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The Impact of Urban Pollution on Soils and Plants of Homestead Gardens in Gorzów Wielkopolski (Poland)

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1. Introduction

Homestead gardens satisfy recreational needs of local communities and are used for amateur growing of vegetables and fruit. Being green areas, improving ecological standards of a given location, they are protected by legal regulations included in the Act on the Protection of Arable and Forest Land as well as the regulations concerning nature and environment protection (2013). In Poland, in 2011 there were 4941 homestead gardens, covering the total area of 43427 ha (GUS 2012). Generally, they are situated on the outskirts of urban-industrial agglomerations. Urban development brings about the intensification of factors limiting their functions e.g. by worsening soil conditions.

Many authors indicate that dust pollution emitted by local industrial plants, power plants and increased car traffic result in excessive accumulation of heavy metals in the soil of allotment gardens (Hjortenkrans et al. 2006, Kabała et al. 2009, Morton-Bermea et al. 2009, Ordóñez et al. 2003, Sindern 2007, Wei & Yang 2010).

Homestead gardens are frequently located close to main transport routes characterised by a great intensity of traffic. The highest accumulation of heavy metals has been observed in the topsoil adjacent to roads (Antisari et al. 2015, Bretzel & Calderisi 2006, Charlesworth et al. 2010, Forman & Alexander, 1998, Meinhardt et al. 2011, Säumel et al. 2012).

Therefore, it is indispensable to determine the amount of heavy metals in vegetables from these gardens. Numerous scientific papers reveal excessive accumulation of certain heavy metals in surface soil layer and the increase in their concentration in different vegetables (Antisari et al. 2015, Bretzel et al**.** 2016, Chaney et al. 1984, Gontarz & Dmowski 2004, Kachenko & Singh 2006, Staniak 2014, Sterrett et al. 1996, Rogóż 2003). Some authors suggest a weak accumulation of heavy metals in vegetables despite of soil contamination (Chodak et al. 1995, Sipter et al. 2008). By consuming contaminated vegetables, heavy metals may be included into a trophic chain (Kachenko & Singh 2006, Pruvot et al. 2006).

The area Gorzów is of about 86 km^2 and has 124.5 thousand. residents. There are a well-developed chemical, electronic, energy, pharmaceutical, machine, metal, automotive, food and textile industries in the city. Many companies operate within the Gorzów Subzone of the Kostrzyn-Słubice Economic Zone. There is also an important transport hub connecting Western and Eastern Europe as well as southern and northern Europe. Reports on the state of the environment in the Lubuskie voivodship for the years 2009-2012 (WIOŚ in Zielona Góra 2011, 2013) indicate that the main source of pollution in Gorzów Wlkp. is the surface emission of dust associated with individual heating of housing in the municipal sector as well as the emission from transportation. Comparing Gorzów Wlkp. to other cities of the Lubuskie Voivodship, one can state that it shows the highest over-average of annual and daily average quantities of particulate matter (WIOŚ in Zielona Góra 2011, 2013). Heavy metals enter the environment together with dust and atmospheric precipitation.

On the pollution of urban soils with heavy metals of some squares, Gorzowa Wlkp. is indicated by the report on the state of the environment in Gorzów Wielkopolski in the years 2000-2001 (WIOŚ in Zielona Góra 2002). According to the report on the state of the environment in Gorzów Wlkp. in the years 2000-2001 (WIOŚ in Zielona Góra 2002), the cause of lead pollution of some urban soils is a faulty communication system of the city, which is a big problem with the growing number of motor vehicles.

The distribution of pollutants in the Gorzów Wlkp. environment is related to the strength and prevailing north-west and west wind directions. The main industrial facilities of Gorzów Wlkp. are located in the north-western and western parts of it. In contrast, the allotment gardens studied are located in the southern part of Gorzów exposed to the imission of air pollutants.

The report on the state of the environment in Gorzów Wielkopolski in the years 2000-2001 (WIOŚ in Zielona Góra 2002) indicates on the pollution of urban soils of some squares with heavy metals. According to this report the main cause of lead pollution of some urban soils is a faulty communication system of the city, which became a big problem due to the growing number of motor vehicles.

