

# The PMF project; towards magnetic and chemical characterisation of urban PM sources and associated early-health effects

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# Intro | Urban particulate matter



Urbanization in Manhattan



# Intro | Urban particulate matter



Vietnam







# Intro | Urban particulate matter



Vietnam



India



Urbanization in Manhattan





# Intro | Urban particulate matter



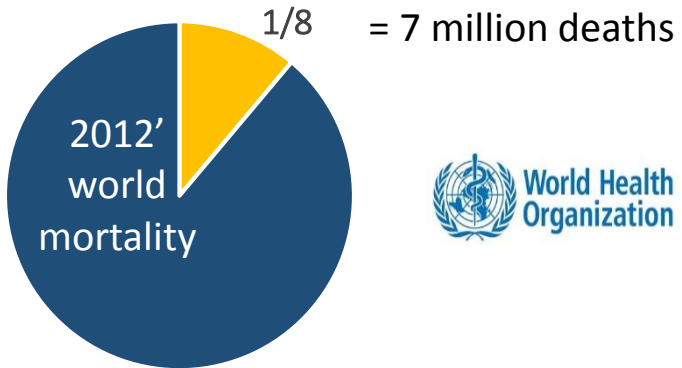
Vietnam



India



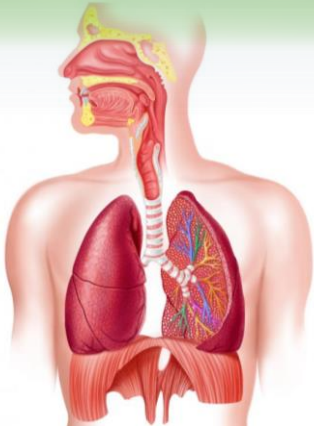
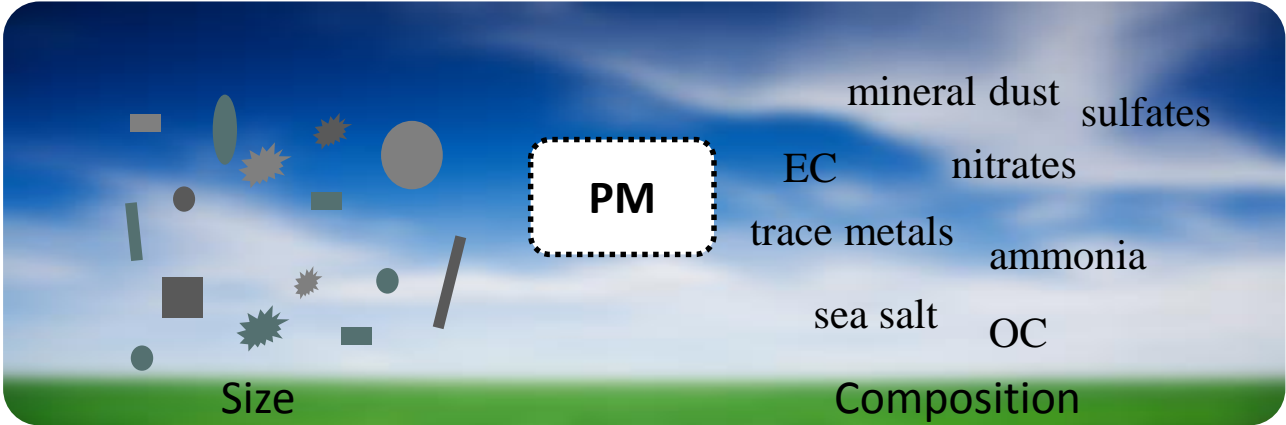
Urbanization in Manhattan





# Intro | Urban particulate matter

Mixture of  $\mu\text{m}$ -size particles suspended in the air with a wide range in size and chemical composition.







# Intro | Urban particulate matter

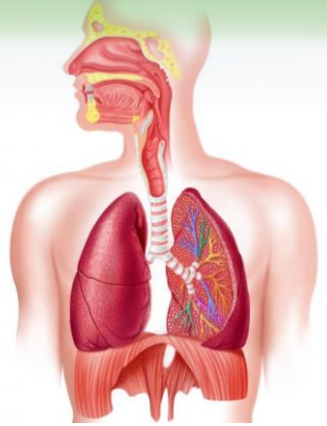
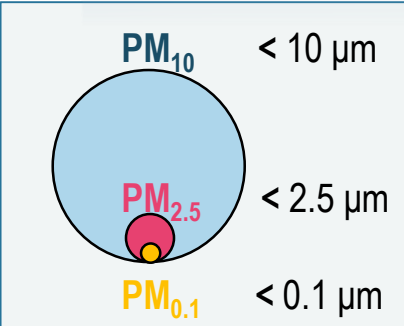
Mixture of  $\mu\text{m}$ -size particles suspended in the air with a wide range in size and chemical composition.

**PM**

**Size**

**Composition**

- mineral dust
- sulfates
- EC
- nitrates
- trace metals
- ammonia
- sea salt
- OC





# Intro | Leaf biomagnetic monitoring

## Air PM concentrations

**Air quality monitoring stations** offer **limited spatial monitoring** due to high investment and maintenance costs

## Biomonitoring

“Measurement of the response of living organisms to air quality of their surroundings”

“biomonitoring as a **powerful, cost effective, user friendly**, tool for **filling the gap between the causes and effects of environmental pollutants**, as bioindication agents **assess the cumulative effects** of pollution” (Nali & Lorenzini, 2007)

→ Human, plants & animals: e.g. Stress-related gene expression, Mosses, POP's in bird feathers







