ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 18, No. 5–6 2011

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HEAVY METALS IN SOILS OF HENRYK JORDAN PARK IN KRAKOW

METALE CIĘŻKIE W GLEBACH PARKU IM. HENRYKA JORDANA W KRAKOWIE

Abstract: Dr. Henryk Jordan Park in Krakow, considering its location in the city centre, is exposed to a strong anthropogenic influence. The conducted research aimed to assess the degree of pollution of soils from the park with Cd, Ni, Cr, Cu, Pb and Zn. A majority of the studied soils were characterized by elevated zinc and cadmium levels but there occurred soils slightly polluted with these metals too. Anthropogenic influence exerted its impact on the content of lead, copper and especially nickel in a lesser degree in studied soils, and in a major part of soils there were natural contents of them.

Keywords: Krakow, urban soils, heavy metals, pollution

Progressing industrialization and urbanization affect negatively the urban environment. The spatial development of towns takes place at the sacrifice of green areas. The non-built-up areas, and urban parks which belong to them, in turn are exposed to a range of transformations including chemical ones. Therefore, in urban parks studies concerning pollution of their soils with heavy metals have been carried out [1–4].

Dr. Henryk Jordan Park, having the surface of more than 20 ha, is one of the biggest and the most willingly visited green areas in the centre of Krakow. However, due to its location it is exposed to the impact of transport, municipal and industrial pollutions.

The aim of the undertaken research was to assess the degree of pollution with Cd, Ni, Cr, Cu, Pb and Zn of Henryk Jordan Park soils in Krakow. The presented studies are the continuation of issues regarding the pollution of urban parks in Krakow [4] and they may be used for the evaluation of the urban green lands quality.

Material and methods

In the area of dr. Henryk Jordan Park 13 research points were established – taking into account their regular distribution (Fig. 1), of which from the surface layer (0–20 cm)

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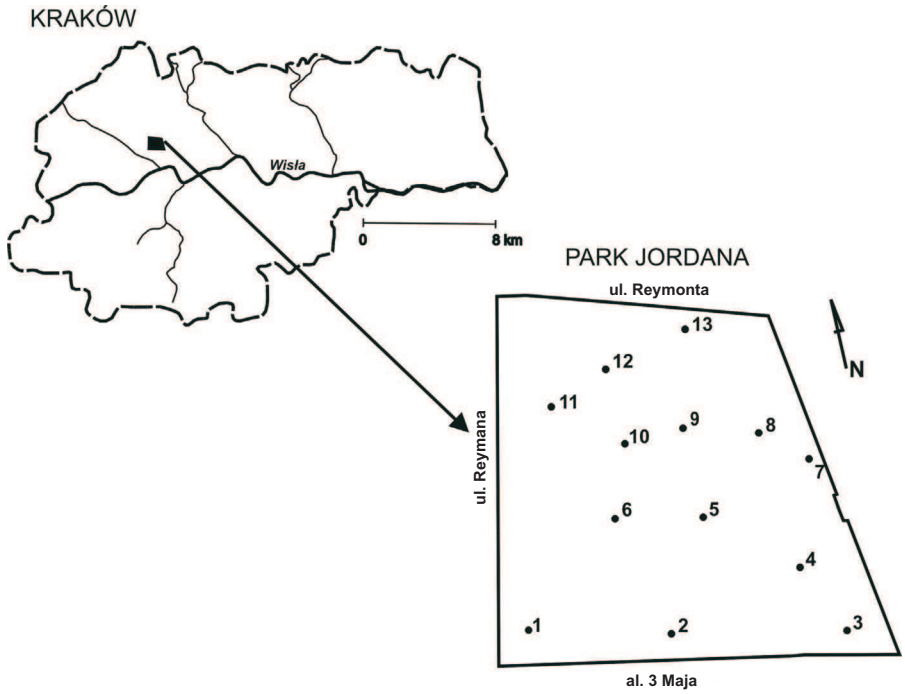

Fig. 1. Location of Jordan Park in Krakow and sites of taking soil samples

soil samples were taken. In dried and sifted through a plastic sieve with 2 mm mesh soil samples pH in 1 mol · dm^{-3} KCl solution [5], soil texture by the densimetric-sieve method [6], organic carbon content with the modified Tiurin method, hydrolytic acidity after the Kappen method [7] and the sum of exchangeable bases in 0.5 mol · dm^{-3} NH_4Cl [8] were determined. On the basis of the two last values a degree of *base saturation* (BS) was calculated. Total studied heavy metal contents after previous mineralization of soil samples in concentrated nitric(V) and perchloric(VII) acids were determined by AAS method [9] (excluding nickel, in case of which the ICP-AES technology was applied).

