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KRYSTYNA CZARNOWSKA

DISTRIBUTION OF COPPER, CHROMIUM, NICKEL, COBALT AND CADMIUM IN SOILS OF THE CITY OF ŁÓDŹ

Department of Soil Science, Agricultural University of Warsaw

INTRODUCTION

The present work constitutes a continuation of the investigations on the content of heavy metals in the upper layer of soils (0–10 cm) from the area of the city of Łódź (Czarnowska, Walczak [5]). Its aim is to determine the spatial distribution of Cu, Cr, Ni, Co and Cd in soils and to prove the relationship between the occurrence of these metals and the iron and organic carbon content.

MATERIALS AND METHODS

In 1985, 238 mixed soil samples were taken from the whole area of the city divided into squares of 1 km^2 area. The soil samples were dried at ambient temperature in the laboratory and ground using an agate mortar. Before degestion their organic matter ashed in muffle furnace at 480°C for 8 hours. The total Cu, Cr, Ni, Co and Cd content were determined by atomic absorption spectrofotometry (AAS) method in solutions obtained after digestion of soil samples with 20% HCl.

Basing on the analytical results obtained, the maps of the content of trace metals in soils of the Łódź city were plotted. Subsequently, the areas where soils contained the same amounts of trace metals were planimetricaly measured. Percent share of areas differing in trace metals are given in Table 2.

RESULTS AND DISCUSSION

The analysis of soil samples allowed to obtain the picture of the spatial distribution of trace metals investigated depending on the soil utilization ways (Figures 1–5).

In the city centre with the highest concentration of dwelling houses, industrial enterprises, municipal implements, ets. a considerable contamination of soils with copper, similarly as with zinc and lead [5] as well as an increased content of Cu, Ni and Co have been found. At farther distances from the city centre the

content of these metals decreased, as a rule, particularly in soils utilized by agriculture and under forests. However, these relationships were complicated, as many environment changing factors, such as traffic, small industrial enterprises, dumps of refuses, were involved here. Similar relationships in the occurrence of heavy metals in differently utilized soils were found on the area of the city of Warsaw [3].

As a reference point in estimation of the contamination of the upper soil layer with heavy metals mean content of these metals in the parent material of soils from the area of the city of Łódź has been assumed. They amounted in mg/kg of soil d.m. as follows: Cu — to 7.2, Cr — to 20, Ni — to 8.7, Co — to 4.8, Cd — to 0.23 (Czarnowska, unpublished data).

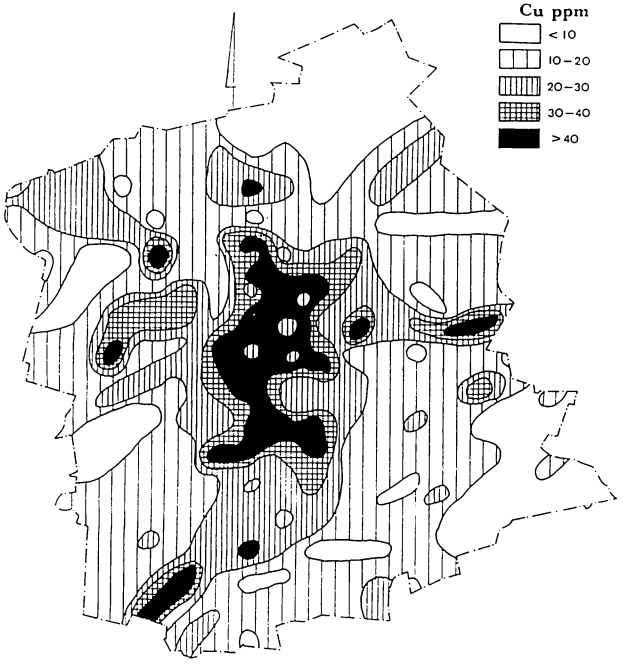

Fig. 1. Distribution of copper in soils from Łódź area

Soils with the *copper* content below 10 mg/kg, i.e. approximating the natural Cu content, occupied 20.4% of the city area (Fig. 1, Table 1). Twice higher Cu amount in soil (10–20 mg/kg) has been found on the area constituting 39.4% of the whole area of the soils under study. A rather wide area of the city, namely 27.8%, occupied soils with the copper content of 20–30 mg/kg. Only on 5.5% of the whole area of the city the copper content in soils varied within 30–40 mg/kg, while soils with the copper content of over 40 mg/kg occupied 6.9% of the city area. Isopletes defining the greatest areas with the content of this element in soils comprised central and industrial part of the city; they were of the shape elongated from north to south. The spatial distribution of copper in soils of the Łódź city

