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Soil Chemistry

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THE CONTENT OF LEAD IN SOILS OF ALLOTMENT GARDENS IN ZIELONA GÓRA, POLAND

Abstract. Lead, as a heavy metal, is harmful to living organisms (both plants and animals) and it is relatively mobile in the environment. In this article we present the results of the monitoring of the lead content in local allotment gardens (Zielona Góra, Poland). We examined both the total and the phytoavailable form. Soil samples were collected in eight places in the allotment gardens, and two places in the neighbourhood of the allotment gardens. The lead content in the soil met the Polish soil ground standards (Regulation by the Minister of the Environment of 9.09.2002). The total content of lead varied from 21 to 39 mg kg^{-1}, (12–14 mg kg^{-1} at reference point) and the form potentially available for plants from 10 to 19 mg kg^{-1} (6–7 mg kg^{-1} at reference point). The content of lead does not exceed the threshold values according to Polish law.

In every Polish town and city, part of the land is used as allotment gardens. As well as decorative plants, fruits and vegetables are also grown for consumption. Because of TV programmes and articles in specialist magazines, people are learning about ecological products and the methods of growing them. According to GUS [Central Statistical Office] [8], in 2012 there were 4,929 gardens (43,350 ha) divided into 965,328 allotments (33,972 ha). The area of the gardens has decreased since the year 2000 (from 43,952 ha) although the area of allotments has increased (from 33,224 ha).

High interest in ecological food goes together with the question: Is what we grow in our allotments really so healthy? The atmospheric dust, traffic, the fact that allotments are often located in post-industrial areas, the use of artificial

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fertilizers and pesticides and contaminated compost may all lead to a high quantity of pollution in the soil, including heavy metals. As early as in 1966 [20], extensive contamination with metals was detected in gardens in Scottish towns. Around the world, other researchers have also started to examine this problem [1, 3 20]. Because of high interest in allotment gardens, the issue of its contamination is still very real [14,17].

MATERIALS AND METHODS

The research site is situated in the southern part of Zielona Góra. The town is located in the middle west of Poland in the Lubusz Region. It is situated on a number of hills and belongs to the Silesia-Wielkopolska climatic region, which is an area with prevailing oceanic influences, characterized by small amplitudes of air temperature fluctuations. In the years 2001–2005 the average rainfall in the town was 533 mm. The lowest average temperature was –6.5˚C, and the highest average temperature was 22˚C [7].

The examined soil samples were collected in the southern part of Zielona Góra, in allotment gardens in Jędrzychów near the Bajkowe Housing Estate (Fig. 1).This part of the city is located outside the industrial zone and communication. Ten samples of soil were collected in total. Eight soil samples were collected in the allotment gardens and two in the neighbourhood of the gardens (wasteland), as a reference.

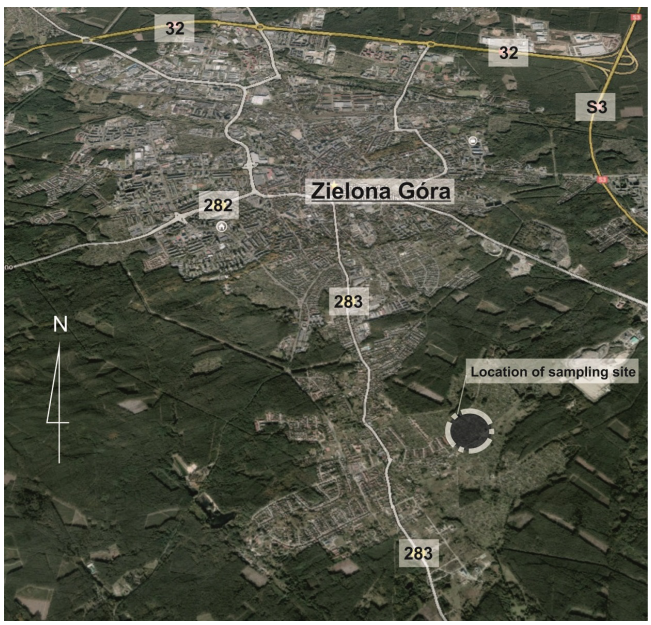

Fig. 1. Soil sampling site, allotment gardens in Zielona Góra, Poland [13].

