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RESEARCH OF THE CONTENT OF HEAVY METALS IN LINDEN AND POPLAR LEAVES IN THE CONDITIONS OF ROAD PLANTATIONS IN VINNITSA

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Abstract

The content of heavy metals in Lime and Poplar in the conditions of planting stripes of Vinnitsa is investigated. It has been found that in the states of plantings of a roadside band on the Hnivanske and Khmelnytskyi highway, the most considerable content of lead was characteristic of leaflets of poplars, while in the letter of Lime, it accumulated less. At the sampling point on the rising highway in wood plants, the Linde of lead was 7.5 mg/kg, and poplars - 9.5 mg/kg, and in the conditions of the Khmelnytskyi highway, this figure was slightly higher - 8.8 mg/kg and 15.2 mg/kg. It has been established that in a sheet mass poplar on a ruling highway, the content of cadmium compared with MPC increases more than 3.26 times (0.98 mg/kg), while in linden - 1.6 times (0.49 mg/kg.). The same trend is observed in the Khmelnytskyi highway - cadmium content compared to the MPC increases by more than 5.6 times (1.68 mg/kg), while in linden - 4.36 times (1.39 mg/kg) . There was an interesting trend: the amount of copper in leaves of linden was greater than in the poplar, both in the zone of Hnivanske and Khmelnytskyi highway and amounted to 25.6 mg/kg and 28.6 mg/kg of dry matter in poplar - 24.4 mg/kg and 26.6. mg/kg, respectively, indicating a more intensive passage of biological processes in poplar than in the linden. The slight zinc content in the leaf and poplar in the risky highway is established: in dry biomass, lindes were recorded 24.9 mg/kg, poplar - 32.0 mg/kg with MPC 50 mg/kg. In the Khmelnytskyi highway, the linden accumulation of zinc was 48.8 mg/kg, within the normal range, and poplars 52.3 mg/kg of dry matter. The accumulation of poplar lead accumulates them in 1.26-1.72 times than linden and cadmium in 1.21-2 times. However, copper and zinc (albeit within allowable concentrations) less in 1.05-1.08 and 1.07-1.28, respectively. The concentration of lead, cadmium, and zinc on the Khmelnytskyi highway in the biomass of the poplar exceeded the MPC in 3.04, 5.06, 1.05 times, respectively, and less than copper – 1.08 times.

Keywords: heavy metals, planting, accumulation, detoxification, gas-resistant, health improvement, environment.

Different ecological systems were under the influence of heavy metals.

Conducted research by Razanov S., Didur I., Pervachuk M. allowed to establish that in the cultivation of only winter rape, 444 mg/ha lead and 11.1 mg/ha cadmium with ammonia nitrate, 1305 mg/ha and 240 mg/ha with superphosphate double, and 450 mg/ha and 450 mg/ha with potassium chloride respectively [3]. Titarenko O. emphasizes that technogenesis is an intensive accumulation of heavy metals in the biodiversity of natural forage lands [4]. Contaminated lands with heavy metals are often considered marginal, which requires unique approaches to their use [1,2]. Experimental studies of the accumulation of heavy metals by plants in urban areas were studied by A. Tsykalo, A. Kosmachev, V. Smirnov [5].

The subject of our research was the peculiarities of the accumulation of heavy metals and trace elements: lead, cadmium, copper, and zinc in the leaf mass of trees in the roadside strips of Vinnytsia.

Modern urbanized medium by many indicators, mainly according to the species composition of plants, is significantly different from natural biogeocoenoses. In industrial centers, technogenic pollution is one of the main factors that affect vegetation. Therefore, tree plants used to plant the territories of industrial enterprises and highways must have high resistance to aerogenic contamination, tall decorative, and the ability to absorb pollutants from the atmosphere and soil.

There is growth in holes in the asphalt and environmental pollution to adversely affect the growth and development of street planting trees, especially emissions from motor transport. However, this unfavorable

factor on plants and the cumulative capabilities of a roadside green bar has been investigated.

