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Heavy metals in the Bystrzyca river flood plain

Downstream of Lublin, the Bystrzyca river represents a very high pollution level. A considerable portion of constituents disposed with effluents to the river accumulates in recent alluvium. River bottom deposits in the downstream stretch from Lublin to this river outlet to the Wieprz river exhibit high concentrations of cadmium, cobalt, nickel, and zinc. Heavy metals of high concentrations have also been detected in soils of the Bystrzyca flood plain. Peak concentrations have been found to occur in soils occurring in the immediate vicinity of the river bed, within a 20 m belt. It has been found that soils subject to cultivation frequently contain very high cadmium content (in excess of permissible concentration).

INTRODUCTION

The Bystrzyca river (a total length of which is equal to 70.3 km) flows across the Lublin Upland and falls into the Wieprz river at Spiczyn. A total annual flow through the section at Sobianowice (10 km away from the Bystrzyca outlet to the Wieprz river) is estimated to be 4.45 m^3/s (on an average) while its summer flow is 3.58 m^3/s only. A major part of the Bystrzyca drainage area is covered with Pleistocene deposits (clays, loams, weathered mantle composed of sands, sands of fluvioglacial origin, and eluvium of glacial till). Their total thickness can reach 60 m. In the vicinity of Lublin, there are Pleistocene loess deposits occurring on the left side of the river whereas such Palaeogene deposits as gaizes, delimed gaizes, and glauconitic sands occupy the right river side. Thickness of Tertiary deposits is several dozen metres. Cretaceous marls and delimed gaizes are cropping out from under the Tertiary and Quaternary deposits in the area situated along the river valley. The Holocene and Pleistocene silts, sands, and gravels of fluvial origin fill up the Bystrzyca valley (J. Malinowski, J. E. Mojski, 1981). They provide a basis for development of muds, black earths, and occasionally — peat soils. When the entire Bystrzyca drainage area is considered, then the silty soils dominate in areas covered with the Pleistocene deposits whereas the rendzina type soils occur in the area composed of Palaeogene marls, gaizes, and delimed gaizes.

The Bystrzyca in its stretch downstream of Lublin belongs to the category of very polluted rivers; its waters are below all quality classes. Sources of the river pollution include industrial and municipal effluents. As refers to industrial effluents, they are disposed from such industrial plants situated in the city of Lublin as: motorcar factory, balance factory, pharmaceutical and chemical agents plants, and some other plants subordinated to food and leather industries. A volume of effluents disposed in 1994 from the city to the Bystrzyca totalled 33.5 hm^3 (*Ochrona środowiska,* 1995). Percolation of effluents in area of industrial waste dumping sites is another source of pollution; this issue deals with metallurgical, chemical, and pharmaceutical plants as wells as tanneries — situated in the city and its vicinity (C. Królikowski, J. Twarogowski, 1992).

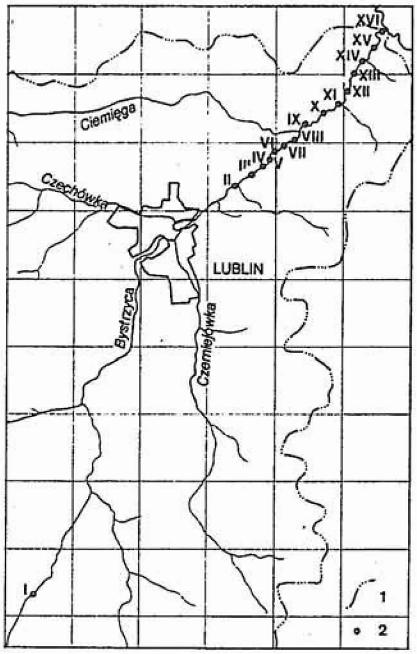

Fig. 1. Location of studied profiles
1 — Bystrzyca basin boundary; 2 — location of profile
Lokalizacja badanych profili
1 — granica zlewni Bystrzycy; 2 — lokalizacja profili

Considerable portion of constituents disposed together with effluents and surface flow to the surface water environments accumulate in the deposits. As the result of progressive pollution of the environment, aqueous deposits of recent sedimentation frequently contain trace elements in increased quantities as compared with the natural geochemical background being influenced by the lithological structure. Particularly high concentrations of heavy metals are detected downstream of disposal sites of effluents produced by the mining industry or metallurgical plants (J. O. Nriagu, 1983; W. Palchen *et al.*, 1991; D. Ciszewski, 1994; I. Bojakowska, 1995). Accumulation in aqueous deposits of hazardous constituents, heavy metals in particular, exerts a serious hazard to the biosphere.

