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Multi-substrate induced microbial respiration, nitrification potential and enzyme activities in metal-polluted, EDTA-washed soils☆

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ABSTRACT

Efficiency and the preservation of soil functions are key requirements for sustainable remediation of contaminated soil. Microbial decomposition and conversion of substrates is a fundamental soil function. Pilot-scale EDTA-based soil washing recycled chelant generated no wastewater and removed 78% of Pb from acidic farmland soil with 860 mg kg^{-1} Pb and 60% of Pb from calcareous garden soil with 1030 mg kg^{-1} Pb. Remediation had an insignificant effect on microbial respiration in acidic soil induced by sequential additions of glucose, micro-cellulose, starch and alfa-alfa sprout powder (mimicking litter components, C-cycle). In contrast, remediation of calcareous soil reduced cumulative CO_2 production after glucose (simple) and alfalfa (complex substrate) addition, by up to 40%. Remediation reduced the nitrification rate (denoting the N-cycle) in acidic soil by 30% and halved nitrification in calcareous soil. Remediation in both soils slightly or positively affected dehydrogenase and β-glucosidase activity (associated with C-cycle), and decreased urease activity (N-cycle). Generally, EDTA remediation modestly interfered with substrate utilisation in acidic soil. A more prominent effect of remediation on the functioning of calcareous soil could largely be attributed to the use of a higher EDTA dose (30 vs. 100 mmol kg^{-1}, respectively).

1. Introduction

Contamination of soils with Pb and other potentially toxic metals (PTM) is a world-wide problem (Loganathan et al., 2008; Bhattacharya et al., 2012). Soils act as integrators of decades of pollution accumulation, and Pb is one of the most pervasive and persistent risks to human health (Cai et al., 2016). Any exposure to Pb is considered to be potentially harmful to human health and even low Pb exposure can impair the brain and nervous system, especially in children (Flora et al., 2012).

Governments have made the clean-up and restoration of contaminated land a priority. However, only a fraction of PTM contaminated soil is treated today, due to the lack of efficient and environmentally safe/sustainable technologies. Although the potential of soil-washing with strong chelants, e.g., ethylenediaminetetraacetic acid (EDTA), was recognised more than two decades ago (Brown and Elliot, 1992) unresolved problems with EDTA recycling, waste water treatment, EDTA environmental persistence (Bloem et al., 2017) and emissions of residual toxic EDTA chelates from remediated soil have long prevented development of a feasible technology. We recently introduced technology that recycles EDTA and process waters, generates no liquid wastes, produces no emissions and promises to preserve remediated soil as a natural resource (Lestan et al., 2016; Lestan, 2017). Leaching of EDTA and toxic metals from remediated soils is minimized to the levels close or bellow limits of quantification by extensive soil rinsing and addition of zero-valent Fe into the soil slurry. This enables for fast and permanent adsorption of residual EDTA chelates. The process is abiotic, poor EDTA biodegradability was not an issue in curbing toxic emissions (unpublished results). The novel technology is cost efficient (Lestan, 2017), uniquely recycles EDTA mostly as Ca-EDTA salt which is less soil-aggressive than more commonly used Na-EDTA (Theodoratos et al., 2000), and does not significantly change the physical and chemical properties of the remediated soil (Lestan, 2017; Zupanc et al., 2017). The technology was recently scaled up to a demonstrational remediation plant (https://www.youtube.com/watch?v=r50LNFog-Hc&feature=youtu.be).

EDTA soil washing is efficient in removing total and bioavailable PTM from soil (Ferraro et al., 2016), preserves soil as a

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