Combined effects of polyethylene microplastics and nanoparticles on *Lemna minor*

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Introduction

ZnO and TiO_2 nanoparticles are frequently used nanomaterials, especially as UV-filters in personal care products.

These nanoparticles follow the same path as primary microplastics used in cosmetics - they both end up in wastewater and eventually in the aquatic ecosystem.

There, they can interact, leading to a change in their bioavailability and toxicity.

The aim of the study was to investigate the toxicity of **microplastics with adsorbed** ZnO and TiO_2 **nanoparticles** on duckweed *Lemna minor.*

Adsorption of TiO_2 lasted for 12 hours until the maximum adsorption capacity of 823 µg TiO_2/g MPs was reached. ZnO reached the maximum adsorption capacity of 286 µg ZnO/g MPs after 3 hours.

The effects on **specific growth rate**, **chlorophyll *a* and *b*** content and **root length** were investigated. The **concentration of desorbed nanoparticles** was also determined during the experiment.

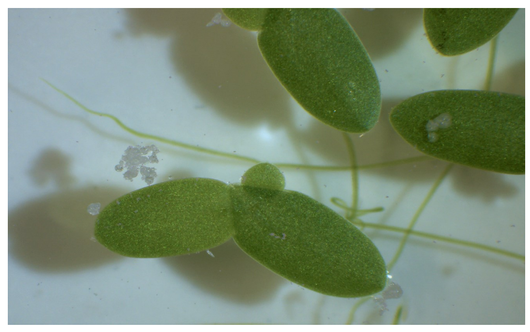

Figure 1: *Lemna minor* exposed to microplastics.

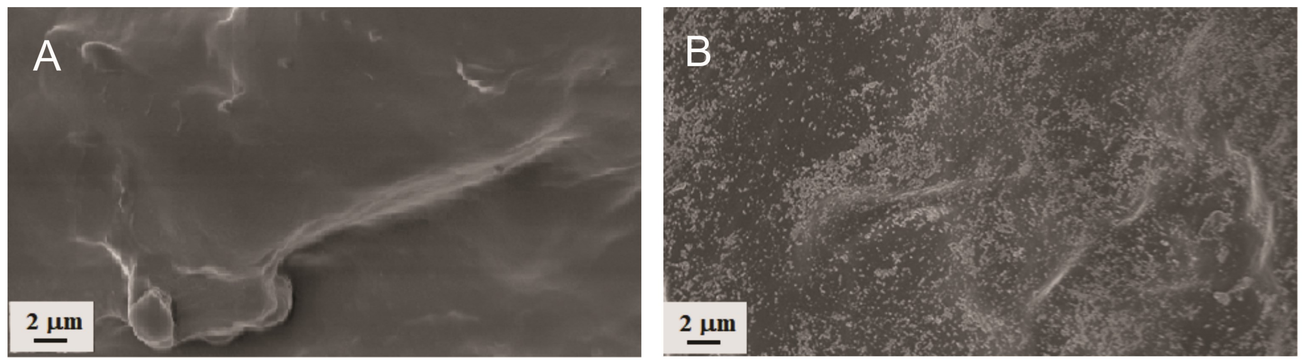

Figure 2: SEM image of A) microplastic surface, B) microplastic surface with adsorbed TiO_2 (white spots).

