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Formation of technogenic magnetic anomalies in forest soils depending on an amount of industrial dust deposition and the time factor

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Soil magnetometry is an approximate, semi-quantitative method for rapid, reliable and inexpensive delineation of pollution areas. Ferrimagnetics present in atmospherically deposited particulate matter, contribute to topsoil magnetic signature and can be measured using concentration-dependent magnetic parameters, such as low field magnetic susceptibility.
The investigations were carried out on the area of about 5000 ha in 61 points (included one profile of fossil soil). Sampling points were located in annually (from 1961 to 2004) reclaimed excavation of the Szczakowa Sand Mine and surrounding areas covered with 40-100 years old forest. Parent rock of the area are Quaternary sands, which contain 0.32% iron. The aim of this study was to explain increase in magnetic susceptibility during about 100 years in dependence on dust and iron fall as well as some heavy metal fall. The Szczakowa Cement Plant, the Bolesław Mine and Metallurgical Plant, Jaworzno and Siersza power plants and other industrial works located in Olkusz, Jaworzno, Sosnowiec, Dąbrowa Górnicza are the main emission sources in the investigated area.
The magnetic susceptibility of forest soils was measured directly in the field using a Bartington MS2D sensor. For determining heavy metals, the samples were dissolved in 2 M nitric acid (HNO3) and the atomic absorption spectrometry method was used. The age of fossil soil horizons was estimated using radiocarbon dating.
The annual dust fall for the period from 1976 to 2004 ranged from 28.5 to 229.6 g/m2 and the iron fall – from 0.8 to 11.1 g/m2 (data was obtained from the Regional Sanitary Station in Katowice).
Magnetic susceptibility rises along with the age of study points (surfaces) from 1.6 $\times$ 10-5 on the youngest surfaces up to 97.4 $\times$ 10-5 on the 80 years old surface, while the iron content in organic horizons varies between 0.53 and 7.75 %, Zn content: between 4.95-859.5 mg/kg, and Pb content: between 2.3–335.0 mg/kg. Magnetic susceptibility of the old humic horizon of the fossil soil (2080 years old) is 5.3 $\times$ 10-5, but in organic horizon formed during last 120 years – 176 $\times$ 10-5, whereas iron content increases almost 40 times (from 0.044 to 1.72%), zinc content ranges from 2.2 to 546 mg/kg, and content of lead from 64 to 194 mg/kg.
Assuming that in the whole study area the dust fall is at the similar level, formation of magnetic anomalies as a result of increasing period of dust deposition should be expected. Value 30 $\times$ 10-5 is often assumed as the beginning of anomaly formation, so it could be concluded that it starts after 15-20 years of dust deposition. It is mostly accompanied by geochemical anomaly, which is determined by the contents of zinc, lead and cadmium exceeding limit values defined for 2 M nitric acid extracts (adequately: 150, 50 and 0.8 mg/kg).