Table 1

Percentage share of classes of Cu, Cr, Ni, Co and Cd content in the whole area of Łódź city

Element	Classes of Cu, Cr, Ni, Co and Cd in urban soils (mg/kg)	City area per cent
Cu	< 10	20,4
	10 – 20	39,4
	20 – 30	27,8
	30 – 40	5,5
	> 40	6,9
Cr	< 20	50,8
	20 – 30	32,0
	30 – 40	12,4
	> 40	6,8
Ni	< 5	4,4
	5 – 10	52,6
	10 – 15	26,2
	15 – 20	9,6
	> 20	7,2
Co	< 5,0	87,5
	5,0 – 7,5	8,1
	7,5 – 10,0	3,9
	> 10,0	0,3
Cd	< 0,5	63,4
	0,5 – 1,0	24,1
	1,0 – 1,5	8,9
	1,5 – 2,0	3,1
	> 2,0	0,5

Table 2

Assessment of chemical and statistic analyses of Cu, Cr, Ni, Co, Cd mg/kg/ and per cent of C-org. in surface soil from Łódź city (n = 238).

Element	Range	Mean	$S\bar{x}$	Mean content in parent rock from Łódź	Index of accumulation
% C — org.	0,46–7,44	2,49	0,086	—	—
Cu	4,40–365[x]	23,00	1,612	7,2	0,61–51,2
Cr	6,00–188[x]	22,00	1,360	20,0	0,30–9,40
Ni	2,30–73	11,50	0,533	8,7	0,26–15,2
Co	0,90–10,9	3,70	0,157	4,8	0,18–2,20
Cd	0,07–2,20	0,52	0,031	0,23	0,30–9,50

x — Means were calculated excluding extremely large figures.

Table 3

Coefficients of correlation (r) for all element pairs (n = 238)

Element	Fe	Cu	Cr	Ni	Co	Cd
C	0,5109**	0,4140**	0,2759**	0,1824*	0,2758**	0,4564**
Fe		0,6059**	0,4178**	0,6044**	0,5067**	0,7103**
Cu			0,3476**	0,3672**	0,3874**	0,5132**
Cr				0,2603**	0,2106**	0,4357**
Ni					0,7287**	0,3890**
Co						0,2598**

* P = 0,05
** P = 0,01

approximated the zinc distribution, as it has been proved in the work of Czarnowska and Walczak [5], what bears evidence of a similar source of both these soil contaminating elements.

In the upper layer of the soils investigated considerable fluctuations of the copper content, viz. from 4.4 to 365 mg/kg of soil (Table 2) have been found. Approximate values of this element were observed also in soils of other cities [8, 10], higher amounts occurring in the cities of Warsaw and Hamburg [3, 9]. A positive highly significant correlation between the Cu and Fe (r = 0.60) and Cu and Cd content (r = 0.51) has been proved. In the soils investigated the copper content was also significantly correlated with the organic carbon content (Table 3).

In most soils of the Łódź city (50.8%) the *chromium* content maintained at a low level — below 20 mg/kg, or at medium level — 20–40 mg/kg of soil (44% of the city area). Soils contaminated to a low degree with chromium containing over 40 mg/kg of Cr occupied 7,82% of the city area, while small enclaves of these soils were encountered in various city quarters, particularly near railway tracks and small industrial plants (Fig. 2).

The chromium content in the upper layer of Łódź city soils varied within 6–188 mg/kg of soil, although the mean content of this element approximated its amount in parent material. The highest amount of chromium contained soils situated around the railway station of Łódź Fabryczna in the city centre.

