ROCZNIKI GLEBOZNAWCZE T. XXXIX, Z. 1 S. 19—27, WARSZAWA 1988

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DISTRIBUTION OF ZINC, LEAD AND MANGANESE IN SOLIS OF ŁÓDŹ CITY [1]

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INTRODUCTION

Air, water and soils on the urbanized areas become increasingly contaminated. This contamination brings about disturbances of the ecological balance since it causes a disruption of metabolism in the living organisms.

Heavy metals belong to the particularly troublesome contaminants, especially in the urban environment.

Since almost all substances that earlier contaminate the air and water ultimately reach the soil, its chemical composition may be used as an indicator of the environmental pollution level.

The aim of the present paper is both to estimate the spatial distribution of zinc, lead and manganese in the top soil layer of the Łódź area and to indicate parts of the town where the greatest amounts of heavy metals occur in the soil.

MATERIAL AND METHODS

The area of Łódź covers 21 446 ha, 7204 ha, i.e. 33.62% of the total surface being taken by the farmlands [16]. In the city centre, 75% of grounds occupy the built-up surfaces. Twenty eight industrial plants in the area are particularly burdensome as they emit large quantities of dust and gases. Here belong the power-, metalurgy- and some cotton processing plants. In addition there are a lot of local heating plants, domestic chimneys and small workshops. Intensifying motorization also

[1] This work has been financed by the Municipal Council of Łódź City.

adds to the increase of the atmospheric air pollution. This is proved by the presence of Zn ions, and of, though in lesser amount, Pb, Fe, Mn, Cu and Cd ions in the precipitation water [16].

In order to determine the spatial distribution of Zn, Pb and Mn in the soils of Łódź, soil samples were taken from the 0—5 cm layer within the whole surface of the city, in 1985. Before starting the field work, a grid of 1 km squares was plotted on the map of Łódź in a scale 1 : 10 000. As a result, 248 squares were obtained and consecutively numbered from west to east. In general, soil samples were taken from the centre of each square if field conditions permitted.

Total of 238 soil samples were analyzed, Zn, Pb and Mn being determined by the method of atomic absorption spectrophotometry on a Perkin-Elmer-300 apparatus, following a treatment of the soil with 20% HCl.

The results obtained were used to elaborate maps showing the content of Zn, Pb and Mn in the soils of Łódź (Figs 1—3). The correlation coefficients were calculated for the following pairs of elements: Zn and Mn as well as Mn and Pb. The results of analyses were collected in the synthetical Table.

RESULTS AND DISCUSSION

When comparing the data concerning heavy metal content in the soils of another towns [1—3, 5, 8—14] with those obtained in the present study it becomes clear that the soils of Łódź are heavily contaminated, especially by zinc and lead. Spatial distribution of z i n c in the soils of Łódź testifies clearly to the influence of anthropogenic factors upon the soil zinc content (Fig. 1) as the area with a higher zinc content (about 200 ppm) corresponds to the oldest urbanized and industrialized space. Assuming that natural zinc content in the farmlands at the outskirts of Łódź is 25 ppm, the zinc accumulation indicator in the soils of the city centre oscillates between 8 and 16. In several places, the zinc content of soils exceeds 20—30 times the level of its natural content.

The largest quantity of zinc (800 ppm) was found at a study point distant from the centre, situated at a fairly busy and narrow street. In another study point situated in the residential part with small houses, also far from the centre, the zinc content was 520 ppm. However, the most Zn polluted soils are encountered mainly in the central part of Łódź where the largest dust fall is observed [7, 16]. The isopleths limiting the largest areas having increased Zn concentrations in the soil arrange concentrically around the centre, though they have an irregular shape.

