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OCCURRENCE OF HEAVY METALS IN SELECTED MADE GROUNDS

WYSTĘPOWANIE METALI CIĘŻKICH W WYBRANYCH GRUNTACH NASYPOWYCH

Abstract: This paper presents the analysis of selected urban and industrial areas containing made grounds in the superstratum. The studied soils were characterized by exceeded quality standards only for the presence of heavy metals. The specificity of the occurrence and the visible regularity of the presence of heavy metals in the geological profile were determined. Preliminary scenarios of the action in the event of the exceeded standards for soil quality were presented, showing also the type and scale of the problem. The quality of the soil was analysed taking into account the already existing legislation regarding standards for soil quality. The analysed soils originated from the Silesian Voivodeship.

Keywords: heavy metals, embankment for non-construction purposes, standards for soil quality

Geochemical state of soils in Poland is regulated by legal standards for soil quality [1]. Analysis of the problem of soil pollution is reduced practically to the soil ranging from 0.0 to 0.3 m below the land surface (bls), or subsoil (to a depth of 1.0 m), while the soil beneath this depth is not the main focus of scientific research. It is often the case that land owners learn about the exceeded contaminants concentrations no sooner than at the onset of the investment process. In Poland, the attention is mainly focused on soils contaminated with petroleum substances, which for obvious reasons are remediated, among others, due to the risk of migration of hydrocarbons from the identified sources of pollution such as old military bases, petrol stations, oil tanks, etc. Such contaminants can be economically and effectively removed by in-situ methods, using biochemical techniques [2]. On the other hand, a land contaminated with only heavy metals remains a problem because of the lack of effective and economical methods for in-situ treatment and due to complicated and uneconomical methods of

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ex-situ remediation (also disputable from the environmental perspective). In most cases these are solidification and immobilization methods, which do not remove contaminants but only immobilise them, which does not solve the problem of the final disposal. In addition, due to the nature of the industry in the Silesian Voivodeship, which was developed mainly in the nineteenth and twentieth centuries, excessive amounts of metallurgical and foundry wastes (slag and dross) were deposited in heaps. These waste materials were readily available for levelling the surrounding areas by creating embankments for non-construction purposes. The type and condition of such embankments do not meet the requirements for earthworks or construction groundwork [3]. At that time, there were no legal limits for control and the environmental considerations were overridden by the need for industrial development. The above-mentioned production wastes, which occur in the form of slag, dross and ash (usually mixed with debris, stones and soil), remain embedded in the geological profile in a substantial area of land of Silesia. Due to the current local regulations for the protection of the land surface, which in accordance with the definition constitutes landform features, soil and the underlying soil to a depth of human impact [...] [4], one should consider embankments for non-construction purposes as an integral part of land surface. This implies the necessity to apply the quality standards for soil also to embankments for non-construction purposes, and after the planned change in legislation – the maximum allowable content of substances causing the risk in the soil.

Virtually all of the analyzed samples, which were found to exceed allowable metals concentrations, contained slag and metallurgical or foundry dross. Metallurgical waste is one of the most diverse groups of industrial waste. Depending on the process by which the by-products are formed, they are characterized by a variable structure, technical properties, and the chemical and mineralogical composition [5–9]. Based on the example of the slags originating from two slag heaps in Silesia, the content of selected metals is as follows [7]: the slag from the Zn-Pb ores smelting heap – manganese from 430 to 2223 mg/kg d.m., zinc from 6270 to 83700 mg/kg d.m., lead from 5340 to 29385 mg/kg d.m., cadmium from 32 to 262 mg/kg d.m., chromium from 16 to 69 mg/kg d.m., copper from 66 to 1859 mg/kg d.m., nickel from 25 to 146 mg/kg d.m., molybdenum from 6 to 25 mg/kg d.m., in the waste from the steel slag heap – manganese from 873 to 86 600 mg/kg d.m., zinc from 1 to 10 800 mg/kg d.m., lead from 6 to 3200 mg/kg d.m., cadmium from < 0.3 to 136 mg/kg d.m., chromium from 15 to 2920 mg/kg d.m., copper from 3 to 837mg/kg d.m., nickel from < 1 to 102 mg/kg d.m., molybdenum from < 1 to 8 mg/kg d.m.

The aim of this study was to analyse the selected areas characterized by exceeded maximum allowable concentrations of heavy metals in the man-made fill layer as regulated by the already existing legislation and in correlation with the capacity to meet the legal requirements for such areas of land in Silesia.

