A STUDY REGARDING HEAVY METALS IN PERENNIAL GRASSES SPECIES HARVESTED FROM PERMANENT MEADOWS IN THE COPȘA MICĂ AREA, ROMANIA

Vera CARABULEA, Nicoleta Olimpia VRÎNCEANU, Bogdan Ștefan OPREA, Mihaela COSTEA, Georgiana PLOPEANU, Dumitru-Marian MOTELICĂ, Ionuț Daniel FUDULU

National Research and Development Institute for Soil Science, Agrochemistry and Environment, 61 Marasti Blvd, District 1, 011464, Bucharest, Romania,
E-mail: carabulea_vera@yahoo.com

Coressponding author: oprea.bogdan95@yahoo.com

Abstract
Copșa Mică is one of the areas known, at national and international level, with a high level of pollution, even though metallurgical activities have been stopped. Heavy metals contamination of the environment is a worldwide concern.
This study shows the content of heavy metals (Cd, Pb, Zn and Cu) in two species of perennial grass plants (Dactylis Glomerata L. and Festuca Rubra L.) from permanent meadows in the Copșa Mică area.
The estimation of heavy metal content is based on a data set made in 17 points for Dactylis Glomerata L. and 19 points for Festuca Rubra L. harvested from permanent grasslands at different distances from the pollution source. For Dactylis Glomerata L. the Cd content varies between 0.05 mg/kg and 1.21 mg/kg, the Cu values were between 2.80 mg/kg and 5.55. The content of Pb and Zn recorded values between 0.15 mg/kg and 49.6 mg/kg and 34.7 mg/kg and 122 mg/kg, respectively. In Festuca Rubra L., Cd values are between 0.04 mg/kg and 3.07 mg/kg, Cu – 0.29 mg/kg and 7.53 mg/kg. Lead (Pb) and zinc (Zn) values ranged between 0.1 mg/kg and 27.5 mg/kg and 25.8 mg/kg and 131 mg/kg, respectively.
The results of this study are important for the estimation of heavy metal accumulation in perennial grass species in permanent grasslands, which are consumed directly by animals and indirectly by the population.

Keywords: *heavy metals; pollution; perennial grasses;*

INTRODUCTION

Environmental pollution is a major problem that is among the main threats to soil and food and feed production (Toth et al., 2016).

Copșa Mică is one of the most polluted areas with heavy metals in Romania. Grazing in these areas affected by heavy metal pollution can raise serious health problems for animals as well as people in the area. In this area, various studies have been done on the heavy metal contents (Cd, Pb, Zn and Cu) in soil and plants (vegetables, fodder plants, trees) and show that sometimes they are higher than the maximum allowed limits (Vrîncenu et al., 2009; Gament et al., 2010; Vrîncenu et al., 2022). Therefore, various plant species in permanent grasslands, including perennial grasses, accumulate large amounts of metals.

The concern of the academic world regarding the accumulation of heavy metals in different species from the floristic composition of meadows is reflected in the numerous studies carried out on this subject worldwide (Marcin et al., 2016; Razanov et al., 2018; Castro-Bedriñana et al., 2021; Jócsák et al., 2022; Ma et al., 2022, De Vries et al., 2022).

Kryzak et al (2006) show that *Festuca* cultivars are good phytostabilizers for soils contaminated with heavy metals because they have good metal sorption properties in root tissues with high metal tolerance properties, and Khashij et al (2018) demonstrate that *Festuca* has a high capacity to absorb lead in the root and then transfer it to the upper organs. Studies by Wyszkowska et al (2022) show that *Festuca Rubra* has a stable calorific value that is not modified by high concentrations of heavy metals (Ni, Co, Cd) and can be grown on soils contaminated with heavy metals, and its aerial biomass can be used to generate energy. High accumulation of zinc and cadmium does not affect the growth yield of *Festuca* plants (Żurek et al., 2013).
Tomaškin et al (2013) shows that the concentration of heavy metals increases with increasing altitude.

