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ECOLOGICAL ASSESSMENT OF ELM SPECIES IN YEREVAN, ARMENIA

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Abstract

The goal of this research was to provide an ecological assessment of one of the most widespread trees in Yerevan - elm tree (Ulmus minor Mill) and to investigate the contents of some heavy metals in its leaves. The state of the trees was assessed and the concentrations of the metals in the leaves were determined by atomic absorption analysis. Our studies have shown that 65.4% of the total studied plants were in poor condition and infected with pests. However, Ulmus minor has the ability to accumulate metals from the environment, especially Mo, Hg and Cu. It was revealed that elm green spaces on the streets of Yerevan need renovating and thorough sanitary care. The research results are presented to the city hall for the further development of measures to improve them.

Keywords and phrases

Ulmus minor, heavy metals, pollution, ecological assessment.

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Համառոտագիր

Այս հետազոտության նպատակն է Երևանի ամենատարածված ծառատեսակներից մեկի՝ թեղի տերևաշատի էկոլոգիական գնահատումը և տերևներում պարունակվող որոշ ծանր մետաղների ~~պարունակության~~ ուսումնասիրությունը: Գնահատվել է ծառերի վիճակը և որոշվել տերևներում մետաղների պարունակությունը ատոմաաբսորբցիոն եղանակով: Մեր ուսումնասիրությունները ցույց են տվել, որ ընդհանուր առմամբ, բույսերի 65.4%-ը գտնվում է անմխիթար վիճակում և վարակված է վնասատուներով: Այնուամենայնիվ թեղին օժտված է շրջակա միջավայրից մետաղներ՝ հատկապես Mo, Hg և Cu կլանելու հատկությամբ: Բացահայտվել է, որ Երևանի փողոցներում թեղու կանաչ տարածքները թարմացման և սանիտարական խնամքի կարիք ունեն: Հետազոտության արդյունքները ներկայացվել են քաղաքապետարան՝ դրանց բարելավմանն ուղղված հետագա միջոցառումների մշակման համար:

Բանալի բառեր և բառակապակցություններ
Թեղի տերևաշատ, ծանր մետաղներ, աղտոտում, էկոլոգիական գնահատական:

ЭКОЛОГИЧЕСКАЯ ОЦЕНКА ДЕРЕВЬЕВ ВЯЗА В ЕРЕВАНЕ(АРМЕНИЯ)

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Аннотация

Целью исследования является экологическая оценка одного из самых распространенных в Ереване деревьев – вяза мелколистого (Ulmus minor Mill) и изучение содержания некоторых тяжелых металлов в листьях. Оценено состояние деревьев и определены концентрации металлов в листьях методом атомно-абсорбционного анализа. Наши исследования показали, что 65,4% из общего числа изученных растений находились в плохом состоянии и были заражены вредителями. Тем не менее, вяз обладает способностью поглощать металлы из окружающей среды, особенно Mo, Hg и Cu. Выявлено, что зеленые насаждения вяза на улицах Еревана нуждаются в обновлении и тщательном санитарном уходе. Результаты исследования представлены в мэрию для разработки дальнейших мероприятий по их улучшению.

Ключевые слова и фразы
Вяз мелколистый, тяжелые металлы, загрязнение, экологическая оценка.

1. Introduction

Urban trees play an essential role in improving the environmental quality of cities and urban dwellers (Livesley et al.,2015; Nowak,2006). They provide a variety of environmental values, including the reduction of air pollution and greenhouse gas emissions, sequester carbon, regulation of air temperature, mitigation of stormwater runoff, reduction of noise, as well as the provision of recreational, social, psychological and aesthetic benefits (Roeland et al.,.2019). It is most important, especially for urban areas, because the urban environment is characterized by high levels of pollution by various toxicants. The main and particularly dangerous pollutants of cities are heavy metals due to their cytotoxic and mutagenic effect on all living organisms, including plants (Baker et al., 1975; Kabata-Pendias,2011; Sanesi et al. 2007). Therefore, researchers have shown an increased interest in indirect monitoring methods such as the response of living organisms to pollutants during recent years (Boquete et al., 2014).

