SEASONAL VARIATIONS OF HEAVY METAL CONTENTS IN LEAVES OF *PLATANUS ORIENTALIS* GROWING IN YEREVAN, ARMENIA

Lilit Khachatryan, Hasmik Hovhannisyan

Center for Ecological-Noosphere Studies NAS RA, Abovian - 68, Yerevan 0025, Armenia

Abstract

The research goal was studying seasonal variations in the contents of heavy metals in leaves of Platanus orientalis in Yerevan. Assessment of condition of the selected tree specimens was also included in the study. Leaf sampling was done in May and September 2015. Pb, Hg, Ni, Mo, Cu, Zn concentrations in pretreated samples were measured by the accepted atomic absorption method.

As indicated, concentrations of Pb, Hg, Mo are higher in the end of vegetation period. Besides, the leaves of studied Platanus orientalis sampled from Yerevan's southern, southwest and central districts are also high in Hg, Ni, Mo.

Key words: *platanus orientalis, heavy metals, urban environment pollution, seasonal variations, urban trees*

1. INTRODUCTION

One of major nature protection issues large cities come across at present is pollution of urban environment. It is well documented that heavy metals have been among most hazardous and most widespread environmental pollutants of modern cities (Wei et al., 2010). There exist natural and manmade sources of heavy metals. In urban areas such sources are mainly of manmade origin and include vehicles, traffic, different industrial enterprises, garbage dumps, municipal waste combution stations, urban construction sites, and so on. It is the sources via which heavy metals enter urban environment.

Lots of studies have indicated that toxic doses of heavy metals produce extremely harmful effects on living organisims and vegetation as well (Lippmann, 2009; Kabata-Pendias, 2011; Jaishankar et al., 2014; Buruiana et al., 2015; Pourkhabbaz et al., 2010; Doganlar et al., 2012). In urban people toxic doses of heavy metals cause serious cerebral, pulmonary, renal, hepatic disorders and dysfunction of other organs, induce infertility, mutagenesis and even cancer diseases (Mahurpawar, 2015; Duruibe et al., 2007). This fact makes it increasingly urgent to remove these health-threatening pollutants from urban environment. This can be done through development and application of appropriate cleanup technologies, but most of them are technically hard applicable and expensive. One of best cost-effective green technologies for removing toxic metals from urban environmental compartments such as soil, air and water is known to be phytoremediation. The technology is based on the use of ecologically high tolerant plants species having good metal-accumulation properties (Raskin et al., 1997).

Over recent decades massive tree cutting and chaotic construction throughout Yerevan, high levels of environmental pollution with different toxicants emphasizing heavy metals has brought to noticeable reduction of public green areas and finally to the loss of some tree species included in the assortment of Yerevan park and street plants, reduction in longevity and worsening of their condition (Danielian, 2007; Hovhannisyan et al., 2008). Heavy man-induced load adds to topicality of studies covering ecological tolerance of urban trees and improvement of efficiency of a health protecting and hygienic role they have.

Over 25 years the Biochemistry Department of the Center for Ecological-Noosphere Studies NAS RA (CENS) has been involved in studies of condition of green spaces in different cities of Armenia, specificities of pollutants uptake and accumulation in urban tree species, ecological tolerance of urban plants and the effect of pollutants (heavy metals, halogen and nitrogen compounds, etc.) on some bio-

physiological indices of urban plants. The obtained research data are transferred to state bodies and included in local urban greening programs.

This pilot research was designed to investigate seasonal variations in the contents of some heavy metals in the leaves of one of most widespread tree species in Yerevan - oriental plane-tree (*Platanus orientalis)* to identify management options to increase the efficiency of phytoremediation and to limit the associated risk of spread of heavy metals.

2. MATERIAL AND METHODS

2.1. Study site

This research was done in Yerevan – the capital of Armenia. Surrounded by mountain ridges, the ancient city with an area of 227sq.km and population of some 1.100.000 people sits in the heart of the Ararat Valley. The relief is strongly dissected, this largely influencing a process of formation of local climate. The city enjoys a sharply continental climate: long warm summer, short cold winter, short spring and the long fall. Averaged annual precipitation ranges 250 to 370mm (National Statistical Service of RA, 2015).