Soil samples were taken in June 2013, from 0 up to 30 cm of the soil profiles. Soil material was air-dried and sifted through a sieve with a mesh diameter of 2.0 mm. Particle size distribution was determined by the Casagrande-Prószynski areometer method. Textural classes were established according to the FAO procedure [5]. Electrical conductivity (EC) was determined conduktometrically. Sorption properties ([hydrolytic acidity – HA] and total exchangeable bases – TEB) were determined by the Kappen method, pH in H_2O and 1M $CaCl_2$ – by the potentiometric method, [TOC] content using the Tiurin method, and the Pb content in aqua regia and 0.1 M hydrochloric acid using atomic absorption FAAS. Extracts in Aqua regia (HCl + HNO_3 in a 3:1 ratio) were prepared according to PN-ISO 11466:2002 [19].

All analyses were performed in triplicate. The results were statistically analyzed using the Statsoft Statistica 10 procedures.

RESULTS AND DISCUSSION

Gardening activities in the allotments resulted in better soil properties in comparison to control samples (Table 1). The particle size distribution of the soils covering the sanitary zone is loamy sand and sand. TOC content ranges from 9.3 to 36.5 g kg^{-1} in samples from allotment gardens, in the reference samples it is more diversified (6.0–56.1 g kg^{-1}). Nevertheless, the sorption properties of allotment gardens are higher than those at the reference points. This may be the result of agrotechnical activities.

Soil samples taken from allotment gardens have a higher pH value than control samples (neutral and alkaline in comparison to acid and heavily acid). Soils with neutral and alkaline reactions decrease the mobility of heavy metals, including lead [10].

Electric conductivity values range from 0.18 to 0.48 mS cm^{-1} (0.06–0.11 mS·cm^{-1} for the references), which illustrates a typical non-saline soil. Hydrolytic acidity was low and ranged from 0.9 to 2.5 cmol kg^{-1} in soil from allotments. Total exchangeable bases in soil from allotment gardens ranged from 22 to 50 cmol kg^{-1} and was approximately four times higher than the control samples. Cation exchange capacity in the soil was typical for horticultural lands. The CEC level ranged from 23.2 to 51.3 cmol kg^{-1} in garden soil.

The average content of total lead in the allotment gardens in Zielona Góra was twice as high as in the control samples. The maximum content of total lead in the examined soil samples from the allotments was 39 mg kg^{-1}, and does not exceed the acceptable lead content as specified in the Directive by the Minister of Agriculture and Rural Development of the 21st March 2002 on the acceptable content of heavy metals in soils [10]. In addition, it does not exceed the standards specified in the Directive by the Minister of the Environment of the 9th September 2002 on the standards of soil quality and the standards of land quality [11].

TABLE 1. PHYSICAL AND CHEMICAL PROPERTIES OF TESTED SOIL

Sample	Soil type	pH		EC	HA	TEB	CEC	BS	TOC	Pb_{total}	$Pb_{av.}$
		H_2O	$CaCl_2$	mS cm^{-1}	cmol kg^{-1}			%	g kg^{-1}	mg kg^{-1} d.m.	
1	Loamy sand	7.4	7.0	0.25	1.2	46.0	47.2	97,5	36.5	39.0	17.0
2	Loamy sand	7.6	7.2	0.38	0.9	32.0	32.9	97,3	9.3	22.0	13.0
3	Loamy sand	7.0	6.8	0.30	1.2	22.0	23.2	94,8	13.1	35.0	11.0
4	Loamy sand	7.2	6.9	0.32	1.2	38.0	39.2	96,9	26.2	32.0	15.0
5	Loamy sand	7.5	7.1	0.18	1.5	35.0	36.5	95,9	14.4	22.0	11.0
6	Loamy sand	7.3	6.9	0.36	1.3	50.0	51.3	97,5	25.8	36.0	12.0
7	Sand	6.6	6.2	0.37	2.5	25.0	27.5	90,9	20.4	21.0	12.0
8	Sand	7.1	6.3	0.48	1.4	40.0	41.4	96,6	24.0	28.0	10.0
Mean	-	-	-	0.33	1.4	36.0	38.2	94,2	21.2	29.4	13.4
S. deviation	-	-	-	0,09	1,34	29,9	31,1	72,0	18.3	21,4	8,96
S. error	-	-	-	0,01	0,17	3,74	3,88	9,00	2.3	2,67	1,12
9	Sand	5.9	5.4	0.06	1.2	7.00	8.2	85,4	53.1	12.0	6.00
10	Loamy sand	4.7	4.2	0.11	3.3	6.00	9.3	64,5	6.0	14.0	7.00
Mean	-	-	-	0.08	2.3	6.50	8.8	73,9	29.6	13.0	6.50
S. deviation	-			0,01	0,56	0,27	0,29	5,59	12.6	0,53	0,27
S. error	-			0,00	0,07	0,03	0,04	0,70	1.6	0,07	0,03

