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INFLUENCE OF MINING EXPLOITATION ON SOIL CHEMISTRY ON THE EXAMPLE OF OSTRAVA-KARVINÁ HARD COAL DISTRICT

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Witold Biały[1]–*orcid id: 0000-0003-2313-0230*
[1]KOMAG Institute of Mining Technology, **Poland**

Abstract: This paper presents the results of soil testing in selected sites of Ostrava city. Soil samples were collected from nine parks in Ostrava from three different depths using a drill. The sites from which the samples were collected are areas near trees and open space. Each of them is located in a different part of the city and is affected by different types of pollution. Soil is one of the resources that very often cannot be reclaimed. This process is spread over time, and restoring land to public use without negative human impact is very costly and long-lasting. The analysis will allow to determine the impact of mining operations on soils in selected places of Ostrava city. The results are compared with the maximum permissible concentrations of harmful elements according to the Regulation of the Ministry of Environment on land protection.
Keywords: mining, exploitation, environment, soil, Ostrava

1. INTRODUCTION

For over 350 years, coal has been mined on the territory of the Republic of Poland and the Czech Republic. This area includes the Upper Silesian Coal Basin (wikipedia, 2020), i.e.: Silesian Upland, Cracow-Częstochowa Upland, Oświęcim Basin and areas of north-western part of Moravian-Silesian Region (Bilans zasobów, 2021).

The coal deposited in the Upper Silesian Coal Basin is located in the triangle: Tarnowskie Góry, Cracow, Ostrava (Fig. 1).

Coal is necessary to ensure energy security of each country where thermal and electric power engineering is based on this raw material. This is the case of Poland and the Czech Republic. The visibility of mine shaft towers, dumping grounds and damages caused by mining is an inseparable element of GZW landscape.

Coal seams are mined using the longwall system with caving, which causes significant changes on the surface.

Initially, during the mining and processing operations, no special attention was paid to the hazards for the surroundings, contamination and degradation of areas adjacent to the mine and covered by mining activities.

Fig. 1 Upper Silesian Coal Basin

Such an approach resulted in gradual destruction of the environment by creation of sinkholes generating surface damage, piles containing various chemical compounds, emitting dangerous and toxic substances to the atmosphere and local environment, reacting among others with oxygen and penetrating groundwater. A noticeable problem in the Ostrava and Karviná regions is surface deformation and local groundwater flooding. It is also important not to forget about the surface vibrations caused by mining tremors that make life unpleasant for local residents and the discharge of salty water from mines into rivers.

Thus, mining activity has a significant impact on the biosphere elements: lithosphere, atmosphere and hydrosphere. Air and water belong to the environment's renewable resources. Soil is one of the resources that very often cannot be reclaimed. The reclamation process is time-consuming, costly, and makes life difficult for residents in areas affected by coal mining and dumping.

Specific regulations on brownfields were introduced at the European Community level and are therefore binding in all member states. These regulations have the form of directives and require transposition into national legislation (Dyrektywa, 2004; 2006; Komunikat 2006).

In terms of instruments for revitalization of brownfield sites, the focus is on environmental issues. All other issues are regulated at a general level. This state is reflected in the detail of terminology used, where the subject of reclamation is clearly and transparently described in legal acts and the lack of such definitions for revitalization.

2. HARD COAL DEPOSITS IN THE CZECH REPUBLIC

The Czech Republic has deposits of coking and thermal coal. The key hard coal mining site is the Ostrava-Karviná coal basin (Ostravsko-karvinská uhelná pánev), which is located in the northeastern part of Moravia-Silesia near the border with Poland.

In addition, the Czech Republic has coal deposits in the northwestern and north-central regions, but their extraction is considered unprofitable and dangerous (Fig. 2).

The most important centers are Karviná, Ostrava, Orlová, Bogumin, Třinec and Havířov. The Ostrava-Karviná hard coal district belongs to the Upper Silesian Coal Basin and accounts for 30% of its area. It is divided into an eastern and western part, separated by the Orlová fault. Coal from the Karviná deposit is a coal of medium degree of coalification, used in the coking and power generation industries. Coal from the

Ostrava deposit is medium to high degree of coalification and is used mainly in the coking industry.

