THE EFFECT OF ASH FROM THERMAL POWER STATION ON THE HEAVY METAL CONTENT OF *FESTUCA ARUNDINACEA* AND *FESTUCA PRATENSIS*

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ABSTRACT
Due to its biological activities, adsorption and absorption properties, the soil can function as a cleaning system for many industrial pollutants in moderate concentrations. Because of the microelement content of ash, it can be used for improvement of acid soils or with microelement deficit. The present paper describes the possibilities of using thermal power station ash as amendment and source of microelements for two gramineous species, used as forage and energetic plants. For the experiment design we used randomized blocks with 3 repetitions. The ash was incorporated in soil before sowing of *Festuca arundinacea* and *Festuca pratensis* species. Experimental variants were the following: V_0 – 0 t/ha non-treated control, V_1 – 1 t/ha, V_2 – 3 t/ha and V_3 – 5 t/ha ash. Plant samples were collected from the above-ground organs, one year after sowing. Heavy metal content was determined using atomic absorption spectroscopy method. Regarding the metal content, the data show that the application of ashes in different dosages had similar effects on both of the gramineous species. The zinc content decreases slightly with the increase of ash dosage at both of the species. Compared to control variant, the copper content increases directly with the amount of applied ash at *Festuca arundinacea* and decreases at *Festuca pratensis*. Cobalt, nickel and manganese concentrations presented an increase due to higher ash concentrations at both of the plant species compared to control. From all of the assessed metal contents, manganese presented the highest concentrations in plants. The concentrations are low compared to non-treated control, thus there was no toxicity effect of the studied heavy metals from thermal power station ashes.

Keywords: *Festuca arundinacea, Festuca pratensis,* thermal power station ash, heavy metals

INTRODUCTION

The problems of using ashes from thermal power stations has been discussed worldwide, especially in countries which use since a long time coal as fuel in thermal power stations and dispose of huge quantities of ashes. Utilization of ashes in agriculture for treating different categories of soils, can be a way to use high quantities of this waste product (OROS, 2002). Due to its biological activities, adsorption and absorption properties, the soil can function as a cleaning system for many industrial pollutants in moderate concentrations. Because of the microelement content of ash, it can be used for improvement of acid soils or with microelement deficit. Besides there is the unburned coal, which could determine a certain increase of organic content of some extremely poor soils. Due to its natural alkalinity and very high active surface, ash has a great capacity of neutralizing acidity (CAPITANU, 1999, RETHMAN, 2001). Though these materials can be used as amendment on some soils, when applied in high quantities, some types of ashes, especially those with increased heavy metal content, can be harmful to plants. In this framework, the present paper approaches the possibilities of using ashes from ash pits as amendment and source of microelements for two gramineous species important as forage and energy culture, without determining a significant accumulation of heavy metals in these plants.

MATERIAL AND METHOD

For researches we used eumezobasic brown soil – vertic, moderately gleic, with alkalization in depth, strongly cogged up on medium/fine river deposits, medium clay/medium clay-loam, with low pH on the superior layer (pH = 5.20). Humus content of the soil profile shows low values (2.42% in the 0 - 38 cm layer). For the experiment design we used randomised blocks with 3 repetitions. The thermal power station ash (pH = 8.10) was collected from the 0-30 cm layer of Utvin ash pit of the Southern Thermal Power Station of Timisoara, "CET Timisoara Sud", which is situated in an area not covered by vegetation, containing recently deposited ash. The ash was applied before sowing and after a disc harrowing. The ash was applied manually then incorporated in the soil with drill. No herbicides were used. 5 days after ash application sawing was realized in rows. Plant material consisted in *Festuca arundinacea* Schreb., Brio variety and *Festuca pratensis* Huds., Tâmpa variety. For each plant species, experimental variants were the following: V_0 – 0 t/ha non-treated control, V_1 – 1 t/ha, V_2 – 3 t/ha and V_3 – 5 t/ha ash. Plant samples were collected from the above-ground organs (leaves and stems), one year after sowing. Heavy metal content was determined from homogenized samples using atomic absorption spectroscopy method (with flame), at Banat University of Agricultural Sciences and Veterinary Medicine of Timisoara, Romania. After calcination to raw ash in porcelain capsules at 525±25°C in a calcinatory with thermal control, the samples were dissolved in HCl. The solution was sprayed into the air-acetylene flame of an atomic absorption spectrophotometer. The absorbance of radiation was measured at the specific wavelength for each element. The data were subjected to analysis of variance using ANOVA.