The chromium content was significantly correlated with the Fe and Cu content, but the correlation coefficients of these elements were lower, what was probably connected with the effect of anthropogenic factors on the content of the mentioned metals in soils.

As far as the *nickel* content is concerned, 57% of the soils under study contained less than 10 mg/kg of this element; this was the amount approximating that found in the parent material. A wide area was occupied by soils with the nickel content of 10–20 mg/kg (35.8% of the city area). Soils slightly contaminated with nickel (over 20 mg/kg) occupied 7.2% of the city area occurring mostly in the city centre, while small enclaves of soils with this contamination were situated in north-western and southern part of the city of Łódź (Fig. 3).

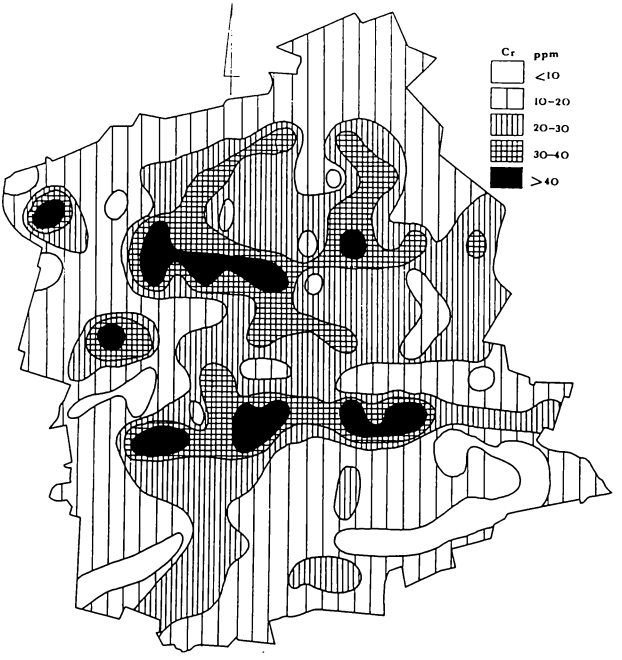

Fig. 2. Distribution of chromium in soils from Łódź area

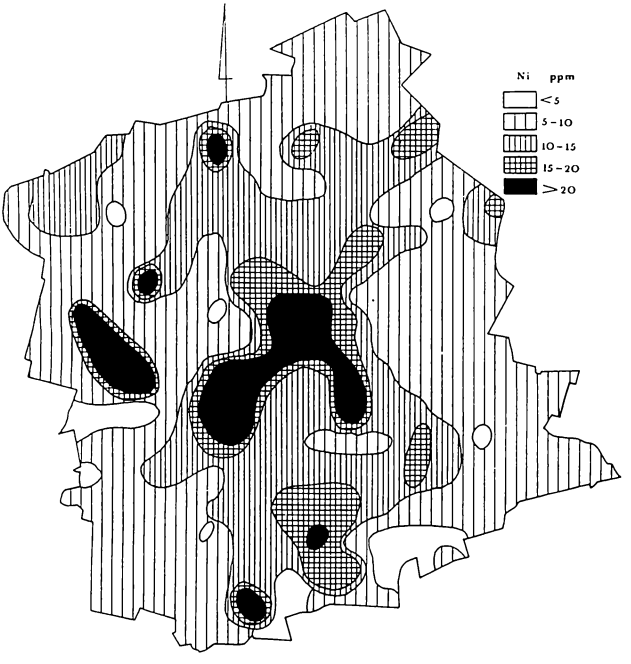

Fig. 3. Distribution of nickel in soils from Łódź area

Thus it can be stated that the soils under study were only slightly enriched in nickel in consequence of the urban contaminations. A positive highly significant correlation between the Ni and Fe content ($r = 0.60$) and Ni and Co content ($r = 0.72$) has been proved. The correlation coefficients between these metals approximated those established for arable soils of central and northern Poland [6].

The *cobalt* content (0.9–10.0 mg/kg) in soils of the Łódź city approximated the amount of this element in light arable soils [7]. The mean cobalt content in the upper layer of the soils investigated was even lower than in the parent material (Table 1).