Materials and methods

Table 1 presents the Polish standards for soil quality for different groups of land including urban, industrial and transportation areas, which were the basis for this study.

Table 1

Soil and land standards in the range of the accepted concentrations of heavy metals [1]

Metal	Maximum allowable concentrations in soils [mg/kg d.m.]								
	Group A[a]	Group B[b]					Group C[c]		
		Depth [m bls]							
		0.0–0.3	0.3–15.0		> 15.0		0.0–2.0	2.0–15.0	
			Soil water permeability [m/s]						
			up to	below	up to	below	not applicable	up to	below
			$1 \cdot 10^{-7}$		$1 \cdot 10^{-7}$		not applicable	$1 \cdot 10^{-7}$	
Arsenic (As)	20	20	20	25	25	55	60	25	100
Barium (Ba)	200	200	250	320	300	650	1000	300	3000
Chromium (Cr)	50	150	150	190	150	380	500	150	800
Tin (Sn)	20	20	30	50	40	300	350	40	300
Zinc (Zn)	100	300	350	300	300	720	1000	300	3000
Cadmium (Cd)	1	4	5	6	4	10	15	6	20
Cobalt (Co)	20	20	30	60	50	120	200	50	300
Copper (Cu)	30	150	100	100	100	200	600	200	1000
Molybdenum (Mo)	10	10	10	40	30	210	250	30	200
Nickel (Ni)	35	100	50	100	70	210	300	70	500
Lead (Pb)	50	100	100	200	100	200	600	200	1000
Mercury (Hg)	0.5	2	3	5	4	10	30	4	50

[a] Group A – landed property included in the area subject to protection under the provisions of the Water Act, and areas subject to protection under the provisions of the Nature Conservation Act; [b] Group B – land classified as agricultural land except land under ponds and ditches, forests and wooded land, barren land, and urban areas with the exception of industrial land, surface mining land in use, transportation land; [c] Group C – industrial land, surface mining land in use, transportation land.

The cases selected for this study included the soils with exceeded maximum allowable concentrations for heavy metals only. The analysed soil samples were collected from 12 industrial/urban areas of the Silesian Voivodeship. The presented results are the maximum values of heavy metals concentrations in the analysed made grounds. All of the studied cases concerned the areas designated for construction investments (land belonging to groups B and C) in accordance with local zoning plans. The soils were compared with the limit values specified separately for each metal, depending on the permeability of the soil and the type of soil (land use). Determinations of metals present in the soil samples were carried out by atomic absorption spectrometry after previous digestion of the samples.

Quality standards were set at two thresholds, *ie* separately for the soil of permeability $< 1 \cdot 10^{-7}$ m/s and separately for the soil with permeability $> 1 \cdot 10^{-7}$ m/s, depending on the depth. The land to be used according to the specifications for group B was analysed in the range of the depth from 0.3 to 15.0 m, and the land belonging to group C was analysed both in the range of 0.0 to 2.0 m, and also from 2.0 to 15.0 m. Hence, the cases within group A and group B (in the range of 0.0 to 0.3) were not analysed. The type of land in which the exceeded standards were found was assessed within the set of identified cases of exceeded standard values. Subsequently, it was examined whether the exceeded values were also found in the layer situated directly beneath a layer in which the exceeded values were found initially, taking into account the geological structure of the land.

The comparison of soil samples was carried out for the samples taken from boreholes in the same area of study and also for the samples taken in the other regions of Silesia. Each of the analyzed area was considered in terms of meeting soil quality standards specified for a particular land zoning: B or C (in accordance with applicable regulations). In addition, however, to illustrate the scale of the problem, all the results were also compared with the second category.

The legal aspect of the case of land exceeding the maximum allowable concentrations was analysed in an attempt to evaluate action strategy for areas in the Silesian Voivodeship. This analysis was performed with respect to the legal situation – *ie* soil and earth quality standards being in force since 2002 and which due to changes in the legislation in September 2014 are to be replaced by "allowable content of risk causing substances in the soil or in the earth" as defined by the regulation to be introduced by September 2016.

Results and discussion

Table 2 shows the observed maximum concentrations of selected heavy metals in the made grounds collected from urban and industrial areas of the Silesian Voivodeship.

All of the made grounds were qualified as highly water-permeable (up to $1 \cdot 10^{-7}$ m/s). The embankments, in each of the analysed cases were a mixture of slag or construction debris and soils, sand or clay or stones. In each of the embankment sample at least one of the identified components was of anthropogenic origin (construction debris, slag, crushed dross, bricks, sinter, etc.).

