Behaviour of *Onobrychis Viciifolia* Growing on Fly Ash Experimental Parcels

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Abstract
Studies were conducted to identify a treatment method for upper layers of fly ash to cover them with vegetation. Fixing plant layer acts against erosion/washes of fly ash deposits. Studies emphasized the need of use of an organic fertilizer mixed with inorganic materials such as volcanic tuff and, also, the need of selecting a plant species compatible with the treated culture medium. The use of an amended variant of compost and modified volcanic tuff of fly ash layers shows that the selected leguminous species, *Onobrychis viciifolia,* installs itself quickly on the third level of Braun - Blanquet scale. The reduction of toxic heavy metals bioaccumulation from the aerial plant tissues such as lead and nickel of 72-79%, and copper and zinc of 50-68%, respectively, allows obtaining of a safe biomass for wildlife visiting the area.

Keywords: bioaccumulation, compost, fly ash deposit, vegetation.

1. Introduction

Fly ash deposits resulting from burning lignite in thermal power units has a potential risk due to natural phenomena produced by wind and water erosion. The rain washes the fly ash deposits and creates torrents that involve large amounts of fly ash which is transported to long distances. In this situation, soluble salts and toxic metals are carried on with waters. Leaks result from washing fly ash deposits reaching groundwater. This increases the quantities of Cd, Pb, Fe, and Cr from the groundwater in the adjacent areas.
Natural changes in the upper layers of fly ash deposit, as their enrichment in humic materials from alternate vegetative cycle, even from very poor vegetation, can alter the characteristics of fly ash, but the phenomenon is very long in time. Many fly ash deposits are in the attention of specialists for vegetation to prevent erosion [1].

Selection of plant species is an important factor in determining the success of deposit rehabilitation. To grow plants on deposits containing toxic metals, you need to choose plants that retain smaller quantities of metals, because after the vegetation has grown, the area is visited by the local fauna, which can be harmed by the potentially dangerous biomass. To achieve a fast layer of vegetation you can use organic fertilizers and amendments [2-6].
In this study, we show the degree of accommodation of *Onobrychis viciifolia* on experimental parcels. These experimental parcels can be fertilized with compost, amended with indigenous volcanic tuff, allowing nitrogen fixation in porous materials, or with compost mixed with indigenous volcanic tuff. We also studied the phytotoxicity of metals, such as Cr, Cu, Fe, Ni, Pb, and Zn, which can be found in fly ash, on *Onobrychis viciifolia* culture and the degree of metal accumulation in the plants.

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2. Materials and methods

The study is carried out on six experiments: fly ash, fly ash treated with indigenous volcanic tuff, fly ash treated with pillared indigenous volcanic tuff type tuff-Aln (patent) [7], fly ash fertilized with compost, fly ash fertilized with compost and treated with indigenous volcanic tuff, fly ash fertilized with compost mixed with pillared tuff type tuff-Aln.

The experimental area had 3 m^2 and the distance between the experimental parcels was 1 meter. The experiment was performed at the Banat's University of Agricultural Sciences and Veterinary Medicine Experimental Station.

The compost used as fertilizer is formed of municipal sludge mixed with vineyard residue and has the following characteristics: N_{total} = 17,072 mg/kg 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, Zn = 487 mg/kg DM.

The volcanic tuff contains up to 70% clinoptilolite and comes from the Mirsid quarry, Romania, and the pillared volcanic tuff is prepared according to patent [7].

The *Onobrychis viciifolia* was selected to be planted into the experimental parcels because of the following reasons:

- can be planted in the eroded areas where other plant species cannot resist, and prevents erosion caused by rains and wind;
- can be grown in very dry areas without irrigation;

allows nitrogen fixation in soil;

- once grown, the plants produce large amounts of seed.

Onobrychis viciifolia prefers soils containing calcium, which is provided by the fly ash itself (contains 6.7 – 10.2% CaO).

The fly ash contains metals like 94.5 mg Cr /kg DM, 66.4 mg Cu /kg DM, 4,107.1 mg Fe/kg DM, 58.4 mg Ni /kg DM, 19.2 mg Pb /kg DM, 102.3 mg Zn /kg DM.

Soil sample analysis was done to determine the total iron, zinc, copper, chromium, nickel and lead concentrations according to the analysis method: the heavy metals were extracted from the soil samples by heating with Aqua Regia for 2hrs, at reflux. After interrupting the heat, the system was left in stand-by for 16 hrs. Then the samples were diluted in a flask with deionized water to exactly 50 ml. Plant tissues were thoroughly washed with deionized water to remove any soil particles attached to plant surfaces. The tissues were dried (105°C) to a constant weight. Plant samples with constant weight are then brought to 550°C; to the residual materials 5ml of concentrated hydrochloric acid are added, samples are maintained 30 minutes on the dry sand bath. After filtering those in a paper filter with small porosity, they were taken to a calibrated flask with hydrochloric acid 1:1 solution. Plant and soil extracts analysis was done using a spectrophotometer, Varian Spectra AAS.. The detection limit of the device is 0.001 mg/l.