# Intro | Leaf biomagnetic monitoring

## Air PM concentrations

**Air quality monitoring stations** offer **limited spatial monitoring** due to high investment and maintenance costs

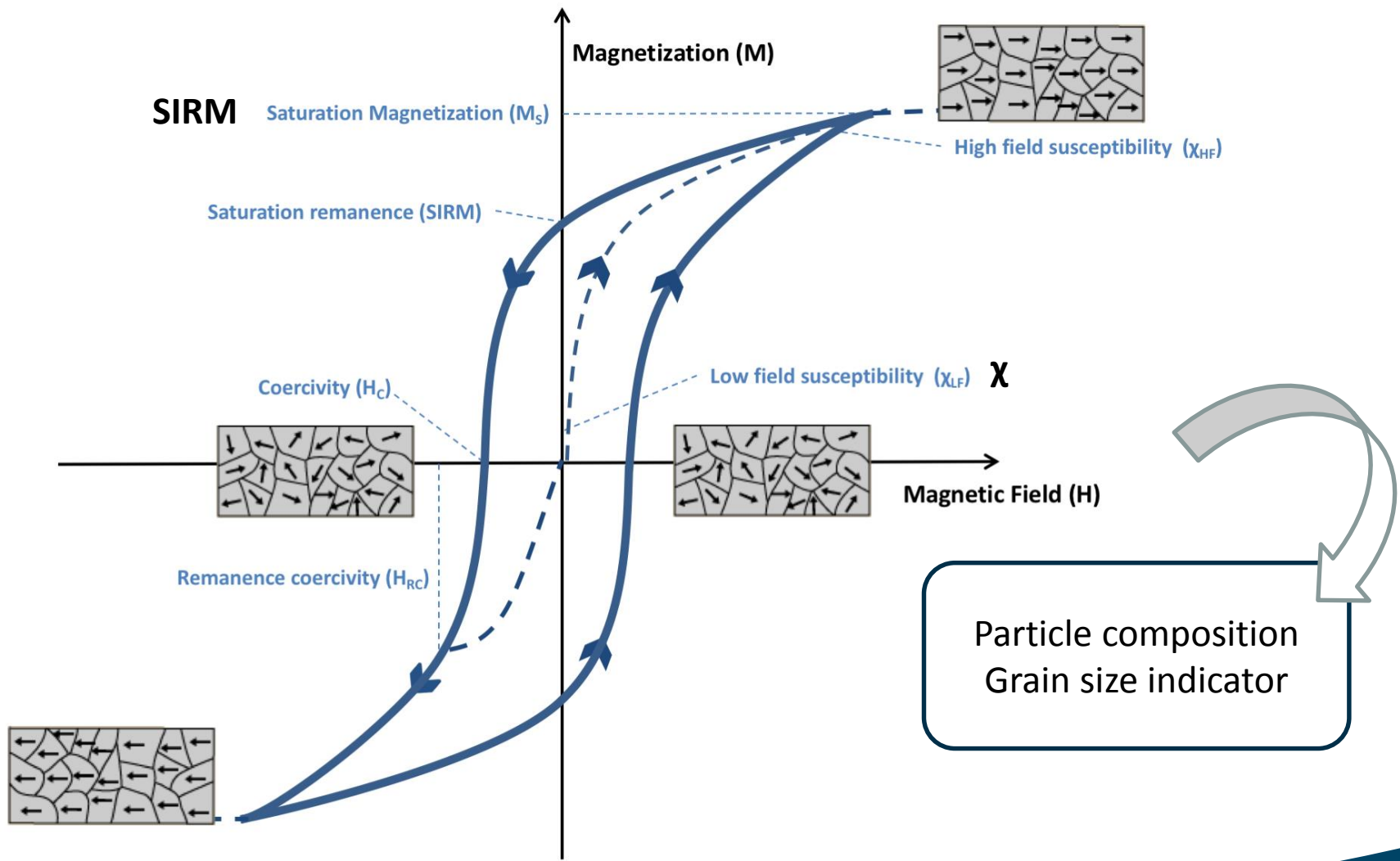
## Biomagnetic monitoring of urban plant leaves

- Magnetic properties of leaves
- Ferrimagnetic fraction of PM:  $\propto$  iron oxides ( $\text{Fe}_3\text{O}_4$  vs  $\text{Fe}_2\text{O}_3, \dots$ )
- Traffic-related sources: combustion or metallic abrasion (engine and brake disks)





# Intro | Leaf biomagnetic monitoring





# Intro | Leaf biomagnetic monitoring

Hofman, J., Maher, B.A., Muxworthy, A.R., Wuyts, K., Castanheiro, A., Samson, R., 2017  
**Biomagnetic monitoring of atmospheric pollution: a review of magnetic signatures from biological sensors.** Environ. Sci. Technol.

**ENVIRONMENTAL**  
Science & Technology

Critical Review

pubs.acs.org/est

## Biomagnetic Monitoring of Atmospheric Pollution: A Review of Magnetic Signatures from Biological Sensors

Jelle Hofman,<sup>\*,†,‡</sup> Barbara A. Maher,<sup>‡</sup> Adrian R. Muxworthy,<sup>§</sup> Karen Wuyts,<sup>†</sup> Ana Castanheiro,<sup>†</sup> and Roeland Samson<sup>†</sup>

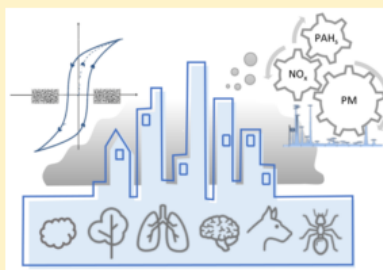
<sup>†</sup>Laboratory of Environmental and Urban Ecology, Department of Bioscience Engineering, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerp, Belgium

<sup>‡</sup>Centre for Environmental Magnetism & Paleomagnetism, Lancaster Environment Centre, University of Lancaster, Lancaster LA1 4YW, United Kingdom

<sup>§</sup>Natural Magnetism Group, Department of Earth Science and Engineering, Imperial College London, London SW7 2AZ, United Kingdom

### Supporting Information

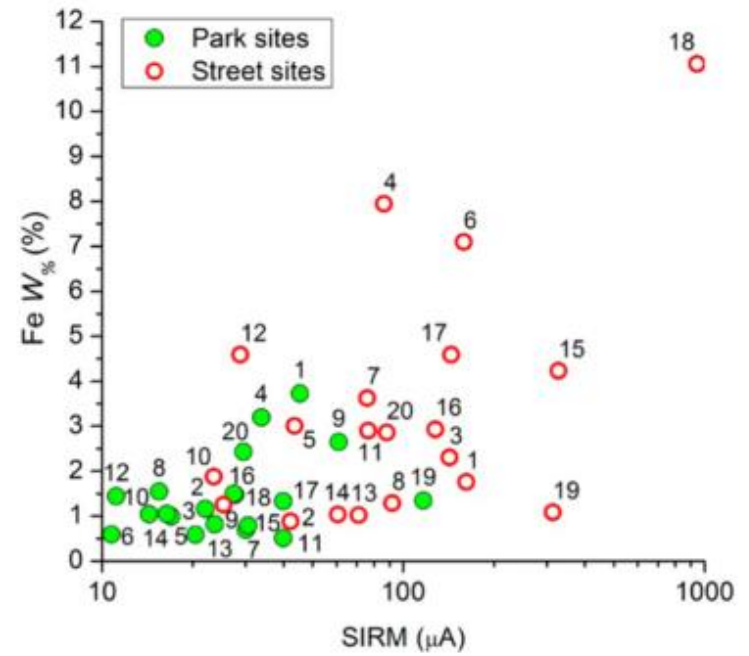
**ABSTRACT:** Biomagnetic monitoring of atmospheric pollution is a growing application in the field of environmental magnetism. Particulate matter (PM) in atmospheric pollution contains readily measurable concentrations of magnetic minerals. Biological surfaces, exposed to atmospheric pollution, accumulate magnetic particles over time, providing a record of location-specific, time-integrated air quality information. This review summarizes current knowledge of biological material ("sensors") used for biomagnetic monitoring purposes. Our work addresses the following: the range of magnetic properties reported for lichens, mosses, leaves, bark, trunk wood, insects, crustaceans, mammal and human tissues; their associations with atmospheric pollutant species (PM, NO<sub>x</sub>, trace elements, PAHs); the pros and cons of biomagnetic monitoring of atmospheric pollution; current challenges for large-scale implementation of biomagnetic monitoring; and future perspectives. A summary table is presented, with the aim of aiding researchers and policy makers in selecting the most suitable biological sensor for their intended biomagnetic monitoring purpose.