MATERIALS AND METHODS

This paper presents a study carried out in 2023, regarding the accumulation of heavy metals (Cd, Cu, Pb and Zn) in perennial grasses (*Dactylis Glomerata L.* and *Festuca Rubra L.*) in permanent meadows in the Copșa Mică area. Recognized area with a high degree of history thanks to the two industrial platforms SOMETRA and CARBOS.
The estimation of heavy metal accumulation in *Dactylis Glomerata L*. and *Festuca Rubra L.* plants was carried out on the basis of 17 and 19 samples respectively from the localities: Copșa Mică, Axente Sever, Târnava, Micăsasa and Valea Viilor (Figure 1).
Dactylis Glomerata L. perennial herbaceous plant, forms rare bushes with a tall stem, with broad leaves, provided with a large ligule, well-developed root system. It is considered the most valuable species among perennial grasses, with a high productivity index. Grows well after mowing and grazing, very early.
Festuca Rubra L. perennial herbaceous plant tall stem, reddish-brown, with 4-7 greenish-purple flowers. It is widespread in dry places from the hill region to the lower alpine floor. A good forage plants. Sensitive to drought, very resistant to frost and grazing.
The plant samples were identified and harvested in the field, then dried in an oven, chopped and milled. Plant samples were treated with nitric acid in a microwave digestion system. The total heavy metal content (Cd, Cu, Pb and Zn) was measured using atomic absorption spectrometry (Flame GBC 932AA or Graphite furnace GBC SavanatAAZ). Microsoft Excel 2010 was used for statistical data processing.

RESULTS AND DISCUSSIONS

Some of the most common grass plants are *Dactylis Glomerata L*. and *Festuca Rubra L.* in the study area. The studied area includes five localities: 7 samples were collected from Copșa Mica, 6 samples from Axente Sever, 2 samples from Târnava and one sample each from Micăsasa and Valea Viilor for *Dactylis Glomerata L.* 8 samples were collected for *Festuca Rubra L* from Axente Sever, 4 each from Copșa Mică and Valea Viilor, 2 from Târnava and one from Micăsasa (Figure 2).
At the level of the European Union according to EU Directive 2005/87/CE and in Romania according to Ord. 18/2007 supplemented by Ord. 19/2009 for the approval of sanitary, veterinary and food safety of animal feed and unwanted substances, setting some maximum permissible limits by National Veterinary and Food Safety (ANSVSA), they are presented in Table 1.

Figure 1 – Copsa Mica area (Original photo).

