



Urban and industrial dust in Southern Europe

-

Impact and recommendations



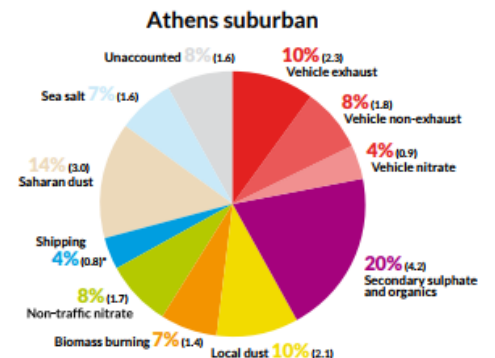
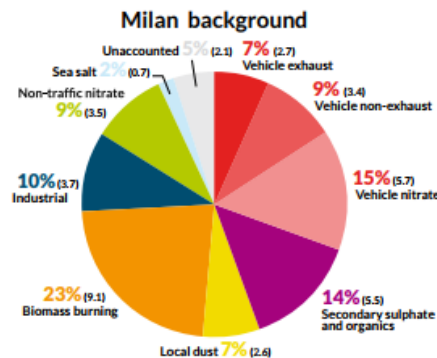
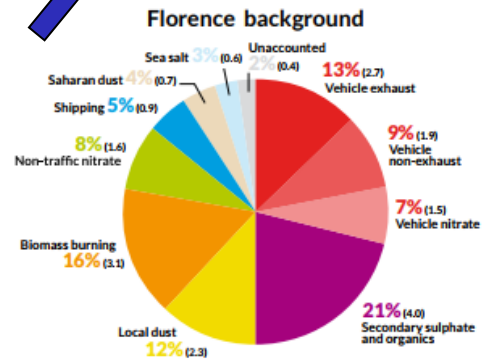
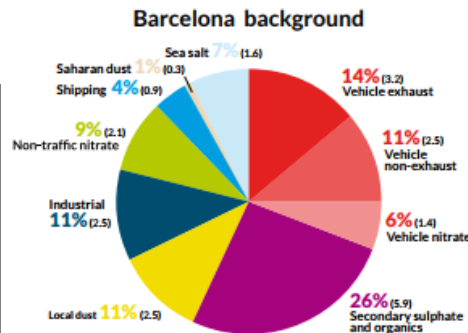
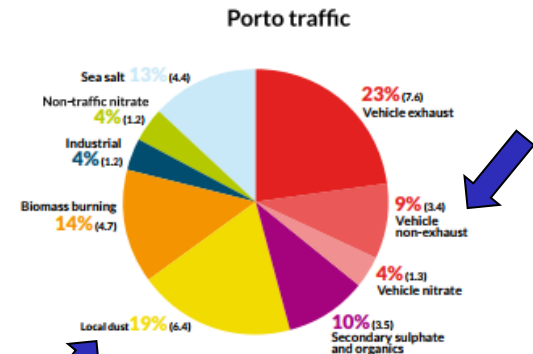
Anthropogenic dust contribution

PM10 Contributions to the annual mean

Amato et al, 2016, ACP

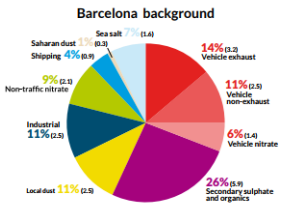
Road dust + local dust

- 16-28% of PM10
- 4-20% of PM2.5

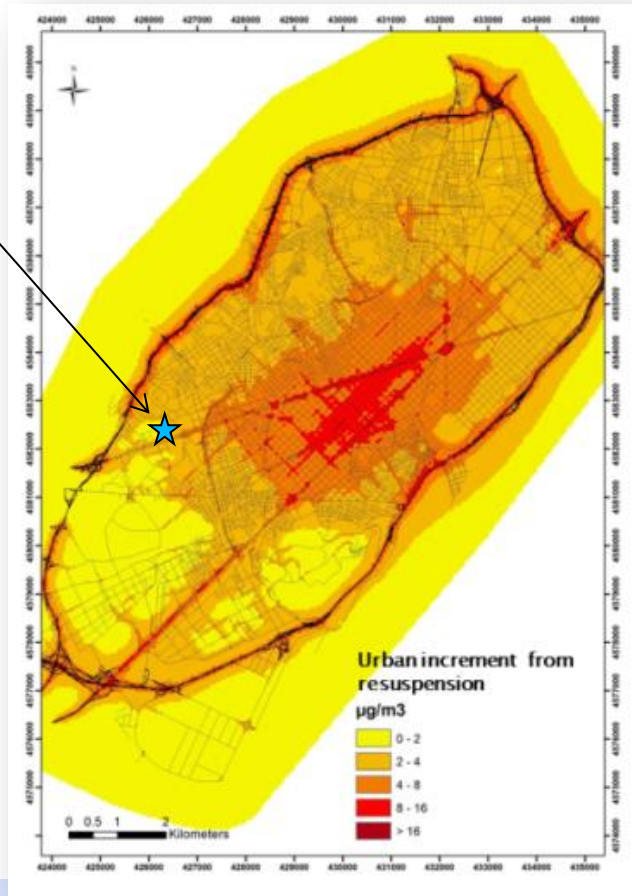




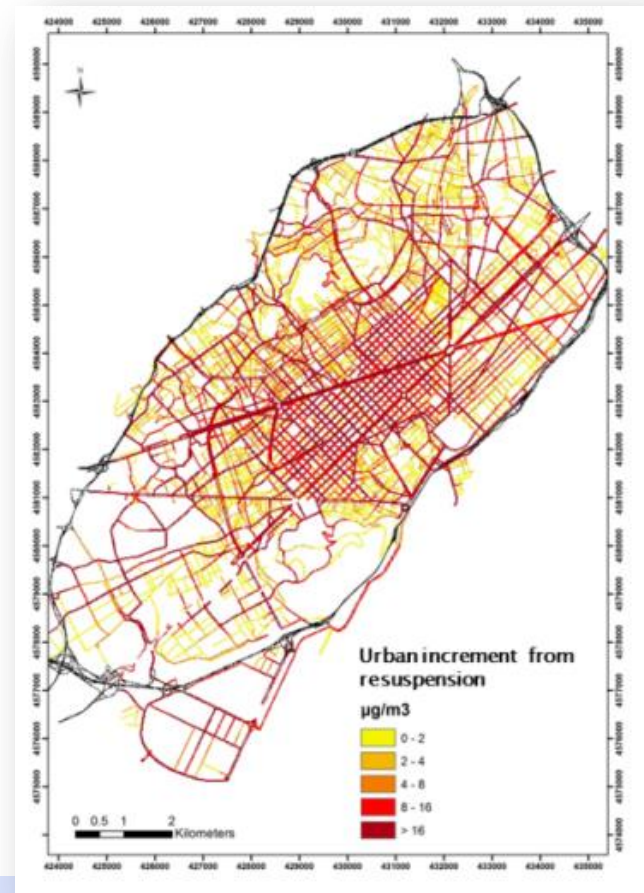
Road dust in Barcelona



Background level

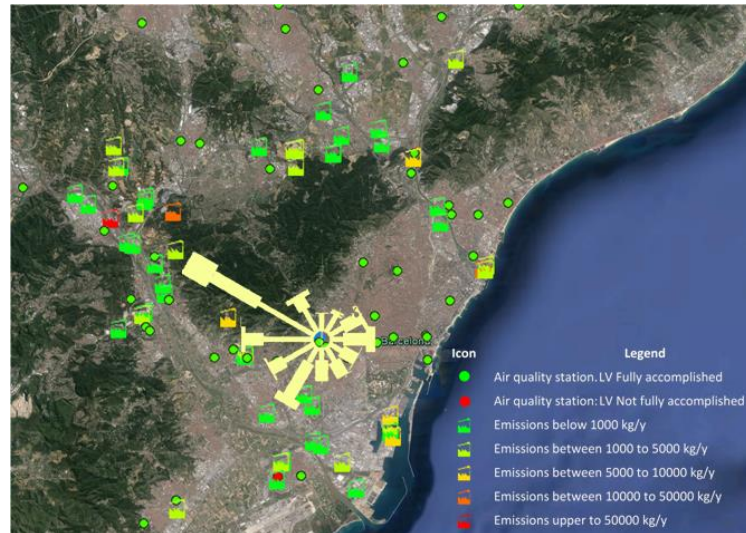


Street level





Local dust in Barcelona (mostly diffuse emissions from industry, construction, harbor...)





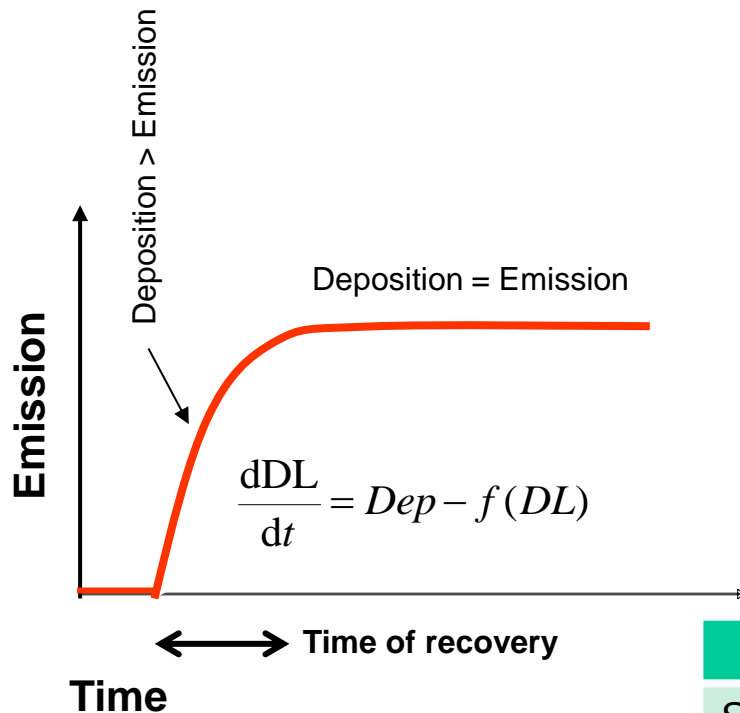
AIRUSE recommendations on anthropogenic dust emissions:

- Emission inventory
- Mitigation measures
 - Resuspension during transportation
 - Demolition
 - Earthworks (Loading/unloading, storage..)
 - Construction

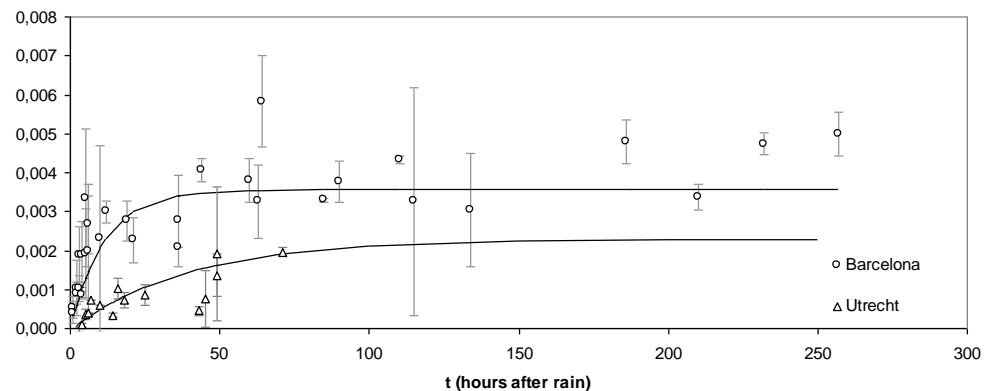




Road dust: improving **temporal** distribution of emissions



Emission recovery after rain



	50% recovery	99% recovery
Southern Europe	8	24
Central Europe	24	72



Industrial dust (diffuse) emissions

Ideal

Required information for inventory

Activities that can generate fugitive emissions

Quantity of dusty material handled

Distance travelled by trucks inside the company

Transport distances on paved and unpaved roads

Storage area and amount of stored dusty material

Mitigation measures implemented

Maintenance of the mitigation measures





Industrial dust (diffuse) emissions

AIRUSE approach

Methodology: PM₁₀ and PM_{2.5} emissions were calculated from amount of bulk material handled or production data, applying generic emission factors.

