Sewage sludge and sewage sludge char soil application: response of earthworm *Eisenia fetida*

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Introduction

Sewage sludge (SS) production in the world is increasing and its management is a growing problem worldwide. Sludge disposal in landfills is strictly prohibited for environmental reasons, such as eutrophication of toxic substances leached into groundwater, and so on. Land application of sewage sludge in agriculture or short rotation energy forestry plantations is a preferred sewage sludge reuse route in EU. As sewage sludge is rich in essential plant nutrients (N, P), it can be applied as fertilizer to soils in order to improve and maintain productivity of soils. However, the use of sewage sludge may pose environmental risk as it has an extensive range of heavy metals and persistent organic pollutants that may accumulate in the soil, be transferred from soil to soil dwelling organisms and be incorporated into the food chain.

The aim of this study was to examine how earthworms *Eisenia fetida* will respond to sewage sludge and sewage sludge pyrolysis char application to soil.

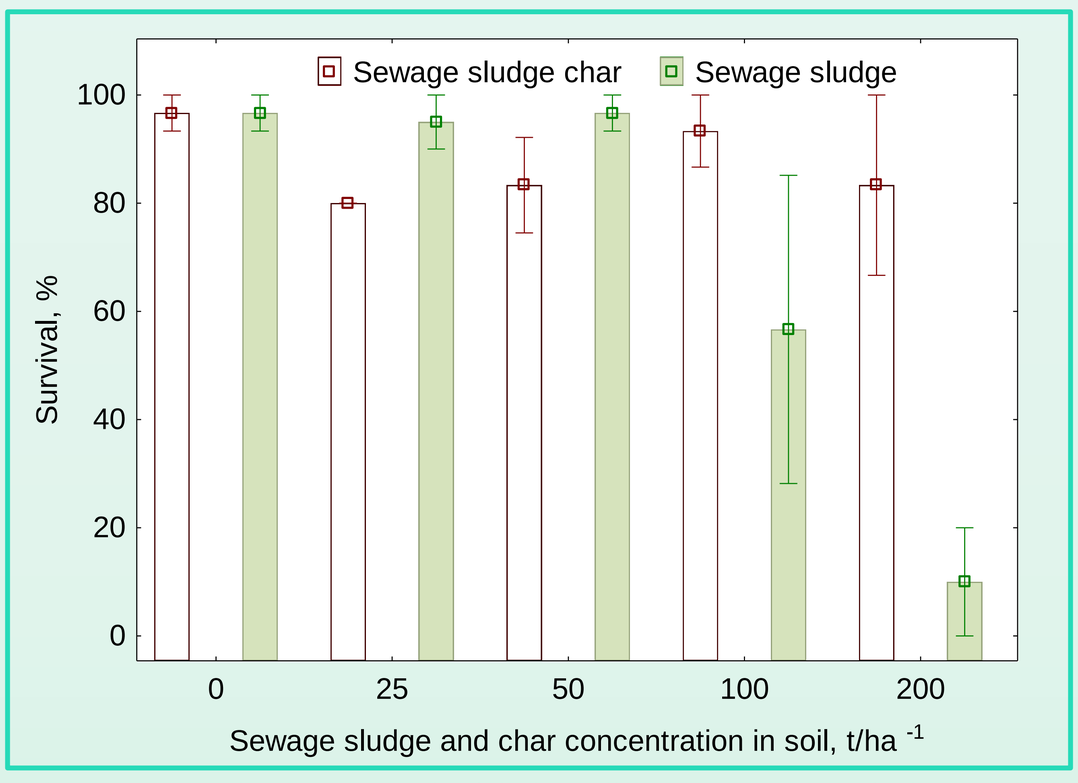

Figure 1: Earthworms survival (%) at different sewage sludge and sewage sludge pyrolysis char application in soil.

