JUXTAPOSING RECENT AND SUB-RECENT MAGNETIC IMPACT RECORDS OF AIR POLLUTION – bio- and soil magnetic monitoring in a Belgian harbour area.

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Introduction

In Flanders (Be), air pollution is monitored primarily through artificial filters that trap polluting particles. However, spatial sampling density of these filters is sparse, with just 40 monitoring stations for particulate matter (PM) and 12 for heavy metal pollution established in 2015. In addition, many of these monitoring stations are planted near so-called hot-spots in urban or industrialised areas. To obtain more spatially continuous data, alternative monitoring methods are increasingly implemented (Hofman et al., 2014). As pollution sources often emit PM with enhanced magnetism, magnetic measurements of soils and vegetation can aid to approximatively assess impact of airborne pollution. Furthermore, because heavy metals tend to be incorporated into the crystalline structure of magnetic minerals, the obtained magnetic signals can serve as indicators of heavy metal contamination.

In this study, we assess the potential of pollution mapping by recording top- and subsoil magnetic variations alongside magnetic properties of vegetation within the Ghent harbor area. The potential of these approaches is evaluated through detailed magnetic and heavy metal analyses to investigate the correlation between the magnetic signal and heavy metal contamination within the study area.

In a following step, soil and vegetation data are compared to evaluate temporal changes in pollution patterns. While topsoil magnetism can be interpreted as a long-term record, incorporating recent and past pollution impact, vegetation samples offer a finer temporal resolution representing the impact during one growing season. Juxtaposing both datasets thus offers potential to evaluate both recent and sub-recent pollution impact and assess possible changes in PM emission.

Methods

The 90 ha study area is situated in a pinewood near the harbour of Ghent, near a metal working factory. It is located on top of a diamagnetic sand, rendering negligible natural magnetic background variation.

In a first step, topsoil magnetic susceptibility (MS) measurements were made on a dense (25-100 m) sampling grid across the study area with a Bartington MS2D-sensor. Meanwhile fern and blackberry leafs were sampled at the same locations. The saturated isothermal remanent magnetization (SIRM) of each leaf sample was measured using a Molspin magnetometer. Secondly, soil cores were taken at a subset of 27 sampling locations to evaluate vertical magnetic soil variations. To this end, both standard as well as frequency-dependent (χ_{fd}%) magnetic susceptibility was measured on retrieved soil cores. Lastly, heavy metal analyses, using ICP-OES and ICP-MS, were executed on the subset soil and leaf to correlate heavy metal contamination to the observed magnetic variations.

Results and discussion

For both soil and leaf samples high magnetic signals were measured. Topsoil MS, in particular, shows a spatial pattern that seems correlated to the position of the metal working factory ('Sidmar' on Figure 1).

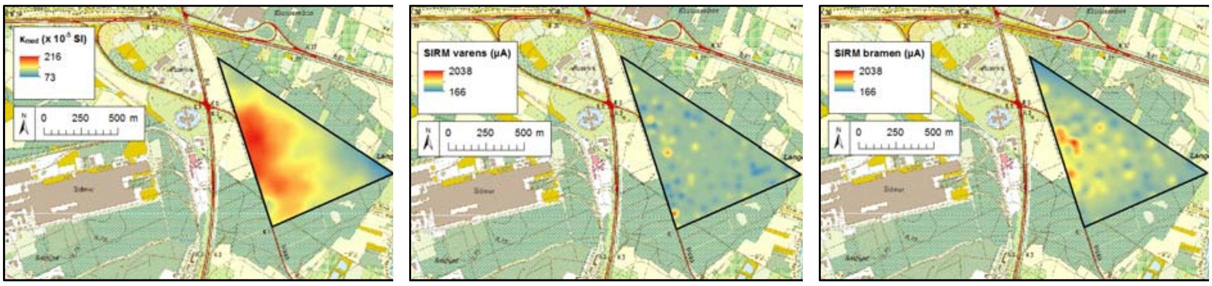

Figure 1. Spatial distribution of the soil MS (left), fern leaf SIRM (middle) and blackberry leaf SIRM (right)

Following Dearing et al. (1996), the anthropogenic origin of magnetic particles was confirmed through the χ_{fd}% data. In addition, high heavy metal concentrations were found (Table 1), which demonstrated high correlations to the obtained magnetic signal.

Table 1. Average heavy metal concentrations ($mg \cdot kg^{-1}$) in soil and vegetation samples.

	Al	Fe	Mn	Zn	Cu	Pb	Cr	Ni	Cd	Co
soil	1570	22507	180	35	17	106	12	12	1.9	5
blackberry	119	282	3949	48	9	2	2	2	0.4	0.1
ferns	243	306	2264	112	9	9	2	3	0.7	0.2

Vegetation samples display a less straightforward spatial variation (Figure 1). Furthermore, a lower correlation was found between the much lower (Table 1) heavy metal concentrations and the obtained magnetic signal. This differing pattern could either indicate changing pollution patterns or increased complexity of short-term depositional processes in the pinewood.

Conclusion

This study confirms the potential of bio- and soil magnetic monitoring in evaluating air pollution impact. Within the diamagnetic soil environment, a robust link can be obtained between magnetic variations and magnetic PM input, showing the feasibility of deploying this method within larger and similar environments. Although results obtained on vegetation samples are harder to interpret, the intense magnetisation of the samples indicates strong magnetic contamination. The weaker correlation between heavy metal concentration in these samples seems to suggest emission changes following recent interventions in pollutant filtering regime in nearby industrial complexes. While this approach needs to be spatially extended, and further validation is on-going, the available data corroborate the feasibility of recording and understanding spatio-temporal variations in pollution impact through simultaneously monitoring magnetic properties of soil and vegetation.

References

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