研究报告

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无机-有机混合改良剂对酸性重金属复合污染土壤的修复效应

Inorganic-organic amendments for immobilization of metal contaminants in an acidic soil

关键词：石灰石 沸石 磷肥 有机肥 酸性重金属复合污染土壤 空心菜

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作 者 单位

蔡 轩 华南农业大学资源环境学院, 环境科学与工程系, 广州 510642

龙新宪 华南农业大学资源环境学院, 环境科学与工程系, 广州 510642

种云霄 华南农业大学资源环境学院, 环境科学与工程系, 广州 510642

吴启堂 华南农业大学资源环境学院, 环境科学与工程系, 广州 510642

摘要：本研究首先通过土壤培养实验,研究了在"石灰+沸石"的基础上,配施不同无机磷、不同有机物对酸性重金属复合污染土壤的改良效果,从中筛选4个最佳改良剂配方,并设置两种改良剂浓度梯度,以空心菜为供试植物进行盆栽实验.土壤培养实验显示,在施加"石灰+沸石"的基础上,配施有机肥或(和)无机磷能够进一步提高土壤pH,降低土壤重金属Cd、Pb、Cu、Zn的有效态含量;蘑菇渣和猪粪对土壤中4种重金属的固化效果优于鸡粪,钙镁磷肥的效果优于羟基磷灰石和磷矿粉.盆栽实验发现,8种处理均显著增加了土壤pH和降低了Cd、Pb、Cu、Zn的有效态含量,其中,处理H1、H2、H4(即在4 g·kg^{-1}沸石+2 g·kg^{-1}石灰石+3 g·kg^{-1}钙镁磷肥(磷矿粉)基础上,配施4 g·kg^{-1}有机物(猪粪或蘑菇渣))改良土壤后,空心菜生长健康,其地上部Cd、Pb、Cu、Zn含量均可达到食品卫生标准.比较土壤中重金属的化学形态,改良剂可能通过增加土壤pH及与重金属发生沉吸、附淀、络合等一系列反应,促进重金属由可交换态向铁锰氧化物结合态转换,从而显著降低了土壤重金属的生物有效性和减少空心菜对重金属的吸收.

Abstract: The main objective of this study was to immobilize heavy metals in contaminated soil collected from the Dabaoshan area of Shaoguan City, Guangdong Province using inorganic-organic mixed amendments. A batch of incubation experiments were firstly conducted to study the efficiency of mixed amendments (limestone + zeolite + phosphate fertilizers + organic manures) on raising soil pH and reducing the mobility of heavy metals (Cd, Pb, Cu, and Zn). On the basis of the added "limestone+ zeolite", the added phosphate fertilizers and/or organic manure could further raise soil pH and reduce the mobility of heavy metals, and the treatments with mushroom compost/pig manure and calcium-magnesium phosphate were chosen in pot experiments in greenhouse for greater efficiency. Results of pot experiments indicated that the application of all eight types of amendments significantly raised soil pH and reduced the concentrations of bioavailable Cd, Pb, Cu, and Zn in the soil. The concentrations of Cd, Pb, Cu, and Zn in the aboveground part of water spinach grown in treatments of H1(4 g·kg^{-1} zeolite+2 g·kg^{-1} limestone+3 g·kg^{-1} calcium-magnesium phosphate+4 g·kg^{-1} pig manure), H2(4 g·kg^{-1} zeolite+2 g·kg^{-1} limestone+3 g·kg^{-1} calcium-magnesium phosphate+4 g·kg^{-1} mushroom compost), and H4(4 g·kg^{-1} zeolite+2 g·kg^{-1} limestone+3 g·kg^{-1} rock phosphate+4 g·kg^{-1} mushroom compost) met the national standards for food hygiene. Application of immobilization amendments can raise soil pH and promote transformation of heavy metals from exchangeable fraction to Fe-Mn oxide-bound fraction, and thus, reduce the bioavailability of heavy metals and suppress the accumulation of heavy metals in water spinach.

Key words: limestone zeolite phosphate fertilizers organic matter acidic multiple-metals-contaminated soil water spinach