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HEAVY METAL CONTENT IN CITY TREE LEAVES USED FOR COMPOST PRODUCTION

ZAWARTOŚĆ METALI CIĘŻKICH W LIŚCIACH DRZEW MIEJSKICH WYKORZYSTANYCH DO PRODUKCJI KOMPOSTU

Abstract: The object of the study was to determine the levels of heavy metal accumulation (lead, cadmium, zinc, copper, iron, and chromium) in the leaves of eight species of trees. Conducted analyses demonstrated that in Warsaw the emissions caused by motor traffic were decisive in the levels of heavy metal accumulation. They also demonstrated a significant dependence of their content in the leaves on the distance from the road. In an industrial area (steel works in the Bielany district of Warsaw) the highest accumulation of heavy metals was observed, with the exception of copper. In turn, the greatest contamination with copper was found in the street trees growing in the city center. Heavy metal content in the leaves of trees was much lower than the levels considered allowable in compost as specified in the EU Directive and by the Polish law.

Keywords: heavy metals, compost, environmental pollution, trees

Civilization development leads to generating ever larger amounts of various kinds of waste. Legal limitations to apply storage as a method of neutralizing wastes that succumb to biodegradation caused increased interest in their biological processing. Wastes removed from the urban green spaces (branches, shrubs, leaves, grass) constitute over 18 % of all communal wastes and are first of all a huge resource of organic matter. The best method for their utilization is composting, and then using the finished product as a fertilizer [1, 2]. According to the Polish Main Statistical Office (GUS) urban and residential green spaces constitute about 65 000 ha in Poland. Assuming that the annual production of plant mass in the green spaces is 5 tons per ha, we get about 325 000 tons of dry raw material for compost production [2]. Plant wastes originating from upkeep of urban green spaces have been composted for a long time to satisfy internal needs of many large parks, for example Lazienki Park in Warsaw, and in some other cities, for example Lodz. However, because of the possibility of contamina-

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ting the compost with heavy metals, one needs to study particularly precisely their chemical composition [1]. The objective of the research conducted was to determine the heavy metal content in city tree leaves used for compost production.

Sites and study methods

The study involved eight tree species, growing in sites in Warsaw that were diverse with respect to the degree of pollution. The research areas were localized at an industrial site, near the main communication arteries, residential streets, and in downtown parks. Leaves of the Crimean Linden were collected in the median area between the traffic lanes of Zwirki i Wigury Avenue, and at distances of 10, 50 and 100 m from the road. The control area was set up in The Botanical Garden in Powsin, and in the case of the Crimean Linden, the Bielany Woods, an area with relatively little contamination [3].

From each site leaves of six trees were collected in mid September, from which a collective sample was formed. The spectrophotometric atomic absorption method applied with a spectrophotometer found the heavy metals (cadmium, lead, zinc, chromium, copper, and iron) in the plant material mineralized dry in a muffle oven [4, 5].

Review, results, and discussion

Heavy metal content in the leaves of studied tree species, growing in the Warsaw area varying with respect to the level of contamination, and in the control area, is represented in Table 1. In Figure 1 was illustrated the effect of the distance from the road on heavy metal content in the Crimean Linden leaves.

Research demonstrated that in Warsaw the emissions caused by motor traffic were decisive about the levels of heavy metal accumulation in the leaves of trees. Demonstrated was the fundamental effect of the distance from the road on their content in the leaves. Among the metals studied, the greatest decline was confirmed in the lead accumulation with the increase in the distance from the road, from 7.2 mg/kg in the median area between the traffic lanes to 3.1 mg/kg at a distance of 100m from the road. This clearly points to the road traffic as the main source of lead emissions. In the case of zinc, iron, copper and chromium the decline was smaller, but still distinct. The impact of motor traffic on the contamination of the environment with cadmium was decisively the smallest among all the metals studied, respectively from 0.334 mg/kg in the median area between the traffic lanes to 0.288 mg/kg at a distance of 100 m from the road.

The highest concentrations of heavy metals were found in the leaves of trees growing in the industrial area of Warsaw (steel works in the Bielany district), and second highest were those from the trees growing along the main arteries in the city center. The contamination in the parks and residential streets were significantly smaller. This tendency concerned all species of studied trees. The biggest relative differences between the control area (The Botanical Garden in Powsin), and the polluted area (area of Warsaw) manifested itself in the case of chromium and, to a lesser degree, lead and zinc. These differences in the contents of iron, copper and cadmium were significantly

