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Ecotoxicological standard tests confirm beneficial effects of nitrate capture in organically coated grapewood biochar

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Due to the rising use of mineral N fertilizers and legume use in agriculture, the input of reactive N into the global N cycle has dramatically increased. Therefore new agricultural techniques that increase N use efficiency and reduce the loss of soil mineral N to surface and ground waters are urgently required. Pyrogenic carbon (biochar) produced from biomass may be used as a beneficial soil amendment to sequester carbon (C) in soils, increase soil fertility in the long term, and reduce environmental pollution such as nitrate leaching or N2O emissions. However, reduced nitrate leaching is not a constant finding when using biochar as a soil amendment and the mechanisms are poorly understood. To investigate if biochar is able to reduce nitrate pollution and its subsequent effects on soil and aquatic fauna, we conducted a series of experiments using standard ecotoxicological test methods: (1) the collembolan reproduction test (ISO 11267 (1999)), (2) the earthworm reproduction test (ISO 11268-2 (1998)), (3) the aquatic Daphnia acute test (ISO 6341 (1996)) and (4) a seedling emergence and growth test (ISO 11269-2 (2006)) also involving leaching events. For the tests grapewood biochar produced with a Kon-Tiki kiln (600-700°C) was used which had previously demonstrated nitrate capture; terrestrial tests were carried out with loamy sand standard soil 2.2 (LUFA-Speyer, Germany). The tests included the factors: (A) nitrate addition (using critical values for the test organisms) or no nitrate addition, (B) control (no biochar), pure biochar and organically-coated biochar. In the aquatic test (3), a nitrate amount which caused 50% of the Daphnia-immobilizing toxic nitrate concentration in leachates was applied to the soil or soil-biochar mixtures. Subsequently, soils were incubated overnight and leached on the next day, producing (in the control) the calculated nitrate concentrations. Daphnids were incubated for 48 hours. Test results without nitrate confirmed that soil-biochar leachates did not impact Daphnia mobility. However, in the nitrate-amended control, Daphnia mobility was reduced by 52% as expected, while mobility was only reduced by 28% (pure BC) and by 16% (coated BC), respectively; this coincided with reduced nitrate concentrations in the leachates. In the presence of both biochars without high nitrate levels, adult earthworm biomass (2) was not different from that of the control, while the reproductive success (number of juvenile) increased by +46% with the coated biochar. With high nitrate concentrations, the reproductive success was strongly reduced by 96.7% (adult earthworm biomass remained constant). With the pure and coated biochars, the reproductive success increased by +171% and +678% compared to the (strongly reduced) soil-only control, respectively. The same response patterns were found in the collembolan test (1). In all cases biochar effects were correlated to nitrate capture in biochar particles which was more pronounced in the organically coated biochar. In conclusion post-treated biochars may be used as a tool for reducing nitrate pollution. However, more research is clearly needed.

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