Transport of bulk solids has not been considered (30-600g PM₁₀/km)

Two handling operations have been considered (1-260g PM₁₀/t)



Primary PM fugitive emissions have been underestimated


PM₁₀/TSP and PM_{2.5}/PM₁₀ ratios and emission factors were obtained from the following databases: EMEP/EEA, AP 42 (US-EPA), AUSTRALIA-EPA and IIASA



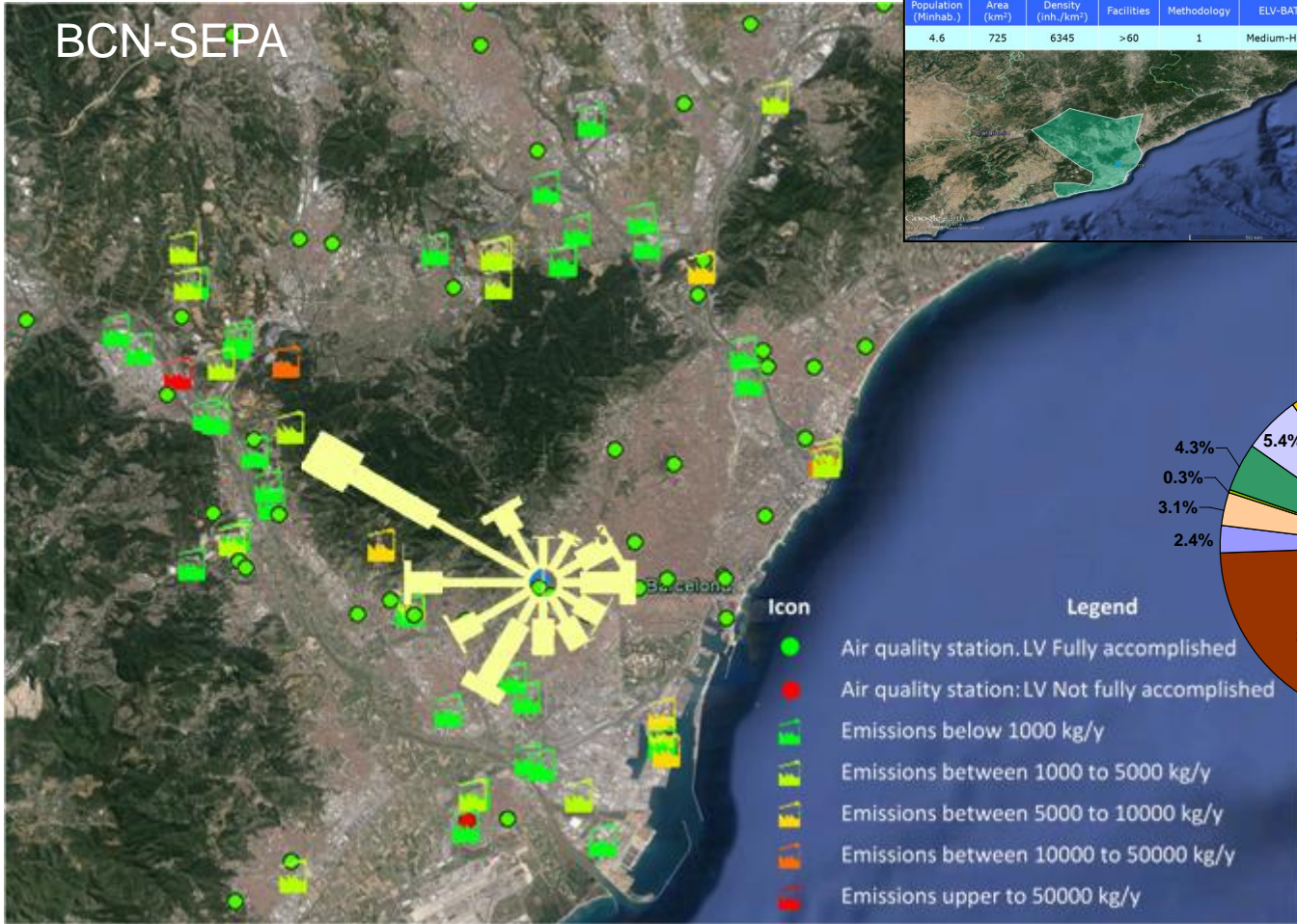
Industrial emissions inventory in Barcelona

BCN-SEPA

Study area			Industrial emission inventory		
Population (Minhab.)	Area (km ²)	Density (inh./km ²)	Facilities	Methodology	ELV-BAT
4.6	725	6345	>60	1	Medium-High

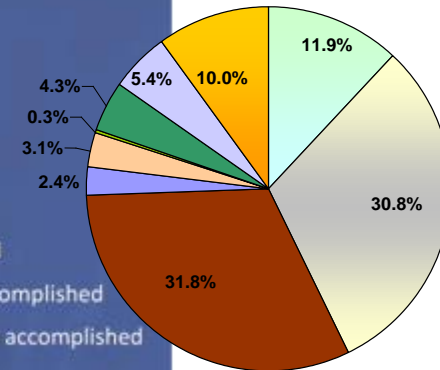


- Energy sector
- Production and processing of metals
- Mineral industry
- Chemical industry
- Waste
- Paper and wood production processing
- Animal and vegetable products
- Other activities non IED
- Port of Barcelona

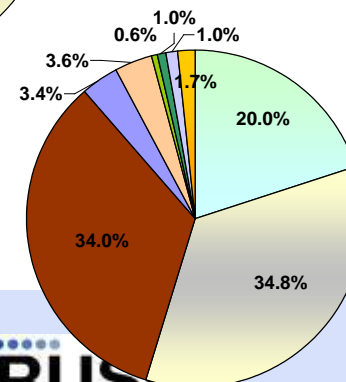


- Icon**
- Air quality station: LV Fully accomplished
 - Air quality station: LV Not fully accomplished
 - Emissions below 1000 kg/y
 - Emissions between 1000 to 5000 kg/y
 - Emissions between 5000 to 10000 kg/y
 - Emissions between 10000 to 50000 kg/y
 - Emissions upper to 50000 kg/y
- Legend**

PM10



PM2.5

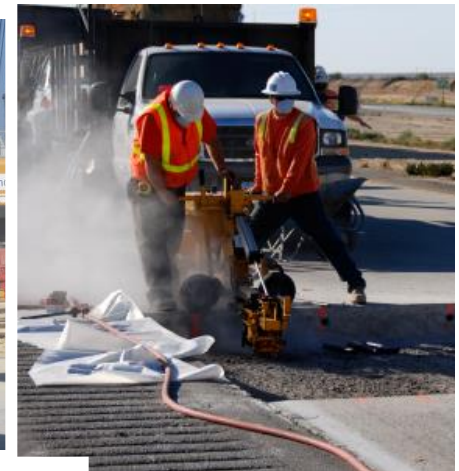




Dust diffuse emissions

Developing and compiling specific **PM fugitive emission factors** and control **efficiencies**

PORT
ACTIVITIES



INDUSTRIAL ACTIVITIES



PUBLIC WORKS





Dust diffuse emissions

Developing and compiling specific **PM fugitive emission factors** and control **efficiencies**

MAIN GAPS:

- A. Most of the inventories do not consider PM fugitive emissions
- B. Port activities are not included in E-PRTR
- C. No emission factors in EMEP/EEA for port activities
- D. Limited information about the efficiency of the best practices

PORT
ACTIVITIES



PUBLIC
WORKS

INDUSTRIAL
ACTIVITIES





Extending information to **improve transparency**

Welcome

The *European Pollutant Release and Transfer Register (E-PRTR)* is the Europe-wide register that provides easily accessible key environmental data from industrial facilities in European Union Member States and in Iceland, Liechtenstein, Norway, Serbia and Switzerland. It replaced and improved upon the previous European Pollutant Emission Register (EPER). The new register contains data reported annually by more than **30,000 industrial facilities** covering 65 economic activities across Europe. For ... **more**

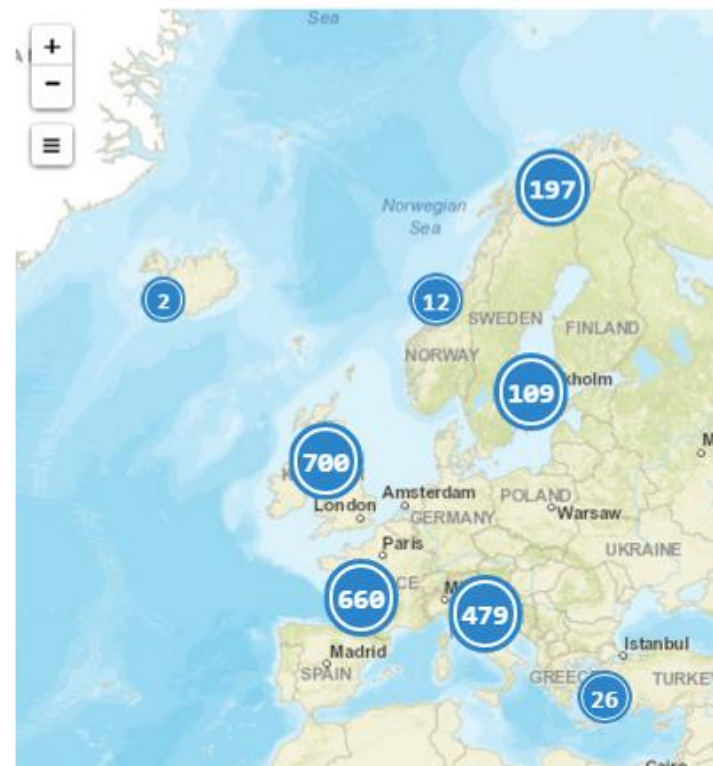
Search the register

- Facility Level
- Industrial Activity
- Area Overview
- Pollutant Releases
- Pollutant Transfers
- Waste Transfers

Diffuse emissions

- Releases to air
- Releases to water

E-PRTR Facilities





Extending information to **improve transparency**

Emisiones a la atmósfera

Contaminante	Año de referencia	Cantidad (t/año)	Categoría	Acción
Monóxido de carbono (CO)	2009	633.831		
	2010	3.870.386	E	
	2014	877.000	C	
Óxidos de nitrógeno (NOx/NO2)	2009	211.041		
	2010	405.150		
	2014	1.650.000	C	
Partículas (PM10)	2009	51.090	M	
	2010	67.686	E	
	2013	103.000	E	
	2014	120.000	C	

Output rate??

Fuel??

Raw materials handled??

Channelled / fugitive sources??

BATs??



Harmonising key control parameters: air quality, ELVs and E-PRTR

DIRECTIVE 2008/50/EC
on **ambient air quality**
and cleaner air for
Europe
(PM10/PM2.5)

DIRECTIVE 2010/75/EU on
industrial emissions
(TSP)

REGULATION (EC)
166/2006 concerning the
establishment of an
European **PRTR**
(PM10)

HARMONISE






RECOMMENDATIONS

Mitigation of resuspension from paved and unpaved roads



Mitigation tests in Europe

	 Redust	 CMA+	Aldrin et al., 2008	Norman and Johansson, 2006	Reuter, 2010	Barratt et al, 2012	 AIRUSE
	Finland	Alps	Norway	Sweden	Germany	UK	Southern EU
Washing	40% weekly						??
CMA		20-30% daily		35% daily	NO effect	40% only at industrial site	??
MgCl₂			30% daily				??
CaCl₂	40% daily						??





AIRUSE tests

Urban road

- Water flushing
- CMA
- MgCl₂

Industrial paved road:

- Sweeping+Washing
- CMA

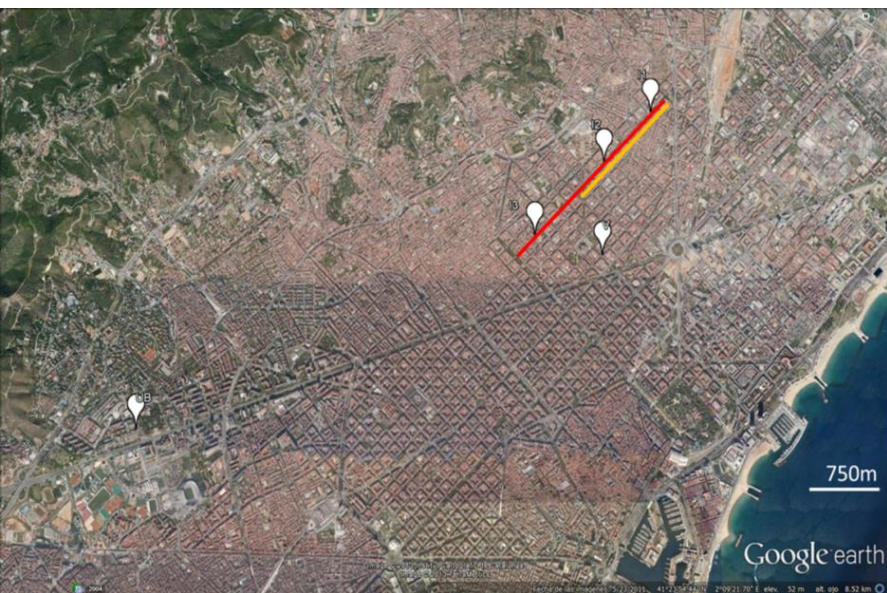
Industrial unpaved road:

