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Application of magnetometry for delineation of anthropogenic pollution in areas covered by various soil types

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Abstract

Soil magnetometry is already frequently applied as a tool for rapid evaluation of contamination in different case-studies. It relies on the well established fact that most of the industrial wastes contain strongly magnetic fraction, which enhances magnetic response of the top-soil. Current regional-scale study applies magnetometry on ~2800 km^2 area in north-eastern Bulgaria. The main pollution sources are several plants of chemical industry (soda production, polymers, fertilizers), cement plant and power plants. Pollutants emitted as a result of these industrial productions do not contain as much magnetic fraction in order to cause extreme magnetic enhancement of top-soils, which is a typical feature for the metallurgical industries, mining, coal-burning power plants. A new approach is proposed to correct the data (field and laboratory) for the effect of different soil types in the area, which is not a negligible factor in such case. As a result, more precise lateral distribution of the anthropogenic magnetic fraction is obtained, delineating all affected by pollution regions. The efficiency of the newly proposed method for taking into account differences in soil types is validated through correlation analysis between magnetic parameters and heavy metal content in selected samples. Correlation between the corrected magnetic susceptibility values, Co, Ni, As, Pb and the Enrichment Factors ($EF = \sum Ci/Ck$, Ci — measured concentrations of Pb, Zn, Cu, Co, Ni, As; Ck — background concentrations for the corresponding elements) increase after the applied correction.

Keywords: Soil; Magnetic susceptibility; Heavy metal pollution; Magnetometry

1. Introduction

Magnetometry is increasingly applied in practice as a proxy method for evaluation of anthropogenic pollution (for review see Petrovsky and Elwood, 1999; Evans and Heller, 2003). A well known fact is that most of the major pollution sources (e.g. power plants, metallurgy, mining, chemical industry, etc.) emit also strongly magnetic iron-containing minerals like magnetite and maghemite (Flanders, 1994; Vassilev and Vassileva, 1997) together with the dangerous heavy metals. Thus, introduced into different environmental systems (soils, sediments, water, air) they cause all together with the other disasters, magnetic enhancement of the medium. The effectiveness of the magnetic method has been proved by simultaneous analyses of chemical and magnetic data (Heller et al., 1998; Hanesch and Scholger, 2002). However, in most cases magnetic particles and heavy metals form separate particulates, in spite of their common origin (Kapicka et al., 2001; Jordanova et al., 2004; Jordanova et al., 2006). The relationship between magnetic particles and heavy metal pollutants is complex and differ in the different industrial processes (power plants, metallurgy, cement production, etc.) which has a drawback that the magnetic proxy method cannot be applied as a single protocol of detecting pollutant concentrations from magnetic susceptibility measurements. Therefore, a site-specific approach should be applied in most cases. Usually when anthropogenic pollution is accompanied by a release of magnetic fraction, magnetic response of affected soils and/or sediments is stronger. The main advantages of magnetometry as a proxy for environmental pollution relate to its rapidity and ability to be applied as a preliminary outline of the polluted areas already during the field measurements. A

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