ZINC ACCUMULATION IN SOILS AND VEGETATION OF POLLUTED AREA COPŞA MICĂ

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Abstract
The study carried out in order to estimate the distribution and accumulation of zinc in soils and vegetation from Copşa Mică area used a radial network centered in the source of pollution – S.C. SOMETRA S.A. Copşa Mică. Soil and plant samples taken from the radial nodes of the network were analyzed to determine the content of zinc. Values of zinc content in plant ranged between 41 mg/kg and 3162 mg/kg. Based on these results has been obtained a regression equation that estimates the zinc content in plants as function of the total zinc content in soil. The spontaneous vegetation developed in the investigated area includes plants belonging to the following species: Amaranthus retroflexus, Artemisia vulgaris, Asclepias syriaca, Calamagrostis epigeios, Calamagrostis pseudophragmites, Cynodon dactylon, Daucus carota, Equisetum pratense, Phragmites australis, Picris hieracioides, Setaria glauca, Sinapis arvensis, Verbascum phlomoides and Xanthium strumarium. The high concentrations of heavy metals do not significantly affect the development of vegetation.

Keywords: zinc, accumulation, soil, plant, Copsa Mica

1. INTRODUCTION

The main polluters in the Sibiu county were for a long time industrial platform Copşa Mică especially SOMETRA - producer of zinc, lead, cadmium and ferrous alloys and CARBOSIN - producer of carbon black, a product used in manufacturing tires. Emissions from these two companies were affected for a long time area and so Copşa Mică town became a sick and black city. In 1993 the area affected by heavy metal pollution covered about 180750 ha [3].
The enrichments in the soils lead to inadvertent and accelerated transfer of heavy metals through the food chain. It has been reported that the concentration of an element in plant tissue increases in proportion to its concentration in soil [2].
One of the main pollutants identified in the polluted area is zinc. This element, like copper, has an important role in the development of plants and animals. Deficiency or presence in excessive amounts in soil can seriously affect the development of living organisms. At elevated concentrations, Zn is toxic to soil microorganisms and plants and may adversely affect soil fertility and crop yield [4].

The objective of this study was to estimate the distribution and accumulation of Zn in soils and vegetation from polluted area Copşa Mică.
The estimation of Zn accumulation and distribution in plants was achieved by means of the power regression curves.