Plant organisms are sensitive to the composition of the environment and actively react to changes in their condition. Trees can reflect the cumulative impacts of heavy metals contamination on ambient air and soil because transported pollutants through their roots and leaves can be accumulated during the time (Tomasevic et al.,2004; Sawidis et al., 2012). There is some evidence that trees play a crucial role in air pollution control through air filtering and can be considered as useful and cost-effective mitigation plan to protect vulnerable urban areas and to reduce human exposure to the anthropogenic pollutants (Escobedo et al. ,2008; Roloff et al.,2009; Dzierzanowski et al., 2011; Speak et al., 2012; Zhan et al., 2014; Liu et al., 2012, 2017). Therefore, using plant leaves primarily as accumulative biomonitors of heavy metals pollution has great ecological importance (WHO, 2000). Different plant species have different ability to accumulate pollutants, including heavy metals, and some species can be used as promising phytoremediants to reduce anthropogenic pollution (Calpafietra,2015; Sawidis et al. 2011). Ulmus (Elm) species are often used for urban greening according to their ecological features. It is important for Armenia's capital – Yerevan, which is characterized by a high, steadily increasing level of traffic induced and dust load. For many years dominant pollutants of all environmental compartments of the city have been heavy metals. (Saghatelyan A.K., 2005, Saghatelyan et al.,2013, Tepanosyan G.H.et al,2016).

Elm contains 20–45 species, mostly north temperate, concentrated in Eurasia and the mountains of tropical Asia. Ulmus species require moderately warm to moderately cold climatic condition and favour moist and fertile soils (Seneta l991). Elm is tolerant of exposure to atmospheric pollution, restricted growing conditions and pollarding, all commonly found in urban areas (Thomas et al., 2018). *U. minor (*field elm) was once widely cultivated across Europe in town and country, but owing to its susceptibility to Dutch elm disease (Sinclair and Lyon, 2005), *U. minor* is now uncommon in cultivation. However, several thousand surviving field elms have been tested for innate resistance by national research institutes in the EU, to return field elm to cultivation (Solla et al.,2005). It is the species most tolerant of drought and shade (Seneta l991). The elm (*Ulmus minor*), which is widespread in Armenia, was selected as the object of our research: it is bred as a forest, anti-erosion and park breed, and is widely used in green areas, especially in streets plantations of Yerevan (Vardanyan et al.,2015). Over the centuries, the introduction of plants into the territory of Armenia continued with varying intensity. It has remarkably been intensified since the end of the 18th century when construction of private and public gardens started in different regions of Armenia. During this period, numerous exotic plants were brought to Armenia, some of them, among which is *Ulmus minor Mill (old name U.foleacea)*, have survived to these days at the age of more than 200 years (Vardanyan, 2012). *U. minor* better tolerates droughts and severe winter frosts, but the negative side of elms is their susceptibility to many insects and fungal diseases. (Mittempergher, L.,2000; Zalapa et al., 2008; Urban J., Dvorak M.,2014, Zavyalov A.A., Iozus A.P, 2019; Thomas et al., 2018).

The goal of this research was providing an ecological assessment of one of the most widespread trees in Yerevan - elm tree (*Ulmus minor Mill*) and investigating the contents of some heavy metals in the leaves to identify management options, to increase the efficiency of phytoremediation and to limit the associated risk of the spread of heavy metals.

2. Material and methods

2.1. Study site

Studies were conducted in the green areas of Yerevan, the capital of Armenia. Yerevan covers an area of 223 km^2 (approximately 0.8% of the total area of the republic) and is a large industrial and administrative center. 40.9% of all the industrial enterprises and 37% of the total population of Armenia is concentrated here. The city is characterized by a high degree of traffic load and large-scale construction work. The relief of Yerevan is strongly dissected, largely influencing the process of the local climate formation. The city enjoys a sharply continental climate: long warm summers, short cold winters, short springs and long falls. Averaged annual precipitation ranges from 250 to 370 mm (National Statistical Service of RA, 2015). For recent decades the area of green spaces of Yerevan has been reduced dramatically in the result of intense construction works across the city followed by extensive cutouts, increasing levels of environmental pollution induced mainly by heavy traffic and lots of different-profile industries, and unmanaged garbage dumping. Finally, this affects both the quantity and quality of plants included in Yerevan green infrastructure to fulfil a recreational, aesthetic and vitally essential sanitary and hygienic role (Hovhannisyan, Nersisyan,2017). Today, the city faces an imperative to increase the amount of its green cover. This may be reached through the improvement and maintenance of the quality of the existing street and park tree species.