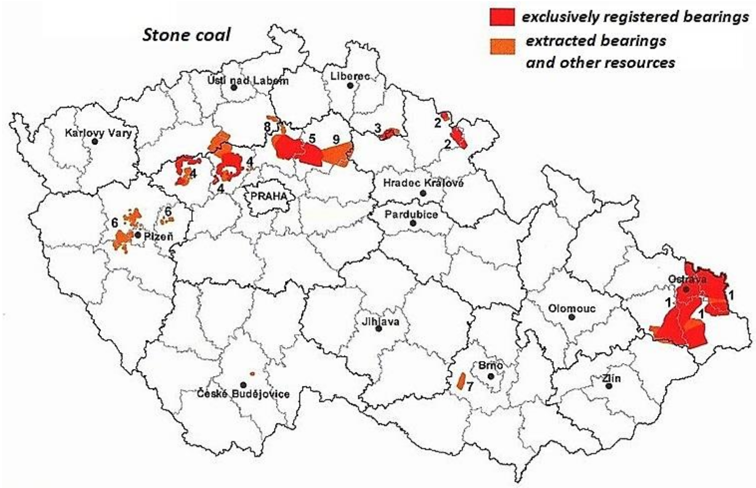

Fig. 2 Hard coal deposits in the territory of the Czech Republic
Source: (is.muni.cz, 2021, surovinove zdroje, 2012)

In the record-breaking year 1971, the mines provided 29 million tonnes, in 2008 it was 12.7 million tonnes and in 2018, only 4 million tonnes.
In the 1990s, the Czech government decided to close mining operations in the Ostrava area, which resulted in a sharp decline. The reason was the high cost of mining and the desire to improve the city's image from one destroyed and polluted by industry to a modern and friendly city. Further reductions in extraction are related to decreasing demand, mainly from the metallurgical industry.
The OKD (Ostravsko-karvinské dolý) is the only producer of hard coal in the Czech Republic. 8.400 people, of which 2.000 are foreigners, mainly from Poland. As of 2018, the OKD's sole shareholder is the state-owned company Prisko, directly controlled by the government.
Currently, coal is mined at only one mine in the Czech Republic – CzSA. The Darkov Mine ceased mining on 23.02.2021, while four days later (27.02.2021), the CzSM Mine was decommissioned.
The latest proposal by the management of the state-owned company OKD, which suffered heavily as a result of the COVID-19 outbreak, envisages the permanent closure of the only remaining mine in the Czech Republic – this will take place in 2022 (forsal.pl, 2021).

3. HARD COAL MINING AND THE ENVIRONMENT

In addition to economic benefits, hard coal mining has a significant impact on the natural environment. Along with coal, large amounts of waste rock are extracted and stored on dumping grounds (heaps). The Mechanical Coal Processing, on the other hand, is accompanied by additional waste collected in settling pits. Hence, in the landscape wherever mines are located, there are many waste heaps, where for over 200 years huge amounts of waste have been accumulated. They are made up of shale, sandstone and waste from sorting and washing plants. In the past heaps were deposited in the immediate vicinity of mines, in the shape of high cones or mountains. Nowadays, the so-called central dumps are created, where waste from many mines is deposited.

These dumps are very often created in a terrain depression in order to level it out. However, about 60% are still overlying dumps. Many of them occupy large areas, are of great height, reaching tens of meters, very often thermally active.

In areas where mining plants have been decommissioned, waste is found in unliquidated heaps and settling pits. The material stored in dumping grounds is mostly claystone, siltstone, gravelstone, sandstone and coal shale. The claystone and siltstone determine the physical and chemical properties. Freshly piled up dumps are characterized by a stone structure and natural segregation of the material being dumped. During piling, heavy rock material of large volume and weight rolls down the slope and settles in the lower part of dump, thus the bottom of dump is dominated by this material, which is characterized by large spaces between rocks. These spaces are filled with air. The top of dump is generally dominated by finer textured material.

The problem of dumps is also their thermal activity. Thermal activity is determined by several factors. The first is the amount of carbon and pyrite in the composition of dump. The second is the heap's porosity – the bigger it is, the better access to oxygen and ventilation. The most exposed to high thermal activity are above-grade dumps, the least exposed are flat dumps. Thermal active dumps are extremely dangerous for both the environment and man. On the heap surface there is total or partial destruction of vegetation, change of soil reaction, death of organic matter. They are dangerous to humans because of fumes emitted, which are often hazardous to health, unpleasant to smell, and the unstable surface of heap, which is usually not protected by a fence or security agency.

