Stabilization of Fly Ash Deposits through Selected Cereal Crops

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Abstract
Fly ash, a waste product from burning coal in power plants, occupies important spaces and is a major harm for environment: water, air, soil and associated ecosystems. New deposits do not have available nutrients for plant growth. The study presents a process of stimulating growth of oats in deposits of fly ash, which eliminates listed. Phytostabilization of new deposit is fast after fertilization with sewage sludge-based compost in the presence/ absence of native or modified volcanic tuff with grain species, *Avena sativa* L., and variety Lovrin 1. Experimental studies have shown the species adaptability to climatic conditions and a growth rate until the maturity correlated with type of treatment of upper layers of fly ash deposit. Fly ash with sewage sludge compost treatment 50 t/ha determined the growth with 75% of the amount of grains vs. the amount of grains harvested from untreated fly ash. Fly ash with sewage sludge compost mixed with modified indigenous volcanic tuff 2.5 t/ha treatment determined the growth with 80% vs. the amount of grains harvested from untreated fly ash. If oat straw harvested from fertilized variant without modified indigenous volcanic tuff increases in weight are 30% and for fertilized variant in the presence of tuff increases in weight are 39.8% vs. quantities harvested from untreated fly ash.

Keywords: *Avena sativa*, compost, fly ash deposits, modified volcanic tuff, phytostabilization

1. Introduction

The plant species selected to fhythostabilize the deposits of fly ash resulted from the burning of lignite in power plants must have the following proprieties:

1. they must tolerate high levels of metals in the topsoil and produce a layer of vegetation that would cover polluting surfaces and protect against fine particles dispersion;
2. the transfer of metal to roots and from roots to exposed part of plant should be minimal and thus not expose links higher up the food chain to pollution [1].

The addition of organic fertilizer on top of the fly ash that is void of nutrients, is a stimulating process for the growth of oat, but also presents the problem that it modifies the degree of mobility of the metals. Fly ash presents no biodegradable forms of pollutants such as metals. Generally these do not dissolve in water and, therefore do not get transferred in the roots of the plants. Through the presence of organic matter, soluble metal compounds get formed and can be absorbed by the roots of the plants together with the nutrients in the topsoil [2-4]. In contrast, research has shown that certain inorganic materials diminish the advanced mobility of metals in topsoil treated with organic matter based on humic substances [5-8]. The result is confirmed through the decreased absorption of metals in the topsoil by the plants tissue, that is a consequence of decreased peroxide activity.

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The aim of the study is to establish the effect that the usage of compost based sewage sludge mixed with vegetation residue in the presence/absence of some zeolitic materials like indigenous volcanic tuff has a morph physiological and bioaccumulation of heavy metals in oat crops of *Avena sativa,* variety Lovrin 1, used for fixing the superior layer of fly ash.

2. Materials and methods

The study was done in pots in which equal quantities of fly ash were introduced (5.5 kg/pot). The surface cultivated was 0.075mp/pot. Oat (*Avena sativa* L., variety Lovrin 1) was seeding in each pot.

The experimental values were as follows:

1C – fly ash fertilized with 50 to/ha compost;

2C – fly ash fertilized with 100 to/ha compost;

3C – fly ash fertilized with 150 to/ha compost;

1CTs – fly ash fertilized with 50 to/ha combined with modified indigenous volcanic tuff;

2CTs – fly ash fertilized with 50 to/ha combined with modified indigenous volcanic tuff;

3CTs – fly ash fertilized with 150 to/ha combined with modified indigenous volcanic tuff;

B – the control group, untreated fly ash.

The compost used in the fertilization is obtained by fermentation of sewage sludge with chopped up organic and has the following proprieties: D.M. 34.3%, volatile substance 75 %, pH = 7.15, N_{total} = 17.072 mg/kg D.M., P_2O_5 = 2.306 mg/kg D.M., K_2O = 28.667 mg/kg D.M., Cr < 0.1 mg/kg D.M., Cu = 110 mg/kg D.M., Ni < 0.08 mg/kg D.M., Pb = 62 mg/kg D.M., Zn=487mg/kg D.M. The indigenous volcanic tuff contains 70% clinopilolite and is brought from the Mirsid Quarry. Volcanic tuff is used with a granulation of 0.2 - 2 mm. The modified indigenous volcanic tuff (tuf-Aln) was prepared in the INC ECOIND laboratories according to the fabrication trademark and is added in a liquid suspension of 80% D.M.[9] The amount used as an amendment 2.5 to/ha.

