DELIVERABLE D.T3.1.1

Assessment of the technical and environmental status of the brownfield site

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INTRODUCTION

Industry in the Silesian Voivodeship has a significant impact upon the environment as well as affecting the living conditions of the population. High emissions lead to the accumulation of contamination and this can have an adverse effect upon human health. On the other hand the area is attractive in many ways. For example, there are high employment possibilities and the standard of living is relatively better when compared to many other regions in Poland. It is thus important to determine the degree of risk caused by industry for the people living in the area.

The environmental impact of dumping site Ruda Śląska is complicated for various reasons. Its influence on surrounding areas results from activities over the last hundred years. Present-day emissions are of a lesser order of magnitude than those found a few years ago and for practical purposes can be compared to the background levels existing in the Upper Silesia Industrial Region (the main area of the Voivodeship). There is now a chance to start remedial measures to combat the damages caused through the years. Without taking into account the financial implications of such actions for the moment, this Report collates existing data which will be helpful in understanding the local situation. The aim is for this data to be used for remediation concept which can be determined in LUMAT project.

1. SCOPE OF WORK FOR THIS REPORT

The scope of work includes a review of existing data concerning the Ruda Śląska dumping site as well as the data which might be needed for remediation plan for this site.

The analysed data consists of:

- Historical data available,
- Actual survey based on: ground pH, electrical conductivity, Pb, Cd, Zn total concentration and bioavailable fraction, assessment of the thickness of the layer suitable for plant growth and determination of types of vegetation across the dumping site.

2. SITE DESCRIPTION AND CHARACTERISATION BASED ON HISTORICAL DATA AVAILABLE

The site was used as a dumping place for wastes from zinc smelter owned by Liebe – Hoffnung company whose operation in Ruda Śląska was terminated and the smelter was closed down in 1925. Topographical map of the site from 1901 year is presented in Figure 1. The company does not exist as well. After the World War II as a result of nationalization the site was owned by the municipality (entailed by the State Treasury).

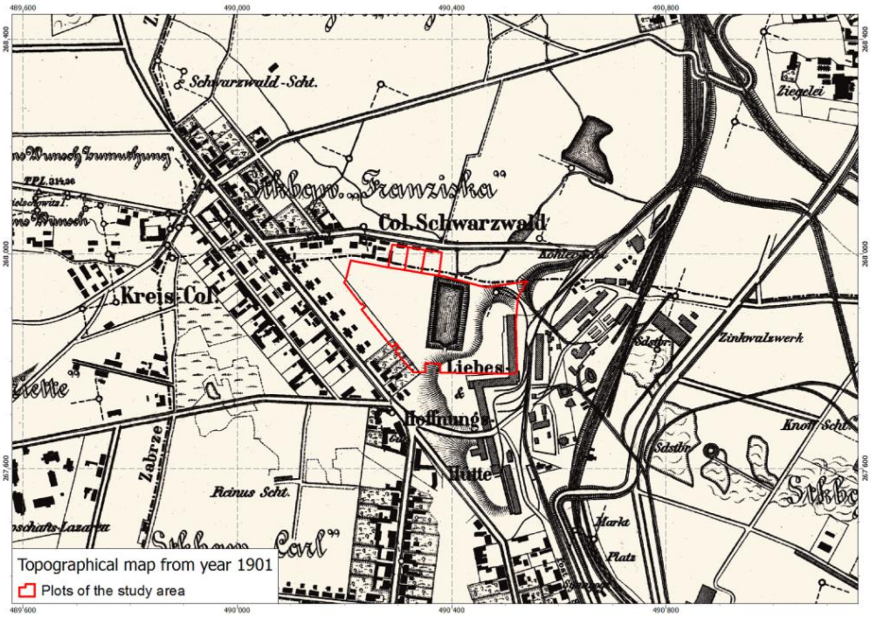

Figure 1. Topographical map of the site from the year 1901. Source: State archive, ORSIP.

Therefore the polluter pays principle is solved by taking the responsibility by the city. In 2009 investigations on the level of contamination have showed increased level of heavy metals. In 70-ties reclamation activities have been already implemented to cover the area with a soil layer 1 m thick. As the preparatory work of the investment the ground examinations will be made to assess the present exposure to environmental hazards. There is a risk associated with no go decision as the investment will minimize the possible negative impact of heavy metals therefore the risk will be minimized by remediation actions implemented in the investment framework.

The brownfield site located in the peri-urban northern part of the Wirek district covers the area of 6.5 ha. It is an anthropogenic elevation constructed from wastes reaching the height of maximum 293 m.a.s.l. and became one landmark in the area. The site is surrounded by dwelling houses, garages, workshops and a school building and on the east there is an underground coal mine (Figure 2).

