

SLAG AND FLY ASH DUMP TREATMENT WITH BIODEGRADABLE WASTE HERBACEOUS VEGETATION PURPOSE

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Abstract. The effects of vegetation with herbaceous species *Lolium perenne* were assessed in different experimental variants using: thermal plant slag and fly ash topsoil fertilised with slaughterhouse sludge or sewage sludge. The amounts of fertiliser agent ranged between 5.0–25.0 t ha⁻¹. The study was conducted over a period of two consecutive years of herbaceous culture. Fertilisation process efficiencies were not influenced by the nature of fertilising agent, but they were directly proportional to the amount of fertiliser used. Using a large amount of fertiliser agent of 25.0 t ha⁻¹ determined the highest yields of green mass. In contrast, the use of small amounts of fertiliser agent, 5.0 t ha⁻¹, resulted in the obtaining of seed quantities up to two times higher versus the seed quantities obtained on other experimental variants. During the two years, plants of *Lolium perenne* formed stable layers of vegetation resistant to hydro-climatic conditions in western Romania, ensuring through fruition the continuity of the restored landscape. Biomass and/ or harvested seeds for optimum phytoremediation variant of slag and fly ash dump will be directed to different sectors after an assessment on metal accumulation in tissues.

Keywords: slag and fly ash, biodegradable waste, *Lolium perenne*, restoration.

AIMS AND BACKGROUND

The aim of the study was to investigate the settling capacity, in time, of vegetation of herbaceous plants of the species *Lolium perenne*, on the surface of the slag and fly ash dumps through phytoremediation processes. Studies were performed using fertilisation of the upper layers of inert waste dumps of slag and ash biodegradable waste: slaughterhouse sludge and sewage sludge.

In Romania are large deposits of slag and fly ash occupying large areas of land for agriculture. These deposits form unpleasant, lunar landscapes, posing a potential risk to agricultural and livestock activities nearby. The deposits contain fly ash ($d < 200 \mu$ with 3.3% C content) in various mixtures with slag ($d > 200 \mu$ with 10.4% C content¹). The settling of natural vegetation on these deposits is difficult and

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there are usually undesirable plants, especially thistles. In literature are presented phytoremediation studies of slag and ash deposits, relative to geographical position, hydro-climatic regime, opportunities for improvement of topsoil characteristics in order to initiate effective plant layers, and plant species tolerance, etc.²⁻⁴ To correct these deposits topsoil structure and to form a nutrient substrate necessary for plant growth, fertiliser additions are required⁵. The use of biological organic waste as fertiliser, containing nutrients necessary for plant growth is a feasible solution to recycle these waste materials. Fertiliser organic matter is known by its ability to aggregate particles by two mechanisms: (1) increasing the micro-aggregate cohesion and decreasing breakdown forces, and (2) increasing micro-aggregate hydrophobic character and decreasing their breakdown by water leaching. Fertiliser organic matter works differently on hydrophobic character and cohesion of soil micro-aggregates depending on the composition, concentration of its components, and especially the inherited microorganisms and their exudates. Humic, solid fertiliser components will determine the appropriate micro-aggregation for a good soil structure and the soluble ones will provide bio-assimilable nutrients⁶.

EXPERIMENTAL

The experimental study was done in the experimental block: (1) three experimental variants of inert slag and fly ash topsoil fertilised with slaughterhouse sludge type in quantity of 5.0, 10.0 and 25.0 t ha⁻¹, variants referred to as: VA 1, VA 2, and VA 3, respectively; (2) three experimental variants of inert slag and fly ash topsoil fertilised with sewage sludge type in quantity of 5.0, 10.0, and 25.0 t ha⁻¹, variants referred to as: VS 1, VS 2, and VS 3, respectively. The experiment was carried out in pots with 5.5 kg of soil. In the pots, 7 g per pot of seeds from the *Lolium perenne* plant species were planted. Each experimental variant was done in three replicates. In the first year of culture, plant samples were taken between July and October, every two weeks. In the second year of culture, plant samples were taken in May–July, every 2 weeks. During August–September, cultures were not harvested to allow their fructification. Seed biomass harvesting was performed at the end of September. Metal analysis was done for the aerial parts of the plants obtained in the 2nd year of culture. The method of aerial part of plant analysis was presented by Masu and Rus⁷.

