Eficàcia de les mesures per prevenir la resuspensió de la pols deguda a la circulació

Fulvio Amato i Xavier Querol
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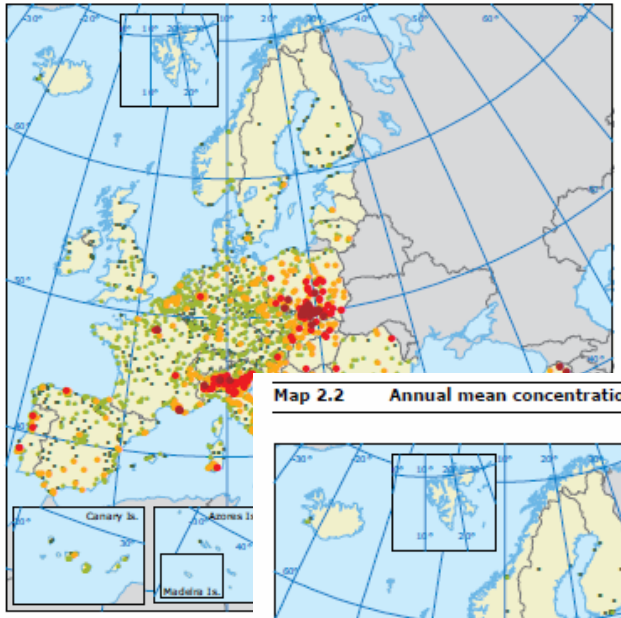
GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
CSIC

El material particulado atmosfèrico (PM): Material heterogeneo sòlido y/o líquido presente en suspensión en la atmosfera

- Impacto en salud
- Ecosistemas
- Clima
- Materiales de construcción
- Visibilidad

Alfons Puertas – Fabra Observatory



Annual mean particulate matter (PM_{10}) 2011, based on daily average with percentage of valid measurements ≥ 75 % in µg/m³

- ≤ 20
- 20–31
- 31–40
- 40–50
- > 50
- No data
- Countries/regions not included in the data exchange process

Note: The red and dark red dots indi
the Air Quality Directive (EU, 2

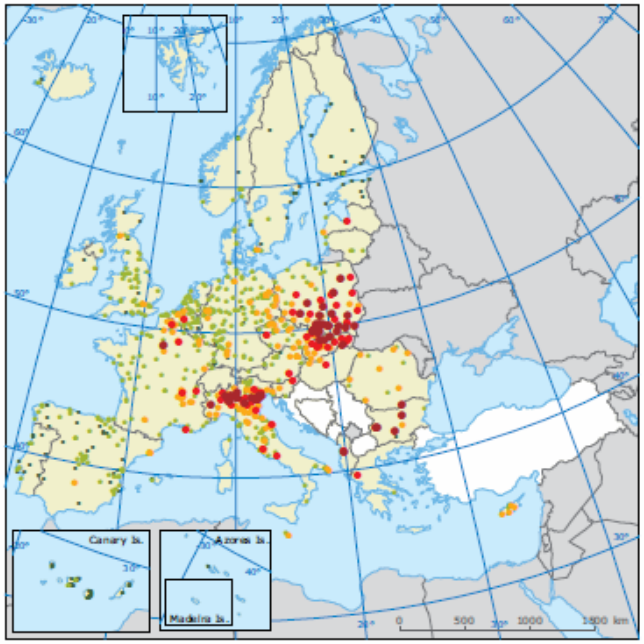
The orange dots indicate statio
24-hour limit value.

The pale green dots indicate st

The dark green dots indicate st

Source: AirBase v. 7.

Map 2.2 Annual mean concentrations of $PM_{2.5}$ in 2011



Annual mean fine particulate matter ($PM_{2.5}$) 2011, based on annual average with percentage of valid measurements ≥ 75 % in µg/m³

- ≤ 10
- 10–20
- 20–25
- 25–30
- > 30
- No data
- Countries/regions not included in the data exchange process

Note: The dark red dots indicate stations reporting exceedances of the 2010 annual target value (25 µg/m³) plus at least 5 µg/m³.

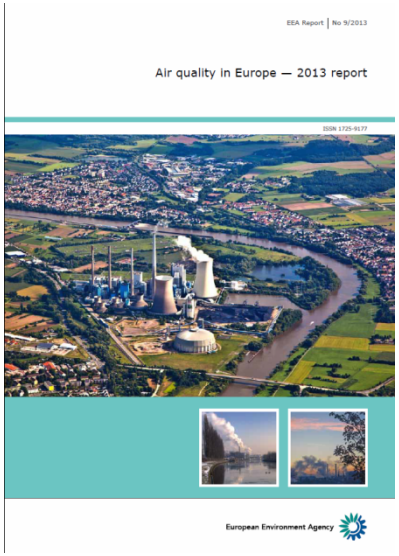
The red dots indicate stations reporting exceedances of the 2010 annual target value (25 µg/m³), as set out in the Air Quality Directive (EU, 2008c).