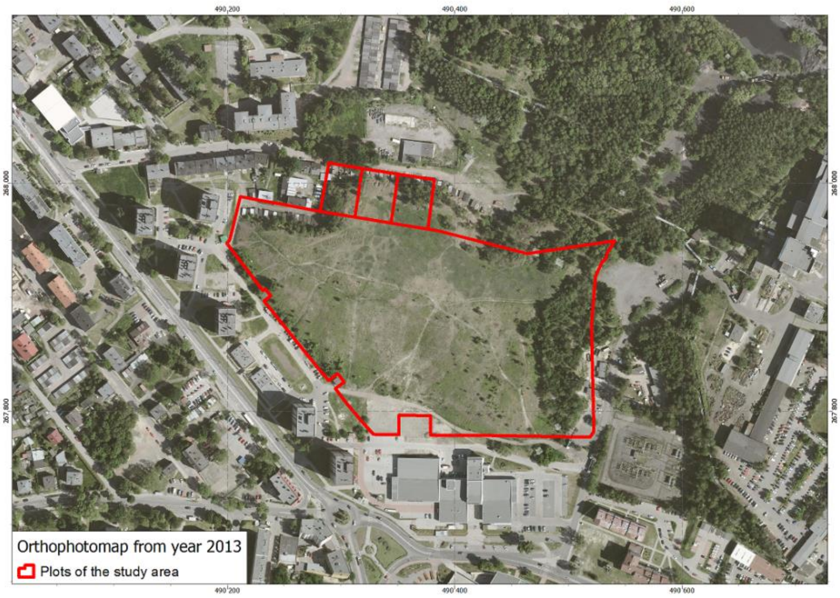

Figure 2. Ortophotomap of the site from the year 2013.

The central and southern part of the brownfield was re-cultivated in the past. Area of the brownfield is covered by grasses; in the north-western part trees are presented. Southern and western part of the brownfield is slightly sloped. Eastern part flattens along technical road of “Pokój” Coalmine, while northern slope of the brownfield is steep, some places vertical and additionally in the bottom of the slope tin garages are located. The top of the brownfield is flat.

On the quaternary background, zinc processing wastes have been deposited, forming a heap with a thickness of about 20 m. Thickness of the heap was specified indicatively, based on the interpretation of the deposition of Quaternary sediments. Material deposited on the heap is a slag from distillation furnaces, operating at the turn of the XIX and XX century. Slag is a mixture of sinter slag, enamel, coke cinders and brick rubbles. Most of the wastes are in the non-cohesive form, brown-red colour, fractions from sand to gravels. In some places post mining wastes (slates and silts) are presented.

According to Decision of the Ministry of Environment concerning wastes classification (Dz.U. from 29.12.2014, poz. 1923) and the genesis of the wastes, material deposited on the brownfield was classified with code 10 05 01 - slags from primary and secondary production (except 10 05 80). Unfortunately, deposited slags were created using different technologies than nowadays, that is why it is hard to classify them using current regulations.

The analysis of the heavy metal presence in the ground show high concentration of lead, cadmium, zinc and arsenic (Figure 3). Concentrations of these elements were several times above the set limits, i.e. zinc concentrations were found 270-fold above limits for postindustrial areas, while led was found 100-fold above mentioned standards. Analyzing the vertical and horizontal changes in heavy metal concentration in the ground there are a lack of regularity, which could be caused by differences of deposit time and used depositing technology across the heap creation.