The distribution of pollutants in the Gorzów Wlkp. environment is related to the strength of the wind as well as its prevailing north-western and west directions. The main industrial facilities of Gorzów Wlkp. are located in the north-western and western parts of it. In contrast, the studied allotment gardens are located in the southern part of Gorzów Wlkp., which is exposed to the imissions of air pollutants.

The main aim of the conducted research was to determine the content of heavy metals in soils and selected vegetables and indicator plants of family allotment in Gorzów Wlkp.

2. Materials and methods

The studies were carried out at the end of vegetation season (20-30 August 2011) in Gorzów Wlkp. within the Homestead Gardens along Kasprzaka street.

Three transects were designated on its area along which four research areas were designated: at the roadway, approx. 20, 50 and 100 meters from the roadway – a total of 12 research areas (Figure 1).

From each of the research areas the collective samples (representing the research area) of parsley leaves, carrot roots, leaves and roots of red beets, plantain leaves, dandelion leaves were collected in four replications. In addition, within the each research area under five examined plants: parsley, carrot, red beet, plantain and dandelion, were collected soil composite samples (a total of 20 individual samples) from the humus level.

Altogether 12 soil samples and 60 plant samples (parsley leaves, carrot roots, red beet leaves and roots, leaves of common plantain, leaves of common dandelion) were taken for laboratory analysis.

Fig. 1. An overview map of research area locations within the Family Garden Garden (ROD) in Gorzów Wielkopolski (I, II and III – transects with research surfaces: at the roadway, about 20, 50 and 100 meters from the road)
Rys. 1. Poglądowa mapa lokalizacji powierzchni badawczych w obrębie Rodzinnego Ogrodu Działkowego (ROD) w Gorzowie Wielkopolskim (I, II i III – transekty z powierzchniami badawczymi)

In the soil material the following determinations were made: granulometric composition by the Casagrande areometric method modified by Prószyński, granulometric groups according to the classification of Polish Soil Society (PTG 2008); pH_{H2O} and pH_{KCl} – potentiometrically; hydrolytic acidity (Hh), total bases (S) – by the Kappen method, on the basis of which adsorbing capacity (T) and base saturation (V) were calculated; the content of total carbon by means of elementary analyser (CHNS-O, Costech Italy); the content of available phosphorus and potassium by the method of Egner-Riehm; the content of available magnesium in mineral soils by the method of Schachtschabel; the content of the so-called total forms of macroelements – K, Mg, Ca, Na and heavy metals – Cd, Co, Cu, Zn, Ni, Pb, Mn, Fe (soluble in concentrated HNO_3+$HClO_4$, at the ratio 1:1) – by means of atomic absorption spectrophotometer Unicam Solaar 929, whereas P – colorimetrically.

The plant material for the experiment consisted of the most common cultivated root vegetables i.e. carrot, parsley and red beet; and indicator plants – common plantain and common dandelion. Collected plants were thoroughly washed under running water and cut. After air-drying vegetables were ground in a high-speed mill. In plant samples the total content of heavy metals – Cd, Co, Cu, Zn, Ni, Pb, Mn, Fe (soluble in concentrated acids HNO_3+$HClO_4$, 1:1) was determined using atomic absorption spectrophotometer Unicam Solaar 929.

In order to assess heavy metals contamination of soil under study, permissible limits given in the Polish Regulation of Minister of Environment on soil and land quality standards (2002) and the criteria developed by Polish Institute of Soil Science and Plant Cultivation (IUNG 1993), based on elaborate, long-term investigations which allowed to determine borderline heavy metals levels in soil used for agriculture, were used.

The chemical composition of soil and plants between the study sites (located at the road, about 20, 50 and 100 meters from the road in three replications) were compared.

The obtained results were verified statistically by means of Anova for single-factor experiments and the Tukey test. Normal distribution of variables was checked by the Shapiro-Wilk test and homogeneity of variances by the Brown-Forsythe test. The programme *Statistica 10.0 PL* was used for statistical analysis.