# Intro | Leaf biomagnetic monitoring



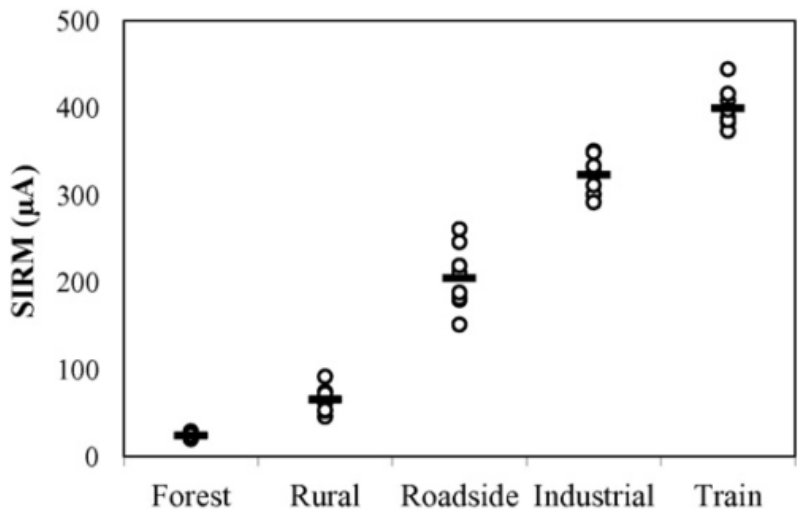
Baldacchini et al., 2017

**How does the amount and composition of PM deposited on *Platanus acerifolia* leaves change across different cities in Europe?** Environ. Sci. Technol.

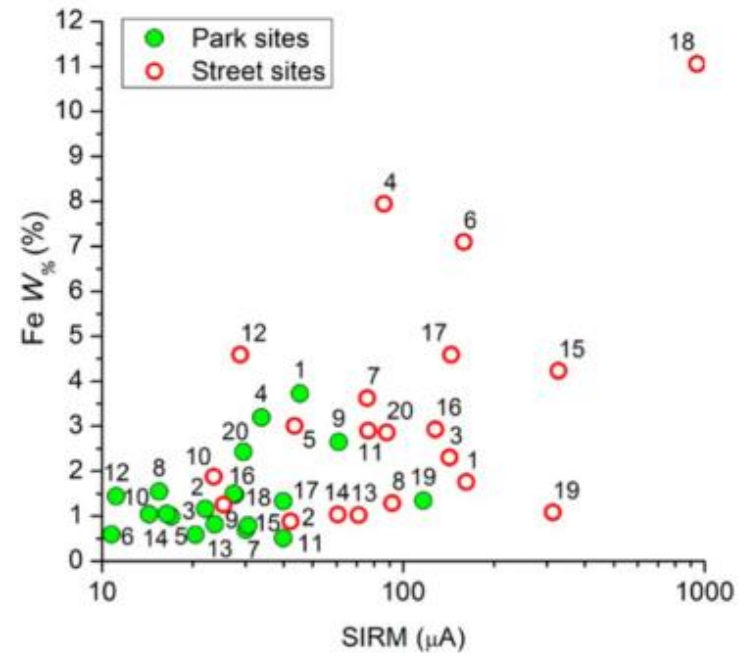




# Intro | Leaf biomagnetic monitoring



Castanheiro, A., Samson, R., De Wael, K., 2016  
**Magnetic- and particle-based techniques to investigate metal deposition on urban green.**  
Sci. Total Environ.

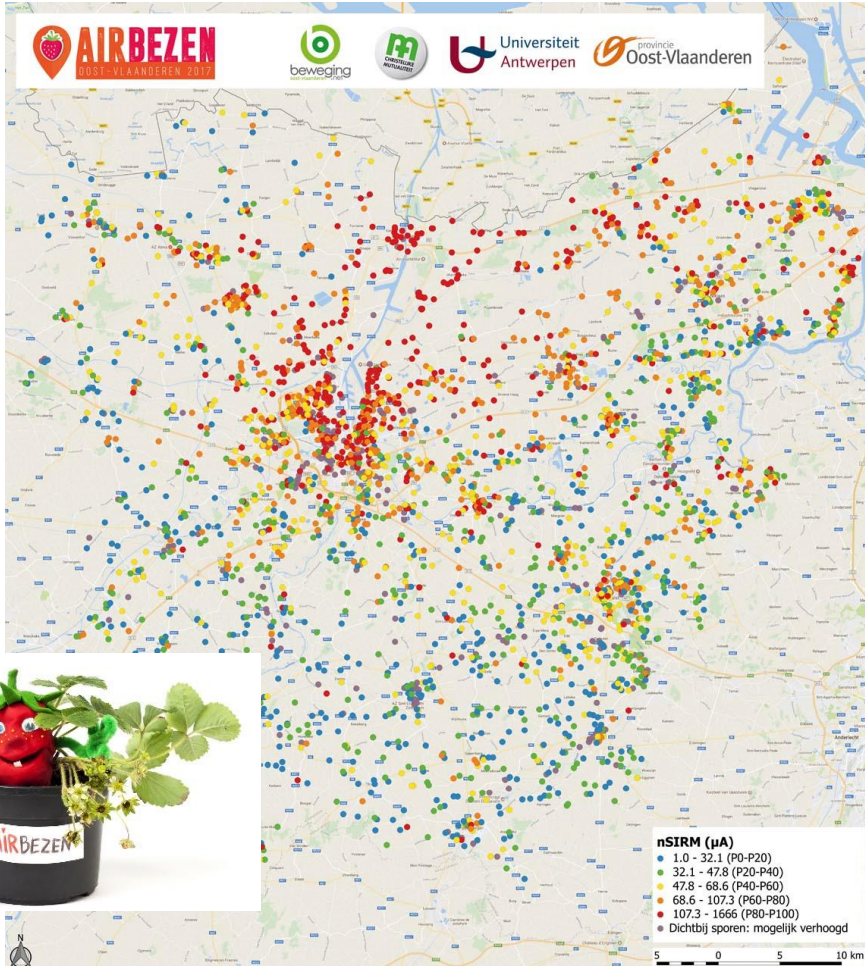


Baldacchini et al., 2017  
**How does the amount and composition of PM deposited on *Platanus acerifolia* leaves change across different cities in Europe?** Environ. Sci. Technol.





