Mitigating Toxicological Effects of PS-NH2 Nanoparticles on Chlorella sp. in Heavy Metal Remediation Systems Using Humic Acid

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Nanoplastics, artificial polymers ranging from 1 nm to 1 μm, have increased significantly in aquatic environments due to microplastic degradation through wind, water, and UV exposure. Microalgae-based Water Treatment Technologies (MWTT) represent a sustainable alternative to conventional water purification methods for removing inorganic and organic compounds and heavy metals. However positively charged nanoplastics such as PS-NH2, negatively impact microalgal organelles including mitochondria, cell vacuoles, and cell membranes, due to increased electrostatic attraction, potentially reducing MWTT effectiveness. We exposed Chlorella sp. cultures to PS-NH2 (10 mg/L) in combination with three humic acid concentrations (2.5, 5, 7.5, and 10 mg/L). Without humic acid, PS-NH2 exposure reduced microalgal growth and decreased chlorophyll A levels by 53.7%. However, humic acid treatment altered nanoplastic zeta-potential, reducing van der Waals interactions with cell surfaces and thereby mitigating toxicity. The highest humic acid concentration (10 mg/L) improved cell viability by 81.4% compared to cultures exposed to PS-NH2 alone. Using water samples from urban, suburban, and agricultural sites. When in the presence of humic acid (10 mg/L), Chlorella sp. maintained effective remediation despite PS-NH2 exposure, showing improved removal of heavy metals by 9.2%, organic nitrogen by 32.3%, and inorganic compounds (nitrates, nitrites, and phosphates) by 31.4% compared to unprotected microalgae exposed to PS-NH2. These findings suggest that humic acid supplementation could preserve microalgae functionality in nanoplastic-contaminated environments, enhancing the resilience of microalgae-based water treatment systems.

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