



Phytoremediation: Nature based solution for contaminated urban soils

Zorana Hrkić Ilić¹, Marijana Kapović Solomun¹ and Nada Šumatić¹
¹University of Banja Luka, Faculty of Forestry, Banja Luka, Bosnia and Herzegovina



1. Nature based solution for remediation of contaminated urban soils

Urban soils have disturbed structure resulting from waste disposal, construction sites, pollution from atmospheric deposition, traffic and industrial activities.

Mismanagement of urban environment can cause severe contamination of urban green areas and serious health risk for urban population.



To improve the sustainability of urban green areas, innovative and nature-based solutions (NBS), particularly tree-based phytoremediation, should gain more attention.

Tree-based phytoremediation allow sustainable management of urban soils and improvement of general environmental, health, social and economic conditions for urban population.

2. Impact of heavy metals excess on urban soils and trees

- Urban green infrastructure consist of different tree species capable to mitigate soil contamination, especially contamination with toxic heavy metals (HMs).
- Regeneration of urban ecosystems is connected with the ability of trees to retain, uptake and decompose pollutants (including HMs) from contaminated urban soils, enabling their re-use process and turning them into green and environmental friendly areas.
- Taking into account advantages of phytoremediation technique, the aim of this paper is to present concentrations of some HMs (cadmium, lead and zinc) in urban soils and trees in cities across Bosnia and Herzegovina and look into the phytoremediation potential of common urban tree species: horse chestnut (*Aesculus hippocastanum* L.) and planetree (*Platanus x acerifolia* (Aiton) Willd.).
- How does urban pollution with HMs affects soils and plants?
- Do common urban tree species have important role in the phytoremediation of urban soils loaded with high content of HMs?

3. Soil and plant sampling

- Urban soils and leaves of the selected tree species are sampled in the city areas across the Republic of Srpska (Bosnia and Herzegovina). The aim was to sample a material in the urban greenspaces (parks and alleys), positioned near traffic-loaded streets and streets with low traffic frequency.
- Two tree species, horse chestnut (*Aesculus hippocastanum* L.) and planetree (*Platanus x acerifolia* (Aiton) Willd.) were chosen, since they are very abundant species in the urban green areas of selected cities.
- Plant material (fully developed leaves of about the same age) was sampled at 2 m height above the ground and at about 1-2 m from the traffic-loaded streets. Leaves were collected from the exterior part of the tree crown oriented towards streets. Sampling was conducted in the beginning of the vegetation period (May 2019.)
- Soils were sampled on the depth of 20 cm, in two distances, 1 m and 20 m from the two streets: with the most frequent traffic and with the lowest traffic frequency.



Figure 1. Horse chestnut (*Aesculus hippocastanum* L.)



Figure 2. Planetree (*Platanus x acerifolia* (Aiton) Willd.)



Figure 3. Soil sampling

4. Results

Table 1. Concentrations of three heavy metals (Cd, Pb and Zn) in urban soils across the cities of the Republic of Srpska (Bosnia and Herzegovina) (mg/kg of dry weight).

Locations	Traffic frequency	Distance of soil sampling from the streets (m)	Concentration of heavy metals		
			Cd	Pb	Zn
Banja Luka	low frequency	1-1	<0.1	50.9	196.3
Banja Luka	high frequency	1-1	0.3	54.8	130.3
Banja Luka	low frequency	1-20	<0.1	49.5	127.8
Banja Luka	high frequency	1-20	0.4	55.5	110.1
Prijedor	low frequency	1-1	0.3	98.3	134.1
Prijedor	high frequency	1-1	0.2	92.9	190.0
Prijedor	low frequency	1-20	<0.1	95.7	139.2
Prijedor	high frequency	1-20	<0.1	47.5	128.0
Prnjavor	low frequency	1-1	0.3	83.6	112.1
Doboj	low frequency	1-1	<0.1	46.0	120.7
Doboj	low frequency	1-20	0.5	55.1	131.8
Doboj	high frequency	1-1	0.3	52.4	143.4
Doboj	high frequency	1-20	<0.1	42.7	110.7
Bijeljina	low frequency	1-1	<0.1	46.7	134.5
Bijeljina	high frequency	1-1	0.1	59.4	206.6
Bijeljina	low frequency	1-20	4.2	116.0	129.7
Bijeljina	high frequency	1-20	<0.1	47.5	136.2
Trebinje	low frequency	1-1	<0.1	73.3	89.1
Trebinje	high frequency	1-1	0.3	94.7	143.0
Trebinje	low frequency	1-20	0.7	97.6	178.1
Trebinje	high frequency	1-20	0.6	85.8	138.1

