CHARACTERIZATION OF SOIL AMENDED WITH SEWAGE SLUDGE AND GROWTH OF RYE PLANT

Hosam Bayoumi Hamuda

Environmental Engineering Institute, Óbuda University, H-1034 Budapest Doberdo Út 6, Hungary
e-mail: bayoumi.hosam@rkk.uni-obuda.hu

Abstract
There is an increasing issue in the agricultural application of sewage sludge obtained from wastewater treatment plants, due to the possibility of recycling valuable components; organic matter, and plant nutrients. The objectives of the pot experiment were to determine the effects of sewage sludge treatment on rye plant growth and the physicochemical soil properties of rye rhizosphere for 9 weeks. Kovárvány brown forest soil from Nyíregyháza was used and treated with various rates of sewage sludge (Control soil (0), 20, 40, 60, 100 (sludge) %). Different soil parameters were studied such as pH, soil moisture, fluorescein diacetate (FDA) activity, carbon dioxide release and rye plant growth. The results indicated that after the application of sewage sludge, the soil retained its moisture content for a longer period than the control. Also, soil pH was maintained to be favourable for plant growth. In addition to exhibiting healthy growth and development, the plants also produced the greatest dry matter mass on soils with the largest proportion of sewage sludge (60–100%). The enzymatic activities in the soil samples treated with sewage sludge were increased in soil with higher sludge doses. Finally, soil treatment with sewage sludge stimulated rye plant growth, improved the biochemical and microbial properties of the rye plant rhizosphere, promoted the retention of soil moisture and raised the soil pH, which also had a favourable effect on rye plant growth.

Introduction
Demographic growth and western economic model seriously menace these vital resources: soil scarcity, soil losses through erosion, natural disasters and contamination; water scarcity and contamination; and limitation and exhaustion of mineral resources and fossil energies. One of the most pressing environmental and environmental problems of our day is the increasing volume of waste, including waste water treatment, sewage sludge treatment, utilization and disposal. Sewage sludge is used as possible way of organic fertilization and also of the utmost importance because it is not only nutrient input into the soil, but it also improves soil structure and induces useful microbiological processes. Nowadays, it is vital to ensure that all kinds of organic matter can be preserved. Sewage sludge is, on the one hand, environmentally polluting and, on the other hand, is suitable for organic farming as fertilizer.

From an environmental and soil protection point of view, it is important that the sewage sludge used does not restrict the production of safe food raw materials. Biodegradation of organic matter in soil is basically the result of microbial and biochemical processes, therefore all factors that have an effect on the structure, function and enzymatic activity of microorganisms affect the rate of degradation.

In the case of agricultural utilization it contributes to increasing the content of organic matter of the soil and has a favourable effect on the physical and chemical properties of the soils. Sewage sludge increases the water absorbing ability of soils, promote aggregation of the medium on sandy soils and increase the cation exchange ability. During the present work, we investigated the effects of sewage sludge on the some soil properties such as soil pH, moisture content, CO_2-release, FDA activity and the rye plant growth at different levels of sewage sludge treated in two soil types.

Experimental

The origin of soil samples was Kovárvány brown forest soil (KBET) collected from the Center for Agricultural and Technical Sciences at the Nyíregyháza Research Institute of the University of Debrecen. Soil samples were collected from the upper layer of 0-25 cm. Some chemical properties of communal sewage sludge from the municipal wastewater treatment plants (Nyíregyháza) and soil samples are presented in Table 1.

Table 1
Properties of the soils and sludge used in the model experiment

Parameters	Soil type: KBET	Wastewater sludge: NySzv
$pH_{(KCl)}$	5.78	6.71
a) Dry matter content, %	na	53
b) Organic matter, %	na	21.7
c) Humus content, %	2.54	na
d) Total-N, $mg \cdot kg^{-1}$	na	7470
NO_3-N, $mg \cdot kg^{-1}$	23	na
NH_4-N, $mg \cdot kg^{-1}$	5.6	na
Mg, $mg \cdot kg^{-1}$	214	2507
Na, $mg \cdot kg^{-1}$	64	994
P_2O_5, $mg \cdot kg^{-1}$	318	28720
K_2O, $mg \cdot kg^{-1}$	412	3171
Zn, $mg \cdot kg^{-1}$	1.7	537
Cu, $mg \cdot kg^{-1}$	1.4	110.4
Mn, $mg \cdot kg^{-1}$	55	421
Fe, $mg \cdot kg^{-1}$	945	11308
Cd, $mg \cdot kg^{-1}$	1.7	2.3
Pb, $mg \cdot kg^{-1}$	1.3	66.9