It is considered that direct migration of chemical pollution from the deposits to organisms is the most important reason of threat exerted on many aqueous floral and faunal species (W. J. Adams *et al.*, 1992). Fluvial deposits with a high concentration of heavy metals create a serious hazard to the terrestrial environment. Pollution of soils may result from displacement of alluvium to the area of flood plain due to flooding if it is loaded with toxic constituents of high concentrations. Such a soil pollution by heavy metals due to river overflow have been noted in many places (D. Cocking *et al.*, 1991; E. V. Axtmann, S. N. Luoma, 1991; K. Kucharzewska *et al.*, 1991; E. Helios Rybicka, M. Wardas, 1989; I. Bojakowska *et al.*, 1996).

A systematic study of fluvial deposits has for several years been carried out at the outlet of the Bystrzyca river at Spiczyn. The study revealed a high concentration of heavy metals,

Table 1

Heavy metals (ppm) in alluvial deposits of the Bystrzyca river at Spiczyn (according to I. Bojakowska, G. Sokołowska, 1991–1995)

Year	As	Cd	Cu	Cr	Co	Hg	Ni	Pb	Zn
1991	4	118	91	71	51	0.57	216	62	509
1992	6	153	141	107	117	0.59	263	103	1020
1993	3	52	71	45	50	0.39	112	71	444
1994	5	29.3	48	31	31	0.37	59	37	322
1995	< 5	38.9	57	39	36	0.47	68	49	399

particularly of cadmium, nickel, and zinc (Tab. 1). Thickness of these deposits is assessed to be 70–80 cm (J. Stochlak, 1993).

SCOPE AND METHODS OF THE STUDY

Soil and river deposit samples were collected along 200 m profile (transverse to the Bystrzyca valley) — Fig. 1. One of the profiles was located at Strzyżewice where the river was relatively clear; this was aimed at determining the geochemical background of soils and aqueous deposits. Other profiles were situated at 0, 1st, 2nd, 3rd, 4th, 5th, 6th, 8th, 10th, 12th, 14th, 16th, 18th, 20th, and 22nd km away from the disposal site of effluents from the treatment plant. 6 soil samples were collected on each profile from sampling points situated at a distance of 1, 5, 10, 20, 50, 100 m away from the river bed; an additional samples was collected from the river bottom material. An interval of 0–0.20 m was the sampling depth; samples of the active deposits were collected from the bank zone of the river bed.

A fraction of river deposits < 0.2 mm and of soils < 1 mm was utilized in this study. Both the soil and bottom samples were subject to leaching with the hydrochloric acid (1:5). Extracts obtained were analysed for the presence of such heavy metals as: As, Ba, Ca, Cd, Cr, Cu, Co, Fe, Mg, Mn, Ni, Pb, Sr, and Zn; P and S were also analysed. An Inductively Coupled Plasma Atomic Emission Spectrometry was the method employed (IPC). As refers to Hg, a Cold Vapour Atomic Absorption Spectrometry (CV-AAS) was applied. Concentration of organic carbon (TOC) in soils and river bottom samples was also examined; a method of coulometric titration was employed.

HEAVY METALS IN THE BYSTRZYCA RIVER BOTTOM DEPOSITS

Samples of river bottom deposits were collected at Strzyżewice which is located upstream of the Zemborzyce man-made lake. The river is relatively clear at this location. Concentrations of constituents under examination occurred to be very low; they are close to the geometric mean concentrations of analysed elements in aqueous deposits in Poland (Tab. 2). Samples of alluvium, collected downstream of disposal site of municipal and