2.2. Research Methods

2.2.1. Assessing the condition of the study tree

Assessment of the general condition of *U. Minor* 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 realised using a 5-point assessment scale (Alekseev, 1989): the1st class – normal, the 2nd class – weakened, 3rd class - severely weakened, 4th class – drying, 5th class - dried out. A significant indicator of the condition of the trees was the degree of damage to the foliage, which was assessed in a 3-point scale: 1st -10-20% damage of the foliage, 2nd- 30-50%, 3rd- more than 50%.

2.2.2. Sampling

For the determination of heavy metals quantity on the foliage, the plant leaves were sampling in the mid of vegetation period (July) 2014 from 23 locations (21 streets plantation and 2 parks) scattered throughout Yerevan. (Fig.1). The study street sites were moderately polluted, located in the area of Yerevan, but with relatively heavy traffic resulting from a large number of cars and public transport during the study period.

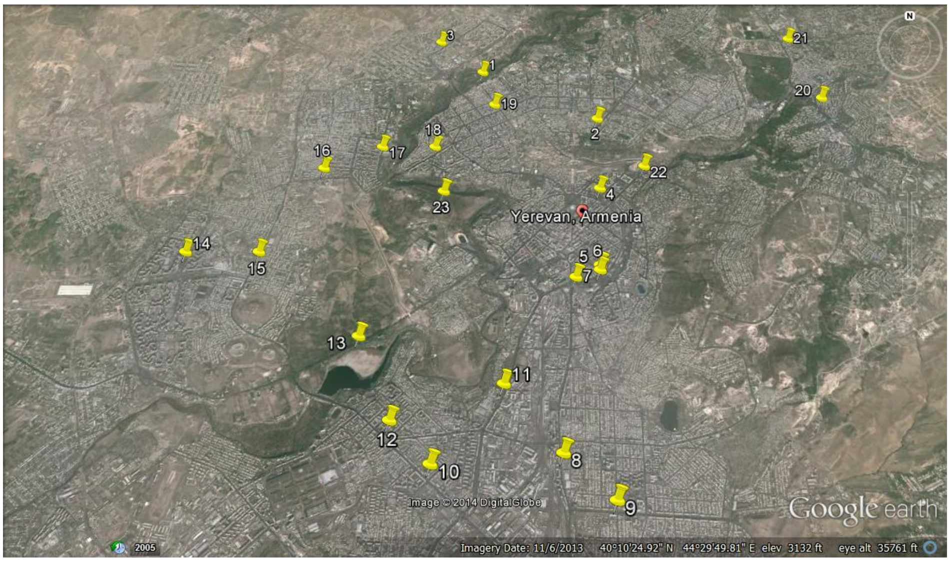


Fig.1. Position of sampling locations in Yerevan

The samples were collected from four plants (biological replications) at 1.5–1.7 m above the ground level. The distance between the sampled trees was 5–7 m, depending on the number of trees at a location. Each sample was composed of 20–25 leaves.

After mixing the sampled leaves, we obtained a single averaged sample; then the samples were placed in paper bags labelled with numbers and transported to the Central Analytical Laboratory CENS.

