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Soil pollution

EFFICIENCY OF FERTILISERS IN RESTORING ECOSYSTEMS ON FLY ASH DEPOSITS

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Abstract. The effect of municipal sludge compost application as a source of nutrients in the vegetation of fly ash deposits with perennial plants *Lolium perenne* species was evaluated. Studies were carried out on experimental plots including compost alone and mixed with indigenous pillared tuff. The study demonstrates the effectiveness of each type of treatment on plants coverage, the amount of biomass and resulted metal bioaccumulation in the aerial parts of harvest. Pillared tuff used as amendment has determined the obtaining of a vegetable cover with low accumulation of toxic metals. Fertilisation with compost resulted in removal of the amount of Cr and Ni with 60 and 76% in the case of Pb in the aerial parts of plants versus the bioaccumulation in plants grown on fly ash experimental variant. Addition of indigenous volcanic pillared tuff has determined a higher removal in the accumulation of toxic metals by over 10%. The highest removal was recorded in Pb bioaccumulation in the aerial parts of *Lolium perenne* versus the accumulation in plants grown on untreated variant fly ash.

Keywords: perennial species, restored ecosystems, fly ash, compost.

AIMS AND BACKGROUND

In the present study experiments on vegetation of fly ash deposits resulting from combustion of lignite-based power plants fertilised with compost and sown with *Lolium perenne* species using a quantity of 50–150 t/ha compost are carried out and indigenous tuff and pillared indigenous tuff used as an amendment.

Increased water retention capacity in the upper layers of fly ash deposits is a necessity if we apply a strategy for restoring destroyed ecosystems[1]. There is minimum water retention in the upper layers of the fly ash deposit. To increase water retention necessary for plant growth, specific properties of compost can be used. Addition of compost is done to increase the amount of nutrients and water retention capacity. The compost is a barrier to wind and water erosion, as well[2,3]. Published papers about utilisation of municipal sludge compost show increased water retention capacity in the upper layers of fly ash deposits[2–8]. Incorporation

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of vineyard residues is used as a base of lignin and may be an important source of nutrients for the fly ash deposits with poor nutritional materials. Reintegration of plant residues, even if it bears a minimum amount of N, P and K, participates in the recovery of humus in a poor nutrient soil. In addition to the nutrient source, vineyard residues used in the composting contain varying amounts of lignin and polyphenols. Depending on crop residues used for composting different amounts of bioavailability nitrogen can be obtained, for example straw production determined 35 kg N/ha, while other plant residues produce 5 times more amounts of nitrogen[9]. Literature indicates that a quantity of compost within 18–140 t/ha produced an increase of 6–163% organic matter[10]. In many cases, in order to maintain crops, it is interfered with amendments to reduce the migration of toxic species[8,11]. In addition, pillared tuff (patent) has increased capacity to absorb and encapsulate metal ions in high amounts[12].

EXPERIMENTAL

The study was carried out in 4 different experiments: 1 – fly ash (C); 2 – fly ash fertilised with compost, (C + C); 3 – fly ash fertilised with compost and indigenous volcanic tuff (C + C + T), and 4 – fly ash fertilised with compost and pillared indigenous volcanic tuff, named tuff-Aln (C + C + Ts) (Ref. 9). Experimental variants are contained in an experimental block area. Each experimental variant was carried out in triplicates. The area of each experimental triplicate was 10 m^2. The compost used for fertilisation had the following characteristics: N_{total} – 17.072 mg/kg dry matter (DM), P_2O_5 – 2.306 mg/kg DM, K_2O – 28.667 mg/kg DM, Cu – 110 mg/kg DM, Pb – 62 mg/kg DM, and Zn – 487 mg/kg DM. Volcanic tuff has up to 70% clinoptilolite. Pillared indigenous volcanic tuff was prepared according to patent[12]. The amount of volcanic tuff (native or pillared) was applied at a dose of 5 t/ha. Experimental variants fertilised with compost or mixed with native and pillared indigenous tuff are seeded with species *Lolium perenne*. The plants are harvested in a mature phenophase. Soil samples analysis was done to determine the metal concentrations according to the analysis method: the heavy metals were extracted from the soil samples by heating with aqua regia for 2 h, at reflux. After interrupting the heat, the system was left in stand-by for 16 h. Then the samples were diluted in a flask with demonised water to exactly 50 ml. Plant tissues were thoroughly rinsed of fly ash with demonised water to remove any soil particles attached to plant. The tissue plants were dried (105°C) to a constant weight. Plant samples with precise weight are then brought to 550°C; to the residual materials 5 ml of concentrated hydrochloric acid are added; samples are maintained 30 min on the dry sand bath. After filtering they were taken to a calibrated flask with hydrochloric acid 1:1 solution. The extracts analysis was done using a spectrophotometer, Varian Spectra.