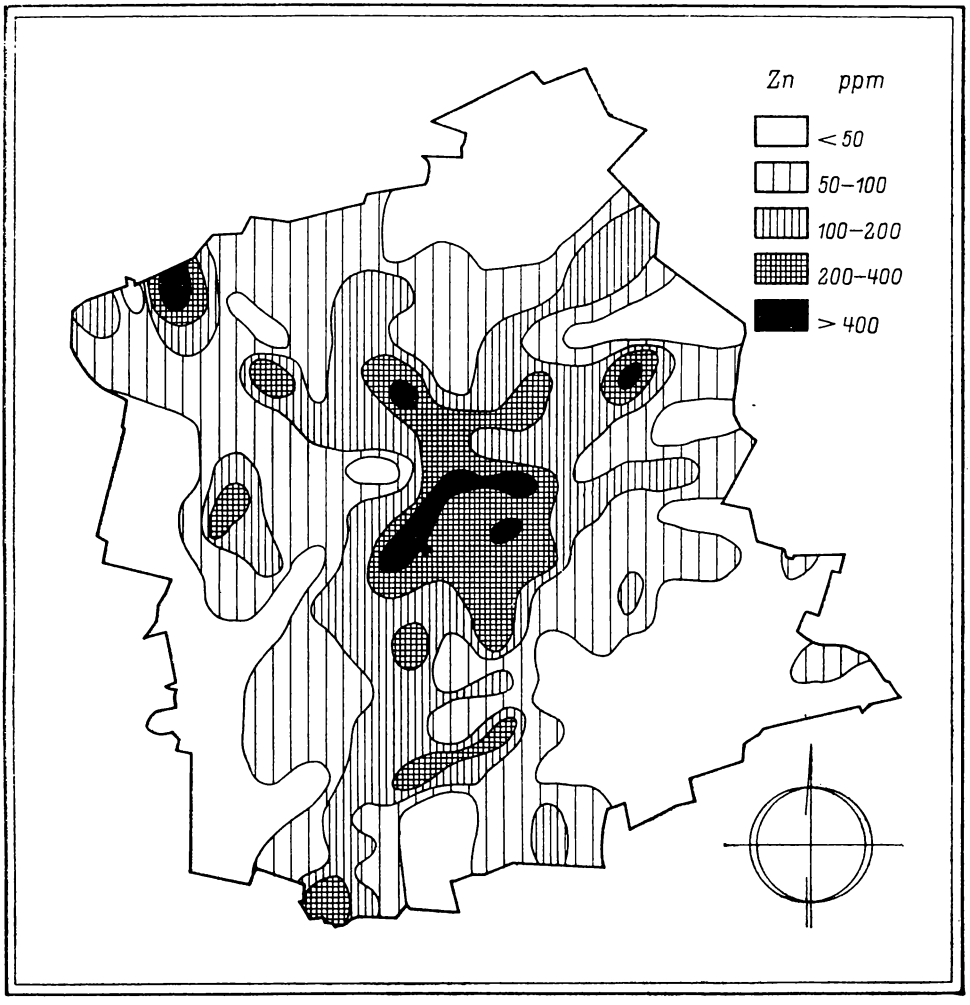

Fig. 1. The distribution of zinc in soils from Łódź

The range of determined Zn contents fluctuates from 16 to 800 ppm, and the average Zn content is 125 ppm (Table 1). In the soils of Łódź, 50—100 ppn Zn occur as a rule, 28% of the city surface having above 100 ppm of this element. Similar Zn distribution was found in the soils of Warszawa and Lublin [4, 12]. Komai and Yamamoto [10] as well as Kovacs and Nyári [11] found considerably greater amounts of this element in urban soils.

The results obtained corroborate information by numerous authors suggesting a widespread, considerable contamination by Zn in the soils of large towns [1—5, 10—13].

In the case of lead spatial distribution in the soils of Łódź, the

Table 1

Assessment of chemical and statistic analyses of Zn, Pb, Mn from Łódź (n = 238)

	Zn	Pb	Mn
Mean content of examined soils — ppm	125,2	55,7	189,4
Range — ppm	16—800	6—650	64—436
Standard deviation	127,6	79,8	68,3
Mean content in natural soils — ppm	25	20	—
Index of accumulation in urban soils	0,64—32,0	0,30—32,5	—

Element	Classes of Zn, Pb and Mn content in urban soils — ppm	Frequency per cent
Zn	< 25	3,7
	25— 50	26,0
	50—100	31,1
	100—200	20,7
	200—400	15,1
	> 400	3,4
Pb	< 20	22,6
	20— 50	42,0
	50—100	23,0
	100—200	9,5
	> 200	2,9
Mn	< 120	11,1
	120—180	39,0
	180—240	32,3
	240—300	11,7
	> 300	5,9

present study corroborates the observations made by different authors [1, 2, 3, 6, 8, 11 and 12]. Increased Pb content is encountered in the central part of the town where traffic is the most dense and along the main communication ways (Fig. 2). In the spatial distribution of lead (as in the case of zinc) changes in its content proceed gradually, never abruptly.