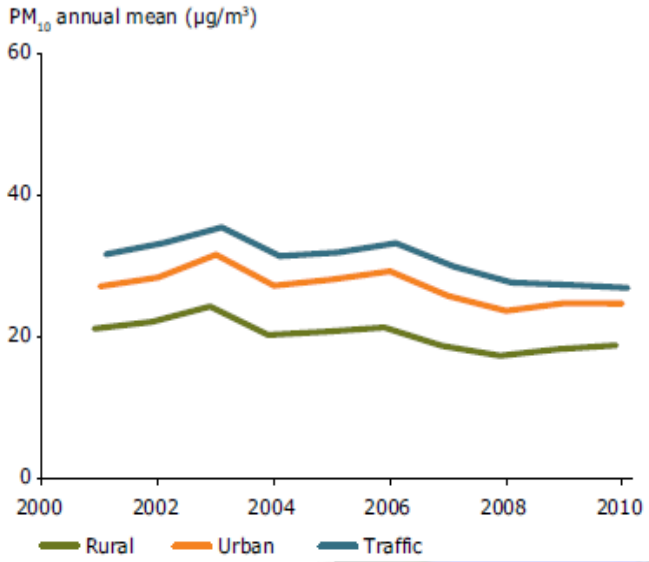
The orange dots indicate stations reporting exceedances of the 2020 indicative annual limit value (20 µg/m³), as set out in the Air Quality Directive (EU, 2008c).

The pale green dots indicate stations reporting exceedances of the WHO air quality guideline for $PM_{2.5}$ of less than 10 µg/m³.

The dark green dots indicate stations reporting concentrations below the WHO air quality guideline for $PM_{2.5}$.

Source: AirBase v. 7.





Emisiones de PM por el tráfico rodado

Combustión

Desgaste frenos

Desgaste neumáticos

Desgaste pavimentación

Carbono elemental, orgánicos…

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

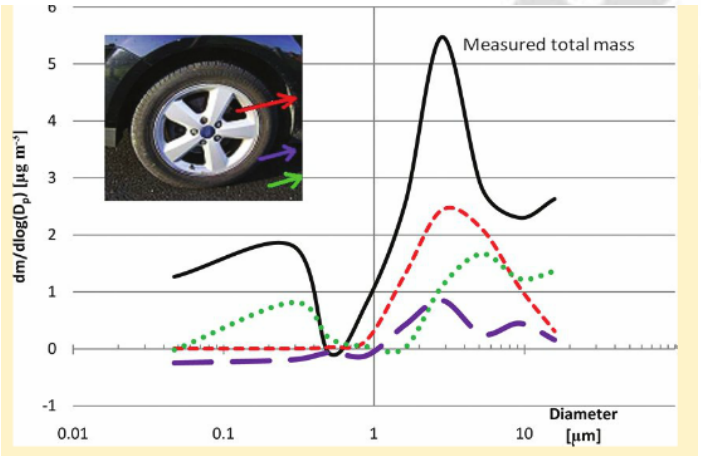
Zn, orgánicos…

Ca, Al, Fe, Si, Ti…

Road dust

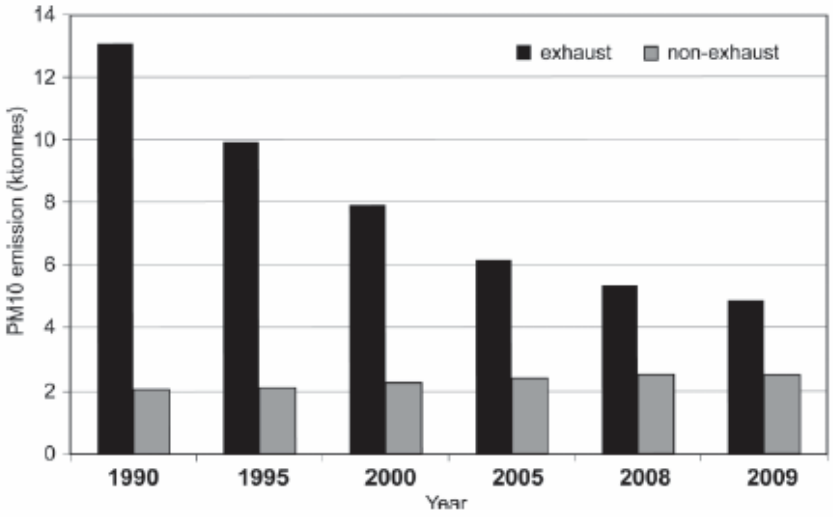
Exhaust

Non-exhaust



Harrison et al., 2012

Evolución temporal de emisiones *exhaust* vs *non-exhaust*



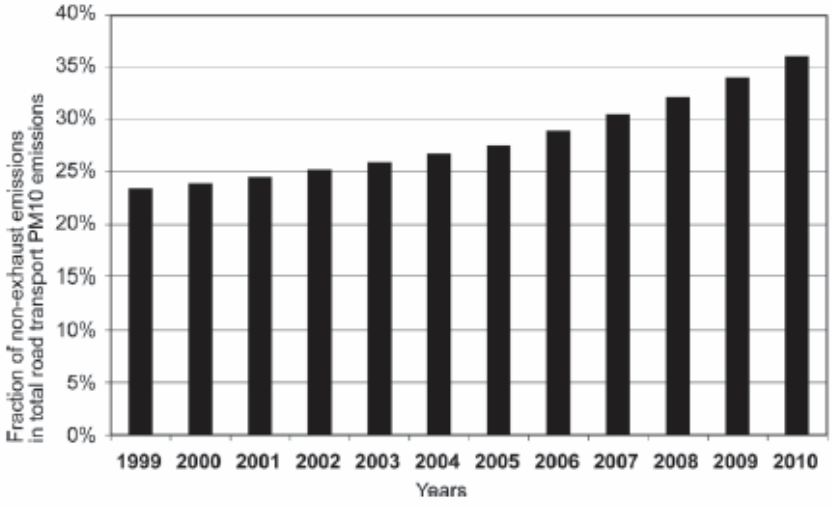


Figure 2. (a) Trend of PM_{10} emission from road transport exhaust and nonexhaust in the Netherlands (source: PRTR, 2011). (b) Average trend in nonexhaust emission for Europe based on extrapolation of base years in the IIASA GAINS model (source: GAINS, 2011).