HA – hydrolytic acidity, TEB – total exchangeable bases, CEC – cation exchange capacity, BS – base saturation, TOC – total organic carbon.

Phytoavailable lead constituted less than 50% of its total form. Only in samples 2 and 7 was this value exceeded (the bioavailable form constituted 59% and 57% of its total form, respectively). Phytoavailable lead dominated soil from the allotment gardens.

There was no significant correlation between the content of lead (both total and bioavailable form) in the tested soil and its physico-chemical properties.

In comparison to other allotment gardens in Poland, the content of lead in Jędrzychów in Zielona Góra is lower. For example, in Wrocław the content of Pb was 13 – 660 mg kg^{-1} [2], in Warsaw – 785 – 2408 mg kg^{-1} [4]. However, in other Polish cities such as Łódź the content of lead in allotment gardens amounts to 37–78 mg kg^{-1} [9]. The quantity of lead depends on the location of the sources of pollution.

Many researchers in their works indicate the contamination of soils from allotment gardens by heavy metals, including lead [13, 14, 16]. The content of this element affects not only the physico-chemical properties of the soil, but also the history of the site, the manner of its use, as well as the location and level of exposure to industrial and traffic emissions [18, 21, 23].

As has been shown by the data, the number of allotment gardens and so-called community gardens (especially in big cities) is increasing every year [6, 8]. The development of urban agriculture is associated with an increase in environmental and consumer awareness. This hobby of urban residents does, however, provide ecological risk and presents a challenge for architects and city planners [17, 24]. The contaminants present in the soil can easily be absorbed by plants and incorporated into the food chain.

CONCLUSIONS

1. Analysis of the physico-chemical composition of the tested soils demonstrates the impact of anthropogenic activities (pH, sorption properties).

2. Soil samples from allotment gardens contain twice as much lead (both total and phytoavailable form) as the control samples.

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ZAWARTOŚĆ OŁOWIU W GLEBACH OGRODÓW DZIAŁKOWYCH W ZIELONEJ GÓRZE, POLSKA

Ołów, jako metal ciężki, jest szkodliwy dla organizmów żywych (zarówno roślin jak i zwierząt) I jest względnie ruchliwy w środowisku. W pracy przedstawiono wyniki badań monitoringowych dot. zawartości ołowiu ogólnego oraz przyswajalnego w glebach ogródków działkowych Zielonej Góry. Próbki glebowe pobrano z 8 miejsc w obrębie ogrodów oraz z 2 miejsc referencyjnych zlokalizowanych w sąsiedztwie ogrodów. Zawartość ołowiu w glebach nie przekraczała wartości progowych wyznaczonych wg prawa polskiego, przyjętego w zarządzeniu Ministra Środowiska z dnia 9 września 2002 r. Zawartość ołowiu całkowitego wahała się od 21 do 39 mg kg^{-1}, (12–14 mg kg^{-1} w punkcie referencyjnym) a ołowiu w formie potencjalnie dostępnej dla roślin od 10 do 19 mg kg^{-1} (6–7 mg kg^{-1} w punkcie referencyjnym).