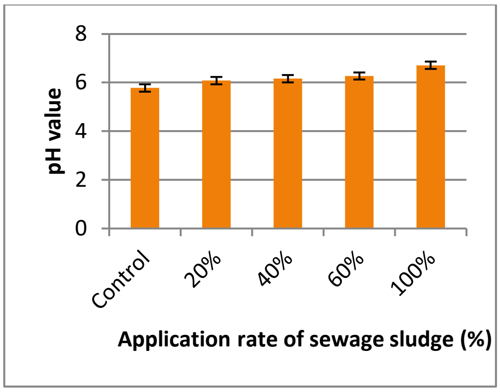
na: no data available

The air dry soil was thoroughly mixed with sewage sludge so that the final mixture contained sewage sludge in the soil sample was as following percentages: 0% (sewage-free control soil), 20, 40, 60 and 100% (sewage sludge only, without soil). Rye (*Secale cereale* L.) seeds were sterilized and planted in plastic containers of 3 kg of tested soil as prepared above. After ten days of germination, young plants were reduced for 10 plant densities/pot.

Soils pH was measured by Pérez De Mora et al. [1] at various sewage sludge doses. The pH of the untreated and treated soil was tested in a 1: 2.5 (soil: 1 mole KCl) g ml^{-1} ratio after shaking for 60 minutes. The moisture content (%) of the treated and untreated soil samples was modified by the method of Brzezinska et al. [2] (measured at 48 hours at 28°C, incubation). The relative dry weight of the rye plants samples was determined after 9 weeks of cultivation at 75°C, drying cabinet, to constant weight. For the measurement of CO_2 emissions, 0.5 kg of sewage sludge treated soil was poured into 2 l glass containers and in the middle of the soil were placed a plastic tube containing 50 mL of 1.0 mol of NaOH solution to bind the developing CO_2, then the containers are tightly closed. The NaOH solution was titrated with 1 mol of HCl solution and calculated the volume of CO_2 released during the soil respiration [3, 4]. Enzyme Activity: Measurement of FDA activity was performed by the method developed by Zelles et al. [5], modified by Schnürer and Rosswall [6]. Fluorescein concentration (µg hydrolyzing fluorescein/g^{-1} dry soil/h^{-1}), in all samples was determined using spectrophotometer at 490 nm. The experimental work was done in triplicates.

Results and discussion

The results in Figure (1) showed that application of sewage sludge increased the pH values as well as the soil moisture content (%). These increases reach the significant level high doses in comparison with control values, although, it was found that the high applied dose extend the moisture time in sewage treated samples and the moisture content remained for longer than in the controls.



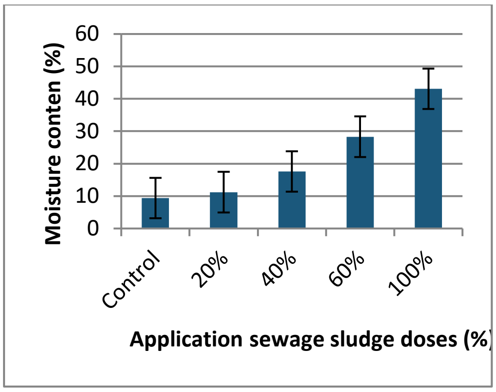


Figure 1. Effect of sewage sludge application on pH and moisture content in soil samples

The addition of sludge to soil significantly increased rye plant dry matter content (Figure 2) for each soil sample. Growth and development of plants were faster and healthier. The total biomass mass of the plants increased proportionally with the increase in the amount of sewage sludge added to soil. Growth and nutritional needs were uniform on the basis of morphological characteristics during the vegetation period. Adverse symptoms were not observed on either control plants or plants derived from sewage sludge treated soil. The morphological characters of all plants (leaves, shape, color and size) were normal and healthy.

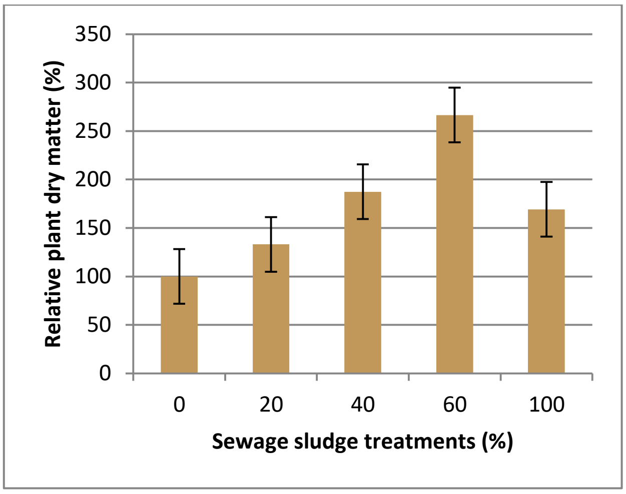


Figure 2. Effect of sewage sludge application on rye plant dry weight in two soil samples

The maximum dry matter of rye plants was obtained at sewage sludge 60. According to the results, the increases in pH values were favors for the growth of rye plants and reduce or inhibit the harmful effects of heavy metals. The degree of microbial activity can be determined by the amount of CO_2 released from the soil samples. It was found that the value of soil respiration compared to the control increased significantly by increasing the sewage sludge dose. Figure 3 shows that the amount of CO_2 released in the soil of brown forest soil from Nyíregyháza amended with different sludge doses.

