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Three-dimensional magnetic susceptibility distribution in different industrially polluted soils

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We investigated magnetic characteristics of soil surfaces and soil profiles near industrial areas in Austria, China and Germany accommodating steel mills and/or coal-fired power plants. At these locations different soil types occur: Brown-earth near the Donawitz steel mill/Leoben/Austria (DSM), aeolic sediment (loess) near the Shijingshan industrial area/Beijing/China (SIA) and podsol near the Trattendorf and Boxberg coal-fired power plants/Lausitz/Germany (TBPP).

At each location two sites (each some m^2 in size) in forest areas with undisturbed soils at different distances to the pollution sources were selected. With respect to high and low surface magnetic susceptibility (MS) values, the sites are regarded as “polluted“ and “less polluted“. Our aim is to study the variability of MS surface values as well as the distribution of MS in vertical soil profiles and its link to surface MS readings.

MS was measured in situ and in the laboratory using a Bartington MS2D and MS2C system, respectively. Bartington MS2D surface measurements were conducted in areas of ca. 5-6 m^2 at grid distances of 10cm or 20cm. The uppermost 2, 4, 6 and 8cm of soil contribute with 60, 80, 90 and 95% to the MS2D signal. Per site 5-24 soil cores of 3.5cm diameter and up to 50cm length were sampled and measured with the MS2C system. “Polluted“ and “less polluted“ sites reveal median surface MS values (MS2D) of 140×10^{-5}SI / 37×10^{-5}SI near DSM, 277×10^{-5}SI / 110×10^{-5}SI near SIA and

214.5×10^{-5}SI / 41×10^{-5}SI near TBPP.

Nearly all soil cores reveal enhanced MS values within the upper 20cm. An exception is the “less polluted“ site near SIA, where no enhancement of MS in the upper part is observed. Median MS peak values of the upper part of soil core sets (n=24 / 22 [DSM), 18 / 5 [SIA] and 13 / 19 [TBPP]) are 725×10^{-5} / 140×10^{-5}SI near DSM, 757×10^{-5}SI / 241.5×10^{-5}SI near SIA and 1418×10^{-5}SI / 184×10^{-5}SI near TBPP. Background MS values at 30cm depth are 100×10^{-5} / 58.8×10^{-5}SI, 208.8×10^{-5}SI / 241.5×10^{-5}SI and 2.8×10^{-5}SI / 41.3×10^{-5}SI at the corresponding sites, resulting in the difference of peak- and background values (DPB) of 625×10^{-5}SI / 81.2×10^{-5}SI in brown-earth, 548.2×10^{-5}SI / 0 in loess and 1415.2×10^{-5}SI / 142.7×10^{-5}SI in podsol. DPB expresses the maximum increase of MS (in the accumulation layer) minus background MS in a vertical soil profile.

Comparison of surface MS measurements (80% of the signal represent the uppermost 4cm) and peak MS values at, e.g. the polluted sites, reveal surface/peak-ratios (SPR) of 0.19 (DSM), 0.37 (SIA) and 0.15 (TBPP). The according peak depth of 4.5cm (DSM), 2.3cm (SIA) and 8.0cm (TBPP) represent the strong dependence of surface MS measurements from the depth of the mainly contributing layer, respectively from the sensor characteristics (investigation depth).

Results show that surface readings can outline MS distribution in the uppermost cm of soils. However, for an integrative analysis of MS distribution in soils vertical sections are required.