Results

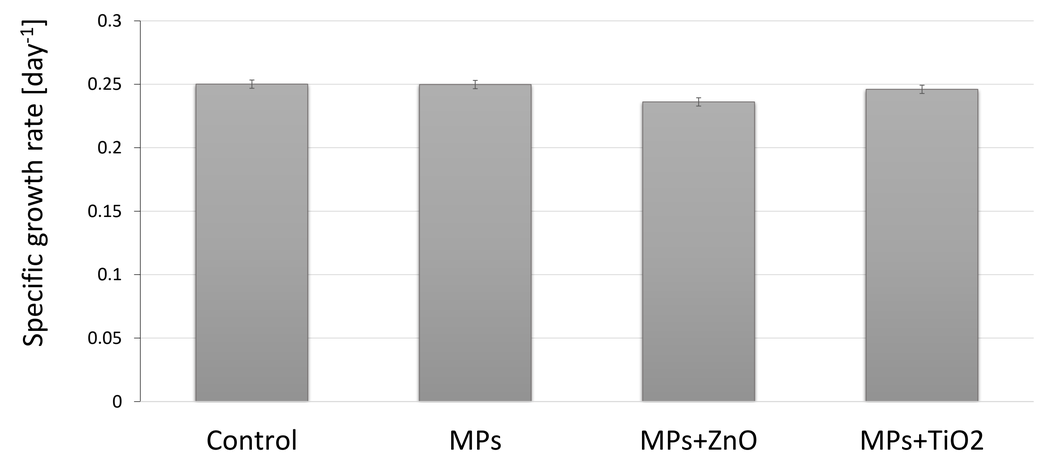

Figure 3: Specific growth rate of *Lemna minor* in control and microplastics (MPs), microplastics with adsorbed ZnO (MPs+ZnO) and microplastics with adsorbed TiO_2 (MP+TiO_2) treatments.

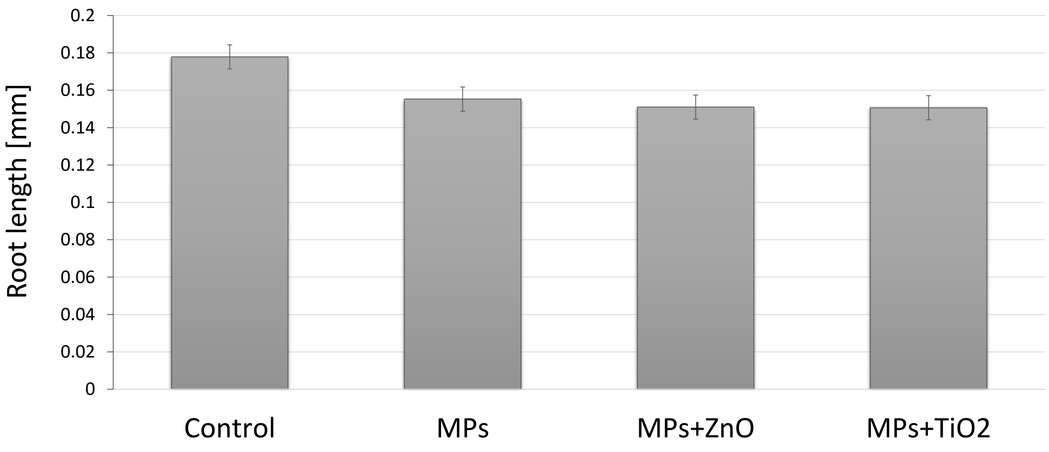

Figure 4: Root length of *Lemna minor* in control and microplastics (MPs), microplastics with adsorbed ZnO (MPs+ZnO) and microplastics with adsorbed TiO_2 (MP+TiO_2) treatments.

- Microplastics with adsorbed TiO_2 and ZnO nanoparticles did **not affect** the specific growth rate of *Lemna minor.*
- Microplastics with adsorbed TiO_2 and ZnO nanoparticles did **not affect** the chlorophyll *a* content.
- Microplastics regardless adsorbed TiO_2 and ZnO nanoparticles **inhibited** root growth.
- Microplastics with adsorbed TiO_2 and ZnO nanoparticles **decreased** chlorophyll *b* content.
- **15.7 %** and **53.0 %** of the TiO_2 and ZnO, respectively, were **desorbed** from microplastics during the 7 day incubation time.

Table 1: Specific concentrations of chlorophyll *a* and *b* of *Lemna minor* in control and microplastics (MPs), microplastics with adsorbed ZnO (MPs+ZnO) and microplastics with adsorbed TiO2 (MP+TiO2) treatments.

Sample	C_{Spa}* [mg/g_{fw}]	C_{Spb}* [mg/g_{fw}]
Control	0.829 ± 0.036	0.418 ± 0.074
MPs	0.813 ± 0.036	0.321 ± 0.023
MPs+ZnO	0.823 ± 0.024	0.285 ± 0.021
MPs+TiO2	0.870 ± 0.043	0.253 ± 0.022

*average ± standard deviation

Conclusions

- Microplastics with adsorbed nanoparticles affected the root growth and chlorophyll *b* content of *Lemna minor*, while they did not affect the chlorophyll *a* content and the specific growth rate.
- The negative effect may be associated with particles/ions that desorbed from the microplastics during the 7 day incubation.