Areas with a considerable Pb amounts in the soil, i.e. within the limits 50—100 ppm, are stretched in the north-south direction. The latter can be explained by the arrangament of main streets. In the soils of Łódź, the prevalent lead content is 20—50 ppm, the soils wherein such a content occurs occupy 51.5% of the total city areas. Higher values are also fairly common since 20% of the city area have soils with 50—100 ppm of Pb, and 6% — more than 100 ppm of Pb.

The lead content in the soils of Łódź fluctuates greatly, from 6 to

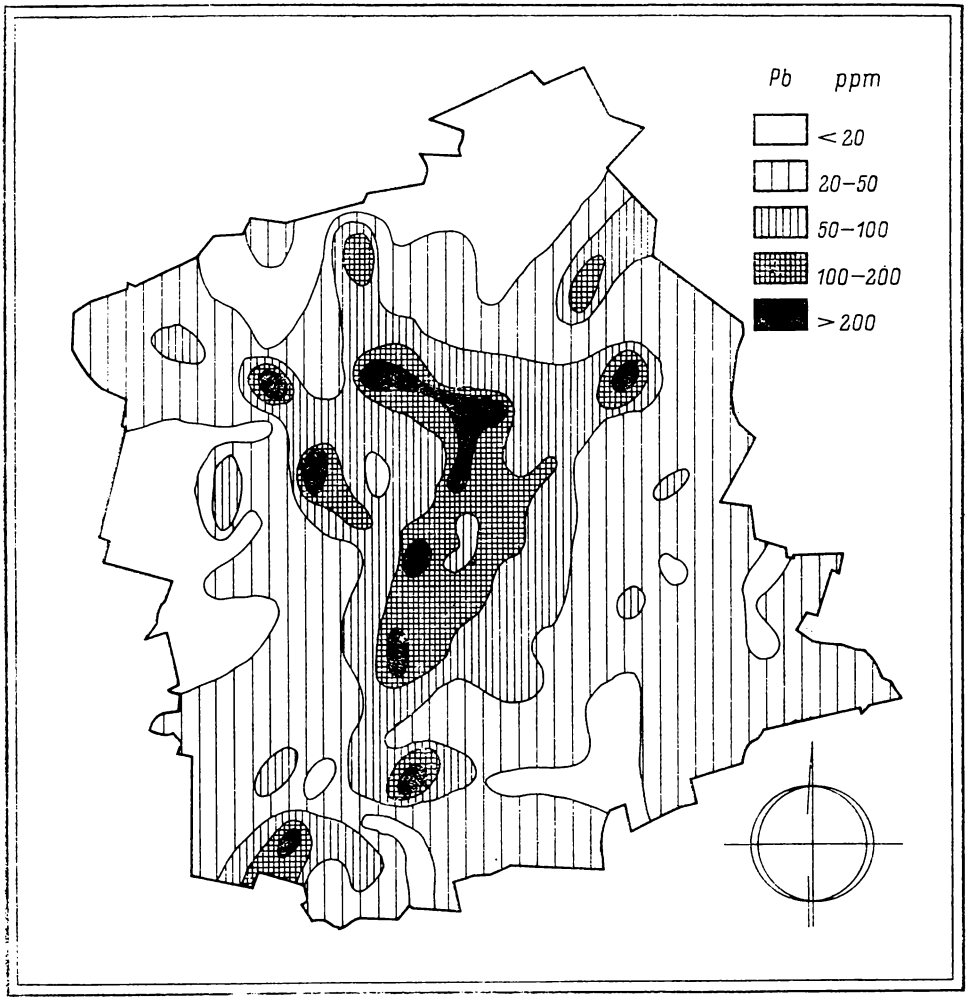

Fig. 2. Distribution lead in soils from Łódź

650 ppm (on the average 55 ppm), and approaches the quantities found in soils of Warszawa and Lublin [4, 12]. A considerably greater lead contamination was observed in the soils of two Canadian towns (40—1500 ppm), in Glasgow (55—744 ppm), Baghdad (32—950 ppm) and in Budapest (28—4500 ppm) [2, 6, 8 and 11].

