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The potential of magnesium potassium phosphate cement for Pb immobilization in Pb-polluted sediments: Confirmation through chemical and biological indicators

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Abstract

Soils and sediments are vulnerable to anthropogenic contamination with Pb which has been considered as the potential carcinogen to humans. The Pb-polluted sediments (PPS) were collected from a river receiving untreated effluents from the Pb-acid batteries dismantling unit. We hypothesized that the addition of magnesium potassium phosphate cement (MKC) in PPS can reduce Pb bioavailability and shrink associated ecological risks. In this pot experiment, PPS was amended with six discrete doses of MKC i.e. 0, 0.5%, 1%, 1.5%, 2% and 2.5% at w/w ratio. Later, two groups of ecological indicators i.e. chemical [NH_4NO_3, $Ca(NO_3)_2$, DGT and SWE] and biological (*Lactuca sativa* and *Eisenia fetida*) were deployed to estimate the effectiveness of MKC for Pb immobilization. Results revealed that increasing rates of MKC significantly reduced Pb concentrations in the shoots and roots of *Lactuca sativa* after forty days of growth, with the highest reduction at 2 and 2.5% rates of MKC. Parallel to it, similar results were observed in terms of Pb concentrations in adults and juveniles of *Eisenia fetida* in an incubation experiment. Interestingly, the 2 and 2.5% of MKC resulted in the generation of the highest biomasses as well as antioxidant enzymes in plant parts (shoots and roots) and earthworm (adults and juveniles). Analysis of post-harvest sediments i.e. from plant experiment and earthworm incubation experiment revealed that the lowest Pb bioavailability in PPS was achieved with 2 and 2.5% doses of MKC as confirmed through chemical extractants [NH_4NO_3, $Ca(NO_3)_2$, DGT and SWE], and DGT. Moreover, the activities of soil enzymes and microbial biomass carbon (MBC) in PPS were found the highest with 2 and 2.5% MKC doses. Interestingly, Pb concentrations in chemical extracts [NH_4NO_3, $Ca(NO_3)_2$, and SWE] and DGT were strongly correlated (>0.95) with Pb concentrations in both juvenile and adult *Eisenia fetida.* The primary mechanism of Pb immobilization was Pb phosphate and struvite-K encapsulation. Thus, a 2% rate of MKC is cost-effective to restore PPS and other Pb-polluted soils to minimize the environmental risks associated with them.