Table 2

Maximum concentrations of heavy metals in selected made grounds in the Silesian Voivodeship

Metal	Observed maximum metal concentration [mg/kg d.m.]								
	Group A[a]	Group B[b]					Group C[c]		
		Depth [m bls]							
		0.0–0.3	0.3–15.0		> 15.0		0.0–2.0	2.0–15.0	
			Soil water permeability [m/s]						
			up to (embankments)	below (native soil)	up to	below	embankments	up to (embankments)	below (native soil)
			$1 \cdot 10^{-7}$		$1 \cdot 10^{-7}$			$1 \cdot 10^{-7}$	
Arsenic (As)			82	14.1			412	378	< 0.2
Barium (Ba)			1420	197			3280	2200	36.8
Chromium (Cr)			38.4	18.1			1060	53.0	28,3
Tin (Sn)			125	9.0			51.2	20.0	8.1
Zinc (Zn)			5540	89.0			50500	86000	206
Cadmium (Cd)	Not analysed	Not analysed	11.8	0.64	Not analysed	Not analysed	398	239	< 0.3
Cobalt (Co)			9.4	12.7			23.7	15.1	8,80
Copper (Cu)			3000	18.3			7991	57.4	8.89
Molybdenum (Mo)			< 5.00	< 5.00			216	< 5.00	< 5.00
Nickel (Ni)			52.6	32.7			188	45.5	14,9
Lead (Pb)			1330	20.6			2810	9460	13.7
Mercury (Hg)			0.345	2.11			0.320	< 0.1	< 0.1

[a] Group A – landed property included in the area subject to protection under the provisions of the Water Act, and areas subject to protection under the provisions of the Nature Conservation Act; [b] Group B – land classified as agricultural land except land under ponds and ditches, forests and wooded land, barren land, and urban areas with the exception of industrial land, surface mining land in use, transportation land; [c] Group C – industrial land, surface mining land in use, transportation land.

The soil directly below the embankments was observed to be both highly permeable (mostly sand) and poorly permeable (mainly clay and silt).

The analyses of soil showed that in all the cases in which the exceeded standards for metals were observed in man-made fill layer, the layers situated directly beneath the embankment contained no contaminants, regardless of the type of those formations, this is, highly permeable or poorly permeable. This demonstrates the absence of a noticeable vertical migration of contaminants from the embankment layer to the native soil. Tables 3 and Table 4 list selected examples of geological profiles with exceeded standards for metals in the embankment layers layer and in the underlying native soil – highly and poorly permeable. Table 3 presents selected profiles from the area B (urbanized), and Table 4 presents selected profiles from the area C (industrial).

It was observed that every soil sample from the area B, in which the exceeded standard value was found for zinc, contained also exceeded concentrations of lead, and most of the samples contained additionally barium and arsenic. In addition, some samples showed exceeded maximum allowable concentrations of tin and copper, and only in few cases of cadmium and chromium. Only a single case was found when the maximum allowable concentration of nickel was exceeded.

For cobalt and mercury no exceeded values were found in the embankment samples, and the exceeded value of molybdenum was found only in one sample. The concentrations of molybdenum and mercury were in most cases below the level of quantification.

The same set of exceed standard values in terms of the presence of a given metal and its concentration range was found for each set of samples taken from all of the tested boreholes within a given area (*eg* within one or several interconnected cadastral land plots). This proves the uniform structure of embankments of the same origin in the area of interest. Comparing a group of samples from different locations in Silesia it was observed that the composition of embankments varied. However, it can be presumed with high probability, that in all of the analysed areas in which metals concentrations were exceeded, the land was levelled using materials containing varying percentage of metallurgical and foundry wastes, mainly from the processing of non-ferrous metals.

The important aspect of the analysis proved to be the classification of land by groups of application. The research shows that the same land classified as category B is considered to be contaminated and by classifying it in category C it would be completely unpolluted, and conversely: no exceeded standard values due to category C of the studied area may be inaccurate in the case of a change of the category to category B. This situation poses a problem resulting mainly in a manner in which the polluted soil is handled. In accordance with the already applicable regulations, the land was considered to be polluted when the concentration of at least one substance exceeds the limit value (standard) [1]. This poses, on the other hand, a problem during the investment process, when the ground has to be excavated, mainly for the foundation. The legal aspect of this situation was examined to find that the polluted soil excavated during earthworks has to be considered as a dangerous waste and is qualified under the code 17 05 03*. According to the hierarchy of methods of waste handling, the soil excavated during earthworks (waste), should be first prepared for re-use or recycled