2.2.3. Chemical analysis

In order to determine the concentration of the metal in plant tissue, the dry ashing method was applied. The samples were washed with distilled water, chopped into small pieces, air-dried at room temperature and weighed accurately. The subsamples of 0.2–2.0 g of the dry plant material were ground in a laboratory mill, and 0.5–1 g of ground dried plant sample was placed in a porcelain crucible. Then, the porcelain crucible was placed in a cool muffle furnace, and the samples were ashed at 500 °C overnight. The ash residues were cooled down to room temperature and dissolved in 5 mL of 20% HCl. The obtained solution was filtered through acid-washed filter paper into a 50-mL volumetric flask, diluted with distilled water and mixed. The concentrations of the selected five heavy metals (Cu, Pb, Hg, Ni, Mo) were measured through the atomic-absorption method (AAnalyst 800, Perkin Elmer, USA). All findings were calculated on a dry weight basis (mg/kg-1 dry weight).

3. Results and discussion

3.1. Tree condition assessment results

In 23 polling stations of the city, the general condition of the small-leaved tree was assessed, the degree of infection with pests. 65.4% of the total studied plants were in poor condition and infected with *Xanthogaleruca luteola* beetles. The worst situation was in the area of Khanjyan Street (location 5) and Leningradyan Street (location 16), which were drying plants, making up 17.4% of the total. The main part of the studied trees, 48%, were very weak (3rd class) plants. Trees growing in two parks: New Arabkir (loc.1) and Tsitsernakaberd Park (loc.23), were also most infected with pests in large orchards. These results evidence that it is necessary to spend special events in Yerevan elm plantation for improvements the tree conditions.

3.2. Chemical assessment

Due to physiological and morphological characteristics and to the intrinsic tolerance to several stress factors, some species seem particularly promising as an indicator of the environmental state of an urban environment and to lower the number of specific pollutants. It must also be pointed out that intrinsic species properties (e.g., tolerance and/or bioindication capacity for a specific contaminant) can help planners to create an effective monitoring net in strategic points of a city, or to detect single contaminants representative of a specific anthropogenic impact (Dadea et al., 2017). The leaves of the tree have a large surface area and can act as a natural filter to remove a substantial amount of airborne particles and subsequently enhance the quality of air in polluted areas (Fourati et al., 2017). Elm species do not have a large size of leaves but are able to absorb trace elements from soil and air. Aghaei et al. (2017) indicate that *Ulmus boissieri* does not function well as a bioindicator of heavy metals under the conditions in Isfahan, especially where the two other species of *Platanus orientalis* and *Morus alba* are available in this city, and the reason for this might be the small leaf surface area of this species. On the other hand, Liu et al. (2017) reported that Ulmus pumila have dust accumulation rate above the mean concentration and suggested to be considered in future green belt planning in Beijing. Hajizadeh et al. (2019) noted that *Ulmus umbraculifera* have low air pollution tolerance index; thus, it is a sensitive plant and has been suggested to use as a bioindicator of air pollutants. According to our obtained results, mean concentrations of studied elements were not excessive standard values (Kabata-Pendias, 2011). In our research the ranges of metal concentrations for U. minor are Pb 0.44 - 2.53, Hg 0.03-0.102, Ni 1.62-3.55, Mo 1.18-7.97, Cu 5.63-50.0 mg kg^{-1} dry weight respectively, with a mean and median values are similar in Mo (3.477 and 3.03 mg kg^{-1}), Hg (0.065 and 0.0690 mg kg^{-1}), Pb (0.946 and 0.84 mg kg^{-1}), Ni (2.573 and 2.37 mg kg^{-1}) and a little bit difference in Cu (16.62 and 17.18 mg kg^{-1}) (Table 1).

Table 1. Heavy metal contents in *Ulmus minor* leaves sampled from the city of Yerevan(mg/kg)

Elements	Mo	Hg	Pb	Ni	Cu
Mean	3.48	0.07	0.95	2.57	16.63
Minimum	1.18	0.03	0.44	1.62	5.63
Maximum	7.50	0.10	2.53	3.55	50.0

Median	3.03	0.07	0.84	2.37	17.18
Std. Deviation	1.66	0.02	0.46	0.50	10.07

The standard deviation is the statistics that measures the dispersion of a dataset relative to its mean and is calculated as the square root of the variance. It is calculated as the square root of variance by determining the variation between each data point relative to the mean. If the data points are further from the mean, there is a higher deviation within the data set; thus, the more spread out are the data, the higher is the standard deviation. The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistics for comparing the degree of variation from one data series to another, even if the means are drastically different from one another. Table 1 shows that the coefficient of variation in some elements is high, for example in Copper, Lead and Molybdenum, respectively 60.6%, 48.5%, whereas 47.6%. Nickel (19.6%) and Mercury (29.6%) have a smaller coefficient of variation tas compared with Copper, Lead, and Molybdenum.