Table 2

Heavy metals (ppm) in alluvium of the Bystrzyca river

Location	Profile	As	Ba	Cd	Co	Cr	Cu	Hg	Ni	Pb	Sr	Zn
Aqueous deposits in Poland*		<5	52	0.6	3	6	7	<0.05	6	15	21	73
Strzyżewice	I	<5	23	<0.5	2	7	5	<0.05	6	10	93	43
Lublin	II	<5	42	13.3	6	11	21	0.27	19	30	73	118
Wólka	III	<5	111	40.6	20	38	80	0.68	74	91	194	428
Długie	IV	<5	76	14.8	9	23	60	0.34	32	66	134	329
Długie	V	<5	77	16.2	11	26	50	0.50	32	59	136	285
Turka	VI	<5	76	20.0	16	29	59	0.50	41	62	150	357
Turka	VII	<5	97	34.3	26	39	79	0.51	71	79	163	488
Sobianowice	VIII	<5	87	35.2	20	34	52	0.44	54	54	119	315
Bystrzyca	IX	<5	87	25.9	22	36	71	0.37	49	68	153	440
Bystrzyca	X	<5	89	26.5	23	35	72	0.40	46	63	175	422
Bystrzyca	XI	<5	95	31.7	26	42	81	0.41	62	68	170	465
Charlęż	XII	<5	97	30.0	25	39	77	0.43	53	66	164	463
Charlęż	XIII	<5	82	30.4	23	38	70	0.46	52	60	160	408
Łysa Góra	XIV	<5	78	29.7	27	36	64	0.48	52	55	142	403
Spiczyn	XV	<5	67	24.5	24	30	51	0.32	44	47	125	325
River outlet	XVI	<5	100	38.4	32	45	83	0.45	62	73	185	27

* — according to J. Lis, A. Pasieczna (1995)

Table 3

Mean geometric concentrations of heavy metals (ppm) in soils in Poland (according to J. Lis, A. Pasieczna, 1995)

Soils	As	Ba	Cd	Co	Cr	Cu	Hg	Ni	Pb	Sr	Zn
Soils of Poland (*n* = 10 840)	<5	32	<0.5	2	4	5	<0.05	4	16	8	40
Cultivated soils (*n* = 4899)	<5	32	<0.5	2	5	5	<0.05	4	13	9	37
Meadow soils (*n* = 985)	<5	42	<0.5	2	4	5	<0.05	4	15	13	42
Fallow soils (*n* = 837)	<5	41	<0.5	2	5	7	<0.05	5	23	12	51
Forest soils (*n* = 2433)	<5	18	<0.5	<1	2	2	<0.05	2	14	3	25

industrial effluents produced in Lublin, are characterized by high heavy metals concentrations. There is visible increase of heavy metals concentrations in river alluvium downstream of effluent disposal site; this deals with cadmium, chromium, cobalt, copper, nickel, mercury, lead, and zinc.

It should be noted that very high concentrations of cadmium occur along the river stretch under present study. Some samples exhibit Cd concentrations as high as almost 100 times the mean geometric of this element concentration in aqueous deposits in entire Poland, which is considered the geochemical background (J. Lis, A. Pasieczna, 1995). Co, Cu, Hg, Ni, and Zn in aqueous deposits are 10 times more than those representing the geochemical background; concentrations of Ba and Cr are 5 times more, respectively. The least increase in concentration deals with strontium. Co-, Cu-, Hg-, Ni-, and Zn-, also Cd-related pollution of sediments is observed along the entire river stretch covered by this study (from Lublin down to the outlet to the Wieprz river).

HEAVY METALS IN SOILS

Concentrations of heavy metals in soils of the Bystrzyca river terraces at Strzyżewice ($n = 12$), where the river is relatively clear, are very small: As — < 5 ppm, Ba — 30 ppm, Cd — < 0.5 ppm, Co — < 3 ppm, Cr — < 6 ppm, Cu — < 6 ppm, Hg — < 0.05 ppm, Ni — < 5 ppm, Pb — < 10 ppm, Sr — < 30 ppm, and Zn < 32 ppm. They are all nearing to their geochemical background values (Tab. 3).

The majority of soil samples collected from the flood plain of the Bystrzyca river within its stretch from Lublin to its outlet ($n = 180$) contain considerably higher concentrations of heavy metals (cadmium, cobalt, chromium, copper, nickel, mercury, lead, and zinc) than those contained in the samples collected at Strzyżewice (the I profile).

Only **arsenic** content is very poor (< 5 ppm) in soils under present study. High concentrations of this element have been found in several ($n = 7$) samples only; besides, they are lower than permissible As concentration (20 ppm) for soils classified among the B category (farmland, forest soils, meadows, built-up areas) (*Wskazówki...*,1994).

Barium in investigated soils appears in increased concentrations with respect to geochemical background; this particularly deals with those soil samples that have been collected within a small distance (1–10 m) off the river bed. However, Ba concentrations in investigated soils did not appear in excess of this element permissible concentrations in farmland and meadows (200 ppm). A close correlation exists between the barium content in investigated soils and copper ($r = 0.916$), cobalt ($r = 0.849$), cadmium ($r = 0.847$), chromium ($r = 0.899$), mercury ($r = 0.883$), lead ($r = 0.898$), and zinc ($r = 0.855$).