The best known active thermal waste heap in the Ostrava-Karviná hard coal district is the Ema heap, known by the inhabitants of Ostrava as "Ostravská Etna" or "Ostrava Volcano" (Fig. 3).

Fig. 3 Post-mining heap Ema – Ostrava

Source: Own study

Its height is 315 m above sea level, its area is 82 ha, it contains about 27 million m3 of material and its temperature inside is about 1500°C. Thermopilous plants grow on its surface, and there is no snow on its top in winter. There are thermally active areas on top of the Ema heap, where entry is prohibited due to the high risk to human health.

Another type of negative environmental impact, is land subsidence due to movement of rock masses. Visible at the surface effects of this process are terrain and hydrological changes. These effects affect both nature and technical aspects, through drainage and flooding of deformed terrain, destruction of buildings and infrastructure, deformation of forest and agricultural areas. Underground mining disturbs water management in the area, which leads to drainage or flooding of the land (Fig. 4). The result is destruction of vegetation and infrastructure.

Fig. 4 Flooded area in the village Karvina Doly

Source: Own study

These changes lead to a decrease in soil productivity, which must undergo long-term reclamation to be restored to its previous state. Sometimes the changes are so permanent and irreversible that the vegetation in a given area dies completely.

4. SOIL ENVIRONMENT – TYPES OF TRANSFORMATION

Soil is the biologically active, surface layer of the earth's crust. The most valuable layer is the humus layer, i.e. the top 10-30 centimeters, because on it the plant life on Earth is possible. It is formed from dead plant and animal remains – it is an organic substance. Soil is the habitat of a huge number of organisms and is made up of layers that comprise the horizons. The soil profile is called the layers from highest to lowest, which consists of the following layers:

1) Humus layer,
2) Mineral and humus layer,
3) Mineral layer,
4) Layer composed of local rock, or material moved by water or glacial force.

The composition of soil includes:

1) Humus,
2) Mineral constituents (sand, silt, gravel, stone, clay),
3) Living organisms,
4) Water,
5) Air.

Industry has led to the division into two types of impacts on soil: direct and indirect. Direct activities include: dumps, settling pits, contamination with emission substances, while land drainage by mining exploitation is an indirect activity. Direct and indirect transformations led to the division into the following types of qualitatively different transformations.

These transformations are divided into:
1) Chemical,
2) Geomechanical,
3) Hydrological.

4.1 Type of chemical transformation

Chemical transformation of soil is generally imperceptible in the soil profile – morphological changes are not noticed. The typical transformation phenomenon is the accumulation of component emitted by industry into the soil, which is responsible for changes in the properties of soil environment. The main cause of chemical transformation is the emission of pollutants into the atmosphere by industry, i.e. air pollution. Direct impacts include mine water discharges, use of chemicals in agriculture and mining. The degree to which air pollution affects the soil depends on the following factors. These factors include:
1) Mineralogical soil composition,
2) Mechanical soil composition,
3) Soil pH,
4) Type of humus,
5) Humus content,
6) Distance from source of emitted pollutants,
7) Amount of emitted pollutants.

The close proximity of an emitter results in the accumulation of one leading component and significant amounts of its associated components in the soil. This leads to the death of plants in the vicinity of emitters or the development of vegetation that is not disturbed by the component. The chemical composition of soil also changes depending on the type of emission. The soil can be acidified, alkalinised or salinised, and the proportion of heavy metals and other organic substances can increase.

Soil acidification is mainly related to SO_2 emissions to the atmosphere from power plants, chemical industry and metallurgical industry. The problem of SO_2 emission is related to power industry based on hard coal and brown coal. In the chemical transformation of soils, SO_2 plays a leading role along with fluorine compounds, nitrogen oxides, ammonia, chlorine, ozone and other combinations of sulphur. Sulfur dioxide from polluted air is removed by diffusion into the soil cover, leached by precipitation, and dry precipitation in the form of sulfates. To stop soil acidification, all forms of lime are used to fertilize the acidified soil.