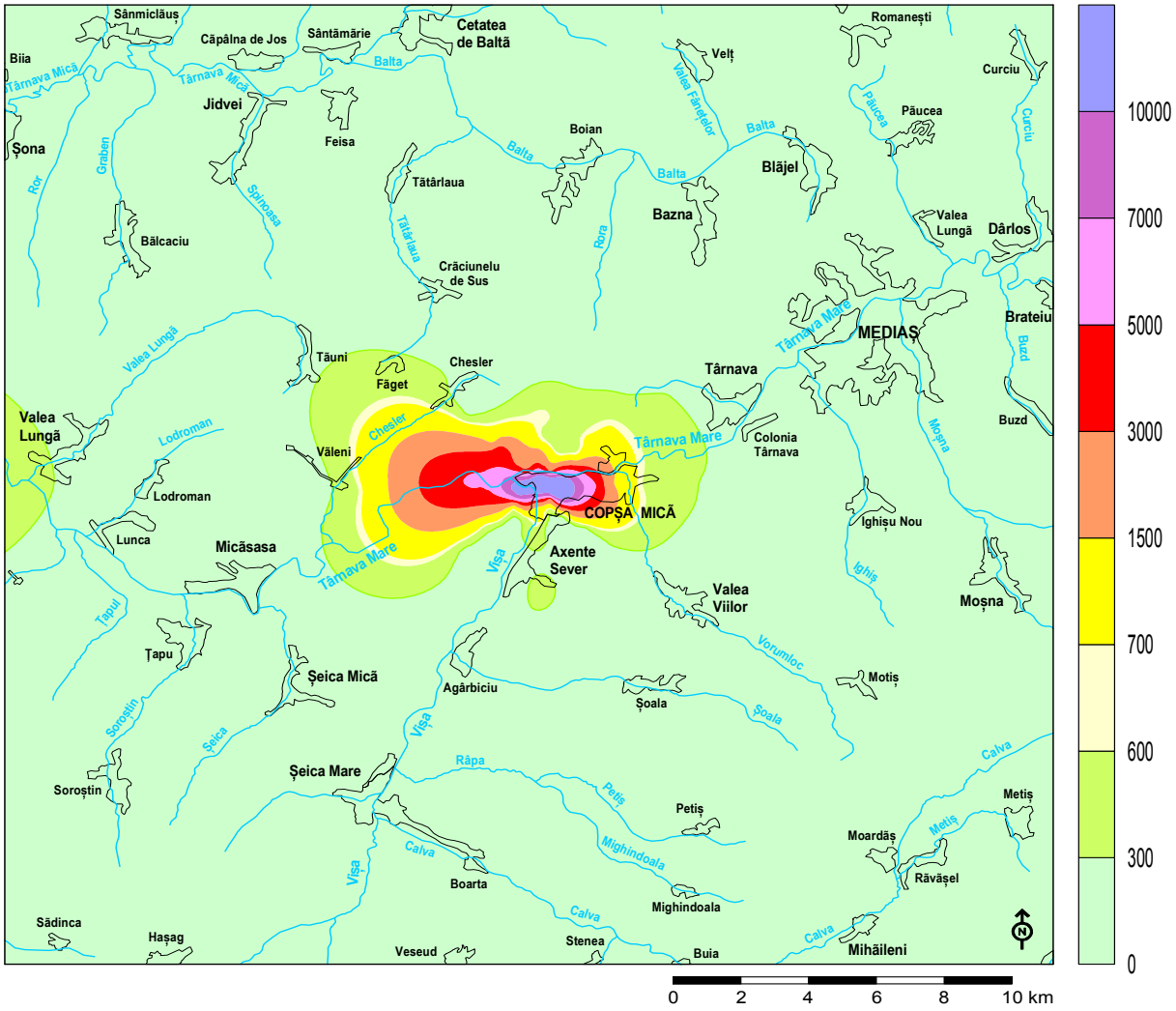
2. MATERIALS AND METHODS

The sampling of soil was done on a radial network of 103 collection sites. Plant samples were harvested from the same points with the soil samples. The plant samples were collected from agricultural crops, pastures, meadows and spontaneous vegetation.
The total zinc content was measured with flame atomic absorption spectrometer in hydrochloric solution resulted by digestion of soil samples in $HClO_4$-HNO_3 mixture.).
The map representing mathematical modeling of content values was obtained using the program Surfer, version 8.
The power regression curves were used to estimate the accumulation and distribution of zinc in plant.

3. RESULTS AND DISCUSSIONS

The estimation obtained by interpolation of content values indicate exceedances of the alert

threshold for zinc, in 0-20cm layer of soil for about 7040 ha in Copşa Mica area (*Plate 1*).



Total zinc content (mg/kg)	Estimated area (ha)
= 300 [a]	89060
301 – 600 [b]	3760
601 – 700 [c]	480
701 – 1500 [d]	1280
1501 – 3000	720
3001 – 5000	480
5001 – 7000	120
7001 – 10000	80
> 10000	120

Total zinc content (mg/kg)	Estimated area (ha)
> 300 [a]	7040
> 600 [b]	3280
> 700 [c]	2800
> 1500 [d]	1520
> 3000	800
> 5000	320
> 7000	200
> 10000	120

[a] – alert threshold for sensitive use of land

[b] – intervention threshold for sensitive use of land

[c] – alert threshold for less sensitive use of land

[d] – intervention threshold for less sensitive use of land

Plate 1. Spatial distribution of zinc in soil estimated by interpolation of values obtained in the nodes of a radial network (0–20 cm layer, Copşa Mică, 2005)

Exceeding of intervention threshold established for sensitive use of land (600 mg/kg) was reported on 3280 ha. The area where the values of zinc content in soil are higher than intervention threshold for less sensitive use (1500 mg/kg) covered about 1520 ha. An important part of Copşa Mică town is located in highly polluted area, that fact could be an major threat to population health.

The highest value of total zinc content in soil was determined in sample collected from site located approximately 0.5 km East of the pollution source. The trend of variation estimated with a power-regression equation indicates that the values of total zinc content in layer 0-20 cm decrease below the intervention threshold at distances higher then 3 km but remain above the alert threshold to about 5 km from the source. The highest values of zinc contents in soil were determined for soils located on West direction at distances lower than 4 km from source (*Figure 1*).

