Effects of nano CuO on aquatic decomposers: from community to cellular responses

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Intensive use of metal nanoparticles increases the chance of their release into freshwaters that may pose risk to biota and associated ecological processes. In streams, microbes play a key role in detritus foodwebs transferring carbon and energy from plant litter to invertebrate shredders. Here, we investigated the effects of nano CuO (<50 nm, nanopowder, Sigma) on aquatic detritus foodwebs by examining i) leaf-litter decomposition by bacterial and fungal communities, ii) cellular damage and physiological responses of fungal populations collected from non-polluted and metal-polluted streams, and iii) survival, growth and leaf consumption by an invertebrate shredder. Results were compared with those obtained with ionic copper.
Stream-dwelling microbial communities were obtained by immersion of leaves in a non-polluted stream (Portugal). Microbial communities were exposed in microcosms to nano CuO (≤ 500 mg L^{-1}) and Cu^{2+} (≤ 30 mg L^{-1}). Leaf decomposition decreased with increasing concentrations of nano and ionic copper. Both copper forms reduced biomass of bacteria and fungi, and fungal reproduction. Cu^{2+} had stronger effects than nano CuO. Exposure to Cu^{2+} and nano CuO led to a decrease in fungal diversity and to shifts in species dominance.
Increased concentrations of nano CuO (≤ 100 mg L^{-1}) stimulated extracellular laccase activity by fungi. Populations from non-polluted streams were more affected by nano CuO than those from polluted streams, as shown by a stronger inhibition of biomass production, higher Cu adsorption, higher levels of reactive oxygen species and DNA strand breaks.
Acute lethality tests suggested low toxicity of nano CuO to the shredder *Allogamus ligonifer*. However, sublethal concentrations of nano CuO (≤ 75 mg L^{-1}) strongly reduced leaf consumption and invertebrate growth under aqueous and dietary exposure. Concentration of leached Cu^{2+} in the stream water increased with increasing nano CuO concentration. Exposure to 75 mg L^{-1} of nano CuO via water or food led to higher Cu adsorption and accumulation in larvae. Moreover, leached Cu^{2+} appeared to have a role in inducing toxicity of nano CuO.

Keywords: Nano CuO, aquatic microbial communities, fungal isolates, invertebrate shredder.

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