Yerevan is Armenia's biggest industrial and economic center which homes some 42.1% of all industrial enterprises of the Republic (National Statistical Service of RA, 2015) and has been under the impact of increasingly heavy traffic load.

So, key manmade factors having a negative impact on the status of Yerevan's environment are:

- Traffic,
- Industrial enterprises,
- Power and heat generating facilities,
- Housing and communal facilities,
- Construction.

Also, high levels of environmental pollution largely depend on geographical position of Yerevan as the city is set in a mountain valley with varying temperature and wind force; dust accumulation is also common.

2.2. Research material

Material for this research were leaves of *Platanus orientalis L.* sampled from 13 locations throughout Yerevan.

Platanus orientalis - one of indigenous species found in Armenia – is a 40-50m tall deciduous tree, a thermophyte and hydrophilic species measuring 1.5 to 3.5m in circumference and having palmately leaves with 5-7 lobes (Vardanyan, 2005). Selection of this tree is supported by the fact of its being the most widespread species in Yerevan. Besides, the tree has sufficiently high phytofiltration potential and is ecologically tolerant (Khachatryan and Hovhannisyan, 2014; Nersisyan and Hovhannsiyan, 2010; Hovhannisyan et al., 2008).

2.3. Methods

2.3.1. Assessing condition of study tree

Assessment of general condition of *P. orientalis* was based on visual observations. It took into account visual injuries of assimilatory apparatus of the trees, the amount of dried out branches, crown and trunk deformation, and other diagnostic indicators and was done using a 5-point assessment scale (Alekseev, 1989):

1st class - normal

2nd class - weakened

3rd class - severely weakened

4th class - drying

5th class - dried out

2.3.2. Sampling

Leaf sampling was done in May and September 2015 from 13 locations scattered throughout Yerevan (Fig.1).