Very high **cadmium** concentrations were detected in soils that have been sampled within the flood plain of the Bystrzyca river (Fig. 2). The majority of samples show Cd concentrations in excess of 0.8 ppm — which is the permissible value for soils under agricultural use. It is generally considered that Cd concentration > 5 ppm is toxic for plants. In many cases the cadmium content has been detected in concentrations many times higher than the value just cited. Cadmium can be assimilated from soils by plants, and this process is particularly effective when a ratio of Zn:Cd is less than 100:1; such is the case of many soil samples covered by this study. Cadmium-related soil pollution has been observed along the entire

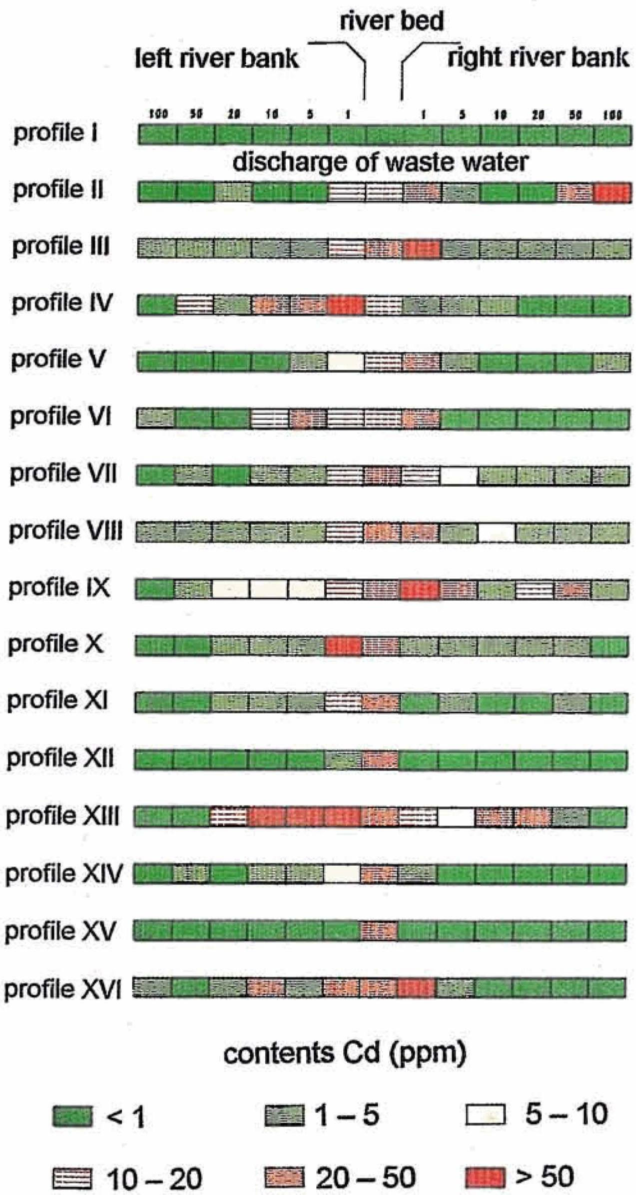

Fig. 2. Cadmium in soils of the Bystrzyca river flood plain and in the river bottom deposits
Kadm w glebach tarasów zalewowych Bystrzycy i w osadach dennych

Bystrzyca stretch. Maximum Cd concentrations occurred to be detected in soil samples collected at sampling points nearest to the river; the average for all the samples in this area is equal to around 23 ppm. The Cd concentrations decrease with the increase of the distance