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http://www.tandfonline.com/loi/uawm20

The Policy Relevance of Wear Emissions from Road Transport, Now and in the Future—An International Workshop Report and Consensus Statement

Hugo A.C. Denier van der Gon [a], Miriam E. Gerlofs-Nijland [b], Robert Gehrig [c], Mats Gustafsson [d], Nicole Janssen [b], Roy M. Harrison [e f], Jan Hulskotte [a], Christer Johansson [g h], Magdalena Jozwicka [a], Menno Keuken [i], Klaas Krijgsheld [j], Leonidas Ntziachristos [k], Michael Riediker [l] & Flemming R. Cassee [b m]

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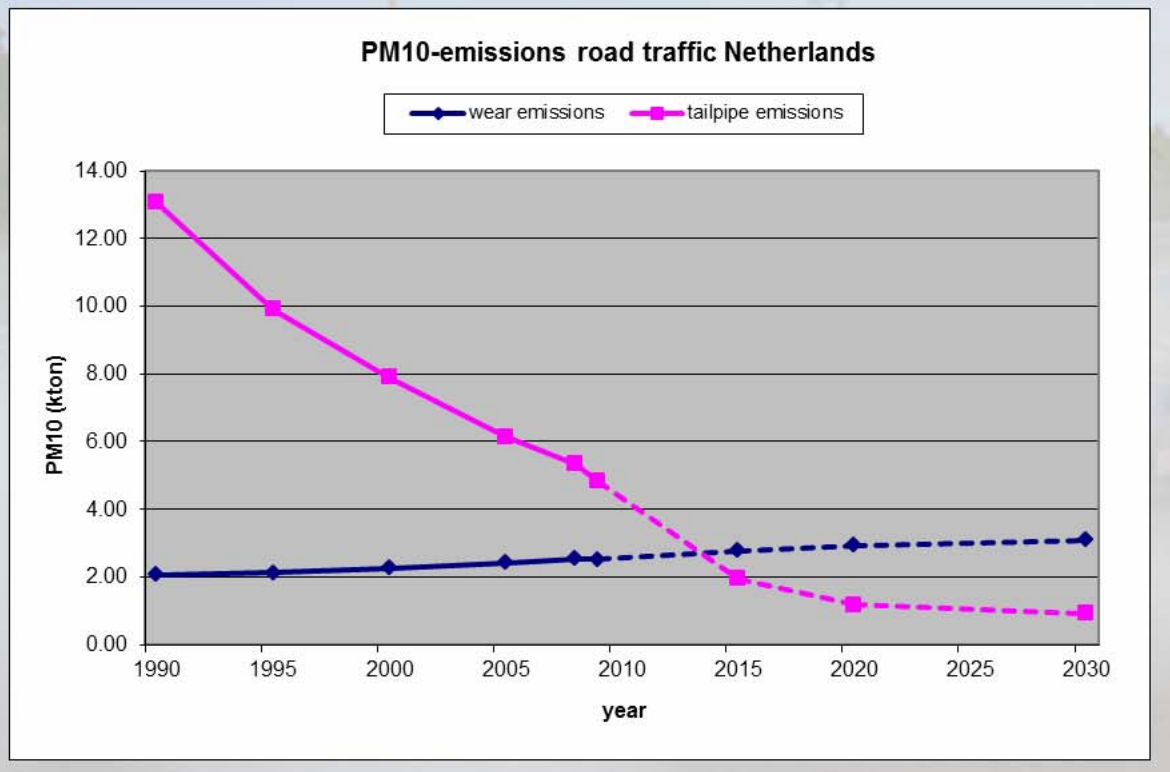
[g] Department of Applied Environmental Science (ITM), Stockholm University, Stocholm, Sweden

[h] Environment and Health Administration, Stockholm, Sweden

[i] Department of Urban Environment and Safety, Netherlands Organisation for Applied Scientific Research, Utrecht, The Netherlands

[j] Ministry of Infrastructure and Environment Directorate Climate and Air Quality, The Hague, The Netherlands

PM_{10} emissions from road traffic in the Netherlands



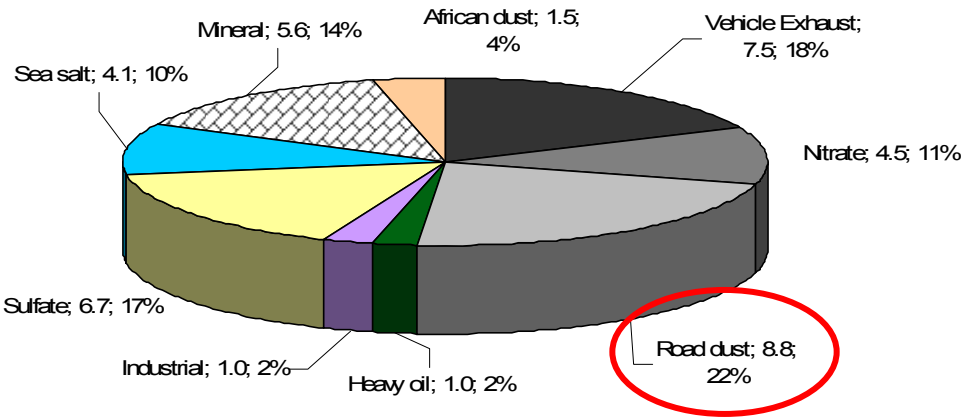
Klaas Krijgsheld
Ministry of Infrastructure and the Environment,
Directorate Climate & Air Quality

