Magnetic quantification of road traffic pollution in atmospheric particulate matter

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Friedrich Heller (1), Ramon Egli (2) and Simo Spassov (3)

(1) Institut für Geophysik, ETH Zürich, 8093 Zürich, Switzerland
(2) Institute of Geodesy and Photogrammetry, ETH Zürich, 8093 Zürich, Switzerland
(3) Department of Geophysics, School of Geology, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

A new method is presented for fast quantification of road traffic pollution in urban particulate matter (PM). The PM consists of natural and anthropogenic components which both contain magnetic mineral fractions with specific magnetic properties.

The method is based on the **analysis of remanent magnetisation** of PM samples, which have been collected mainly around the city of Zürich at sites with a different exposure to pollution sources: rural region, city centre light traffic, city centre heavy traffic, highway tunnel. These sites represent a typical air pollution scenario for Switzerland, which is predominated by road traffic pollution (**Figure 1**).

The PM fraction < 10 µm (PM10) was collected on fibre glass filters using a high volume air sampler and was analysed by **fast coercivity spectra analysis**.

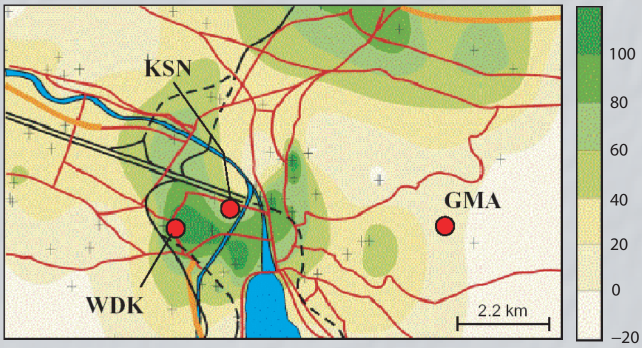

Figure 1. Spatial distribution of magnetic susceptibility of tree leaves in the city of Zürich after Hannam and Heller (2001). In total, 64 sites of road side trees have been considered (black crosses). The samples have been taken over two days in September 2001. The susceptibility is given in units of 10^{-6} SI (see green scale). The red points indicate some PM10 sampling sites.

The samples were magnetized in a steady magnetic field and then demagnetized stepwise by alternating fields. The remanent magnetization remaining after each step was measured (**Figure 2a**). The first derivative of the resulting curve reflects the coercivity spectrum (**Figure 2b,c**). The **PM10** spectra can be modelled using a linear combination of **two magnetic components C1, C2**. The areas below the graphs C1 and C2 represent the individual contribution of two specific groups of magnetic particles to the total magnetisation. Always the same components were observed in the PM10 samples: similar in shape but different in intensity.

