Geophysical Research Abstracts
Vol. 21, EGU2019-4840, 2019
EGU General Assembly 2019

Soil contamination with technogenic magnetic particles derived from metallurgical processes

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Technogenic magnetic particles (TMPs) are mostly iron oxide and hydroxide which are formed in a high temperature industrial processes where different iron minerals, present in raw materials, fuels and additives are transformed to highly magnetic iron oxides. TMPs are emitted to the atmosphere and then deposited on the soil, plant and building surfaces. Due to their specific mineral and magnetic properties, and well developed specific surface area, TMPs are characterized by an affinity for some metals and metalloids (e.g. potentially toxic elements – PTEs), therefore magnetic parameters can be used as heavy metal pollution proxy.
The aim of the study was identification and characterization of TMPs deposited in the topsoil, in the vicinity of four metallurgical plants located in Mo I Rana (Nordland, Northern Norway), Trinec (Moravian-Silesian Region, Czech Republic), Dąbrowa Górnicza (Silesian Province, Southern Poland) and Ostrowiec Świętokrzyski (Świętokrzyskie Province, Central Poland). TMPs were separated from topsoil cores collected (with the use of HUMAX cores sampler) in areas of revealed topsoil magnetic anomalies, in distance up to 10 km from the emission sources which were active from decades. For the mineral and magnetic characterization of TMPs the following analyses were applied: in situ and the laboratory low-field volume magnetic susceptibility measurements, temperature dependent magnetic susceptibility measurements, magnetic hysteresis parameters and Mössbauer spectroscopy.
Vertical distribution of magnetic susceptibility shown the typical deposition pattern with strong magnetic enhancement in the organic horizon of soil profile. The highest K values were observed in the upper part of the profiles in the depth 3 – 4 cm. The highest magnetic signal was measured in cores from Mo I Rana (over 1000 $\times$ 10-5 SI units). In the vicinity of Trinec the maximum of K value was 600 $\times$10-5 SI units and in other two sites from Poland the topsoil enhancement was less than 200 $\times$ 10-5 SI unit. In all cases the thermomagnetic curves (K–T) of topsoil samples showed a similar pattern with magnetite-like phase identified by a distinctive Curie temperature of approximately 580°C. Independently of the magnetic susceptibility value, which is only the concentration-related parameter, the magnetic mineral composition and magnetic domain fraction in all four cases was similar. TMPs from iron metallurgy are mostly multidomain particles, which are very often non-stoichiometric and strongly defected (oxidized) magnetite with visible surface maghemitization and in some cases also with hematite admixtures.

Acknowledgements: The study was founded by the Polish National Science Centre in the frame of scientific project: No: 2016/23/B/ST10/02814.