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The activity has been implemented within the framework of national project
***Information and providing advice on improving the quality of environment in Slovakia**.*
The project is cofinanced by Cohesion Fund of the EU under Operational programme Quality of Environment.

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Historical and Contemporary Soil Pollution in the City of Zielona Góra (Poland)

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SCIENTIFIC BACKGROUND

In the 21st century, it can be observed a constant growth of cities, both in terms of their total area and the number of inhabitants. At the end of 2014, approximately **54%** of the world's population and **73%** of the European population are urban dwellers. According to forecasts, in 2050 these indices will reach **66%** and **82%**, respectively (UN 2015). Today, urban areas cover ca. **6%** of the total area of the European continent, and this value increases every 5 years by **0.34-0.50%** (UN 2011). Therefore, it is of particular interest to recognize changes caused in urbanosphere by human impact.

SCIENTIFIC BACKGROUND

An important part of discussion about the urban soils has been their **chemical state**. Many chemical changes have been indicated by scientists as a result of **multi-factorial transformation**, including the presence of different **waste materials** (Greinert et al. 2013, Hulisz et al. 2018). The results obtained from research on soils and land in the urban area of the town of Zielona Góra support this thesis (Pickett and Cadenasso 2009, Greinert et al. 2013, Greinert 2015).

The most common anthropogenic materials in urban soils are: building debris, slags, dusts and ashes, translocated rock material, communal wastes, sludges, subgrades and mulches. The most commonly described artefacts in Technosols are widespread admixtures of building materials, wastes and waste building materials produced as a result of mass demolition of buildings (Wessolek et al. 2011, Nehls et al. 2013).

SCIENTIFIC BACKGROUND

The recognition of the geochemism of urban soils is especially important due to the possibility of **direct impact of pollutants on people** and other organisms (Irvine and Perrelli 2009, Pfeiderer et al. 2012, Charzyński et al. 2013).

A common phenomenon in the industrial and communication areas is **accumulation of salt** in the soil. Despite this, in the most of urban areas, a relative low EC (below 1 $mS \cdot cm^{-1}$) is a typical value (Linde et al. 2001, Madrid et al. 2002, Ruiz-Cortes et al. 2005). The local higher EC values (above 2 $mS \cdot cm^{-1}$) have been reported in soils occurring near the roads, chemical plants and in the waste disposals.

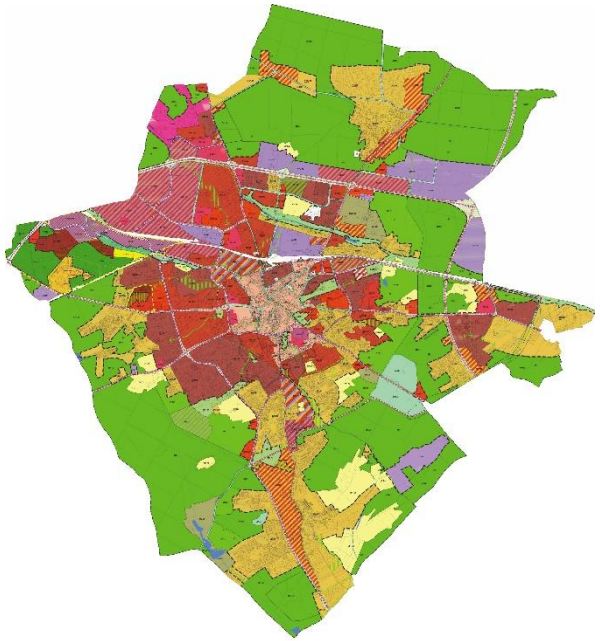
The soils of urban areas can be characterised also by a **high content of heavy metals**, the main sources of which are industrial wastes, vehicle emissions and coal burning plants (Manta et al. 2003). Most of the research results show a relatively low bioavailability of heavy metals in the soils of urban areas (Madrid et al. 2002, Yang et al. 2006, Tack 2010).

SITE DESCRIPTION AND METHODS

Zielona Góra is a medium-size town inhabited by about **140 thousand residents**, located in the western part of Poland (51°56'07"N, 15°30'13"E). Until the mid-nineteenth century, the small town was surrounded by cultivated fields, gardens and vineyards. Then the character and appearance of the town have changed. Intensive industrialization processes have taken place in the 19th century and early 20th. After the political transformation of Poland, Zielona Gora lost its industrial character, becoming a town with mainly tertiary economy.

