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ABSORPTION OF PB, CU, ZN AND CD TYPE *MORUS ALBA* L. CULTIVATED ON SOILS CONTAMINATED WITH HEAVY METALS

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Abstract

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In recent years, interest in heavy metals and fitoremediatsionnite technologies increases. The fact that phytoremediation can be performed on the spot (*in situ*) at significantly less cost, determined research in this area as highly relevant.

The purpose of this study was to explore the possibilities of the mulberry tree to be used as fitoremediator contaminated soils with heavy metals. And to establish the accumulation of lead, copper, zinc and cadmium in the root system and aerial biomass (habitus).

The results obtained show that increasing the saturation of the roots with heavy metals is increased and the concentration in the aerial parts - stems, branches, leaves and the most in the mulberry fruit. Heavy metals accumulate in plant parts not significantly affect the growth and development of the species *Morus alba* L.

Key words: mulberry, heavy metals, phytoremediation technology

Abbreviations: KCM - Factory for non-ferrous metals Plovdiv

Introduction

Solving the problem of soil pollution with heavy metals and no impact on soil fertility is one of the biggest challenges facing modern science. The most promising approach in this respect seems fitoremediatsionnite technologies.

Phytoremediation more successfully applied for the recovery of soils with high content of heavy metals and persistent organic pollutants. Plants develop thick root mass in contaminated soil, and rapid and strong growth creates vertical migration of significant amounts of water from the soil in which substantially reduces the levels of heavy metals in groundwater.

A number of our authors have worked on the issue of pollution and heavy metals, but until now no study on sycamore tree planted in one of the most polluted areas of the country. Studies have been made about highways (Petkov et al., 1999; Ranta et al., 1988; Mikhalkov, 1985) the authors find correlation between the distance from the road and the content of lead (Pb) related to heavy traffic.

Velichkova and Pencheva (2003) explored high levels of lead, close to sewage canals and pumping stations. According to the authors this is mainly due to aerosols - Surface contamination. In the soil toxic metals accumulate in the arable layer of depth to 20 cm. It has been found that 57-74% of the toxic metals - lead and mercury contaminants are concentrated in the soil surface layer from 0 to 10 cm, and only 3 to 8% migrated in depth of 30-40 cm.

Increased content of heavy metals in the soil leads to an increase in their plants, which in turn depends on the soil properties, the type of plants, the shapes and the compounds of the elements. (Bolyshakov and Klimenko, 1976; Chuldzhiyan, 1989; Plugchieva, 1989; Yorova and Veli-dice, 2000).

Rafati et al. (2011) investigated the absorption of heavy metals Cd, Cr and Ni from different parts of plants White Poplar and White mulberry. Follows the absorption and accumulation of heavy metals in the root, stem, green leaves, leaves opadnalite and contaminated soil. The greatest accumulation was found in the leaves of plants. As the highest concentration of cadmium (Cd) in opadnalite leaves compared with green leaves.

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The roots of plants with microorganisms of the rhizosphere can reduce the bioavailability of the metal and therefore - their phytotoxicity. Membranes of plant cells have some binding properties against metals. Various detoksfikatsionni mechanisms can be distinguished at the cellular level: metallic exclusion, translocation, binding complexes in the cytoplasm (Marschner, 1995; Ernst, 1998; Mench et al., 1998)

According to Stoyanov (1999), degree of saturation of the tissues of the main organs of plants with heavy metals they are ranked in the following descending order: roots > stems > leaves > fruit. Research results of many authors in terms of environmental pollution with heavy metals, and show high positive correlation between the content of these elements in the soil and in plants (Atanasova and Stoyanov, 1992; Dimitrova-Chervenkova et al., 1995; Stafilov and Jordanovska, 1996; Tasev et al., 1997; Yordanova, 2009; Dospatliev, 2011).

Zhao (2012), Ashfaq (2009) for in his studies prove that *Morus alba* L. extract heavy metals from soil and their concentration grows from the root to the leaves. Accumulated at the top of larger quantities of heavy metals can be easily removed after cutting and destruction of the branches of the mulberry tree. Plants develop thick root mass in the contaminated soil, and rapid and strong growth of the tree creates vertical migration of significant amounts of water from the soil in which substantially reduces the risk of washing heavy metals from groundwater.

This species is suitable for planting around highways and landscaping in settlements. Reduction zaprashentostta in major cities around the factories. To reduce noise and improve the living environment. Cut branches can be used as firewood for the production of paper and cardboard and enclosed material.

In the present study we have set a goal to establish the presence of heavy metals in plant samples from mulberry. Grown into one of the most polluted areas of the country (KCM Plovdiv).