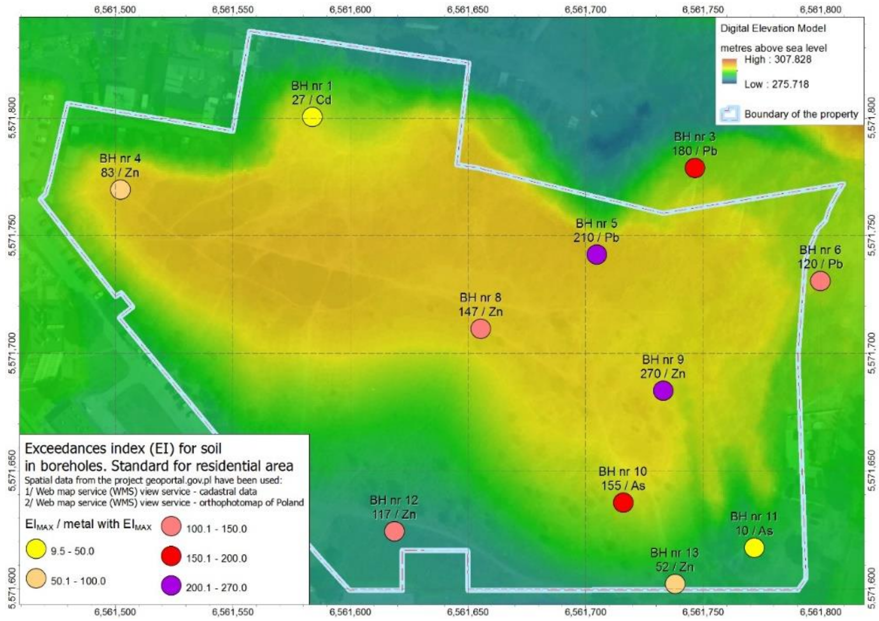

Figure 3. Map of exceedances index for soil sampling in boreholes.

Additionally, content of Pb and Zn was analyzed from metal recovery point of view. It was found that total content of Zn vary from 0.28 to 8.1 % (mean 2.9 %) while for Pb from 0.06 to 2.1 % (mean 0.68 %). Results show clearly, that lead and zinc recovery from the heap are not economically feasible.

3. SITE CHARACTERISTICS BASED ON THE DATA COLLECTED AND ANALYZED IN 2016

3.1. Sampling network

Sampling network was designed as regular triangular network (Figure 4). The aim of such sampling pattern was to minimize the area of circles located between sampling points. The sampling network covers the area of the waste dump and not covered by the wooded area. From many patterns the one with the circle having radius 20m has been selected.

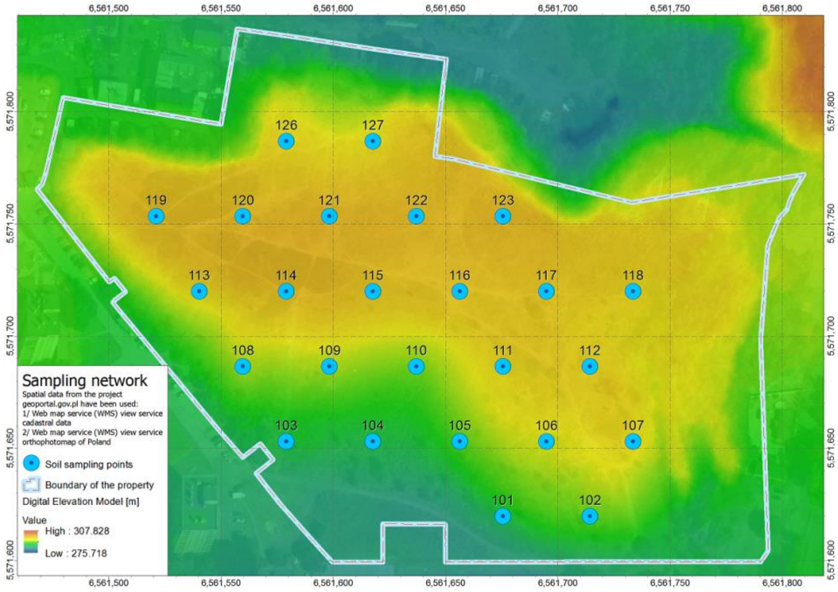

Figure 4. General view of sampling network.

3.2. Soil thickness

Previous studies described that in the 2nd half of XX century the brownfield was revitalized, by covering the wastes with soil layer (of unknown origination). Current surveys determined the soil layer thickness across the heap. Differences were found (Figure 5), the thickness of soil layer varied from 3 to 30 cm, depending on sampling points and heap slope. The most of the heap surface is covered by soil layer of thickness about 15-25 cm, what may indicate that this area was revitalized in the past, or the layer was created by decomposition of plants grown on the surface.

