

Studies Regarding the Decrease of Heavy Metal Accumulations in Herbaceous Plants Tissues Grown on Fly Ash Dumps

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Abstract

Fly ash dumps are an environment difficult to vegetable because of the high content of inert materials (metal oxides in excess of 95-99%) and it does not contain any nutrients based on N and P. Carbon compounds resulting from incomplete combustion lignite are and not easily assimilated by plants. Fly ash properties do not allow water retention in the upper layer. The addition of fertilizers as biosolids (municipal sludge) and a material in type of indigenous volcanic tuff, with capacity of water retention and gradual release based on plants necessities, allowing both plant growth and protection against excessive accumulation of toxic metals in air tissues. A field experiment was conducted on a lignite fly ash dump, on two types of experimental parcels, control parcels and experimental parcels (fertilized with biosolids and treated with volcanic tuff). In this study, through work technique, were obtained in case of plots fertilized with biosolids and treated with tuff volcanic indigenous, reduction of metal accumulation in aerial tissues of the examined species of: 73-94% for Pb, 37-50 % for Cr, 28-43% for Ni and 12,5-22% in comparison with control plots.

Keywords: accumulation decrease, heavy metals, fly ash dumps, herbaceous plants

1. Introduction

Application of biosolids on fly ash dumps is a promise for the rational use of sludge from urban sewage plants. These sludges contain large amounts of carbon compounds available to plants and to be use in their metabolism. It also is a source of phosphorus and nitrogen compounds required for plant. In addition this type of sludge contains many components that determine the initiation and development of soil micro-organisms.

It was demonstrated that the use of biosolids determine the improvement of physical-chemical properties of soil layers that are treated with these materials.

In addition to use sludge for fly ash fertilization may be a method of storing them for good purposes in areas where are not expected agricultural crops because of their high content of toxic metals. [1-3]

The use of biosolids to form a layer of nutrient rich material covering the fly ash dumps is made in quantities of 100-Mg/ha. If biosolids contain a number of compounds that have the ability to solubilize metals, then, they create conditions to be accumulated in plant tissue. [4]

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A number of researchers have analyzed the behavior of plants grown on soils fertilized with biosolids and have showed the high ability of plants to accumulate metals in their aerial parts. [5]

Bioavailability of metals in soil can affect plant growth. Therefore to start a culture on fly ash dumps, plants must be selected to tolerate conditions from sowing and later to tolerate the conditions of maintaining the culture. In many cases, in order to maintain crops, is interfering with amendments to reduce the migration of toxic species, chemical solubilized.

Such an amendment is indigenous volcanic tuff as such (native) or modified (modified). Tuff has a porous structure that can absorb some of the ions that are dissolved in soil solution. In addition, modified tuff (patent) has increased capacity to absorb and encapsulate metal ions in high amounts. [6, 7]

The presents study issues how to cover a fly ash dump with a layer of herbaceous plant as *Festuca arundinacea* species, in conditions of addition of biosolids and volcanic tuff native and modified.

2. Materials and methods

A field experiment was conducted on a lignite fly ash dump. The most usual techniques were used for soil preparation and agricultural maintaining works.

Due to lack of moisture caused by the dryness summer, the sowing was done in August 2009.

The favourable weather conditions, a delay autumn, allow us to study the first vegetative growing phenophase and the plants were observed till December.

Experimental plot was fertilized with biosolids (municipal sludge anaerobically stabilized) in quantity of 25 t of D.M. /ha. The biosolids characteristics are shown in table 1.

Experimental plots are control - fly ash with no added fertilizer, fly ash + biosolids + native volcanic tuff and fly ash + biosolids + modified volcanic tuff.

Experimental plots, after fertilization, were allowed to stabilize biogeochemical for 30 days. The plants were studied during three 3 months, September to December 2009.

Soil samples analysis was done to determine the metals quantity according to the analysis method of ISO 11047/99. Soil sample preparation for analysis was done in accordance with ISO 11464/98.