Explanation:

- study soil profiles
- city center
- developed area
- main roads
- railway
- stream
- parks and allotment gardens
- administrative boundaries of Zielona Góra
- Zielona Góra before 1870
- city expansion 1870-1918
- city expansion 1919-1945



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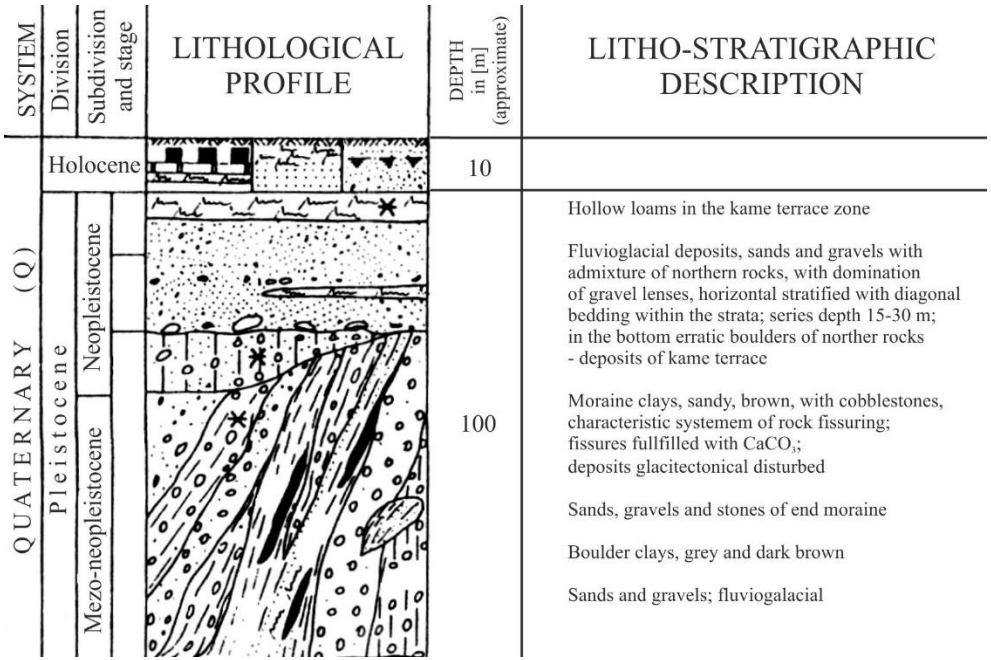
SITE DESCRIPTION AND METHODS

Most of geological materials building superficial layers of the Zielona Góra locality are medium and coarse sands of glacial and water origin, gravels and in some areas silts and clays within glacitectonically disturbed moraine structures. In the close surroundings of Zielona Góra the presence of **Podzols** and **Brunic Arenosols** is a typical phenomenon. In smaller areas, the presence of **Luvisols**, **Albeluvisols**, **Gleysols** and **Phaeozems** has been noted. As a result of multilateral human pressure, in the area of Zielona Góra the presence of **Anthrosols**, **Regosols** and **Technosols** is noted (IUSS WG WRB 2015).



SITE DESCRIPTION AND METHODS

The researches were carried out in the town of Zielona Góra. In total 200 soil profiles at the depth of 150 cm (samples from each of the morphological layers or genetic horizons) + 60 collective surface samples (an area of approximately 20 m^2 each, samples from humus horizons).

- Particle size distribution was determined for the parts above 2 mm and the sand particles by sieving and for silt and clay particles using the hydrometer method and described following the PSSS classsification (2009).
- pH was determined in 0.01 M $CaCl_2$ potentiometrically with a glass electrode WTW SenTix 41 in the 1:2.5 soil : supernatant suspension.
- The content of heavy metals in the soil samples from the beginning of 21ºC. was determined by means of atomic absorption FAAS (Varian analyser) and the newer ones using ICP-OES technique (Perkin Elmer analyser). Extracts in aqua regia ($3HCl:HNO_3$) were made acc. to ISO 11466, extracts in 0.1M HCl – the fraction potentially available to plants acc. to Baker and Amacher (1982).