Contribución media a los niveles de PM

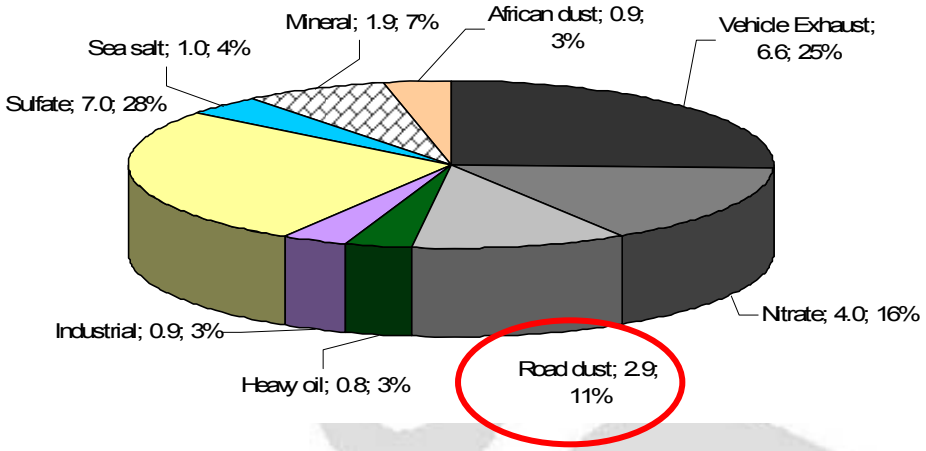
Barcelona (2003-2010)

µg/m³ , %

PM10



PM2.5



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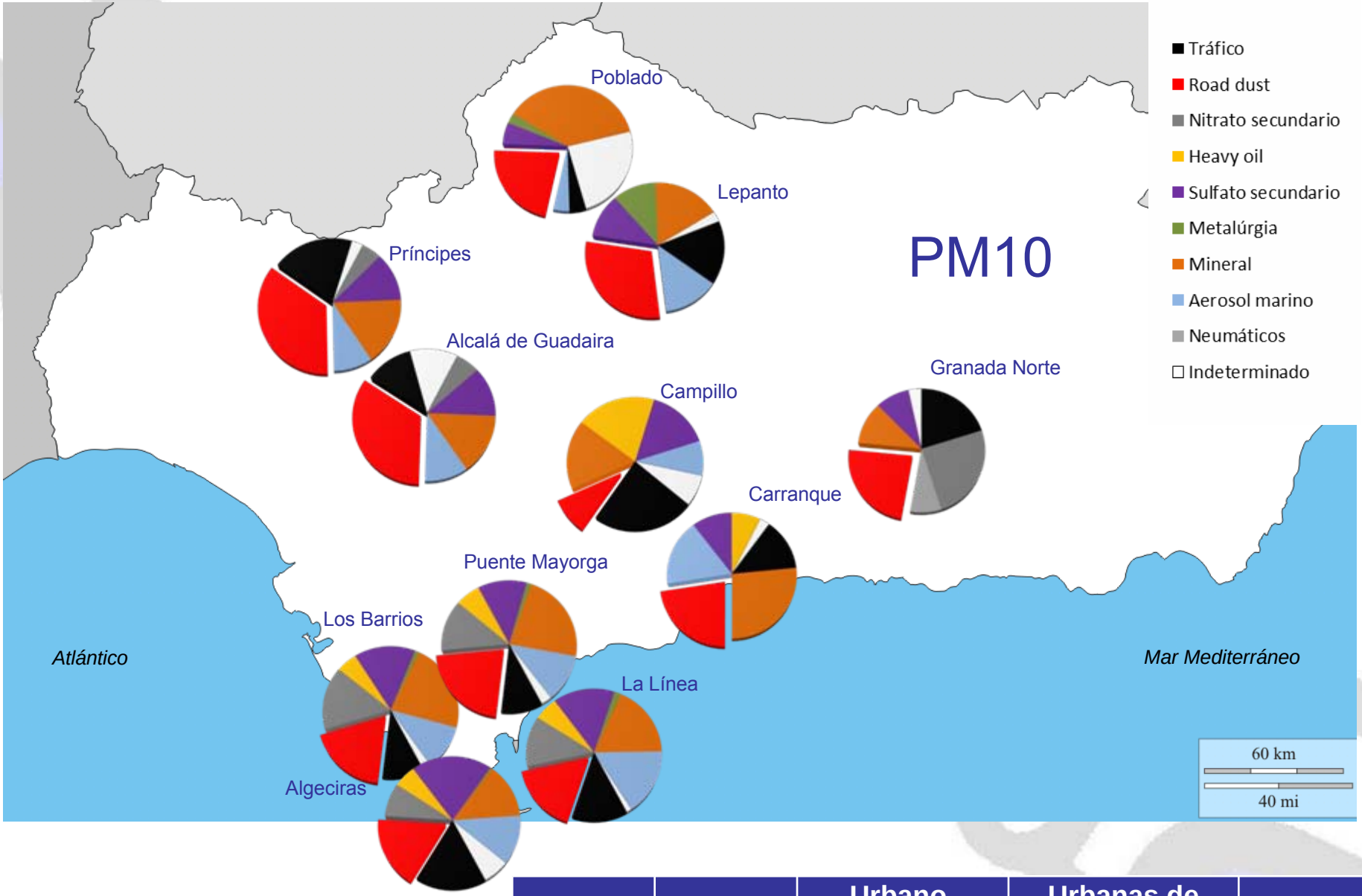