The interdependence between the contents of the analyzed heavy metals and selected soil properties was determined by computing the correlation coefficient (r) according to Spearman's rank with the use of *STATISTICA* program. Graphical presentation of the spatial distribution of selected heavy metals in soils of the park was performed using Surfer 8 program.

Results and discussion

Results of basic soil properties assessments which affect heavy metal mobility, their fitoavailability and contents were presented in Table 1. Studied soils differed in texture.

In the southern part of the park (from 3 Maja Av.) there occurred common silts (points 1–3 and 5) and in the remaining part soils had strong loamy sand or light loam textures but with a big share of silt fraction. Only the soil in point 13 had the texture of silty light loamy sand. The presence or absence of calcium carbonate influenced pH values of studied soils. It ranged from 5.3 to 7.0. Non-carbonated, acid soils occurred in the central part of the park (points 6 and 8–11). The high pH of remaining soils, besides natural causes, could be affected by the introduction of the anthropogenic substances of alkaline character considering the vicinity of buildings and roads. The alkalization of soil environment is one of the characteristic transformations of soils in urban areas [4, 10]. A degree of sorption complex saturation with basic cations was high and on average exceeded 90 %. The humus content in the analyzed soils was also high, which evidences organic C content amounting on average to 25.6 $g \cdot kg^{-1}$.

Table 1

Soil reaction, degree of sorption complex saturation with bases, content of fraction ∅ < 0.002 mm, organic carbon and heavy metals

Point No.	pH_{KCl}	BS [%]	Fraction < 0.002 mm [%]	org. C [$g \cdot kg^{-1}$]	Cd	Ni	Cr	Cu	Pb	Zn
					[$mg \cdot kg^{-1}$]					
1	6.3	91.6	5	19.51	0.80	11.4	28.2	9.9	28.6	93.6
2	7.0	96.5	6	24.94	1.20	14.9	39.3	29.2	77.3	320.4
3	6.9	95.5	6	22.65	0.90	13.0	37.2	19.8	52.2	138.6
4	6.8	95.8	7	24.59	1.06	15.8	41.2	142.6	62.8	214.0
5	6.8	95.7	10	30.13	0.89	17.8	49.6	36.9	61.7	232.2
6	5.3	80.8	5	22.39	1.15	11.0	33.4	11.1	43.3	97.7
7	7.0	97.5	5	22.76	0.61	11.3	33.2	23.2	70.9	161.5
8	5.7	89.3	12	25.24	1.30	17.4	51.1	14.3	57.5	132.9
9	5.5	83.2	8	34.35	1.27	12.4	42.9	15.3	55.1	130.6
10	5.6	85.5	6	28.09	0.87	12.8	28.7	11.0	41.2	91.5
11	5.4	75.6	8	22.35	0.64	11.8	31.7	8.7	29.7	69.1
12	6.5	94.3	7	35.50	0.75	13.7	41.7	15.7	53.7	129.3
13	6.8	94.6	3	20.70	0.55	10.5	24.5	20.0	76.1	112.8

Soil environment of Henryk Jordan Park was exposed to anthropogenic influence. There occurs at least a few soils with contents of each of determined heavy metals, higher than recognized as natural. However, it must be clearly emphasized that these amounts are not worrying. Taking into consideration criteria proposed by IUNG [11] most of studied soils are characterized by natural contents of nickel, copper and lead. In the case of nickel and lead, a few, particularly lighter soils, revealed their elevated contents. A strong pollution with copper occurred only in point 4 (IV degree of

pollution, the highest in these studies), which is surely the effect of a point introduction of this element. Investigated soils were characterized, compared to soils from Krakowski Park [4] by relatively high amounts of chromium and therefore they should be recognized as elevated [12].