RESULTS

Particle-size composition of Zielona Góra soils clearly shows the domination of the sand fraction. An average content of separated fractions from all of the investigated profiles should be shown as follows:

- skeleton **23.5%**
- particles < 2 mm 76.5%

including:

- 2 mm – 50 μm 81.2%
- 50-2 μm 17.8%
- < 2 μm 1.0%

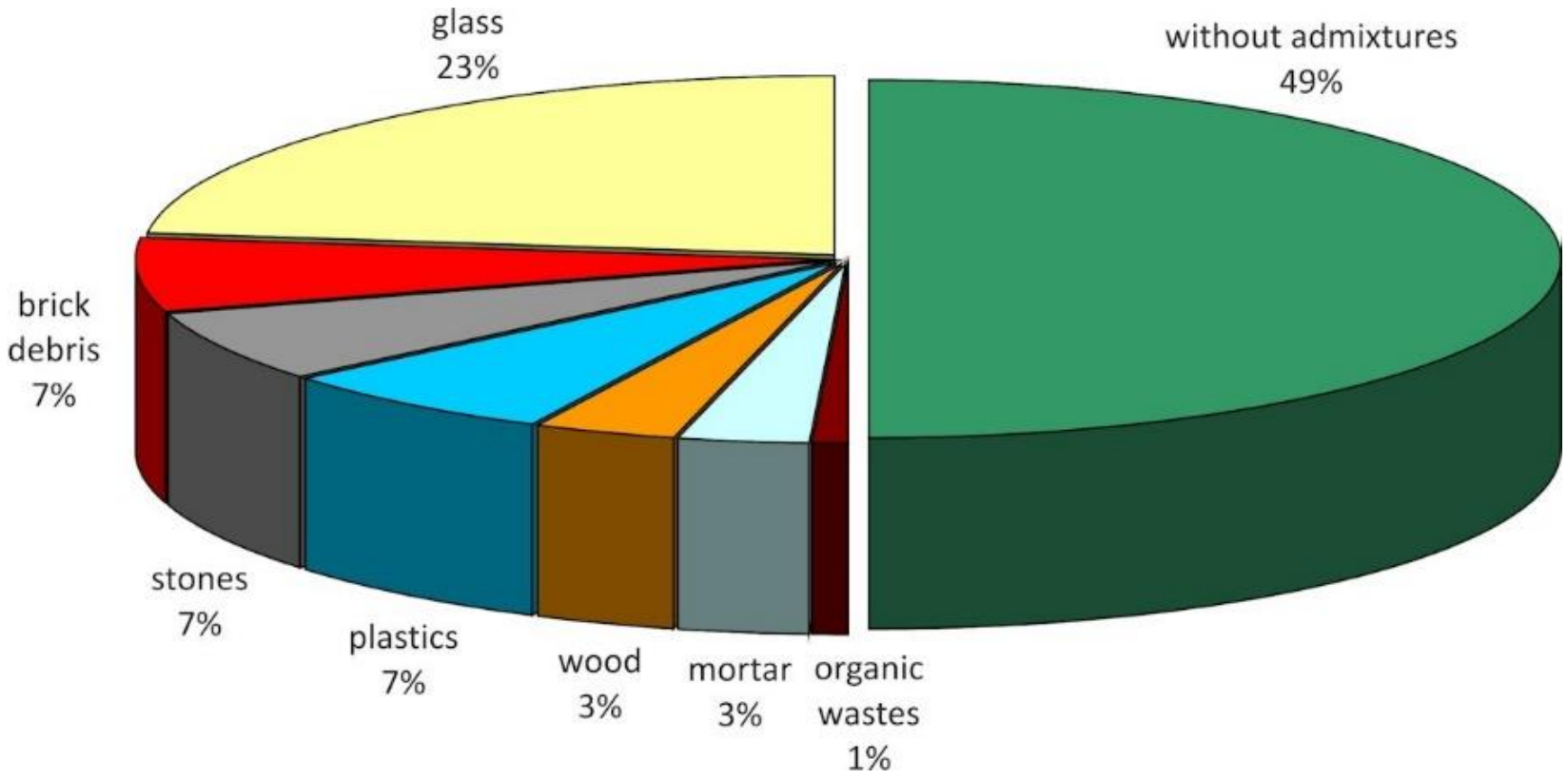
The analysis of the surface layers of the studied soils showed that merely **21.9%** of layers/horizons were characterized by a neutral reaction and **9.4%** – by alkaline. In case of deeper layers, often enriched with alkaline materials (construction site wastes), it was **24.4%** and **50.7%**, respectively.

