Determination of sewage sludge soil treatments' effect on Cu bioaccumulation by earthworms and Cu contents of cast and surrounding soil

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Introduction

Sewage sludge (SS) is increasingly used as an organic amendment to soil, especially to soil containing little organic matter. Interest in the disposal of SS, which contain a range of valuable nutrients (N, P, Fe, Ca, Mg) and various other macro and micro-nutrients essential for plant growth, on agricultural land has increased during the last decade (Kızılkaya and Hepşen, 2004). Sewage sludges are a by-product of sewage treatment and contain not only nutrients and organic matter, but also toxic components such as metals discharged into the sewers. Earthworms, an important group of soil organisms in term of biomass, as food for many animals and in maintaining soil structure and fertility, are known to accumulate heavy metals when exposed to contaminated soil. Recent experiments which investigate the role of earthworms in contaminated soils have shown that tissue heavy metal concentration in earthworms is higher than the soil metal concentration. The experiment in the present study was conducted in the laboratory; simulating field conditions of organic matter management with successive doses of SS added soil. Our objectives were (i) to determine the Cu uptake by earthworm *L.terrestris* in successive doses of SS added soil, (ii) to determine DTPA extractable Cu content of wormcast and surrounding soil at SS added soil.

Materials and Methods

Surface soil (0-20 cm) was taken from the agricultural land in Merzifon, Turkey. The soil contained 14.09 % clay, 10.02% silt, and 75.89% sand. Soil texture can accordingly be classified as sandy (S). The pH in water was 8.1, the organic matter content was 3.29%, the soil C:N ratio was 28, and DTPA-extractable Cu content 0.220 μg g-1. Lumbricus terrestris L., an anecic earthworm species, were collected from the same spot as the soil was. Anaerobically digested SS (pH 7.2, N 2.3%, C/N 9.22, Cu 286 μg.g-1) was obtained from the wastewater facility set up by the Ankara Wastewater Treatment Plants, Ankara, Turkey. The sewage sludge was composed of approximately 37% by weight of organic matter.

Experimantal procedure: Soil samples were air-dried in a laboratory and sieved through 2 mm screens. Then the samples (500 g air-dried soil) were placed in 1 L cylindrical plastic containers. The subsequently doses (0, 2, 4, 6, 8 and 10%) of SS were thoroughly mixed with the soil on air-dried weight basis. Then, four individuals of L.terrestris each weighing between 7.0 and 7.5 g were placed in the SS treated soil. All plots was incubated for 15 days in laboratory conditions in the dark at 200C and the moisture content in pots was maintained around 60% of maximum water holding capacity by weighing the pots during incubation everyday. The soil moisture was kept at the same level by adding distilled water at regular intervals throughout the incubation period. There were three replicates per treatment. At the end of the incubation period, samples were collected by hand from wormcast deposited on the soil surface and from bulk soil. These samples were used to determine Cu contents of soils at the moisture condition.

Cu determination: Available metals in surrounding soils were determined by extraction with DTPA solution and analyzed by atomic absorption spectrophotometer (AAS). The total Cu contents of the earthworm cast were determined after digestion with aqua regia solution using AAS. Earthworms were oven-dried in glass flask at 1050C. The dried earthworms were analyzed by wet digestion method according to Scaps et al. (1997). All data were analyzed using SPSS 11.0 statistical software. Analysis of variance was performed to compare the means of successive doses of SS added soil; where significant F-values were obtained, differences between individual means were tested using the LSD test.

Results and Discussion

The effects of SS application doses to the contents of Cu in the earthworm *L. terrestris* tissue, wormcast and surrounding soil are illustrated in Fig. 1. This figure shows that total Cu contents in wormcasts were significantly greater in all doses of SS treatments compared to the control soil (non SS treatment soil). The increase in wormcast Cu was due to 10% SS application to soil compared to control soil. Similarly, levels of DTPA-extractable Cu in surrounding soil were increased by the addition of successive increases in the doses of SS as compared to the control at $P<0.001$. Similarly, Marinussen et al. (1997) and Kenette et al. (2002) also found higher total and extractable metal contents in wormcasts and surounding soils.

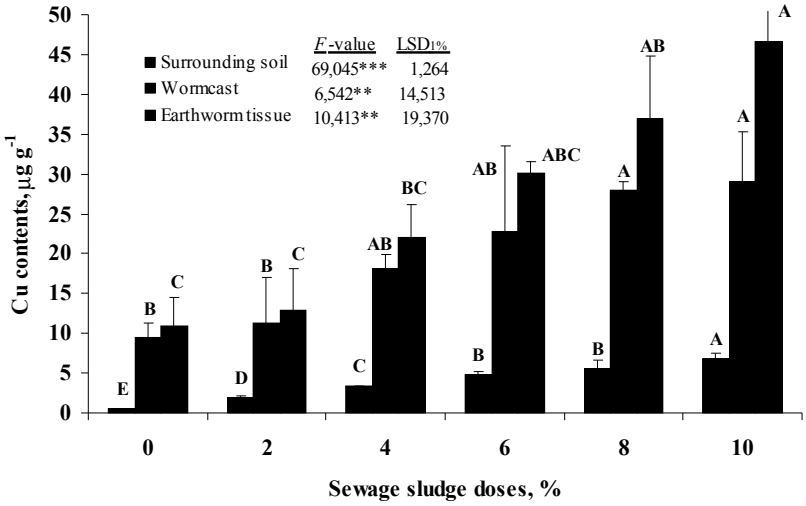

Fig.1. Changes in Cu contents in earthworm *L.terrestris* tissue, wormcast and surrounding soil at the end of the incubation period (15 days in the dark at 20 ± 0.5^0C).

Either control soil or SS treatment soils earthworms do accumulate Cu. For earthworms to the control soils, consistent trends of uptake were found for copper examined in this study. In addition, in the worms exposed to all doses of SS treatment soils, the Cu accumulated. Earthworms are known to accumulate metals when exposed to contaminated soil (Marinussen et al., 1997). The uptake of copper by earthworms, demonstrated both in the field and in the laboratory (Marinussen et al., 1997; Kennette et al., 2002), makes these invertebrates' excellent accumulation bioindicators. In conclusions, those laboratories experiments can be in good agreement with accumulation of earthworms at sewage sludge amended soils. Bioaccumulation of Cu may be related to contents of these metals in soil and SS application doses.

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