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Plastics in the Environment
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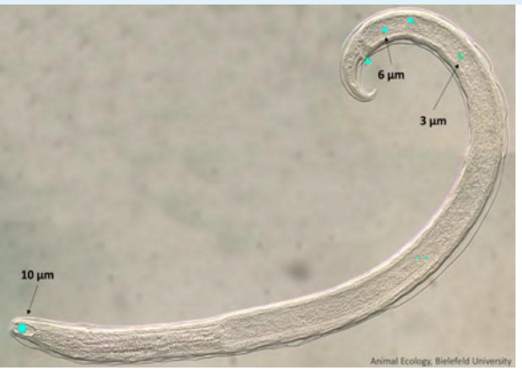
Microplastics in the aquatic food web

Impact and transfer analysis based on the example of roundworms (nematodes)



Predatory nematode (Mononchidae) found in the wild with ingested microplastic (polystyrene) particles of various sizes.
Photo: © Hendrik Füser, Bielefeld University, Department of Animal Ecology

Roundworms (nematodes) live in the sediment layer of water bodies and serve as a food source for larger aquatic organisms. Nematodes are capable of absorbing microplastics within a matter of minutes, resulting in these small plastic particles entering the food chain. Nematodes continuously ingest and excrete microplastics, such that the number of particles in their bodies is always in balance with that in the external medium. The microplastic particles compromise the nematodes' food intake both inside and outside the body and therefore have an inhibitory effect on their reproduction.

A large quantity of microplastic is passed through the body of the nematodes

As a rule, nematodes are able to ingest all particles that are smaller than their mouth opening (Fig. 1). However, particles that resemble food (e.g. bacteria) in shape and size are ingested preferentially. Laboratory tests have shown that a nematode can consume up to 200 polystyrene particles within a few minutes (Fig. 2) and excretes the particles just as quickly.

This means:
1. that at constant environmental concentrations there is always a certain number of microplastics within the nematode, and
2. that a large quantity of microplastic is passed through the body.

These findings are useful when considering the transfer of microplastics into the food web, as nematodes are a significant food source for organisms in the bottom zone of the water column, such as midge larvae and fish.

"To assess the ecologic danger posed by microplastics, one must also consider indirect effects in the food web."

Sebastian Höss, Ecossa;
Marie-Theres Rauchschwalbe,
Bielefeld University

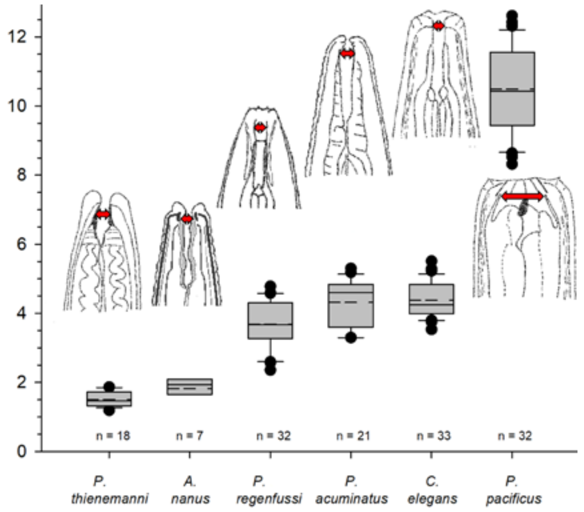


Fig. 1: Diameter of the oral cavities of six nematode species in µm – (Panagrolaimus thienemanni, Acrobeloides nanus, Poikilolaimus regenfussi, Plectus acuminatus, Caenorhabditis elegans, Pristionchus pacificus)

Modified in accordance with Fueser et al. 2019, Environ. Poll., 255, 113227.

Can microplastics limit nematode reproduction?

Very high concentrations of microplastics (50 - 4,000 times higher than usually expected in the environment) inhibit the reproduction of nematodes. The extent of this effect depends on the total surface area of the particles.

Research on the direct and indirect effects of microplastics on aquatic organisms in reservoirs

The joint research project MikroPlaTaS investigates the effects of microplastics. The project partners worked in the field, laboratory and in semi-outdoor systems (micro- and mesocosms) to determine impact thresholds and mechanisms on a model basis using individual laboratory species of meio- and macrofauna. These could then be verified under realistic conditions for complex organismal communities.

Understanding impact thresholds and recording impact mechanisms that are not routinely considered (e.g. the disruption of forage availability) allows for a more realistic assessment of the ecological risks of plastic pollution to the aquatic environment. Reservoir ecosystems polluted by microplastics are used for exemplary purposes.

Direct toxic effects of dissolved monomers (styrene) or oxidative stress of the particles themselves could be excluded as a mechanism of action (Fig. 3).

Microplastics interfere with the nematodes' food intake

The effect of microplastics on nematode reproduction is strongly dependent on the food availability (Fig. 3). It could be shown that polystyrene particles impair feeding by nematodes more than quartz particles (natural reference particles), since polystyrene particles are very similar to the food bacteria in terms of behavior in the test medium. The amount of food in the habitat thus becomes the decisive factor in the risk assessment for microplastics.

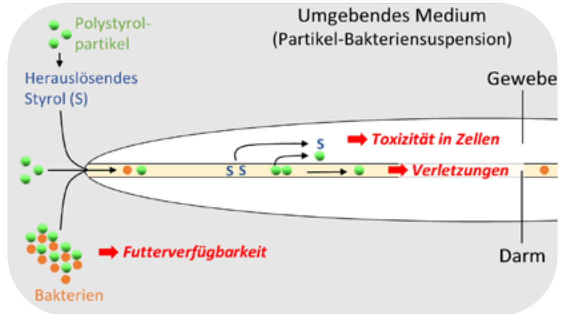


Fig. 3: Possible mechanisms that may explain inhibition of nematode reproduction by polystyrene particles.
Modified in accordance with Mueller et al. 2020, Environ. Sci. Technol., 54, 1790-1798

Fig. 2.1: Nematode C. elegans ingests >200 microplastic particles within 30 min.

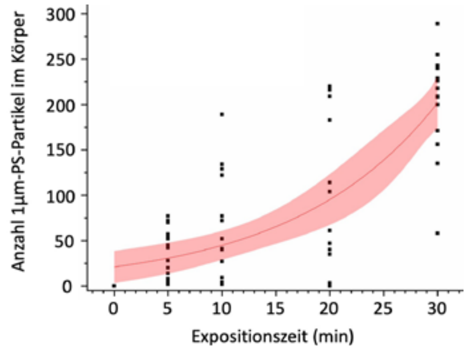
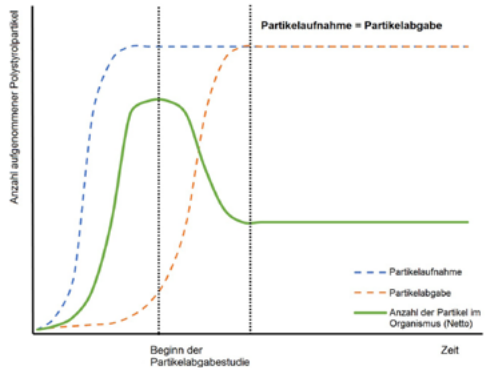


Fig. 2.2: Continuous ingestion and excretion of particles eventually establishes an equilibrium in the body of the nematode.



Modified in accordance with Fueser et al. 2020, Chemosphere, 261, 128162.

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