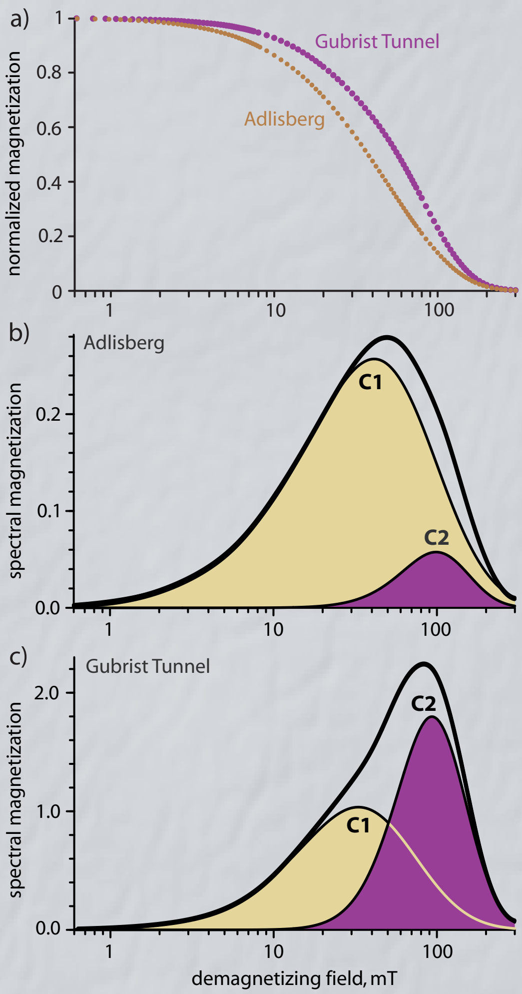

Figure 2. a) Demagnetization of two PM10 samples from a little polluted site (Adlisberg) and a strongly polluted site (Gubbristtunnel). b) Magnetic component C2 is weak at Adlisberg. c) C2 is strong in the tunnel.

The magnetic concentration of component C2 correlates very well with the amount of exhaust pipe PM10 as estimated independently by Hüglin (2000) using a chemical receptor model (**Figure 3**). C2 is identified with a specific magnetic contribution of traffic PM10. Hence the **concentration of C2** can be used for an empirical **quantitative estimate of the mass contribution of exhaust emissions**. Component C1 is rather uniform and largely of natural origin. Since C2 can be calibrated as a measure for traffic pollution, it may be used as an inexpensive and fast proxy for systematic pollution monitoring of wide areas with passive sampling methods.

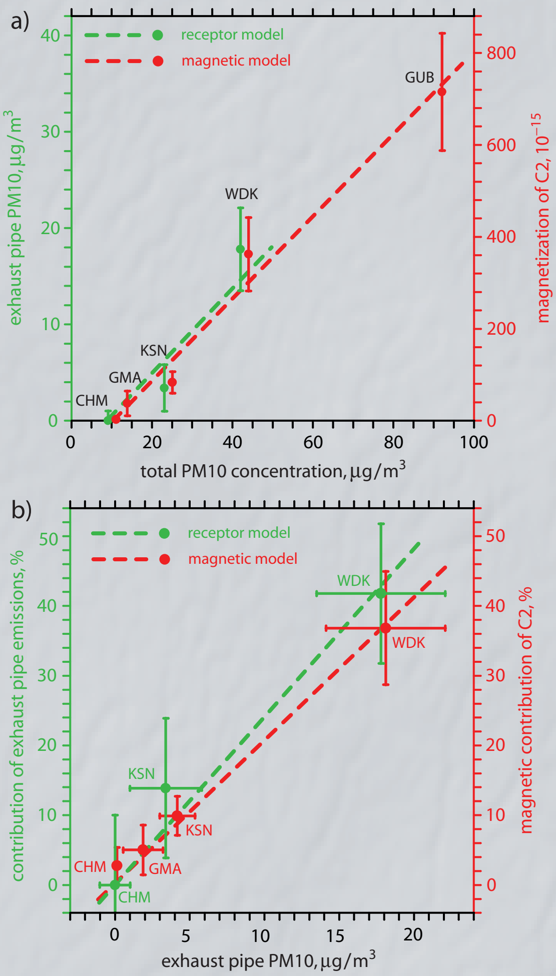

Figure 3. a) Annual mean PM10 concentration at various sites versus PM10 produced by exhaust emissions (green), both after Hüglin (2000), and versus the magnetic component C2 (red). C2 and exhaust PM10 show the same linear dependence on the total PM10 concentration, defining a background PM10 concentration comparable to unpolluted CHM site. b) Absolute (abscissa) and relative (ordinate) contributions of exhaust emissions in PM10. Green: Chemical analysis of Hüglin (2000). Red: Magnetic results whereby exhaust emissions were identified with component C2.

Reference: Hüglin, C., Anteil des Straßenverkehrs an den PM10 und PM2.5 Immissionen, Berichte des NFP 41 Verkehr und Umwelt, Bericht C4, BUWAL, Bern, 1-89, 2000.