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Soil Amendments for the Remediation of Cu-Contaminated Vineyard Soil: Effects of Biochar, Nanobiochar and Chitosan on Copper Bioavailability and Ecotoxicity

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ABSTRACT

Copper (Cu) contamination in vineyard soils present environmental risks and affect the respective quality and ecosystem functions. This study evaluated the mitigation effect of different soil conditioners on Cu lability and ecotoxicity. A vineyard contaminated soil, relative to four treatments, with (1% of biochar-BioC, nanobiochar-nBioC and chitosan-Chit), and without (control) conditioner, was incubated for two months under controlled conditions, and copper lability was assessed by DTPA extraction. The ecotoxicity was evaluated by a behaviour test, using *Eisenia fetida* as biologic model, with avoidance as an endpoint (A%). All amendments reduced Cu availability, with DTPA-extractable Cu decreasing from 29.2 ± 0.3 mg kg^{-1} (control) to 28.3 ± 0.2 (BioC), 27.5 ± 0.2 (nBioC), and 26.6 ± 0.1 mg kg^{-1} (Chit) order. Avoidance responses were -68% (nBioC), -48% (BioC), 12% (control), and 62% (Chit). Despite decreasing Cu lability, chitosan promotes the strongest avoidance response, suggesting a potential biocidal effect on earthworms. Conversely, in BioC and nBioC treatments, pH increase, surface sorption, and Cu complexation factors can explain both reduced Cu bioavailability and enhanced ecological compatibility, especially for the nanobiochar due to its higher reactivity. For this, nanobiochar presented the most balanced performance, combining effective immobilization with lower ecotoxicological impact, suggesting its potential as a sustainable amendment for remediating Cu-contaminated vineyard soils.

Keywords: copper, remediation, biochar, nanobiochar, chitosan

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