# Intro | Biomagnetic fingerprinting



Air quality monitoring and modelling applications

Spatio-temporal variation

Source apportionment

AIRbezen Oost-Vlaanderen 2017 – citizen science project







# Intro | Biomagnetic fingerprinting

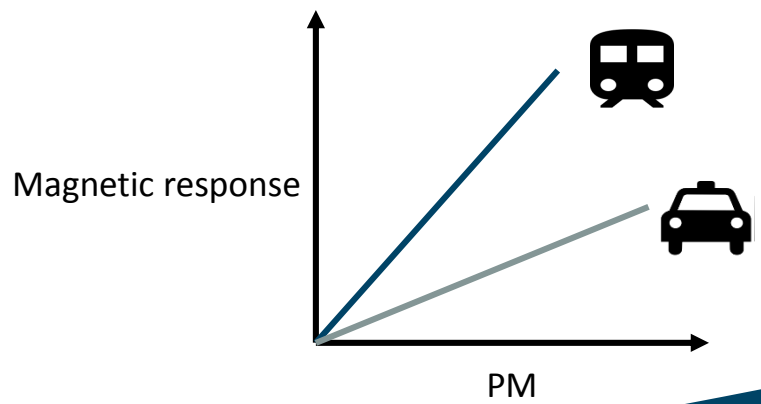
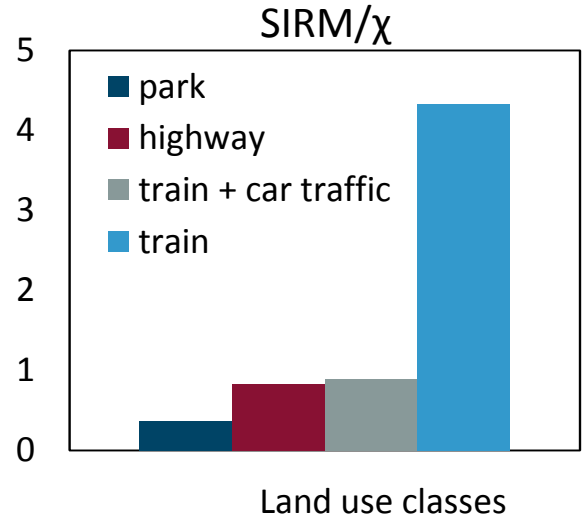
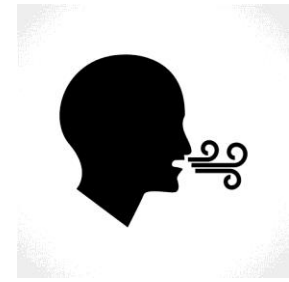
Source apportionment



# Intro | Biomagnetic fingerprinting

No straightforward relation between magnetic parameters and PM load and/or composition when including multiple sources

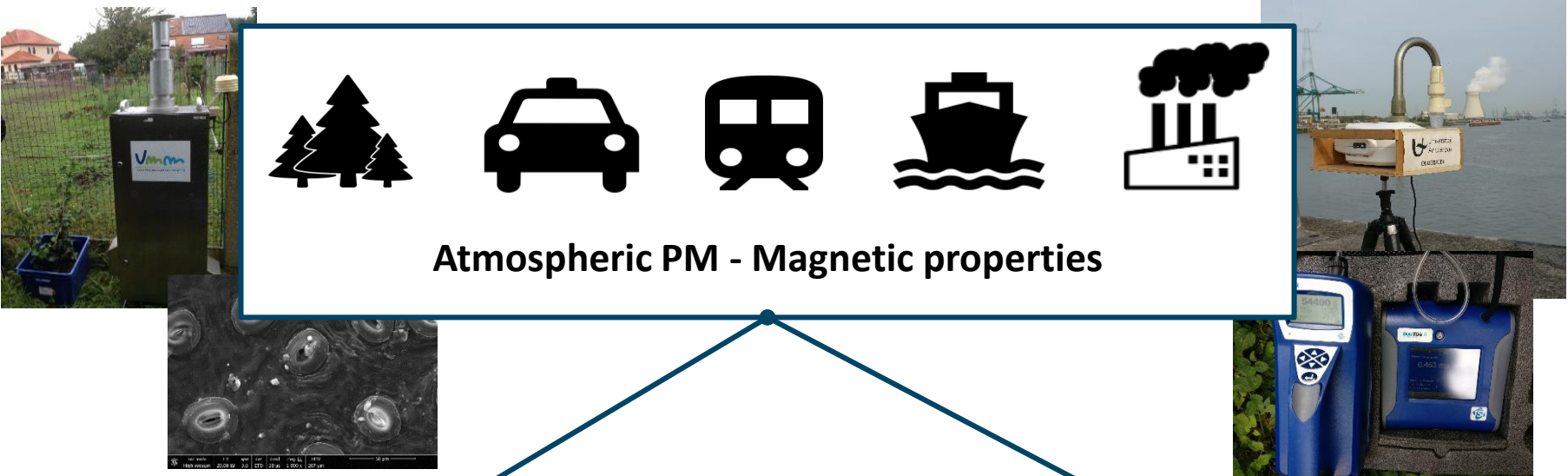
Source-dependent magnetisable composition





# Strategy & goal

## Health relevance of biomagnetic monitoring in urban environments



## Biomagnetic-based fingerprinting of PM sources







# Methodology



## SOURCE SAMPLING

### Tissues

- Magnetic properties
- SEM-EDX
- HR-ICP-MS

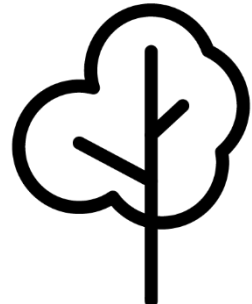


## AIR SAMPLING

Leckel SEQ47/50

PM (Dusttrak II), BC (AE51), UFP (P-Trak)

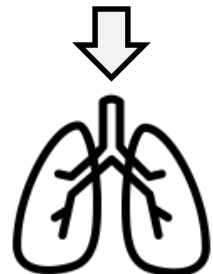
- Magnetic properties (Leckel)
- ED-XRF (Leckel)
- SEM-EDX (Leckel)
- HR-ICP-MS (Leckel)
- GCxGC-TOFMS (Leckel)



## LEAF SAMPLING

### Ivy leaves

- Magnetic properties
- ED-XRF
- SEM-EDX
- HR-ICP-MS
- GCxGC-TOFMS



## ACUTE HEALTH EFFECTS

### Coriolis

- Pro-inflammatory markers of U937 lung cells
- mRNA expression IL8, IL1-β and TNFα





## Methodology pre-campaign

- ✓ Test planned analyses on leaf & filter surfaces  
*ED-XRF, HR-ICP-MS, SEM-EDX, magnetic properties*
- ✓ Test plant species (*Hedera sp., Fragaria sp.*)
- ✓ Test accumulation period needed

