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研究报告

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利用稳定同位素^{202}Hg稀释技术判定不同来源有机肥施用对外源汞在土壤中形态分布的影响

Application of ^{202}Hg dilution technique in assessing species distribution and potential bioavailability of exogenous mercury in different organic fertilizers-applied soils

关键词：同位素示踪 汞 有机物料 形态 连续提取法

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摘要：有机肥施入土壤后,是否会对土壤重金属的活性及植物吸收造成影响是人们关心的问题.本研究应用稳定同位素^{202}Hg稀释技术,通过培养实验和改进的Tessier连续提取法,探索不同来源有机肥(秸秆、杨树叶、油枯、酒糟、猪粪、鸡粪)施用对外源汞在天津潮土中形态分布及有效性的影响.结果表明,在连续提取法中结合同位素^{202}Hg稀释技术,通过同位素比值R_{Hg}(^{202}Hg/^{200}Hg)的变化对Hg进行形态分析,相比传统的对Hg形态直接进行含量测定,可以更精确直观地反映出Hg形态分布的变化.在潮土中加入外源^{202}Hg和有机肥后,同位素比值R_{Hg}最为显著的变化集中在交换态(含水溶态)、胡敏酸结合态、富里酸结合态及有机质结合态,且不同来源有机肥对Hg形态的影响也主要集中在这部分形态,对碳酸盐结合态、铁锰氧化物结合态和残渣态的影响较小.与未加入有机肥的对照处理相比,猪粪及鸡粪的施用使外源示踪^{202}Hg显著向活性较强的交换态(含水溶态)、富里酸结合态转移,而在胡敏酸结合态中比例降低,下降幅度约为55%(猪粪)和58%(鸡粪).油枯及酒糟的施用,使外源示踪^{202}Hg显著向活性较低的胡敏酸结合态转移,其同位素比值R_{Hg}分别增长了约90%(酒糟)和85%(油枯),而在活性较高的交换态(含水溶态)和富里酸结合态中分布比例降低.秸秆和杨树叶对于污染土壤Hg形态分布的影响并不显著.研究结果表明,不同来源的有机肥对Hg污染潮土中Hg的形态分布有显著影响,因此,在Hg污染农田土壤上施用有机肥料需要格外谨慎.

Abstract: There are concerns that organic materials used in agricultural soils may affect the distrilation and bioavailbility of heavy metals in soils. In this study, effect of organic materials from different sources (rice straw, polar leaf, oil cake, distillers' grains, pig manure and chicken manure) on the species distribution of exogenous Hg (Ⅱ) in contaminated vegetable-growing soils has been investigated by a modified Tessier scheme of sequential extraction procedures (SEPs). The SEPs were detected with a quantitative analytical method and an isotopic ^{202}Hg labeling method, respectively. The results showed that the summed value of Hg concentrations in all eight species extracted with the SEPs protocol was lower than the total Hg concentrations directly measured in soil, and the isotopic labeling technique coupled with the modified Tessier scheme provides a novel method which can distinctly indicate the distribution, mobility and potential bioavailability of exogenous Hg in contaminated soil. It was found that after amendments of exogenous ^{202}Hg and different types of organic materials, isotope ratio of R_{Hg} (^{202}Hg/^{200}Hg) significantly varied in exchangeable (including water-soluble), fulvic acid, humic acid and organic fractions, while it barely changed in the fractions of carbonate, Fe/Mn oxides, and residual species. By comparison with the control without organic materials amendment, pig manure and chicken manure application resulted in more movement of exogenous ^{202}Hg towards unstable fractions, including water soluble, exchangeable, and fulvic acid fractions. R_{Hg} of humic fractions decreased by 55% (pig manure) and 58% (chicken manure), respectively. Distillers' grains and oil cake applications favored decreases of water soluble, exchangeable and fulvic acid fractions. R_{Hg} of humic fractions increased by 90% (distillers' grains) and 85% (oil cake), respectively. Rice straw and polar leaf application did not significantly influence the distribution of exogenous Hg speciation in soils. The results suggested that organic materials application with different types could change the speciation of Hg-polluted soils, and thus influenced the potential bioavailability of Hg in soil. This demonstrates that regular monitoring of

metal speciation dynamics as well as appropriate management are needed to keep the safe application of organic materials for agriculture.

Key words: isotopic tracer mercury chemical speciation organic materials sequential extraction procedures