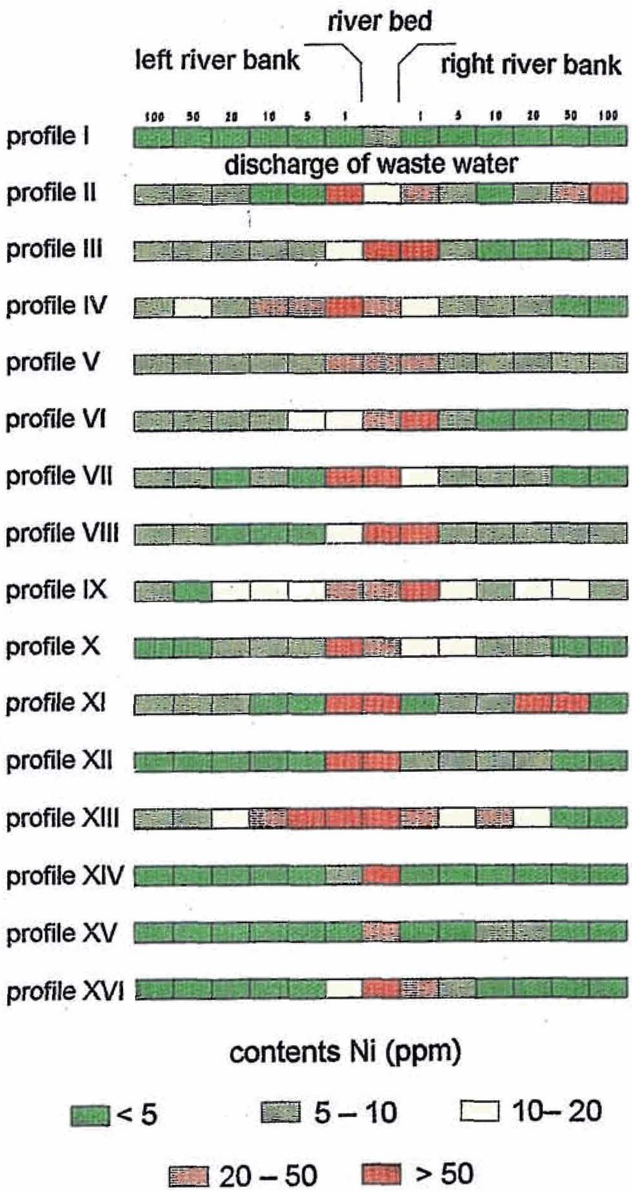

Fig. 3. Nickel in soils of the Bystrzyca river flood plain and in the river bottom deposits
Nikiel w glebach tarasów zalewowych Bystrzycy i w osadach dennych

to the river. Particularly high concentrations of this toxic element occur in soils in the vicinity of Charlęż, Turka, and Długie.

In general, **cobalt** is such the element which in the soil environment appears in small concentrations and is geochemically iron bound. Permissible Co concentration in farmland,

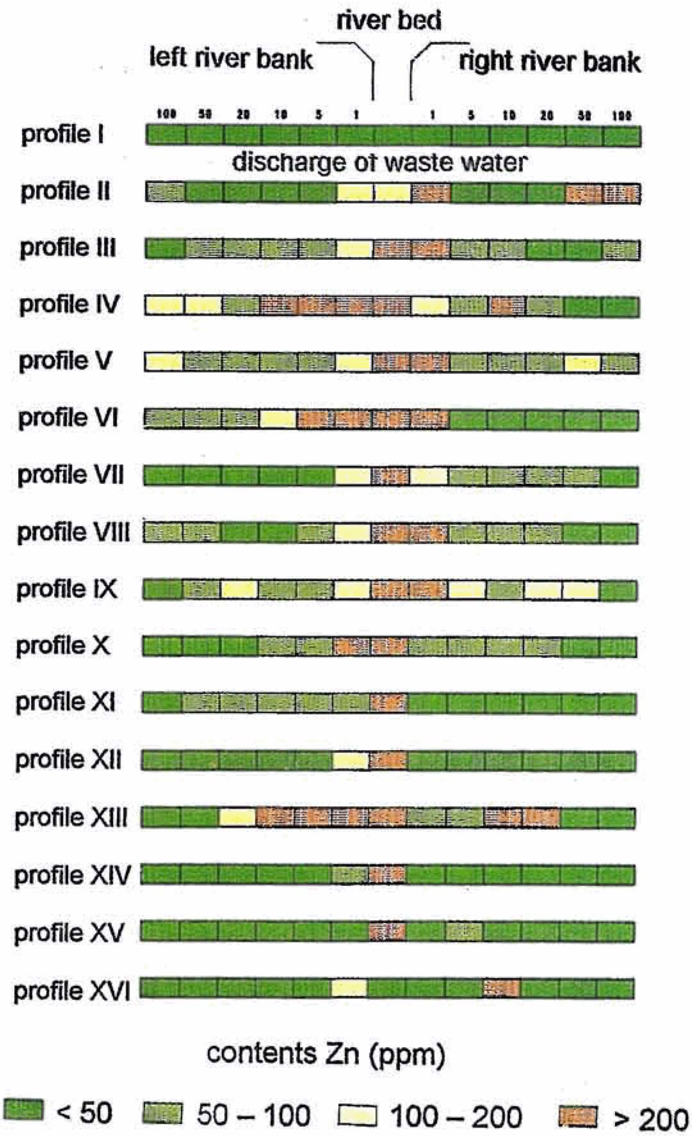

Fig. 4. Zinc in soils of the Bystrzyca river flood plain and in the river bottom deposits
Cynk w glebach tarasów zalewowych Bystrzycy i w osadach dennych

meadows, and forest soils is 20 ppm. Cobalt content > 10 ppm is infrequent in soils. As compared with soil samples collected from the I profile at Strzyżewice, the examined soil samples contain the increased Co concentrations. Higher Co content appears in soils displaying high concentrations of other heavy metals.