RESULTS

Regarding the heavy metal content, statistical analysis of data shows that the application of ashes in different dosages had similar effects on both of the gramineous species. At *Festuca arundinacea* the concentration of zinc decreased with 2.97% when 1 t/ha ash was applied, with 4.38% at 3 t/ha and with 5.56% at 5 t/ha ash treatment compared to control variant (*Table 1*).

Table 1. Effect of ashes on the zinc content in *Festuca arundinacea* Schreb. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	18.51	-	100	
1 t/ha ash	17.96	-0.55	97.03	-
3 t/ha ash	17.70	-0.81	95.62	-
5 t/ha ash	17.48	-1.03	94.44	-

LSD 5% = 1.27 LSD 1% = 1.93 LSD 0.1% = 3.09 [mg]

Table 2. Effect of ashes on the copper content in *Festuca arundinacea* Schreb. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	11.00	-	100	
1 t/ha ash	11.27	0.27	102.45	-
3 t/ha ash	11.47	0.47	104.27	*
5 t/ha ash	11.70	0.70	106.36	**

LSD 5% = 0.43 LSD 1% = 0.65 LSD 0.1% = 1.05 [mg]

The copper concentration increased with 2.45% when 1 t/ha ash was applied, with 4.27% at 3 t/ha and with 6.36% at 5 t/ha ash treatment compared to control variant (*Table 2*).

Table 3. Effect of ashes on the cobalt content in *Festuca arundinacea* Schreb. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	2.43	-	100	
1 t/ha ash	2.46	0.03	101.23	-
3 t/ha ash	2.47	0.04	101.65	-
5 t/ha ash	2.50	0.07	102.88	-

LSD 5% = 0.19 LSD 1% = 0.28 LSD 0.1% = 0.45 [mg]

The other metal contents also increased, as follows: at 1 t/ha ash treatment cobalt content increased with 1.23%, nickel with 6.43% and manganese with 3.72%; at 3 t/ha, cobalt content increased with 1.65%, nickel with 8.19% and manganese with 4.15%; at variants where we applied 5 t/ha ash, cobalt content increased with 2.88%, nickel with 9.36% and manganese content increased with 9.74%, compared to control non-treated variant (*Tables 3, 4 and 5*).

Table 4. Effect of ashes on the nickel content in *Festuca arundinacea* Schreb. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	1.71	-	100	
1 t/ha ash	1.82	0.11	106.43	-
3 t/ha ash	1.85	0.14	108.19	*
5 t/ha ash	1.87	0.16	109.36	*

LSD 5% = 0.11 LSD 1% = 0.17 LSD 0.1% = 0.27 [mg]

Table 5. Effect of ashes on the manganese content in *Festuca arundinacea* Schreb. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	153.11	-	100	
1 t/ha ash	158.80	5.69	103.72	**
3 t/ha ash	159.47	6.36	104.15	**
5 t/ha ash	168.03	14.92	109.74	***

LSD 5% = 3.45 LSD 1% = 5.23 LSD 0.1% = 8.40 [mg]

The concentration of heavy metals in Meadow fescue increased with the increase of ash dosages, with the exception of zinc and copper, but the differences between variants were low or even extremely low in case of some elements.