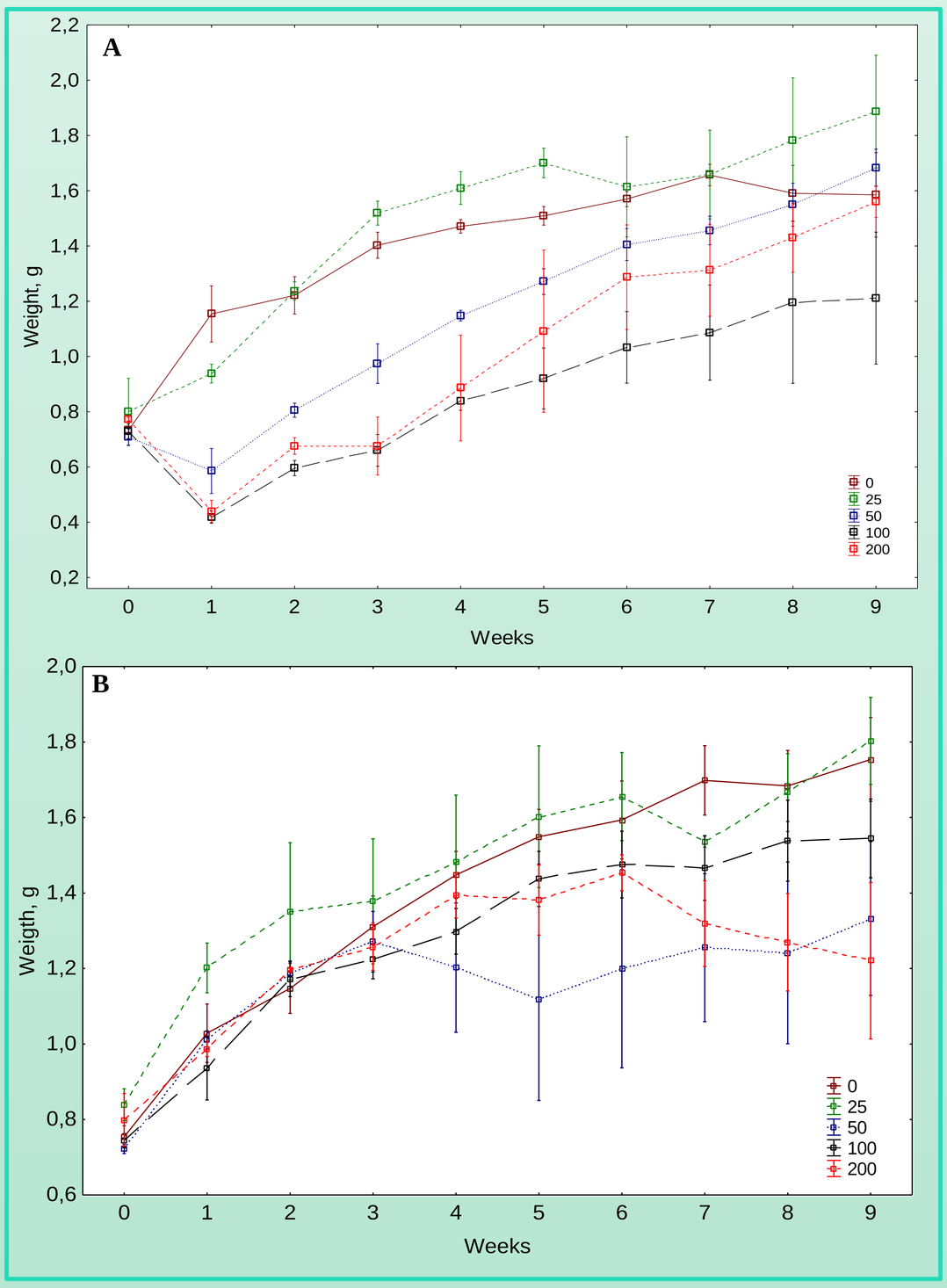

Figure 2: Earthworms weigth (g) at different sewage sludge (A) and sewage sludge pyrolysis char (B) application in soil.

Methods

Adult *Eisenia fetida* were exposed to 25-200 t/ha of SS and its pyrolysis char in soil for 9 weeks. The preparation of SS and its char was performed at the Lithuanian Energy Institute. Prior to combustion, an inert atmosphere was created using nitrogen gas in the reactor to prevent the formation of gas during pyrolysis and the temperature of the sample surface. It was maintained at 850°C for 90 minutes and at atmospheric pressure. 500 g of prepared soil mixture was added for each container and the required amount of distilled water (WHC 50%). 10 adult earthworms were placed into each container. Earthworms growth was evaluated every week and survival was recorded at the end of the experiment.

Figure 1: Earthworms *Eisenia fetida*.

Figure 2: Earthworms cultivation containers.

Results & Discussion

SS and its biochar did not cause sudden acute mortality of the earthworm *Eisenia fetida* at concentrations below 200 t/ha, but at 200 t/ha SS concentration after 1 week 50-40 % survival was recorded. SS concentration had a significant effect on earthworm survival ($F=4.97$; $p<0.05$). There was no significant effect of SS biochar concentration on survival ($F=0.52$; $p>0.05$). After 9 weeks the lowest survival percentage (~10 %) was recorded at the highest concentration - 200 t/ha (Figure 1).

The biggest concentration of SS in individuals elicited an avoidance behavioral response - earthworms avoided infiltration into the soil (were found on the soil surface). After 4 weeks, there was visible high pressure of coelomocytic fluid, tissue damage due to chronic exposure to sewage sludge.

The chronic effects of sewage sludge char was observed and the lowest survival percentage after 9 weeks, same as in the case of SS application, was recorded at a highest concentration of 200t/ha (83%).

SS concentration had a significant effect on earthworm growth ($F = 3.88$-67.02; $p <0.05$) over a period of 1-7 weeks. Sewage sludge pyrolysis char had lower effect on growth than SS and statistically significant only at the 9th and 7th study weeks ($F=2.87$-12.71; $p<0.05$). At the end of the exposition the maximum weight of the earthworm in both variants was recorded at 25 t/ha.

Low concentrations of SS in the soil increased the weight gain of earthworms. Because small amounts of sludge are a very good source of nutrients that support their growth, but high concentrations had a negative effect due to the presence of heavy metals and other hazardous contaminants in it.

Conclusions

Soil fertilization with sewage sludge and char at concentration of 25 t/ha will not have a negative impact on the compost earthworm (*Eisenia Fetida*), but higher concentrations adversely affect earthworms growth and survival.

The toxic effects of sewage sludge were higher than that of biochar. So SS or it‘s pyrolysis char usage for soil fertilifer can be successfully used as a one of disposal options.