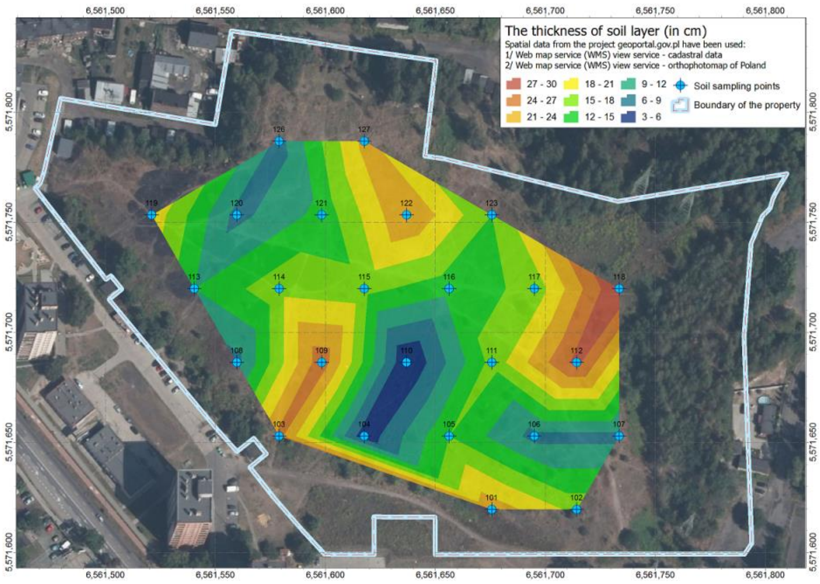

Figure 5. General view of the thickness of the soil layer.

3.3. Soil pH

Differences of top level soil pH were determined and presented on the Figure 6. Soil pH ranged from 5.27 to 7.70, from acidic to slightly alkaline. Acidic soil pH was found in the northern part of the brownfield, while neutral or alkaline pH was determined in the southern part. In acidic conditions metals mobility might raise, based on that higher metal bioavailability is expected on that part of the brownfield. It should be confirmed by analyzing total ad bioavailable concentration of lead, cadmium and zinc.

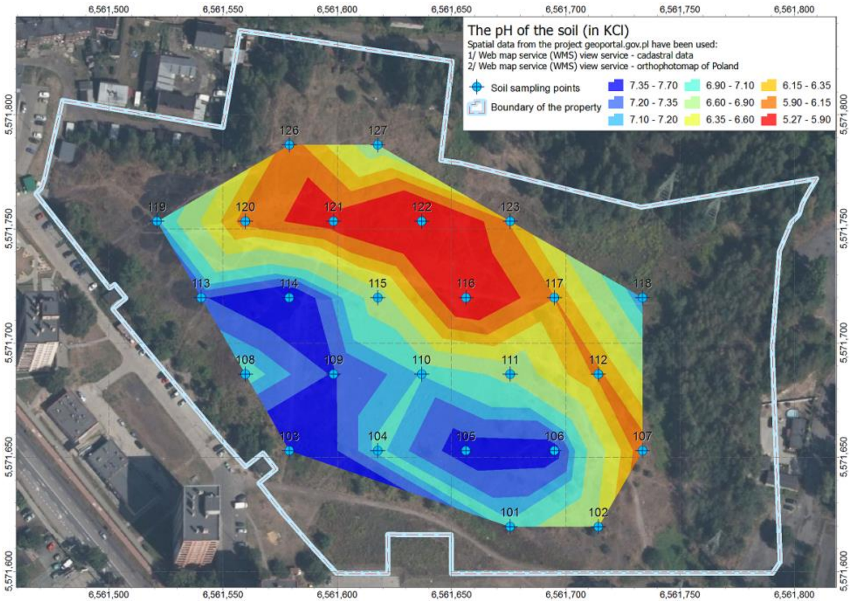

Figure 6. Differences in the soil pH on the brownfield.

3.4. Soil electrical conductivity

As in case of soil pH, soil surface layer electrical conductivity varied across the heap, from 116 to over 2000 μS/cm (Figure 7). The highest values of EC was found at the bottom of the heap, what could be explained by runoff of the mineral salts and organic matter, especially form places with less compacted plant cover.

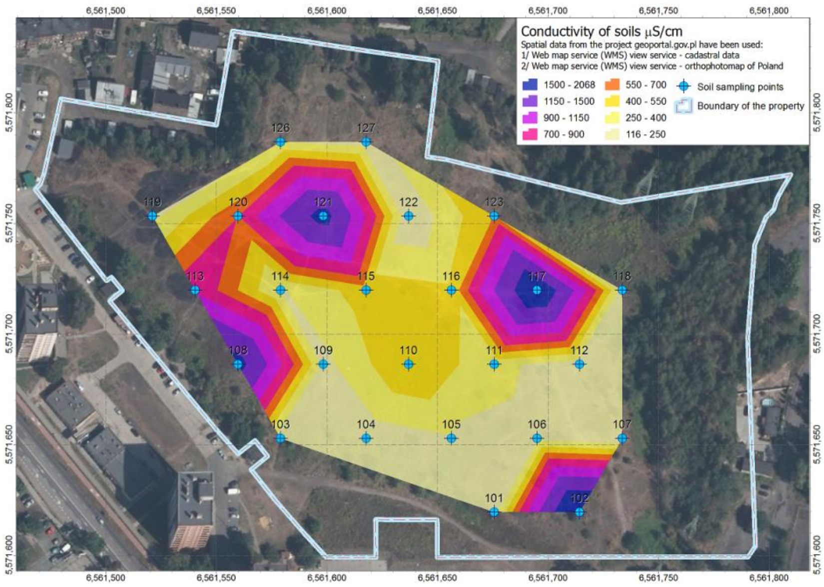

Figure 7. Map of the soil EC

3.5. Total metal concentration in the top layer of the brownfield

In Poland limit values of heavy metals content in the gorund and soil is regulated by the Decission of Ministry of Environmnet (Dz.U. 2002. nr.165 poz.1369) depending on the land use type (Table 1). The regulation defined three groups of areas based on their actual an future use: (i) Group A – lands under water law and nature protection; (ii) Group B – arable land; (iii) Group C – industrial and postindustrial areas.