Our research has become peculiarities of accumulation of heavy metals and traces elements: lead, cadmium, copper, and zinc in sheet mass of trees of roadside strips of Vinnytsia.

Heavy metals create a powerful impact on the biosphere. Complete vegetation is often observed in soil contamination, water, and atmosphere of salts of heavy metals: copper, zinc, chromium, cobalt, mercury, titanium, and the like.

The need to study the toxicity of heavy metals is determined by the specificity of several metals on the photoproduction capacity of wood species used in landscaped and the need to predict their suitability for cultivation in pollution conditions, especially in the system of roadside greenery.

To limit the excessive flow of microelements, plants have genetically due to protection mechanisms - selective absorption, physiological barriers, biochemical reactions of detoxification of heavy metals of nonspecific nature. The tolerance of plants to accumulate certain chemical elements is due to their genetic and physiological features. The accumulation of an element in a certain body of a plant is determined by its participation in biochemical processes and depends on the path of its migration on the leading tissue of the plant.

However, in the conditions of enhanced technogenesis, the protective mechanisms of detoxification of heavy metals cannot wholly block the migration of excess ions of toxic elements to xylem, as evidenced by their accumulation in the above-ground vegetative reproductive bodies of plants growing in zones of technogenic load.

The peculiarity of plants to maintain their viability at high concentrations of gases, usually not inherent in the atmosphere's average composition, characterizes their gas content. Green plants are healing the urban environment.

It should be noted that a rather often dominant factor of high content of heavy metals in above-ground parts of plants is atmospheric air, which is polluted by emissions of motor transport and industrial enterprises, which increases the proportion of toxic concentrations of metals through stomata and cuticle sheet surface. Thus, pollution of CD plants, Pb, in areas of intense technogenic influence occurs mainly due to the deposition of these elements from the atmosphere.

Thus, the laws of absorption, migration, and accumulation of chemical elements in plant organisms are determined by the whole complex of interconnected natural and anthropogenic factors. Interaction of biological factors, among which dominant landscape, geomorphological, climatic, hydrological conditions, and soil differentiation, determines the background content of elements in specific components of the environment and their territorial distribution by forming geochemical barriers in the environment path of geochemical flows. However, the influence of natural factors is largely offset by the pressing of anthropogenic factors. Technogenic introduction of heavy metals into the environment makes an ecological factor for forming a chemical composition of plants dominant over the genetic features of the plants themselves and natural patterns of distribution of chemical elements.

Lead by a degree of danger is an element of the first class. Even low lead concentrations can slow down some life processes in plants. The data presented in Fig. 1 indicate that in the conditions of plantings of a roadside band on Hnivanske and Khmelnytskyi highway, the most significant lead content was characteristic of leaflets of poplar the letter of linden it accumulated less.

