THE INTERACTION BETWEEN ENVIRONMENTAL TEMPERATURES AND HEAVY METALS (Cu, Zn, Pb, Cd, Ni) ACCUMULATION IN FOLIAR TISSUE OF *Tillia cordata* Mill. ORNAMENTAL TREES FROM CLUJ-NAPOCA TOWN

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Abstract. *Air pollution is an essential issue for the environment and society in general. Tilia is a genus of over 20 species of deciduous trees that occur in forests in Europe, Asia and North America. Tilia varieties from Romania are frequently planted as ornamental trees in urban plantations along city streets. The spread of fungi depends practically on the weather conditions. The humidity and the active solar radiation influence the development of these pathogens more than the temperature. These spots usually become evident from the end of June to August. Infections of the leaves that begin at the beginning of the growing season can lead to premature defoliation. The points on the leaves frequently increase in number and size in late summer and early fall, as the leaves begin to fall. If it occurs over two or more successive years, it can seriously weaken a tree, reduce its growth, and increase its susceptibility to losing bark, injury and other diseases. The aim of this study is to emphasize the interactions between the concentrations of the heavy metals quantified in the foliar tissue of the linden trees and temperature, in specific conditions of different locations of Cluj-Napoca town, characterized by a series of different potential pollution sources. For the quantification of Cu, Zn, Pb, Cd and Ni from the leaf tissue of the Tilia cordata Mill. trees, monitored, the atomic absorption spectrometer (AAS) was used, respectively a Perkin-Elmer atomic absorption spectrometer (Perkin-Elmer, USA) with flame and graphite furnace. Data were statistically processed with STATISTICA v.8.0 for Windows. Throughout the experimental period, 2019, the increase of the pollution level does not positively influence the increase of the accumulations of Zn in the leaf tissue of the Tilia cordata Mill. trees taken in the study, in all experimental locations. The bioaccumulation capacity, however, positively favors the accumulations of Cu and Ni, but does not influence the bioaccumulations of Pb and Cd.*

Keywords*: environment, heavy metals, pollution*

INTRODUCTION

Tilia is a genus of over 20 species of deciduous trees that occur in forests in Europe, Asia and North America (BRÉDA AND BADEAU, 2008). Tilia varieties from Romania are frequently planted as ornamental trees in urban plantations along city streets. Then, the trees are susceptible to diseases caused by fungi. The diseases that fall among them are the staining of the leaves. Leaf stains are the most common diseases of ornamental trees (DE JAEGERE ET AL., 2016; LESTRADE ET AL., 2013) . Most of these diseases are favored by cold weather, light and thick rain, fog, high humidity and crowded or shady plantations (OPINCARIU ET AL., 2018). Many of the leaf diseases are caused by fungi, which attack one species of tree or more species.

The spread of fungi depends practically on the weather conditions. The humidity and the active solar radiation influence the development of these pathogens more than the temperature. These spots usually become evident from the end of June to August. Infections of the leaves that begin at the beginning of the growing season can lead to premature defoliation (PIGOTT ET AL, 1989; SEMAŠKIENĖ, 2006)). The points on the leaves frequently increase in number and size in late summer and early fall, as the leaves begin to fall. If it occurs over two or more successive years, it can seriously weaken a tree, reduce its growth, and increase its susceptibility to losing bark, injury and other diseases (RADOGLOU ET AL., 2009 ; VAINIO ET AL, 2009). According to the EEA (2017), air pollution is an essential issue for the environment and

society in general. It is also a complex problem that imposes multiple challenges regarding the management harmful pollutants in the atmosphere, in order to mitigate their presence. Atmospheric pollutants may come from both natural and anthropogenic sources (TOMOHIRO AND MASAAKI, 2002). They are considered as causing important health problems (EUROPEAN ENVIRONMENT AGENCY, 2008; KHAN ET AL., 2008). Toxic heavy metals, such as Cu, Cd, Pb and Ni, are primarily responsible for air pollution (HAN ET AL., 2007; JIN ET AL., 2010). Concerning often found as air pollutants. The level of the concentrations of these pollutants in the air are closely linked to certain industrial installations in and around urban areas (CAI, 2007; SPOKES AND JICKELLS, 1995).

