Practice abstract n°15: Microplastics alter the nitrogen cycle in soil affecting nutrient availability to crops

Microplastics (MPs) are increasingly recognized as a serious pollutant in terrestrial ecosystems. Emerging research shows that MPs are accumulating in soils at potentially even higher concentrations than in oceans, threatening vital processes linked to soil fertility. A recent global meta-analysis synthesizing data from 147 peer-reviewed studies (over 1100 observations) sheds light on how MPs affect soil enzymes crucial for nitrogen (N) acquisition. The findings offer critical insights for environmental policy, agricultural sustainability, and soil management strategies.

A comprehensive survey of all available knowledge

This comprehensive meta-analysis applied rigorous statistical techniques to evaluate **how MPs impact the activities of key soil enzymes** linked to the breakdown of proteins, chitin, and urea—substances found in natural soil organic matter and some fertilizers. These enzymes are essential to making nitrogen available to plants and supporting crop growth and quality. The survey included data from a wide range of soil types, environmental conditions, and MP types (from both biodegradable and conventional plastics, often derived from agricultural materials).

Main Findings

The meta-analysis highlighted that **scientific evidence strongly indicates MPs in soil can substantially alter the nitrogen cycle**. MPs from biodegradable plastics had a stronger impact on enzyme activity than conventional MPs, indicating that even seemingly "eco-friendly" plastics can disrupt soil biochemical functions. Depending on soil conditions, different effects can be observed: in acidic soils (pH < 6), the activity of urease (the enzyme that breaks down urea into ammonium—a plant-available form of nitrogen) increases, while in neutral soils (pH 6–7), this process is hindered. Soils with 10–40% clay content and low organic carbon levels showed the highest sensitivity to these effects. **A concentration of MPs greater than 1% in soil may act as a threshold for detectable effects**; however, several studies have shown impacts even at lower concentrations.

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PAPILLONS results reinforce these findings

Within the PAPILLONS project (funded by the EU under the Horizon 2020 program), several comprehensive experiments were conducted using MPs generated from agricultural plastics such as mulching films. These experiments were conducted by artificially adding these MPs to the soil at relative low concentrations that reflected the levels commonly measured in European soils. In particular, PAPILLONS focused on a series of field studies conducted in real agricultural settings across Europe and tested effects at low MP concentrations. **Even at levels as low as 0.005% MPs in soil, a significant reduction in soil microbes' ability to convert organic nitrogen into plant-available forms was observed—especially in experiments conducted in southern Europe. These effects were consistent for both biodegradable and conventional MPs.**

Conclusion

Soil MPs alter fundamental processes critical to plant nutrition and ecosystem health. R**egulatory frameworks should be adapted to address MP contamination in soils, with a focus on waste management, plastic use in agriculture, and thresholds for safe exposure**. These insights can inform agricultural practices that reduce MPs accumulation in farmland while ensuring soil conditions that can buffer against the negative effects of these pollutants.

Reference
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