Since the manganese content varies greatly in the natural soils it is hardly possible to estimate the soil manganese level exceeding of which might be regarded as contamination. Comparing the present results with literature data [10, 11 and 12], it can be stated that no distinct increase in the soil manganese content was observed in the soils of Łódź area. The manganese contents found in the analyzed samples do

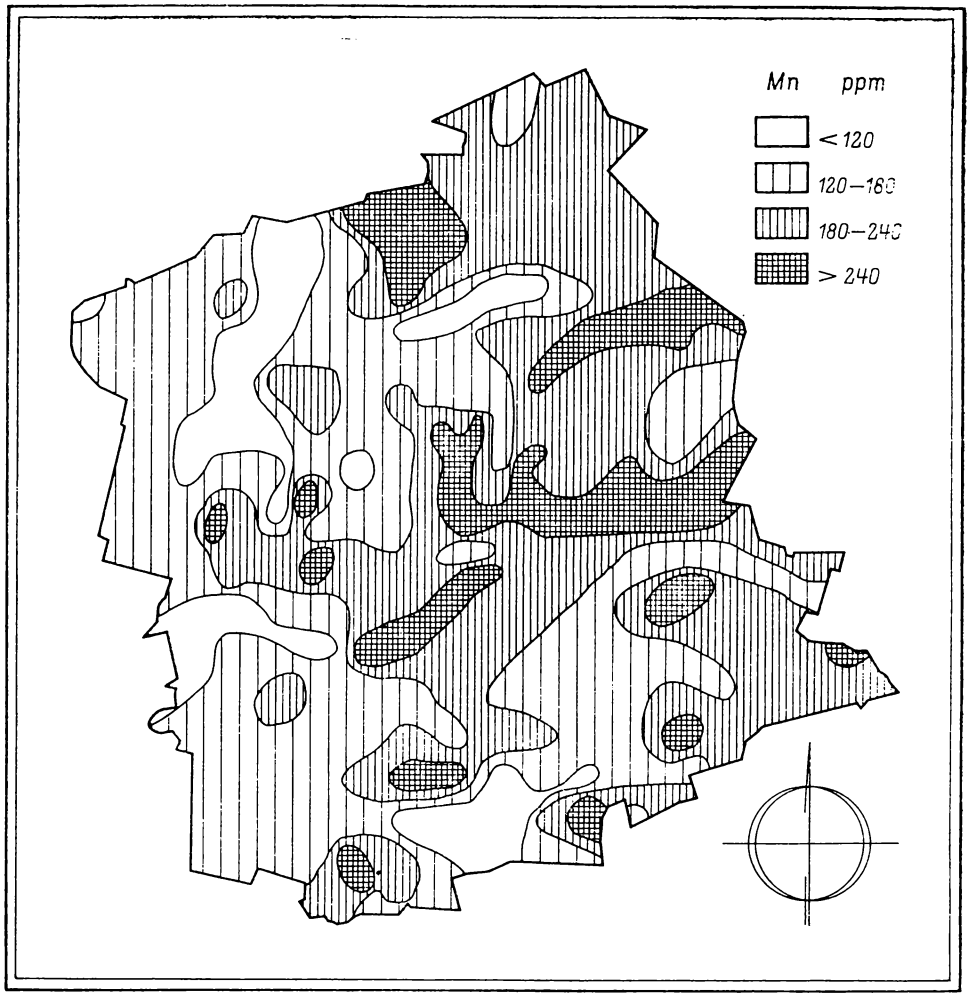

Fig. 3. Distribution of manganese in soils from Łódź

not exceed concentrations encountered in the natural soils [15]. The great differentiation in the soil manganese contents in Łódź is due to the variability of soils in the area.

Spatial distribution of manganese shows certain regularity (Fig. 3), as the largest areas having the increased content of Mn are situated in the eastern, central and northern parts of the city. Such a distribution differs from that found in the soils of Lublin [12], where the soil manganese content was distinctly lower within the built-up area.

A larger surface (indicated on the map) where the manganese content in the soil exceeds 300 ppm is located in the eastern part of the city, outranging its limits and embracing also the farmland. Other areas

having relatively high manganese contents are scattered in various parts of the town.