RESULTS

Typical form of area construction	Skeleton (parts > 2 mm)	Parts < 0.02mm	Parts < 0.002mm	Total Carbon	pH 0.01M $CaCl_2$
	%				
XIX/XXth Century	11.8-51.1	1-25	0-6	0.39-3.26	3.9-7.5
50-60. of XXth Century	6.9-39.5	1-11	0-8	0.32-1.68	3.8-7.0
XX/XXIth Century	0.4-79.9	0-19	0-9	0.07-4.59	3.8-7.5
Extensive	0.0-58.7	0-31	0-15	0.46-4.95	3.2-5.1

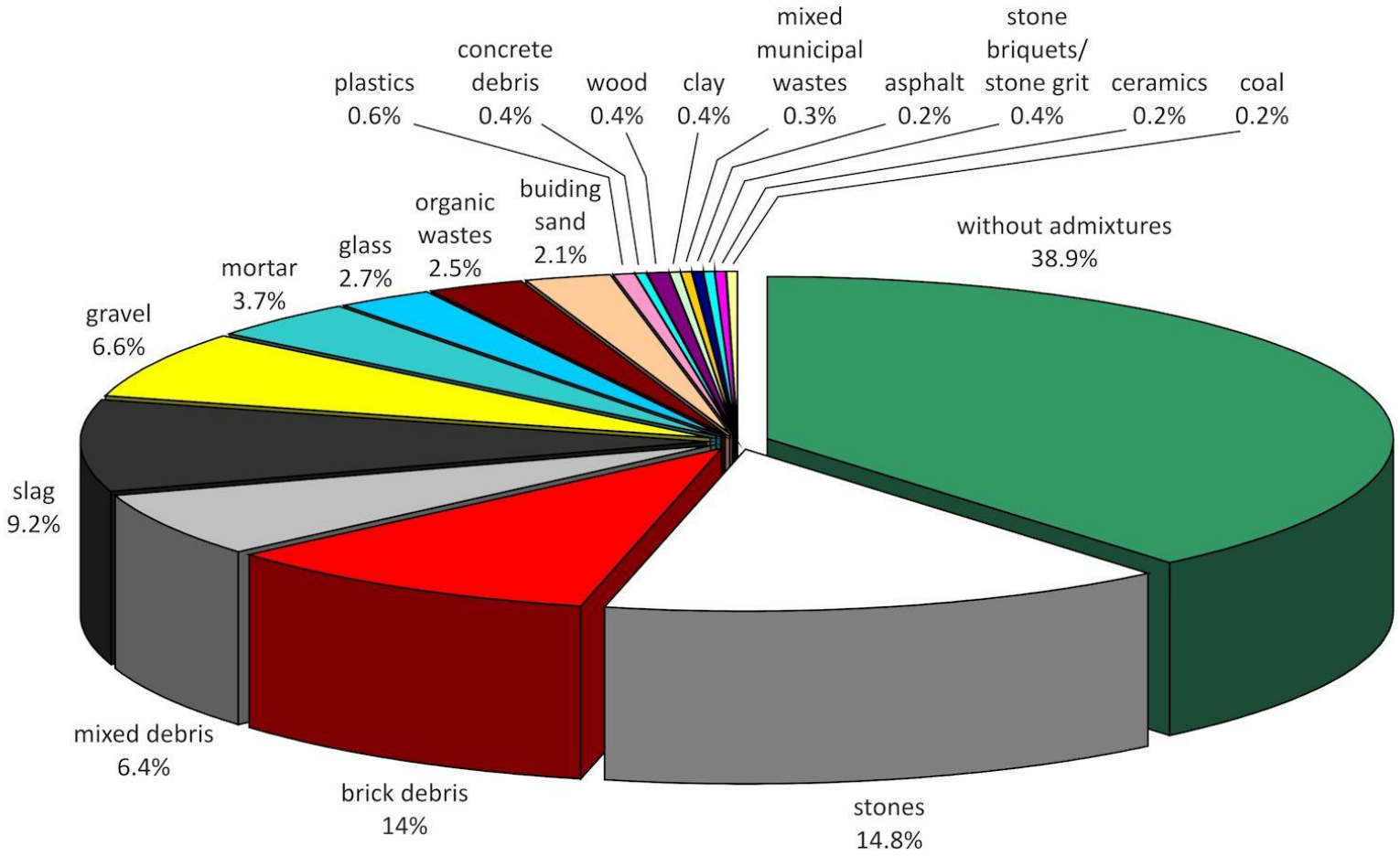
The impact of urbanisation on the chemical properties of soils on the background of following periods of areas construction

RESULTS



The content of waste materials in the urban soils from Zielona Góra (0-20 cm b.s.l.)