3 plants per species next to air quality monitoring station

12<sup>th</sup> of May – 4<sup>th</sup> of August, 2017

Blank – 3w – 6w – 9w – 12w





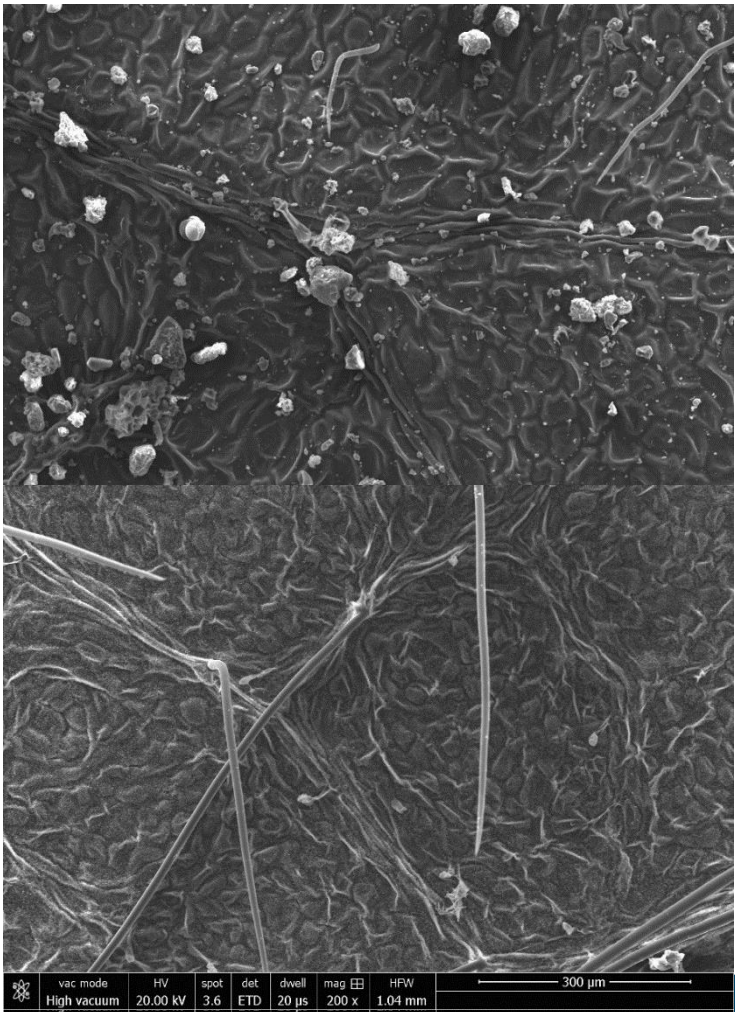
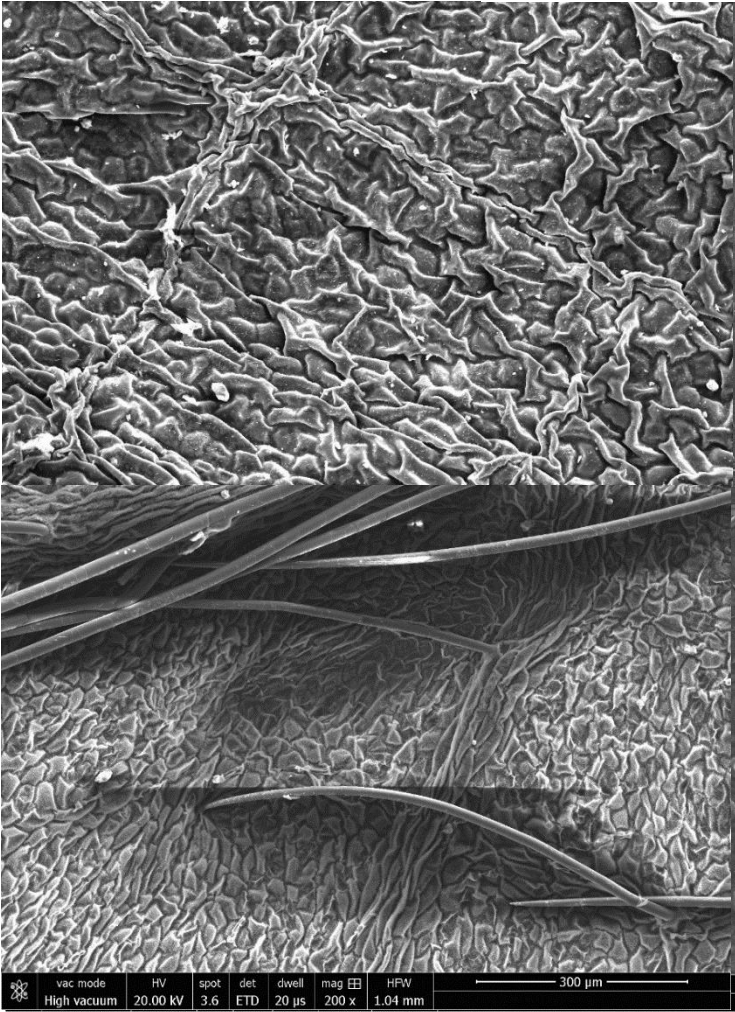
# Results pre-campaign

0 weeks

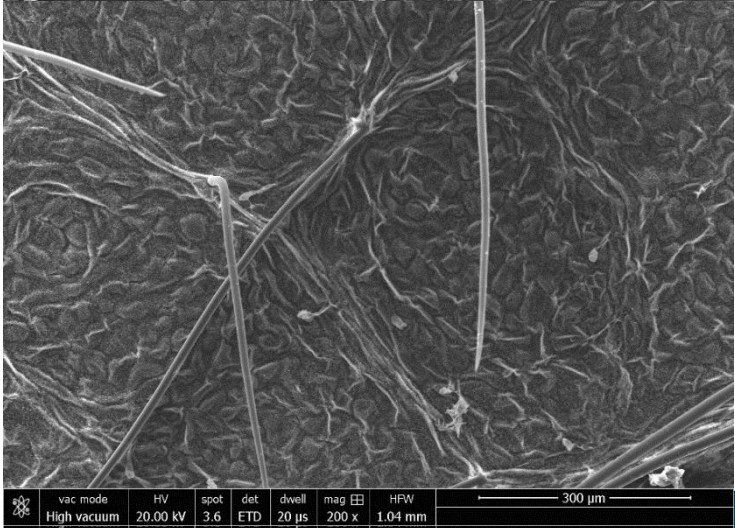
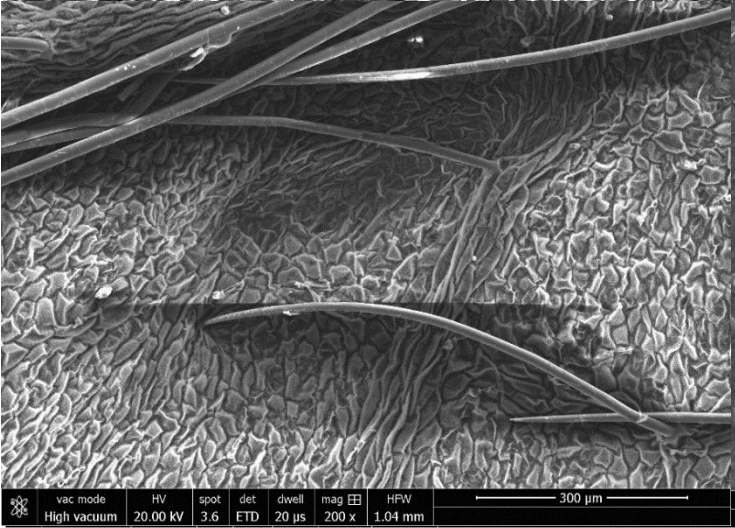
Strawberry leaves