The present study also revealed that **copper** was also of increased concentration in soils of the flood plain of the Bystrzyca river. On the average, copper content in soils of Poland is < 10 ppm. Permissible copper content in cultivated soils and meadows is 36 ppm. It is a common idea that hazardous impact of copper due to its properties is being disclosed at concentrations in excess of 200 ppm. This element occurs in soils under present study at concentrations dozen times or so higher than the copper geochemical background. The peak Cu concentrations (80.84 ppm) have been recorded in the vicinity of the sewage-treatment plant and in villages of Długie and Charlęż.

Chromium is other element which appears in excessive concentration in the majority of soil samples, particularly those collected not far off the river bed. Average Cr content in those samples is 28 ppm. Maximum chromium-related pollution of soils has been noted in the village of Bystrzyca and Charlęż.

Mercury in soils under present study has been found in concentrations considerably higher than those of the geochemical background (< 0.05 ppm). In many samples, especially those collected not far off the river, an average Hg concentration is equal to 0.38 ppm; such concentration is much above the permissible mercury concentration for cultivated soils and meadows. The peak mercury concentration has been detected in soils at Sobianowice and Charlęż.

As refers to **nickel** (Fig. 3), its concentration is very high in soils of the flood plain of the Bystrzyca river. Concentrations in excess of 100 ppm have been found in many soil samples (Fig. 3). Such high concentrations have been noted in soils sampled close to the river bed at such locations as Długie, Turka, and Charlęż. In general, Ni concentrations in soils in Poland do not exceed 10 ppm.

Also increased concentrations in soils over the flood plain of the river deal with **lead**. A permissible lead concentration is 85 ppm for cultivated soils (*Wskazówki...*, 1994); in contrast, soil samples collected near the river at the village of Długie contain as much Pb as 105 and 98 ppm.

Strontium in soils covered by this study is slightly increased only; this increase is proportional to higher Ca concentration in soils.

Higher concentrations of **zinc** have also been noted in soils sampled along the Bystrzyca river. In particular, soils with high concentrations of Zn in excess of permissible limit for cultivated soils (140 ppm) have been recorded in soils of the villages of Długie, Turka, Sobianowice, and Charlęż (Fig. 4).

The study revealed that maximum concentrations of heavy metals were recorded in soil samples collected from the sampling points situated nearest to the river bed (1–10 m). Soil pollution in more distant places were observed where a small decline of land surface was visible. The smallest concentrations of heavy metals in soils were noted in such places where a high bank scarp exists, e.g. at Spiczyn.

High concentrations of elements under study were detected in a sample collected from a point 100 m away from the river, in the area of the treatment plant (the II profile). It is most likely that the high concentrations are connected with the pollution of soils due to waste disposal or storing the sludge.

A factor analysis was employed (Tab. 4) with the aim of defining factors responsible for distribution of heavy metals in examined soils covering the flood plain of the Bystrzyca river. The most important factor (no. 1) occurred to be of anthropogenic character; it is

Table 4

Factor analysis

Elements	Factor no. 1	Factor no. 2
Cd	0.9107	0.2714
Hg	0.8833	0.2756
Cr	0.8760	0.3645
Co	0.8515	0.4276
Cu	0.7970	0.5668
Ba	0.7786	0.5344
Zn	0.7709	0.5058
Pb	0.7449	0.5748
Ni	0.5432	0.1258
As	0.1499	-0.0106
Mn	-0.1087	0.8785
S	0.2567	0.8095
Fe	0.4149	0.7915
Ca	0.5183	0.7072
Sr	0.6249	0.6816
P	0.6259	0.6591
Eigenvalue	10.7975	1.4402
Percentage of variability	67.5	9.0

responsible for the occurrence in examined soils of such heavy metals as: cadmium, cobalt, chromium, copper, mercury, lead, and zinc. All of them appear in high concentrations in deposits accumulated in the river bottom material. This fact indicates that polluted alluvium is the source of these metals in soils as they are relocated during high water stages and floods to the Bystrzyca river flood plain. Other factor (no. 2) is of lithological character; it includes the occurrence in soils of sulphur, phosphorus, calcium, strontium, iron, and manganese — as the elements constituting the fundamental components of soils.