RESULTS



The content of waste materials in the urban soils from Zielona Góra (0-150 cm b.s.l.)

RESULTS

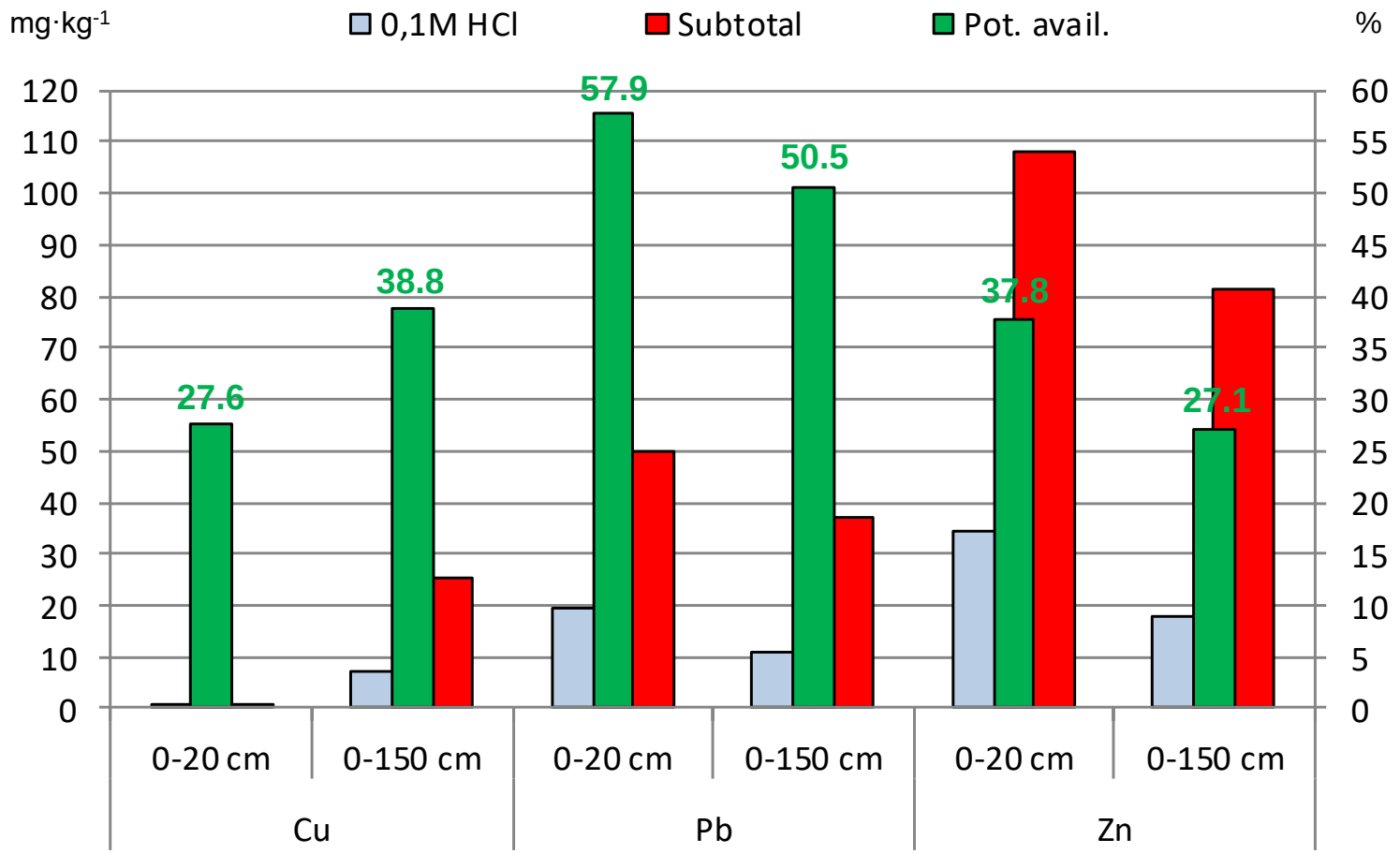
Polish Regulations about the state of soils:

