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Effects of Earthworms on Remediation of Sewage Sludge Containing Heavy Metals

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BACKGROUND/OBJECTIVES

Generation of sewage is increasing due to rapid urbanization. Municipalities all over the world are concerned with safe and feasible methods of its disposal. Current methods for disposal include landfilling, incineration, dumping in the sea and field application for agricultural use. Incineration and landfilling are unpopular because of the high cost and environmental hazards involved. The main problems of excessive application of sewage sludge are plant toxicity due to accumulation of heavy metals in soils but also the increase in its salt content. Sewage sludge remediation is an important process for plants, animal and human health with earthworm remediation.

APPROACH/ACTIVITIES

For this purpose, worms have been added into several levels of heavy metal contented wastes. Five different wastes were selected, each having different properties and heavy metal content. Samples were taken weekly and the heavy metal contents were tested. At the end of 3-month incubation period, the trial was finalized and the heavy metal content in sewage sludge was determined. In addition to worm addition, several effective enzyme combinations such as protease, lipase, amylase, dehydrogenase, urease were added. This addition of enzymes was to decrease the 3-month incubation period to 1 month.

RESULTS/LESSONS LEARNED

As a result of the study, application of different levels of worms decreased the available heavy metal content to an important level and the eligibility of macro and micro nutrients were increased. The effect of worms on remediation of heavy metal content was determined. The addition of the enzyme combination fastened the incubation period for remediation of heavy metals and the duration decreased from 3 month to 1 month.

MATERIALS AND METHODS

Sewage sludge preparation: Five different sewage sludge materials with a mean moisture content of 60-70% were placed in a plastic box with the dimensions of 70 x 50 x 60 cm. Holes were drilled in the bottom of the box so the sludge liquid would drain and in the top to ensure adequate aeration and oxygen content. The inside of agro textile container was lined.

Acclimatization and insertion of sewage sludge: Californian earthworms were inserted in the container with sewage sludge. This earthworm species was chosen for easy insertion into the environment, the efficient and rapid organic waste recycling, and reduced sensitivity to environmental fluctuations. Before inserting the earthworms into the sewage sludge, acclimatization was conducted (Shamyaa, 2010). The process was conducted in a 42×30×22 cm dimension box divided into two sections. The first section was the living environment of earthworms. It consisted of compost made up of cow dung, straw, and organic waste residues. The second section contained the sewage sludge with heavy metals solution mix. The box was covered with a lid to prevent exposure to direct sunlight. When earthworms from the original environment (first section) began to migrate to the second section, they were inserted into sewage sludge with heavy metals. Then the box was covered with a lid and stored in a cool and dark place.

The determination of heavy metals concentrations in sewage sludge: Samples of sewage sludge for determination of heavy metals concentrations were taken every 10 days. Then they were burned (samples were burned about 3 hours at 450°C temperature). The burned samples were mineralized – 0.5 g of burned sewage sludge was poured with 12 ml of concentrated nitric acid (HNO_3) and 2 ml of hydrogen peroxide (H_2S_2). Then the sample was mineralized in a mineralizator for about an hour at 200°C temperature. After mineralization the sample was cooled to 70–50°C and filtered through a glass filter into a 50 ml flask and the solution was diluted with distilled water. Then heavy metals concentrations were measured by atomic absorption spectrometer.

RESULTS

The content of heavy metals in five-sewage sludge compared with the limit values for sludge used for agricultural purposes.

TABLE 1. Description of the influence of selected properties of sewage sludge on the heavy metals content.

Metal, [mg kg^{-1}]	1. Sewage sludge	2. Sewage sludge	3. Sewage sludge	4. Sewage sludge	5. Sewage sludge
Cd	5.44	6.77	10.11	4.54	7.11
Pb	133.44	178.67	244.35	145.44	211.22
Cu	445.45	245.55	544.34	344.32	390.88
Zn	1212.56	876.56	1546.44	1011.22	997.66
Cr	35.45	30.12	39.11	32.65	34.25
Ni	27.68	20.55	30.22	24.35	31.44

TABLE 2. Description of the influence of selected properties of sewage sludge on the heavy metals content after adding of earthworm.