Analysis of plant metal accumulation in the aerial parts of the plants, on dried plant tissues and digested with concentrated hydrochloric acid. Plant sampling was done in accordance with the methodology described in STAS 9597/1-74, and the sample analysis was done in accordance with STAS 9597/17-86.

Plant and soil extracts analysis was done using a spectrophotometer with atomic absorption, Varian Spectra AAS.

Table 1 Metal content of biosolids

	Metal content mg/kg D.M.						
	Fe	Cu	Cd	Cr _{tot}	Zn	Ni	Pb
Biosolids*	2,003.7	333.9	7.3	134.7	304.6	27.4	157.8

*Humidity 90%, organic matter = 26.4%, N_{total} = 0.7%, P = 0.65%, pH = 6.1.

3. Results and discussion

In Table 2 are presented the characteristics of the top layer of fly ash deposit that has been sown with *Festuca arundinacea* in three plots: control, fertilized with biosolids plus native volcanic tuff and fertilized with biosolids plus modified volcanic tuff.

The fly ash contains heavy metals and the addition of biosolids can bring a surplus of metals in the upper layer.

In Table 3 are given quantities of metals accumulated in tissues, aerial parts of *Festuca*

arundinacea, after a growing season of 3 months, September to December 2009.

Just as in the table, the total amount of mineral substances from plants (aerial part tissue) increase at the addition of tuff, which shows higher accumulation of inorganic substances. However this toxic content is significantly reduced, especially in case of lead with 73-94%. A strong lead blocker came in the presence of modified volcanic tuff.

Another metal inhibited by tuff presence was the iron, whose accumulation was reduced by 53-63%, while chromium was reduced to 50%.

Table.2. Characteristics of experimental soil layers grown with *Festuca arundinacea* plant

Experimental plots	pH	Metal contents mg/kg D.S.					
		Fe	Cu	Cr	Ni	Zn	Pb
Control (fly ash)	6.5	1860	64.2	72.4	56.2	54.7	7.0
fly ash + biosolids + native volcanic tuff	6.4	1890	63.05	88.9	61.6	70.0	7.2
fly ash + biosolids + modified volcanic tuff	6.3	1892	79.6	97.7	64.5	74.0	10.6

Table 3 Accumulation of metals in aerial tissues of *Festuca arundinacea* species harvested from experimental plots located on the fly ash dumps (in-situ)

Experimental plots	Fly ash content in tissue, %	Metal contents mg/kg D.S.					
		Fe	Cu	Cr	Ni	Zn	Pb
control (fly ash)	15,43	1185	19,2	97	7,2	39,5	26,4
fly ash + biosolids + native volcanic tuff	17,15	559,9	15,02	4,9	4,1	42,9	7,04
fly ash + biosolids + modified volcanic tuff	21,20	436,2	16,8	5,0	5,2	39,2	1,52
Reductions of metals accumulation in comparison with control (%)	-	53-63	12,5-22	47-50	28-43	-	73-94

Copper and nickel accumulation is less reduced. Zinc bioavailability was not affected by treatments performed on fly ash layers.

At this stage of plant development, the effect of tuff, in the two forms, as addition to biosolids fertilization, was strongly on plant behavior respectively on the amount of accumulated metals.

4. Conclusions

Land occupied by fly ash dumps have an inert nature and are unsuitable for the rapid coverage with plant layers.

Biosolids fertilization with the addition of native volcanic tuff determined the germination and formation of a vegetation layer of *Festuca arundinacea* specie.

Adding biosolids and native volcanic tuff has determined the maintaining the green cover and plants protection against high accumulations of metals that affect the quality and quantity of culture.

The accumulation of lead in aerial tissue is significantly reduced, with 73-94%. A strong lead blocker came in the presence of modified volcanic tuff.

Iron was inhibited by tuff presence, whose accumulation was reduced by 53-63%, while chromium was reduced to 50%.

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