The tolerance to Hg in higher plants also was reported. Although the mechanism of the physiological barrier is not known, it is most probably related to the inactivation of Hg at the membrane sites (Kabata-Pendias,2011). However, according to some researchers (Baker D.E., Chestin L.,1975) Hg maximal concentration in plants foliage was 0.04 mg kg^{-1} dry weight. As we mentioned, according to results of our research mean and maximal concentrations of Hg in plants are 0.065 and 0.10 mg kg^{-1} respectively and, in this case, they were excessive critical value (0.04 mg kg^{-1}) more than 1.5 and 2.5 times. (tab.1).

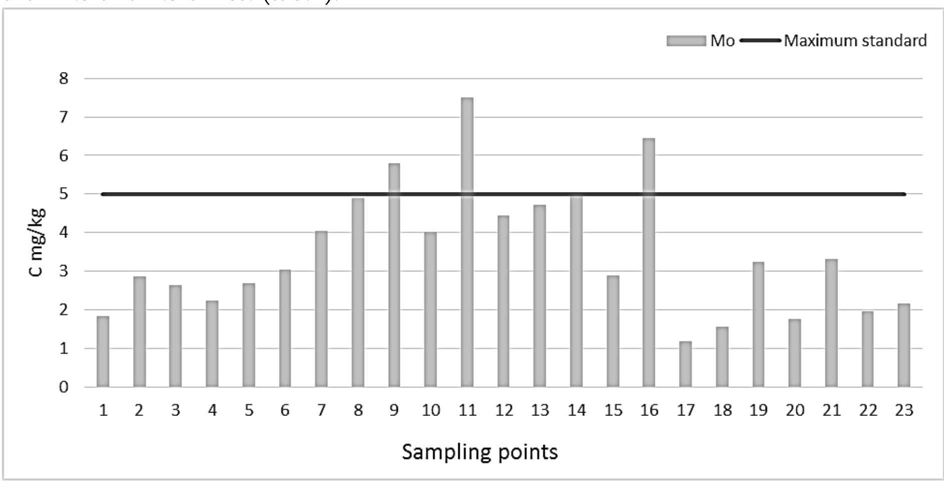


Fig.2. Mo concentrations in the leaves of *U. minor* in Yerevan.

Maximal levels of all observed metals in plant material were not excessive normal range of elements in plants too, except Mo, Cu and Hg. For example, Pb maximal value in plants leaves was 2.53 mg kg^{-1}, while normal concentrations of this element in leaf foliage are 5-10 mg kg^{-1} dry weight (Kabata-Pendias,2011). According to Liu et al. (2017), elm could remove atmospheric dust efficiently, accumulated much larger amounts of Cu and Zn, but lower Pb. Authors noted that metal reduction of this species might be considered based on MAI values for leaf dust (Liu et al.,2017).

Mo concentration in tree leaves was higher than the critical value of 5 mg kg^{-1}. For *U. Minor* it was 7.97 mg kg^{-1} and exceeded critical value more than 1.5 times. Maximal levels of Mo accumulate in the leaves of plants, growing in the south (locations 11, 9 and 8) and the southwest (loc.16) of the city (fig.2). There are immediate pollution sources in the south of the city: two metallurgical plants: "Pure Iron" and Armenian Molybdenum Production, the latter being the major molybdenum pollution source to Yerevan. At point 16, apparently, there was local pollution, besides, as indicated above (see 3.1.), an assessment of the state of elms revealed that the trees were in poor condition: rarefaction of the crown, dry branches and leaf damage were recorded pests.