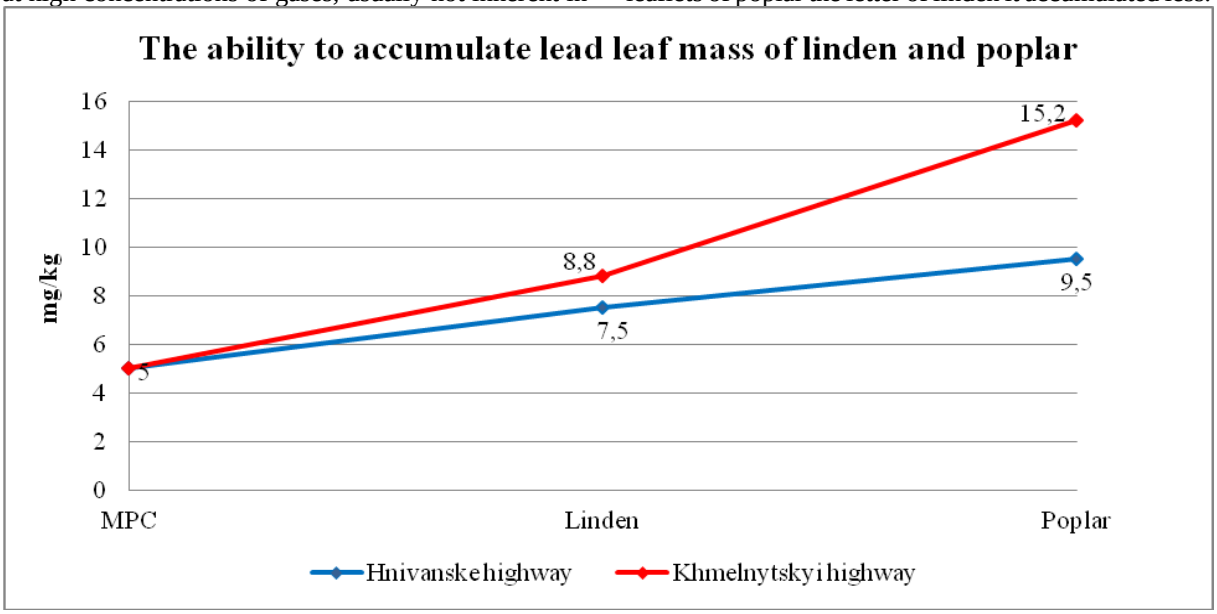

Fig. 1. Ability to accumulate lead sheet mass of linden and poplar

Lead belongs to the most dangerous, has a high cumulative effect, not subject to biodegradation, and is practically not excreted from the plant organism. The analysis of lead content showed a reasonably high background level of this metal in linden and poplar.

At the sampling point on the Hnivanske highway in wood plants, the linden of lead was 7.5 mg/kg, and poplars - 9.5 mg/kg, and in the conditions of the Khmelnytskyi highway, this figure was slightly higher - 8.8 mg/kg and 15.2 mg/kg.

There is an increased content of the permissible lead concentration on two objects immediately. However, one may notice the highest level in the foxes of poplar and exceeds the allowable value on the Highway in 1.9 and 3.04 times on the Khmelnytskyi highway.

The physiological role of cadmium in plants is not entirely clarified today. Although its background content in plants, as a rule, is many times smaller than microelements, its movement is much larger than other heavy metals. Together with the above, one should consider the feature of cadmium that it is very slowly excreted from the body; that is, the probability of cumulative effect for it is very high. Our studies of sheet mass of lindens and poplars showed a significant, exceeding level of permissible concentrations of cadmium (Fig. 2).