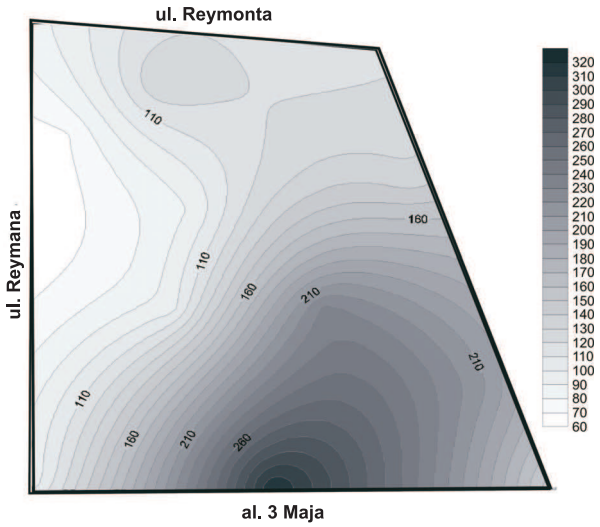

Fig. 2. Spatial distribution of zinc content [mg · kg^{-1}] in Jordan Park soils

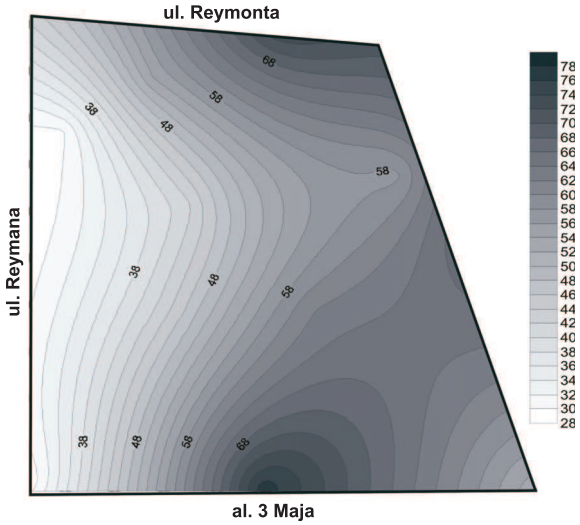

Fig. 3. Spatial distribution of lead content [mg · kg^{-1}] in Jordan Park soils

In more than a half of studied soils an elevated content of cadmium occurred, soils from points 1, 3, 5 and 12 had its natural contents while soils from points 6 and 9 should be recognized as slightly polluted with Cd [11]. A considerable majority of soils in Jordan Park revealed an elevated content of zinc, three soils (points 2, 4 and 9) were polluted in a slight degree and only soils from points 2 and 11, taking into account IUNG classification [11], can be counted among soils with natural contents of this element. According to the Regulation of Minister of the Natural Environment on the soil quality standards and earth quality standards [13] studied soils should be recognized as unpolluted.

Lead and especially zinc were these heavy metals which contents oscillated within a relatively large range, with smaller amounts of them occurring in the western parts of the park (Fig. 2 and 3). It results surely from the fact that Reyman street is characterized by incomparable smaller traffic capacity than 3 Maja Avenue and Reymont street. Considering the high abundance of the park soils in humus, it is supposed to have a great importance in immobilization of heavy metals.

In studied soils significant relations between nickel and chromium, and clay and humus contents occurred (Table 2), which in the case of Ni – clay relation is confirmed in the literature [12]. In studied soils Cu, Pb and Zn contents were positively correlated with pH and amount of bases.

Table 2

Spearman's rank correlation coefficients (r) determining the relationship between heavy metal contents and selected properties of the analyzed soils (n = 13)

	Cd	Ni	Cr	Cu	Pb	Zn
∅ < 0.002 mm	0.479	0.772**	0.797**	0.025	–0.047	0.220
pH_{KCl}	–0.170	0.275	0.071	0.797**	0.676*	0.775**
BS	–0.132	0.302	0.121	0.863***	0.736**	0.819***
C_{org}	0.396	0.643*	0.747**	0.280	0.209	0.368

* $p \leq 0.05$, **$p \leq 0.01$, *** $p \leq 0.001$.

Conclusions

1. Soils of dr. Henryk Jordan Park, in dependence of which part of it they were taken, differed in texture and reaction, and they revealed also a high degree of sorption complex saturation with bases and a high content of humus.

2. A majority of park soils were characterized by elevated zinc and cadmium contents, but there occurred also soils slightly polluted with them.

3. In studied soils anthropogenic influence affected in a lesser degree lead, copper and especially nickel contents, there occur only a few soils enriched in these elements.

4. Basing on the Regulation of Minister of the Natural Environment on the soil quality standards and earth quality standards dated 2002 soils from the park should be considered as unpolluted with analyzed heavy metals.

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METALE CIĘŻKIE W GLEBACH PARKU IM. HENRYKA JORDANA W KRAKOWIE

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Abstrakt: Park im. dr. Henryka Jordana w Krakowie, ze względu na swą lokalizację w centrum miasta, jest narażony na silne antropogenne oddziaływanie. Przeprowadzone badania miały na celu określenie stopnia zanieczyszczenia gleb parku Cd, Ni, Cr, Cu, Pb i Zn. Większość gleb parku charakteryzowała się podwyższoną zawartością cynku i kadmu, występowały również gleby słabo nimi zanieczyszczone. Antropogenne oddziaływanie wpłynęło w mniejszym stopniu na zawartość w badanych glebach ołowiu, miedzi a zwłaszcza niklu, w większości gleb była naturalna ich zawartość.

Słowa kluczowe: Kraków, gleby miejskie, metale ciężkie, zanieczyszczenie