Table 1

Heavy metal content [mg/kg] in the leaves of trees from the Warsaw area

Localization	Pb	Cd	Zn	Cu	Fe	Cr
<i>Betula pendula</i> Roth						
Steel works ArcelorMittal	10.9	0.568	845	8.3	397	2.34
Sikorskiego St.	5.9	0.231	467	9.8	245	1.35
Wielkopolski Park	3.0	0.167	408	7.6	231	1.23
Control	1.9	0.095	313	7.0	147	0.76
<i>Quercus robur</i> L.						
Marszalkowska St.	7.8	0.295	45	10.6	286	1.40
Wielkopolski Park	4.6	0.283	36	8.8	224	1.09
Control	2.3	0.112	28	7.1	154	0.81
<i>Gleditsia triachantos</i> L.						
Niepodległości Av.	4.7	0.197	35	13.3	274	1.22
Krasickiego St.	3.5	0.190	28	6.1	193	1.05
SGGW Park	3.3	0.192	29	8.8	128	1.13
Control	1.7	0.089	17	5.6	89	0.66
<i>Aesculus hippocastanum</i> L.						
Marszalkowska St.	8.1	0.307	44	15.6	303	1.57
Saski Garden	3.1	0.297	35	11.6	275	1.50
Control	2.0	0.123	21	6.0	205	0.81
<i>Acer platanoides</i> L.						
Swietokrzyska St.	7.7	0.283	42	9.0	279	1.46
Saski Garden	3.9	0.277	35	9.3	265	1.40
Control	2.1	0.143	26	5.5	137	0.65
<i>Robinia pseudoacacia</i> 'Umbraculifera'						
Belwederska St.	4.8	0.207	36	8.3	257	1.12
Komorska St.	3.2	0.186	25	6.7	176	1.01
Control	1.8	0.103	18	4.7	132	0.53
<i>Tilia cordata</i> L.						
Marszalkowska St.	7.1	0.289	49	14.6	311	1.49
Saski Garden	3.3	0.274	28	10.2	282	1.33
Control	2.0	0.157	22	6.0	119	0.80
<i>Tilia</i> 'Euchlora'						
Zwirki and Wigury Av.						
Median area between the roads	7.2	0.334	55	9.2	268	1.33
10 m from the road	7.0	0.297	49	9.0	260	1.30
50 m from the road	5.0	0.295	33	8.5	221	1.22
100 m from the road	3.1	0.288	26	7.8	187	1.19
Bielany Woods (control)	2.4	0.232	23	5.4	137	0.66

