Soil pH Effects on the Toxicity of Zinc Oxide Nanoparticles to Soil Bacterial Communities

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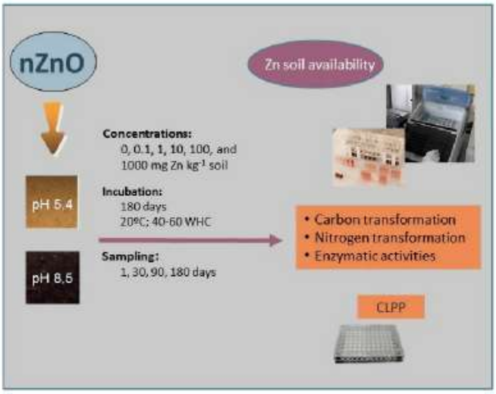

The environmental levels of ZnO nanoparticles (nZnO) are increasing continually given the widespread and expanding applications of this material. Soil pH appears to be one of the key factors affecting the behavior and toxicity of metal nanoparticles in soil. Soil microorganisms play a very important function in geologic, hydrologic and ecological cycles, maintaining soil health, ecosystem function and production. Little research has been conducted on the interaction between nZnO and microbial communities in vivo that would mimic the natural environment [1]. In this work, we evaluated the role that soil pH (an acidic soil pH 4.7 and a calcareous soil pH 8.5) plays on the toxicity of nZnO to soil bacterial communities.

The soils were spiked with 0 (control), 0.1, 1, 10, 100 and 1000 mg Zn/kg soil as nZnO. Subsamples were taken at 1, 30, 90 and 180 days to analyze available Zn soil concentration and microbial toxicity. The effects studied were the changes on carbon and nitrogen transformation and the alterations on soil microbial metabolisms (dehydrogenase (DH) and acidic (ACP) and alkaline (ALP) phosphatases activities). Moreover, changes in microbial communities were determined by the microbial community-level physiological profiles (CLPP) method.

The available Zn soil concentration was remarkable higher in acidic than in calcareous soil. There were not differences in available Zn soil concentration in the treated soils at low loading rates (<10 and <100 mg Zn/kg in acidic and calcareous soils, respectively) compared to control soils.

Toxic effects of nZnO in respiration were observed only at the highest concentration and were less than 25% related to control in both soils. nZnO generally did not affect nitrification in both soils. In the calcareous soil, the DH activity increased in the 100 and 1000 mg Zn/kg treatments at 180 days, with percentages between 30-80%. By contrast, it decreased at the highest nZnO dose over the assay (70-87%), in the acidic soil. Dose of 1000 mg Zn/kg inhibited the activity of ACP at 180 days in basic soil and over the assay in acidic soil. The ALP activity showed the maximum differences between both soils, with values very close to the control in calcareous soils and dose-response increases in acidic soil that increased along the time. The higher effects found in acidic soil than in calcareous soil seems related with the highest bioavailability of Zn in the acidic soil. The enzymatic activities did not correlate to microbial biomass (respiration assay). This suggests that the changes in enzymatic activities were not driven by changes in microbial abundance, but in soil microbial populations [2]. The average utilization of the C sources increased in both soils along 30 days. Then, values of average well color development, richness and Shannon-Weaver index were reduced to virtually zero in calcareous soil. In acidic soil, the highest dose produced an elevated increase of bacterial growth without changes in their metabolic profiles over time. Microbial biomass represents the entire spectrum of the catabolic functions of the microbial communities, while CLPP is confined to only a subpopulation of cultivable aerobic microorganisms. This possibly explains the differences between the microbial parameters analysis and microbial physiological profiles results.

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References

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