The aim of this study is to emphasize the interactions between the concentrations of the heavy metals quantified in the foliar tissue of the linden trees and temperature, in specific conditions of different locations of Cluj-Napoca town, characterized by a series of different potential pollution sources.

MATERIAL AND METHODS

The experiment was conducted during April 1, 2019 - September 30, 2019, in the municipality of Cluj-Napoca.

The leaf tissue of the chestnut tree species constituted the biological material taken into account during the experiments. In the field, the observations were made in 6 experimental points, in which there are ornamental trees belonging to the species *Tilia cordata* Mill., respectively:

- 1, in the vicinity of the Air quality monitoring station located on Aurel Vlaicu Street;
- 2, in the vicinity of the Suburban type air quality monitoring station located on Boulevard 1 December 1918;
- 3, in the vicinity of the urban air quality monitoring station located on Boulevard 1 December 1918;
- 4, in the USAMV Campus Cluj-Napoca;
- 5, in the vicinity of the Suburban type air quality monitoring station located on Constanța Street, and
- 6, Central Park of Cluj-Napoca. The air quality monitoring stations are located by the Cluj Environmental Protection Agency.

The samples were harvested twice a week during the experimental period. Immediately after harvesting, the leaf tissue samples were transported to the USAMV Cluj-Napoca Environmental Quality Monitoring Laboratory.

The samples were processed as soon as their reception was performed, in order to determine the dry substance, by the gravimetric method. Temperature data were collected from the Cluj Environmental Protection Agency

For the quantification of Cu, Zn, Pb, Cd and Ni from the leaf tissue of the *Tilia cordata* Mill. trees, monitored, the atomic absorption spectrometer (AAS) was used, respectively a Perkin-Elmer atomic absorption spectrometer (Perkin-Elmer, USA) with flame and graphite furnace. Data were statistically processed with STATISTICA v.8.0 for Windows.

RESULTS AND DISCUSSIONS

Interaction between Cu, Zn, Pb, Cd, Ni concentrations in the leaf tissue of *Tilia cordata* Mill. and temperature, during the experimental period April - September, 2019, on the whole experimental locations, quantified with the help of the multiple regression analysis,

indicates that correlations of different degrees of intensity are recorded, from weak to medium and strong.

Thus, the strongest of the correlations (R = 0.715) is recorded between the accumulations of Pb and temperature, and the least intense, respectively a weak correlation, between Cd and temperature (R = 0.128), the interactions being described by the regression lines, which are available for more than 51% and 1.6%, respectively, of the situations registered in the experimental device (R^2 = 0.511 and R^2 = 0.016 respectively).

The regression lines show that the greatest accumulations of heavy metals are negatively influenced by the temperature increase with a different intensity depending on the metal species (Table 1).

Regarding Principal Component Analysis (ACP) applied for heavy metal concentrations, mg/kg, in the leaf tissue of *Tilia cordata* Mill., in all the experimental sites (April - September, 2019) it generated four main components, but only the degree of pollution and bioaccumulation capacity can be associated with the selection criterion, being responsible for 49.13% of the variance and 31.17% of the variance respectively (Table 2).

Table 1

The multiple correlations between the Cu, Zn, Pb, Cd și Ni, mg/kg concentrations identified, by experimental sites, in foliar tissue of *Tilia cordata* Mill., and temperature, °C (April – September, 2019)

Issue	R	R^2	Regression line
Cu - temperature	0.352	0.124	Y1 = 20.131 – 0.344 X
Zn - temperature	0.143	0.020	Y2 = 71.315 – 0.116X
Pb - temperature	0.715	0.511	Y3 = 73.129 – 0.781X
Cd - temperature	0.128	0.016	Y4 = 4.219 – 0.155X
Ni - temperature	0.568	0.323	Y5 = 9.407 – 0.558X

Y1 –Cu concentration; Y2 – Zn concentration; Y3 – Pb concentration; Y4 – Cd concentration; Y5 –Ni concentration; X – temperature. R –the coefficient of multiple correlation: R^2- the determination coefficient.