3. Results and discussion

The soils of analyzed homestead gardens are characterized by a relatively little diversified granulometric composition. They are mostly slightly loamy sands, sandy loams and loose sands in the direct vicinity of roads (Table 1).

Soil reaction on which ion balance depends is an important and a decisive parameter for the solubility of heavy metals in soil, is. The solubility of heavy metals is usually low at neutral and alkaline reaction and is growing with decreasing pH values (Kabata-Pendias & Pendias 1999).

Table 1. Mean content of size fractions in the soil adjacent to road and soil of allotment gardens
Tabela 1. Średnia zawartość frakcji granulometrycznych w glebie przyległej do jezdni i glebach ogródków działkowych

Distance from road (m)	Sand (2.0-0.05)	Silt (0.05-0.002)	Clay (<0.002)	Soil textural group
	%			
0	93	4	3	loose sand
20	76	18	6	slightly sandy loam
50	84	10	6	slightly loamy sand
100	77	15	8	sandy loam

The reaction of examined soils ranged from neutral to alkaline. The highest values were recorded in the direct vicinity of roads pH_{H2O} and pH_{KCl}. With the distance from the road pH value was deacreasing and statistically significant lower pH was detected on the study areas located 100 m away from the road. Similar regularity was found by Filipek & Badora (1992). The alkalinity of Lublin soils, analysed by these authors, was the higher the closer to the road they were situated, which was the result of chemicals alkalinising the soil, used in winter to fight ice and snow on roads.

Sorption capacity is an important parameter for estimating soil quality since it conditions the nutrient retention ability including immobilisation of potentially toxic elements. In the analysed soil material sorption capacity values were similar, only in the case of hydrolytic acidity a statistically significant increase was observed at a greater distance from the road (Table 2). The obtained sorption capacity values are lower than those recorded by Świerszcz & Sykała (2009) in the topsoil of Kielce allotment gardens (310.0 to 601.0 mmol(+)$\cdot kg^{-1}$).

Base saturation (V) of examined soils ranged from 92.8 to 98.4%, the highest values were found in the soils adjacent to the road. Both high sorption capacity and the highest saturation of soils adjacent to the road, may contribute to heavy metals retrogradation and therefore, as it had been emphasised by Kabata-Pendias & Pendias (1999), are vital factors preventing negative effects of soil contamination.

Total carbon content was in the range 13.54 to 21.36 $g\cdot kg^{-1}$ (Table 2), which in Gałka's opinion (2011) is typical of allotment gardens.

The highest level of organic carbon was obtained in the samples from the area 100 m from the road and the lowest from the site lying near the road.

The resources of available macroelements varied in the examined soil (Table 2). The soils bordering the road contained a low content of available phosphorus and magnesium whereas in the other soil samples it was within the values considered as very high by the Institute of Soil Science and Plant Cultivation (IUNG 1990). The concentration of these elements, found on the surface of study areas lying 20, 50 and 100 meters from the road, was significantly higher in comparison with the values obtained from the soil neighbouring the road. In the case of potassium the content of its available forms was low according to the criteria of IUNG (1990), in all analysed samples irrespective of localisation.

Table 2. Chosen soil properties of allotment gardens in Gorzow Wielkopolski
Tabela 2. Wybrane właściwości chemiczne gleb ogrodów działkowych Gorzowa Wielkopolskiego

Specification			Distance from road (m)				$LSD_{0,05}$
			0	20	50	100	
pH_{H2O}			7.47 a*	7.43 a	7.26 ab	7.05 b	0.32
pH_{KCl}			7.41 a	7.36 a	7.19 ab	6.97 b	0.27
Hh		$mmol(+)\cdot kg^{-1}$	6.5 a	9.0 ab	13.5 ab	17.0 b	0.86
S		$mmol(+)\cdot kg^{-1}$	417.0 a	249.0 a	202.0 a	252.0 a	249.0
T		$mmol(+)\cdot kg^{-1}$	423.5 a	258.0 a	215.5 a	269.0 a	244.0
V		%	98.4 a	95.6 a	93.8 a	92.8 a	6.0
Available	P	$mg\cdot kg^{-1}$	54.6 a	272.2 b	281.6 b	250.5 b	128,5
Available	Mg	$mg\cdot kg^{-1}$	14.4 a	89.7 b	106.0 b	143.4 b	57,2
Available	K	$mg\cdot kg^{-1}$	31.6 a	78.9 a	112.3 a	147.3 a	127,3

Table 2. cont.
Tabela 2. cd.

