ENHANCEMENT OF MAGNETIC SUSCEPTIBILITY OF SOIL RESULTING FROM RESUSPENSION OF DUST FROM A METALLURGICAL SLAG HEAP

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Introduction

Upper Silesia is the most industrial region of Poland. Rich deposits of hard coal as well as zinc, lead, iron and silver ores caused the development of mining and metallurgical industry since 12th century. Numerous shafts, excavations, mine waste heaps and subsiding trough are inseparable view in this region. There are many metal-rich waste heaps related to historical ore mining and processing. Such anthropogenic activities have influenced the conditions of waters and soils, and the presence of heavy metals may significantly influence the health of human beings and other organisms. Moreover, owing to their properties some metals may be accumulated in terrestrial food chains. Hence it is very important to investigate and monitor heavy metal pollution of soils.
The aim of the present study was development of an integrated two-stage geophysical/geochemical evaluation method of soil pollution, and to implement it as a new tool for soil quality management based on magnetometric measurements followed by soil sampling and geochemical analyses of soils in the vicinity of metallurgical slag heaps.

Methods

Studies were carried out on a 1 km^2 area of arable land. The field was located in the prevailing wind direction about 300 m east of a large dump of slag remaining after processing of Zn and Pb ores. On this study area surface magnetic susceptibility (κ) measurements were performed using a magnetic susceptibility meter MS2 "Bartington" with an MS2D loop sensor. Subsequently maps of magnetic susceptibility distribution were prepared using Surfer 8 software (Golden Software Inc.). On the basis of acquired maps topsoil core sampling (0-30 cm depth) was performed employing a Humax soil sampler. On the basis of the vertical distribution of κ in topsoil cores obtained by measurements using "Bartington" MS2C sensor, the layers with maximum values were selected for further analysis. The concentrations of 60 elements were determined with ICP-MS after digestion in nitric acid. The Tomlinson Pollution Load Index (PLI) (Tomlinson et al., 1980; Angulo, 1996) was calculated in order to assess the overall contamination level of the soil.

Results

The preliminary field measurements showed that the above 80% of studied area had κ values higher than 100 × 10^{-5} SI. The highest κ values were observed in a western part of the field (98-255 × 10^{-5} SI). Values of κ

decreased downwind at increasing distance from the waste dump and from the road. Vertical distribution of magnetic susceptibility values in cores was typical for arable land with mixed upper soils layers due to ploughing. The spatial distribution of some elements corresponded with the distribution of κ values. The highest contents of Pb, Zn, As, Ba, Cd were observed in the western part of the field. Moreover contents of Zn, Pb and Cd in all investigated samples exceeded Polish threshold values for arable soils. According to the obtained PLI index values the eastern part of the investigated area can be described as "heavily polluted" and the western part as "extremely polluted". Generally the PLI was used for comparison between different geographic sites and for different times (e.g. Rachwal et al. 2015), but in this case its spatial distribution reflected the extent of contamination in a better way than contents of individual elements. The best relationships between magnetic susceptibility and element content (correlation coefficient > 0.8) were observed for Cu, Ba, Se, Zn, Tl, Hg, In, As, Cd, Sn, and Ni, which may all be related to past and present pollution sources. In the investigated area the main source of elevated contents of many elements was obviously resuspension from the adjacent metallurgical slag dump, but a nearby busy road and several small enterprises may also have contaminated the studied soils.

Conclusion

Spatial distribution of soil magnetic susceptibility (κ) showed enhanced values in the western and southwestern part of the study area, which suggests the nearby metallurgical heap as a main source of soil contamination, but influence from the nearest road cannot be excluded. Calculated PLI values confirmed the direction of the main contamination influx: from the westerly-located metallurgical slag heap. Furthermore calculation of correlation coefficients between magnetic susceptibility and contents of chemical elements was helpful in identification the sources of soil contamination. The calculated coefficients confirmed that soil contamination at the investigated site was caused by suspended dust from the heap as well as by road dust. The investigations proved the two-stage method to be a feasible, reliable, and cost-effective tool for identification of the extent of soil pollution and its origin.

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