The soils of Łódź, compared to these of other cities, contain low quantities of manganese (on the average 189 ppm) and the relatively small fluctuations of the determined concentrations testify to the lack of important sources of manganese contamination. In effect, large fluctuations of manganese content were found in another towns, its concentrations exceeding 1000 and even 3400 ppm, what may be considered as the contamination of the soils by this element [11, 12]. It should be added that in the spatial distribution of lead and zinc, as observed in Łódź, another regularity exists, i.e. the soil samples taken from central parts contain largest amounts of these metals while with the increasing distance from the centre the concentrations of Zn and Pb in the soil decrease. The same regularity was observed in Warszawa and in Lublin [4, 12].

In order to estimate the interrelationship between the occurrence of the metals in question in the soil, the correlation coefficients were calculated. For individual pairs of elements these coefficients were established as follows: for Zn-Mn — $r = 0.33$, for Mn-Pb — $r = 0.19$ and for Pb-Zn — $r = 0.64$. Davies [5] also found a high degree of correlation of zinc and lead contents occurring in the urban soils.

The results obtained in the present study indicate that the soil contamination by zinc and lead is of the anthropogenic character, i.e. the quantity of zinc increases along with the increase in the content of lead, and inversely, while the content of manganese in the soils is not clearly related to the urbanization processes.

CONCLUSIONS

— Soils of Łódź are, in some places, heavily contaminated by zinc and lead. The zinc accumulation indicatior in the top soil layer (0—5 cm) attains up to 32, while that of lead — up to 32.5. Zinc and lead concentrate chiefly in the soils in the city centre and their concentration decreases with the distance from the centre.

— Largest amounts of manganese were observed in the soils at the city outskirts. In general, the soils of Łódź are not contaminated by manganese.

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ROZMIESZCZENIE CYNKU, OŁOWIU I MANGANU W GLEBACH ŁODZI

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Streszczenie

W latach 1985—1986 przeprowadzono na terenie Łodzi badania dotyczące przestrzennego rozmieszczenia cynku, ołowiu i manganu w warstwie 0—5 cm. Analizowano 238 próbek glebowych z 248 kwadratów o powierzchni 1 km². Na podstawie uzyskanych wyników analiz sporządzono mapy rozmieszczenia Zn, Pb i Mn w gle-

bach miasta. W celu wzajemnej zależności omawianych metali w ich występowaniu w glebie obliczono współczynniki korelacji między nimi. Dla poszczególnych par pierwiastków współczynniki te mają następujące wartości: $r = 0{,}33$ dla Zn—Mn, $r = 0{,}19$ dla Mn—Pb oraz $r = 0{,}64$ dla Pb—Zn. Jak dowodzą wyniki uzyskane w niniejszych badaniach, zanieczyszczenie gleb cynkiem i ołowiem ma charakter antropogeniczny. Wskaźnik nagromadzenia cynku w wierzchniej warstwie gleby dochodzi do 32, a ołowiu do 32,5. W próbkach glebowych pobranych ze środkowej części miasta zawartość cynku i ołowiu jest największa i maleje w miarę oddalania się od Śródmieścia. Największe ilości manganu zanotowano w glebach położonych we wschodniej części miasta. Ogólnie można stwierdzić, że gleby Łodzi nie są zanieczyszczone manganem.

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РАСПРЕДЕЛЕНИЕ ЦИНКА, СВИНЦА И МАРГАНЦА В ПОЧВАХ ГОРОДА ЛОДЗИ

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Резюме

В 1985-1986 гг. на территории гор. Лодзи проводились исследования по пространственному размещению цинка, свинца и марганца в почвенном слое 0–5 см. Анализировали 238 почвенных образцов отобранных из 248 квадратов площадью 1 км^2. На основании полученных результатов анализов были составлены карты размещения Zn, Pb и Mn в почвах города. С целью определения взаимозависимости указанных металлов и их наличия в почве были исчислены коэффициенты корреляции между ними. Для отдельных пар элементов эти коэффициенты показывают следующие значения: $r = 0{,}33$ для Zn—Mn, $r = 0{,}19$ для Mn—Pb и $r = 0{,}64$ для Pb—Zn. Согласно результатам полученным в рассматриваемых исследованиях, загрязнение почв цинком и свинцом носит антропогенный характер. Показатель аккумуляции цинка в поверхностном слое почвы достигает 32, а свинца 32,5. В почвенных образцах отобранных на площади центра города содержание цинка и свинца самое высокое и снижается по мере отдаления от центра. Самые высокие количества марганца были установлены в почвах расположенных в восточной части города. В общем можно констатировать, что почвы гор. Лодзи не загрязнены марганцем.

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