Alkalization of soils is primarily influenced by dust from cement manufacturing and other chemical plants. Alkali dusts are emitted by ferrous and non-ferrous metallurgy. It follows that the greatest alkalization of soils occurs in close proximity to cement plants. Calcium and potassium are present in the dust emitted by these industries and are responsible for the impact on soils. To a lesser extent, the alkalization of soils is influenced by iron smelters, and the alkalization process can take 25 years.

The growth of heavy metals in the soil is influenced by non-ferrous metal smelters, ironworks, coke industry, power plants based on coal and brown coal. The accumulation of one leading component along with accompanying metals around emitters is the rule – it causes the death of plants in the vicinity of emitter. Most heavy metal pollution takes place through dust, and its spread is related to precipitation, which washes the dust away.

4.2 Type of geomechanical transformation

Construction of retention tanks, mining operations, dumps, landfills, geological works are responsible for geomechanical transformations. Transformations of the geomechanical type cause the complete elimination or mechanical damage to the soil. As indirect phenomena, the deformation of soils through the formation of funnels and fissures as well as the change of its structure can be mentioned. Through reclamation and appropriate management of post-mining areas, it is possible to restore the appearance and intended use of the landscape.

Reclamation is a series of activities aimed at restoring the natural landform and achieving the content of substances by the soil or the ground in accordance with recognized standards, in order to restore the degraded areas to their usable or natural values (Białecka & Biały, 2014)

4.3 Type of hydrological transformation

Dumps, settling pits and excavations are a type of geomechanical transformation that affect hydrology. They cause drainage or flooding of the area under mining operation or the area where mine waste is stored. Coal mines need water mainly for domestic purposes, but also for consumption, which also affects hydrology.

Industrial Districts face the problem of water withdrawal for industrial purposes. The mining operation disturbs the water veins by changing their course or drying them up, which depletes the water resources or changes their chemical composition. In the Ostrava-Karviná district, the areas that were created by the land subsidence are flooded. It is caused by the method of hard coal mining by caving, which causes the subsidence of rock mass and leads it nearer to the groundwater. Dumps that cause the ground to deflect can prevent further water flow, resulting in flooding of the area next to the dump. These transformations, leave significant changes in soil morphology. In order to eliminate the deformation, mining waste is most often used, backfilling the flooded or drained area to restore landscape and utility values (Strzyszcz, 1982).

5. CHARACTERISTICS OF THE ANALYZED AREA

The Ostrava is a city in the Czech Republic, located at the mouth of the Ostravice and Opava rivers on the Oder River. It is the capital of the Moravian-Silesian Region and the Ostrava City District. It is located 10 kilometers from the border with Poland. The highest point of the city is Krasne Pole (334 m above sea level) and the lowest point is Antosovice (208 m above sea level). The Ostrava is situated between two geological formations: Bohemian Massif and Western Carpathians. The region is made up of Quaternary rocks, while at greater depths there are formations from the Carboniferous period. The Ostrava area is highly industrialized despite the fact that coal mining has been decommissioned. There are still coal seams under the city, and a landscape of dumps prevails around the city. The main industries that have influenced the pollution of the city area are: metallurgy, mining, metal processing and chemical industry.

Samples for the study were taken in nine parks in Ostrava. They were collected from three depths using a drill, from places near trees and in open space. Places (parks), from which samples were collected, are located in different parts of the city, have been marked on the map and are shown in Figure 5. Distances of these parks from roads and sources of pollution are presented in Table 1.