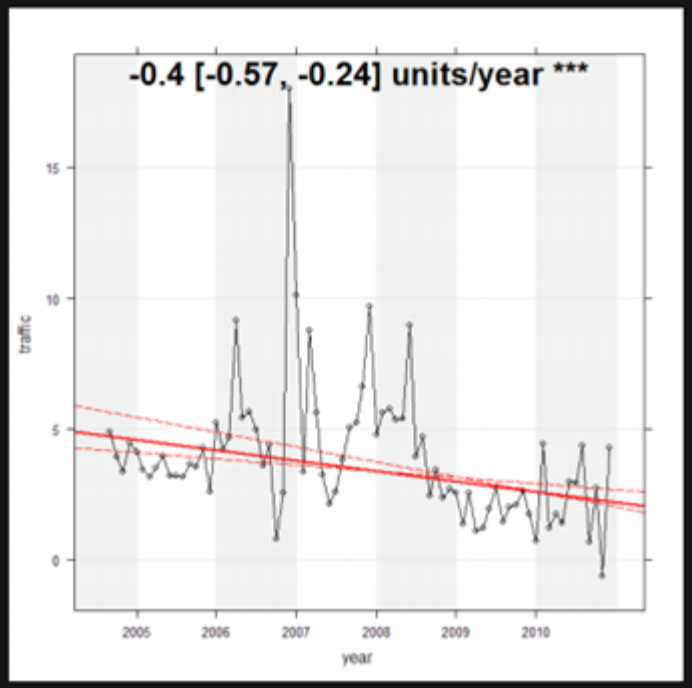
	Rurales	Urbano-industrial	Urbanas de fondo	Tráfico
PM10	9-22%	17-22%	29-34%	21-35%
PM2.5	7%	6-16%	11-31%	21-31%

THE PROBLEM OF PM

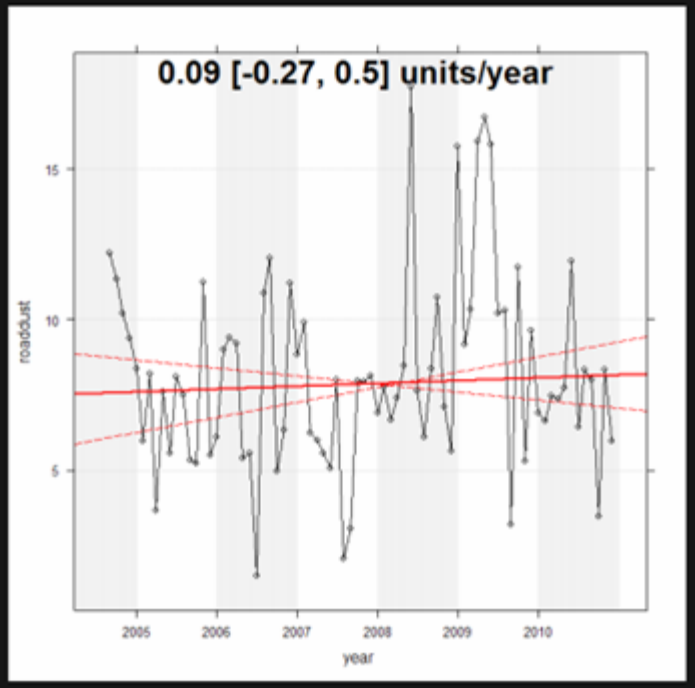
ROAD DUST CONTRIBUTIONS, ANDALUCÍA (2003-2010)

Trend of source contributions (Algeciras Bay 2005-2010)