Metal, [mg kg^{-1}]	1. Sewage sludge	2. Sewage sludge	3. Sewage sludge	4. Sewage sludge	5. Sewage sludge
Cd	2.45	4.44	6.77	2.34	4.57
Pb	98.78	133.23	177.65	102.33	144.56
Cu	377.68	122.34	342.33	255.43	278.9
Zn	1012.34	564.33	1123.22	768.79	772.32
Cr	28.79	19.8	31.24	22.32	27.68
Ni	21.33	14.35	20.12	17.68	25.61

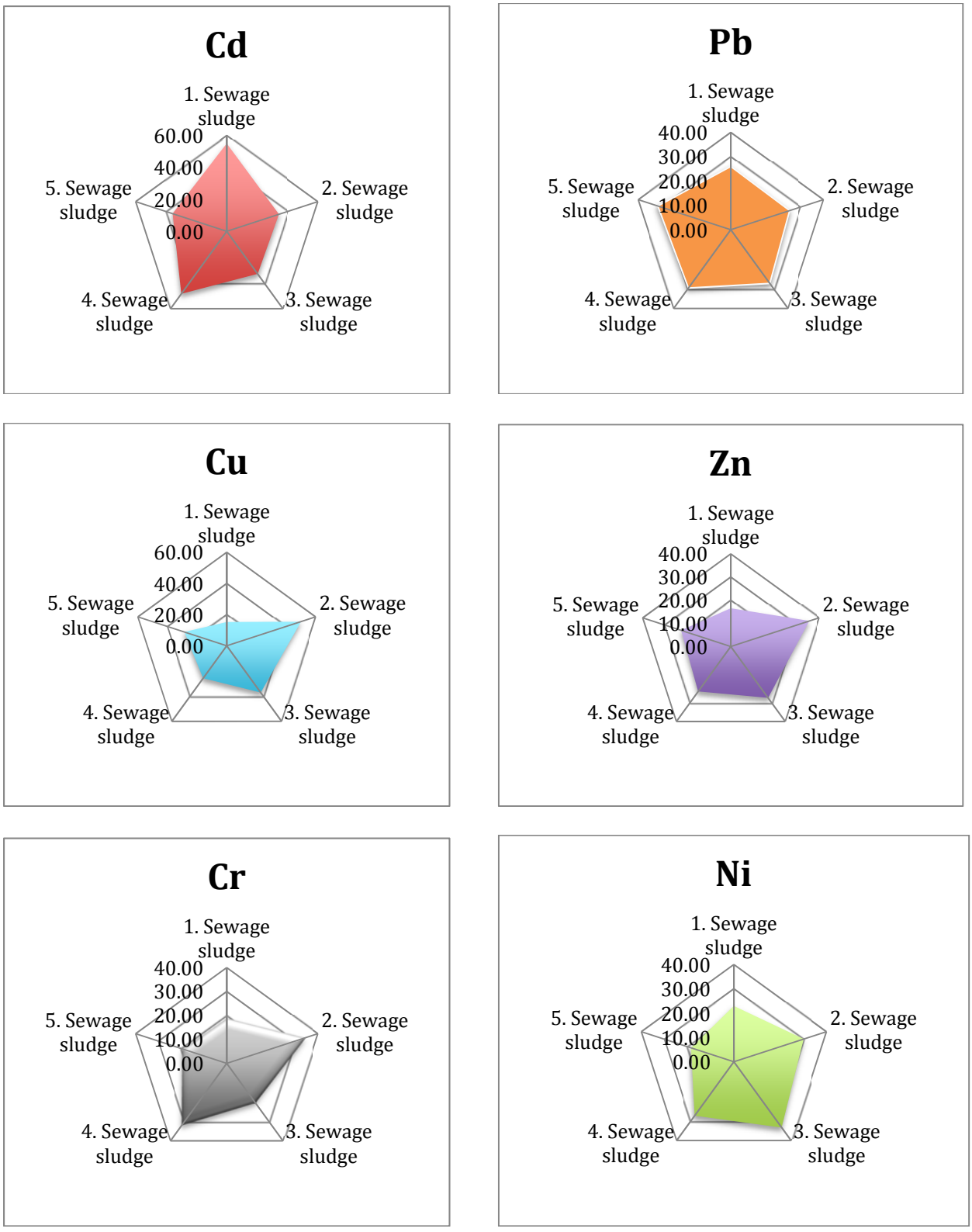

FIGURE 1. Effects of earthworm on rate of decrease sewage sludge heavy metal contents to no applications earthworm.

CONCLUSION

The objective of the study was to evaluate the heavy metals disposal of sewage sludge and bioaccumulation of these substances in Californian earthworms. Having analyzed the results of other studies, it can be stated that the experimental results confirm the efficiency of Californian earthworms when removing heavy metals from sewage sludge. Studies have shown that when vermicomposting sewage sludge, a large amount of heavy metals bioaccumulate in earthworm body tissues, while some heavy metals concentrations in sewage sludge decrease.

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