6 weeks

adaxial



abaxial

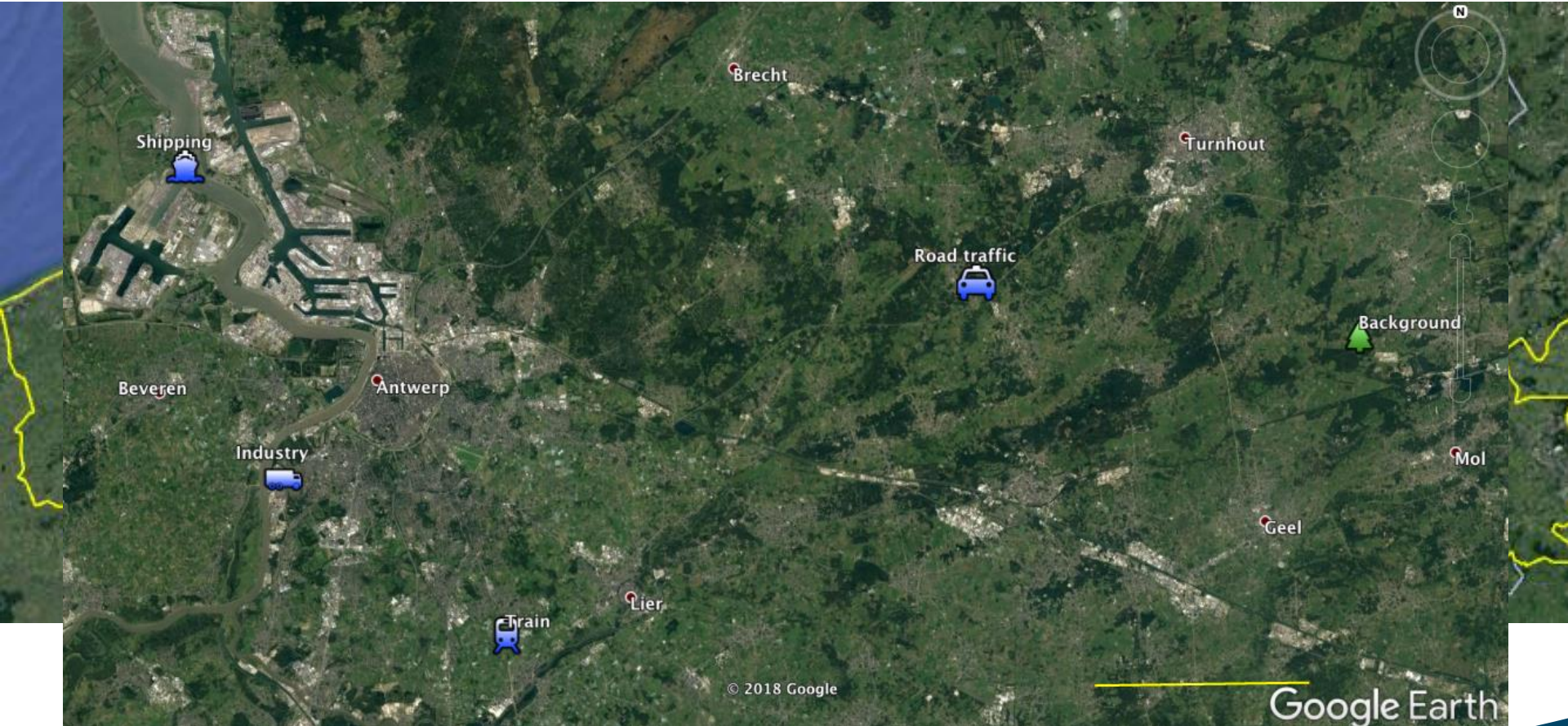






# Methodology PMF project

## PMF Campaign:







# Monitoring sites - Background







# Monitoring sites – Road traffic

- Downwind of E34 (Antwerp – Turnhout)
- Vorselaar





# Monitoring sites – Railway traffic

- Antwerp-Mechelen traject
- Rechtstraat, Duffel

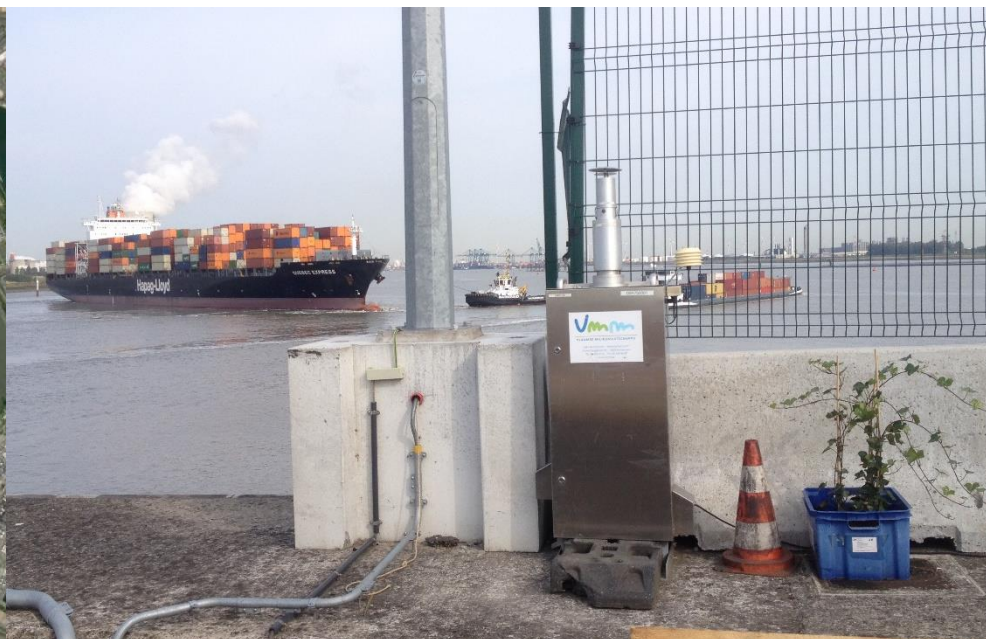






## Monitoring sites – Shipping

- Deurganckdok, Antwerp harbor
- Tidal dock
- DP World - Antwerp Gateway







## Monitoring sites – Industry

- Metal recycling plant
- Umicore, Hoboken
- VMM 40HB23





# Monitoring sites – Industry

- Metal recycling plant
- Umicore, Hoboken
- VMM 40HB23



**A**

U woont in de nabijheid van Umicore? Ondanks de vele maatregelen die het bedrijf neemt om de uitstoot van zware metalen onder de veiligheidsnorm te houden, blijft voorzichtigheid een goed idee. Zware metalen zijn een bedreiging voor je gezondheid en kinderen zijn hier nog gevoeliger aan. Je kan jezelf en je gezin beschermen door nauwgezet de volgende tips te volgen.