Materials and Methods

- The study was conducted during the period 2012 – 2013. Experimental work involves the use of contaminated material from the mulberry garden adjacent to the Factory for non-ferrous metals (KCM) Plovdiv. Located in the village of Kuklen, Plovdiv and Asenovgrad.
- Studied heavy metals in plant samples are from mulberry (roots, stem, branches, green, yellow leaves and fruit).
- Plant samples were dried in the weight of the laboratory of the Institute of Soil and agricultural technologies and plant protection “Nikola Poushkarov”.
- Test Method: EPA 3052, and the content of Zn, Pb, Cd and Cu determined by flame atomic absorption spectrometry in accordance with ISO 11047.
- Samples of green leaves are taken in May-June, when the most intensive vegetation of mulberry. The leaves were studied in two versions immediately dialed and washed with distilled water and unwashed. Washing is necessary to establish the influence of the air dust pollution of the leaves. Plant samples from other parts the plant were taken during the months of October, November. Yellow leaves picked from the tree just before shedding.
- Control samples of the vegetable garden of the Agricultural University of Plovdiv. This mulberry garden is located outside the area of contamination.

Results and Discussion

Figures 1, 2 and 3 are presented the results of the content of heavy metals - zinc (Zn), lead (Pb) and cadmium (Cd) in plant samples taken from the two mulberry gardens.

Figure 1 shows the presence of zinc (Zn) in two samples of washed and unwashed mulberry leaves taken from the garden of KCM, compared with control contaminated leaves. As can be seen from the figure in all leaf samples from unwashed amount of zinc is higher values, ranging from 110 mg/kg in the first sampling to 243 mg/kg during the last sampling. Unwashed leaves are exposed to air and impact. When washing with distilled water, mulberry leaf values are significantly lower than the 71 to 207 mg/kg. The difference in values is an indicator of the dynamics of air pollution in the area around the plant. The results obtained from contaminated leaves examined in both variants had significantly higher values compared to the control.

Figure 2 shows the presence of lead (Pb). Again, the trend of the quantity of the analyzed element is the highest values unwashed mulberry leaves 84 to 310 mg/kg. When the washed leaves the amount of lead varies from 62.5 to 185

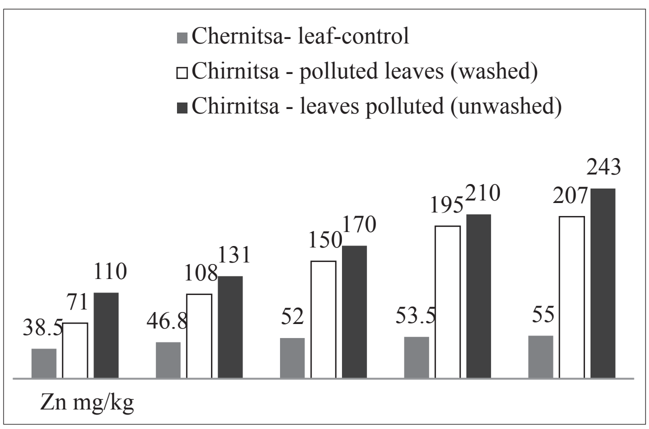

Fig. 1. Zn content in mulberry leaf

mg/kg during the last sampling. These values exceed the values in times of control.

Figure 3 shows the results obtained by the presence of cadmium (Cd). In comparison with the other two elements the values of that item are lowest. In control samples, the amount of cadmium is 1.0 mg/kg. In contaminated leaves values range from 4-11.9 mg/kg in the washed and 12-24 mg/kg in unwashed sheets. And there is a significant difference between the results in the washed and unwashed mulberry leaves, which is most likely due to air pollution in the area.

Table 1 presents the results of analyzes of samples roots, stem, branches and fruit of mulberry. The dynamics of accumulation in roots and aerial parts of Morus alba L. grown on contaminated soil is different. Plant roots are able to reduce the amount of heavy metals and their phytotoxicity in taking them from the soil. Absorbed mainly of root hairs and accumulate in the cell membranes. (Kabata-Pendias and Pendias, 2001).

The results show that in the largest amount is accumulated element zinc (Zn) – 63.9 mg/kg, followed by a lead (Pb) – 28.2 mg/kg, and copper (Cu) – 10.3 mg/kg . With the lowest values is cadmium (Cd) in the roots 1.31 mg/kg. There is a difference compared with the control value.

In the samples taken from the plant of mulberry steblato highest amount is zinc (Zn) - 95 mg/kg, and lead (Pb) – 22.9 mg/kg, followed by the element copper (Cu) – 3.62 mg/kg, and cadmium (Cd) is low and not essential.

In Table 1 is compared to the presence of heavy metals in samples of green and yellow mulberry leaves. The obtained results show that the higher the amount of zinc element (Zn) in the green 149 mg/kg and in the yellow leaves 112 mg/kg. History has it that this element plays a role in the cellular defense system by affecting lipid, protein and chlorophyll (Cakmak, 2000) The next element with higher values that is lead (Pb) 112.0 mg/kg in the green and 85 mg/kg in the yellow leaves.