- Water flushing
- CMA





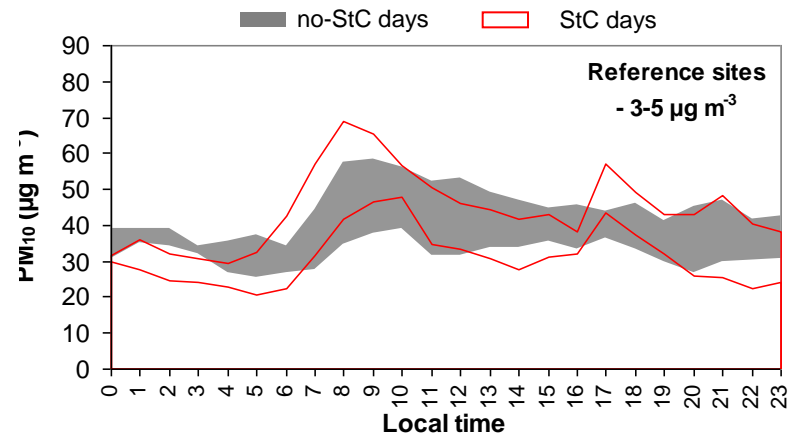
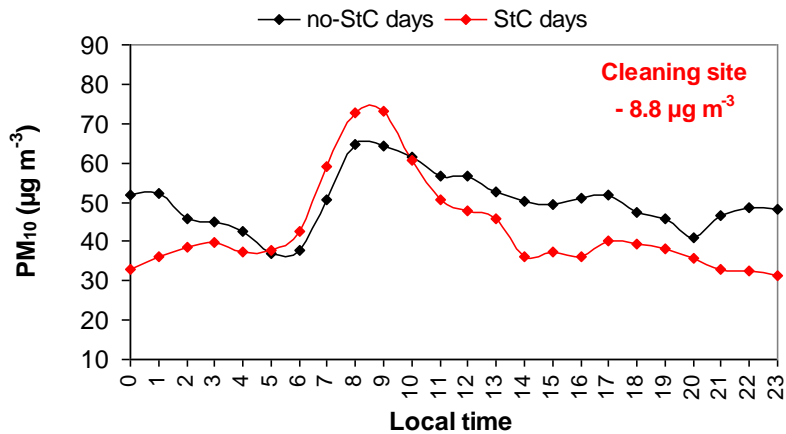
Urban road (Barcelona)



- Dust Track, TEOM and GRIMM;
- High volume samplers PM₁₀ (daily)
- High volume samplers PM_{2.5} (every third day).
- PM chemical characterization (ions, elements, OC and EC);
- Streaker for PM_{2.5} and PM_{2.5-10};
- Black Carbon (MAAP and mini-aeth);
- NO_x, O₃ and SO₂ and meteo.



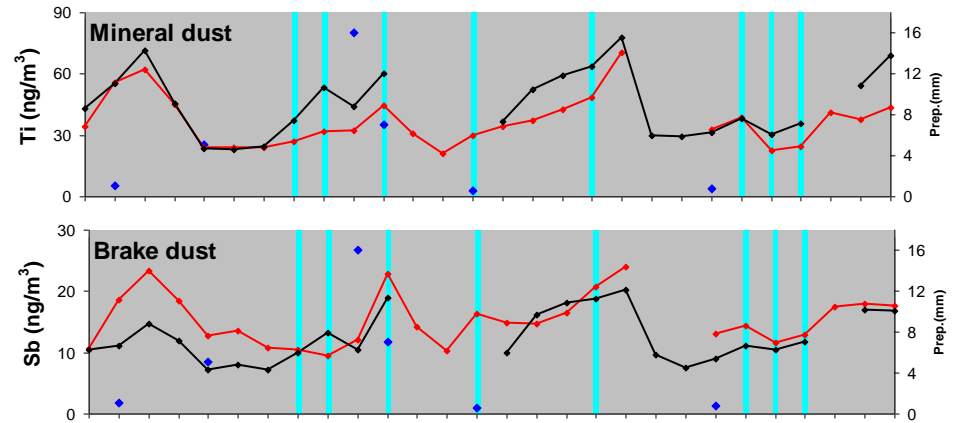
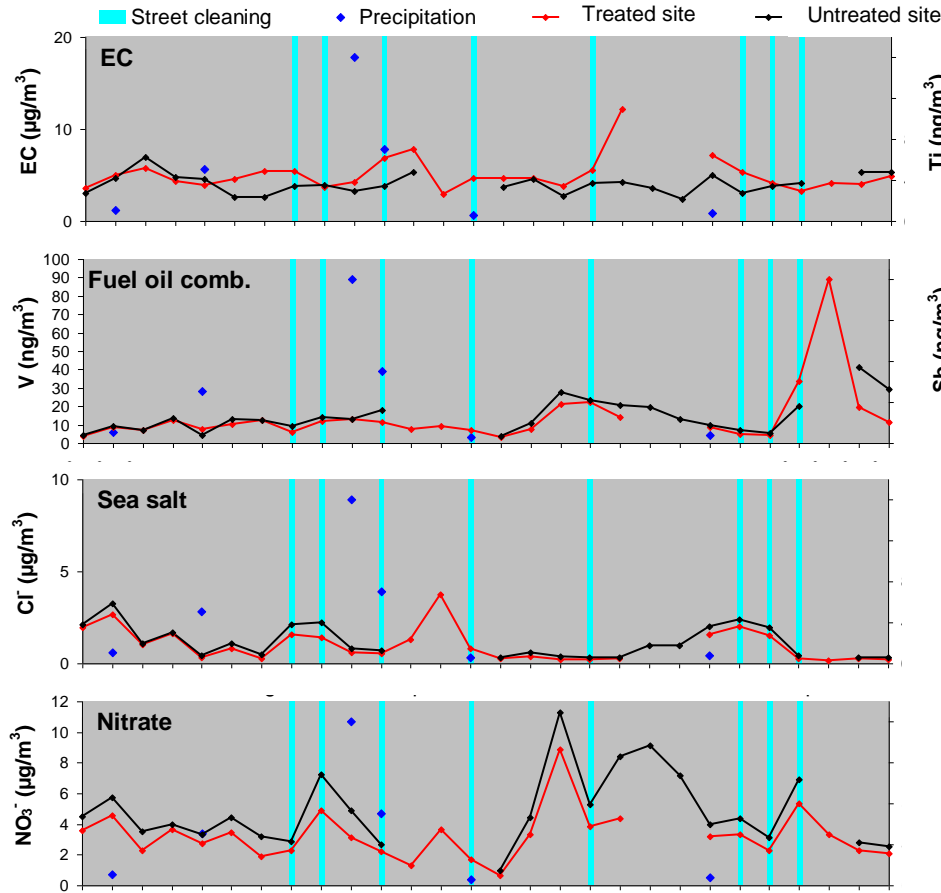
Urban road (Barcelona): **water flushing**



Reduction: 4-5 $\mu\text{g m}^{-3}$ (7-10%)

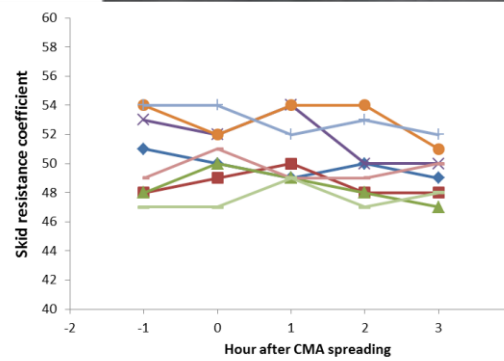
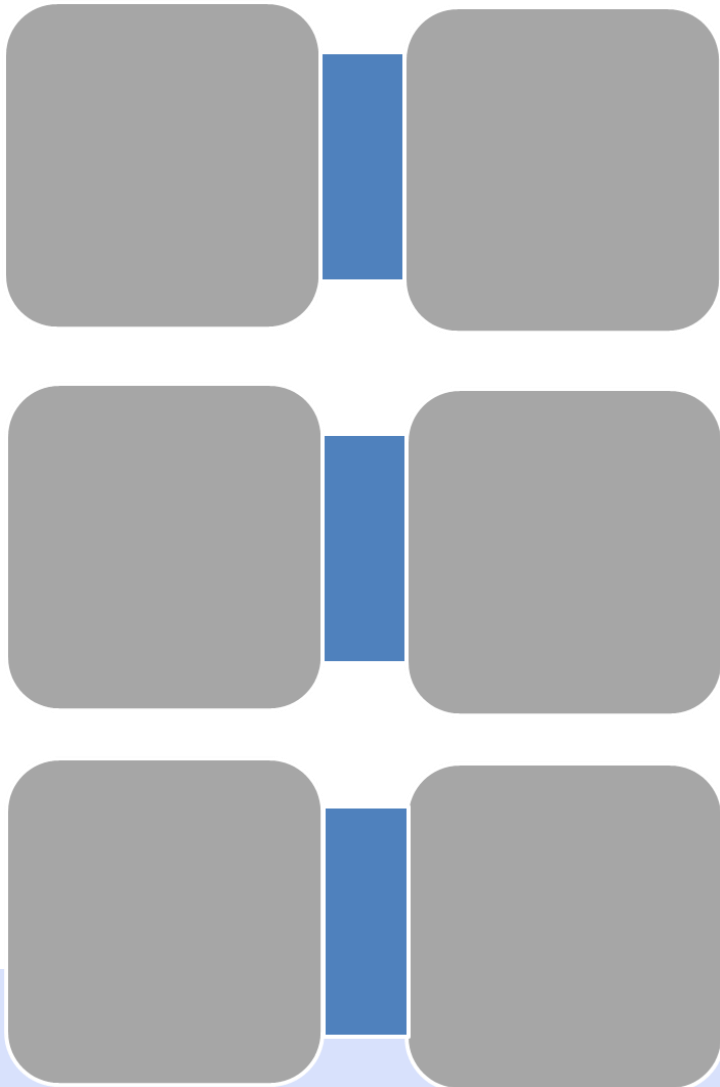


Urban road (Barcelona): water flushing



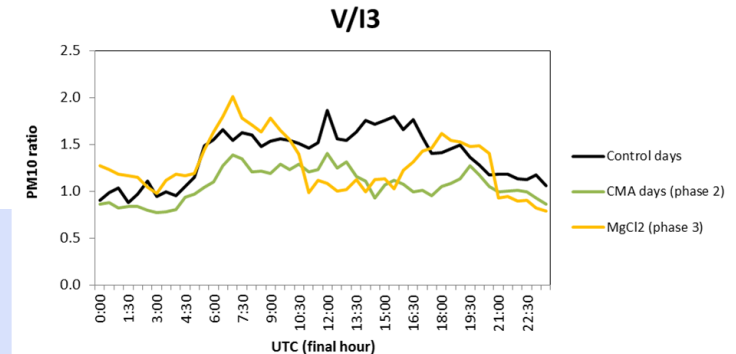
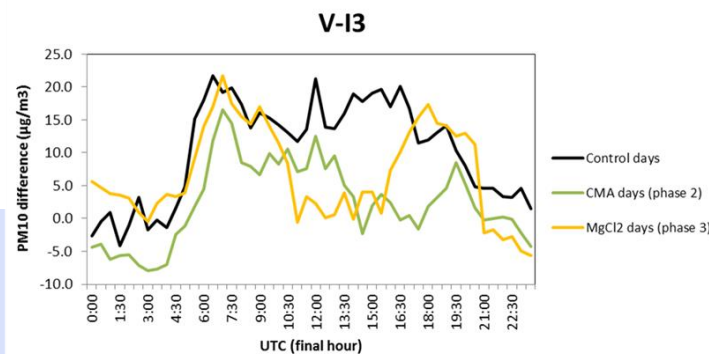
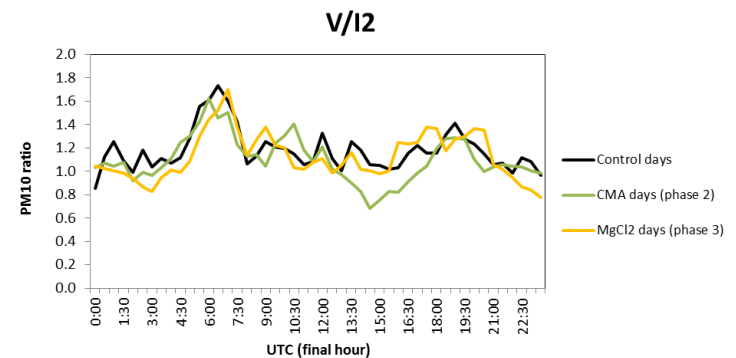
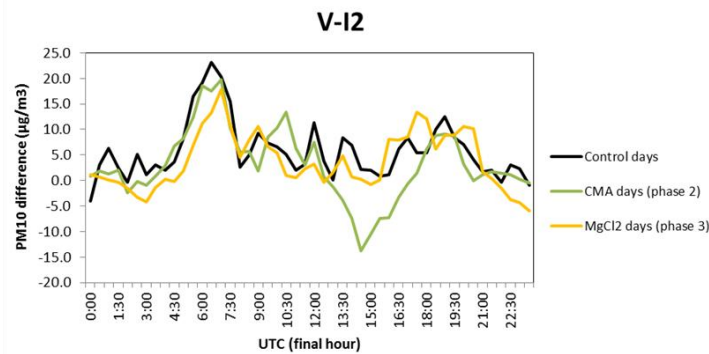
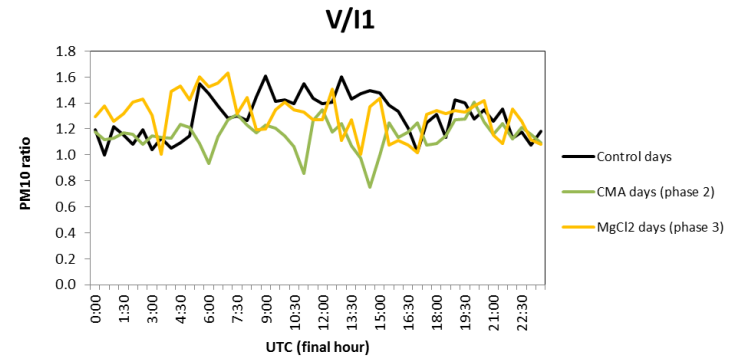
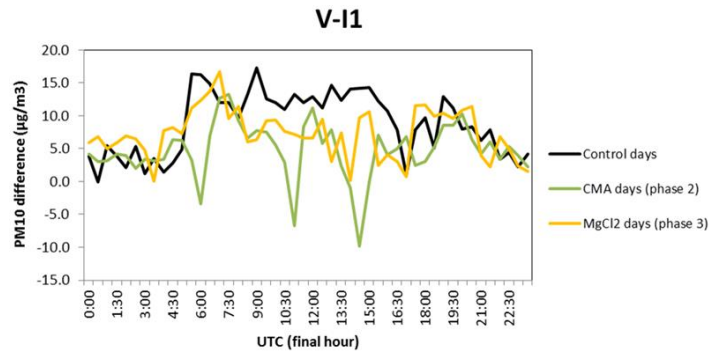


