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Magnetic susceptibility of organic (Oh) and mineral (Ap, Ah) soil horizons in Saxony and their origin

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Abstract

Studies on magnetic susceptibility of Saxony soils were made on the basis of archival soil samples taken in 4×4 grid in 1992/1993 from organic horizons of forest soils (Oh) as well as topsoil horizons (Ap, Ah) of arable lands, pastures, meadows and reclaimed lignite mine sites (Leipzig area) (RANK, 1999). Number of soil samples amounted to 1126 from Ap, Ah horizons and 261 from Oh horizon. Mass magnetic susceptibility measurements (χ) were made using MS2B Bartington apparatus. Results of study show that magnetic susceptibility in soils of Saxony has mainly techno- and geogenic character.

Key words
magnetic susceptibility, soil horizons, industrial dusts

Introduction

Surface of Earth, including soils, is the main receiver of fallen substances of volcanic, industrial and space origin. Industrial dusts are mainly related to metallurgical dusts, cement dusts and fly ashes from coal power plants and cokery plants as well as transportation dusts (both automobile and railway). Emitted dusts are often highly enriched in ferromagnetic minerals and present varying magnetic susceptibility (MS) values (STRZYSZCZ, 1993). Magnetic susceptibility is defined as a measure of the degree to which a substance can be magnetised. Beside technogenic magnetic susceptibility - related to industry and human activity, we can distinguish pedogenic MS – related to pedogenic processes and geogenic MS – related to parent rock rich in ferromagnetic minerals i.a. basalts, phyllites.

Material and methodology

Research on soil MS for Oh horizons (261 soil samples) is a continuation of previously leaded measurements on Ah an Ap horizons for soils of Saxony area (PÄLCHEN et al. 2005).
Mass specific magnetic susceptibility (χ) measurements were made using MS2B Bartington apparatus. The soil samples were taken in 4 × 4 km grid (KARDEL, 1996). Air-dried soil samples were sieved through 2 mm screen before measurements. On the basis of achieved results maps of magnetic susceptibility in Oh, Ap, Ah soil horizons were made for Saxony (Fig. 1a,b,c).

Results

Percentage share of values of magnetic susceptibility for Oh, Ap and Ah horizons are presented in Table 1. Magnetic susceptibility in Oh horizon ranged from 9.3 to 1328 × 10^{-8} m^3kg^{-1} (mean 222, median 185 × 10^{-8} m^3kg^{-1}). Soil samples with elevated values of magnetic susceptibility (over 100 × 10^{-8} m^3kg^{-1}) in Oh horizons amounted to nearly 78% of the total number of samples, while in Ah and Ap horizons – 28% and 4% respectively (Tab. 1). Magnetic susceptibility of organic horizons Oh (mean 222) is significantly higher than in

