Tagungsnummer
V205

Thema
Kommission III: Bodenbiologie und Bodenökologie

Freie Themen inkl. Beiträge zu Humusformen

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Titel
Mitigating negative microbial effects of p-nitrophenol, phenol, copper and cadmium in a sandy loam soil using biochar

Abstract
Biochars are adsorptive solids potentially of benefit to soil microbes by providing improved nutrient retention, a carbon substrate and contaminant adsorption. A 28-day incubation experiment gauged the interactive effects of biochar application and contaminants on the microbial biomass and respiration of a sandy loam soil. Soil was amended with 250 mg/kg phenol or p-nitrophenol (two toxic but nevertheless biodegradable organic contaminants) or 50 mg/kg cadmium or copper. Biochar application generally caused increased microbial respiration and biomass relative to non-amended controls. Of the heavy metal-amended soils, Cu effected significant reductions in microbial biomass carbon and basal respiration, which were improved with concurrent biochar amendment. The biochar's functional groups are likely to have mitigated the metals' negative effects via complexation and sorption, while the soil's proportion of negative pH-dependent sites was increased by the pH rise induced by biochar application, allowing more cationic retention. Organic contaminant-spiked soils had higher microbial biomass-specific respiration without biochar amendment, indicating that surviving microbes utilised the compounds and necromass as substrates. Paranitrophenol proved to be particularly toxic without biochar application, causing marked reductions in the microbial quotient and biomass carbon. Remarkably, concurrent biochar and pNP application led to hugely increased microbial biomass carbon and nitrogen, significantly higher than those in contaminant-free replicates. It is likely this arose from biochar sorbing the contaminant and allowing its microbial utilisation as a carbon and nitrogen source, stimulating growth. Biochar application is a highly promising strategy for reducing the soil microbial toxicity of heavy metals and aromatic organic contaminants, particularly p-nitrophenol.