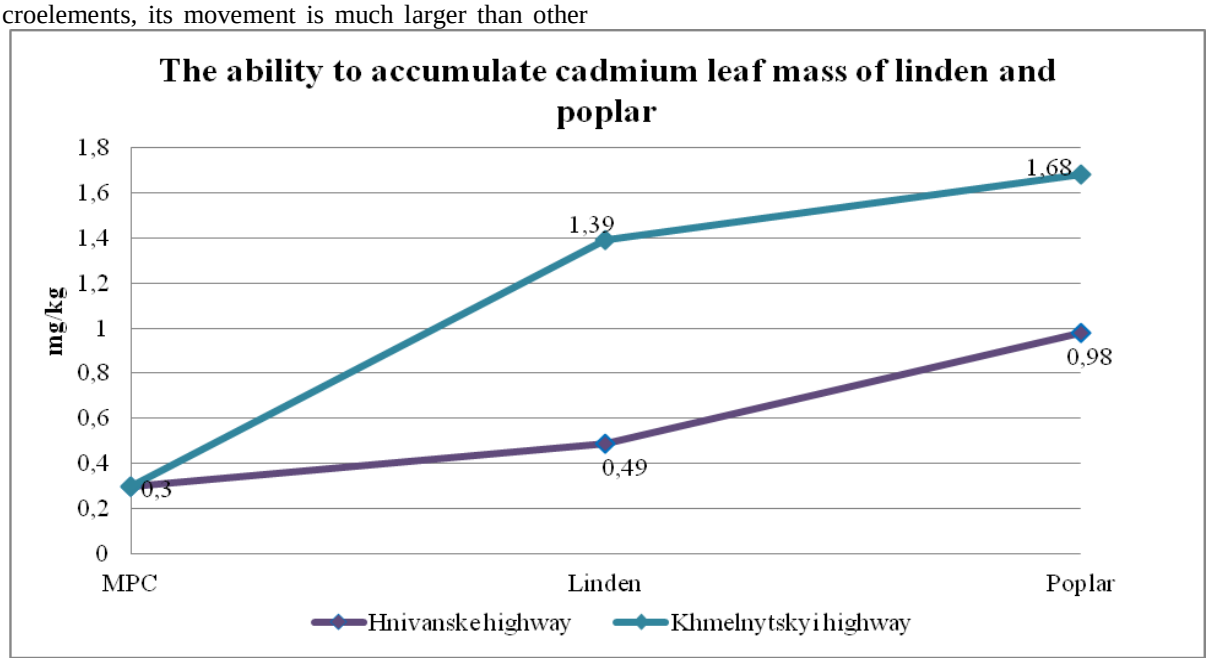

Fig. 2. Ability to accumulate cadmium sheet mass of linden and poplar

Studied poplars are much more accumulated by cadmium in road conditions. Thus, in the leaves on the Hnivanske highway, its content compared to MPC increases more than 3.26 times (0.98 mg/kg), while in linden - 1.6 times (0.49 mg/kg).

The same tendency is observed in Khmelnytsky everywhere - the content of cadmium compared with MPC increases by more than 5.6 times (1.68 mg / kg), while in linden - 4.36 times (1.39 mg/kg) .

An analysis of the data testifies that cadmium in the elements of the sheet mass Poplar can accumulate more than in the linden in 1.21 - 2 times. That is, poplar alleys near roads have a larger accumulating ability than lime.

Cadmium is one of the most toxic metals for living organisms, the concentration of which in the amount of 5 mg/kg of dry matter is dangerous to plants. The content of this metal in the leaves of the stick is small and even in a heavily contaminated zone of the Khmelnitsky highway does not exceed 1.39 mg/kg of dry matter (in Tilia Cordata leaves).

In addition, from Fig. 2 The dynamics of increasing cadmium content with an increase in the car load on the street is well traced Khmelnitsky highway. So at the time of the peak, the number of cars on the Hnivanske highway is 980-1470 cars per hour, then in Khmelnytsky this figure is 1860-2630.

Research results showed a tendency to accumulate copper in a dry leaf of wood plants (Fig. 3.). This element is biometal and in certain quantities required by plant organisms, because it plays an important role in physiological processes. However, their concentrations have a toxic effect.