Urban road (Barcelona): **CMA and MgCl₂**



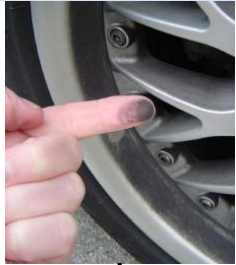


Urban road (Barcelona): CMA and MgCl₂





Urban road (Barcelona): CMA and MgCl₂



Fe, Cu, Sb, Sn, Ba...

Zn

Ca, Al, Fe, Si, Ti...

Mineral	phase 1				phase 2			phase 2 - 48h			phase 3		
	V-I2	V-I1	I3-I2	I3-I1	V-I3	V-I2	V-I1	V-I3	V-I2	V-I1	V-I3	V-I2	V-I1
Mineral	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	-	-	-	-	-	1	-	2	0	-	9	5	-
Ca	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe	-	-	-	-	-	-	-	-	-	-	-	-	-
K	5	-	7	-	-	5	-	5	4	3	-	6	3
Mg	-	-	-	-	-	-	1	-	-	8	19	-	29
Li	-	-	-	-	-	4	-	8	7	9	4	-	-
Ti	-	-	-	-	-	-	-	1	-	1	-	-	-
Cr	5	26	-	-	10	7	-	30	12	-	16	12	24
Mn	-	-	-	-	-	-	-	8	-	1	-	-	-
Cu	22	45	-	9	8	2	-	5	-	-	-	-	-
Zn	-	-	-	-	2	-	3	24	1	17	25	-	11
Ga	-	-	-	2	0	-	6	18	-	11	2	2	-
Rb	-	-	4	-	-	-	-	-	-	-	1	-	-
Sr	-	-	-	-	-	-	-	1	-	-	-	-	-
Sn	-	-	-	11	-	-	-	-	-	-	-	-	-
Sb	12	53	7	43	8	31	8	-	24	14	-	-	-
Ba	-	-	-	-	-	-	-	-	-	-	-	-	-
La	-	-	5	14	-	-	0	8	-	13	-	9	-
Ce	-	-	8	25	-	-	-	-	-	1	-	4	-
Pb	8	6	5	2	-	-	-	17	-	5	6	-	-
Bi	-	31	15	49	-	-	-	5	-	-	-	-	12



Industrial (ceramic) paved road

- 250 companies (tiles, spray-dried granules, pigments..)
- 17% of the worldwide supply
- consumes 12 Mt/year of clay

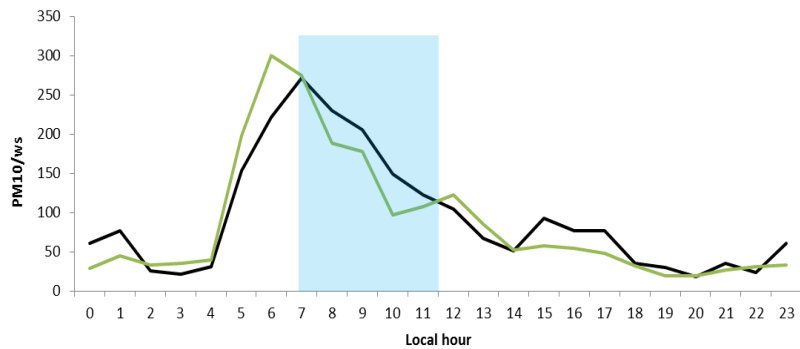




Industrial paved road

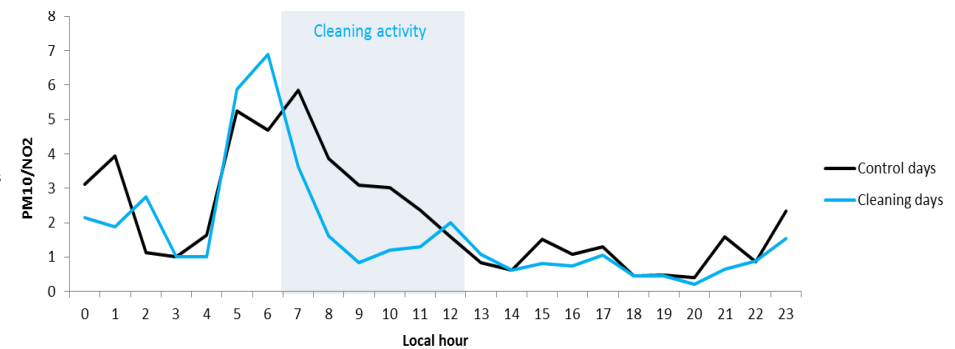


CMA 8% reduction

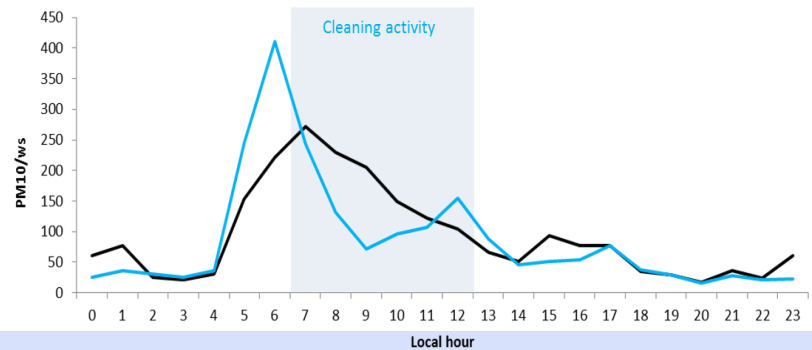
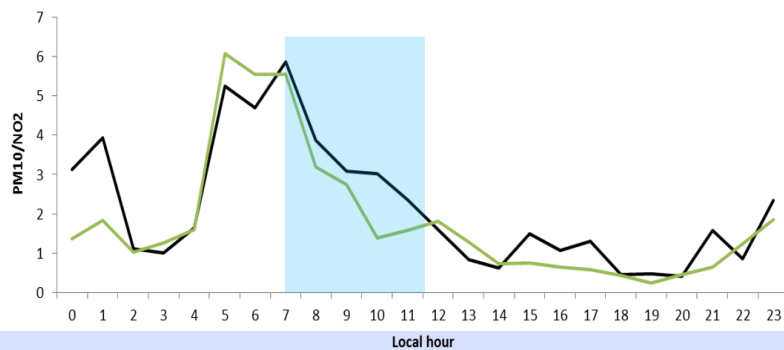