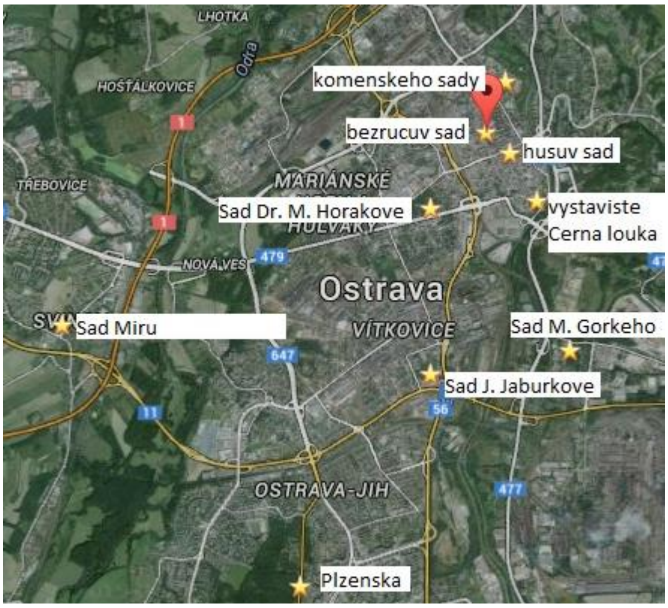

Fig. 5 Location of research sites in Ostrava

Source: Own study based on (google maps, 2021)

Table 1 Selected locations for research

Name of the park	Town district	Distance from possible sources of pollution	Possible major source of contamination
Bezrucuv sad	Morawska Ostrawa	Nadrazni str./0.025 km	Transportation
Husuv sad		Ceskobratrska str./0.027 km	Transportation
		Privozska str./0.03 km	
		Intersection of streets Ceskobratrska str. Privezska str./0.039 km	
		Metallurgical furnaces/2km	
Vystaviste Cerna louka		Frydecka str./0.2 km	Ironworks
		Metallurgical furnaces/1.8 km	
Sad M. Harakove		Varenska str./0.057 km	Historical contamination, metallurgical furnaces, transportation
		28 października str./0.273 km	
Komenskeho sady		River Ostravica/0.08 km	Transportation
		Bohuminska str.0.279 km	
		Metallurgical furnaces/2.8 km	
		Sadova str./0.088 km	
Plzenska	Hulvaky	Ironworks Witkowice/1.4 km	Metallurgical furnaces, transportation
		Metallurgical furnaces/1.5 km	
		Plzenska str./0.1 km	
Sad J. Jaburkove	Witkowice	Vystavni str./0.09 km	Historical contamination, metallurgical furnaces
		Metallurgical furnaces/0.8 km	
Sad Miru	Svinov	Nad Porubkou str./0.04 km	Power station Trebovice
		Power station Trebovice/2km	

Sad M. Gorkeho	Śląska Ostrawa	New steelworks ArcelorMittal/1.3 km	New steelworks
		Rudna str./0.671 km	
		Metallurgical furnaces/0.671 km	

Source: Own study

6. COMPARISON OF SOIL TEST RESULTS AT SELECTED LOCATIONS

In order to analyze the comparative results of this study, the concentrations of cadmium, copper, lead, and zinc, in milligrams per kilogram of soil, from two different cities with different soil pollution problems were compared. Samples were collected at different locations of publicly accessible parks, at different depths. The analysis will determine the impact of mining on Ostrava's soils at selected locations. The study was conducted by employees and graduate students of VSB-TU in Ostrava.

The law defining the maximum permissible concentrations of harmful elements was signed by the Minister of Environment on 29 December 1993 in the field of land protection, it has the number 13/1994 Sb. The content of maximum permissible concentrations of hazardous elements in soil, in milligrams per kilogram of soil, is presented in Table 2.

Table 2 Maximum allowable concentrations in milligrams per kilogram of soil

Maximum allowable concentration [$mg \cdot kg^{-1}$]		
Chemical element	Light soils	Other soils
As (Arsenic)	4.5	4.5
Be (Beryllium)	2.0	2.0
Cd (Cadmium)	0.4	1.0
Co (Cobalt)	10	25
Cr (Chrome)	40	40
Cu (Copper)	30	50
Hg (Mercury)	-	-
Mo (Molybdenum)	5	5
Ni (Nickel)	15	25
Pb (Lead)	50	70
V (Vanadium)	20	50
Zn (Zinc)	50	100

Source: (kr-karlovarsky)

Table 3 determines the amount of hazardous elements, in milligrams per kilogram of soil, in the Ostrava parks, depending on the depth and sampling location.