Motor exhaust

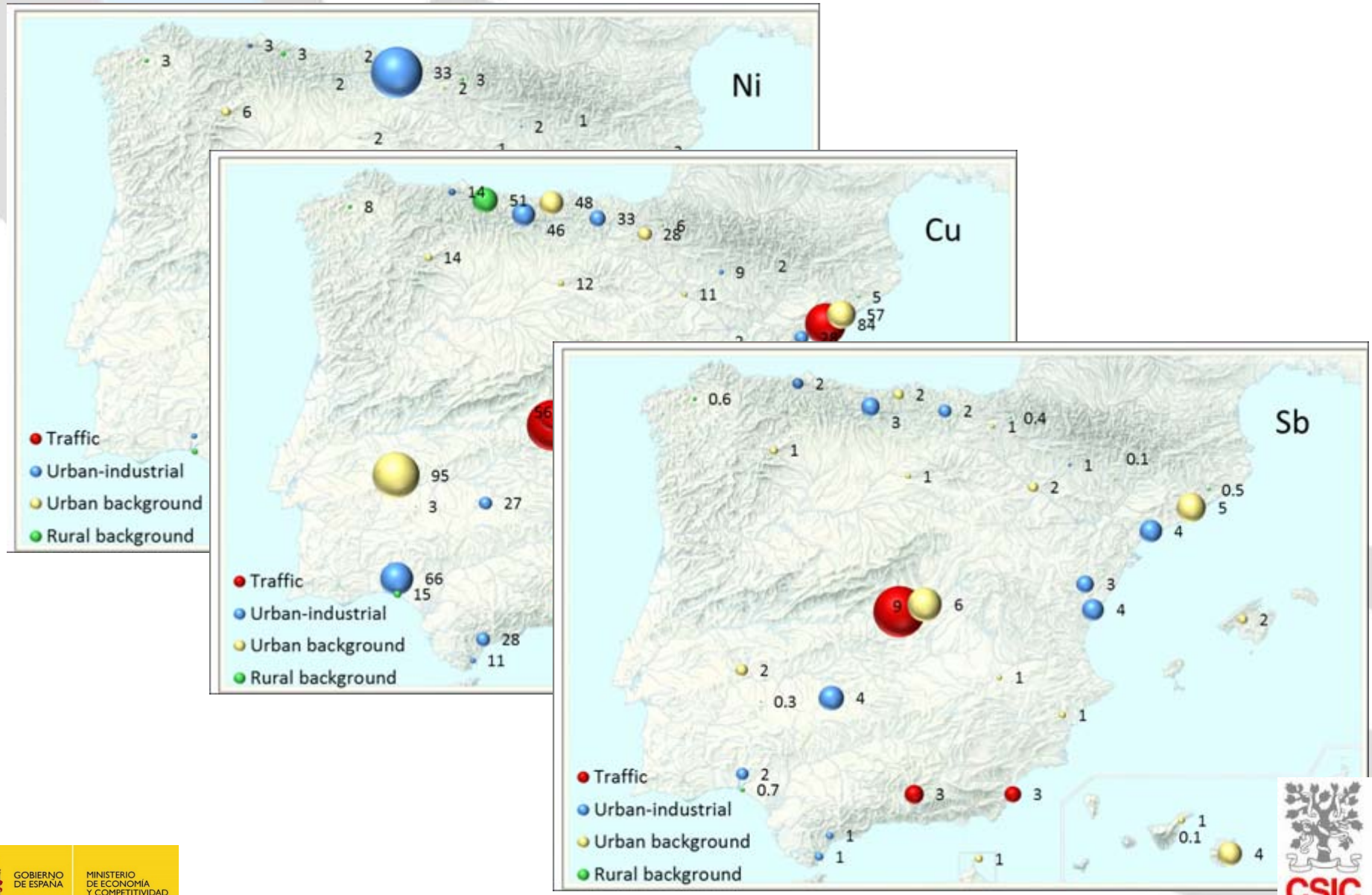


Road dust

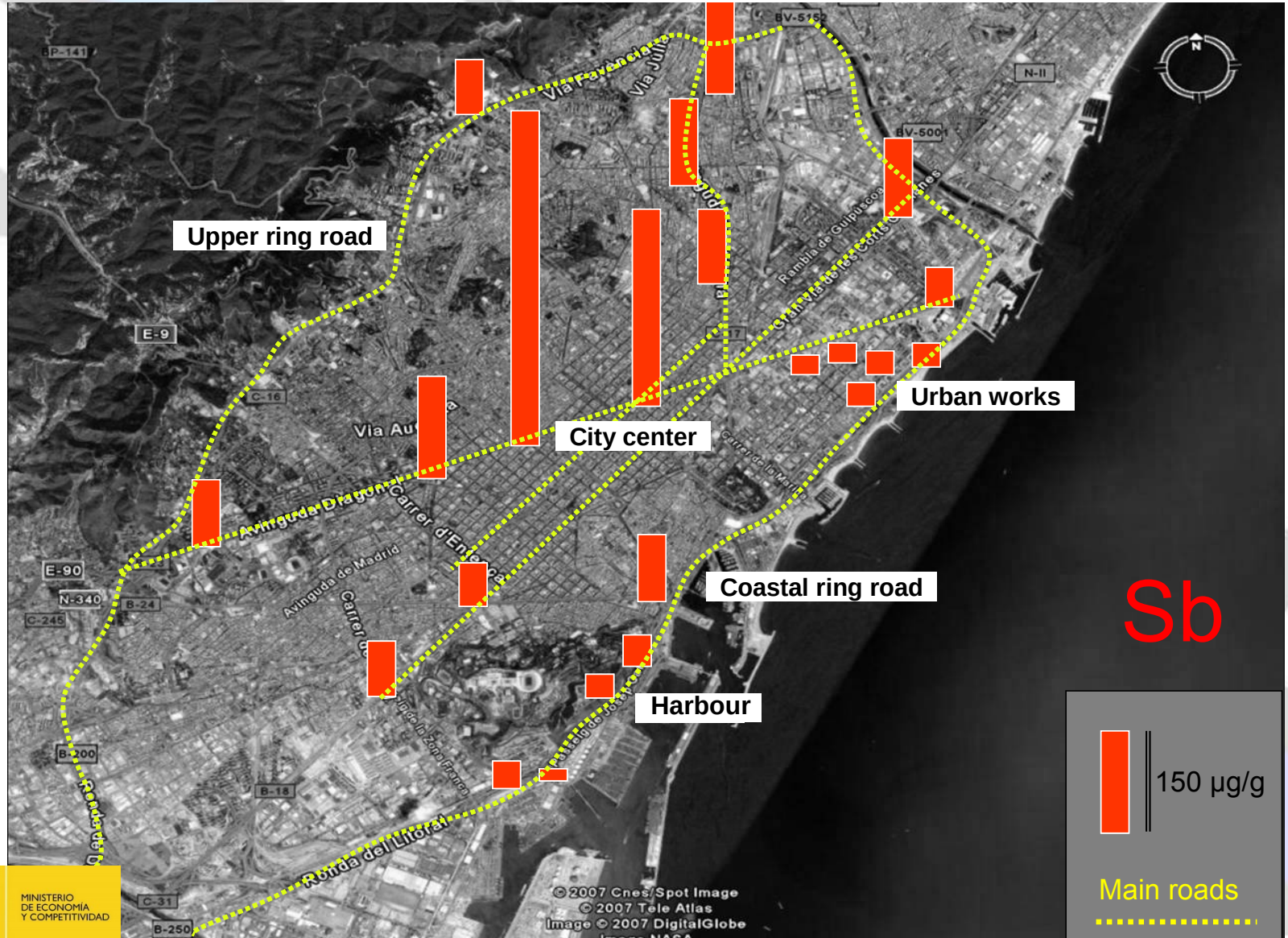


http://www.bdebate.org/moreinfo/2613

Distribución de metales (ng/m^3) en España



Sb depositado en vía de tráfico



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Medidas para mitigar la resuspensión