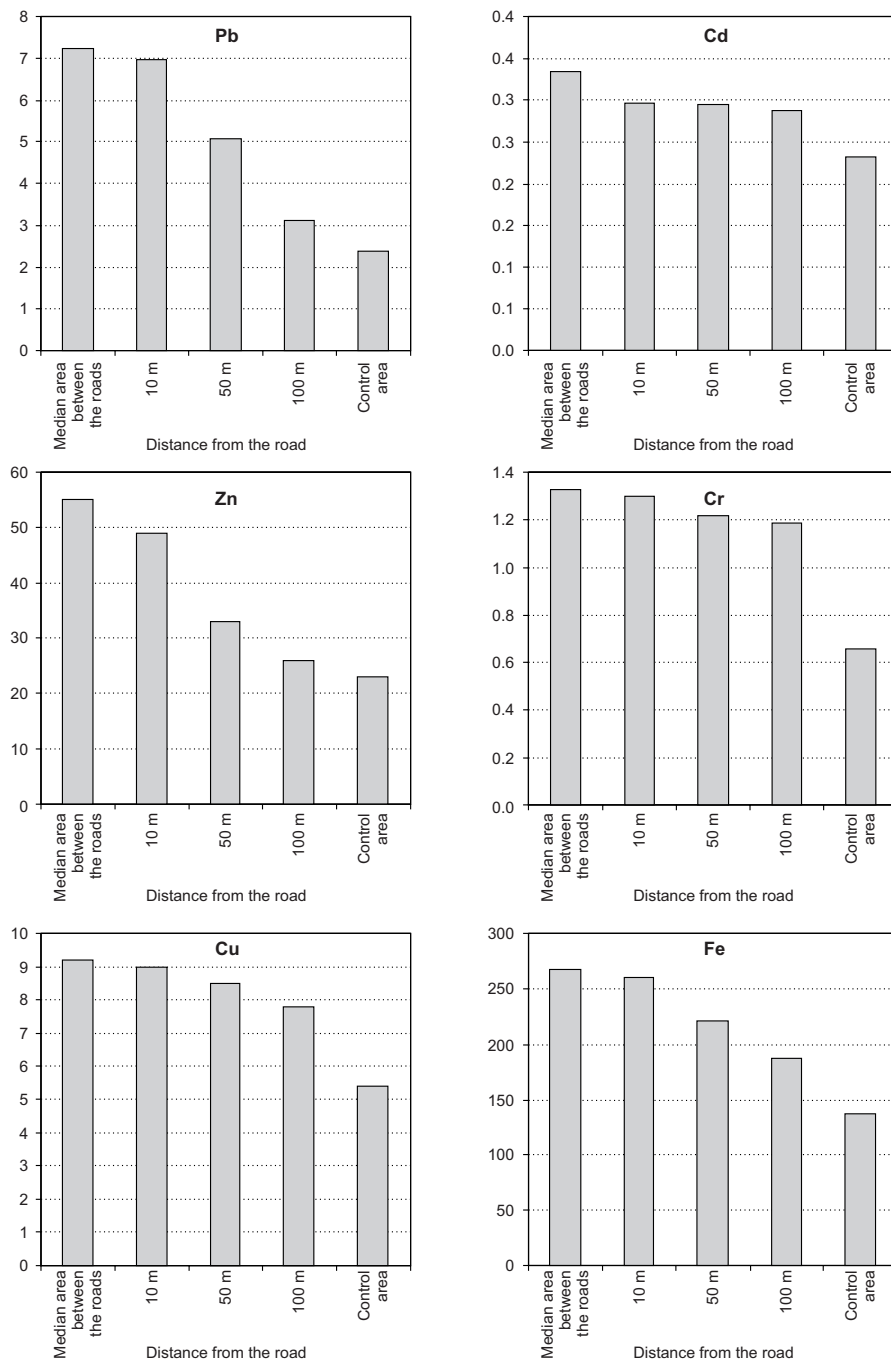


Fig. 1. Heavy metal content [mg/kg] in the Crimean Linden leaves as a function of the distance from the road of Zwirki and Wigury Avenue

smaller. In the industrial area (steel works in the Bielany district of Warsaw) the highest accumulation of heavy metals was recorded (with the exception of copper). In turn, the biggest contamination with copper was concluded for the street trees growing in the city center.

The studied tree species accumulated heavy metals to different degrees. The biggest difference was found in the case of zinc. The leaves of Silver Birch contained the most of this element, whereas with other species the content was smaller by over an order of magnitude. Published data indicate that the leaves of Silver Birch contain naturally higher levels of zinc than those found in other species. This is a species specific characteristic [6, 7].

From the research conducted it follows that the large leaf trees (Chestnut, Maple, Oak and Linden) had accumulated more lead, cadmium, zinc and chromium than the small leaves of trees from the family *Leguminosae* (Legume Family): Honey Locust and Acacia Robinia.

Heavy metal content in the leaves of trees was much lower than those described as the allowable levels specified in the EU Directive and the Polish regulations [8, 9]. Lowering of the plant mass even by 50 % through the process of mineralization will not cause a threat of going over the allowable contamination limits for compost (Table 2).

Table 2

Allowable metal content in compost in the Polish regulations and the EU Directive [8]

		Cd	Cr	Cu	Pb	Zn
Limits of maximum heavy metal content [mg/kg] in the European Union regulations						
Ecological agriculture (2092/91/EEC)		0.7	70	70	45	200
Eco-mark for fertilizers (2001/688 EC)		1.0	100	100	100	300
European Commission Proposals	Class I	0.7	100	100	100	200
	Class II	1.5	150	150	150	400
Poland (Regulation MRiRW, 2004)		3	100	400	100	1500

Despite not going over any legal limits governing contamination with heavy metals of the raw materials used for the production of compost, their application raises doubts. Because the material introduced into the environment is, to some extent, contaminated. However, the existing regulations enforce the production of compost utilizing waste collected from urban green spaces. So their application requires insightful monitoring of the levels of environmental pollution.

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Abstrakt: Przedmiotem badań było określenie poziomu akumulacji metali ciężkich (ołowiu, kadmu, cynku, miedzi, żelaza i chromu) w liściach ośmiu gatunków drzew. Przeprowadzone analizy wykazały, że w Warszawie emisje pochodzenia motoryzacyjnego decydowały o poziomie akumulacji metali ciężkich. Wykazano także istotny wpływ odległości od ulicy na ich zawartość w liściach. Na terenie uprzemysłowionym (huta ArcerolMittal na Bielanych) odnotowano najwyższą akumulację metali ciężkich z wyjątkiem miedzi. Największe skażenie miedzią stwierdzono natomiast w drzewach ulicznych rosnących w centrum miasta. Zawartość metali ciężkich w liściach drzew była o wiele niższa niż przewidują dopuszczalne poziomy w kompostach określone w Dyrektywie UE i polskim prawie.

Słowa kluczowe: metale ciężkie, kompost, zanieczyszczenie środowiska, drzewa