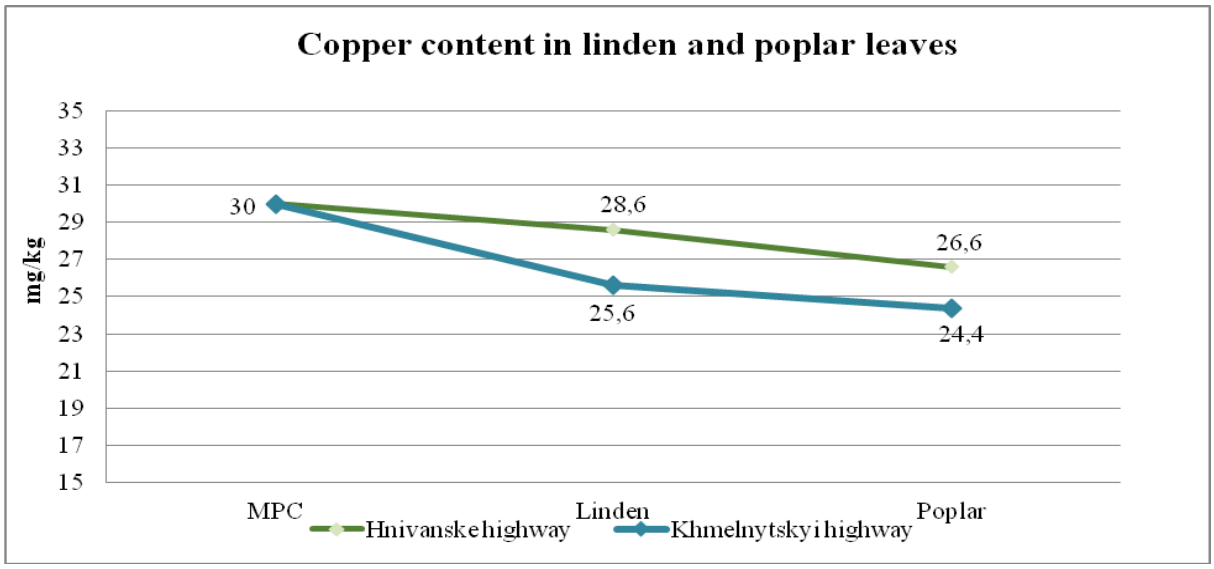

Fig. 3. The ability to accumulate copper sheet mass of linden and poplars

In our studies exceeding the concentration of permissible norms in copper was not observed. However, an interesting tendency was revealed: the amount of copper in the leaves of the linden was greater than in the poplar, both in the zone of Hnivanske and Khmelnytsky highway, and amounted to 25.6 mg/kg and 28.6 mg/kg of dry matter in poplar - 24.4 mg/kg and 26.6. mg/kg respectively. Although the difference in accumulated copper and not large, only 2-2.2 mg/kg of dry matter indicates a more intensive passing of biological processes in poplar than in the linden. Thus, increasing the amount of copper in the linden leaf does not exceed the upper critical level.

The accumulation of zinc content in all studied linden and poplar leaves was within the limits of allowable concentrations, except for samples selected by the Khmelnytskyi highway on biomass poplar, where the excess was not significant amounted to 2.3% (Fig. 4).