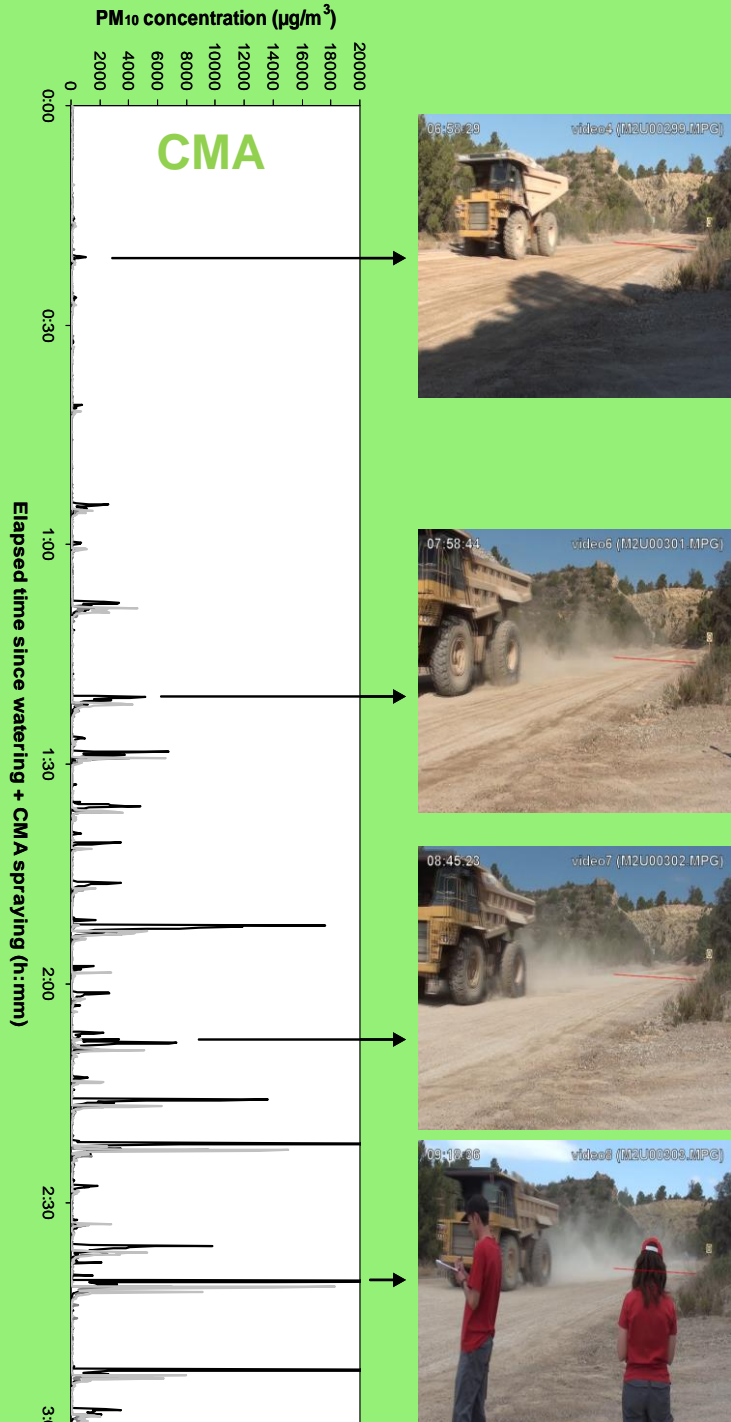
Control days
CMA days

Water-flushing 18% reduction



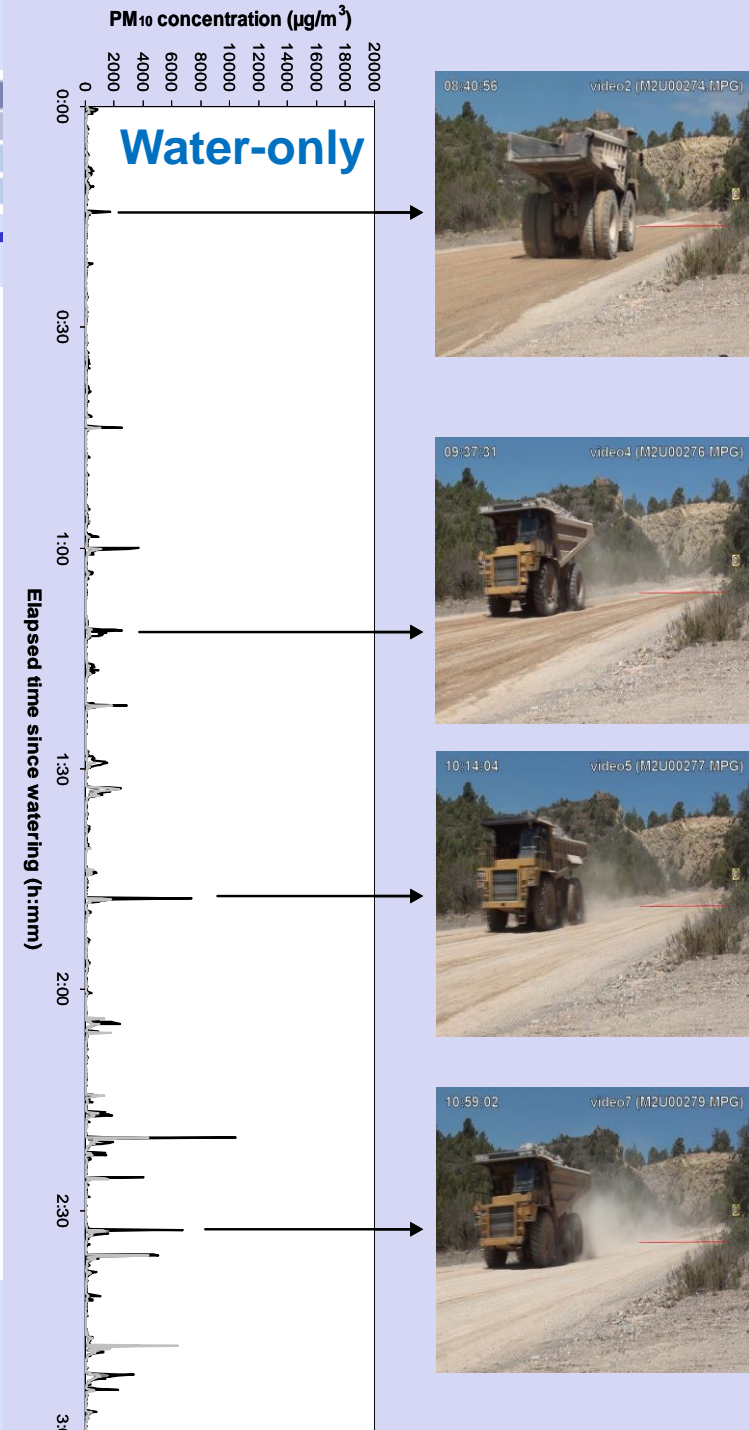
Control days
Cleaning days





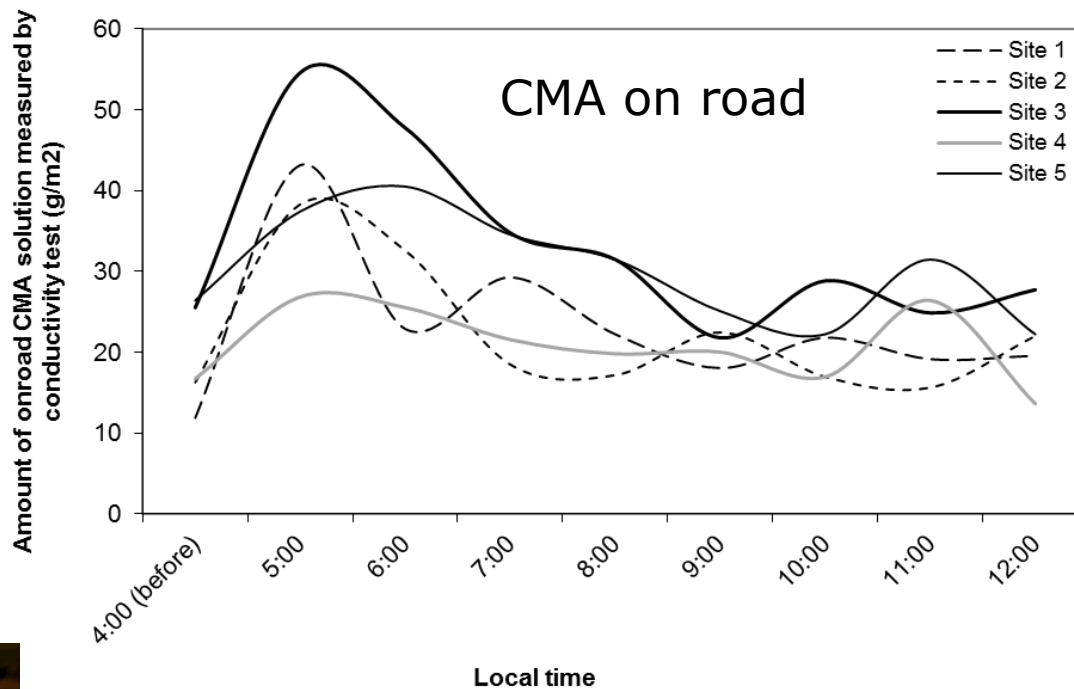
Unpaved r

<http://airuse.eu/media/watering.mp4>





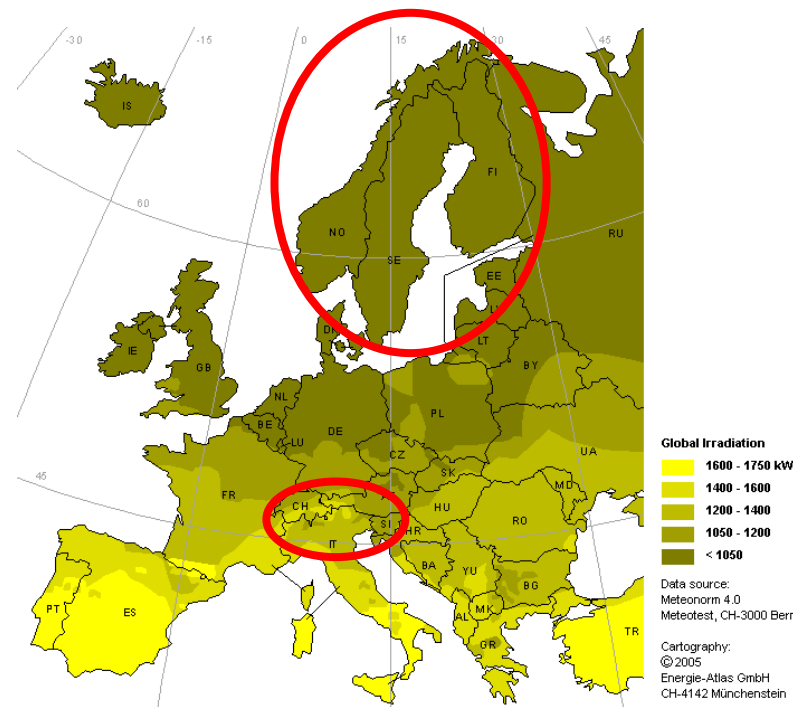
Why dust binders don't work in South Europe?





Critical parameters for dust binding efficacy:

- Solar radiation (low)
- Relative humidity (high)
- Dust loading (high)





Conclusions

- Anthropogenic dust contributes 16-28% and 4-20% to background PM10 and PM2.5, respectively
- Concentrations rise sensibly at kerbside or hotspots
- Fugitive emissions from traffic, industry, harbor and construction need to be included in Emission Inventories
- Dust resuspension in Southern Europe is better reduced by water flushing (rather than dust suppressants)
- Recommendations available in AIRUSE deliverables (e.g. Guidebook)

Thank you very much for your attention



ACKNOWLEDGEMENTS

EC- LIFE+ PROGRAM

Spain	MAGRAMA, GenCat, Barcelona, Alcora and Madrid City Councils, URBASER, Cantera La Torreta
Italy	ARPA-Lombardia, Regione Lombardia, Regional Government of Tuscany, ARPA Toscana
Portugal	Porto City Council, North Regional Coord. & DeveloP. Comm. (CCDR-N)
Greece	Ministry of Environment, Energy and Climate Change
Spain	M. Brritte Larka, A. Orio, M. Pallares, I. Hernández, A. Cristobal, E. Aulí
Portugal	C. Figueiredo (CCDR-N); J. Monjardino (CENSE, Universidade Nova de Lisboa)
Italy	F. Forni (Regione Toscana),
Greece	M. Lazaridis y Athina Progiou (Proyecto ACCEPT AIR)

***Thank you very much
for your attention!!!***



Conclusions on mitigation in South Europe

- ✓ Road/Mineral dust emissions can be mitigated
- ✓ Street washing revealed the highest efficiency in reducing mobility of particles in S. Europe.
- ✓ The effect is short lived (<8hours), and should be performed before rush hours
- ✓ Sweeping, CMA and $MgCl_2$ do not offer evidence of efficacy in the Mediterranean climate



RECOMMENDATIONS

Addressed to stakeholders



Awareness-raising activities

1. **Organising specific events** (workshops, info-days...) for cities, industrial associations, harbour managers, local authorities, health groups, etc
2. **Involvement of stakeholders** can greatly increase **emission inventories accuracy**



Thank you very much for your attention!

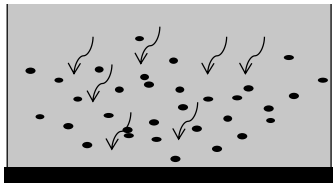
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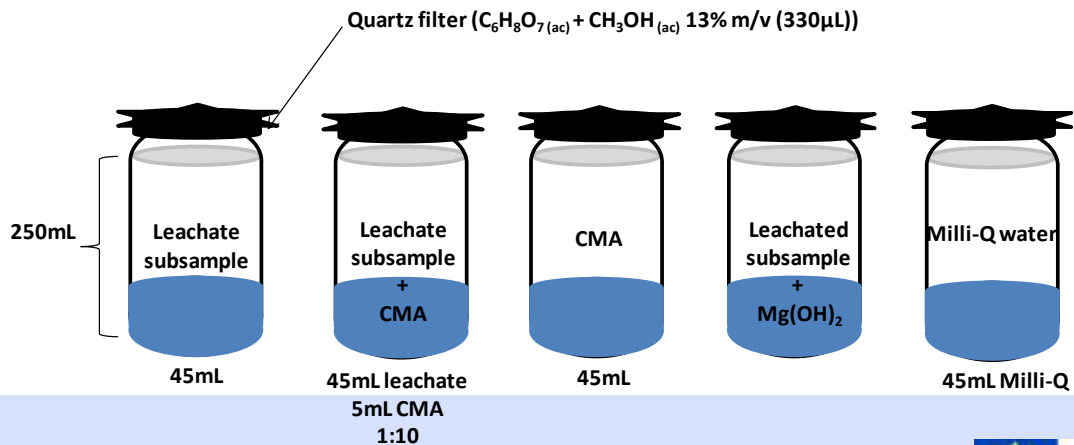
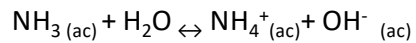
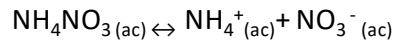
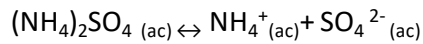
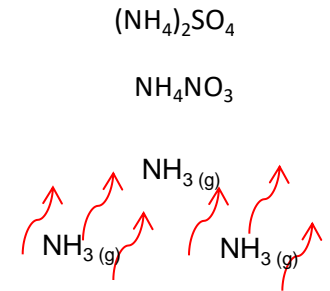
CMA: possible NH₃ stripping



pH = 6.8



CMA
pH = 9.2



97% NH₃ stripping



Conclusions

Source	Location	Dust loading	Measure	Dosage	PM10 reduction	Notes on measurement
Road dust	Urban paved road	3-6 mg/m ²	Street washing	1 L/m ²	7-10% on a daily mean	kerbside
			CMA	15-20 g/m ²	Negligible	kerbside
			MgCl ₂	15-20 g/m ²	Negligible	kerbside
	Industrial paved road	20-40 mg/m ²	Street washing	27 L/m ²	18% on a daily mean	kerbside
			CMA	30-60 g/m ²	8% on a daily mean	kerbside
	Industrial unpaved road		Street washing	3.5 L/m ²	>90% up to 1 h	downwind
			CMA	100 g/m ²	Not observed	downwind

Thank you for the attention!