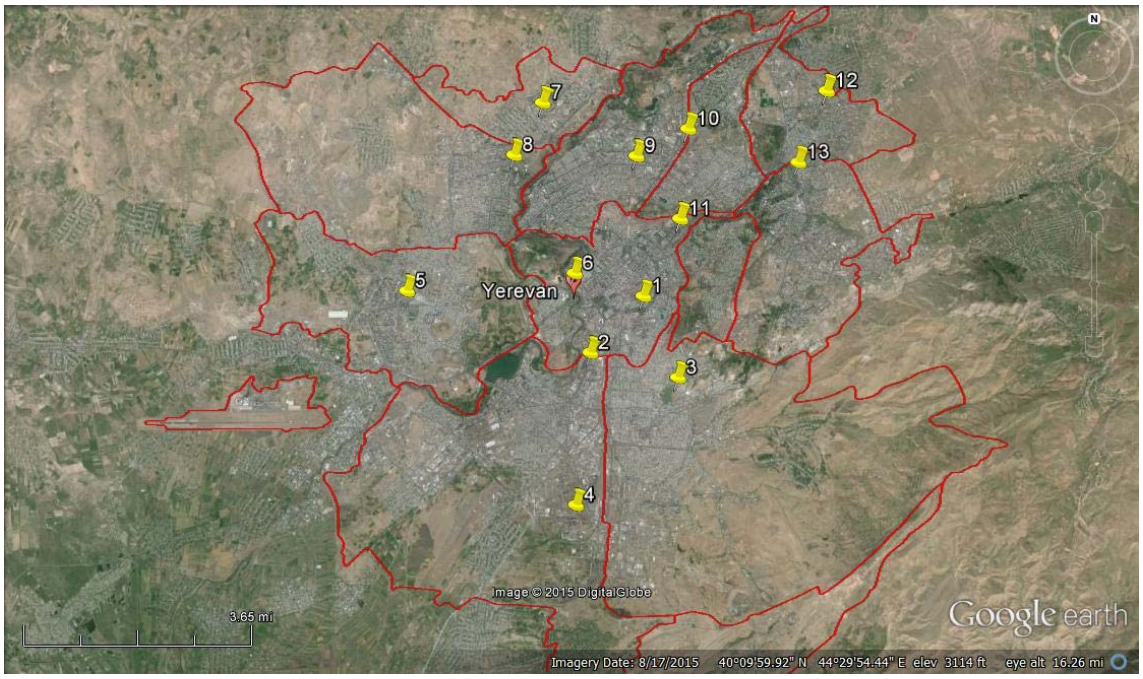


Fig.1. Position of sampling locations in Yerevan

On each of 13 locations we selected some 8-10m tall 2-3 tree specimens. From the central layer of different portions of a crown green, intact, fully mature leaves were sampled, 20-25 leaves per tree. After mixing the sampled leaves, we obtained a single averaged sample. Then the samples were placed in paper bags labeled with numbers and transported to the Central Analytical Laboratory CENS.

2.3.3. Chemical analysis

After undergoing lab pretreatment, the samples were analyzed to determine the contents of 6 heavy metals: Pb, Hg, Ni, Mo, Cu, Zn through the atomic absorption method (Aanalyst-800 PE USA). One should say, that heavy metals have been dominant pollutants of Yerevan plants and that recent results obtained by the staff of Biochemistry Department CENS have indicated high contents of that very set of 6 heavy metals provided above (Hovhannisyan et al., 2015; Nersisyan et al., 2010), so it is precisely the fact that explains selection of toxicants for this pilot research.

3. RESULTS AND DISCUSSION

3.1. Tree condition assessment results

The obtained assessment results have indicated that condition of 54% of a total amount of trees in May can be assessed as normal (1st class), that of 46% tree specimens in September - as weakened and 39%- as severely weakened (2nd and 3rd class according to the assessment scale). This presumably may be determined not only by the impact of man-made factors, but also by the final phase of vegetation period.

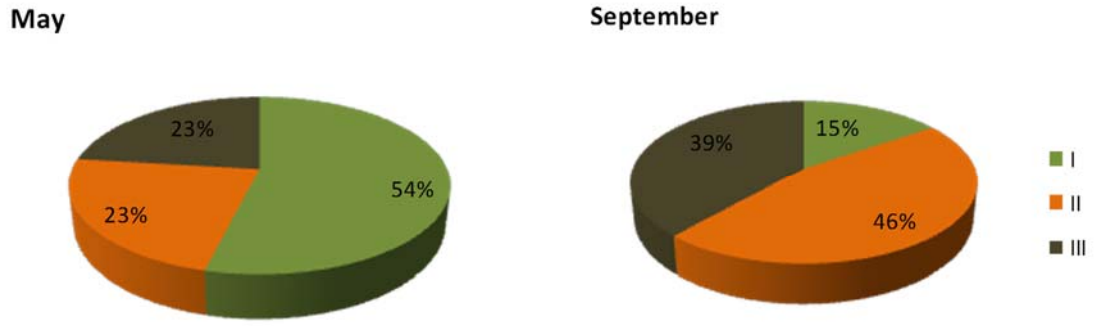


Fig. 2. *P. orientalis* condition assessment data

3.2. Chemical assessment

Chemical analysis of the collected leaf samples was done with an intention to determine seasonal peculiarities of heavy metal uptake by the studied oriental plane-tree leaves.

Sampling locations													
	1	2	3	4	5	6	7	8	9	10	11	12	13
Hg*	0.074	0.102	0.08	0.089	0.082	0.079	0.05	0.071	0.05	0.08	0.06	0.071	0.09
Pb	0.39	0.55	0.288	0.96	0.36	0.39	0.57	0.38	0.38	0.44	0.52	0.29	0.6
Ni	2.97	1.77	1.59	1.71	3.57	2.34	2.61	2.71	2.1	1.5	3.32	2.28	1.92
Mo	0.96	1.47	1.25	11.37	0.8	0.98	0.63	0.87	0.67	0.67	0.76	0.67	2.02
Cu	8.86	9.09	15.25	16.66	6.75	9.21	9.02	30.15	11.04	13.12	8.3	17.23	8.33
Zn	17.86	20.94	15.33	17	20.15	16.9	21.05	18.7	18.8	14.53	13.3	20	12.3

Table 1. Averaged concentrations of heavy metals in the leaves of *P. orientalis* growing in Yerevan, mg/kg.