- Barrido
- Baldeo
- Aglomerantes (CMA, $MgCl_2$)
- Asfalto poroso

Barrido en seco

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journal homepage: www.elsevier.com/locate/scitotenv

Review

A review on the effectiveness of street sweeping, washing and dust suppressants as urban PM control methods

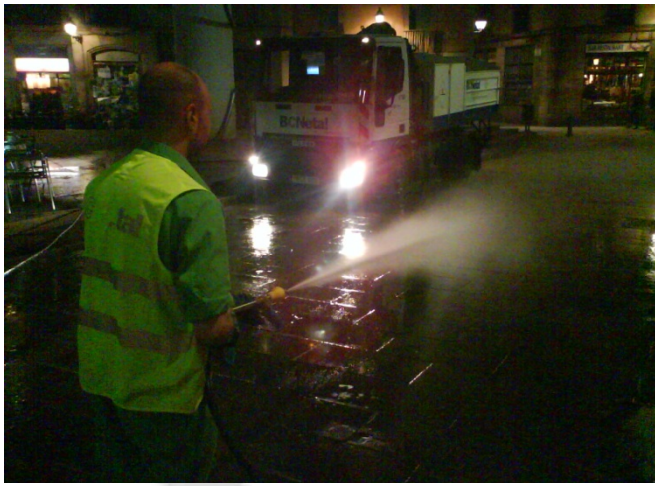
F. Amato [a,*], X. Querol [a], C. Johansson [b,c], C. Nagl [d], A. Alastuey [a]

[a] Institute of Environmental Assessment and Water Research (IDAEA), Spanish National Research Council (CSIC), c/Jordi Girona 18-26, 08034 Barcelona, Spain
[b] Stockholm Environment and Health Administration, P.O. Box 8136, S-104 20 Stockholm, Sweden
[c] Department of Applied Environmental Science, Stockholm University, S-106 91 Stockholm, Sweden
[d] Luftqualität & Energie, Air Quality & Energy, Umweltbundesamt, Spittelauer Laende 5, 1090 Vienna, Austria

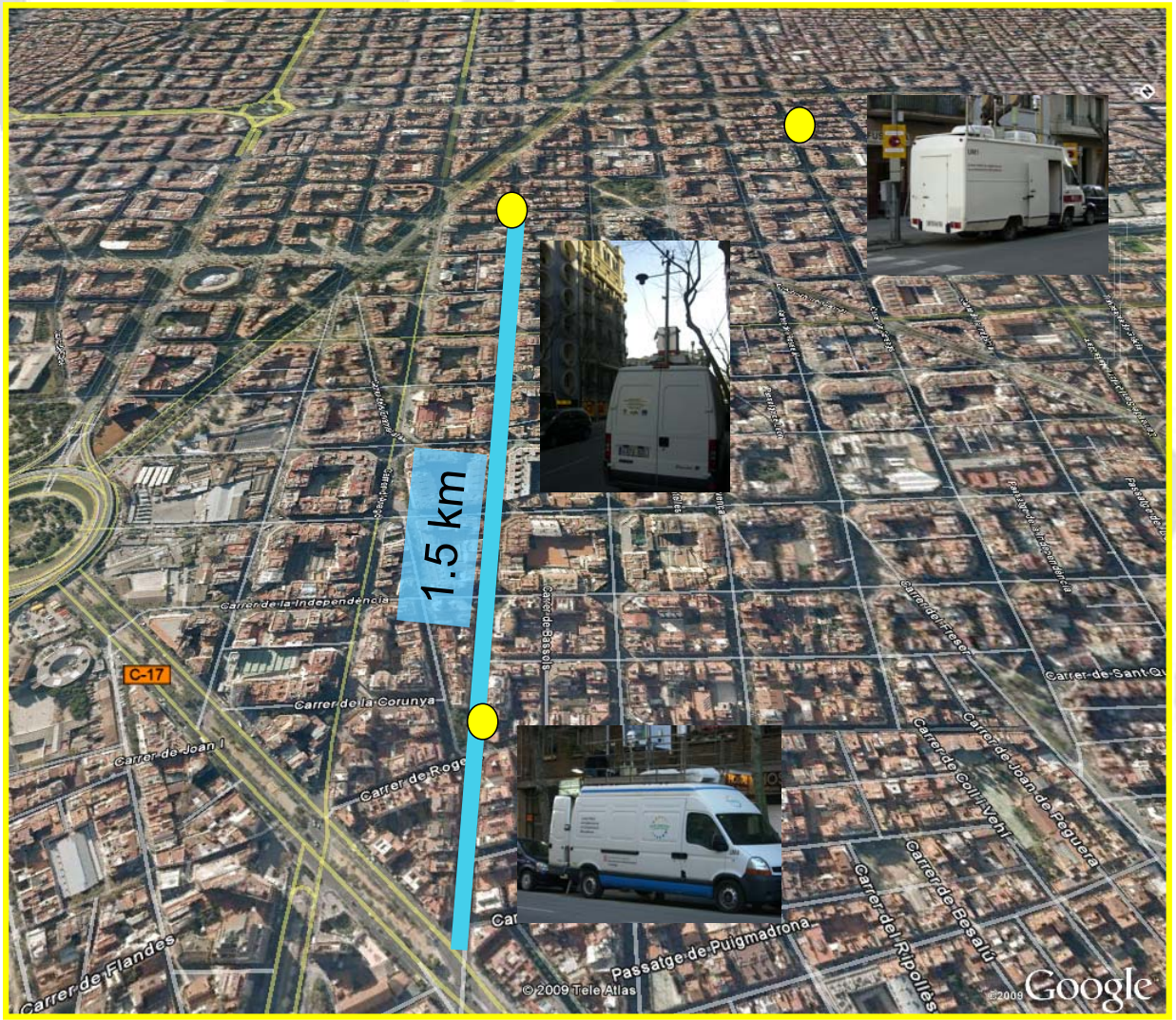
Study	Location	Cleaning method	Background assessment	Detailed effects
Chow et al., 1990	Nevada, USA			No discernable differences in airborne geologic PM10
Kantamaneni et al., 1996	Spokane, Washington, USA	Regenerative air vaccum sweeper	Upwind/downwind technique	Only a little decrease in PM10 emission
Kuhns et al., 2003	Treasure Valley, Idaho, USA	Mechanical and vacuum sweppers	Upwind/downwind technique	No measurable reduction in PM10 emission potentials
Norman and Johansson, 2005	Stockholm, Sweden	Mechanical sweeper	Ratio with a reference site	No reductions in PM10 (short term)
Gertler et al., 2006	Lake Tahoe, Nevada, USA	Wet and dry broom sweepers	Upwind/downwind technique	Deicers emit less than abrasives; Sweeping increased the PM10 re-entrainment rate
Düring et al., 2007	Berlin, Germany	Vacuum sweeper	NOx and meteorology monitoring	No significant difference was found in PM10 levels
Baumbach et al. 2007	Stuttgart, Germany	Vacuum sweeper	NOx and meteorology monitoring	No significant reduction of PM10 levels
Aldrin et al., 2008	Drammen, Norway	Sweeper (not specified)	Tunnel study, meteo conditions were assessed	No reductions in PM10 nor PM2.5