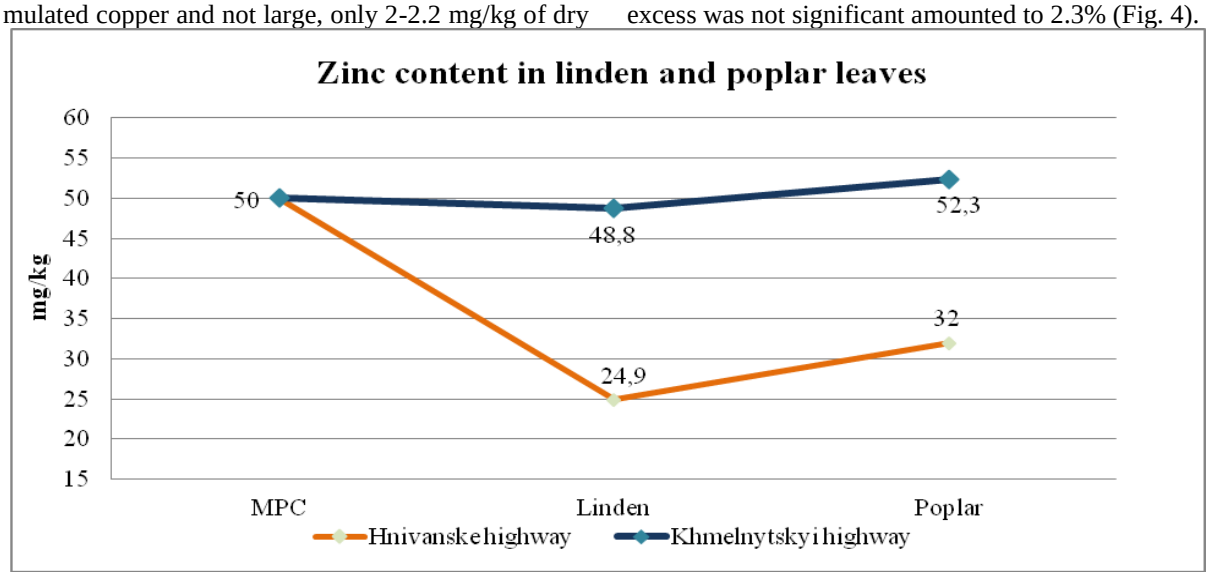

Fig. 4. The ability to accumulate zinc leaf mass of linden and poplar

Insignificant zinc content was observed in linden and poplar leaves on Hnivanske highway: 24.9 mg/kg was recorded in dry linden biomass, 32.0 mg/kg in poplar at 50 mg/kg MPC.

On Khmelnytskyi highway: the accumulation of zinc in lindens was 48.8 mg/kg, within normal limits, and in poplar 52.3 mg/kg of dry matter. The detected content of this metal in the leaves does not exceed the physiological norm.

Greenery is considered reliable and recognized protection against air pollution. They are called the "lungs of the city" by right. Of course, foliage adorns the city, but above all, they play an essential role in improving the environment.

Directed, intended use of polyfunctionality of green plantations is the essential modern direction in the landscaping of cities, stabilization of an ecological condition, reduction of technogenic pressure on the health of the population.

Trees of the genus Tilia L. (Linden) and Populus L. (Poplar) occupy a significant share in the landscaping of urban landscapes, making a significant contribution to cleaning the atmosphere of the industrial city. Plants accumulate metal-bearing aerosols and accumulate heavy metals, so we analyzed the efficiency of accumulation of heavy metals in the leaf mass of linden and poplar (Table 1).

Table 1

Comparative characteristics of the efficiency of accumulation of heavy metals and microelements by linden and poplar leaf mass

№	Object of measurement, mg/kg	Hnivanske highway		+ -, times	Khmelnytsky highway		+ -, times
		Poplar	Linden		Poplar	Linden	
1.	Lead	9,5	7,5	+1,26	15,2	8,8	+1,72
2.	Cadmium	0,98	0,49	+2,0	1,68	1,39	+1,21
3.	Copper	24,4	25,6	-1,05	26,6	28,6	- 1,08
4.	Zinc	32,0	24,9	-1,28	52,3	48,8	-1,07

The table shows that poplar accumulates more toxicants in the leaves than linden. Although, perhaps, there is a factor of the biological intensity of metabolic processes inherent in each species. However, significant absorptive properties of poplar have been revealed, and this is indirect evidence of the significant cumulative and bioindication value of poplar in the conditions of urban-technological ecosystems. The high intensity of microelement accumulation in the leaf fraction of linden phytomass was also experimentally established, which indicates its high cumulative capacity. According to the relative absorption coefficient, we give a consistent intensity of heavy metals accumulation in the dry mass of poplar and linden leaves. In terms of lead accumulation, poplar accumulates 1.26-1.72 times more than linden and cadmium 1.21-2 times. However, copper and zinc (although within acceptable concentrations) are less than 1.05-1.08 and 1.07-1.28, respectively.

It is known that along highways with high traffic intensity (more than 10 thousand cars per day), the roadside strip is polluted at a distance of up to 200 m. With diesel products, lubricants, and waste tires, cadmium and zinc enter the environment. The distribution of heavy metals along the roads depends on the intensity and speed of vehicles, wind direction, etc. We made a comprehensive analysis of the content of heavy metals in the dry leaves of linden and poplar on the studied highways Hnivanske and Khmelnytsky highways (Fig. 5-6).