Note: *the Accepted Standard Concentration (ASC) of elements according to Baker, mg/kg: Hg – 0.001-0.01; Pb – 0.1-5.0 ; Ni – 0.1-1.0 ; Mo – 0.2-1.0; Cu – 3.0-40.0; Zn – 15.0-150.0 .

The chemical analysis of the samples has indicated that oriental plane-tree leaves in Yerevan best acccumule Hg, Ni, Mo averaged concentrations exceeding the upper threshold of ASC (Tab. 1) by several times. Averaged concentrations of Hg exceeded the upper threshold of ASC by 5-10.2 times, Mo and Ni – by 0.63-11.3 and 1.5-3.5 times, respectively.

Fig. 3 provides a diagram of averaged total concentrations of Hg, Ni, Mo in the leaves of oriental plane-tree in Yerevan.

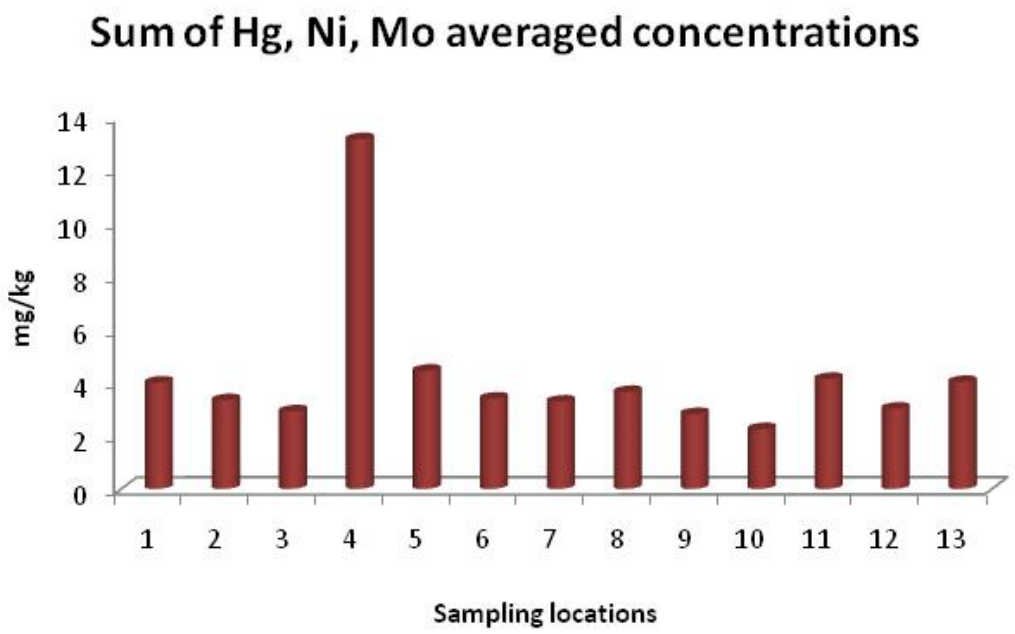


Fig. 3. Averaged total concentrations of Hg, Ni, M o in the leaves of *P. orientalis* in Yerevan, mg/kg.

As seen from the diagram, the highest concentrations were detected on location N4 (in the southern, industrial part of the city), N5, N11(in the southwest and center of the city). and N13 (in the northeast of the city).

Hg concentrations in all the plane-tree specimens on all the sampling locations exceeded both ASC (0.01mg/kg) and MAC (Maximum Acceptable Concentrations) values (0.04mg/kg). Averaged contents concentrations of the element were 1.25-2.5 times excessive vs. MAC.