The method of analysis of the metals in plant and topsoil is presented by Mâsu and Dragomir, 2011 [1]. The determination of the metals is made with an AAS Varian type atomic absorption spectrophotometer. The detection limit of the device for Cr, Cu, Fe, and Zn is of 0.05 mg/L and for Pb and Ni is of 0.10 mg/L.

3. Results and discussion

Table 1 presents the characteristics of the vegetation of *Avena sativa* installed on the fly ash experimental variants in the presence/absence of the compost based on sewage sludge. Table 2 presents the characteristics of the vegetation in the presence/absence of the fertilization agent, compost based on sewage sludge amended with modified indigenous volcanic tuff.

Characterization of the plant layer formed on the experimental variants of fertilized fly ash with compost / unfertilized fly ash, with and without the amendment, according to the Braun-Blanquet scale [10].

Table 1 Characteristics of plant on the experimental variants on the fly ash fertilized with compost/unfertilized fly ash [10]

Crt. no.	Experimental variant	Supremacy/abundance index Braun-Blanquet scale [%]	Morph physiological characteristics
1	B	22.7	Poorly developed plants, weak roots
2	1C	45.7	Plants do not complete vegetative cycle, weak roots
3	2C	64.1	Plants complete vegetative cycle, ramified roots
4	3C	64.2	Plants complete vegetative cycle, ramified and conjoined roots

From table 1 we may infer the positive influence of the fertilization agent that, through the quantity of nutrients introduced in the biologically inert layers of fly ash, determine the development of both the roots and aerial parts of plants.

The degree of vegetation coverage grows by a factor of 2-3 vs. the degree of coverage in unfertilized fly ash variant. By gradually increasing the amount of agent fertilization is observed improvements in quality and quantity of biomass formed.

In table 2 we notice the positive influence that the addition of the modified indigenous volcanic tuff has in the mix with the fertilization agent introduced in the biologically inert fly ash layers. The treatment applied determines a degree of

coverage of the fly ash of about 58.3-73.1% according to the Braun-Blanquet scale. The degree of vegetation coverage grows by 10% if modified indigenous volcanic tuff was used towards the degree of coverage when simple fertilization is used. Plants are more developed and present both ramified and conjoined roots and the vegetative cycle is always complete.

Table 2 Characterizations of the plants on the variants of fly ash fertilized with compost mixed with modified indigenous volcanic tuff / unfertilized fly ash

Crt. no.	Experimental variant	Supremacy/abundance index Braun-Blanquet scale [%]	Morph physiological characteristics
1	B	22.7	Poorly developed plants, weak roots
2	1CTs	58.3	Plants complete vegetative cycle, ramified and conjoined roots
3	2CTs	73.1	Plants complete vegetative cycle, ramified and conjoined roots
4	3CTs	71.1	Plants complete vegetative cycle, ramified and conjoined roots

In table 3 is presented the degree of accumulation of metals in the aerial part of the plants (straw and grains) from *Avena sativa* from experimental variants of fly ash fertilized/unfertilized.

Table 3 The degree of accumulation of metals in the aerial parts of the plants (straw and grains) from *Avena sativa* from variants of fly ash that was fertilized/ unfertilized

Crt.	Experimental	Heavy metal content [mg / kg D.M.]						
no.	variant	Cr	Cu	Fe	Mn	Ni	Pb	Zn
1	B	6.62	11.08	62.5	77.5	3.4	8.3	39.66
2	1C	8.11	13.45	104.5	85.0	3.9	9.0	58.70
3	2C	8.11	13.34	125.2	97.6	5.5	9.0	79.74
4	3C	8.11	15.49	222.1	107.6	5.8	7.0	71.82

When is used as fertilizer, organic matter based on humic compounds has characteristics of solubility of heavy metals Cr, Cu, Fe, Mn, Pb and Zn. In table 3 we notice that in plants grown on fly ash with compost the aerial part of the plant accumulates larger quantities of heavy metals than plants grown on the unfertilized variants of fly ash.