The heavy metal concentration in plants tissues as well as in the soil is affected by atmospheric trace metal concentrations. According to Onete et al. (2010) in Bucharest the heavy metal concentration in *Ulmus minor* tissues and respective in aerial depositions is high on Zn, also a high concentration of that metal in plants tissues present (Onete et al.,2010). In our previous research, we determined high values of Mo in leaves of other plant species too in the south of the city (Hovhannisyan et al.,2014). In our study, Cu maximal concentration in plants was 50.0 mg kg^{-1} vs critical value of Cu in plants 30 mg kg^{-1} (Kabata-Pendias,2011) only in one sampling point (loc.20). (fig.3). That point is located on-site with heavy traffic, and besides, we have concluded that it is a local polluted zone.

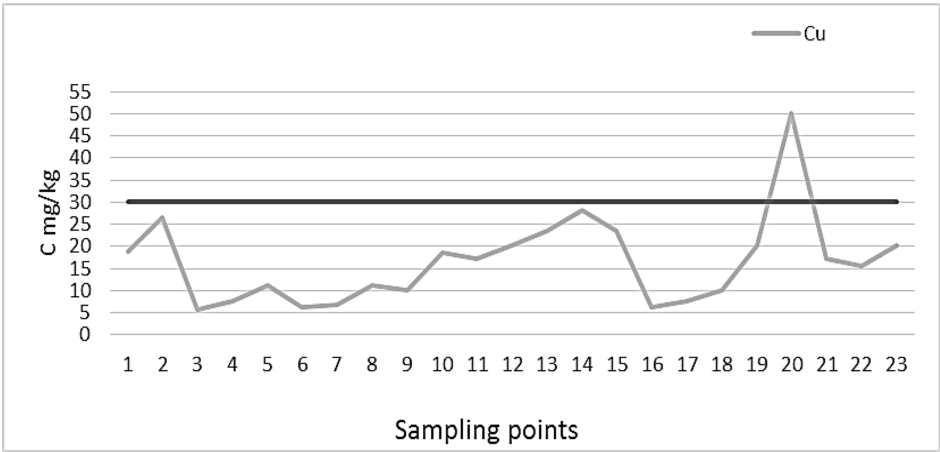
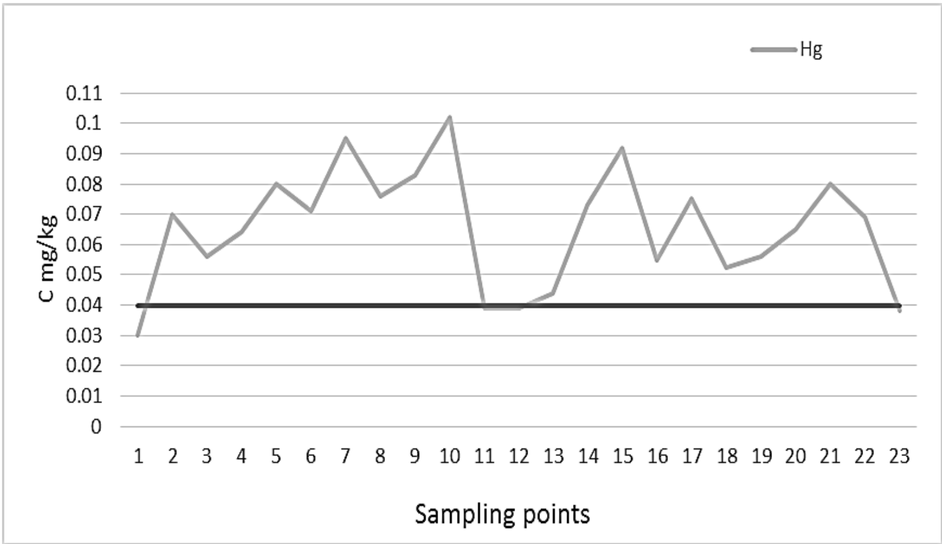


Fig.3. Cu concentrations in the leaves of *U. minor* in Yerevan.