B2 SUMMARY OF FINDINGS

- PM10 and PM2.5 limit values are exceeded in traffic sites and in the urban background at the Milano (the issue of the Po Valley)
- B6,7,8** • Emissions from road traffic accounts for a high proportion of PM10 and PM2.5 on both annual basis and days of exceedance of the limit values (30-45%)
- B7** • Mineral dust+road dust account also for a large proportion of PM (10-30% PM10)
- B4** • In a number of cities biomass burning is the second source contributing, but in exceedance days contributions are similar to road traffic
- B8** • Primary emissions from shipping contribute around 5% of PM in coastal areas
- B5** • Industry still contributes around 10-15 % of PM with primary emissions, and 15-25% with primary+secondary PM
- B3** • Natural contributions are very relevant in Porto (sea salt) and Athens (African dust), but also present in the other cities

B3. Natural sources

B4. Biomass burning

B7. Developing & testing cost-effective PM measures & strategies

B5. Industrial sources

B6. Traffic related sources

B8. Applicability of selected measures from N to S Europe

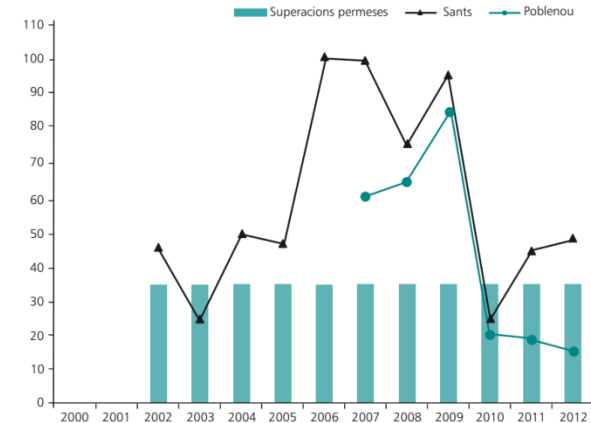


Urban park: Nano-polymer

Product: 10-20 nm Optimadust
Area: 6200 m²
Spreading: 18th March 2013 (1%)
22nd April 2013 (2.5%)
23rd April 2013 (2.5%)



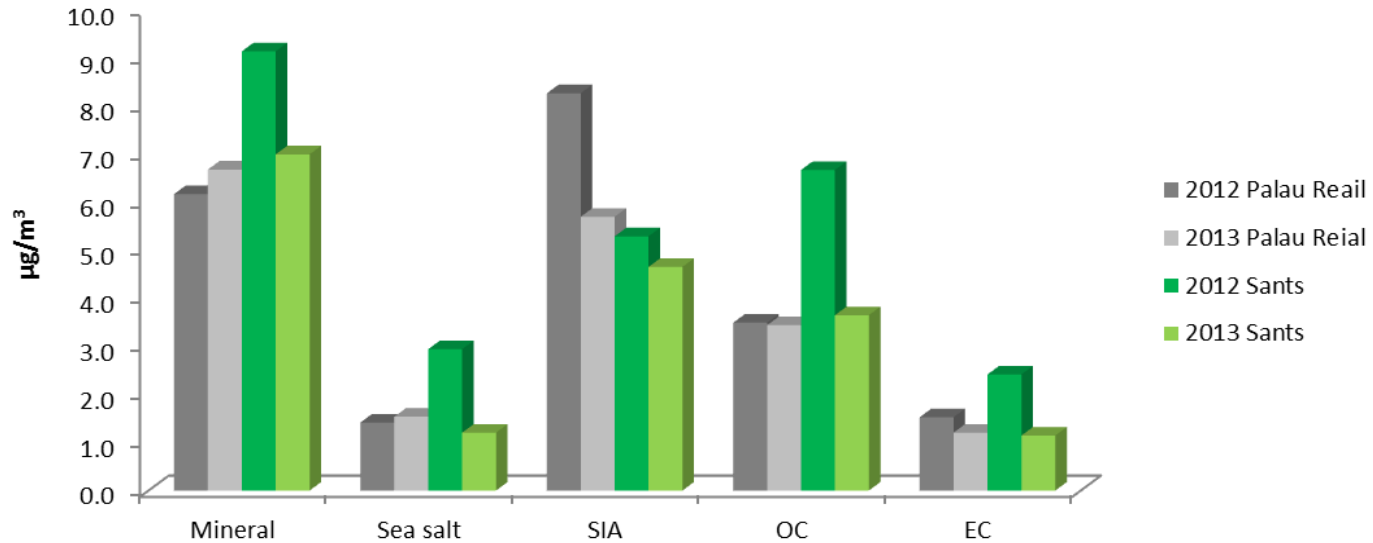
Estacions de trànsit moderat





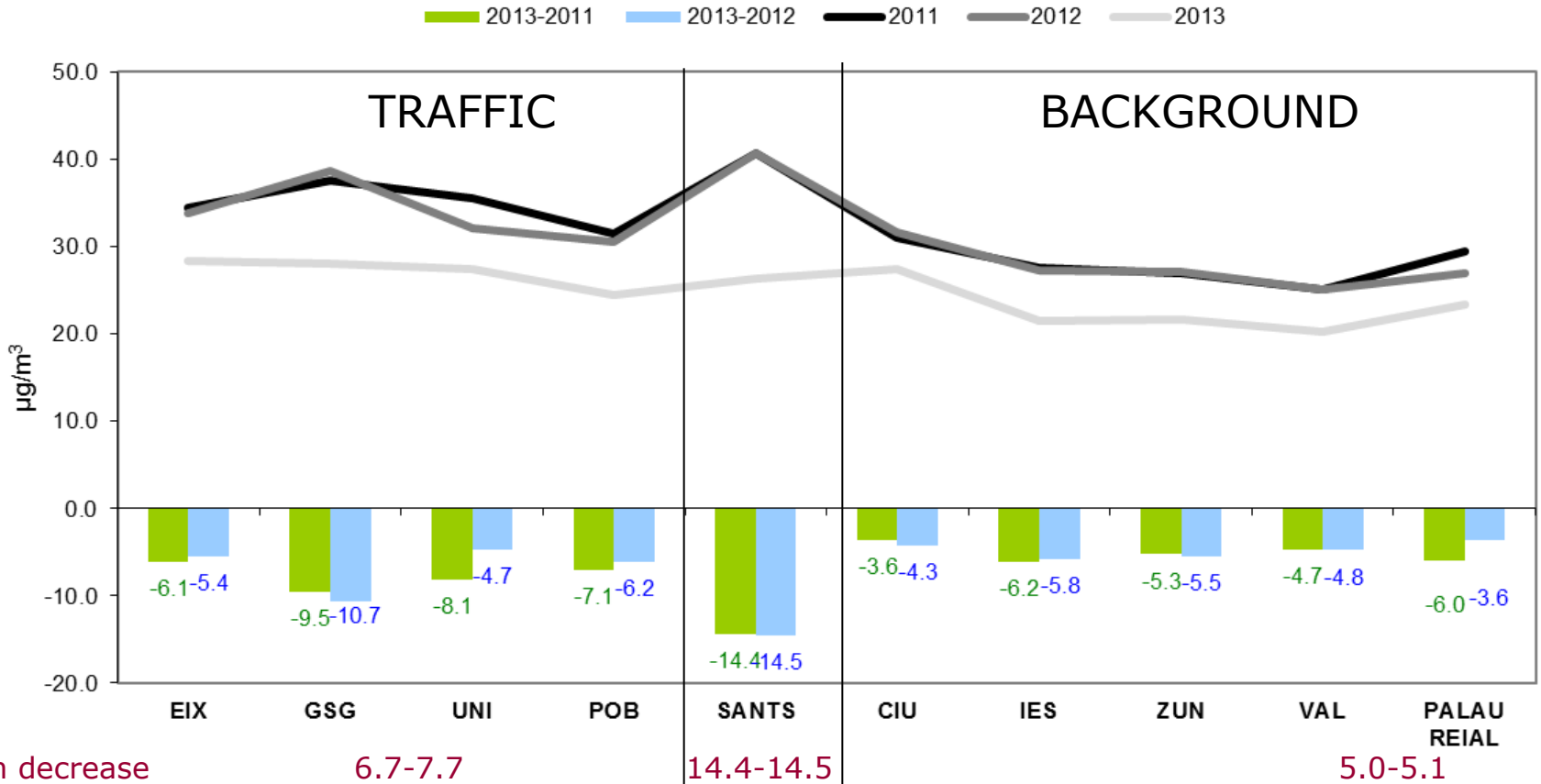
Urban park: Nano-polymer

Net decrease Mineral dust: $2.9 \mu\text{g}/\text{m}^3$

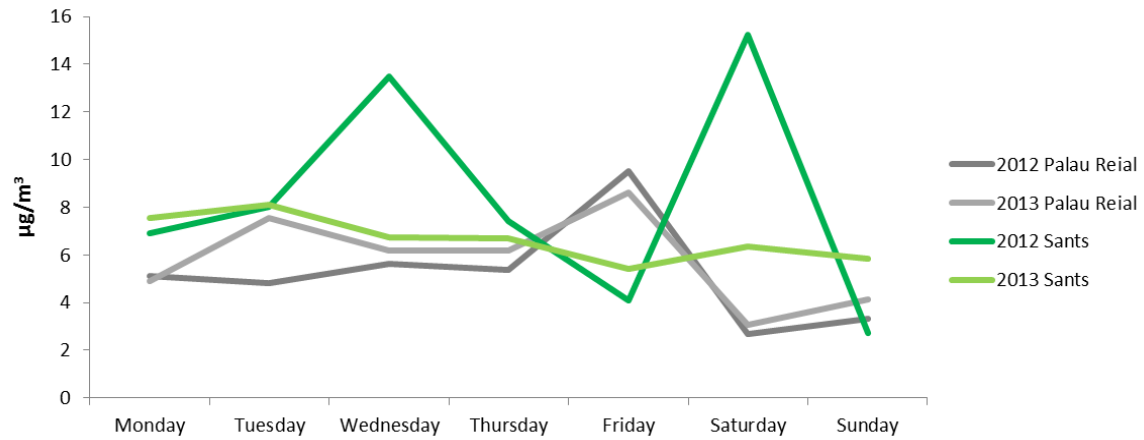




Urban park: Nano-polymer



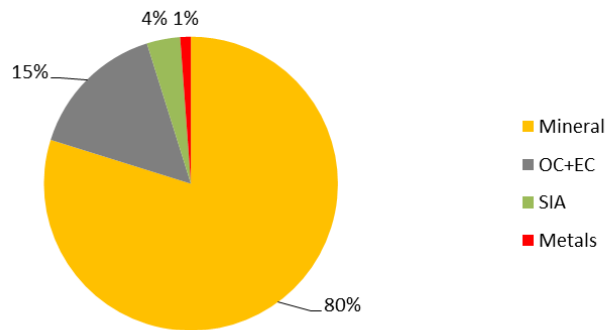
Net decrease: 4-5 µg/m³ (11%)