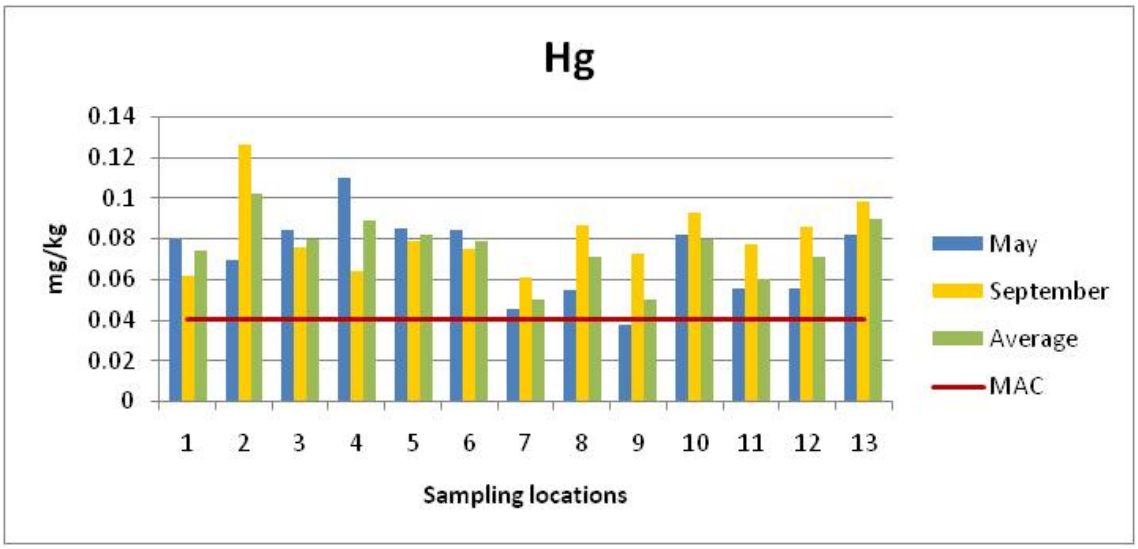


Fig. 4. Seasonal dynamics of Hg concentrations in the leaves of *P. orientalis* in Yerevan.

The highest concentrations of this hazardous element (a 2.4-3.2 times excess vs. MAC) were detected in September on sampling locations N2 and N13, respectively in the south and northeast of the city (Fig. 4).

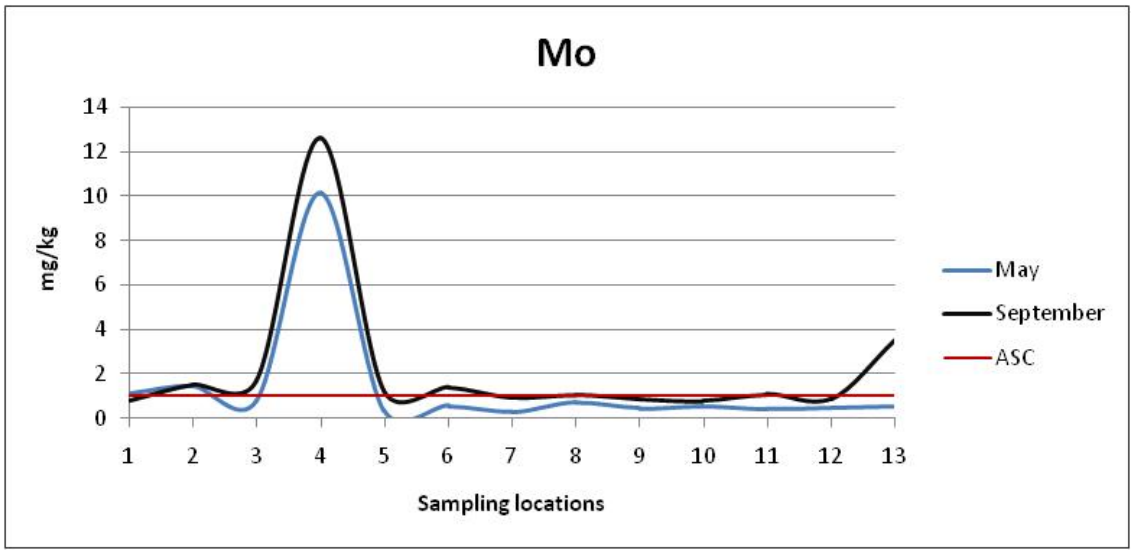


Fig. 5. Seasonal dynamics of Mo concentrations in the leaves of *P. orientalis* in Yerevan.

As seen from Fig. 5, the highest concentrations of Mo occurred in September and exceeded ASC value (1mg/kg) by 0.8-11.4times on 6 out of 13 sampling locations. Maximal concentration of Mo was found out in the oriental plane-tree leaves sampled from N4 situated in the industrial district which homes Yerevan power and heat generating stations, a set of chemical plants "Nairit" and two metallurgical plants: "Pure Iron" and Armenian Molybdenum Production, the latter being the major molybdenum pollution source to Yerevan.