Table 3 The amount of hazardous elements in the soil of Ostrava parks, [$mg \cdot kg^{-1}$]

Location	Sampling depth (cm)	Open space				Shaded space (under trees)			
		Zn	Cd	Cu	Pb	Zn	Cd	Cu	Pb
Husuv Sad	0-10	76	1.0	20	47	109	1.2	28	60
	10-20	64	1.0	20	44	105	1.2	28	66
	20-30	79	1.0	25	55	127	1.3	34	63
Plzenska	0-10	43	0.9	19	47	64	0.9	31	49
	10-20	52	0.8	21	45	85	1.1	36	45
	20-30	50	0.7	22	41	125	1.1	55	60

Sad J. Jaburkove	0-10	38	0.9	13	34	104	1.6	32	83
	10-20	71	1.3	25	67	88	1.3	26	80
	20-30	77	1.5	31	82	47	0.8	17	52
Sad Miru	0-10	31	0.8	17	30	65	1.0	16	50
	10-20	28	0.9	15	27	58	1.0	17	74
	20-30	28	0.8	14	22	57	0.9	24	38
Sad M. Gorkeho	0-10	26	0.6	12	27	34	1.0	18	51
	10-20	27	0.9	15	26	27	0.8	17	48
	20-30	39	0.8	18	31	22	0.7	13	39
Bezrucuv Sad	0-10	86	0.9	16	34	76	0.9	21	38
	10-20	75	0.9	12	32	56	0.8	17	55
	20-30	107	0.9	11	29	64	0.9	21	35
Cerna louka	0-10	61	1.0	21	39	74	1.1	18	41
	10-20	55	0.9	20	33	53	1.0	15	35
	20-30	53	0.8	14	27	44	0.8	13	28
Sad M. Horakove	0-10	332	1.7	92	85	568	2.8	118	109
	10-20	391	1.8	95	78	631	2.7	53	112
	20-30	639	2.3	145	114	325	1.6	43	69
Komenskeho Sady	0-10	87	0.9	24	57	195	1.6	38	86
	10-20	102	1.1	26	63	119	1.3	26	55
	20-30	173	1.2	33	85	114	1.2	29	62
Average		107	1.0	30	48	127	1.2	30	59
Median		64	0.9	20	41	76	1.1	26	55
Standard 13/1994 Sb.		100	1.0	50	70				

Source: Own study based on (Galuskova, 2010)

Table 4 shows the statistical results of the amount of hazardous elements in soils, in the parks in Ostrava and Prague, at selected depths.

Table 4 The amount of hazardous elements in the parks of Ostrava depending on the depth of sampling [mg·kg^{-1}]

The depths of the samples taken from the soil [cm]	Statistics	Ostrava			
		Zn	Cd	Cu	Pb
0-10	Minimum	26	0.6	12	27
	Maximum	568	2.8	118	109
	Average	115	1.2	31	54
	Median	75	1	21	48
10-20	Minimum	27	0.8	12	26
	Maximum	631	2.7	95	112
	Average	116	1.2	27	55
	Median	68	1.0	21	52
20-30	Minimum	22	0.7	11	22
	Maximum	639	2.3	145	114
	Average	121	1.1	31	52
	Median	71	0.9	23	47

Table 5 shows the results of measurements in the area with high concentration of trees and in open space.

Table 5 Statistics of the amount of hazardous elements in the parks of Ostrava divided between open space and with a high concentration of trees [mg·kg^{-1}]

	Place of sampling	Statistics	Zn	Cd	Cu	Pb
Ostrava	Open area	Minimum	26	0.6	11	22
		Maximum	639	2.3	145	114
		Average	107	1.1	30	48
		Median	64	0.9	20	41
	Shaded space (under trees)	Minimum	22	0.7	13	28
		Maximum	631	2.8	118	112
		Average	127	1.2	30	59
		Median	76	1.1	26	55

Based on the obtained results, it can be concluded that the quality of soils in Ostrava deviates quite significantly from the permissible values. The given maximum values for Ostrava are multiple exceedances of soil quality standards. The values obtained as an average of all results are higher for zinc, cadmium and copper.

7. RESULTS ANALYSIS

The analysis of results regarding pollution of soils in parks of Ostrava in some cases can be difficult due to surface reclamation of some parks. The top layer of soil could have been piled up on the ground for investments in park infrastructure such as benches, playgrounds, sidewalks. In addition, it could also have been piled up for better and faster growth of grasses, shrubs and planted trees. The samples often contained fractions not associated with soil such as construction materials, which were removed from the samples. However, the sampling method was not based exclusively on examining the topsoil. Samples were taken from depths of 0-10 cm, 10-20 cm, and 20-30 cm.