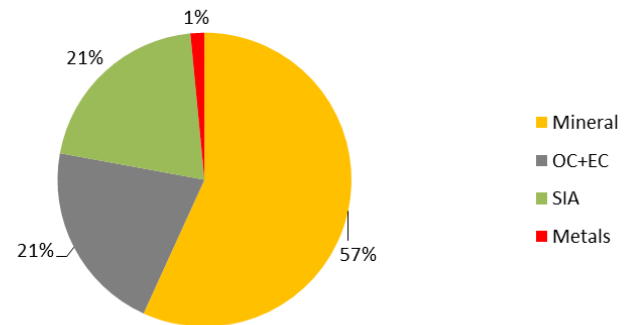


Road dust and African dust

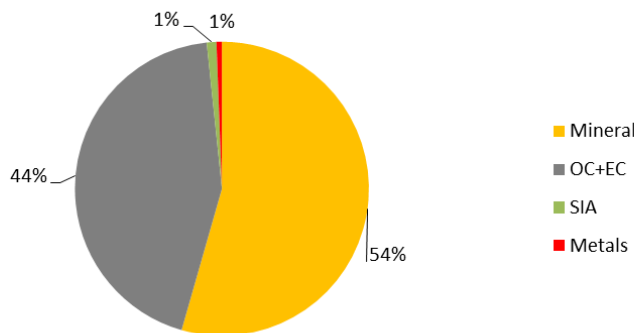
Barcelona



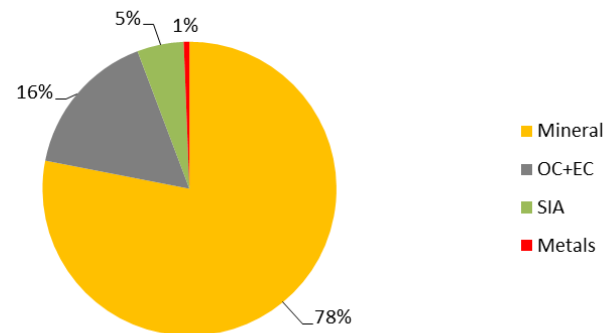
Athens



Porto



Florence





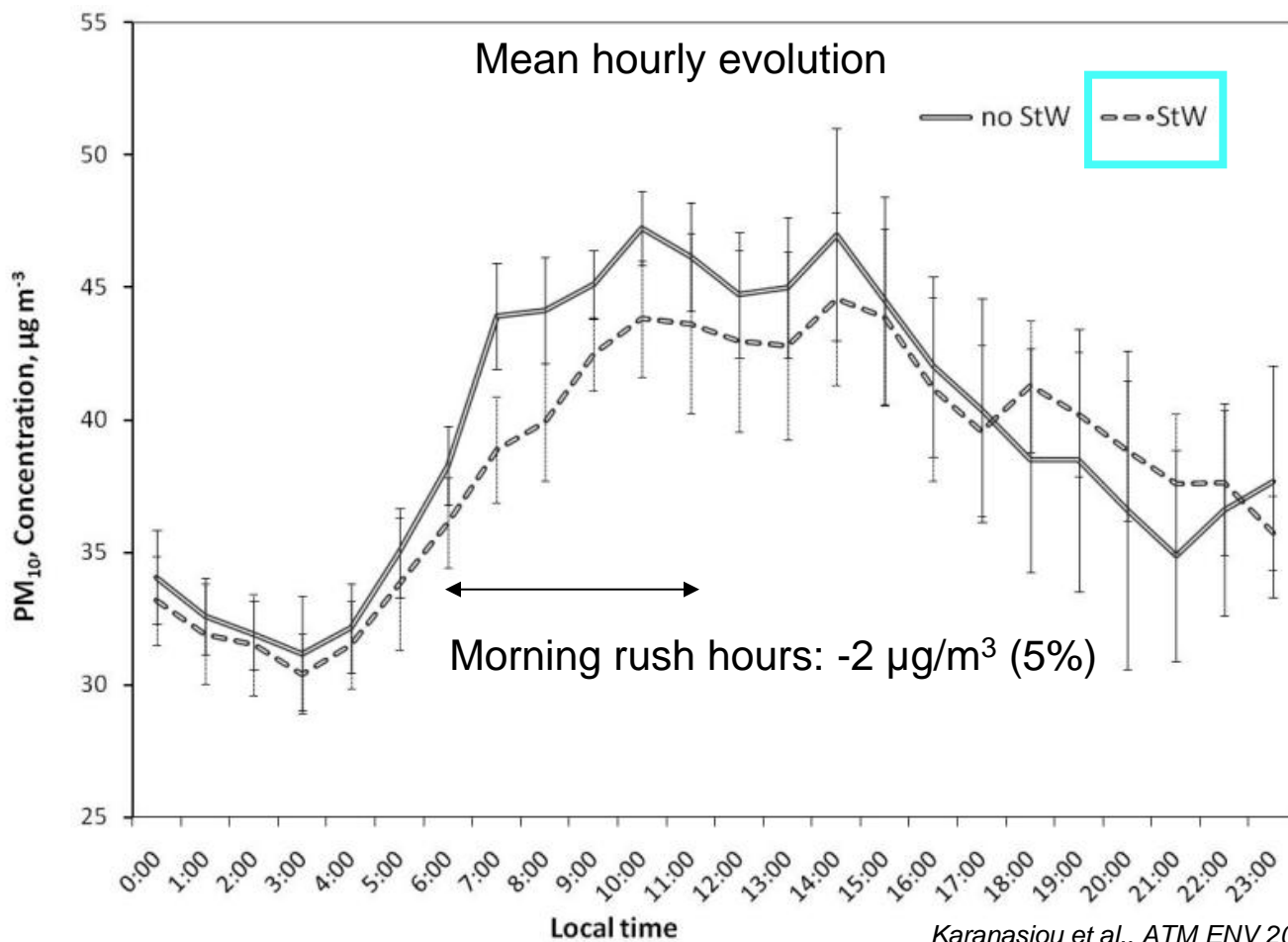
Madrid city center



Velazquez Avenue
32,000 veh day⁻¹

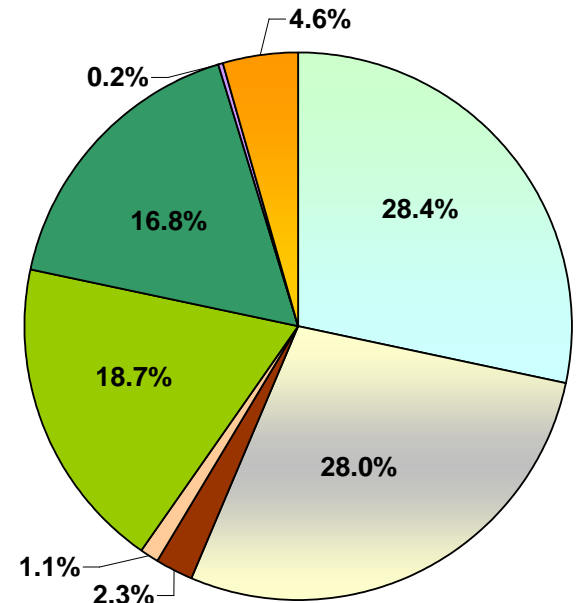
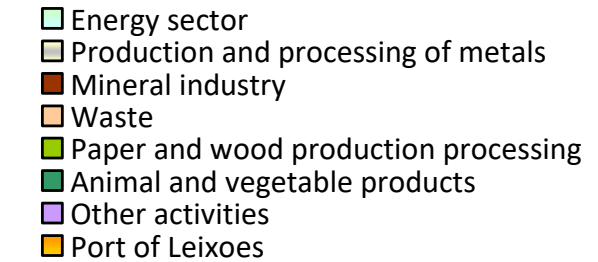
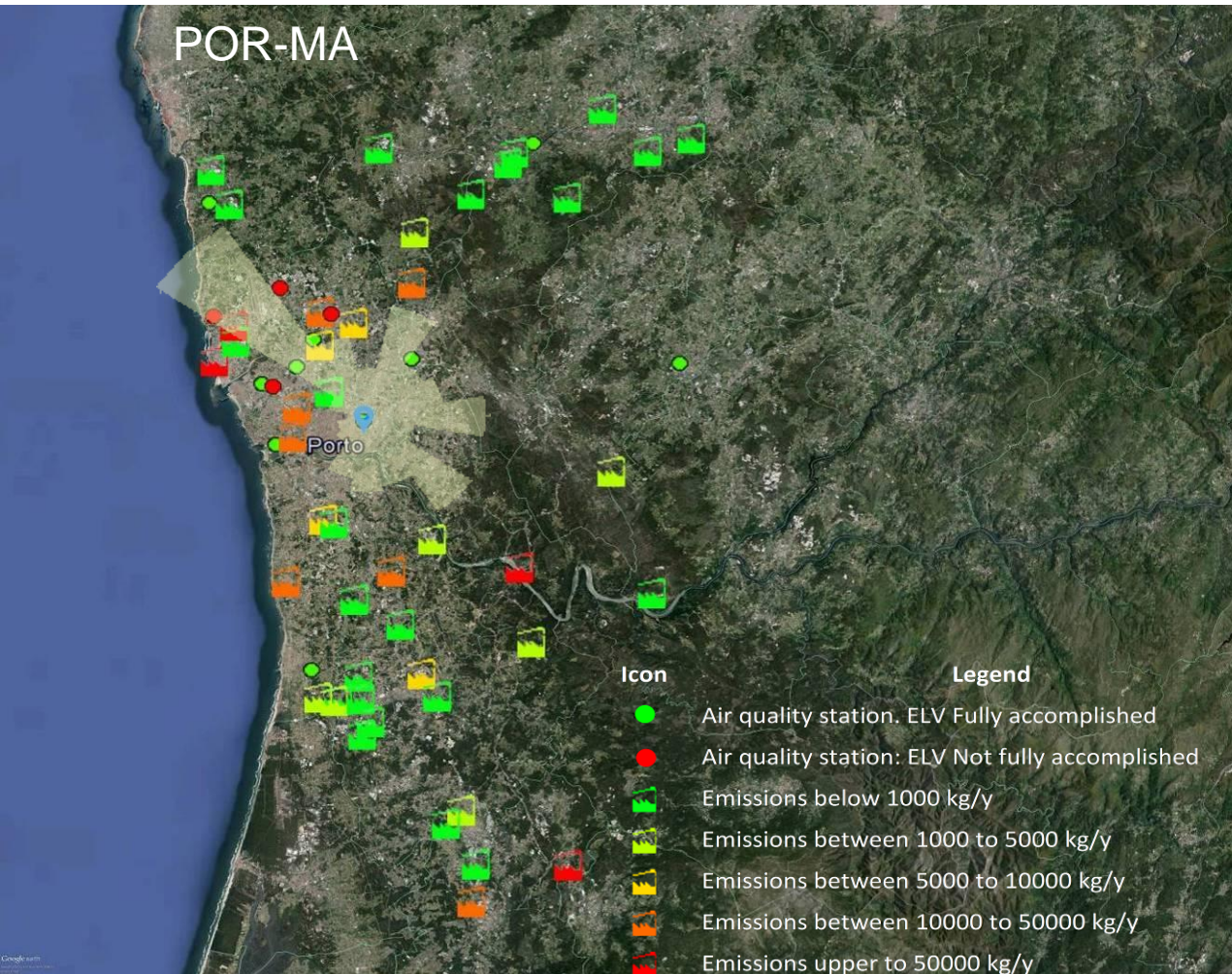


