# FLY ASH DEPOSITS REVEGETATION

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## ABSTRACT

Plants that grow on heavy metals polluted sites, resulting from human activities, as well as in the surrounding areas contain large amounts of these metals. Given the fact that laying a vegetal layer over the fly ash disposal site would attract birds and wild animals, this study aims to establish an *in situ* revegetation strategy and assess the level of heavy metal accumulation within the aerial part of the vegetal layer. The addition of a mixture consisting of modified volcanic tuff and biosolids lowers the heavy metal content within the aerial part of *Lolium perenne* by 20-26% and for *Onobrychis viciifolia* the decrease is three times higher. Despite this finding, the amounts of accumulated heavy metals within plants are remarkable. By using this kind of treatment, the heavy metal (chromium, copper, nickel and lead) accumulation within *Onobrychis viciifolia* is up to 14.6 – 20.4 mg/kg dried matter. This result requires the continuation of the studies in order to identify other materials that are able to abate the metal accumulation within plants or to remove the bioaccumulation species.

**Keywords***:* fly ash, biosolids, *in situ* revegetation, natural zeolite.

## INTRODUCTION

The risk potential of the fly ash deposits produced by coal power plants is related to the natural phenomena of wind and water erosion. The storm waters, especially torrents wash off the deposits, causing transport of large amounts of ash on large distances. Under these conditions, transport of some soluble salts of toxic metals also occurs, carried by water that spreads them all around. The run-off resulting from the washing of the ash deposit ends up in the ground water table of the surrounding areas. An increase in the amounts of Cr, Pb, Fe, Cu, etc. in the ground water table is therefore noted. On the other hand,

significants amounts of fine solid particles dislocated from the fly ash deposits will be transported on the surrounding grounds with agricultural use.

Plants that grow on heavy metals polluted sites, resulting from human activities, as well as in the surrounding areas contain large amounts of these metals. If these plants get into the food chain, they can generate a series of health problems, possible leading to death. Such was the case of polluted sites, where the presence of lead in soil caused the death of the horses in the area. [1]

Due to accumulation of metals in plants, people have been looking for methods to reduce their transfer from soil into vegetation, by treatment with organic and inorganic fertilizers.

***1. Use of organic fertilizers****:* The organic fertilizers such as compost, manure, biosolids or composted biosolids can efficiently reduce the transfer of heavy metals from the polluted soils to aerial plant tissues. [2]. This effect may be achieved by organic matter bonding with metals, in this way impeding their takeover by plants and spreading into the surrounding areas. The study shows that the strength of the organic fertilizers bond depends on the quality of the respective organic matter and their immobilization is inversely proportional with the ion exchange capacity [3,4].

***2. Use of inorganic ammendments****:* The inorganic ammendments are efficient because they can bond heavy metals to certain positions on solid surfaces, thus reducing their bioavailability. They can also have significant effects on pH alteration. Materials such as Al-Montmorilonite and clinoptilolite are reffered as efficient for cadmium, nickel and zinc. [5,6]

***3. Treatment with biofertilizers*** *such as organic zeolites* has more advantages than treatment with chemical fertilizers. Many references are to be found in literature on clinoptilolite properties, which, when added to compost of biodegradable organic waste, initiates and absorbs nitrogen based components (ammonia, nitrates etc) and gradually releases them as they are needed to plants. Hence, the air emissions of the nitrogene volatile compounds are significantly reduced. [7,8,9]

Taking into account that the installation of a vegetal layer will attract birds and wildlife in the area, this study is aimed towards the in situ recultivation strategies of the fly ash deposits, namely to those issues related with the accumulation of heavy metals in the aerial parts of the cultivated plants.

## EXPERIMENTAL PART

The experimental lots analyzed consisted of two categories:

1. Unfertilized experimental lots *C+T,* ammended with 2% modified local volcanic tuff and

2. Experimental lots *C+T+B*, treated with biofertilizers such as organic zeolites, municipal sludge 25t/ha or mixed with 2% modified volcanic tuff.

The cultivated species were *Lolium perenne,* a grassland species and *Onobrychis viciifolia,* a legume species. The study was carried over during summer period of 2010. The accumulation of iron, zinc, copper, chrome, nickel and lead in the aerial parts of the mature plants of the two analysed species was studied. The study was performed during fruit ripening, when first harvesting is done and during second harvest season.