In the case of samples collected in Ostrava, the limits for hazardous substances specified in the Act 13/1994 Sb were significantly exceeded in two parks – these are M. Horakove and Komenskeho Parks.

For M. Horakove Park the standards for concentration of hazardous elements were exceeded several times at all depths of taken samples. For zinc the standard was exceeded 6 times and amounts to 639 [mg · kg^{-1}] at the depth of 20-30 cm in the place not shaded by trees and 631 [mg · kg^{-1}] at the depth of 10-20 cm in the place shaded by trees. The remaining results of zinc concentration in the soil, are also characterized by significant exceedance of the standards in soils. The lowest value of zinc concentration was obtained at the site shaded by trees at the depth of 20-30 cm. It amounted to 325 [mg · kg^{-1}] and exceeded the standard three times.

Cadmium content was exceeded in the park at all depths of the samples taken. The lowest value was found at the depth of 20-30 cm in the place under the trees and it was 1.6. The highest value was found at the same place at the depth of 0-10 cm and it was 2.8 which is almost three times exceeding the standard.

In the case of copper, the standard was not exceeded only at the site under trees at the depth of 20-30 cm and it was 43 [mg · kg^{-1}], in relation to the standard of 50 [mg · kg^{-1}]. The highest value of copper was reached in the open space at the depth of 20-30 cm, it reached 145 [mg · kg^{-1}]. The concentration of dangerous element lead was also exceeded for this park and reached the highest concentration of 114 [mg · kg^{-1}] in the open space at the depth of 20-30 cm. The reason for such high exceeded standards is the historical pollution in this area of Ostrava. The Karolina coking plant, the largest emitter of pollutants at that time, operated in the vicinity of park until 1985. As a result of land reclamation from the former coking plant, the Forum Nova Karolina shopping center was built, which resulted in the development of a road network and increased traffic in the area.

In the case of Komenskeho Park, the standards were exceeded for zinc and cadmium at most depths of collected samples. The highest concentration of zinc in soil is 173 [mg · kg^{-1}] for a depth of 20-30 in the open area and is almost twice the standard exceeded. The highest exceedance of standards for cadmium was found in sheltered areas in the topsoil. The main reason for the exceedance of standards is the environmental impact of transportation. Roads with extremely heavy traffic pass through the area. In other parks of Ostrava single exceedances of standards were found, but they are not as distinct as in Komenskeho and M. Horakove parks. The exceedances of zinc and lead standards are related to industrial production, mainly heavy industry.

8. CONCLUSION

Coal mining, processing, is associated with a number of adverse environmental factors. Soil pollution is a problem of large cities with industrial character. Ostrava, as a city with a high industrial index, has soils with sufficient chemical state. The mining dumps surrounding the city emit high concentrations of dust pollutants entering the atmosphere. The dumps and settling pits significantly affect the condition of soils and waters by deteriorating their condition. Soil examinations in parks prove high contamination with elements harmful to animal and human health, but also negatively influence the growth of vegetation in the city. The soil in M. Horakove Park, which is located on the site of a former coking plant, is one of the most contaminated of all investigated soils. Although the coking plant ceased operation in 1985, the soil continues to suffer from the negative effects of its activities. Despite the fact that 30 years have passed since the plant was shut down, the standard for zinc was exceeded 6 times, and for copper almost 3 times. This shows that soil is not a component of the biosphere that can be easily reclaimed, and sometimes reclamation is impossible. The results of soil testing in parks of Ostrava are characterized by high levels of fluctuation, depending on the park location and the operating emitter of harmful substances in the surroundings. The average values for all parks are not alarming. Standards for zinc were exceeded in places of open space and in places with a high concentration of trees. The results analysis shows the efforts of the city of Ostrava to change its image from that of an industrial city to a more citizen-friendly city. The mine decommissioning in the Ostrava region has improved the condition of soils in the city, and the results are not catastrophic. The reclamation activities that have been carried out in the area contribute to changing the city's character and create an image of Ostrava as a city open to new investments.

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