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Modulation of silver nanoparticle phytotoxicity by surface coating and microplastic co-exposure in Lemna minor

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Silver nanoparticles (AgNPs) and microplastics (MPs) are among the most prevalent emerging contaminants in freshwater ecosystems, yet the role of nanoparticle surface coating in modulating phytotoxicity, particularly under co-exposure conditions, remains poorly understood. To address this, we examined the individual and combined effects of two surface-coated AgNPs, cetyltrimethylammonium bromide (AgCTAB) and polyvinylpyrrolidone (AgPVP), and two MPs, polystyrene (PS) and polymethylmethacrylate (PMMA), on the duckweed Lemna minor over a 7-day exposure period. Control plants were grown without the addition of AgNPs or MPs. Relative growth rate, chlorophyll a fluorescence (JIP-test), pigment content, and expression of photosynthesis-related genes were assessed on days 1, 3, and 7. AgPVP-based combinations with MPs (AgPVP+PS, AgPVP+PMMA) induced the most pronounced physiological stress from the earliest timepoint, while AgCTAB and AgPVP alone caused moderate effects on day 1. By day 3, stress in AgPVP-treated plants intensified, whereas AgCTAB-exposed plants showed signs of recovery towards control values. On day 7, AgPVP+PS remained the most severely affected treatment, while plants treated with AgPVP and AgPVP+PMMA displayed partial recovery, though with persistently reduced growth suggesting lasting physiological consequences. The observed physiological responses in the most affected treatments indicate a decline in photosynthetic efficiency, ultimately resulting in reduced plant growth. These results highlight the coating-dependent nature of AgNP phytotoxicity and suggest that microplastic co-exposure may modulate, but not eliminate, the adverse effects of AgNPs on aquatic macrophytes.

Corresponding author email

sandra.vitko@biol.pmf.unizg.hr

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References

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Primary author(s) : Dr. VITKO, Sandra (University of Zagreb, Faculty of Science, Department of Biology,

Croatia); Ms. MILIŠIĆ, Tina (University of Zagreb, Faculty of Science, Department of Biology, Croatia); Ms. BRAUT, Jelena (University of Zagreb, Faculty of Science, Department of Biology, Croatia); Prof. BALEN, Biljana (University of Zagreb, Faculty of Science, Department of Biology, Croatia); Prof. TKALEC, Mirta (University of Zagreb, Faculty of Science, Department of Biology, Croatia)

Presenter(s) : Dr. VITKO, Sandra (University of Zagreb, Faculty of Science, Department of Biology, Croatia)

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