RECAPITULATION

1. Disposal of municipal and industrial effluents to the river contributes to accumulation of heavy metals in the river bottom deposits. Alluvial deposits of recent origin in the Bystrzyca river are characterized by high concentrations of cadmium, cobalt, nickel, and zinc.

2. Based on present study, high concentrations of heavy metals were found in soils of the flood plain of the Bystrzyca river. The highest concentrations were detected in soils occurring near the river bed; in general, polluted soils occur within a 20 m belt along the river. At further distance of the river, the increased concentrations of heavy metals were detected in places where river banks are flat and land surface decline is insignificant; natural hollows in the land surface where flood waters could be stored make other characteristic

places for the appearance of heavy metals in high concentrations. There are some places with very steep banks where no evidence of relevant soil pollution has been recorded.

3. High correlation factors among: Cd, Co, Cr, Cu, Pb, and Zn for soils of the flood plain of the Bystrzyca river and simultaneously high concentrations of these elements in the river bed deposits indicate that just the bottom material is the source of pollution of the soil environment. Loaded with heavy metals, the material deposited on the river bottom is set into motion during high water stages and floods as well and relocated, accordingly, to soils of meadows and farmland situated on the river banks; such is the mechanism of soils enrichment with heavy metals.

4. At present, the soils containing heavy metals in high concentrations are the secondary source of pollution of the Bystrzyca river. The said metals are supplied to the river by the surface flow, then they re-sediment in the already accumulated deposits.

5. Vegetation planted in the soils of flood plain of polluted rivers, similarly to vegetation growing along highways, should be excluded from consumption by people and animals.

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METALE CIĘŻKIE W GLEBACH TARASÓW ZALEWOWYCH BYSTRZYCY

Streszczenie

Bystrzyca, dopływ Wieprza, przepływa przez Wyżynę Lubelską. Na obszarze zlewni rzeki występują głównie gleby pyłowe wykształcone na utworach plejstoceńskich (iły, gliny, piaski zwietrzelinowe i wodnolodowce, eluwia glin zwałowych oraz utwory lessowe), a w okolicy Lublina i wzdłuż doliny rzeki — rędziny na podłożu zbudowanym z paleogeńskich i kredowych margli, opok i gez. W dolinie rzeki występują mady, czarne ziemie i sporadycznie gleby torfowe, wykształcone na holoceńskich i plejstoceńskich mułkach, piaskach i żwirach pochodzenia rzecznego.

Bystrzyca, poniżej Lublina, należy do rzek bardzo zanieczyszczonych, jej wody nie odpowiadają obowiązującym normom czystości. Głównym źródłem zanieczyszczenia są ścieki komunalne i przemysłowe, odprowadzane z zakładów znajdujących się w mieście. Znaczna część składników docierających do rzeki wraz ze ściekami gromadzi się w osadach. Akumulacja szkodliwych składników w osadach wodnych, zwłaszcza metali ciężkich, stwarza duże zagrożenie dla środowiska wodnego i lądowego.

Próbki glebowe oraz osady rzeczne pobrano wzdłuż 200-metrowych przekrojów, poprzecznie przecinających dolinę Bystrzycy. W celu określenia tła geochemicznego jeden z przekrojów został zlokalizowany powyżej Lublina — w Strzyżewicach — w miejscu, gdzie rzeka jest stosunkowo czysta. Pozostałe przekroje znajdowały się w odległości 0, 1, 2, 3, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20 i 22 km od miejsca zrzutu ścieków z oczyszczalni. Wzdłuż każdego profilu pobrano próbki glebowe po obu stronach rzeki w odległości: 1, 5, 10, 20, 50 i 100 m od koryta oraz jedną próbkę osadów rzecznych. Próbki gleb pobrano z głębokości 0–20 cm, zaś próbki czynnych osadów — z koryta rzeki, ze strefy brzegowej. Do badań wykorzystano frakcję osadów < 0,2 mm oraz frakcję gleb < 1 mm. Próbki osadów i gleb ługowano kwasem solnym 1:5. W uzyskanych roztworach oznaczono zawartości metali ciężkich: As, Ba, Ca, Cd, Cr, Cu, Co, Fe, Hg, Mg, Mn, Ni, Pb, Sr i Zn oraz P, S i węgla organicznego (TOC).