3. Madrid





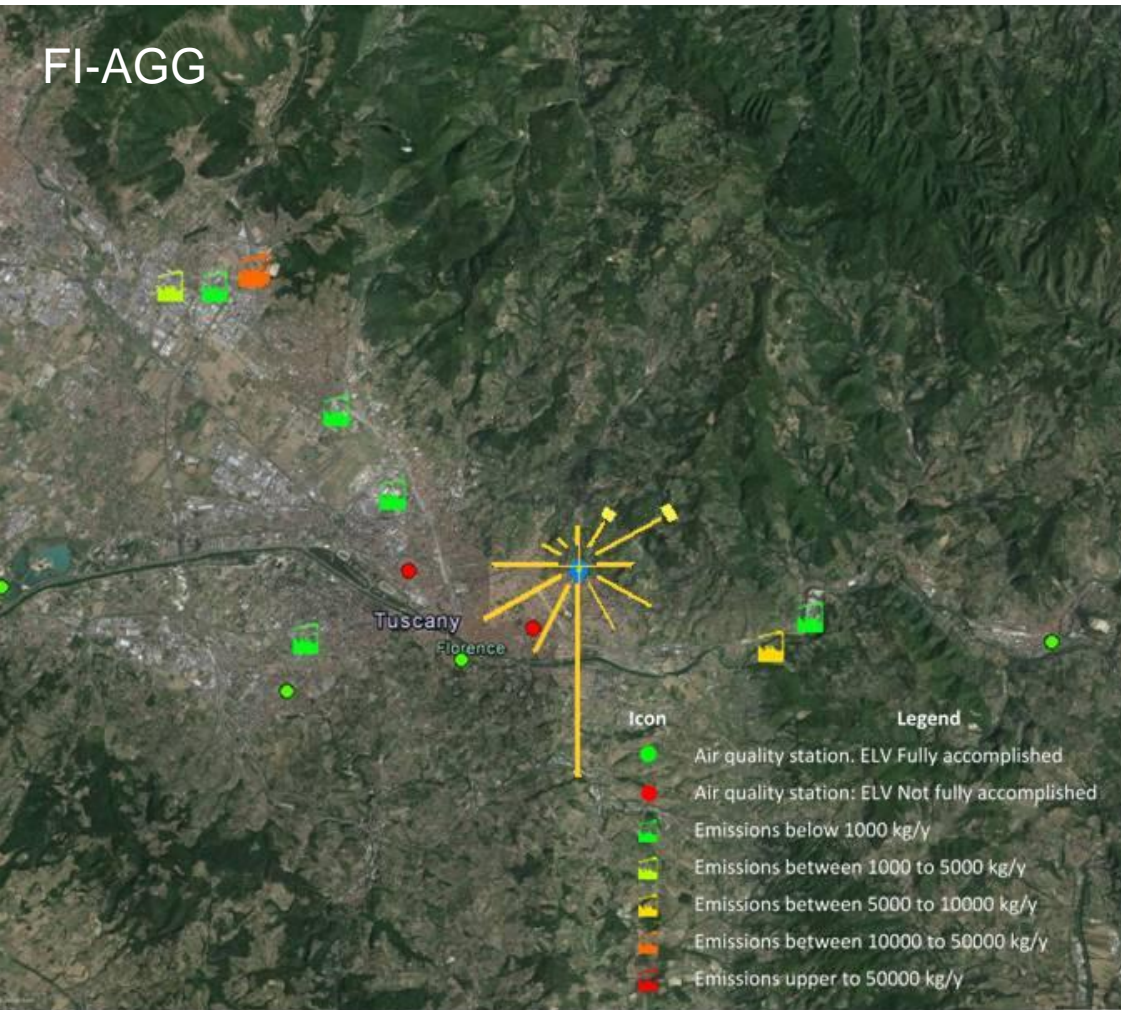
Primary Industrial PM10 emissions



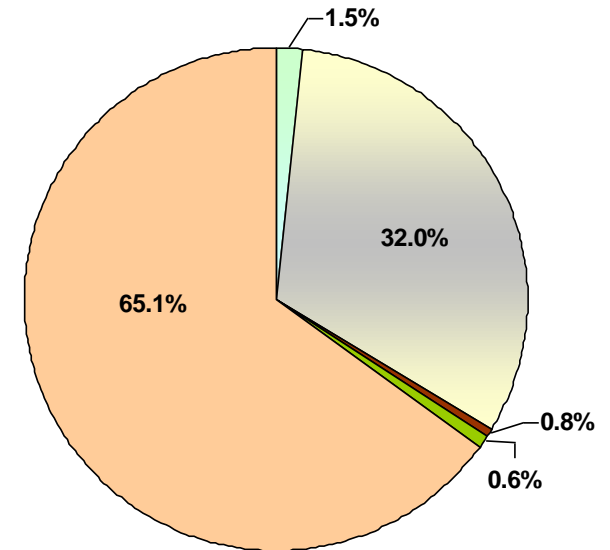


Primary Industrial PM10 emissions

FI-AGG



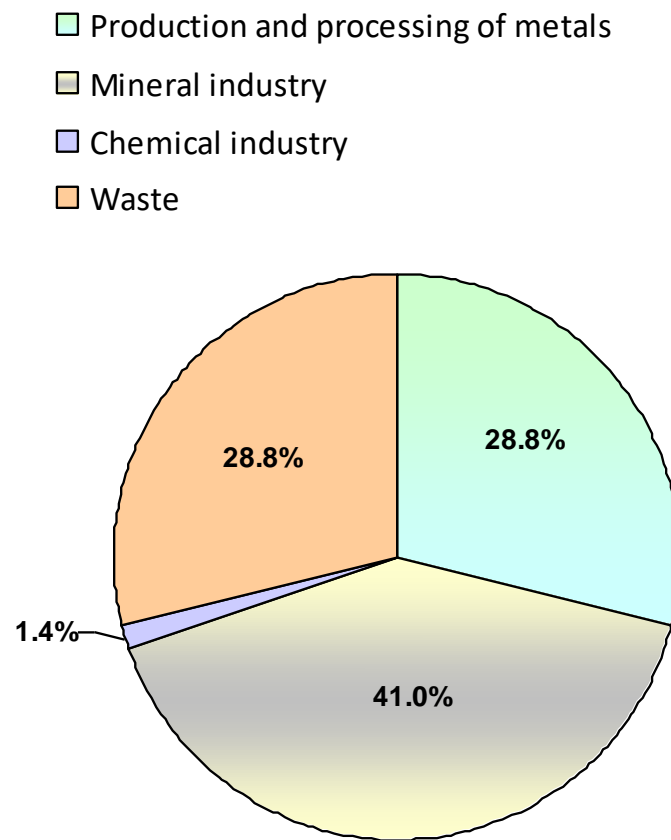
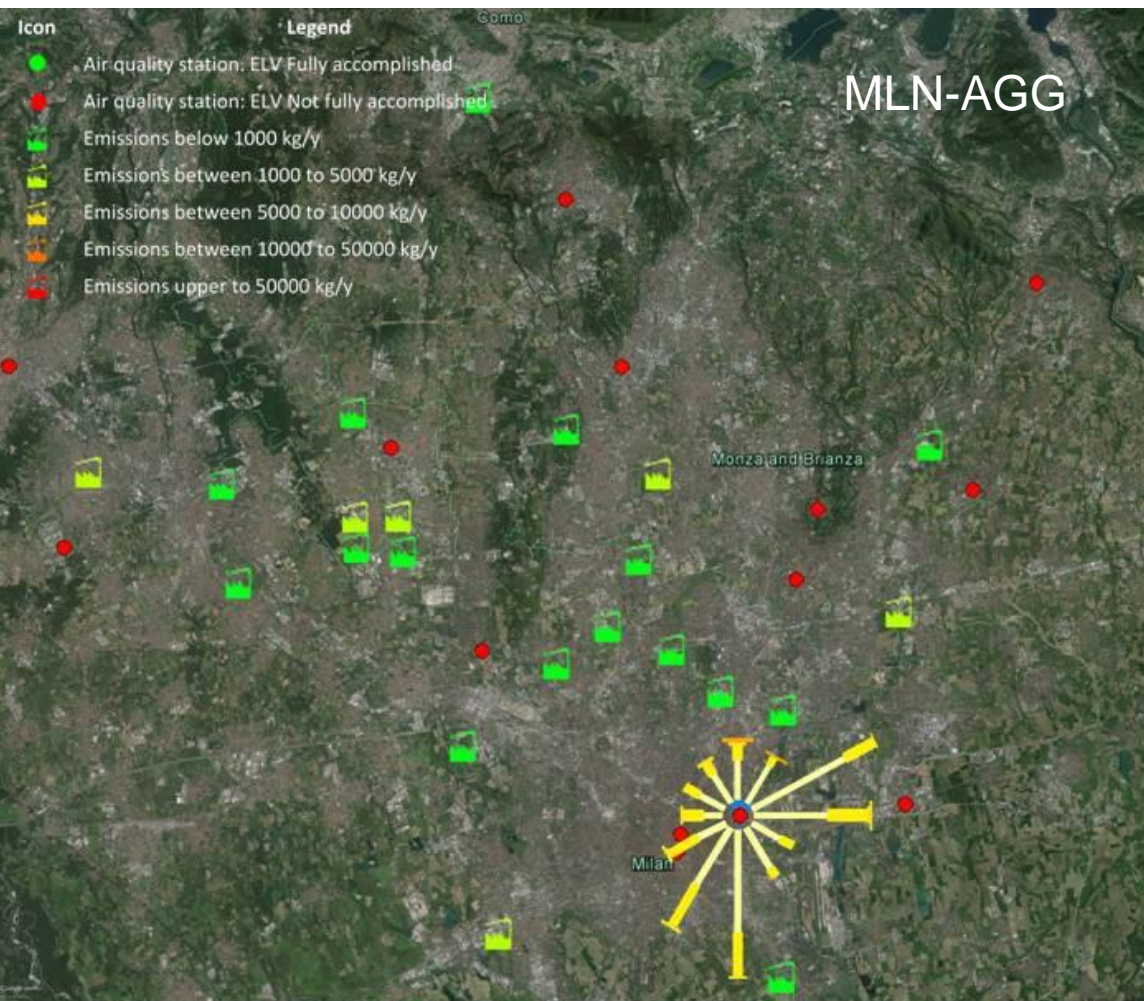
- Energy sector
- Production and processing of metals
- Waste
- Paper and wood production processing
- Other activities non IED



Other activities: Concrete manufacturing, silver processing and biomass co-generation plant (<50Mw)



Primary Industrial PM10 emissions





Channelled emissions

1. Developing and compiling **specific PM₁₀/TSP and PM_{2.5}/PM₁₀ ratios**
2. **Regulating maximum temperature** in exhaust gases / abatement systems
3. Fostering **control of secondary PM precursors and heavy metal emissions**





Emission inventories

1. Encouraging efforts to standardise and coordinate baseline information

Channelled primary PM	Fugitive primary PM
Main industrial activity (IPPC or E-PRTR code)	
Annual production (kg, tonnes, m ² , ...)	
Type of fuel	
Process stages: number of point sources	Activities that can generate diffuse emissions
Implemented BATs	Quantity of dusty material handled
Emission duration (hours/year)	Distance travelled by trucks inside the company
Emission temperature	Transport distances on paved and unpaved roads
Emission volume flow rate (dry basis)	Storage area and amount of stored material
Emitted PM concentration	Mitigation measures implemented
BATs maintenance operations	Maintenance operations of the mitigation measures



Measures

Preventive

- Reduce number of vehicles
- Reduce traffic speed
- Reduce HDV
- Reduce wear

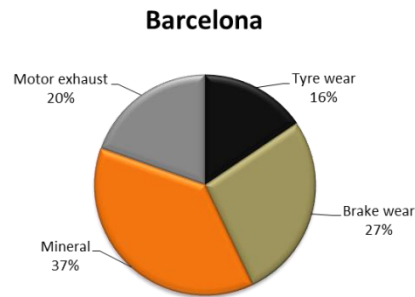
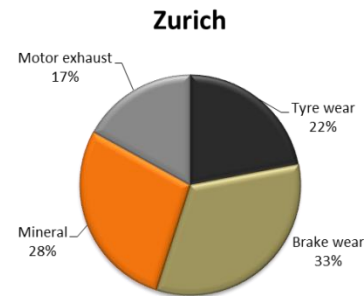
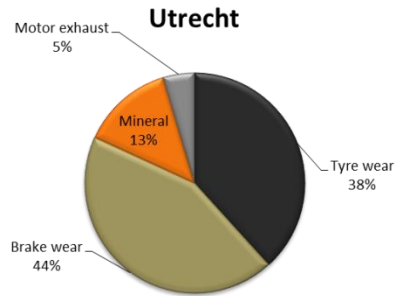
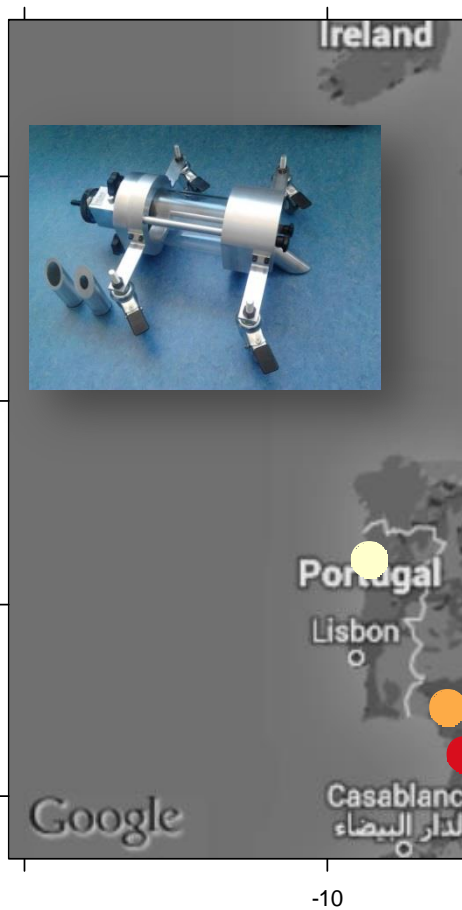
Mitigation

- **Street cleaning**
- **Calcium Magnesium Acetate (CMA)**
- **MgCl₂**, CaCl₂
- Polymers
- Porous asphalt

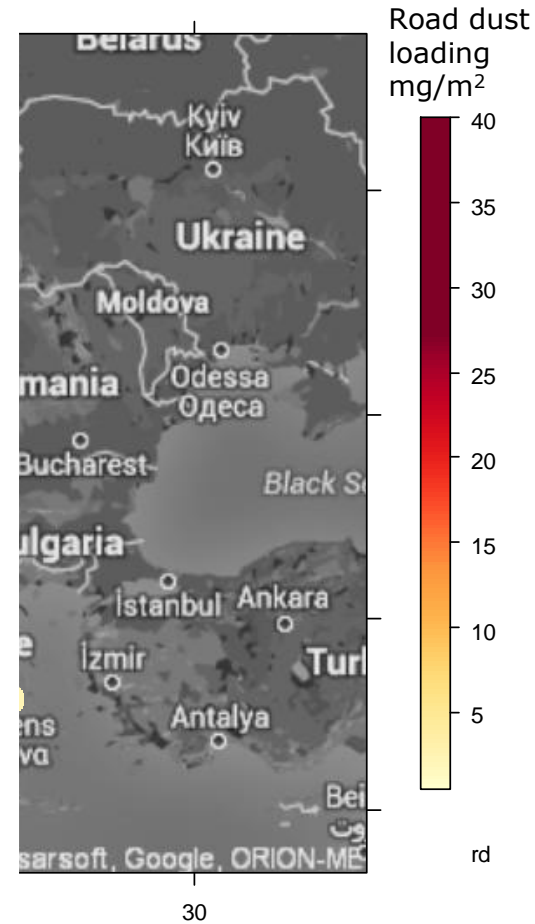




Road dust in EU



- Tyre wear
- Brake wear
- Mineral
- Motor exhaust





RECOMMENDATIONS

Addressed to National and/or Regional
environmental bodies



Primary PM emissions

1. **Updating the ELVs** adopted in the BREF documents

2. Increasing emission control frequency to **ensure proper BATs operation**

3. Including **real control and quantification** of fugitive emissions



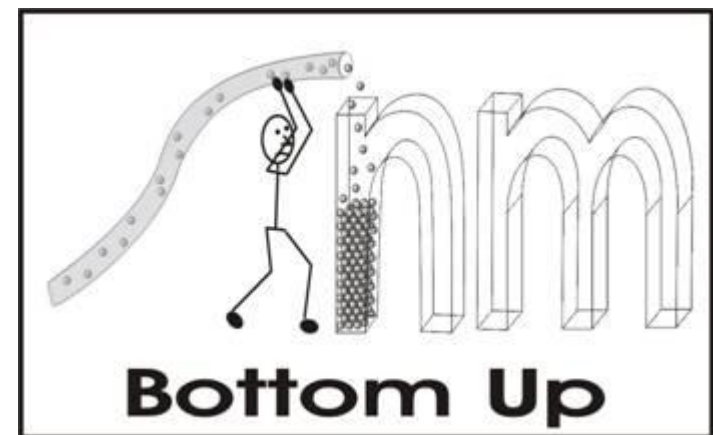


Regional inventories of PM industrial emissions

1. Periodically **updating** the **list of industrial activities**
2. Using a **bottom-up approach**, including non-IED activities and fugitive emissions
3. Controlling and quantifying **shipping, harbour, and public works emissions**



Source: <http://www.cittametropolitana.mi>



Source: <http://www.chem.toronto.edu/>