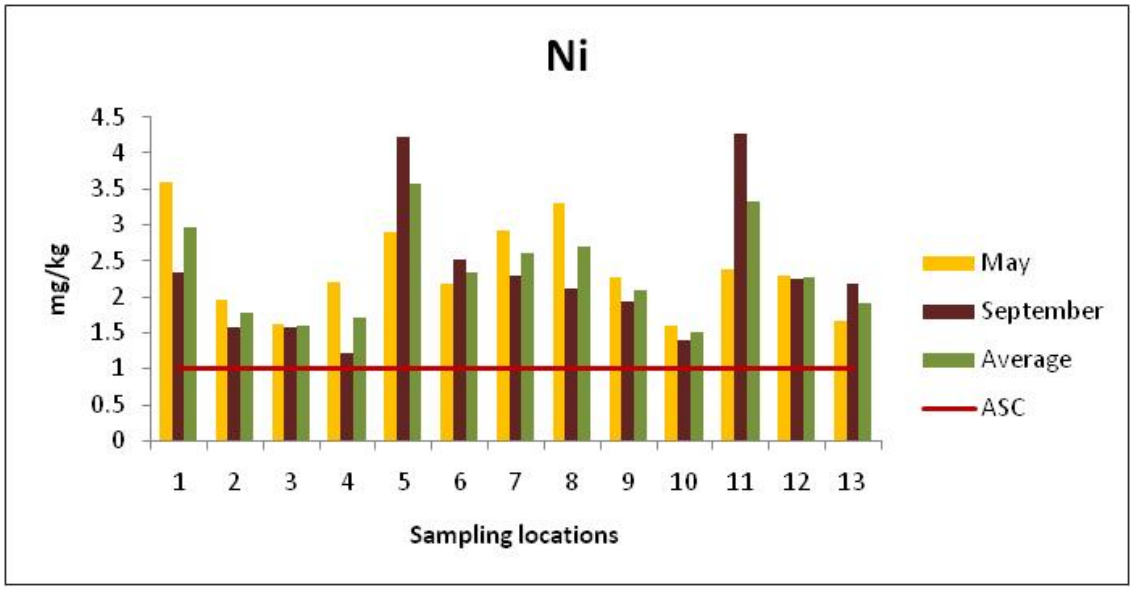


Fig. 6. Seasonal dynamics of Ni concentrations in the leaves of *P. orientalis* in Yerevan.

Ni concentrations in the leaves of all the studied oriental plane-tree specimens on all sampling locations exceeded the upper threshold of ASC (1mg/kg), averaged concentrations of the element for May and September overstepping ASC values by 1.5-3.6 times. Maximal concentrations (a 3.3-3.6 times excess) were established for N11 and N5 located respectively in the southwest and in the center of the city. However, in September the concentrations of Ni as compared with the rest of elements discussed above, decreased on 8 out of 13 sampling locations. This was particularly apparent in

respect of location N4 as Mo contents in leaves sampled from there were also high as described above. This phenomenon may presumably be determined by peculiarities of Ni-Mo relationships in metabolic processes in plants.

4. CONCLUSIONS

The obtained research data regarding seasonal dynamics of heavy metal accumulation in the leaves of oriental plane-trees in Yerevan enable us to conclude that

a) *Platanus orientalis* leaves accumulate highest concentrations of Hg, Mo, Ni, the averaged concentrations of which exceed the upper threshold of Accepted Standard Concentrations by 5-10.2; 0.63-11.3; 1.5-3.5 times, respectively.

b) Highest concentrations of Pb, Hg, Mo accumulate in oriental plane-tree leaves mostly in late September, whereas averaged contents of Cu, Zn, Ni decrease in September.

c) The highest concentrations of almost all elements are detected in the leaves of oriental plan-tree specimens growing on the south, southwest and central sections of city of Yerevan.

This pilot research was designed to support an extensive urban greening research Biochemistry Department CENS plans to launch in the near future. On its completion, a relevant database will be produced and statistical data analysis done.

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