

## 畜禽有机肥对典型蔬果地土壤剖面重金属与抗生素分布的影响

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## Effects of Livestock Manure on Distribution of Heavy Metals and Antibiotics in Soil Profiles of Typical Vegetable Fields and Orchards

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**摘要** 采集不同类型的畜禽有机肥及施用后的土壤,测定其重金属浓度,同时利用超声波提取-SPE-LC/MS/MS方法分析土壤中14种抗生素的污染特征,研究长期施用畜禽有机肥对典型蔬果地土壤剖面重金属与抗生素分布的影响。结果表明,猪粪、羊粪、鸡粪3种畜禽有机肥中最易造成土壤污染的是猪粪,Cu、Zn和Cd含量分别为197.0、947.0和1.35 mg·kg<sup>-1</sup>。不同土地利用方式下,施用有机肥均使重金属在土壤剖面呈现表聚现象,以设施菜地最为突出,Zn和Cd积累明显,0~20cm土层含量分别为203和0.48 mg·kg<sup>-1</sup>。不同土地利用方式下,14种抗生素的含量与组成在土壤剖面上存在明显分异,随土层深度增加含量迅速下降,但在>80~100cm土层仍有检出;设施菜地表层土壤抗生素含量为39.8 μg·kg<sup>-1</sup>,积累和残留明显高于林地和果园,特别是四环素类和氟喹诺酮类,含量分别为34.3和4.75 μg·kg<sup>-1</sup>。可见,农田土壤长期大量施用畜禽有机肥可引起重金属和抗生素的复合污染,具潜在生态风险。

**关键词:** 畜禽有机肥 蔬果地 土壤剖面 重金属 抗生素

**Abstract:** Samples of different kinds of animal and poultry manures and of soils from typical vegetable fields and orchards of Hangzhou area that had been applied with these manures, were collected separately for analysis of concentrations of heavy metals and pollution of 14 selected antibiotics to study the effects of long-term application of the manures on distribution of heavy metals and antibiotics in soil profiles of these fields. Results show that of the three kinds of livestock and poultry manures, pig manure was the most liable to soil pollution, for it contained 197.0 mg·kg<sup>-1</sup> of Cu, 947.0 mg·kg<sup>-1</sup> of Zn and 1.35 mg·kg<sup>-1</sup> of Cd. Among the lands under different patterns of land use, greenhouse vegetable lands were the most prominent in having heavy metals accumulated in the surface soil, especially Zn and Cd, being 203 and 0.48 mg·kg<sup>-1</sup>, respectively, in the 0-20cm soil layer. The 14 selected antibiotics, including tetracycline (TC), oxytetracycline (OTC), chlortetracycline (CTC), doxycycline (DXC), sulfadiazine (SD), sulfamethoxazole (SMZ), sulfamethazine (SMX), norfloxacin (NFC), ofloxacin (OFC), erythromycin-H<sub>2</sub>O (ETM-H<sub>2</sub>O), roxithromycin (RTM), chloramphenicol (CPC), thiamphenicol (TPC) and florfenicol (FFC), varied significantly in concentration and distribution in soil profiles with land use pattern. They decreased rapidly in concentration with soil depth, but some of them were still detectable in the 80-100 cm soil layer. Compared to orchards, the vegetable lands had more antibiotics accumulated in the surface soil layer as residue, which was 39.5 μg·kg<sup>-1</sup> in concentration and composed mainly of TCs and fluoroquinolones antibiotics, reaching 34.3 and 4.75 μg·kg<sup>-1</sup>, respectively. Obviously, long-term application of livestock manure in farmland might result in the combined pollution of heavy metals and antibiotics, and is apparently a potential ecological risk.

**Keywords:** livestock and poultry manure vegetable garden orchard soil profile heavy metals antibiotics

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