RESULTS AND DISCUSSION

Table 1 shows the green biomass quantities harvested from the experimental variants. In the first year the amount of biomass increases with the increase of the amount of fertiliser. In the second year, the quantity of grass harvested from the studied variants increases by 35.2–51.3% for the variants fertilised with sewage sludge and 38.2–53.6% for the variants fertilised with slaughterhouse sludge versus the quantity harvested in the first year. In the second year, the plants formed a dense cover which strongly fixes the dumps topsoil.

Table 1. Quantities of biomass from experimental variants cultivated with *Lolium perenne*

No	Harvest period	Fertilising agent					
		slaughterhouse sludge			sewage sludge		
		VA 1	VA 2	VA 3	VS 1	VS 2	VS 3
1	first year (g/pot)	125.5	177.0	228.7	138.0	173.6	215.5
2	second year (g/pot)	348.0	308.6	369.0	213.5	355.7	396.0
3	total (g/pot)	473.5	485.6	597.7	351.5	529.3	611.5

Table 2 shows the seeds quantities harvested from the experimental variants. Highest amount of seeds was obtained in variants VA 1 and VS 1, fertilised with the least amount, of 5 t ha⁻¹ slaughterhouse sludge or sewage sludge.

Table 2. Quantities of harvested seeds from soils cultivated with *Lolium perenne*

No	Seed quantity	Fertilising agent					
		slaughterhouse sludge			sewage sludge		
		VA 1	VA 2	VA 3	VS 1	VS 2	VS 3
1	g/pot	3.55	1.52	2.67	3.12	1.65	1.75

Table 3 shows the minimum-maximum metal quantities that have accumulated in the green biomass harvested in the second year of culture, in the aerial part. It is seen that plants accumulate small amounts of toxic metals (Cd, Cr, Cu, Ni). Plants accumulate large amounts of Pb, higher than the allowed limit. Biomass and/ or harvested seeds for optimum restoration/phytoremediation variant of slag and fly ash dump will be directed to different sectors after an assessment on metal accumulation in tissues, according to national regulations.

Table 3. Metal content from aerial biomass cultivated with *Lolium* spp

No	Metal (g kg ⁻¹ DM)	Fertilising agent	
		slaughterhouse sludge	sewage sludge
		minimum–maximum	minimum–maximum
1	Cd	<0.45	<0.48
2	Cr	1.08–1.92	1.76–2.66
3	Cu	2.75–6.30	1.55–2.56
4	Fe	29.00–70.80	27.34–77.78
5	Mn	34.77–58.34	32.34–54.90
6	Ni	1.48–1.54	1.56–2.10
7	Pb	7.50–13.20	6.30–26.30
8	Zn	12.70–22.30	7.21–25.22

DM – dry matter.

CONCLUSIONS

The use of biodegradable waste, sewage sludge and slaughterhouse sludge, led to the settling of a stable and healthy vegetation cover over a long period of time (2 successive years of culture with *Lolium perenne* species). The amount of harvested biomass increased by 53.6% in the 2nd year of culture compared to the amount harvested in the first year. To obtain a vegetative cover with a decisive role in the ecological restoration/phytoremediation of the landscape destroyed by this ash and slag dumps and a maximum amount of seeds, a minimum amount of 5 t ha⁻¹ of fertilisation agent (slaughterhouse sludge or sewage sludge) was sufficient. Biomass and/ or harvested seeds for optimum ecological restoration/phytoremediation variant of slag and fly ash dump will be directed to different sectors after an assessment on metal accumulation in tissues, according to national regulations.

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