RESULTS AND DISCUSSION

In Table 1 are presented the concentrations of heavy metals Cr, Cu, Fe, Mn, Pb and Zn in the top layer of untreated and treated experimental variants sown with *Lolium perenne* species.

Table 1. Metal concentrations in the top layer of untreated and treated experimental variants sown *Lolium perenne* species

No	Experimental variant	Contents of heavy metals (mg/kg DM)					
		Cr	Cu	Fe	Ni	Pb	Zn
1	C	85.8	63.8	4636.4	50.1	12.9	65.8
2	C+C	82.7	62.1	4714.2	47.5	12.4	83.9
3	C+C+T	84.1	64.8	4724.8	50.8	10.5	72.2
4	C+C+Ts	83.3	63.2	4713.6	44.2	13.0	71.6

In Table 2 are shown the degree of seed germination of *Lolium perenne* and vegetation coverage of experimental variants according to the Braun-Blanquet abundance scale[13].

Table 2. Degree of seed germination of *Lolium perenne* and vegetation coverage of experimental variants according to Braun-Blanquet abundance scale[13]

No	Variant	Germination degree 11.04.2009 (%)	Coverage degree 06.05.2010 (%)	Correlated levels with the Braun-Blanquet abundance scale[13]	Biomass (kg/ha)
1	C	few plants only	20	level 2 5–25%	805
2	C+C	40	35	level 3 25–50%	1040
3	C+C+T	45	45	level 3 25–50%	1035
4	C+C+Ts	45	45	level 3 25–50%	2527

The degree of germination of 40–45% is similar to that obtained in the experimental variants fertilised with compost and compost mixed with tuff. Seed germination in the first month of the control variant is very low, only a few plants germinated. Later, however, seed germination occurs in the fly ash experimental variant, as well, but it is over 50% lower than the other experimental variants. Coverage degree of about 35–45% on land fertilised with compost and indigenous tuff is 2 times larger than the degree of vegetation coverage in the control fly ash variant. Even if the coverage degree of experimental variant C+C is good, the amount of biomass harvested increased only by 22% versus quantity of biomass harvested from the control variant. Addition of native tuff determined the increase of the harvested biomass by 65% versus amount harvested from the variants fertilised with compost (C+C). In Table 3 is shown the accumulation degree of metals (Cr, Cu, Fe, Ni, Pb and Zn) in the aerial part of *Lolium perenne* species.

Table 3. Accumulation degree of metals (Cr, Cu, Fe, Ni, Pb and Zn) in the aerial part of *Lolium perenne* species

No	Experimental variant	Contents of heavy metals (mg/kg DM)					
		Cr	Cu	Fe	Ni	Pb	Zn
1	C	14.6	20.0	4753.0	7.5	46.4	29.4
2	C+C	5.6	20.2	4939.4	3.1	10.9	35.3
3	C+C+T	12.6	19.8	4332.0	4.9	10.1	80.6
4	C+C+Ts	4.9	19.9	4174.2	1.8	6.4	49.9

The use of fertiliser determined the reduction of the amount of chromium and nickel with 60% in each case and of lead with 76% in the aerial part of plant versus the quantity accumulated in the aerial part of plants harvested from the control variant. Addition of indigenous pillared tuff determined the removal of the accumulation degree of Ni by 16% in the aerial part of plants grown with fertiliser variant treated with organic-zeolite fertiliser. The highest reductions of 86% are recorded in the bioaccumulation of lead in the aerial part of plants grown on the unfertilised variant of fly ash. Addition of pillared tuff determined the removal of the accumulation of toxic metals by over 10%.

CONCLUSIONS

Vegetation coverage degree with the *Lolium perenne* species is 35–45% of the experimental variant fertilised with compost and pillared tuff, e.g. 2 times more than the coverage degree in unfertilised variants. Even if the coverage degree with plants of variants with fly ash fertilised with compost and compost with native tuff is satisfactory, the amount of biomass harvested is only 22.0% higher than the amount of biomass harvested from untreated variants. Addition of pillared tuff determined increase of the amount of biomass 4 times more than the amount harvested from control fly ash. Fly ash fertilisation with compost resulted in the removal of the amount of Cr and Ni from aerial part of plants, respectively with 60 and 76% Pb versus the quantity bioaccumulated by plants from untreated fly ash. Addition of pillared tuff determined the removal of the accumulation of toxic metals by over 10%. The highest recorded bioaccumulation reduction was of 86% in Pb bioaccumulation in the aerial part of plants versus plants grown on untreated fly ash.

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