Soils with the cobalt content below 6 mg/kg occupied on the Łódź city 87% of its whole area. Higher amounts of this element, of over 10 mg/kg, were found sporadically and only in 0.3% of soils on the whole area of the city (Fig. 4). Hence it can be concluded that soils of the city of Łódź are not contaminated with cobalt. Other authors report also about a natural content of cobalt in soils of urban areas [8, 9]. Asami [1] — who investigated the cobalt content in street dust of many Japanese cities — did not found such a considerable increase of this element contrary to other heavy metals, such as Zn, Cu, Cr and Cd.

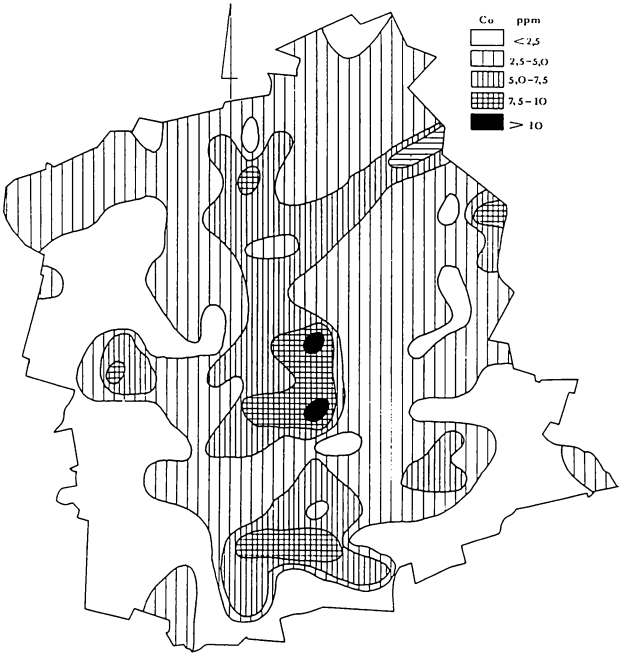

Fig. 4. Distribution of cobalt in soils from Łódź area

The *cadmium* content in the Łódź city soils varied within 0.10–2.20 mg/kg of soil, whereas the concentration index of this element calculated in relation to its content in parent material varied within 0.30–9.50. The mean content of cadmium in the upper layer of soils under study was higher than in their parent

materials and also higher than an average Cd content (0.4 mg/kg) in soils of the world (Berrow, Reaves [2]). The cadmium content in soils was significantly correlated with the Fe ($r = 0.71$), Cu ($r = 0.51$), Cr ($r = 0.43$) content and with percentual content of organic carbon ($r = 0.45$).