Specification			Distance from road (m) 0	20	50	100	$LSD_{0,05}$
Total	C	g·kg^{-1}DM.	13.54 a	14.95 ab	18.85 ab	21.36 b	7.78
	Ca		3.07 a	1.89 ab	0.43 b	0.83 ab	2.32
	Na		0.34 a	0.09 b	0.10 b	0.10 b	0.17
	K		0.73 a	1.29 ab	1.39 b	1.69 b	0.63
	Mg		0.93 a	0.58 a	0.39 a	0.47 a	0.71
	Co	mg·kg^{-1}DM.	2.31 a	0.33 b	0.21 b	0.40 b	1.19
	Cd		0.31 a	0.05 b	0.01 b	0.04 b	0.22
	Ni		4.23 ab	5.37 a	5.00 a	1.77 b	2.58
	Cu		19.70 a	6.93 b	8.03 b	9.50 b	7.83
	Pb		15.13 a	7.23 a	10.13 a	13.07 a	9.30
	Zn		72.9 a	40.8 b	41.7 b	56.2 ab	29.9
	Mn		162.3 a	397.0 b	400.3 b	278.4 ab	153.8
	Fe		6471 a	8961 a	10784 a	9126 a	6406

*- homogeneous groups

The soil of allotment gardens under study, were characterised by differentiated resources of macroelement total forms (Table 2). The richest resources of total forms Ca, Na and Mg were detected in the soil next to the road but there were the lowest concentrations of potassium and carbon. As Gałka (2011) suggests, a great diversity in the content of total forms of macroelements, in the soil of particular allotment gardens, may be the effect of different agricultural practices and fertilisation.

According to the Polish Regulation of Minister of Environment (2002) and (IUNG 1993), the discussed soils of Gorzow Wielkopolski should be regarded as unpolluted. However, elevated concentration of zinc was only recorded in the soil adjacent to the road.

Due to the report on the state of the environment in the Lubuskie Voivodeship in the years 2000 - 2001 (WIOS in Zielona Góra 2002), the state of the soils of the municipal gardens in Gorzów is good. There are a few places, which are polluted by lead form the public transport.

Our findings are in line with the investigations of Bielicka et al. (2009) on the soils and vegetables in allotment gardens of Gdańsk and its surroundings in which there was no breaking of legal norms concerning the soil heavy metals content. The lack of contamination of urban soils with lead is also indicated by Bielińska (2006), Bretzel et al. (2016), Sterrett et al. (1996). In turn, indicated that the soils of allotment gardens in Upper Silesia are strongly contaminated with zinc, lead and cadmium. Similar conclusions were drawn by Baran et al. (2007), Kabała et al. (2009), Wójcikowska-Kapusta (2007), who examined the soils of homestead gardens in Silesia, Biała Podlaska and Lublin. Piotrowska and Koper (2007) in the studies conducted in Inowrocław found out that among 11 allotment garden samples, contamination with zinc, lead and cadmium was only in three of them. In addition, the studies of Antisari et al. (2015), Chaney et al. (1984), Charlesworth et al. (2010), Hough et al. (2004) and Mitchell et al. (2014) show also the heavy metals pollution of household gardens in urban agglomerations.

Although the permissible limits have not been exceeded in the analysed soils, there is no doubt that in the case of Co, Cd, Cu, Zn and Mn, their level is affected by the vicinity of the road. There is a statistically significant higher concentration of the above mentioned heavy metals in the soils adjacent to the road in comparison with the soils lying further away from the road (Table 2). Similar relationship was observed by Antisari et al. (2015), Baran et al. (2007), Czarnkowska (1995), Gherardi et al. (2009) and Säumel et al. (2012) in whose opinion the risk of soil and vegetation contamination with heavy metals mainly depends on the intensity of traffic and the distance from emission sources.