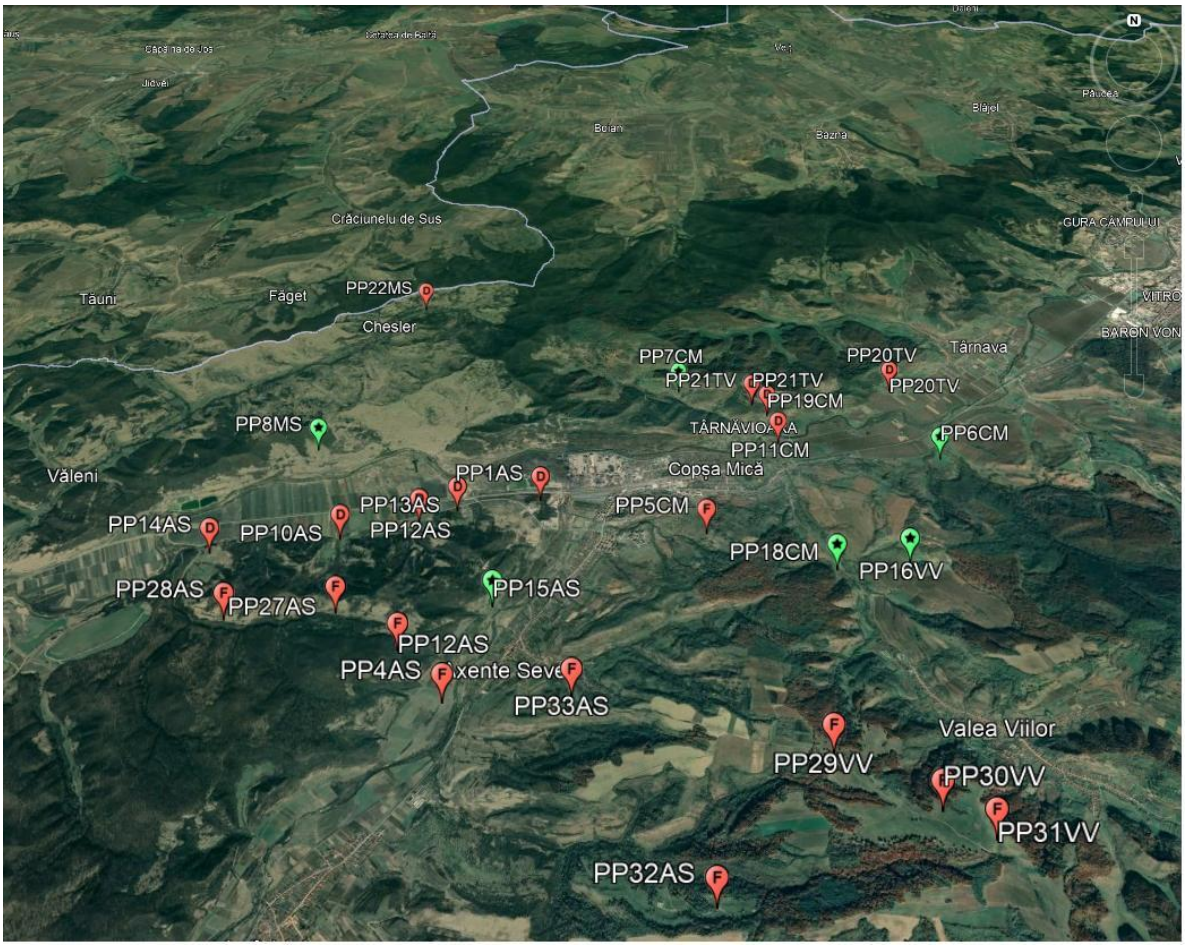

Figure 2 – The location studied in the Copsa Mica area (Source: Google maps).

The characterization of heavy metals in the 17 plant samples (*Dactylis Glomerata L*.) collected from the permanent grasslands are presented in Table 2.

The content of cadmium in orchardgrass (*Dactylis Glomerata L*.) planes varies 0.05 mg/kg (minimum) and 1.21 mg/kg (maximum) and an average value of 0.48 mg/kg. The maximum values of cadmium exceed the maximum limit allowed in green plants according to EU Directive 2005/87/EC AND Ord. ANSVSA. 18/2007. Lead values range from 0.15 mg/kg to 49.6 mg/kg, with an average of 5.03 mg/kg. According to EU Directive 2005/87/EC, the maximum lead values are above the maximum allowed limit in green fodder. Zinc content is 34.7 minimum and 67.38 maximum, with an average of 67.38 mg/kg dry matter. The Cu content varies between 2.80 mg/kg and 5.55 mg/kg, and the arithmetic mean is 4.17 mg/kg.