**Hoboken**

Deze meetpost van de Vlaamse Milieumaatschappij meet gedurende het jaar de luchtvervuiling, zodat de Vlaamse Overheid kan controleren of de luchtkwaliteitsnormen worden gerespecteerd.

Tips om de inname van zware metalen te beperken

- Was de handen van de kinderen nadat ze buiten gespeeld hebben.
- Veeg je voeten aan de deur.
- Poets met water.
- Was regelmatig het speelgoed van je kinderen.
- Verwissel van schoeisel om zo weinig mogelijk stof in huis te brengen.
- Spoel verharde oppervlakken waarop kinderen spelen geregeld af.
- Gebruik matten die minder stof opnemen zoals rubber en kunststof. Reinig ze regelmatig met water. Andere matten klop je best regelmatig buiten uit.
- Ga je verbouwen? Contacteer Logo Antwerpen voor extra tips.

Logo Antwerpen, tel. 03 369 16 10, kathleen.degroeve@logoantwerpen.be







# Weekly point measurements

## PM<sub>10</sub>, UFP and BC



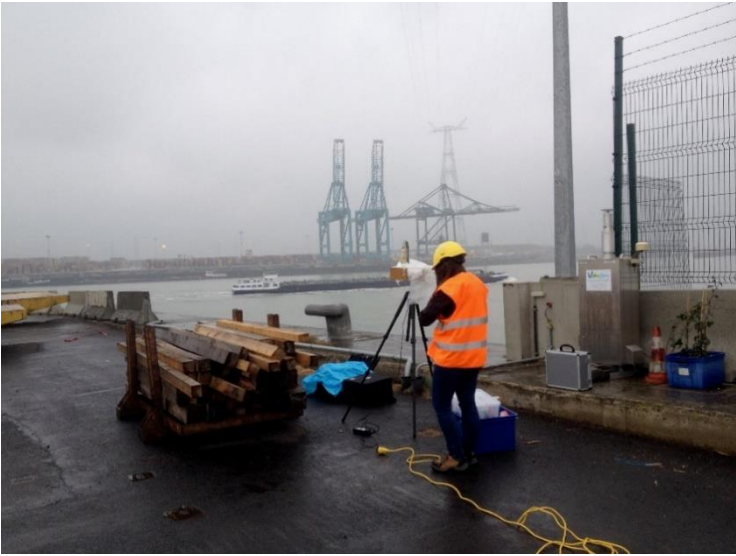
## Coriolis



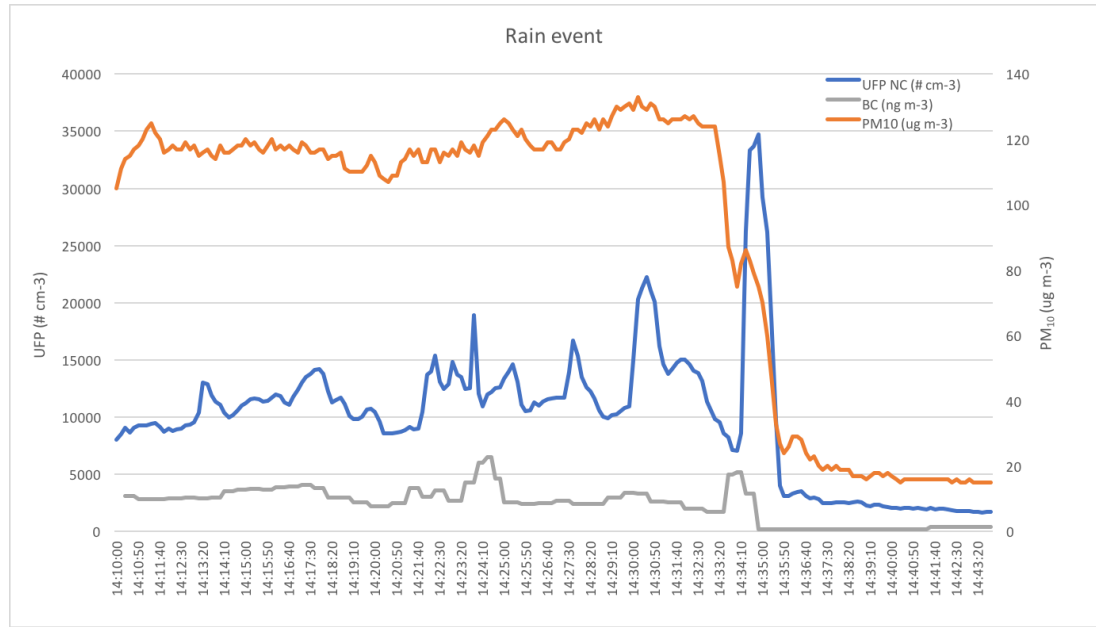


# Weekly point measurements

## PM<sub>10</sub>, UFP and BC



### Rain wash out – a real time observation

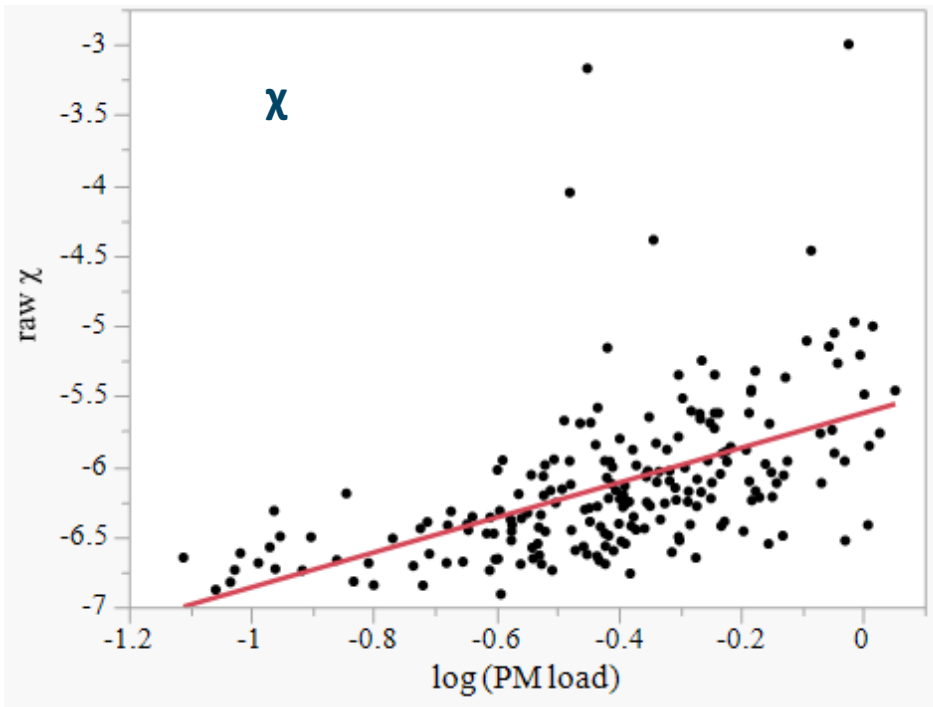




