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Absorption of crops grown in loess improved by sludge for heavy metals Ni and Cd in the seedling stage

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Abstract

Sludge land application is now one of the most promising approaches for disposing urban sewage sludge at home and abroad. Particularly in the northwest loess areas, sludge that abounds in organic matters and nutrients including N and P is applicable to improve the barren loess with loose structure. Meanwhile, sludge with heavy metals is another research subject of concern. This study selected corn and wheat (two main crops in northwest of China) as test crops, and the loess added with different dry weights of composted sludge as experimental soil. The crops were planted in pots to compare the influences of different dry weights of composted sludge on the seedling growth of the crops (corn and wheat) and the absorption of heavy metals (Ni and Cd). The result indicated that composted sludge with dry weights ranging from 1% to 10% can promote the seedling growth of corn and wheat and 1% was optimal for the growth with increases about 14% and 3% for corn and wheat respectively. While more than 10% of dry weight can inhibit the growth and the inhibition effect kept pace with the dry weight of composted sludge. At the end of the experiment, majority of the Ni and Cd were still accumulated in the matrix and the absorption coefficients of Ni and Cd in crops were about 0.02-0.17 and 0.02-0.12 respectively. Comparing with the control experiment, sludge land application can improve the performance of the loess and provide Ni and Cd for corn and wheat. When 5% and 10% of composted sludge was added, the content of Ni and Cd contained in the experimental soil met the secondary standard (pH>7.5, Ni≤60 mg/kg and Cd ≤0.6mg/kg) set by the *Environmental Quality Standard for Soils* (GB15618-1995). Therefore, to apply sludge in land use, the annual addition amount of sludge needs to satisfy both the *Disposal of Sludge from Municipal Wastewater Treatment Plant-Control Standards for Agricultural Use* and the *Environmental Quality Standard for Soils*.

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Keywords: composted sludge; heavy metal; loess;crop;absorption

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1 Introduction

China as a country with widest and thickest loess in the world, 6.6% of its total land area is covered by loess, which accounts for 4.9% of the global loess area. Malan loess is the typical eolian loess and main parent material with loose structure in the Loess Plateau region, and its main component is silty soil. Meanwhile, a large amount of soluble salt is contained with the content of organic matters usually varying in the range of 0.7-1.5%. Therefore, the nutrient deficiency makes it hard to meet the demands of plant growth.

In recent years, China has seen fastest urbanization at largest scale in the world. As the urbanization level and the amount of sludge treatment increase annually, sludge yield per year in China is expected to reach more than 30 million tons soon[1]. Therefore, it has been the solid waste which is most difficult to be disposed following municipal solid waste[2]. At present, land use is regarded as one of the most promising methods among various ways of disposing sludge[3, 4]. Many countries have utilized sludge as an organic fertilizer resource in field planting. Especially in the loess areas with barren soil, the organic matters abundant in sludge can improve and remedy drawbacks such as insufficient water stable aggregate structures, and poor water and fertilizer holding capacity caused by the loose structure of silty particles. The returning application of sludge organic matters not only solves the problem of sludge disposal, but also develops organic resources and improves the soil fertilizer, which further increases the plant yield [5-7]. Therefore, the sludge land application is endowed with more prospects and significance in Loess Plateau region of China. However, because of the deleterious materials contained in sewage sludge such as heavy metals, the long term and large scale application is expected to give rise to the accumulation and migration of heavy metals in soil[8]. Therefore, the heavy metals in sewage sludge have been paid much attention in land use of sewage sludge and restrict the development of sewage sludge land application to a large extent.

Few researches have been performed on the accumulation and migration of heavy metals of sewage sludge in soil. Huang Gang *et al.*[9], Mbila *et al.*[10], Baveye *et al.*[11], Bergkvist *et al.*[12] and Toribio *et al.*[13] conducted their researches respectively on the desert soil in north of Shaanxi, China, sandy soil in Nigeria, silt loam soil in the United States, cultivated clay in Sweden and forest soil in Mediterranean. Their researches demonstrated that heavy metals contained in sewage sludge accumulate and move in soil to some extent. Plant absorption is one of the important ways for heavy metals entering into food chain. And the evaluation on the total amount of heavy metals entered into plant is of crucial importance for risk assessment and environmental management. Owing to heavy metals are likely to accumulate in soil and plants, plant absorption brings potential hazard to animals, plants and the environment[14, 15]. The commonly seen heavy metals in sewage sewage sludge include As, Cd, Cr, Cu, Hg, Ni, Pb and Zn. As demonstrated in relevant studies[16, 17], although contents of Ni and Cd are low in sewage sludge, their carcinogenicity, toxicity and activity are expected to severely jeopardize the surrounding environment. Therefore, the accumulation and migration of heavy metals including Ni and Cd have attracted wide attentions.

This experiment belonged one of the series studies of composted sludge application in Loess Plateau areas. Corn and wheat, as two main food crops in Northwest loess area of China, are widely planted with strong adaptability. The Malan loess in Lanzhou, China with different added dry weights of composted sludge was applied as experimental soil in the experiment. Meanwhile, the pot culture cultivation was adopted to compare the influence of composted sludge in different dry weights on the seedling growth of corn, wheat and the absorption of heavy metals Ni and Cd. The experiment can provide evidence for formulating technical index system for risk assessment and scientific management in composted sludge applied loess areas, as well as the determination of a reasonable application amount of composted sludge.

2 Materials and Methods

2.1 Test materials

The experimental loess was taken from the hillside of Cuiying Mountain in Yuzhong Campus of Lanzhou University, where the surface layer of 0-40 cm is the Malan loess (Q_3^{2eol}). Its main texture is the silt with the size of 0.075-0.005 mm and proportion for 80%. After the loess samples were selected, the samples were naturally dried, filtered through a sieve with hole size of 10 mm, and sacked for experimental use. The dewatered sludge taken from