MAPPING HEAVY METAL DISTRIBUTION AROUND THE KOZANI-PTOLEMAIS POWER PLANTS (NORTHERN GREECE) USING MAGNETIC PARAMETERS OF SOILS

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Introduction

Since the early 1950ies, Greece has progressively shifted from an agricultural to an industrial country. This change implied a rapid development of urban and industrial areas, resulting in serious consequences for the Hellenic environment. The present study focuses on fly ash and heavy metal pollution, one of the major environmental problems of the broader Kozani – Ptolemais region (northern Greece) where five thermoelectric power plants are operating. The target of the project is twofold: (a) to challenge the correlation between ferrimagnetic mineral content and geochemical properties of samples from polluted areas; and (b) to estimate the spatial distribution of several pollutants within the study area (~10×5 and ~15×15 km).

Methods

Towards this scope, soil surface magnetic susceptibility was mapped at a spatial resolution of 1×1 km, using a Bartington susceptibility meter (MS2D-loop). In addition, soil samples were collected at each measurement point. They were subjected to standard laboratory experiments, such as magnetic hysteresis, anhysteretic (ARM) and isothermal remanence (IRM) and susceptibility in function of temperature, in order to determine the nature of the magnetic minerals present in the soil sampled.

The concentrations of As, Fe, Mn, Cr, Cu, Pb and Zn in the studied soils were determined by X-ray fluorescence and ICP-AES analyses on 5% HCl leaches from the same samples.

Results

A significant correlation was found between magnetic susceptibility and the concentrations of Cr, Ni and Pb, with r_{Peason} ranging between 0.6 and 0.8, while the correlation with Fe, Mn and Zn was much weaker. In contrast, no correlation was seen for As, Cu and Cd. Magnetic susceptibility measurements in function of temperature revealed a mainly ferrimagnetic nature. Most samples are thermo-chemically unstable after heating to 700 °C, resulting in considerable differences between heating and cooling curves. The frequency dependence of susceptibility is rather low with 5% and indicates a weak contribution of natural components to the bulk susceptibility.

Plotting the ratios of saturation remanence/saturation magnetisation vs. remanent coercive force / coercive force, i.e. the Day-Dunlop diagram (Day et al., 1977; Dunlop, 2002), as well as the ARM and IRM analyses, shows that the magnetic content of the measured samples consists mainly of multidomain grains, thus grains larger than 100 nm.

An exceptionally high correlation coefficient of 0.952 was derived for Cr/Ni and somewhat lowers for others, e.g. Fe/Cu, Fe/Mn, Mn/Pb, Cu/Fe, Fe/Zn and Mn/Zn.

Conclusion

In situ magnetic property analyses revealed significant presence of micrometre sized ferrimagnetic minerals in soils surrounding the Kozani-Ptolemais power plants. The correlations established indicate a strong link between magnetic particulates and heavy metal concentrations, and from the inter-comparison between different element concentrations it is concluded that this enhancement (magnetic/geochemical) results from a single point source, i.e. the nearby power plants.

Because the contribution of natural components to the magnetic susceptibility is negligible, e.g. weak frequency dependence of magnetic susceptibility, enhancement up to 900 times with respect to the background, it is concluded from the instable thermo-chemical behaviour during thermomagnetic experiments, that pollutants from fallout may become mobile in case of strong chemical weathering.

This study demonstrates that in situ magnetic susceptibility measurements are a useful scoping tool to investigate the spatial demarcation of pollution, but ground-truthing, using chemical and laboratory magnetic measurements for representative samples would be prudent.

References

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