In Table 1 we present the agrotechnical works done on experimental parcels with *Onobrychis viciifolia.*

Table 1. Agrotechnical works on experimental parcels with *Onobrychis viciifolia*

Agrotechnical work done	Date	Comments
1. Preparing parcels, adding fly ash. Adding fertilizer.	01.09. 2009	Experimental block is divided in parcels and 40 cm from topsoil each parcel is removed then filled with fly ash. Parcels should be treated with compost according to the diagram.
2. Adding indigenous volcanic tuff and pillared indigenous volcanic tuff type tuff-Aln.	13.09. 2009	Parcels should be treated with volcanic tuff according to the diagram Mixing the materials added on the parcels: fly ash, compost, volcanic tuff. Parcels should be biogeochemical stabilized for 10 days
3. Seeding with *Onobrychis viciifolia* species.	23.09. 2009	Parcels seeded should be covered with fly ash.
4. Tracking the germination plant degree	04.11. 2009	The degree of growing plants is monitored.
5. Determination of plant development and evaluating coating surface	15.06. 2010	Analyzing accumulation of heavy metals in the aerial part of plants

Studies of quantitative ratios between plant species from a phytocenosis allow the completion of the ecological research onto any biocenosis. From a practical point of view the biomass

production, the rate of this productivity process and its contribution to the ecosystem stability and biodiversity are studied. The abundance is given by the number of plants from a species that are grown in a phytocenosis. The abundance is an expression of plant density and vitality, but also of favorable environmental conditions. Supremacy expresses the degree of soil covered with plants, resulted due to aerial parts projection on soil. Because the abundance is in direct relation with supremacy, a supremacy-abundance index was proposed by Braun-Blanquet, taking into consideration the following Cover – Abundance Scale [8].

3. Results and discussion

The tracking of the emergence of plants of *Onobrychis viciifolia* is performed in the next period.

In Table 2 are presented the degrees of germination and vegetation of parcels cultivated with *Onobrychis viciifolia.*

Table 2. Germination and vegetation degree of parcels cultivated with *Onobrychis viciifolia*

No.	Experimental parcel	Germination degree %	Coverage degree %	Blanquet – Braun scale coverage	Physiological state Mature plant
1	Fly ash	No germination	-	-	-
2	Fly ash + tuff	40	20	Level 2 5 – 25%	Medium size 10 – 12 cm
3	Fly ash + pillared tuff	35 – 40	20 – 25	Level 2 5 – 25%	Medium size 15 – 18 cm
4	Fly ash + compost	10	5	Level 2 5 – 25%	Medium size 7 – 10 cm
5	Fly ash + compost + tuff	30 – 35	15 – 20	Level 3 25 – 50%	Medium size 15 – 18 cm
6	Fly ash + compost + pillared tuff	35 – 45	35 – 40	Level 3 25 – 50%	Medium size 15 – 18 cm

Table 2 shows that seeds do not grow on parcels with untreated fly ash. Adding compost increases the germination degree with 10%, and adding tuff and modified tuff without or with compost increases germination degree with 40%. The parcels were covered on winter. Although the germination degree was satisfactory, further development has undergone, so the vegetation degree is around 20 – 25% if amendments are present in mixture with compost or not. An exception is the culture on the plot treated with compost and pillared volcanic tuff, where plants grown on a surface 2 times more than the others. The plants grown on parcels with amendments had twice the size of those grown on the parcels fertilized with compost without volcanic tuff.

In Table 3 we present the content of metals in *Onobrychis viciifolia* aerial plant tissue.

Table 3. Content of metals in *Onobrychis viciifolia* aerial plant tissue

No.	Experimental parcels	Content on heavy metals Mg/kg DM					
		Cr	Cu	Fe	Ni	Pb	Zn
1	Fly ash + tuff	9.3	6.2	4,242.6	2.5	3.8	18.5
2	Fly ash + pillared tuff	6.4	6.2	1,694.8	2.1	0.8	16.5
3	Fly ash + compost	6.4	9.1	6,592.3	3.6	3.8	25.4
4	Fly ash + compost + tuff	6.0	3.0	3,918.4	3.7	4.1	34.0
5	Fly ash + compost + pillared tuff	4.8	2.9	2,977.4	0.2	0.3	12.5

Addition of compost resulted in the highest accumulation of copper, iron and nickel, which probably lead to plant injury as shown in Table 2 (small number of individuals, small size plants with spotted or dry leaves). The smallest accumulation of metals is for the parcel treated with tuff without or with compost. Addition of pillared volcanic tuff resulted in lower bioaccumulation in plant tissue in comparison with the bioaccumulation in plants grown on

parcels fertilized with compost with 30 – 40% copper, nickel and zinc and 73 – 79% iron and lead. Using a mixture from pillared volcanic tuff and compost resulted in greater reduction in bioaccumulation, copper and zinc with 50 – 68%, nickel and lead 92 – 94% and chromium 25%.

4. Conclusions

Addition of compost based on municipal sludge and vineyard residues increases the growth rate of plants on parcels with fly ash, with small sizes, small number of individuals and large amounts of copper, iron and nickel. Bioavailability of these metals caused physiological modifications in *Onobrychis viciifolia*. Bioavailability decreases with the use of volcanic tuff, especially by using pillared volcanic tuff. Analyzing the results from these six experiments, the most efficient treatment for fly ash on vegetation layer is recorded using a mixture from compost and pillared volcanic tuff; the reduction of the bioaccumulation of metals reached 50 – 68% for copper and zinc, 92 – 94% for nickel and lead and 25% for chromium in comparison with the parcels treated with compost. The inhibitory capacity of metal ions exhibited by mixing compost and pillared volcanic tuff resulted in a lower level of accumulation in biomass.

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