Other studies indicate that in urban agglomerations, despite the lack of soil contamination with heavy metals, vegetation is contaminated. It is related to the physiological predispositions of some plant species for accumulation in various parts (roots, shoots, fruits, seeds) of heavy metals from the soil and dust settling on plants (Murray et al. 2009, Kabata-Pendias & Pendias 1999, Peris et al. 2007).

Among field crops, vegetables are the most capable of storing metals, both by their uptake from soil and precipitation, via their above-ground parts (Hough et al. 2004, Staniak 2014).

From the surface of vegetables for consumption, the majority of metals may be removed by thorough washing but those absorbed by roots are built into the plant tissues and pose a threat to humans (Bielicka et al. 2009, Hough et al. (2004), Kabata-Pendias & Pendias 1999, Staniak 2014).

The content of particular heavy metals in plants depends on many factors including reaction and base saturation of a soil (V). High concentration of salts may reduce water uptake and thus ions, by increasing osmotic potential of soil solution. High pH immobilises metals in soils by the formation of carbonates and phosphates (Islam et al. 2007, Ross 1994).

In our studies, the content of heavy metals in vegetables varied, depending on plant species (Table 3).

Similar differences were found by Antisari et al. (2015), Finster et al. (2004), Säumel et al. (2012). No negative influence of the vicinity of the communication route and urban agglomeration on the content of heavy metals in the analyzed vegetables was found. However, research provided by Antisari et al. (2015), Säumel et al. (2012), Staniak (2014) show the impact of the communication route on the heavy metals content in vegetables. Hough et al. (2004) indicates that vegetables from urban agglomerations can be dangerous to human health. Cadmium and lead are particularly dangerous for human health. In the studied soils, the content of lead and cadmium was below the detectable level of the applied method ($<0.01\ mg \cdot kg^{-1}$ d.m.).

Table 3. Content of heavy metals in vegetables from allotment gardens in Gorzow Wielkopolski
Tabela 3. Zawartość metali ciężkich w warzywach pochodzących z ogrodów działkowych Gorzowach Wielkopolskiego

Specification			Distance from road			$LSD_{0,05}$
			20	50	100	
Parsley aboveground parts	Mn	mg·kg^{-1}D.M	40.70 a	21.08 b	19.98 b	10.53
	Zn		36.17 a	26.79 a	33.77 a	13.30
	Co		1.33 a	3.22 b	4.90 b	11.74
	Ni		6.40 a	6.73 a	7.19 a	2.50
	Cu		9.34 a	8.43 ab	7.17 b	2.10
	Fe		470.1 ab	580.1 a	258.7 b	228.3
Carrot root	Mn		17.57 a	12.97 a	14.00 a	4.95
	Zn		31.47 a	22.76 b	24.30 ab	8.35
	Co		1.48 a	3.08 a	3.09 a	3.71
	Ni		14.27 a	5.93 b	5.75 b	4.89
	Cu		11.46 a	12.89 a	10.81 a	6.97
	Fe		256.6 a	188.8 a	299.2 a	317.3

Table 3. cont.
Tabela 3. cd.

Specification			Distance from road 20	50	100	$LSD_{0,05}$
Red Beet aboveground parts	Mn		43.37 a	69.09 b	40.30 a	24.68
	Zn		30.57 a	42.57 a	89.20 a	117.6
	Co		0.89 a	2.13 b	3.68 c	0.93
	Ni		6.23 a	13.81 b	6.00 a	6.41
	Cu		9.69 a	9.53 a	8.80 a	3.08
	Fe		469.3 a	660.7 a	866.0 a	545.1
Red Beet root	Mn		24.01 a	32.06 a	26.85 a	24.2
	Zn		27.05 a	34.07 a	50.23 b	15.23
	Co		5.39 a	6.05 ab	6.45 b	0.78
	Ni		6.14 a	7.65 b	6.72 ab	1.09
	Cu		12.44 a	13.20 a	15.56 a	5.70
	Fe		134.6 a	206.5 a	142.0 a	147.0