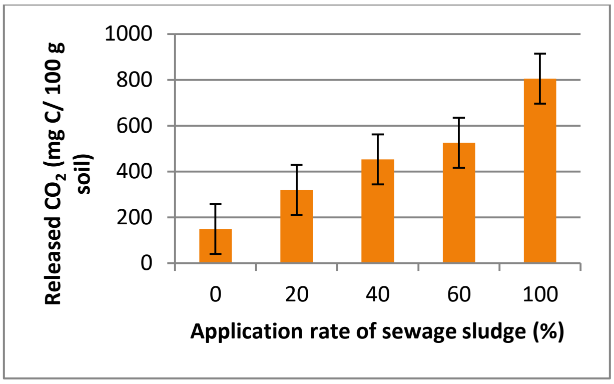


Figure 3. Effect of sewage sludge application on the amount of CO_2 released in soil samples

Such rate of respiration can provide valuable information on the increased metabolism activity of the soil biotas. The enzyme activity of FDA hydrolysis is shown in Figure 4. In soil samples amended with sewage sludge had high FDA activities and these activities are directly proportional with the rate of sewage sludge applied to the soil. The results show that the amount of fluorescein produced by FDA hydrolysis is in direct proportion with microbial growth, and the hydrolytic activity of FDA shows a close correlation with soil respiration.

The equilibrium effects of sewage sludge did not only significantly increase the soil microbial population, but also the activity of the soil enzymes investigated, soil respiration and FDA activity.

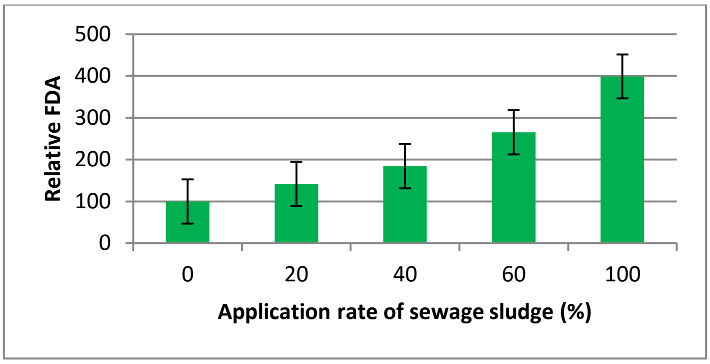


Figure 4. Effect of sewage sludge application on the activity of FDA enzyme in soil samples

Evaluation of results:

Eid et al. [7] mentioned that the application of sewage sludge significantly increased the soil organic matter content and most plant growth parameters, as well as the biomass of treated wheat, were significantly increased with the amendment of sewage sludge. The use of sewage sludge in agriculture will make the land in the inadequate regions more efficient in terms of organic matter for the soil [8]. Sewage sludge application in forest plantations is an interesting complementary alternative practice to sewage sludge reutilization and recycling,with a significant and sustainable net effect in climate change mitigation [9]. The study demonstrated the possibility of sludge application as a soil fertilizer in urban areas. In most of cases city landscapes are covered with poor soils, sludge application provides soil amendment and additional nutrient supply for planted trees, as it had been shown in the study of Soudani [10]. Chu et al. [11] suggested that a reasonable rate of sewage sludge compost addition can enhance *M. persiciforma* growth without causing the contamination of landscaping soil by heavy metals. When proper sludge products quality attained and recycling is feasible many objectives connected with sustainability of the soil. In pot experiment we found that beside rye growth, the plant health was better than control. So the plant utilized the micro and macro nutrients necessary and easy to apply from the immediate environment. Our results are in agreement with the Pierzynski et al. [12] that soil quality is determined mainly by physical, chemical properties which can strongly affect fertility, biological activity, or other important soil factor. The degradation of the organic material of the sewage sludge can be monitored well in the soil based on the measured amounts of the releasing of CO_2. Previous studies [13] have shown that soil respiration has increased due to addition of sewage sludge. In summary, the treatment of soil samples with sewage sludge stimulates the development of plants, improves the physical, biochemical and microbial properties of the rhizosphere, helps to maintain soil moisture and increases soil pH, which is favorable for plant development.

Conclusion

The present study is considered as a short-term study, so the selected variables are indicative for future long-term studies, which will allow technical definitions to create specific legislation for the use of this effluent in agricultural production. The results of pot experiments support the above mentioned works that the plant dry matter is related to the amount of sewage sludge mixed with the soil samples, increases the fertility rate, the crop production and soil biological activity by increasing the proportion of sewage sludge mixed with soil. At the same time, due to the aspects of food safety, the use of continuous state monitoring methods is recommended. We consider it important to continue the research, and to study the process with other long-term observations in addition to other soil conditions.

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