Table 1. Limit values of Pb, Cd and Zn content based on the regulation of Ministry of Environment on soil and ground quality standards

Metal (mg/kg d.w.- dry weight)	Group A	Group B					Group C		
		Depth (m bgl)							
		0-0.3	0.3-15		>15		0-2	2-15	
			Water permability of soil(m/s)						
			to	below	to	below		to	below
			1×10^{-7}		1×10^{-7}			1×10^{-7}	
Lead	50	100	100	200	100	200	600	200	1000
Cadmium	1	4	5	6	4	10	15	6	20
Zinc	100	300	350	300	300	720	1000	300	3000

Total lead concentration in the depth (0-20 cm) was presented on the Figure 8. Lead content exceed limit value for group C (industrial areas, permitted value 600 mg/kg d.w. – dry weight) from 2 to 38-times. Only a smart part of the brownfield (navy blue on the map, content of Pb between 153-300 mg/kg d.w.) not exceed limit value for such areas. The highest content of this metal was found in the North-West part of the cheap.

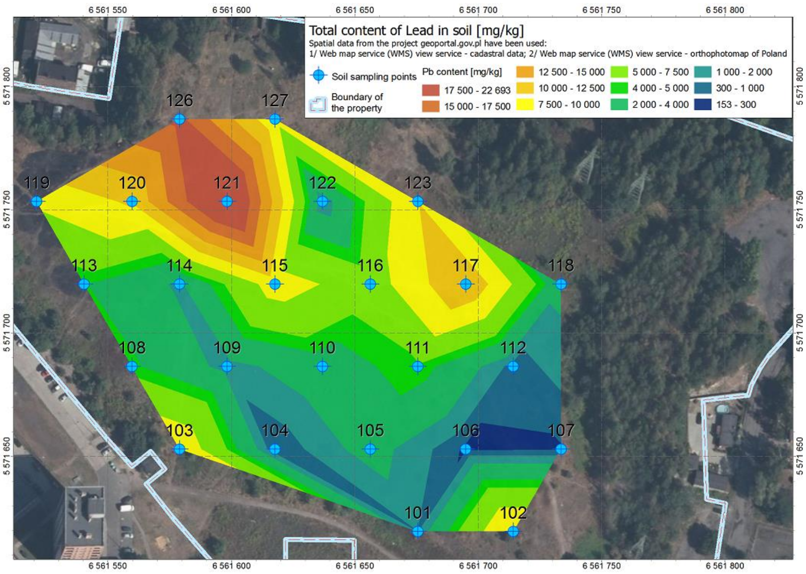

Figure 8. Total Pb concentration in soil layer on the brownfield.

Total cadmium concentration in the depth (0-20 cm) was presented on the Figure 9. Cadmium content exceed limit value for group C (industrial areas, permitted value 15 mg/kg d.w.) from 1.5- to 11-times. 30% of total area of the brownfield was below permitted value for cadmium (for navy blue to blue part of the map, central part of the cheap), while the highest content of this metal was found in the North-West and North- East parts of the cheap.

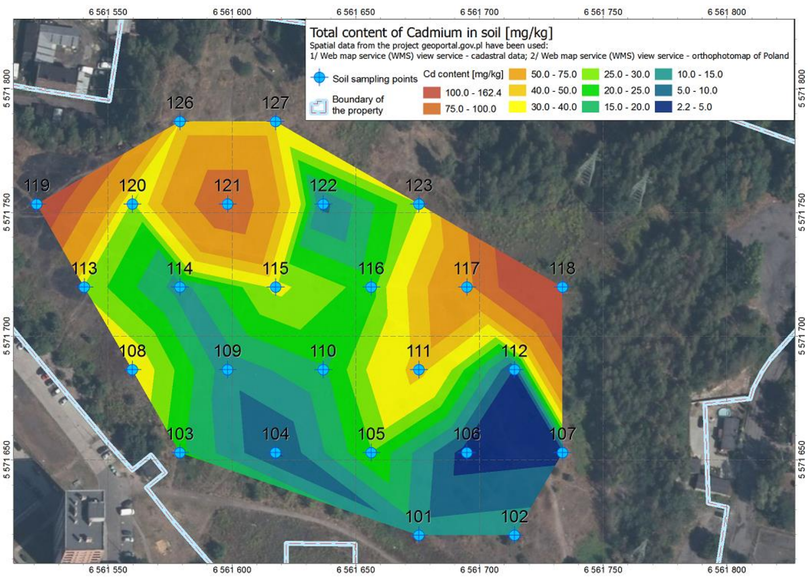

Figure 9. Total Cd concentration in soil layer on the brownfield.