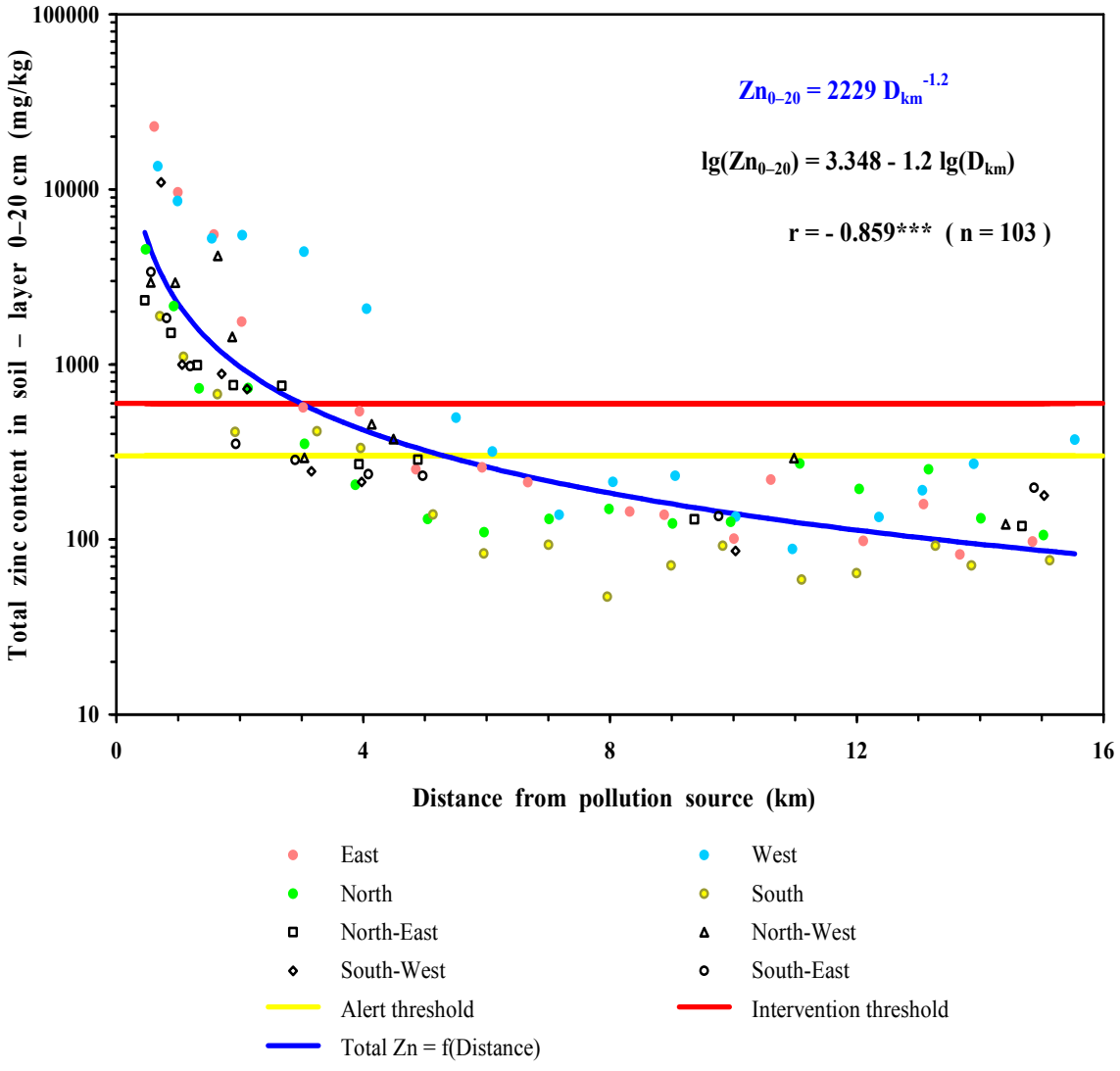


Figure 1. Total zinc content in soil as a function of the distance from pollution source – S.C. SOMETRA S.A. (Copşa Mică, 0–20 cm layer)

