Nanoplastics put stress on trees and impair photosynthesis

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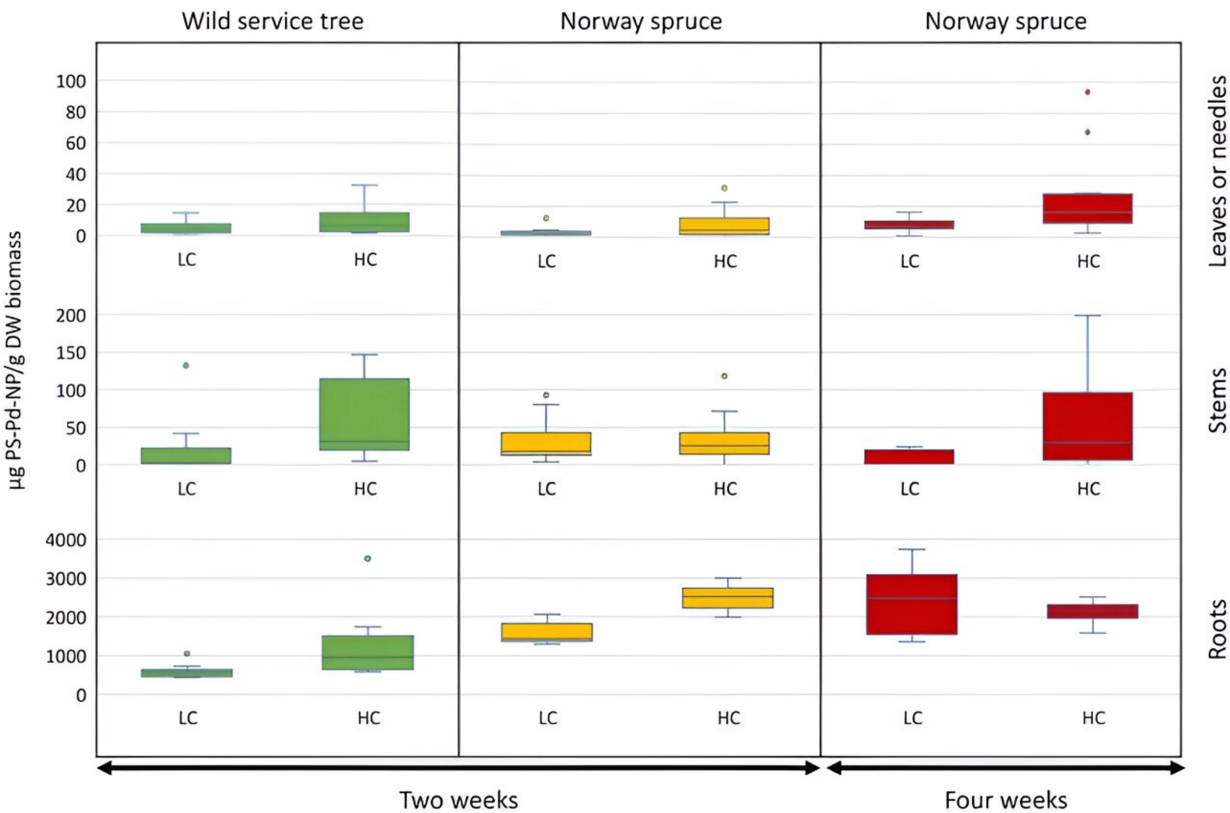

Distribution of µg PS-Pd-NP per g DW biomass in the three different tissues of wild service tree and Norway spruce across the two different PS-Pd NP concentrations and the two different exposure times. Credit: *Environmental Science: Nano* (2024). DOI: 10.1039/D4EN00286E

It is well known that more and more plastic waste is ending up in soil and bodies of water. Researchers are particularly concerned about tiny micro- and nano-sized particles. It remains unclear how and to what extent they are able to enter living organisms—and what effect they may have on metabolism.

ETH researcher Denise Mitrano has now been able to show how trees take up nanoplastics contained in water through their roots. In collaboration with ecologist Arthur Gessler from the Swiss Federal Institute for Forest, Snow and Landscape Research, she has demonstrated for the first time that this has a negative effect on photosynthesis. To do this, Mitrano used a method she had developed to quickly and precisely detect microplastics and nanoplastics.

Hundreds of saplings in a water bath

First, the researchers grew 100 seedlings of each of two tree species with different water-use strategies: the wild service tree, a deciduous tree that is widespread in Europe and requires a lot of water, and the Norway spruce, which needs little water.

The wild service tree saplings were transferred to hydroponic cultivation after seven months, followed by the slower-growing spruce after 18 months. This meant that the roots of the saplings were now growing in nutrient-enriched water rather than in soil.

The team then added different concentrations of model metal-doped nanoplastics to the water and analyzed the content of plastic particles in different parts of the trees at varying intervals. They also determined photosynthesis activity throughout the study, which has now been published in *Environmental Science: Nano*.

Within just a few weeks, the researchers were able to detect 1 to 2 milligrams of nanoplastics per gram of plant material in the roots. The plastic content was around 10 to 100 times lower in the trunks, leaves and needles.

There were no significant differences between the two tree species; although the Norway spruce takes up less water, roughly the same amount of nanoplastics accumulated in this tree as in the thirsty wild service tree.

"That was surprising. We had expected the amount of nanoplastics to correlate with the amount of water absorbed and transported to the leaves," says Gessler. This finding suggests that nanoplastics do not enter the trees through tiny fissures in the root tissue as previously thought, but rather are absorbed into cells in the root and transported from there further up into the tree.

Likely stored in the cell membrane

The researchers also succeeded in proving that nanoplastics in the leaves and needles can affect important physiological processes. Their measurements showed that the effectiveness of photosynthesis in the wild service tree decreased by a third within two weeks, and in the Norway spruce by about 10% within four weeks—in each case they were compared with trees growing in water without the addition of nanoplastics.

"In the needles, the particles have to overcome an additional cellular barrier, which may be why it takes longer in the spruce than in the deciduous tree," says Gessler.

The result indicated that some of the energy from sunlight is no longer used for photosynthesis, but is instead dissipated as heat. "This is a typical stress reaction in trees," says Gessler. "My hypothesis is that nanoplastics are stored in cell membranes and are damaging them."

Storing nanoplastics in this way may also damage other living organisms. This is because cell membranes play a key role in a range of physiological processes.

Reduced photosynthesis had no effect on tree growth. However, the researchers only observed the trees over a short period of four weeks—so no conclusions can be drawn about the longer-term consequences. In addition, relatively high amounts of nanoplastics were used in this study. The effects may be different with lower concentrations of nanoplastics or when the trees are grown in soil rather than in hydroponic cultivation.

"Our study is not intended to give the impression that trees could die as a result of nanoplastics," says Mitrano. But it could be an additional stress factor, particularly for trees in cities, which are already suffering from increased heat, aridity and air pollution.

More information: Maria Elvira Murazzi et al, Uptake and physiological impacts of nanoplastics in trees with divergent water use strategies, *Environmental Science: Nano* (2024). DOI: 10.1039/D4EN00286E

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