The absorption of heavy metals by elm species leaves has been reported often. *U. pumila* has a significant absorption capacity for Pb, Cd, Cr and Hg as pollutants in the atmosphere (Mu Li et al., 2004). Saba, G. et al. (2015) reported that *Ulmus pumila* accumulated Zn and Pb in leaves in industrial zones of Iran. Some researchers (Dukic et al.,2014) results could mark a step forward in defining the tolerance of *U. pumila* to the presence of Cd and Pb, and to the possibility of using this fast-growing tree which is resistant to different abiotic and biotic stresses, for phytoremediation or soil reclamation purposes. *Ulmus carpinifolia* tree leaves, which is in great supply in Iran, were evaluated for removal of Pb, Cd and Cu from aqueous solution (Sangi et al.,2008).



Note: *Maximum Standard Concentration of Hg in plants foliage according to Baker et al. (*Baker D.E., Chestin L.,1975)* is 0.04 mg/kg

Fig.4. Hg concentrations in the leaves of *U. minor* in Yerevan.

In recent years, attention has been paid to Hg uptake from the atmosphere. In some cases, the major part of Hg in the above-ground parts of trees seems to be associated mainly with its atmospheric deposition (Ericksen et al., 2003). In the present study, we determined high rate of Hg concentration in tree leaves from all studied locations, except two parks (loc.1 and 23) and two points in the city (loc.11 and 12). Maximal levels of Hg discovered in samples of trees in the south of the city (loc.10), and they were excessive critical value (0.04 mg kg^{-1}) more than 2.5 times.(fig.4). As we mentioned above, the south part of the city is an industrial zone, and there are immediate pollution sources.

Thus, elm species have not a large leaf surface area but can act as a natural filter to remove pollutants and subsequently enhance the quality of air in polluted areas. According to some researchers. (Pourkhabbaz et al.,2010) the decrease in leaf surface range and length of petiole causes less contact with natural toxins, notably air pollution and enhances resistance of plants against pollution. Elm species have dust accumulation rate above the mean concentration, it is a sensitive plant and has been suggested to use as a bioindicator of air pollutants in urban areas (Liu et al.,2017; Aghaei et al.,2017; Hajizadeh et al.,2019; Dukic et al.,2014; Onete et al.,2010). In the same time, the negative side of elms is their susceptibility to many insects and fungal diseases (Urban J., Dvorak M.,2014; Thomas et al.,2018).

CONCLUSIONS

Our present studies have shown that 65.4% of the total studied plants were in poor condition and infected with pests, but only 48% of the studied trees were very weak plants. However, Ulmus minor has the ability to absorb and accumulate metals from the environment. The elm leaves most accumulated Mo, Hg and Cu. Although the average content of elements (except for Hg) did not exceed the accepted normal concentrations in plants, however, in some parts of the city, especially in the south, high concentrations of metals were recorded. According to the results of our research mean and maximal concentrations of Hg in plants were excessive critical value more than 1.5 and 2.5 times. Our results indicate that although the U.minor has the ability to absorb metals from the environment; however, this species is quickly affected by pests in the conditions of Yerevan.

Given all of the above, we can conclude that elm green spaces in Yerevan need updating and thorough sanitary care. The research results are presented to the city hall for the further development of measures to improve them.

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РОЛЬ ОКИСЛИТЕЛЬНОГО СТРЕССА И СУПЕРОКСИДДИСМУТАЗЫ ПРИ ШИЗОФРЕНИИ

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Аннотация

Шизофрения тяжелое психическое заболевание с частично описанным патогенезом. Ряд исследований свидетельствует о нарушениях окислительного стресса при психоатрических заболеваниях, включая больных шизофрении. Тем не менее, до настоящего времени данные относительно характера изменений уровней и активности ферментов этой системы при шизофрении противоречивы. Цель данной работы - оценить активность антиоксидантного фермента супероксиддисмутазы у больных шизофренией.

Ключевые слова и фразы

Шизофрения, окислительный стресс, супероксиддисмутаза, ферментативная активность.

ՕՔՍԻԴԱՏԻՎ ՍԹՐԵՍԻ ԵՎ ՍՈՒՊԵՐՕՔՍԻԴԴԻՍՄՈՒՏԱԶԻ ԴԵՐԸ ՇԻԶՈՖՐԵՆԻԱՅԻ ԺԱՄԱՆԱԿ

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