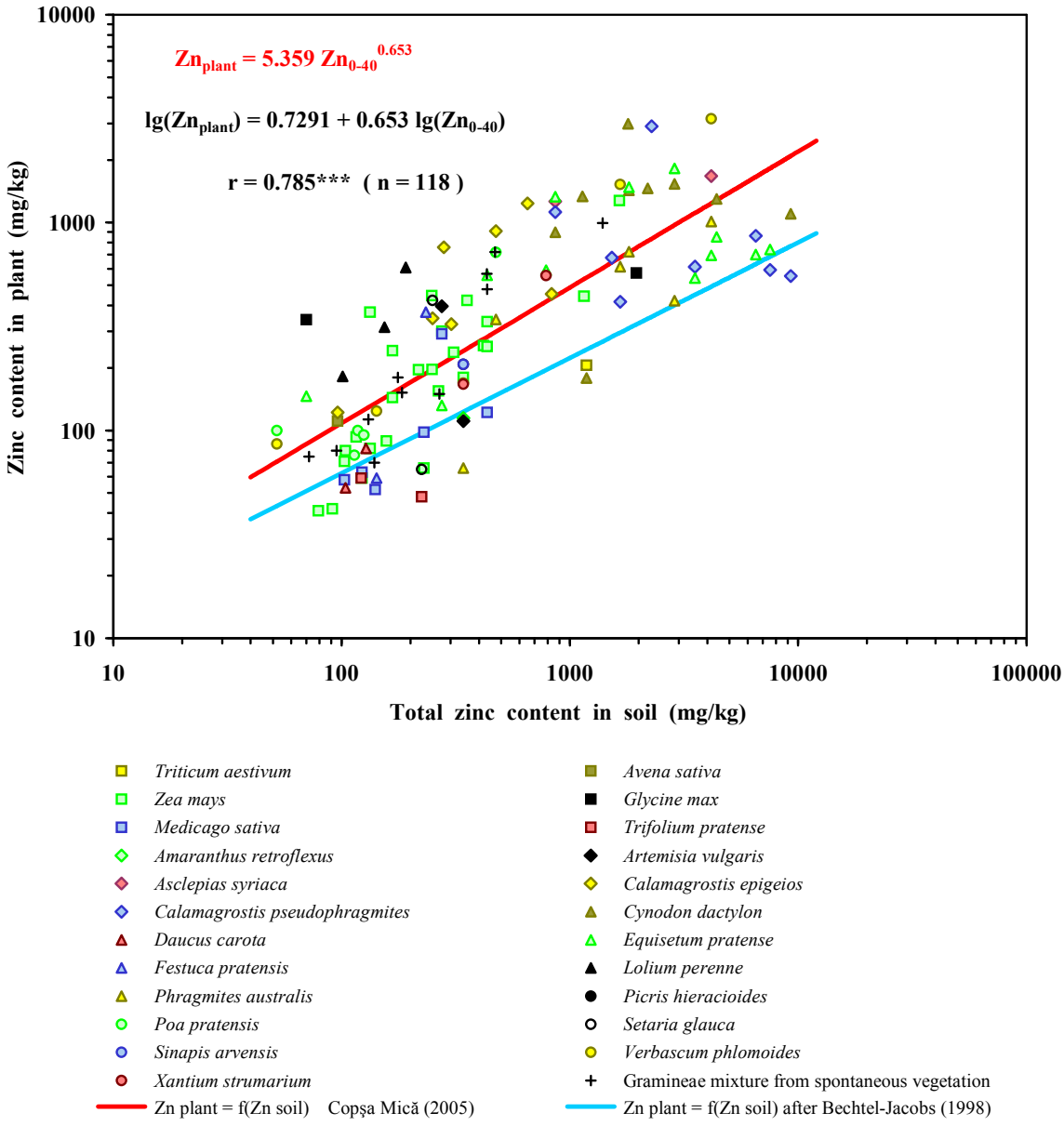


Figure 2. Log-log diagram for two power regression curves that estimate the stochastic dependency between total zinc content in soil and zinc content in plant

The main crops identified in the investigated area were: maize (*Zea mays*), wheat (*Triticum aestivum*), oats (*Avena sativa*), soybean (*Glycine max*), alfalfa (*Medicago sativa*) and red clover (*Trifolium pratense*).