Table 3

Selected geological profiles with exceeded metals standards in the embankment layers and in the underlying native soils – highly and poorly permeable from an urbanized area (group B)

Metal	Metal concentrations in the selected ground profiles for the area B [mg/kg d.m.]							
	Profile 1		Profile 2		Profile 3		Profile 4	
	Embankment	Silt clay occurring directly beneath the embankment	Embankment	Sandy loam occurring directly beneath the embankment	Embankment	Medium sand with coarse sand intercalations occurring directly beneath the embankment	Embankment	Silt clay occurring directly beneath the embankment
Arsenic (As)	82*	11.0	20.7*	< 0.200	17.0	8.4	77*	< 0.200
Barium (Ba)	734*	197	249	58.1	577*	45.6	599*	60.4
Chromium (Cr)	18.0	14.5	14.9	10.6	10.0	3.62	10.3	10.7
Tin (Sn)	125*	8.7	5.40	1.95	14.2	3.98	3.88	5.73
Zinc (Zn)	5540*	89	1040*	45.5	580 *	49.1	3770*	30.5
Cadmium (Cd)	10.6*	< 0.300	5.52	< 0.300	2.19	< 0.300	10.2	< 0.300
Cobalt (Co)	9.4	5.37	4.79	3.93	6.45	14.7	3.40	5.63
Copper (Cu)	96.2	7.70	19.8	10.70	33.0	1.88	83.9	9.65
Molybdenum (Mo)	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
Nickel (Ni)	35.2	10.4	9.5	11.3	17.0	9.4	10.7	9.6
Lead (Pb)	1330*	20.6	696*	19.9	160*	14.8	571*	11.4
Mercury (Hg)	0.148	< 0.100	< 0.100	< 0.100	0.152	< 0.100	< 0.100	< 0.100

* Exceedance of the standard.

Table 4

Selected geological profiles with exceeded metals standards in the embankment layers and in the underlying native soils – highly and poorly permeable from an industrial area (group C)

Metal	Metal concentrations in the selected ground profiles for the area C [mg/kg d.m.]							
	Profile 5		Profile 6		Profile 7		Profile 8	
	Embankment	Sandy loam	Embankment	Fine sand	Embankment	Fine sand	Embankment	Fine sand
Arsenic (As)	< 0.200	< 0.200	6.6	< 5.0	5.32	< 5.0	< 5.0	< 5.0
Barium (Ba)	450	36.8	424	< 20.0	181	21.1	378	< 20.0
Chromium (Cr)	1060*	15.1	51.5	< 10.0	128	28.3	33.4	< 10.0
Tin (Sn)	51.2	8.1	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Zinc (Zn)	3730*	30.1	2560*	30.3	2740*	42.8	1570*	206
Cadmium (Cd)	15.2*	< 0.300	9.4	< 2.0	8.50	< 2.0	8.1	< 2.0
Cobalt (Co)	6.33	4.80	23.7	8.8	15.8	7.50	21.8	2.4
Copper (Cu)	135	8.50	44.5	< 5.0	17.1	< 5.0	58.8	< 5.0
Molybdenum (Mo)	< 5.00	< 5.00	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Nickel (Ni)	43.3	13.7	32.8	< 10.0	23.7	14.9	49.7	< 10.0
Lead (Pb)	65.0	10.7	362	< 20.0	889*	< 20.0	373	< 20.0
Mercury (Hg)	< 0.100	< 0.100	< 0.100	< 0.100	< 0.3	< 0.3	< 0.3	< 0.3

* Exceedance of the standard.

when the re-use method is unavailable, if both of these methods are unavailable the soil should be subjected to other methods of recovery and finally disposed of (including landfilling) [10]. The current version of the document "Waste Management Plan for the Silesian Voivodeship 2014" (hereinafter PGO) was analysed to find only three functioning installations in the Silesian Voivodeship which could handle the waste denoted as 17 05 03*. These installations include: an incineration plant; solid fuel production plant (accepts only the waste which is contaminated with petroleum compounds), which rules out processing of soil contaminated with heavy metals; and the third installation which is a plant producing pellets and aggregates, where pollutants are not removed but solidified by the Geodur method. The production capacity of this plant is 10 000 Mg (in total for several types of waste). In addition to these installations, PGO of the Silesian Voivodeship does not suggest any other installation that could handle waste bearing the code 17 05 03* (such as soil contaminated by metals only). It is noted that none of the landfills in the Silesian Voivodeship permit landfilling of this type of waste. Taking into consideration the observed area of pollution in the investigated areas of investment, it becomes clear that it is virtually impossible to respect the "proximity principle" applicable to waste producers (waste transfer to the nearest sites where they can be processed [10]). The assumption of an average thickness of the made grounds (depth 2.2 m), and the occurrence of an area with exceeded standard metal concentration with surface of 20 m × 20 m, yields at least 640 Mg of waste to be handled from only one construction site. Moreover, the observed thickness of non-conforming made grounds can be even 5.5 m, as well as the area of investment is much more extensive, so the mass of soil that has to be disposed of in this case is much greater.