- Act on the protection of agricultural and forest land (Journal of Laws 2017, item 1161)
- Act on the Prevention of Damages in the Environment and their Repair (Journal of Laws 2007, item 493)
- Regulation of the Minister of Environment of 1 September 2016 on the manner of conducting the assessment of the pollution of the earth's surface (Journal of Laws of 2016, item 1395)
  - Urban areas – TLV: Zn **500**, Cu **200**, Pb **200** $mg \cdot kg^{-1}$
  - Agriculture – TLV: Zn 300/500/1000, Cu 100/150/300, Pb 100/250/500 $mg \cdot kg^{-1}$
  - Forest – TLV: Zn 1000, Cu 300, Pb 500 $mg \cdot kg^{-1}$
  - Industrial and traffic areas – TLV: Zn 2000, Cu 600, Pb 600 $mg \cdot kg^{-1}$

RESULTS

	Cu			Pb			Zn		
	0.1M HCl	Subtotal	Pot. avail.	0.1M HCl	Subtotal	Pot. avail.	0.1M HCl	Subtotal	Pot. avail.
	mg·kg^{-1}		%	mg·kg^{-1}		%	mg·kg^{-1}		%
Square									
Range	1-67	4-146	26-46	0.6-51	4-603	8-13	0.3-72	12-454	2-16
Mean	7	22.7	30.8	11.2	33.4	33.5	18.9	94.9	19.9
Park									
Range	1-94	5-475	20-21	0.2-98	3-423	6-23	0.7-68	6-406	12-17
Mean	10.7	35.8	29.9	14.1	41.8	33.7	25.4	92.1	27.6
Forest									
Range	0.3-34	4-115	8-30	0.4-18	4-81	10-22	0.3-56	9-185	3-30
Mean	4.5	17.3	26.0	7.3	17.4	42.0	13.1	54.5	24.0
Sealed area									
Range	1-74	5-320	18-23	0.2-54	3-118	6-46	0.2-70	10-442	2-16
Mean	9.5	32	29.7	13.3	28	47.5	17.6	72.3	24.3
Roadside area									
Range	0.4-32	5-295	7-11	0.4-64	4-376	9-17	0.2-59	5-402	4-15
Mean	7.5	25	30.0	11.7	31	37.7	17.9	75.6	23.7
Area near the building									
Range	1-18	5-130	14-22	0-39	4-117	0-34	0-54	9-422	0-13
Mean	5.1	17.8	28.7	8.9	22.6	39.4	11.8	63.6	18.6
Industrial area									
Range	2-16	5-23	54-69	0-21	6-32	0-65	0.4-21	15-76	3-28
Mean	6	10.6	56.6	8.2	17.3	47.4	6.7	42.8	15.7
Barren land									
Range	0.3-34	5-102	6-34	0.2-74	3-407	7-18	0.4-64	8-443	5-14
Mean	4.9	20.6	23.8	9	43.7	20.6	17.8	87.3	20.4

RESULTS



Solubility of Cu, Pb and Zn in soils vs. subtotal and 0.1M HCl solved heavy metal content

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CONCLUSIONS

- An important but non-standard urban soil pollution are **artefacts**, **mainly of construction origin**, which strongly change soil properties, including particle size distribution, pH and EC.
- In the majority of the Zielona Góra area there was **low concentration of heavy metals** in soils. Such a situation took place despite the historically high degree of industrialization, and contemporary dense network of communication and urban development.
- The content of heavy metals in urban soils is the result of many factors affecting both the deposition of heavy metals and their retention. Week, mostly **sandy grain-size composition** and **low carbon content** in soils do not allow the retention of large amounts of cations, including heavy metals.
- A specific source of heavy metals in soils can be **pesticides** used in agriculture. In Zielona Góra a **high copper content** was found **in the areas of former vineyards** protected with fungicides based on its compounds.
- An important indicator for assessing the condition of urban soils is the **construction time** of a given area. New areas are often constructed using clean materials from outside the city. New construction technologies are also more cost-effective – less waste production.

THANK YOU FOR THE ATTENTION

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