Total zinc concentration in the depth (0-20 cm) was presented on the Figure 10. Zinc content exceed limit value for group C (industrial areas, permitted value 1000 mg/kg d.w.) from 1- to 40-times. Like lead also zinc not exceed limit value on the same part of the brownfield (navy blue on the map, content of Zn between 656-1000 mg/kg d.w.) The highest content of this metal was found in the North-West part of the cheap.

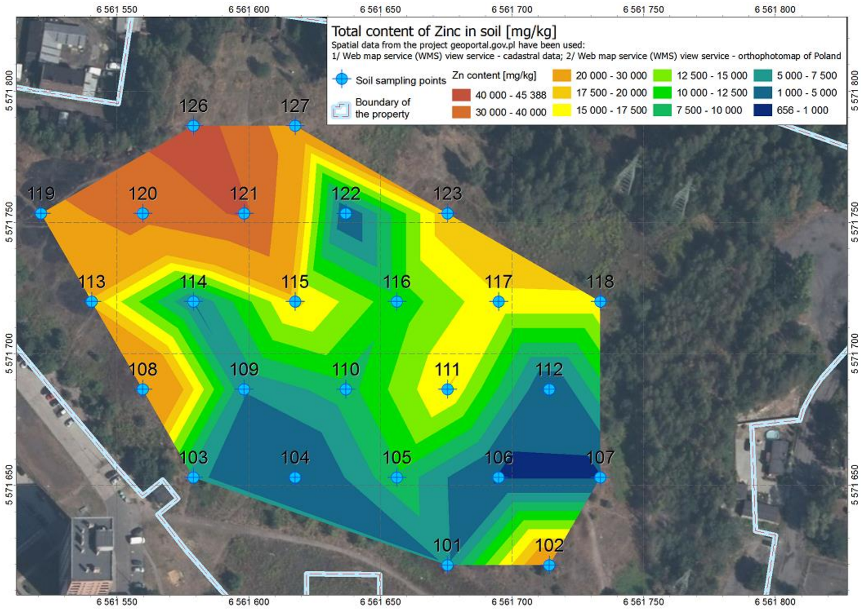

Figure 10. Total Zn concentration in soil layer on the brownfield

3.6. Bioavailable metal concentration in the top layer of the brownfield

There are not applicable regulations in Poland concerning bioavailable fraction of heavy metals in grounds and soils. But the bioavailability of contaminants is the main factor influencing the health for all living organisms due to its high mobility. Also based on bioavailability of the metals remediation activities could be planned.

Bioavailable lead concentration (mg/kg d.w.) in the depth (0-20 cm) was presented on the Figure 11. It was found that bioavailable fraction of Pb represents from 0.01 to 0.3% of total lead concentration. Also the area with highest lead bioavailability was comparable with the highest total concentration of the metal (Figure 8). So due to the very low lead bioavailability the main attention during remediation activities should be addressed to the North-West part of the brownfield.