From spontaneous vegetation of Copşa Mică area were collected plants belonging to the following species: *Amaranthus retroflexus, Artemisia vulgaris, Asclepias syriaca,*

Calamagrostis epigeios, Calamagrostis pseudophragmites, Cynodon dactylon, Daucus

carota, Equisetum pratense, Phragmites australis, Picris hieracioides, Setaria glauca, Sinapis arvensis, Verbascum phlomoides and Xanthium strumarium.

The regression curve obtained on the basis of determinations made on samples from Copşa Mica (2005) was compared with that obtained from a research study made by [1].

It is noted the differences between these two regression curves proposed to estimate zinc content of plants depending on total metal content of soil (*Figure 2*).

Zinc content in plants ranged from 41 mg/kg to 3162 mg/kg. The highest value was determined for plants of Verbascum phlomoides harvested from 1.5 km West from the source of pollution. Maize leaves harvested from 15 km East from the pollution source had the lowest content of zinc (41 mg / kg).

The plants identified and harvested from areas where the total content of zinc in soil (0-40cm) exceeded 6000 mg/kg belong to following species: *Equisetum pratense*, *Cynodon dactylon* and *Calamagrostis pseudophragmites*. These plants have adapted to stressful conditions induced by excessive levels of heavy metals in soil managing to grow even in such a hostile environment.

It is noted the ability of plants to limit the transfer of zinc in aboveground part by inactivation of this pollutant in roots. *Phragmites australis* is a plant species recognized as able to tolerate high levels of zinc in soil [5]. In studied area were identified some *Phragmites australis* plants that have developed on a soil with a total zinc content higher than 4000 mg/kg. These plants accumulated amounts of zinc in the aboveground part about 3 times lower than plants of *Verbascum phlomoides* harvested from the same site (1011 mg/kg compared to 3162 mg/kg).

With regard to agricultural crops, values of zinc content in plant ranged between 41 mg/kg and 1273 mg/kg. The lowest value of zinc content was determined in maize leaves the plants were grown on soil with a relatively low content of zinc (79 mg/kg). Maize plants harvested at 1 km SE from the source were the most polluted (1273 mg/kg). Worrying is the fact that these plants were cultivated near a residential district in Copşa Mică. Long-term consumption of products with high content of heavy metals may damage the health of the population.

4. CONCLUSIONS

In Copşa Mică area soil pollution with zinc remains at high levels. The zinc content in soil in very polluted area (up to 5 km from the source of pollution) exceeded the intervention threshold (600 mg/kg) imposed by the Order 756/1997.

In the very polluted area were identified plant species able to accumulate zinc in tissues in excessive amounts without adverse effects on the general development of the plant (*Asclepias syriaca, Cynodon dactylon, Calamagrostis pseudophragmites, Equisetum pratense, Verbascum phlomoides*).

Estimated zinc content in plant according to the total zinc content in soil using the suggested regression equation can sometimes lead to erroneous results, but is particularly useful in the early stages of a risk assessment in the Copşa Mica area.

5. REFERENCES

[1] [1] Bechtel - Jacobs,. Empirical models for the uptake of inorganic chemicals from soil by plants, Bechtel-Jacobs Company LLC, Oak Ridge, TN.BJC/OR-133, 1998.
[2] Chen W., Krage N., Wu L., Pan G., Khosrivafard M.,
[3] Chang A.C.,. Arsenic, cadmium and lead in California cropland soils: role of phosphate and micronutrient fertilizers, Journal Environmental Quality, 2008; 37: 689-695.
[4] Toti M., Răuță C., Dumitru M., Căpitanu V., Gamenț
[5] E., Zelinschi C.,. Evoluția fenomenului de poluare cu metale grele şi oxizi de sulf în zona Copşa Mică, Analele ICPA, 1993, LII: 255-266.
[6] Voegelin A., Topka G., Jacquat o., Barmettler K., Kretzschmar R.,. Zinc fraction in contaminated soils by sequential and single extractions: influence of soil properties and zinc content, Journal Environmental Quality, 2008; 37: 1190-1200.
[7] Ye Z.H., Baker A.J.M., Wong M.H., Willis A.J.,. Zinc, lead and cadmium tolerance, uptake and accumulation by the common reed, Phragmites australis (Cav.) Trin. ex Steudel. Annals of Botany., 1997, 80:363-370.