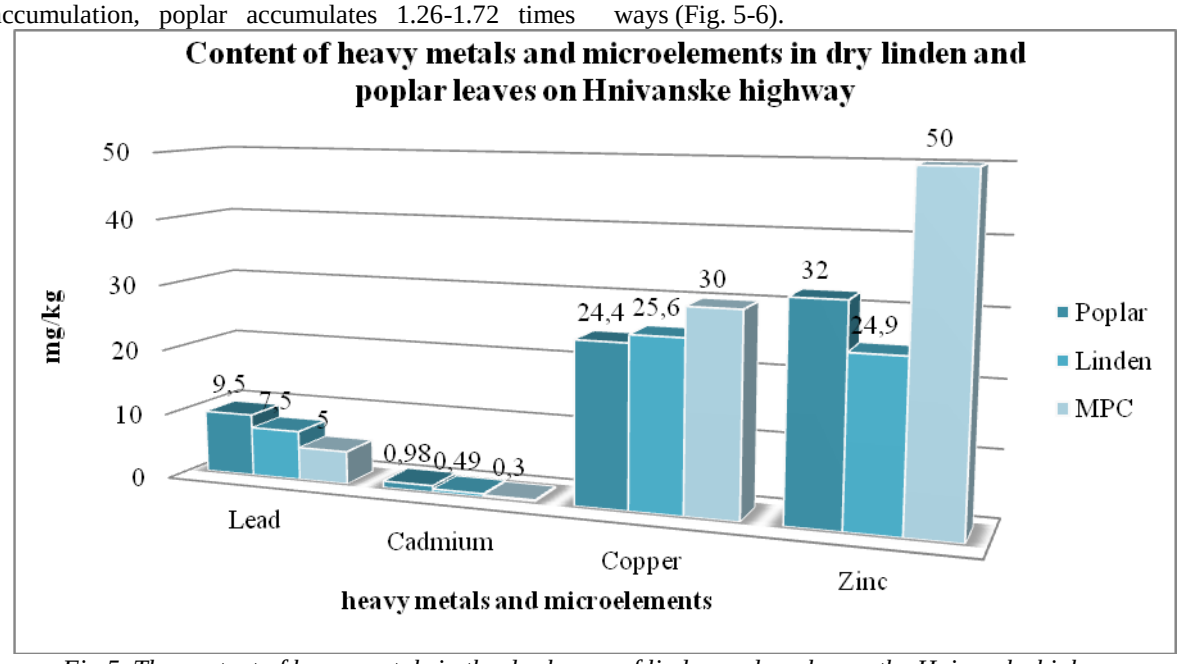

Fig.5. The content of heavy metals in the dry leaves of linden and poplar on the Hnivanske highway

Characterizing the level of heavy metal pollution of linden and poplar biomass on the territory of Hnivanske highway, it should be noted that the maximum permissible levels in linden leaves for lead and cadmium are 1.5, 1.6, times and more miniature zinc than the maximum concentration limit two times and copper – 1.08 times. In poplar biomass, the concentration of lead and cadmium was also 1.9 and 3.26 times higher than the maximum allowable levels, respectively, and 1.5 times lower than that of zinc and 1.05 times lower than that of copper. At the same time, it should be noted that the concentration of lead, cadmium, and zinc on Khmelnytskyi highway (Fig. 6) in poplar biomass also exceeded the MPC by 3.04, 5.06, 1.05 times, respectively, and less than copper - 1.08 times.

The accumulation in the dry mass of linden lead and cadmium, respectively, exceeded the MPC by 1.76, 4.6 times. However, copper was 1.02 and zinc 1.12 times less.