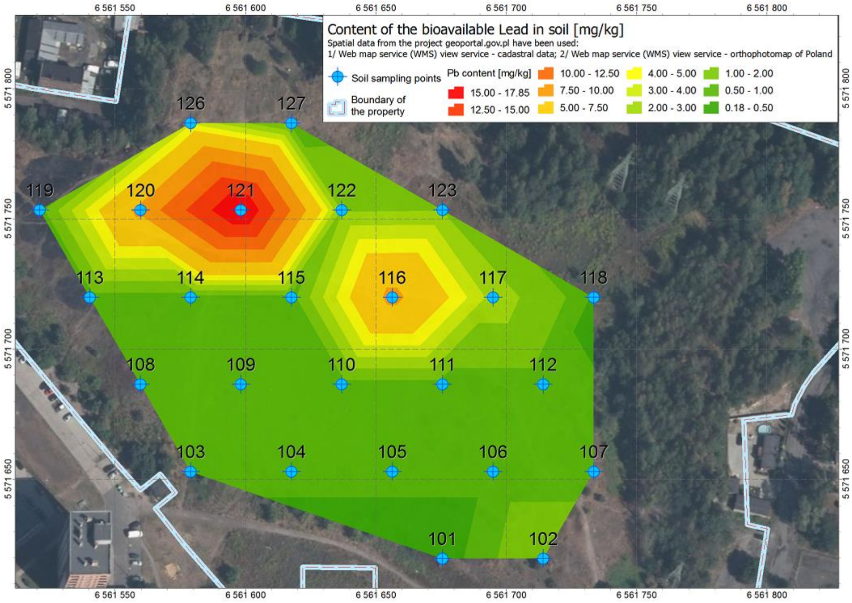

Figure 11. Content of bioavailable Pb in the brownfield top soil layer

Bioavailable cadmium concentration (mg/kg d.w.) in the depth (0-20 cm) was presented on the Figure 12. It was found that bioavailable fraction of Cd represents from 0.14 to 14% of total cadmium concentration. This high bioavailability of Cd (in some part of the brownfield) means that special attention should be paid to diminish the mobility of that contaminants base on stabilization process. It was also assessed that area with highest cadmium bioavailability was comparable with the highest total concentration of this metal (Figure 9).

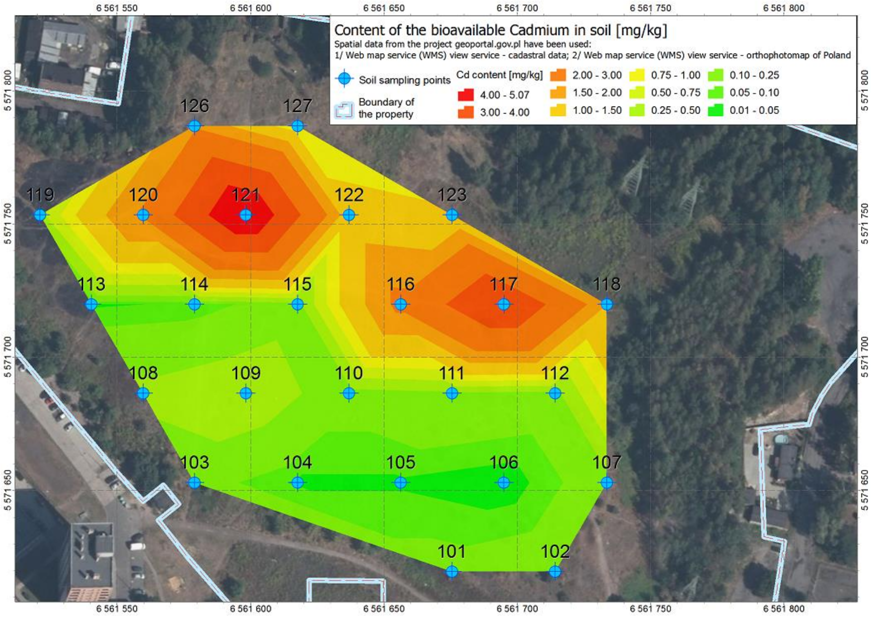

Figure 12. Content of bioavailable Cd in the brownfield top soil layer.

Bioavailable zinc concentration (mg/kg d.w.) in the depth (0-20 cm) was presented on the Figure 13. It was found that bioavailable fraction of Zn represents from 0.01 to 3%

of total zinc concentration. As in case of lead and cadmium, the same trend was found for zinc -area with highest zinc bioavailability was comparable with the highest total concentration of this metal (Figure 10). This moderate bioavailability of Zn (in some part of the brownfield) means that special attention should be paid to diminish the mobility of that contaminants base on stabilization process during remediation activities.