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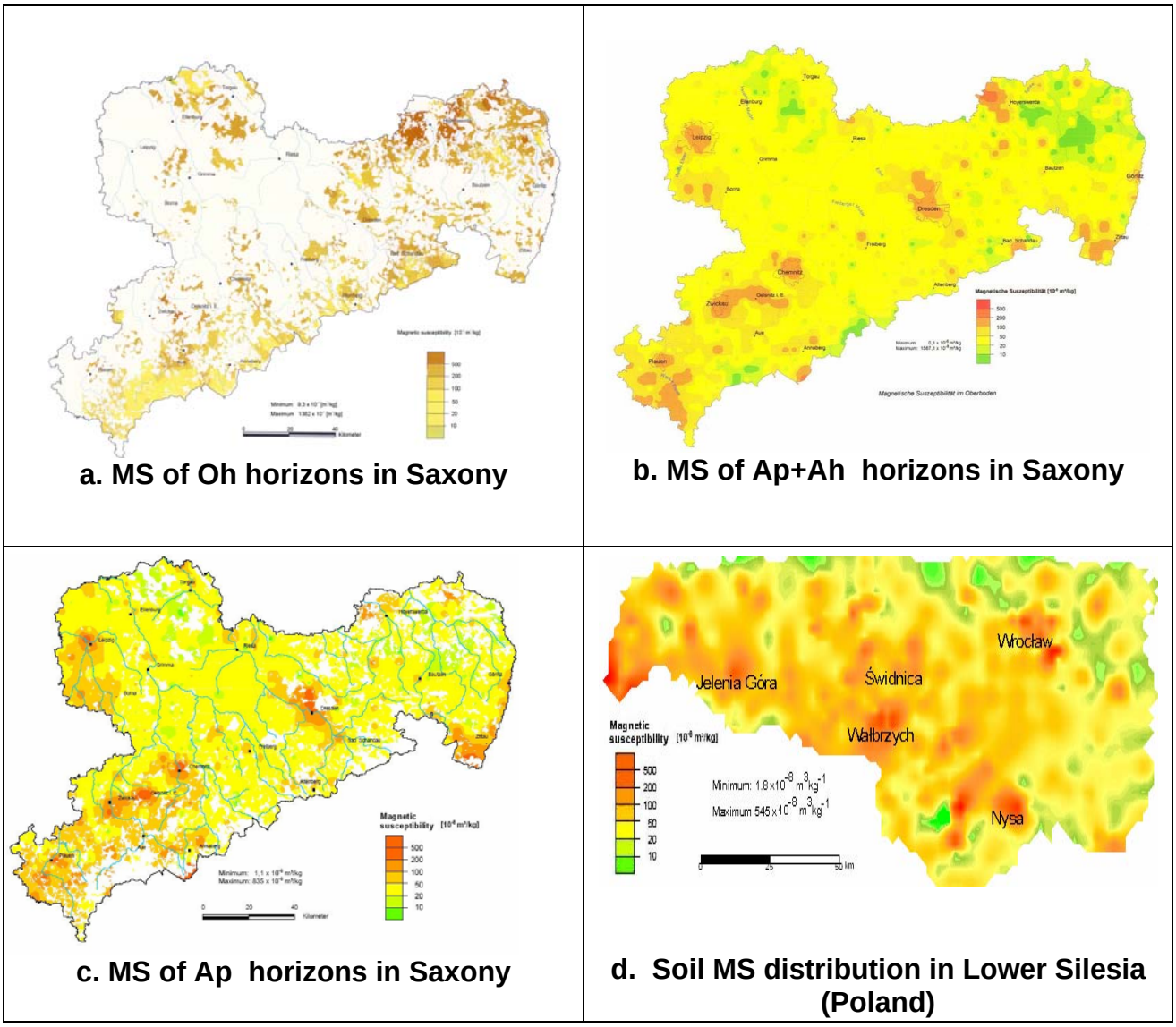
mineral horizons Ah (mean 52) and Ap (mean 41). It is related to the fact that tree canopies are able to intercept higher amounts of air pollution in comparison to open areas. Furthermore, natural arrangement of soil horizons in a forest soil profile (lack of modification by human activity e.g. ploughing) has a strong influence on MS values.

Discussion

The highest values of MS in Oh horizon were observed in north-east and south-east areas of Saxony. Those regions are affected by power industry and non-ferrous metallurgy (Zn, Pb, Cu). Dust emissions from brown coal briquette combustion in Saxony ranged from 550 to 600 Gg in 1989 (SMUL, 1991). Spatial distribution in vertical configuration of soil profile and similar values of MS were observed in areas of Upper and Lower (Fig. 1d) Silesia (Poland) and border zone of Poland and the Czech Republic (MAGIERA, 2006). In those regions magnetic susceptibility has both technogenic and geogenic character. In non-forested regions of Saxony, influence of industry on soil MS is observed in Ap and Ah mineral horizons (Fig. 1b). Additionally geogenic MS susceptibility in those horizons ought to be taken into account.

Figure 1. Maps of spatial distribution of magnetic susceptibility in Saxony and Lower Silesia.



a. MS of Oh horizons in Saxony

b. MS of Ap+Ah horizons in Saxony

c. MS of Ap horizons in Saxony

d. Soil MS distribution in Lower Silesia (Poland)

Table 1. Percentage share of MS values in Oh, Ap, Ah soil horizons in Saxony.

MS range [× 10^{-8} m^3kg^{-1}]	Number of samples			Percentage share [%]		
	Oh	Ah	Ap	Oh	Ah	Ap
<10	1	**100**	4	0.4	**17.1**	0.7
11 – 30	9	**204**	**249**	3.5	**34.8**	**42.9**
31 – 50	14	**109**	**213**	5.4	**18.6**	**36.7**
51 – 100	34	**111**	92	13.0	**18.9**	15.9
101 – 200	**88**	42	18	**33.7**	7.2	3.1
201 – 400	**85**	13	3	**32.6**	2.2	0.5
401 – 500	16	1	0	6.1	0.2	0
501 – 700	6	5	1	2.3	0.8	0.2
701 – 900	3	0	0	1.1	0	0
901 – 1000	1	0	0	0.4	0	0
>1000	4	1	0	1.5	0.2	0

Conclusions

1. Present research shows that MS of soils in Saxony has techno- and geogenic origin.
2. Enhancement of MS in Oh horizon results from concentrating of air pollution by tree canopies and then releasing them by throughfall and stemflow to the soil surface.
3. Geogenic character of MS occurs in regions where soil parent rock is rich in ferromagnetics (basalts, phyllites).
4. Pedogenic character of MS of soils will be determined by studies currently made on 1200 samples from subsoil horizons.

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