* – homogeneous groups

The contents of Mn, Zn and Fe in the examined plant material was lower compared to the data presented by Ostrowska & Porębska (2002). In the aboveground parts of parsley they found Mn – 77; Zn – 170; Fe – 984 $mg \cdot kg^{-1}$ DM. However, the content of copper was almost 6-fold higher (mean 9.64 $mg \cdot kg^{-1}$ DM on the study areas lying 20 m from road) than the results of the above mentioned authors (1.5 mg $Cu \cdot kg^{-1}$ DM).

Moreover, in carrot roots ca. 2-fold higher than natural, amount of copper, was obtained in comparison with the data given by Ostrowska & Porębska (2002).

Kabata-Pendias & Pendias (1992) consider that the natural content of copper in plants to be less than 20 mg $\cdot$ kg^{-1} dm.

In the case of red beet, heavy metals values were closer to the amounts commonly regarded as natural (Ostrowska & Porębska 2002). Comparison of heavy metals level in red beet leaves and roots showed quantative variations in their chemical composition. In aboveground parts there was higher concentration of manganese, zinc and iron than in roots, whereas the roots contained more cobalt and copper than the aboveground parts.

To assess the degree of environmental pollution, the so-called bioindicators of pollution (plants with high tolerance to pollution and commonly occurring in various environments) as dandelion and plantain can be used (Kabata-Pendias & Dudka 1991, Keane et al. 2001, Ligocki et al. 2011, Marr et al. 1997, Stolarska et al. 2004). At the same time Stolarska et al. (2004) points that the plantain is a better bioindicator than the dandelion. Marr et al. (1997) found that the dandelion did not show elevated concentrations of heavy metals according to their increase in soils.

Analysis of chemical composition of common dandelion did not indicate, except zinc, a negative impact of the road (Table 4). Bomze et al. (2007) and Dzierżanowski & Gawroński (2011) indicate the plain impact of communication routes on the heavy metal pollution of dandelion plants.

The increased contents of some heavy metals, however, indicate their anthropogenic origin (dust and gas pollution of the air). The obtained values in the aboveground parts are similar to those given by Dąbkowska-Naskręt et al. (2000), Kabata-Pendias & Krakowiak (1998), Ligocki et al. (2011), Marr et al. (1997), Niedźwiecki et al. (2004).

The carried out research have shown that under the same environmental conditions within studied plants the dandelion accumulates nickel in the highest values. These quantities are much higher than those found in urban agglomerations by Keane et al. (2001), Ligocki et al. (2011) and Stolarska et al. (2004). According to Kabata-Pendias & Pendias (1992), the values of 0.1-5 are natural and 10-100 mg$\cdot$kg^{-1} s.m. excessive or toxic. Nickel is an element easily absorbed from the soil but also by aerial parts of plants (it is bound by a cuticle in the leaves of plants Kabata-Pendias & Pendias 1999). The so-called hyper-accumulators, can uptake this element up to about 0.5% dm (Kabata-Pendias & Pendias 1992). According to values given by Kabata-Pendias & Pendias (1992) the content of cobalt in dandelion leaves can be described as high, more than normative.

Table 4. Content of heavy metals in selected indicator plants
Tabela 4. Zawartość metali ciężkich w wybranych roślinach wskaźnikowe

