MAGNETIC PROPERTIES OF SOILS UNDER HIGH ANTHROPOPRESSION – KRAKOW CITY, SOUTHERN POLAND

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Introduction

Citizens of Krakow are recently more aware of health problems connected with the poor air quality (smog), but unfortunately, they cannot perceive dangers arise from consumption of vegetables and fruits cultivated in the Krakow area, e.g. in household gardens or cultivated lands. A state of Krakow soil predominantly depends on the amount (and chemical composition) of atmospheric pollution (solid particles) which have been deposited on the surface. In the case of Krakow city, a soil enrichment with toxic elements is most often a result of industrial activity in the city area (Rosowiecka and Nawrocki 2010), so-called low emission and road transport. The article presents the results of laboratory magnetic studies of soil samples originating from the Krakow area. The aim of the study was to: determine an anthropopression level (map of frequency dependent susceptibility of soils of the entire Krakow area), study of the magnetic minerals content, recognize the magnetic minerals, establish a domain state and grain size of magnetic particles and also describe a mineral composition for obtained magnetic fractions.

Description of materials and methods

The surveys executed in 2011 included both *in situ* and laboratory measurements of samples collected from precisely established 112 locations (2 x 2 km grid) in the Krakow city. The soil material was taken from the uppermost soils horizons (0-20 cm depth). The mass magnetic susceptibility and frequency dependent susceptibility (κ_{fd}) of 112 soil samples were measured. For stronger magnetic samples, collected in the areas recognized (Wojas 2017) as topsoil magnetic susceptibility anomalies (apparent magnetic susceptibility values above 50×10^{-5}), laboratory investigations of other magnetic parameters (anhysteretic remanent susceptibility, magnetic susceptibility and remanent magnetization changes with temperature, parameters of hysteresis loop) were carried out in order to describe magnetic fraction of soils in detail (Górka-Kostrubiec & Szczepaniak-Wnuk 2017). Additionally, magnetic studies have been supplemented by geochemical analyses of soils (pH, contents of heavy metals) and also XRD and SEM-EDS analyses (Magiera et al. 2011).

Results

Specific magnetic susceptibility of soil samples, in the range of $(37.5\text{-}651.4)\times10^{-8}$ m^3kg^{-1}, showed a high probability of soil pollution. Nevertheless, only for a small group of samples, the limit values of heavy metal contents (Pb, Zn) were exceeded. The highest contribution of the magnetic fraction was identified in fertile chernozem located mainly in the eastern part of a city, in the close neighbourhood of the steel plant. Geochemical analyses confirmed a high zinc content in soil (max value 1494 mg/kg, the limit value 300 mg/kg) in this region. Very low values of κ_{fd} (< 3%), which characterize soils of urban and/or industrial areas, show a significant human impact in the creation of soil magnetic properties. The results (Figs. 1, 2) among other allowed us to establish that soils contain mainly pseudo-single domain (PSD) grains of ferrimagnetic minerals like magnetite and hematite.

Conclusions

Human activity is a dominant factor leading to the increase of magnetic properties of Krakow soils, in which magnetite and hematite are the main magnetic phases. Studies confirmed that cultivations should be prohibited in the close vicinity of the power plant due to the high content of heavy metals in soil and extremely high value of magnetic susceptibility (651.4×10^{-8} m^3kg^{-1}). The attention should be paid to soils

used for cultivation, in the eastern part of Krakow, where periodic magnetic susceptibility monitoring (control measurements) should be started.

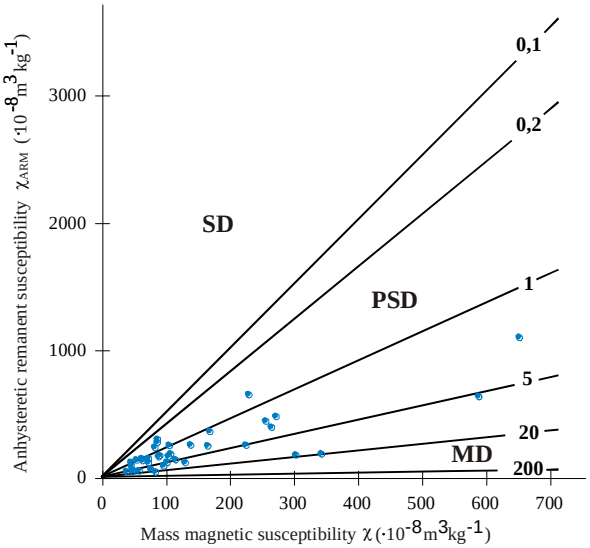

Figure. 1*. The relationship between anhysteretic mass magnetic susceptibility (χ_{ARM}) and mass magnetic susceptibility (χ) in low magnetic field (≈80 A/m) (so called King plot) obtained for 37 soil samples from the Krakow area. Number next to straight line means the grain size (μm) of ferrimagnetic minerals. Abbreviations: SD- single-domain, PSD – pseudo-single-domain, MD – multi-domain.*

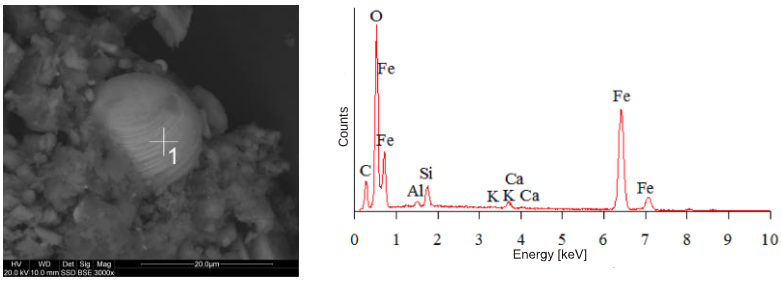

Figure. 2. *The photo of iron spherule in magnetic fraction extracted from the sample no 112_2 (chernozem, surroundings of ArcelorMittal Poland S.A. plant) obtained by the means of scanning electron microscope (SEM) with energy dispersive spectroscopy (EDS).*

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