In table 4 is presented the degree of metal accumulation in the aerial parts (straw and grains) of oat (*Avena sativa*) in the presence / absence of the compost based on sewage sludge mixed with modified indigenous volcanic tuff.

Table 4 The degree of metal accumulation in the aerial parts of the plants (straw and grains) of oat in the presence/ absence of the compost based on sewage sludge mixed with modified indigenous volcanic tuff.

Crt.	Experimental	Heavy metal content [mg / kg D.M.]						
no.	variant	Cr	Cu	Fe	Mn	Ni	Pb	Zn
1	B	6.62	11.08	62.5	77.5	3.4	8.3	39.66
2	1CTs	sld	2.00	64.3	45.9	5.5	sld	48.07
3	2CTs	sld	5.79	64.6	66.3	5.4	sld	43.81
4	3CTs	sld	5.19	78.4	65.1	3.4	sld	46.21

The modified indigenous volcanic tuff (tuff – Aln), when used as additive to fly ash fertilization has limiting characteristics on the solubility of heavy metals Cr and Pb. In plants grown in the fertilized fly ash with the modified indigenous volcanic tuff, bioaccumulation is reduced by 56%-84% in Cu, and 14-40 % in Mn, vs. the quantity accumulated in plants grown on untreated fly ash.

From the comparative analysis of the characteristics of vegetation layers and the probability of metal transfer in the aerial part of plants and the nature of the applied treatment we may establish that from the experimental variant fertilized with 50 to/ha compost mixed with modified indigenous volcanic tuff we obtain a healthy vegetation layer that covers over 50 % of

the inseminated area and the biomass of the aerial part of the plant accumulates the lowest rate of heavy metals Cr, Cu and Pb.
Table 5 presents the quantities of straw and grains of oat (*Avena sativa*) in the fly ash experimental variants in the presence/absence of the fertilizing agent, compost mixed with modified indigenous volcanic tuff.

Table 5 The quantities of straw and grains of oat (*Avena sativa*) in the fly ash variants in the presence / absence of the fertilizing agent, compost mixed with modified indigenous volcanic tuff.

Crt. no.	Experimental variant	Amount of straw and grains [g/pot]	
		Straw	Grains
1	B	14.2	3.0
2	1C	19.6	8.0
3	1CTs	23.6	12.1

Treating the fly ash with compost based on sewage sludge, mixed with vegetation residue, 50 to/ha, determines a growth in the quantity of oat grains by 62.5% and the adding of modified indigenous volcanic tuff determines growth of up to 75% vs. the amounts of grains obtained on the unfertilized fly ash variant. If oat straw harvested from fertilized variant without modified indigenous volcanic tuff increases in weight are 30% and for fertilized variant in the presence of tuff increases in weight are 39.8% vs. quantities harvested from untreated fly ash variant.
Results obtained can be used as a basis for durable vegetation coverage strategy with oat of new fly ash dump sites and the harvests obtained may be reused.

4. Conclusions

Characteristics of the vegetation layers installed on all the experimental variants depend solely on the type and nature of the treatment applied.
We may establish that the optimal variant of fertilization of the inert layers of fly ash, with compost based on sewage sludge mixed with vegetation remains is 50 to/ha. The addition of zeolithic rock, modified indigenous volcanic tuff, provides a vegetation layer that covers over 50% of the inseminated surface. If this treatment is used for the fertilization of the topsoil on the fly ash dump sites, the aerial tissue of the plant, straw and grains, does not accumulate Cr and Pb above detection limits. The amount of copper is brought down to 84% vs. the amount accumulated in the aerial part of the plant harvested from the untreated variants.
Fly ash with sewage sludge compost treatment 50 t/ha determined the growth with 75% of the amount of grains and resulted in a tuff addition to 80 % vs. untreated fly ash. If straw is harvested from these variants, weight increases have yield to 33-40 % vs. the untreated variant

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