Table 6. Effect of ashes on the zinc content in *Festuca pratensis* Huds. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	18.58	-	100	
1 t/ha ash	18.03	-0.55	97.04	-
3 t/ha ash	17.70	-0.88	95.26	-
5 t/ha ash	17.17	-1.41	92.41	o

LSD 5% = 1.14 LSD 1% = 1.73 LSD 0.1% = 2.78 [mg]

Compared to control variant, the zinc concentration decreases with 2.96% at 1 t/ha ash variant, with 4.74% in case of 3 t/ha variant and with 7.59% when 5 t/ha ash was applied (*Table 6*).
The copper concentration in plants also decreased, as follows: with 1.55% at 1 t/ha variant, with 3.82% at 3 t/ha variant and with 3.91% at 5 t/ha variant compared to control (*Table 7*).

Table 7. Effect of ashes on the copper content in *Festuca pratensis* Huds. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	11.00	-	100	
1 t/ha ash	10.83	-0.17	98.45	-
3 t/ha ash	10.58	-0.42	96.18	-
5 t/ha ash	10.57	-0.43	96.09	-

LSD 5% = 1.11 LSD 1% = 1.68 LSD 0.1% = 2.70 [mg]

Table 8. Effect of ashes on the cobalt content in *Festuca pratensis* Huds. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	2.33	-	100	
1 t/ha ash	2.37	0.04	101.72	-
3 t/ha ash	2.42	0.09	103.86	-
5 t/ha ash	2.47	0.14	106.01	*

LSD 5% = 0.11 LSD 1% = 0.17 LSD 0.1% = 0.28 [mg]

Table 9. Effect of ashes on the nickel content in *Festuca pratensis* Huds. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	3.24	-	100	
1 t/ha ash	3.29	0.05	101.54	-
3 t/ha ash	3.31	0.07	102.16	-
5 t/ha ash	3.33	0.09	102.78	-

LSD 5% = 0.32 LSD 1% = 0.48 LSD 0.1% = 0.77 [mg]

Table 10. Effect of ashes on the manganese content in *Festuca pratensis* Huds. plants (mg/kg D.M.)

Variant	Content (mg/kg S.U.)	Differences (mg)	Differences %	Significance
Control (0 t/ha ash)	146.44	-	100	
1 t/ha ash	151.80	5.36	103.66	*
3 t/ha ash	153.45	7.01	104.79	**
5 t/ha ash	161.60	15.16	110.35	***

LSD 5% = 4.44 LSD 1% = 6.72 LSD 0,1% = 10.80 [mg]

The other metal contents presented an increase, as follows: compared to control, at 1 t/ha variant the cobalt concentration increased with 1.72%, the nickel with 1.54% and the manganese with 3.66%; at 3 t/ha variant, the cobalt content increased with 3.86%, the nickel with 2.16% and the manganese with 4.79%; when 5 t/ha ash was applied, the cobalt content increased with 6.01%, the nickel with 2.78% and the manganese with 10.35% compared to control variant (*Tables 8, 9 and 10*). The manganese concentrations in all variants are also high compared those in *Festuca arundinacea*. The manganese content reached 161.6 mg/kg dry matter at variant treated with 5 t/ha ash.

CONCLUSIONS

The analysis of data showed that the two gramineous species presented the same reaction to different dosages of thermal power station ashes. At both species, the zinc concentration decreased only slightly with the increase of ash dosages. Compared to control variant, the copper concentration increased at *Festuca arundinacea* and decreased at *Festuca pratensis* with the application of ash treatments. The cobalt, nickel and manganese concentrations increased compared to control with the increase of ash dosages at both species. Of the analyzed heavy metals, the manganese presented the highest concentrations. The low differences in heavy metal content compared to non-treated control plants there was no problem with toxicity at the dosages we tested. It can be concluded that both of the *Festuca* species resist without difficulties to dosages of 5 t/ha (and even more) thermal power station ash, with the condition to be applied on soils with the same properties as used in our experiment. These two species are tolerant to even higher heavy metal concentrations, accumulating concentrations of 418.18 mg/kg zinc in shoots of *Festuca arundinacea* and average concentrations of 354.66 mg/kg zinc, on soils polluted with zinc salts (YANG, 2008, SIMON, 2005).

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