The content of heavy metals in *Festuca Rubra L.* plants are shown in table 3. The content of Cd varies between 0.04 mg/kg (minimum) and 3.07 mg/kg (maximum), with an arithmetic mean of 0.84 mg/kg. The maximum Cd content exceeds the maximum limit allowed according to EU Directive 2005/87/EC which is 1 mg/kg. Wyszkowska (2022) shows that *Festuca rubra* has a considerable accumulation factor on cadmium-contaminated soils. Values lead range from 0.10 mg/kg to 27.5 mg/kg and an arithmetic mean of 2.43 mg/kg. Zinc values range between 25.8 mg/kg (minimum) and 131 mg/kg (maximum), with an average of 74.01 mg/kg. The copper content in *Festuca Rubra L.* varies between 0.29 mg/kg and 7.53 mg/kg, and the average is 4.12 mg/kg. After the average values, higher concentrations of Cd and Zn accumulated in *Festuca Rubra L.* plants and higher values of Pb and Cu in *Dactylis Glomerata L* plants. The concentration of heavy metals in *Dactylis Glomerata L.* and *Festuca Rubra L*. plants had the following pattern: Zn>Cu>Pb>Cd.

Table 1. Maximum limits allowed in feed (mg/kg) for Pb and Cd according to Directive EU 2005/87/EC and Ord. ANSVSA 18/2007

Substance	Product intended for animal feed	Maximum content in mg/kg with 12 % humidity
Lead (Pb)	Feed materials except: green fodder	30
Cadmium (Cd)	Feed materials of plant origin	1

Table 2. Values of cadmium, lead, zinc, copper contents in *Dactylis Glomerata L.* (n=17)

Variable	Cd	Pb	Zn	Cu
	mg/kg DW			
Minimum	0.05	0.15	34.7	2.80
Maximum	1.21	49.6	122	5.55
Arithmetic mean	0.48	5.03	67.38	4.17

Table 3. Values of cadmium, lead, zinc, copper contents in *Festuca Rubra L.* (n=19)

Variable	Cd	Pb	Zn	Cu
	mg/kg DW			
Minimum	0.04	0.10	25.8	0.29
Maximum	3.07	27.5	131	7.53
Arithmetic mean	0.84	2.43	74.01	4,12

CONCLUSIONS

This study shows that *Dactylis Glomerata L.* and *Festuca Rubra L.* can accumulate a large amount of heavy metal. The closer the harvesting point is to the pollution source, the higher the heavy metal content of the plant. The concentration of heavy metals in *Dactylis Glomerata L*. and *Festuca Rubra L.* plants had the following pattern: Zn>Cu>Pb>Cd. Higher concentrations of Cd, Zn and Cu accumulated in *Festuca Rubra L*. plants and higher concentrations of Pb in *Dactylis Glomerata L*.

These results are important for estimating the accumulation of heavy metals in perennial grass species in permanent grasslands, which are consumed directly by animals and indirectly by the population.

ACKNOWLEDGEMENTS

This work was funded by two projects of the Ministry of Research, Innovation and Digitalization from Romania, project number PN 23 29 04 01, entitled: “Assessment of the heavy metals bioaccumulation in meadows vegetation using the regression analysis to develop a guide of good practices for grazing and animal feedstock in areas affected by industrial pollution” and project number 44 PFE /2021, Program 1 – Development of the national research and development system, Subprogram 1.2 – Institutional performance – CDI Excellence Funding Projects.

REFERENCES

Castro-Bedriñana, J., Chirinos-Peinado, D., Garcia-Olarte, E., Quispe-Ramos, R. (2021). *Lead transfer in the soil-root-plant system in a highly contaminated Andean area*. *PeerJ*, *9*, 10624.

Commission Directive 2005/87/EC of 5 December 2005 amending Annex I to Directive 2002/32/EC of the European Parliament and of the Council on undesirable substances in animal feed as regards lead, fluorine and cadmium.

De Vries, W., Römkens, P.F.A.M., Kros, J., Voogd, J.C, and Schulte-Uebbing, L.F., (2022). *Impacts of nutrients and heavy metals in European agriculture. Current and critical inputs in relation to air, soil and water quality*, ETC-DI, 72 p.

Gament, E., Carabulea, V., Plopeanu, G., Vrinceanu, N., Ulmanu, M., Anger, I. (2010). Hot areas polluted with heavy metals. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series*, *40*(1), 391-398.