Próbki aluwiów pobrane z rzeki poniżej miejsca odprowadzania ścieków komunalno-przemysłowych Lublina charakteryzują się wysokimi zawartościami metali ciężkich: kadmu, chromu, kobaltu, miedzi, niklu, rtęci, ołowiu i cynku w porównaniu do tła geochemicznego. Na szczególną uwagę zasługuje bardzo wysokie stężenie kadmu, w niektórych próbkach blisko stukrotnie wyższe w porównaniu do średniej geometrycznej zawartości tego pierwiastka w osadach wodnych Polski. Zanieczyszczenie osadów przez Cd, Co, Cu, Hg, Ni i Zn obserwowane jest na całym badanym odcinku rzeki od Lublina aż do jej ujścia do Wieprza.

W większości próbek gleb pobranych z tarasów zalewowych Bystrzycy na odcinku od Lublina do ujścia rzeki stwierdzono metale ciężkie: Cd, Co, Cr, Cu, Ni, Hg, Pb i Zn w znacznie wyższych stężeniach niż w próbkach pobranych w Strzyżewicach; jedynie arsen w większości próbek glebowych występuje w niewielkich koncentracjach, < 5 ppm. Kadm w wielu próbkach wielokrotnie przekracza dopuszczalną zawartość dla gruntów wykorzy-

stywanych rolniczo. Zanieczyszczenie gleb tym pierwiastkiem jest obserwowane wzdłuż całego badanego odcinka Bystrzycy. Ponadto w glebach położonych blisko koryta rzeki zaobserwowano podwyższone zawartości kobaltu (22–33 ppm), a także miedzi (stężenia nawet kilkunastokrotnie wyższe w porównaniu do tła geochemicznego). Najwyższe zawartości Cu (80, 84 ppm) stwierdzono w pobliżu oczyszczalni ścieków oraz we wsiach Długie i Charlęż. W większości próbek gleb obserwuje się także podwyższone ilości chromu; największe zanieczyszczenie gleb tym pierwiastkiem stwierdzono w okolicy Bystrzycy i Charlęży. W badanych glebach rtęć jest obecna w stężeniach znacznie wyższych od wartości tła geochemicznego (< 0,05 ppm) i w wielu próbkach w wyższych od dopuszczalnej zawartości dla gleb uprawnych i łąk. Najwyższe zawartości tego pierwiastka wykryto w glebach w Sobianowicach i Charlęży. Zawartości niklu w wielu próbkach glebowych przekraczają 100 ppm. Stwierdzono tu także podwyższone zawartości ołowiu; najwyższe (105 i 98 ppm) występują w próbkach ze wsi Długie. Ponadto, szczególnie we wsi Długie, Turka, Sobianowice i Charlęż, notowano wysokie udziały cynku.

Bar w próbkach gleb pobranych w niewielkiej odległości (1–10 m) od koryta rzeki występuje w ilościach podwyższonych w porównaniu do tła geochemicznego, jednak nie przekraczających dopuszczalnej zawartości dla gruntów uprawnych i łąk, stront zaś w nieznacznie wyższych, proporcjonalnie do wyższych w nich zawartości wapnia.

Najwyższe zawartości metali ciężkich wykryto w glebach pobranych w najbliższym sąsiedztwie koryta rzeki; na ogół zanieczyszczone są gleby w pasie do 20 m szerokości po obu stronach rzeki. W większych odległościach podwyższone zawartości metali ciężkich stwierdzono w miejscach, gdzie brzegi rzeki są płaskie (spadek terenu niewielki) oraz w naturalnych zagłębieniach, w których mogły się gromadzić wody fali powodziowej. Tam, gdzie brzegi są bardzo strome, zanieczyszczenia gleb nie obserwowano.

Zastosowana analiza czynnikowa wyznaczyła dwie najważniejsze przyczyny wpływające na rozmieszczenie metali ciężkich w glebach tarasów zalewowych Bystrzycy. Pierwszy czynnik o charakterze antropogenicznym łączy występowanie w badanych glebach metali ciężkich: kadmu, kobaltu, chromu, miedzi, rtęci, ołowiu i cynku z pierwiastkami o wysokich stężeniach gromadzącymi się w osadach na dnie rzeki. Wskazuje to, że źródłem tych metali są zanieczyszczone aluwia przemieszczane podczas wysokich stanów wody i powodzi na tarasy zalewowe Bystrzycy. Drugi czynnik ma charakter litologiczny, obejmuje on występowanie w glebach siarki, fosforu, wapnia, strontu, żelaza i manganu — pierwiastków, które są podstawowymi składnikami gleb.