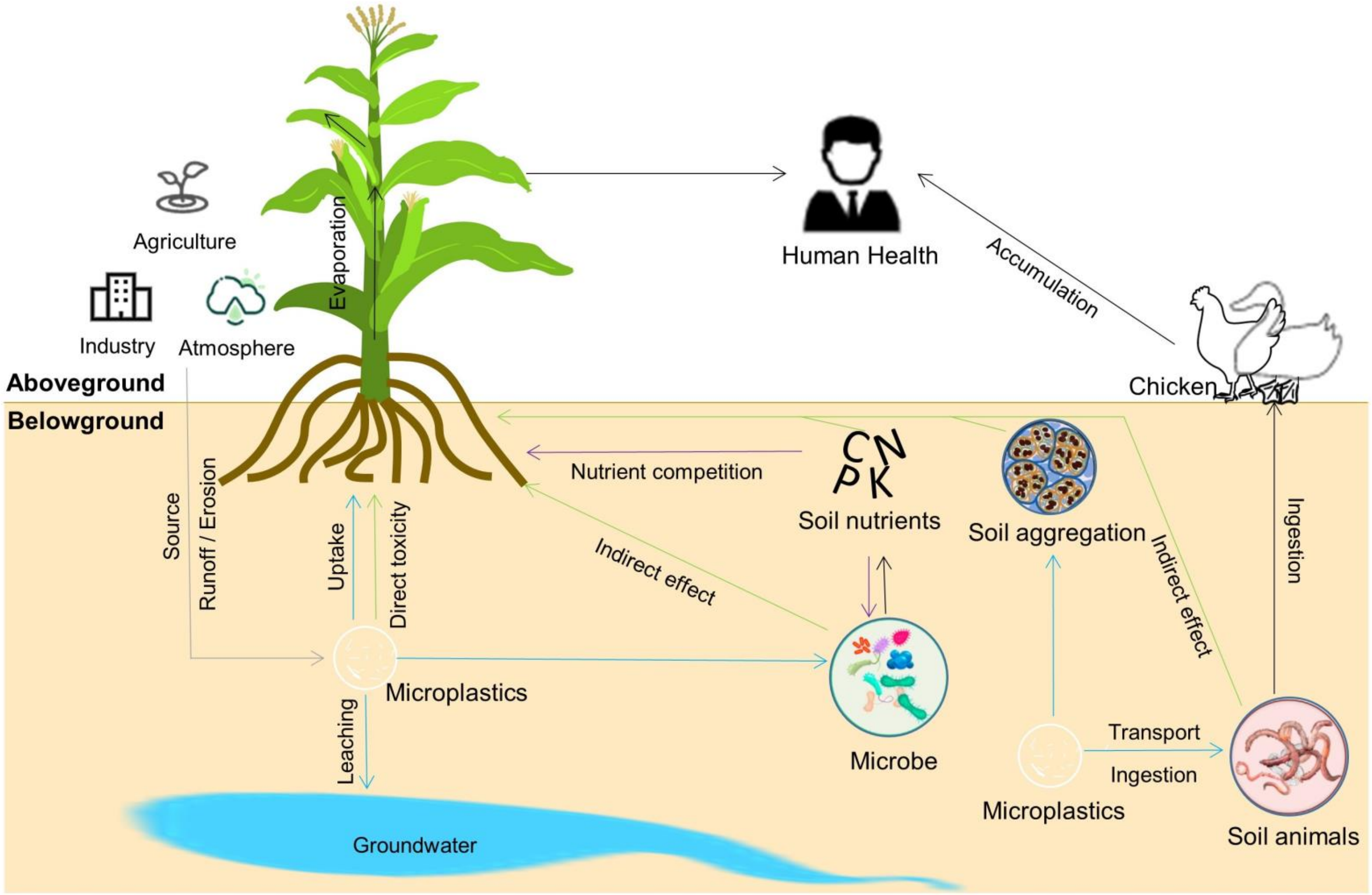
Abstract

The use of plastic within modern society is endemic with global plastic consumption, and subsequent disposal, now exceeding 280 million tons annually. Despite the remarkable benefit of plastics to society, there are increasing concerns associated with the vast amount of plastic entering our environment and its subsequent resistance to degradation. Thin plastic mulch films (4–8 μm thick) are widely used in agricultural systems to improve plant growth and water use efficiency. Although extremely effective, after crop harvest they are notoriously difficult to recover from soil and are rarely recycled. Consequently, plastic films are often incorporated into the soil where fragmentation is facilitated by tillage and exposure to UV radiation. Of these, microplastics (MPs; particles <5 mm in diameter), typically formed from the disintegration of larger plastic debris, are thought to be the most environmentally damaging. Due to our poor understanding of MPs behavior in soils, it is currently not possible to make informed decisions on future policies relating to the use and disposal of agricultural plastics.

Microplastics have been widely recognized as a critical environmental issue due to their extensive use and low degradation rate. Based on current evidence, we aims to evaluate whether MPs represent an emerging threat to plant-soil health in agroecosystems. We assess the ecological risks to plant-microbe-soil interactions associated with MPs and discuss the consequences of MPs on soil carbon (C), nutrient cycling, as well as greenhouse gas emissions in agroecosystems. We also identify knowledge gaps and give suggestions for future research. We conclude that MPs can alter a range of key soil biogeochemical processes by changing its properties, forming specific microbial hotspots, resulting in multiple effects on microbial activities and functions. Mixed effects of MPs on plant growth and performance can be explained by the direct toxicity of MPs or the indirect alteration in soil physical structures and microbial communities (i.e. symbiotic arbuscular mycorrhizal fungi). Because of the diverse nature of MPs found in soils, in terms of polymer type, shape and size, we also see differing effects on soil organic matter (SOM) decomposition, nutrient cycling, and greenhouse gases production. Importantly, increased bioavailable C from the decomposition of biodegradable MPs, which enhances microbial and enzymatic activities, potentially accelerates SOM mineralization and increases nutrient competition between plant and microbes. Thus, biodegradable MPs appear to pose a greater risk to plant growth compared to petroleum-based MPs. Although MPs may confer some benefits in agroecosystems (e.g. enhanced soil structure, aeration), it is thought that these will be far outweighed by the potential disbenefits.

Keywords: Microplastics, plant growth, soil carbon storage, nutrient cycling, greenhouse gas emissions, biodegradable plastics, agroecosystem

Graphic Abstract



Biography

Huadong Zang

Huadong Zang works as an associate professor at China Agricultural University (CAU) since 2018. Before joining CAU, he obtained PhD at the University of Goettingen and works as a PostDoc at Bangor University. He has wide experience in agronomy and soil science, and extensive experience in ^{13}C natural abundance techniques and multiple stable/radioactive isotope (^{13}C, ^{14}C, ^{15}N, ^{18}O) labeling approaches. His past research focused on N and C cycles in the plant-soil system, specifically, how N fertilization, temperature, and crop management influence C sequestration, organic matter stabilization, turnover, and priming effects in the agroecosystem. His current research interests in investigating C and nutrients cycling, as well as the plant-plant and plant-microbial-soil interactions in diversified cropping systems and agroecology. In his work he uses a combination of methods including on-station and on-farm experiments, isotopic labeling, zymography, and molecular techniques.