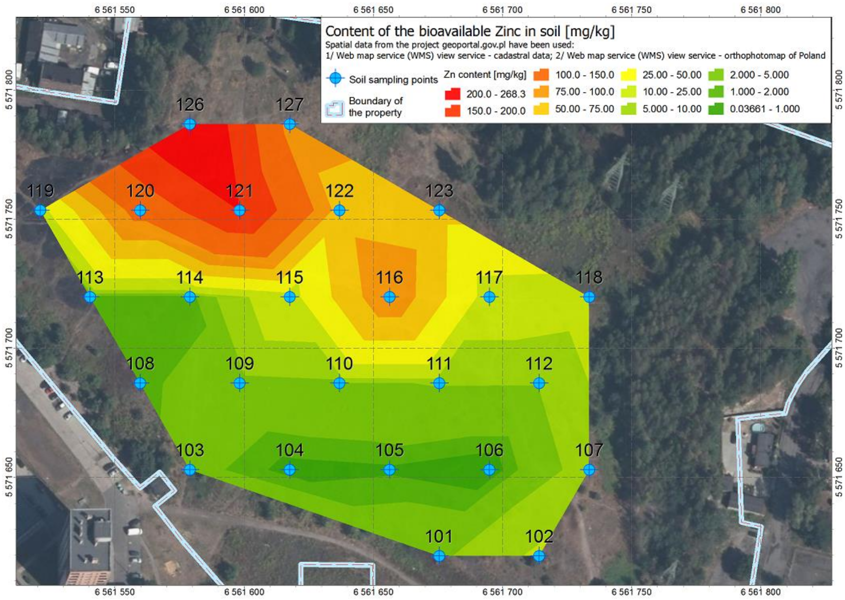

Figure 13. Content of bioavailable Zn in the brownfield top soil layer

3.7. Plant cover including plant dominants and metallophytes presence

Surface of the heap is covered by grassy vegetation; in the northern-west part some trees are presented (mainly *Betula pendula, Pinus sylvestris*). Dominant plant species were determined based on the survey in the vicinity of sampling points. Among the determined plant species the most frequent were: *Soildago canadensis* and *Calamagrostis epigeios* in the central and southern part of the heap (Figure 14). Presence of the plant species associated with soil heavy metal contamination was also found. The determined plant species as *Silene vulgaris* and *Cardaminopsis arenosa* (metallophytes) may indicate presence of high levels of the heavy metals in the top soil layers, what is also in accordance with the results of soil pH (low soil pH - possible increased of metals bioavailability - presence of metallophytes).

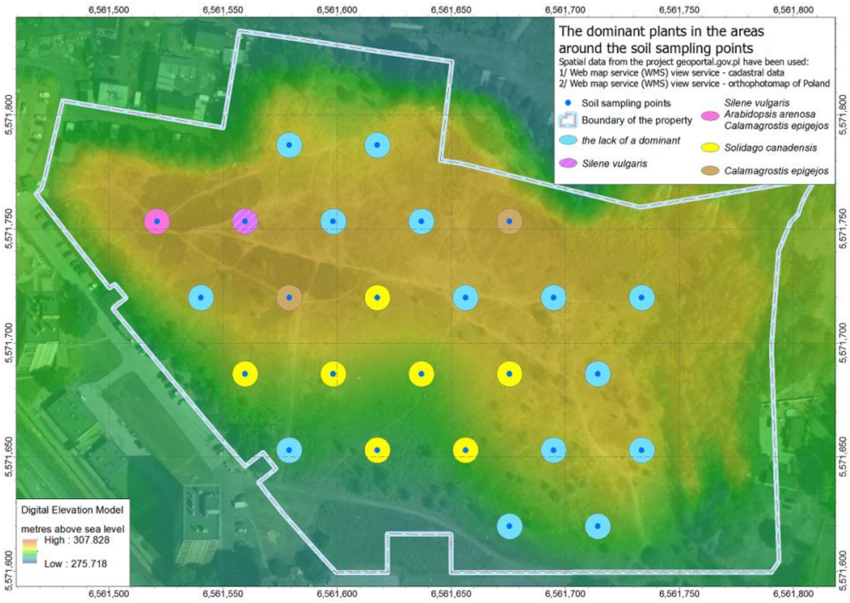

Figure 14. Presence of the plants species on the brownfield.

4. CONCLUSIONS

The environmental impact of dumping site Ruda Śląska is complicated for various reasons. Its influence on surrounding areas results from activities over the last hundred years. Previous studies described that in the 2nd half of XX century the brownfield was revitalized, by covering the wastes with soil layer (of unknown origination). Current studies confirmed that soil and ground of the heap is heavily contaminated with cadmium, lead and zinc, especially in northern and northern-west part. Surface of the heap is covered by grassy vegetation; in the northern-west part some trees are presented. Metallophytes species found at the heap also confirmed heavy metal contamination. Future remediation activities should be focused on metal immobilization, especially cadmium and zinc and replacing current vegetation by grass species which cumulates contaminants in root zone, with limited uptake to above ground parts.

5. LITERATURE

CBP projekt, 2009. Wykonanie geodezyjnego określenia objętości masy hałd pocynkowych, badań geotechnicznych, planu rozbiórki i wyceny wartości materiału odzyskiwanego z tych hałd - hałda ul. 1-go Maja, ul. Czarnoleśna - Ruda Śląska Wirek

Dz.U. 2002. nr.165 poz.1369 – Regulation of the Polish Ministry of Environment on Soil and Ground Standards (in Polish)

Decision of Ministry f the Environment (2014) on wastes classification (in Polish)