Table 2

Total variance explained for common factors action, 2017–2018

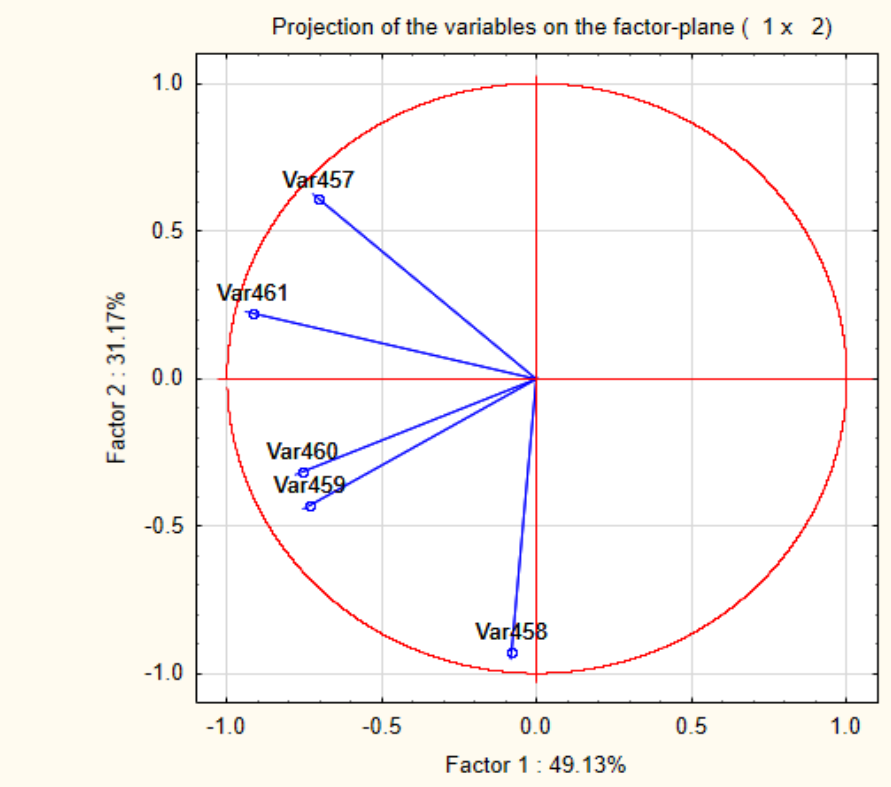
Factor	Initial Eigenvalues	% Total variance	Cumulative Eigenvalue	% Cumulative Eigenvalue
1	1.8779	37.5578	1.8779	37.5578
2	1.0670	21.3392	2.9449	58.8970
3	0.9230	18.4591	3.8679	77.3561
4	0.7733	15..4655	4.6412	92.8216
5	0.3588	7.1784	5.0000	100

Also, the Analysis of the Main Components (ACP), shows that, at the level of the city of Cluj-Napoca, during the experimental period April - September, 2019, the increase of the pollution level does not positively influence the increase of the accumulations of Zn in the leaf tissue of the *Tilia cordata* Mill. trees taken in the study, in all experimental locations. The bioaccumulation capacity, however, positively favors the accumulations of Cu and Ni, but does not influence the bioaccumulations of Pb and Cd (Fig. 1, Table 3).

Table 3

The components matrix

Issue	Factor 1	Factor 2
Var 457	-0.835	0.632
Var 458	-0.115	-0.956
Var 459	-0.713	-0.227
Var 460	-0.729	-0.427
Var 461	-0.895	0.319
Explained variance	1.8779	1.0670
Total variance	0.387	0.228



Var 457 – Cu concentration - experimental site 1, mg/kg; **Var 458** – Zn concentration - experimental site 2, mg/kg; **Var 459** – Pb concentration - experimental site 3, mg/kg; **Var 460** – Cd concentration - experimental site 4, mg/kg; **Var 461** –Ni concentration - experimental site 5, mg/kg;

Fig. 1. The patterns of principal and supplementary factors within PCA for Cu, Yn, Pb, Cd and Ni, mg/kg, concentrations in foliar tissue of *Tilia cordata* Mill., in all experimental sites (April – September, 2019)

CONCLUSIONS

Throughout the experimental period, 2019, the increase of the pollution level does not positively influence the increase of the accumulations of Zn in the leaf tissue of the *Tilia cordata* Mill. trees taken in the study, in all experimental locations. The bioaccumulation

capacity, however, positively favors the accumulations of Cu and Ni, but does not influence the bioaccumulations of Pb and Cd.

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