Table 2. Concentrations of three heavy metals (Cd, Pb and Zn) in horse chestnut and planetree across the cities of the Republic of Srpska (Bosnia and Herzegovina) (mg/kg of dry weight).

Locations	Plant species	Concentration of heavy metals		
		Cd	Pb	Zn
Banja Luka	horse chestnut	<0.1*	<0.1	24.2
Prijedor	horse chestnut	<0.1	<0.1	20.2
Doboj	horse chestnut	<0.1	<0.1	25.0
Bijeljina	horse chestnut	0.3	<0.1	44.7
Trebinje	horse chestnut	<0.1	<0.1	20.5
Banja Luka	planetree	<0.1	15.8	17.5
Prijedor	planetree	<0.1	<0.1	16.3
Prnjavor	planetree	<0.1	<0.1	18.5
Doboj	planetree	<0.1	<0.1	17.6
Bijeljina	planetree	<0.1	<0.1	35.9
Trebinje	planetree	<0.1	<0.1	14.2
-	„reference plant“	0.05	1	50

*Average values of three samples are presented
<0.1 – value below detection limit

5. Discussion

- The results of the measurements of heavy metal concentrations in the soils from urban green areas are showed in a Table 1. The highest level of Cd (4.2 mg/kg), Pb (116.0 mg/kg) and Zn (206.6 mg/kg) in urban soil has been detected in the city park of Bijeljina. According to the Rulebook on allowed quantities of hazardous and damage materials in agricultural soil and water for irrigation and methods for their testing („Official Gazette of the Republika Srpska“, no. 56/16), limit values of examined HMs are in range: 0.5-2 mg/kg Cd, 50-150 mg/kg Pb and 60-200 mg/kg Zn. The contents of Cd and Zn were above recommended limit values. Bijeljina is second biggest city in the Republic of Srpska, less populated than Banja Luka, but still with more contaminated urban soils compared to the other cities of the Republic of Srpska. Traffic frequency may not be considered as a parameter that significantly influence level of soil contamination, particularly in smaller towns (e.g. Prijedor), where streets with different traffic frequency are close to each other. According to the European soil database (2004) those concentrations of HMs are low elevated, but still above concentrations in the soils of the world.
- Concentration of Cd in the leaves sampled in the Bijeljina city park and Pb in the leaves sampled in Banja Luka city park were above the “reference plant” values, the system that has been widely used to compare different plant species and different localities (Table 2). Elevated metal contents in the sampled tree leaves indicates that horse chestnut and planetree could be a good choice for phytoremediation of urban areas, where they are very abundant species. However, it should be noted the results of this investigations depend on examine plant species as well as of the plant water and mineral nutrition, HMs availability for plants and HMs concentrations in the urban air and soils. Vegetation period also influences the content of HMs in leaves, since the concentrations of HMs increases along a vegetation period.
- The results showed significant phytoremediation potential of above mentioned tree species, which opens space for further research and introduction of this NBS for remediation of many severely polluted urban soils, drawing attention to better-understood urban sustainability and importance of application of phytoremediation as NBS on local level.

6. Acknowledgements

This research was supported by the Ministry of Science-Technological Development, Higher Education and Information Society of the Republic of Srpska, Grant No. 19/6-020/961-43/18.

Contact

Email: marijana.kapovic-solomun@sf.unibl.org; zorana.hrki-lic@sf.unibl.org; nada.sumatic@sf.unibl.org

Website: <http://www.sf.unibl.org>

Phone: Headquarters: +387 51 464 628, 464-884, 464-298

Dean: +387 51 460 550

Fax: +387 51 460 550

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