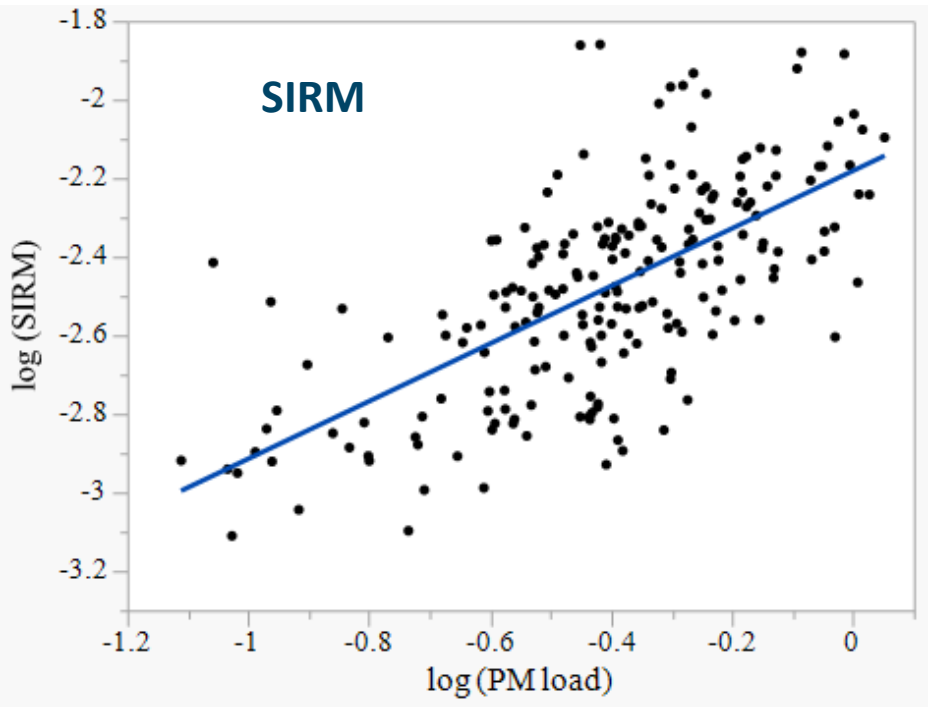


# Results PMF project | filters

## Filter-magnetic properties $\propto$ PM load



Linear fit  
 $R^2 = 0.28$  (n = 210)  
 $P < 0.0001$



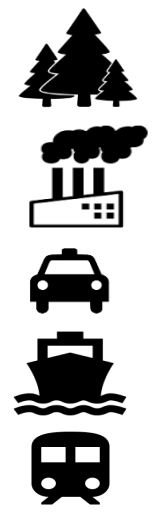
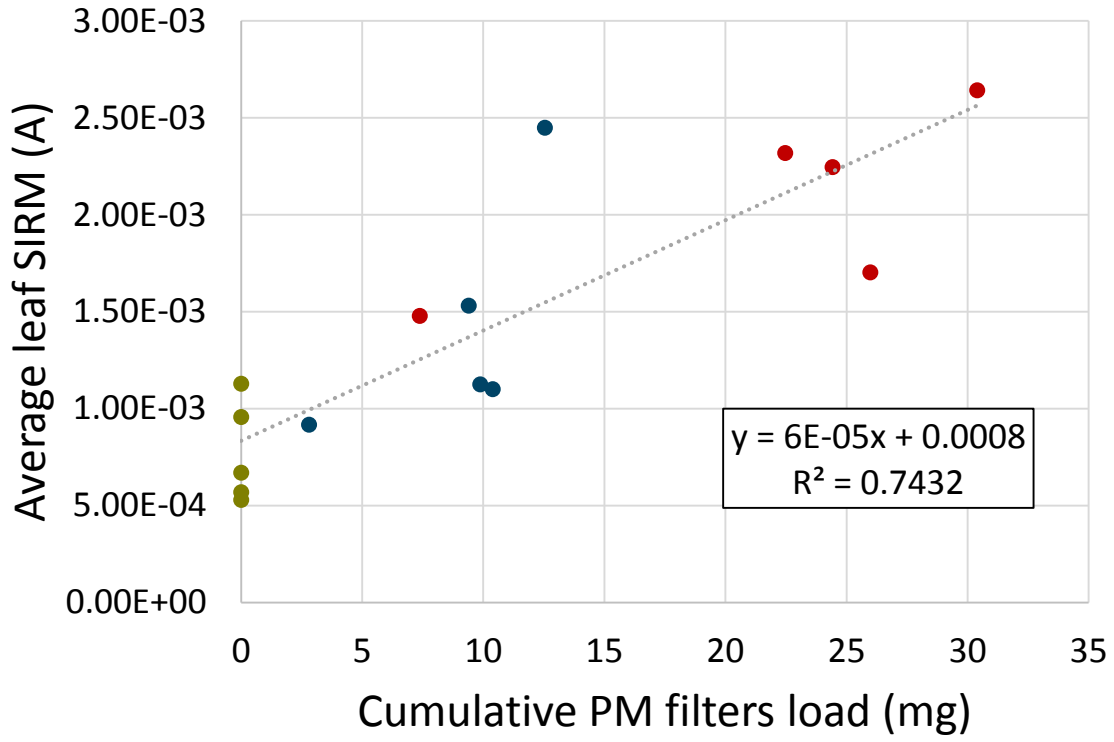
Linear fit  
 $R^2 = 0.44$  (n = 210)  
 $P < 0.0001$





# Results PMF project | filters & leaves











## Leaf SIRM as bio-indicator for cumulative PM filter load





## Take home message | the PMF project

Results are still coming in; nevertheless...

- ✓ Accumulation & elemental analysis have proven suitable using ivy leaves over 6 weeks
- ✓ PM load:  >  >  >  > 
- ✓ Magnetic PM:  >  >  >  > 
- ✓ Filters: Magnetic properties  $\sim$  PM<sub>10</sub> mass  
    **→ source-specific**
- ✓ Leaves: Magnetic properties  $\sim$  cumulative atmospheric PM<sub>10</sub>
- ✓ Different inflammatory responses observed for different sources (e.g. Shipping vs Background)





BIOMAP 8

2-7 July 2018  
Dubna, Russia



More info --> [ResearchGate!](#)