Soil samples analysis was made to establish the total iron, zinc, copper, chromium, nickel and lead concentrations, according to the ISO 11047/99 test method. Soil samples preparation for analysis was made in accordance with ISO 11464/98. Dried soil samples were digested with aqua regia. Analysis of metal accumulation in the aerial parts of the plants was made with dried plant tissues, digested with concentrated hydrochloric acid. Plant sampling was done in agreement with the methodology described in STAS 9597/1-74, and the sample analysis was done in accordance with the specifications of STAS 9597/17-86. Plant and soil extracts analysis was realized using Varian Spectra AAS, an atomic absorption spectrophotometer. The device detection limit is of 0.001 mg.

## RESULTS AND DISCUSSIONS

The *Lolium perenne* has a ground coverage degree of 20-60% and the *Onobrychis viciifolia* one of 5-15%. The tables 1 and 2 show the accumulation of heavy metals in the aerial parts of the *Lolium Perenne* and *Onobrychis viciifolia* cultivated on the *C+T* experimental lots (unfertilized and ammended with local modified volcanic tuff) and on the *C+T+B* experimental lots (treated with biofertilizers such as organic zeolites, municipal sludge or mixed with 2% modified volcanic tuff).

**Table 1.** Accumulation of heavy metals (Cu, Cr, Ni, Pb) in the aerial parts of the *Lolium perenne* cultivate on the *C+T* and *C+T+B* experimental lots

| ***Nr. crt.*** | ***Heavy metals*** | ***Content of heavy metals in Lolium Perenne aerial plant tissue [mg/kg D.M.]*** | | | |
|---|---|---|---|---|---|
| | | ***Harverst I 19.08.2010*** | | ***Harvest II 15.10.2010*** | |
| | | ***Lot C+T*** | ***Lot C+T+B*** | ***Lot C+T*** | ***Lot C+T+B*** |
| ***0*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** |
| 1 | Iron | 343,3 | 306,1 | 383,9 | 223,6 |

| *0* | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|
| 2 | Copper | 1,9 | 1,8 | 2,9 | 2,5 |
| 3 | Chromium | 3,2 | 1,8 | 3,2 | 1,3 |
| 4 | Nickel | 1,9 | 1,1 | 3,0 | 3,5 |
| 5 | Lead | 0,1 | 0,4 | - | - |
| 6 | Zinc | 10,4 | 10,4 | 28,3 | 37,2 |
| 7 | *Cu+Cr+Ni+Pb** | *7.1* | *5.1* | *9.1* | *7.2* |

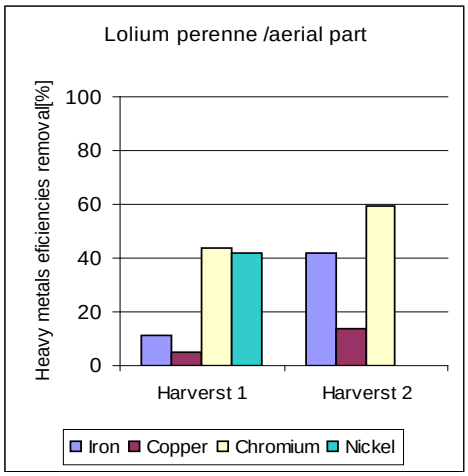
***** Cumulative amount of toxic metals Cu + Cr + Ni + Pb

**Table 2.** Accumulation of heavy metals (Cu, Cr, Ni, Pb) in the aerial parts of the *Onobrychis vicifolia* cultivated on the *C+T* and *C+T+B* experimental lots