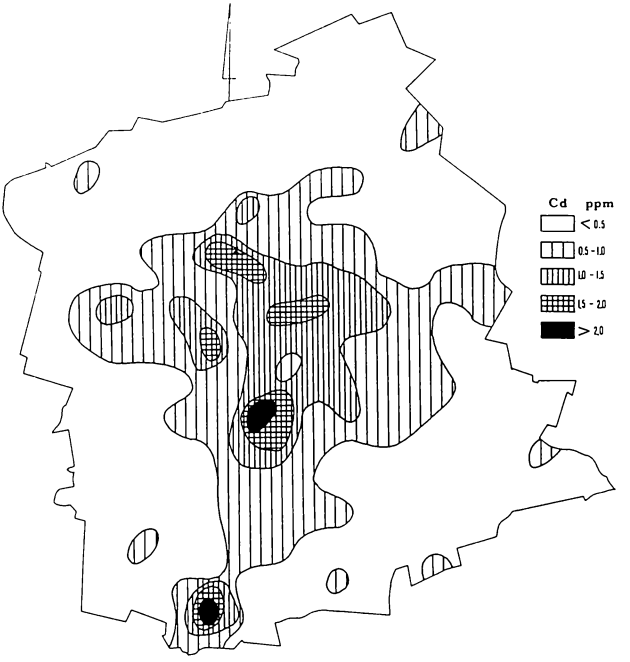

Fig. 5. Distribution of cadmium in soils from Łódź area

Most soil samples analyzed lay in the first (< 0.5 mg/kg) and second class of the cadmium content (0.5–1.0 mg/kg). Soils with such an amount of cadmium occurred in 87.5% of the city area (Fig. 5). Czarnowska, Gworek [6] have proved similar spatial distribution of cadmium in the Warsaw city soils. Soils containing cadmium in the amount of over 1 mg/kg (slightly contaminated with this element) lay in the central part of the city. Although in the periphery of the southern part of the city of Łódź soils with much higher cadmium content (2.20 mg/kg) occurred it can be presumed that this was caused by local contamination of soils with this element.

CONCLUSIONS

1. Soils of the Łódź city are unequally contaminated with copper; the highest content of this element is in soils of the central city quarters, strongly urbanized and industrialized.

2. Soils contaminated to a low degree with cadmium occupy 12.5%, with nickel — 7.2%, with chromium — 6.8% of the Łódź city area.

3. Soils investigated contain natural amounts of cobalt.

4. In soils of the Łódź city area the iron content is highly significantly correlated with the Cu, Ni, Co and Cd content, whereas the nickel content is correlated with cobalt and the cadmium content with copper.

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К. ЧАРНОВСКА

РАЗМЕЩЕНИЕ МЕДИ, ХРОМА, НИКЕЛЯ, КОБАЛЬТА И КАДМИЯ В ПОЧВАХ ГОРОДА ЛОДЗИ

Кафедра почвоведения Варшавской сельскохозяйственной академии

Резюме

Настоящая работа составляет продолжение исследований по содержанию тяжелых металлов в почвах нескольких городов Польшы. Анализировали смешанные почвенные образцы отобранные в 1985 г. со всей площади города Лодзи из квадратов 1 кв, км. Результаты анализов касающихся общего содержания Cu, Cr, Ni, Co и Cd в верхнем слое почв (0–10 см) представлены на картах. Установлено, что исследуемые городские почвы загрязнены в значительной степени медью, особенно сильно застроенные и индустриализованные городские кварталы. Почвы загрязненные кадмием в небольшой степени занимали 12,5%, никелем — 7,2%, хромом — 6,3% площади города. Содержание кобальта в исследуемых почвах было сходным в количеством этого элемента в пахотных землях незагрязненных площадей. Показатель накопления меди в верхнем слое почв достигает 51,2, никеля — 15,2, кадмия — 9,5, хрома — 8,4, а кобальта лишь 2,2

K. CZARNOWSKA

ROZMIESZCZENIE MIEDZI, CHROMU, NIKLU, KOBALTU I KADMU W GLEBACH MIASTA ŁODZI

Katedra Gleboznawstwa SGGW w Warszawie

Streszczenie

Praca stanowi kontynuację badań dotyczących zawartości metali ciężkich w glebach kilku miast Polski. Analizowano próbki glebowe mieszane pobrane w 1985 roku z całego terenu miasta Łodzi, z kwadratów o powierzchni 1 km². Wyniki analiz dotyczące ogólnej zawartości Cu, Cr, Ni, Co i Cd w wierzchniej warstwie gleb (0–10 cm) przedstawiono w postaci map. Stwierdzono, że badane gleby miejskie zostały w znacznym stopniu zanieczyszczone miedzią, szczególnie dzielnice centralne silnie zabudowane i uprzemysłowione. Gleby w niewielkim stopniu zanieczyszczone kadmem zajmowały 12,5%, niklem — 7,2%, chromem — 6,3% powierzchni miasta. Zawartość kobaltu w badanych glebach miasta była podobna do ilości tego pierwiastka w glebach uprawnych z terenów nie zanieczyszczonych. Wskaźnik nagromadzenia miedzi w wierzchniej warstwie gleb dochodzi do 51,2, niklu do 15,2, kadmu do 8,5, chromu do 9,4, a kobaltu zaś tylko do 2,2.

Prof. dr K. Czarnowska
Katedra Gleboznawstwa
SGGW w Warszawie
02-528 Warszawa, Rakowiecka 28/30

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