The amended regulations of the Environmental Protection Law (Act of 11 July 2014. Amending the Act – Environmental Protection Law and other laws; Dz.U. 2014 No. 0 pos. in force since 05.09.2014) regarding the pollution of land, change the approach in dealing with contaminated soil or earth. They announce that in two years a regulation determining the manner of assessing the contamination of the surface of the earth will come into force. This assessment will include the identification of substances causing a risk particularly important to protect the surface of the earth, their allowable content in soil and their allowable content in earth, differentiated for individual soil properties and land groups, distinguished depending on their usage. The amended regulation will include specific requirements for determining the maximum allowable content in the soil of a risk-causing substance, including the analysis of its impact on human health and the environment. Therefore, the current standards of soil quality, which are used as a reference of all the soil contamination analyses, will be withdrawn no later than by September 2016. Long-term observations of the land (with the exceeded standards for metals only) in Silesia suggest urgent need for changes in the decision-making on the treatment of the soil. The existing legislation, which mandates that in every single case of such land the standards established depending on the usage of the area (A, B or C) have to be met, is irrational. All the cases studied indicate no noticeable metal migration to the layers underlying the embankments. Additionally, taking into consideration the problems with the management of contaminated soil as a waste (which in accordance to the legislation is a hazardous waste) and no reasonable means of technical metal removal from the soil (especially in the areas of investment), the necessity to cease referring to the quality standards (determining the decision to remove the contaminants) in favor of risk assessment of the impact of these pollutants on human health and the environment becomes essential.

Furthermore, it seems inappropriate to decide that the contaminants should be removed only because of the exceeded allowable values, which are significantly different for the urbanized areas and industrial areas, as the land zoning is often subjected to changes.

A review of the local zoning plans indicates that the planned function of the land use often combines industrial and commercial/service uses. In such a case, the assessment of the area as polluted or unpolluted depending on the current or planned land use becomes an absurd procedure.

A comparison of the standards shown in Table 1 indicates great difference between the allowable concentrations established for heavy metals in the areas B and C.

For example, there is a several-fold difference for two the most often exceeded metal contents in embankments which are Zn and Pb (Zn standard for the area B is 350 mg/kg d.m. and for the area C it is 1000 mg/kg d.m.; the standard value for Pb for the area B is 100 mg/kg d.m. and for the area C it is 600 mg/kg d.m.).

This causes that the embankment originating from the same source and having the metal content between the B and C standards would be considered to be polluted and to be a hazardous waste when excavated (in the areas B), and in the strictly industrial areas it would be treated as unpolluted soil.

It also distorts the overall analysis of the soil, especially in the areas C, because often high concentrations of Zn and Pb indicating their unnatural origin and proportions (metallurgical source of soil components) do not exceed the standard C.

An example is the analysis of embankments indicated in Tables 3 and 4 where it can be seen that in the area B (Table 3) every sample containing slags in the embankment is characterized by exceeded zinc but also by exceeded lead, but for the areas C (Table 4) most of the samples with exceeded zinc do not exceed the standards for lead.

This is due to the fact that the current standards for metals have been established disproportionately – for example, the standard for Pb in the areas B is 3.5 times lower than the standard Zn concentration. On the other hand, for the areas C high standard value for Pb (only 1.7 times smaller than the standard for Zn), often does not show its increased content in the slags (in which it occurs with zinc), which interferes with the assessment of the situation.

Table 5 provides an example of made grounds in the area C (industrial land use) where, in accordance with the existing regulations, they would not be considered as polluted, but in the area B (commercial/service land use) this land should be subjected to reclamation by removing the contaminants to the depth specified by the quality standards.