	Specification		Distance from road (m)				$LSD_{0,05}$
			0	20	50	100	
Common dandelion *Taraxacum officinale*	Mn	$mg \cdot kg^{-1}DM$	50.31 a*	139.2 b	65.76 a	49.90 a	45.13
	Zn		70.43 a	61.22 b	55.02 b	62.03 b	7.56
	Co		3.19 a	4.48 a	4.09 a	4.68 a	2.08
	Ni		22.15 a	50.21 b	47.07 b	14.18 a	21.31
	Cu		16.86 a	16.23 a	12.96 a	16.52 a	6.59
	Fe		1365.8 a	4227.0 a	1602.0 a	1395.8 a	4008.9
Common plantain *Plantago maior*	Mn		94.43 a	110.96 a	63.69 ab	35.66 b	56.31
	Zn		54.68 a	50.46 a	45.70 a	68.00 a	28.11
	Co		3.15 a	3.67 a	7.18 b	3.18 a	0.81
	Ni		20.49 a	11.75 a	8.93 a	6.48 a	14.27
	Cu		17.29 a	32.22 a	36.88 a	22.79 a	25.31
	Fe		2536.3 a	2536.0 a	976.6 a	904.1 a	16.64

* – homogeneous groups

The vicinity of road had no statistically significant negative effect on the chemical composition of common plantain (Table 4). The obtained heavy metal contents were similar irrespective of localization, only in the case of manganese and nickel they were higher closer to the road.

The amounts of heavy metals found in leaves of plantain do not exceed natural values in plant tissues given by Kabata-Pendias & Pendias (1992). Only the nickel and cobalt content, regardless of the distance from the road, is unnaturally high (Kabata-Pendias & Pendias 1992). Similar exceedance of natural content of nickel in common plantain in Szczecin agglomeration were also reported by Stolarska et al. (2004).

4. Conclusions

The following conclusions can be attained:

1. On the basis of heavy metal content, the soils of homestead gardens in Gorzów Wielkopolski may be regarded as the soils with their natural level. Neutral or alkaline soil reaction reduce heavy metal availability to plants.
2. No apparent negative impact of the vicinity of road on heavy metal concentration in parsley leaves, carrot roots and red beets. The obtained heavy metal values were generally lower or close to those commonly considered to be natural. Only the nickel and cobalt content was high.
3. The distance between homestead gardens and roads has no effect on the content of heavy metals in common dandelion (*Taraxacum officinale*) and common plantain (*Plantago maior*).

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Wpływ zanieczyszczeń miejskich na glebę i rośliny ogródków działkowych w Gorzowie Wielkopolskim (Polska)

Streszczenie

Ogrody przydomowe są często zlokalizowane w pobliżu głównych szlaków komunikacyjnych, charakteryzujących się dużym natężeniem ruchu. Najwyższe nagromadzenie metali ciężkich zaobserwowano w wierzchniej warstwie gleb przylegającej do dróg. Celem przeprowadzonych badań było określenie: wpływu zanieczyszczeń miejskich na właściwości chemiczne gleby i skład chemiczny wybranych warzyw i roślin wskaźnikowych w glebie rodzinnych ogródków działkowych w Gorzowie Wielkopolskim. Stwierdzono statystycznie istotne wyższe stężenie metali ciężkich w glebach przylegających do drogi w porównaniu z glebą leżącą 20, 50 i 100 m od drogi. Uzyskane wartości metali ciężkich były na ogół niższe lub zbliżone do tych powszechnie uznawanych za naturalne w glebach, warzywach i roślinach wskaźnikowych. Tylko zawartości niklu i kobaltu były wysokie.

Abstract

Homestead Gardens are frequently located close to main transport routes characterized by a great intensity of traffic. The highest accumulation of heavy metals has been observed in the topsoil adjacent to roads. The aim of conducted studies was to determine: the effects of urban pollution on soil chemical properties and chemical composition of selected vegetables and indicator plants, in the soil of family allotment gardens in Gorzów Wielkopolski. There is a statistically significant higher concentration of the heavy metals in the soils adjacent to the road in comparison with the soils lying ca. 20, 50 and 100 m from the road, respectively. The obtained values of heavy metals were generally lower or close to those commonly considered natural in soils, vegetables and indicator plants. Only the nickel and cobalt content was high.

Słowa kluczowe:
metale ciężkie, zanieczyszczenia miejskie, gleba, warzywa,
rośliny wskaźnikowe

Keywords:
heavy metals, urban pollution, soil, vegetables, indicator plants