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To cite this version:

Margaux Lefèvre, Patrick Nicol, Thierry Poidras, Davia Dosias-Perla, Pierre Camps. Air quality biomonitoring: application of environmental magnetism to provide air pollution cartographies in a road requalification context. EGU General Assembly 2023, Apr 2023, Vienna (AUSTRIA), Austria. 2023, ⟨10.5194/egusphere-egu23-12660⟩. ⟨hal-04493931⟩

HAL Id: hal-04493931

https://hal.science/hal-04493931v1

Submitted on 7 Mar 2024

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Air quality biomonitoring: application of environmental magnetism to provide air pollution cartographies in a road requalification context

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I) Particulate matter (PM) : a multi-source origin

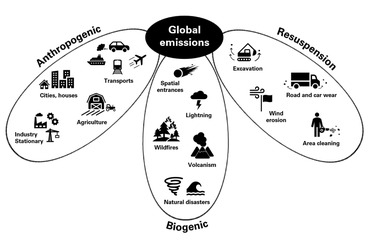


Figure 1 : Main sources of particulate matter (PM) emissions

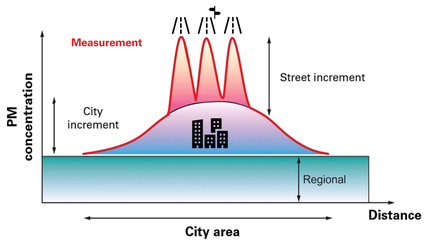


Figure 2 : An unmixing problem (adapted from Harisson, 2018)

Studying the road traffic input on local air quality requires an accurate measurement of the background level. To this end, we defined a relative change from a baseline measurement acquired at reference stations.

⚠ **The localization of the reference station as to be carefully chosen.**

How to isolate traffic emissions from other sources ?

$$RV = \frac{Vstation - Vbase}{Vbase} \rightarrow$$

Adapted from Letaïef et al., 2020

II) PM capture by plants : an interplay with leaf traits

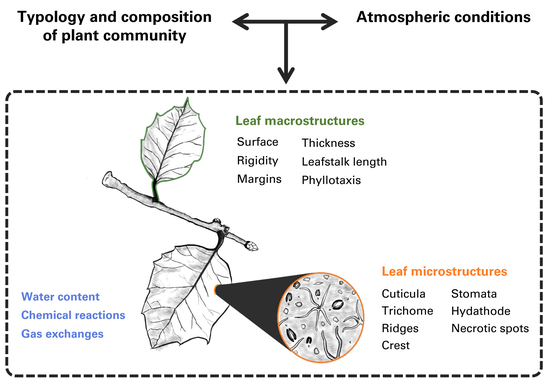


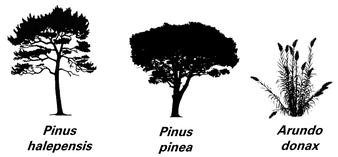
Figure 3 : Plurality of vegetal characteristics having a role in efficiency PM capture

Plants could be very good pollution sensors, yet their capture efficiency come from a panel of environmental and own morphological characteristics.

⚠ It is Important to work only on a same specie at a time.

III) Magnetic monitoring of air quality with accumulative surfaces

Target species (not at scale)



Paper filters and humid wipes



Mapping dust deposition

Saturation Isothermal Remanent Magnetizations (SRIM) imparted at 1T with an ASC pulse magnetizer were measured with a JR-5A Spinner magnetometer after a relaxation time of 24h.
Leaf surfaces were measured with a leaf scanner (CI-202 Portable Laser, CID Bio-Science). Surface of pine needles were measured with Johnson's (1984) formula involving the total length (l) and the total volume (V) of the needle set :

$$\mathbf{A}_{cm^2} = 2l \times \left(1 + \frac{\pi}{n}\right) \times \sqrt{\frac{V_n}{\pi \times l}}$$

⚠ **We believe important to normalize SIRM by the areas of the accumulative surfaces.**



Figure 4 : Leaves (A) and needles (B) surfaces acquisitions in our laboratory

VI) Traceability of PM sources by SEM images

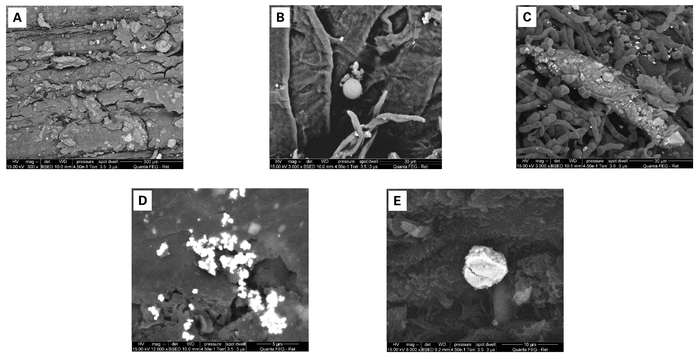


Figure 5 : Observed particulate matters (Scanning Electron Microscopy, SEM).
A – Cracked cuticle with multiple micro particles (*Arundo donax* leaf), a potential resuspension source. B – Silica spherule and soot carbon. C – Tire rubber and road wear micro particles aggregated on mycelium matrix. D – Aggregate of metalloid and metal fine dust. E – Copper and iron particle. All identifications have been based on spectral analysis.

V) Results : a complex and heterogenous air quality

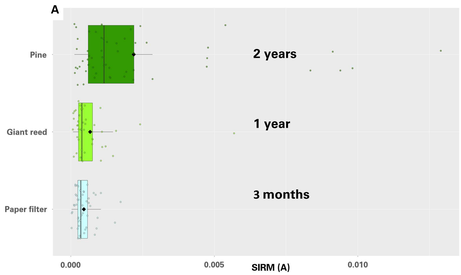


Figure 6 : A – Distribution of SIRM measured on three accumulative surfaces ordered by time exposure. B – Pine needles coated by road dust (left) and cleaned pine needles (right) (*Pinus pinea*).

⚠ **We believe that is important to keep constant some parameters such as : time exposure, accumulative surface's nature, etc…**

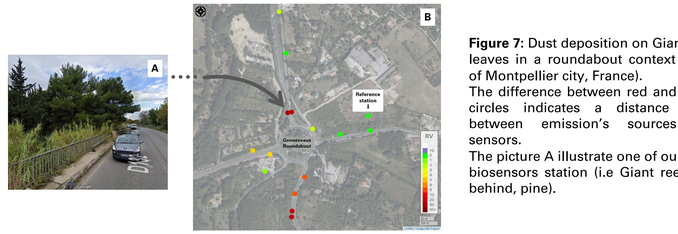


Figure 7: Dust deposition on Giant reed leaves in a roundabout context (West of Montpellier city, France).
The difference between red and green circles indicates a distance effect between emission's sources and sensors.
The picture A illustrate one of our biosensors station (i.e Giant reed and behind, pine).



Figure 8: A - Effect of environmental openness on PM concentration on pine needles, D123E2 road sector (West of Montpellier city, France). Red to yellow circles illustrate a mixing effect between closed area and traffic conditions (B). Yellow to green circles mostly illustrate a good pollutant atmospheric dispersion due to an open environment (C).



Figure 9 : Different pollution patterns (B) obtained from wiping of the guardrails (A), West of Montpellier city, France.

VI) Conclusions

1 – Working with well chosen reference station
2 – SIRM intensities decrease after a distance of 10 m from the traffic lanes.
3 – Bio and classical magnetic monitoring are relevant tools to make a quick, a low-cost and a suitable air quality diagnostic.

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