Table 5 clearly shows that the same land with the quality exceeding the standards for the area B, depending on the planned investment (*eg* construction of a shopping mall in one case or a manufacturing plant in another), would have to be subjected to costly

Table 5

Comparison of the metal content of the embankments to the standards for areas B and C

Metal	Metals concentrations in the selected made grounds [mg/kg d.m.]														
	Soil 1			Soil 2			Soil 3			Soil 4			Soil 5		
	embank-ment	Group B	Group C	embank-ment	Group B	Group C	embank-ment	Group B	Group C	embank-ment	Group B	Group C	embank-ment	Group B	Group C
Arsenic (As)	28.6	+	–	0.433	–	–	20.1	+	–	2.30	–	–	24.1	+	–
Barium (Ba)	470	+	–	364	+	–	141	–	–	208	–	–	682	+	–
Chromium (Cr)	63.0	–	–	289	+	–	53.0	–	–	8.93	–	–	17.5	–	–
Tin (Sn)	22.1	–	–	15.3	–	–	< 20.0	–	–	4.69	–	–	42.5	+	–
Zinc (Zn)	920	+	–	451	+	–	828	+	–	477	+	–	657	+	–
Cadmium (Cd)	3.53	–	–	0.930	–	–	< 2.00	–	–	3.85	–	–	3.17	–	–
Cobalt (Co)	10.5	–	–	8.70	–	–	15.1	–	–	2.77	–	–	8.22	–	–
Copper (Cu)	122	+	–	39.7	–	–	37.6	–	–	19.3	–	–	249	+	–
Molybdenum (Mo)	< 5.00	–	–	95.0	+	–	< 5.00	–	–	< 5.0	–	–	< 5.00	–	–
Nickel (Ni)	28.9	–	–	188.0	+	–	45.5	–	–	6.68	–	–	21.7	–	–
Lead (Pb)	166	+	–	67.3	–	–	196	+	–	117	+	–	213	+	–
Mercury (Hg)	< 0.100	–	–	< 0.100	–	–	< 0.10	–	–	< 0.10	–	–	0.320	–	–

"+" exceedance of the standard; "–" non-exceedance of the standard.

disposal and would be treated as a hazardous waste when excavated (in the first case), would be treated as an unpolluted soil, which could be used for levelling the investment area (in the second case). So far, the other factors such as leachability, geological structure, toxicity, pH, metals speciation etc. were neglected. The announced new regulations should take into account the risk analysis of the identified pollutants to human health and the environment as a basic condition for further handling of the ground.

Conclusions

Observations of the cases of made grounds characterized by exceeded standard metals concentrations allow the following conclusions:

– Proper diagnosis of the geological structure plays an important role in carrying out any ground assessment. Careful attention should be devoted to distinguish between soil and embankment built with anthropogenic materials when taking samples of the top layer. This can be of great importance when the results are analysed in terms of sources of metal contamination.

– As evidenced by geological cross-sections no exceeded standard values for metals were observed in the layers situated directly below the man-made fill layer in which metals concentrations were found to be higher than the maximum allowable concentrations. This was observed regardless of their permeability, which suggests no noticeable migration of metals from the embankments containing steel slags.

– There is a certain regularity, this is, in the case of made grounds with exceeded standard value for zinc it was also observed that the concentration of lead was also elevated, and often also in order of: barium and arsenic, sometimes copper and tin, which allows determination of the origin of materials used to build the embankments: metallurgy/foundry of a given type of non-ferrous metal.

– The Silesian Voivodeship does not have any installations which could be used to dispose of the soil with exceeded maximum allowable concentrations of heavy metals.

– The legal regulations governing the treatment of polluted soil should be amended to take into account the case of made grounds with elevated concentrations of metals.

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WYSTĘPOWANIE METALI CIĘŻKICH W WYBRANYCH GRUNTACH NASYPOWYCH

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Abstrakt: W pracy dokonano analizy wybranych terenów zurbanizowanych oraz przemysłowych zawierających w stropowej strefie podłoża grunty nasypowe. W badanych gruntach występowały przekroczenia w zakresie standardów jakości jedynie pod względem występowania metali ciężkich. Określono specyfikę występowania przekroczeń oraz zauważalną prawidłowość obecności metali ciężkich w profilu geologicznym. Przedstawiono wstępne scenariusze dopuszczalnych działań w przypadku stwierdzenia przekroczeń standardów jakości gleby i ziemi, wykazując rodzaj i skalę problemu. Stan gruntów analizowano przy uwzględnieniu obowiązujących przepisów prawnych w zakresie standardów jakości gleby i ziemi. Rozpatrywane grunty pochodziły z obszaru województwa śląskiego.

Słowa kluczowe: metale ciężkie, nasyp niebudowlany, standardy jakości gleby