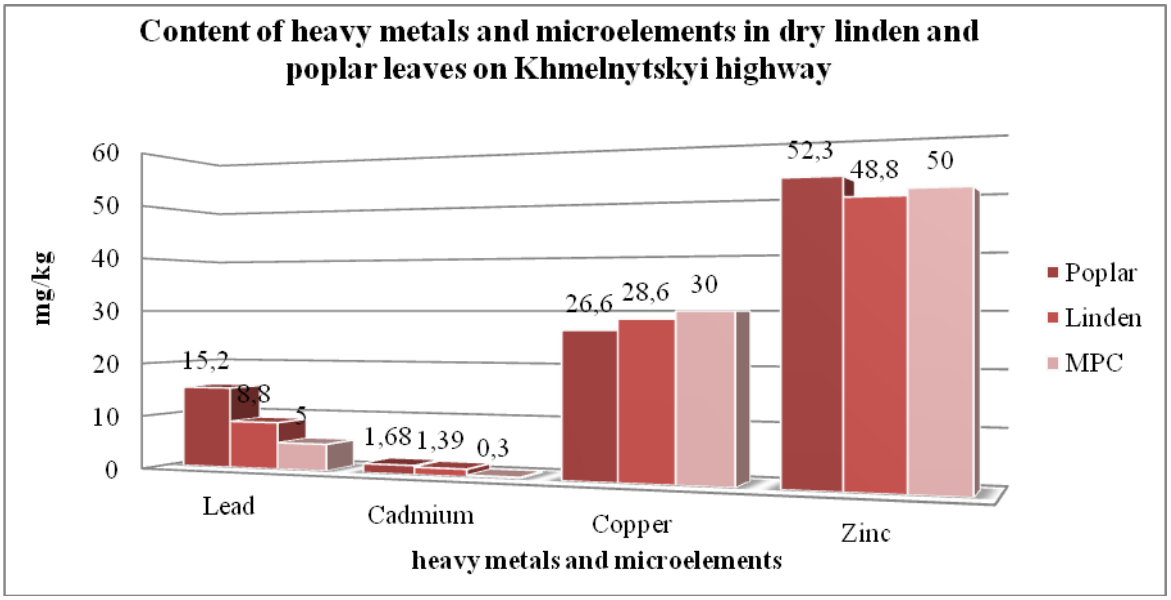

Fig.6. The content of heavy metals in the dry leaves of linden and poplar on Khmelnytsky highway

Thus, the obtained data of the critical level of heavy metals in the leaf surface of the crown of roadside lanes indicate an increase in the manufactured environmental pollution on roadside lands and the cumulative role of woody vegetation in urban manufactured ecosystems.

Complex, complex, interrelated factors determine the uptake and distribution of chemical elements in the plant body, so it is difficult to accurately determine the specific contribution of root and leaf input to the increase in heavy metals in plant tissues. However, based on the research results, it can be argued that we should pay attention to the use of green linden and poplar trees in landscaping in the case of the possibility of manufactured air pollution.

Considering the phytomeliorative efficiency of roadside plantations along transport routes, we can conclude about their different storage capacity depending on the species.

The nature of heavy metal contamination of roadside green areas and their ability to accumulate dangerous toxicants and grow and develop without any visible pathological abnormalities was revealed experimentally. And this indicates the phytomeliorative efficiency of existing greenery and indicative opportunities for woody vegetation.

In the urban environment, wood species and shrubs, and grasses act as universal biological filters to purify the atmosphere, soil, and water from manufactured pollutants.

The peculiarity of the accumulation of heavy metals by vegetation is a necessary condition and one of the most critical environmental factors in creating and forming pollution-resistant tree plantations in which they perform a cumulative function. This approach is of fundamental ecological importance in the urban ecosystem and can become a priority innovation project.

Conclusions. Even though the total volume of gas emissions in Vinnytsia decreased by 25.1 thousand tons in 2020, 124.5 thousand tons of pollutants enter the environment, including a significant share of heavy metals.

Placement and use of greenery in roadside lanes and species selection of plants should be carried out considering their sensitivity to heavy metals, the possibility of gas resistance of plantations, and their protection and health properties.

We propose to use the results of our research in the development of innovative projects as the peculiarities of vegetation accumulation of heavy metals. It is a necessary condition and one of the most critical environmental factors in creating and forming pollution-resistant tree plantations in which they perform both protective and health functions.

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