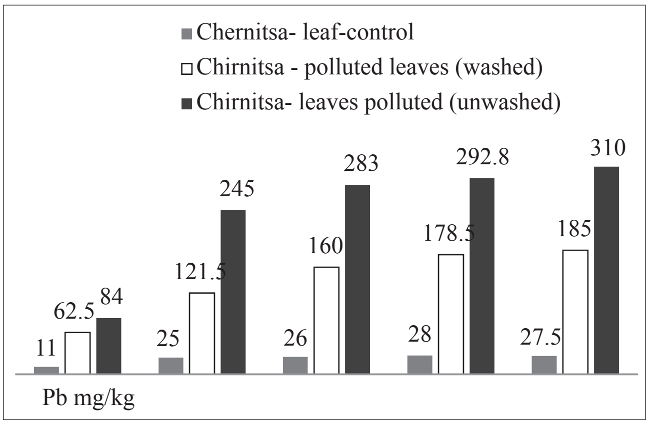

Fig. 2. Pb content in mulberry leaf

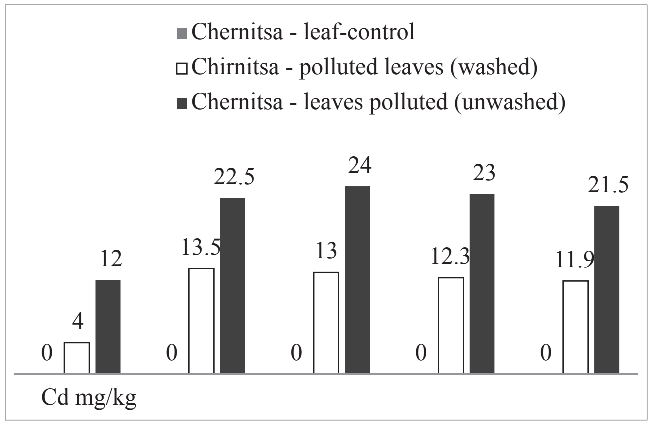

Fig. 3. Cd content in mulberry leaf

Table 1
Content of heavy metals in different parts of mulberry

№ sample	description	Zn, mg/kg	Pb, mg/kg	Cd, mg/kg	Cu, mg/kg
1	roots control	24.5	<0.5	<0.1	<0.5
2	roots contaminated	63.9	28.2	1.31	10.3
3	trunk control	15.5	<0.5	<0.1	<0.1
4	stem contaminated	95	22.9	1.21	3.62
5	control branches	10.5	11.2	<0.1	<0.1
6	branches contaminated	35.2	31.9	1.21	2.8
7	green leaves control	37.5	6.4	<0.1	9
8	green leaves contaminated	149	112	19.2	23.1
9	yellow leaves control	29.6	6.4	<0.1	<0.5
10	yellow leaves contaminated	112	85	<0.5	6.1
11	mulberry fruit -control	17.2	<4.0	<0.5	4.01
12	mulberry fruit contaminated	134	92.1	2.3	9.8

The difference in results is probably due to the rapid growth, nutrition and development of plants in the growing season. The concentration of heavy metals in the aerial parts of mulberry can be influenced by the intensity of transpiration. When the yellow leaves this process is delayed and the amount of heavy metals in plant samples is less. The presence of copper (Cu) and cadmium (Cd) is low and there is no essential for the proper development and function of the plants.

Of all studied plant parts in the highest percentage of accumulated heavy metals occur in the fruit of the mulberry tree. The content in the fruits of four types studied heavy metals is high in comparison with the control. At greater quantity of zinc element (Zn) 134 mg/kg, and lead (Pb) 92.1 mg/kg as compared to those observed in the control sample. The other two elements and with much lower values.

Fruit of mulberry trees grown on contaminated soils are unsuitable for food.

Our results are close to those of Petko al. (1999) and confirmed the results of Stoyanov (1999), Rafati (2011) and Zhao (2012). Mulberry has the unique ability to akulira in themselves relatively large quantities of heavy metals and hold aerosol pollutants from the air. Proof of this is the difference in values between the washed and unwashed mulberry leaves (Figures 1, 2 and 3). Heavy metals are absorbed by plant roots transported to the aerial parts, which are stored and exported with defoliation in autumn.

The results show that the amount of the accumulated four tested by us heavy metals increases significantly from the roots to the leaves shown in Table 1. With roots mulberry is able to absorb the contained metals in the soil without being affected by the development and productivity of the plant . This trend continued during the two years of study. The amount of the tested metals increases in the roots and transported in the aboveground parts, accumulates at the highest rate in the fruits of the plant that are unfit for consumption.

Conclusions

Mulberry is a tree that can be successfully used for phytoremediation of highly contaminated soils. With increasing saturation of roots with heavy metals is increased and the concentration in the aerial parts - leaves, stems and the highest percentage in mulberry. Heavy metals accumulate in plant parts not significantly affect the growth and development of the species *Morus alba* L.

Rapid growth, ease of breeding, great foliage and deep root system make it suitable for phytoremediation.

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