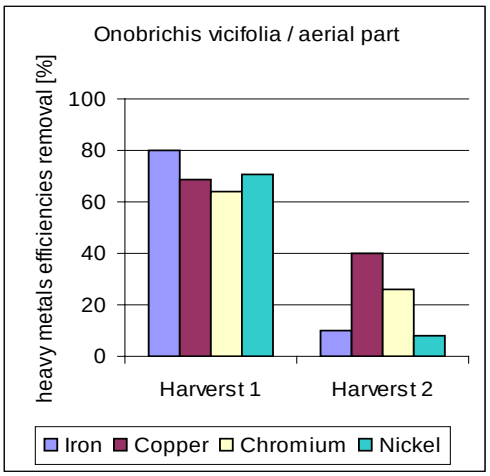
| ***Nr. crt.*** | ***Heavy metals*** | ***Content of heavy metals in Onobrochis viciifolia aerial plant tissue [mg/kg D.M.]*** | | | |
|---|---|---|---|---|---|
| | | ***Harverst I 19.08.2010*** | | ***Harverst II 15.10.2010*** | |
| | | ***Lot C+T*** | ***Lot C+T+B*** | ***Lot C+T*** | ***Lot C+T+B*** |
| 1 | Iron | 1059,0 | 205,9 | 775,0 | 705,0 |
| 2 | Copper | 4,9 | 1,5 | 12,5 | 7,5 |
| 3 | Chromium | 7,0 | 2,5 | 5,0 | 3,7 |
| 4 | Nickel | 4,5 | 1,3 | 3,0 | 2,8 |
| 5 | Lead | - | - | - | - |
| 6 | Zinc | 33,3 | 31,2 | 35,0 | 45,0 |
| *7* | *Cu+Cr+Ni+Pb** | *16.4* | *5.3* | *20.5* | *14.6* |

* Cumulative amount of toxic metals Cu + Cr + Ni + Pb

Influence of modified volcanic tuff added to the organic fertilizer in order to reduce the heavy metal accumulation of iron, copper, chromium and nickel from the *Lolium perenne* and *Onobrychis viciifolia* aerial tissues of plant is shown in Figure 1.




a)




b)

**Figure 1.** Influence of modified volcanic tuff added to the organic fertilizer in order to reduce the heavy metal accumulation of iron, copper, chromium and nickel from the *Lolium perenne* and *Onobrychis viciiifolia* aerial plant tissues

Tables 1 and 2 and Figure 1 reveal the following:

- the accumulation of heavy metals in the aerial tissue of the mature *Onobrychis viciifolia* was higher than the accumulation of heavy metals in the *Lolium perenne*;
- the accumulated amount of Cu+Cr+Ni+Pb in *Onobrychis viciifolia* was 2 times higher than the accumulated amount of heavy metals in *Lolium perenne,* except of the crop from the *C+T+B* lot;
- the zeolite material added to the used fertilizer led to the reduction in the Fe, Cu, Cr and Ni content in the aerial part of the *Lolium perenne* and *Onobrychis viciifolia.* tissues, at various rates;
- the accumulated amount of heavy metals in the aerial part of the plants was higher for the second harvest as compared to the first harvest, for similar experimental conditions;
- the aerial part of the *Onobrychis viciifolia* did not absorb lead while the *Lolium perenne* accumulated it in extremely small amounts, only in certain phenophases;
- the amount of zinc in the aerial tissue of *Lolium perenne* and *Onobrychis viicifolia* rose after the first harvest but the accumulation did not exceed the highest admissible value for plants.

## CONCLUSIONS

The addition of organic zeolites as biofertilizers is more efficient for the decrease in the accumulated amount of iron, copper, chrome and nickel, as compared to the addition of chemical fertlizers.

The monitoring of the crops grown on fly ash soils in optimal circumstances established by treatment with biosolids associated with tuff

enriched Al-clinoptilolite based natural zeolites allows accrual of data with relevance to the accumulation of metals in the aerial parts of the plants.

The cultivation of the industrial plants is considered to be a feasible option for the reclamation of heavy metals polluted sites for many reasons:

- cover of the ash deposits and limiting the spreading of pollutants into the surrounding areas;
- fertilization of poor soils with nutrients resulting from the decay of the vegetal residues.

The decrease in the metal bioaccumulation rate of in the plants cultivated on fly ash deposits resulting from coal power plants, by treatment with biosolid organic fertlizers enriched with modified local volcanic tuff is not sufficient for the biomass that may get into the trophic chains by means of the ecosystem lifeforms. The addition of tuff leads to a decrease in the metal accumulation in the aerial parts of the *Lolium perenne* of 20-28%, and an up to 3 times higher reduction for the *Onobrychis viciifolia.* Despite all this, the accumulation of metals in plants occurs. The accumulated amount of heavy metals (chromium, copper, nickel and lead) in the aerial part of *Onobrychis viciifolia.,* which in this case can reach up to 14.6-20.4 mg/kg dried matter has to be taken into account. Therefore, it is necessary either to carry on studies for the identification of materials which can reduce the transfer of metals from soil into plants or to remove this bioaccumulating species.

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