Jócsák, I., Knolmajer, B., Szarvas, M., Rabnecz, G., Pál-Fám, F. (2022). *Literature Review on the Effects of Heavy Metal Stress and Alleviating Possibilities through Exogenously Applied Agents in Alfalfa* (*Medicago sativa L*.). Plants, 11, 2161.

Khashij, S., Karimi, B., Makhdoumi, P. (2018). *Phytoremediation with Festuca arundinacea: a mini review*. International Journal of Health and Life Sciences, *4*(2).

Krzyżak, J., Lane, T., Czerwińska, A. (2006). *The potential use of Festuca cultivars and lignite for phytostabilization of heavy metal polluted soils*. In Chemicals as Intentional and Accidental Global Environmental Threats, 367-374.

Ma, T., Zhang, Y., Hu, Q., Han, M., Li, X., Zhang, Y., Li, Z., Shi, R. (2022). *Accumulation Characteristics and Pollution Evaluation of Soil Heavy Metals in Different Land Use Types: Study on the Whole Region of Tianjin*. Int. J. Environ. Res. Public Health 19, 10013.

Marcin W.W., Kapusta, P., Stefanowicz. A.M. (2016). *Variation in dry grassland communities along a heavy metals gradient*. Ecotoxicology 25:80-90.

Razanov, S.F., Tkachuk, O.P., Mazur, V.A., Didur, I.M. (2018). *Effect of bean perennial plants growing on soil heavy*

metal concentrations. Ukrainian Journal of Ecology 8(2), 294-300.

Sandeep, G., Vijayalatha, K. R., Anitha, T. (2019). *Heavy metals and its impact in vegetable crops*. *Int J Chem Stud*, 7(1), 1612-1621.

Tomaškin, J., Tomaškinová, J., Kmeťová, J., Drimal, M. (2013). *The concentration of heavy metals in grassland ecosystems of the central Slovakia national parks*. Carpathian Journal of Earth and Environmental Sciences, *8*(4), 35-40.

Toth, G., Hermann, T., Szatmári, G., Pászto, L. 2016. *Maps of heavy metals in the soils of the European Union and proposed priority areas for detailed assessment*. Science of the Total Environment 565:1054–1062.

Vrinceanu, N., Motelica, D. M., Dumitru, M., Gament, E. (2009). *Zinc accumulation in soils and vegetation of polluted area Copșa Mică.* Annals Food Science and Technology, 10(2), 630-634.

Vrînceanu, N. O., Motelică, D. M., Costea, M., Oprea, B. Ș., Plopeanu, G., Carabulea, V., Tănase, V., Preda, M. (2022). *Cadmium accumulation in some leafy vegetables from private gardens in Copșa Mică.* Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering, Vol. XI, Online ISSN 2393-5138, ISSN-L 2285-6064.

Wyszkowska, J., Boros-Lajszner, E., Kucharski, J. (2022). *Calorific value of Festuca rubra biomass in the phytostabilization of soil contaminated with nickel, cobalt and cadmium which disrupt the microbiological and biochemical properties of soil*. Energies, 15(9), 3445.

www.ansv.ro Ordin nr. 18 din 1 februarie 2007 Norme sanitar veterinare şi pentru siguranţa alimentelor privind substanţele nedorite din hrana animalelor completat cu Ordinul 19 din iunie 2009 privind modificarea şi comletarea Ordinului preşedintelui Autorităţii Sanitar Veterinare şi pentru Siguranţa Alimentelor nr. 18/2007 Pentru aprobarea Normei sanitare veterinare şi pentru siguranţa alimentelor privind substanţele nadorite din hrana animalelor.

Żurek, G., Pogrzeba, M., Rybka, K., Krzyżak, J., Prokopiuk, K. (2013). *The effect of heavy metal contaminated soil on growth and development of perennial grasses*. In E3S Web of Conferences, Vol. 1, p. 13006.