Baldeo

- Experimentos en EU
  - Barcelona (2008 y 2009)
  - Madrid
  - Castellón
  - Holanda
  - Alemania
  - Suecia
  - Italia
  - Noruega



Carrer Valencia



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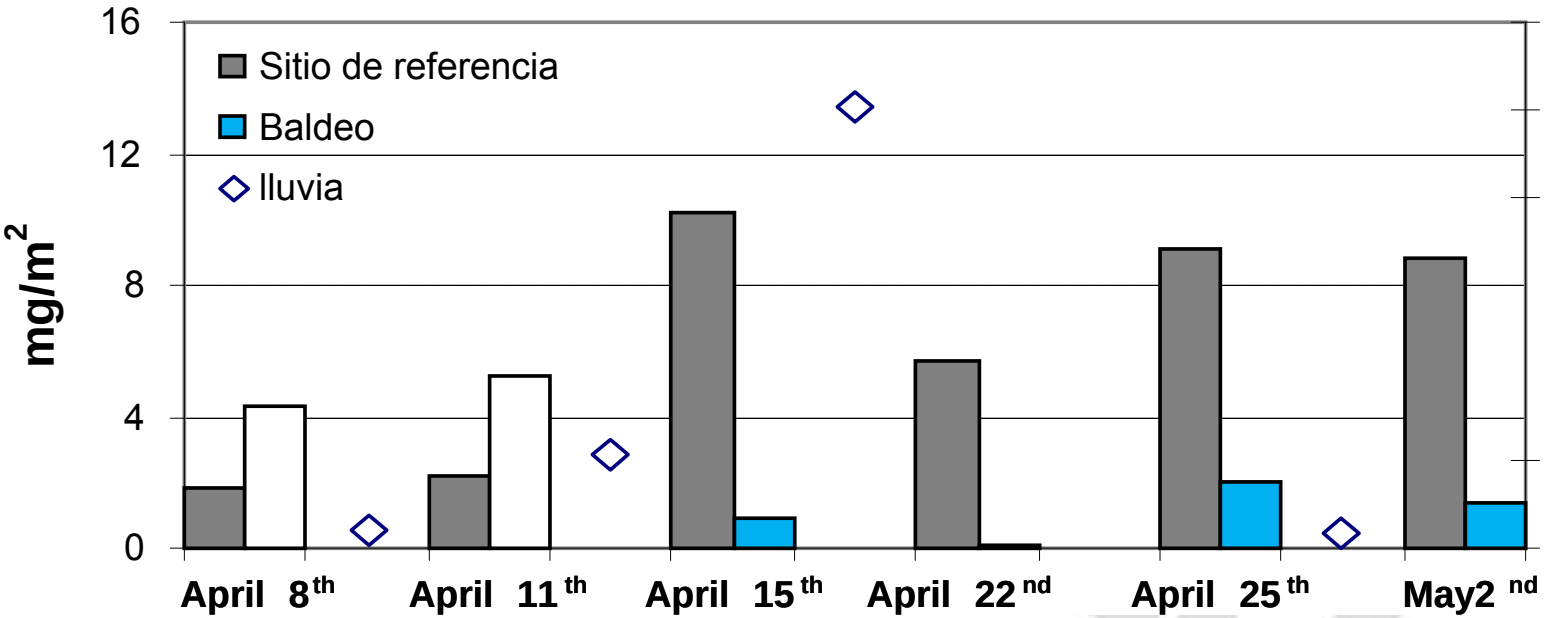
Barcelona: efecto en la masa de partículas depositadas



Amato et al., 2009 Atm. Env.

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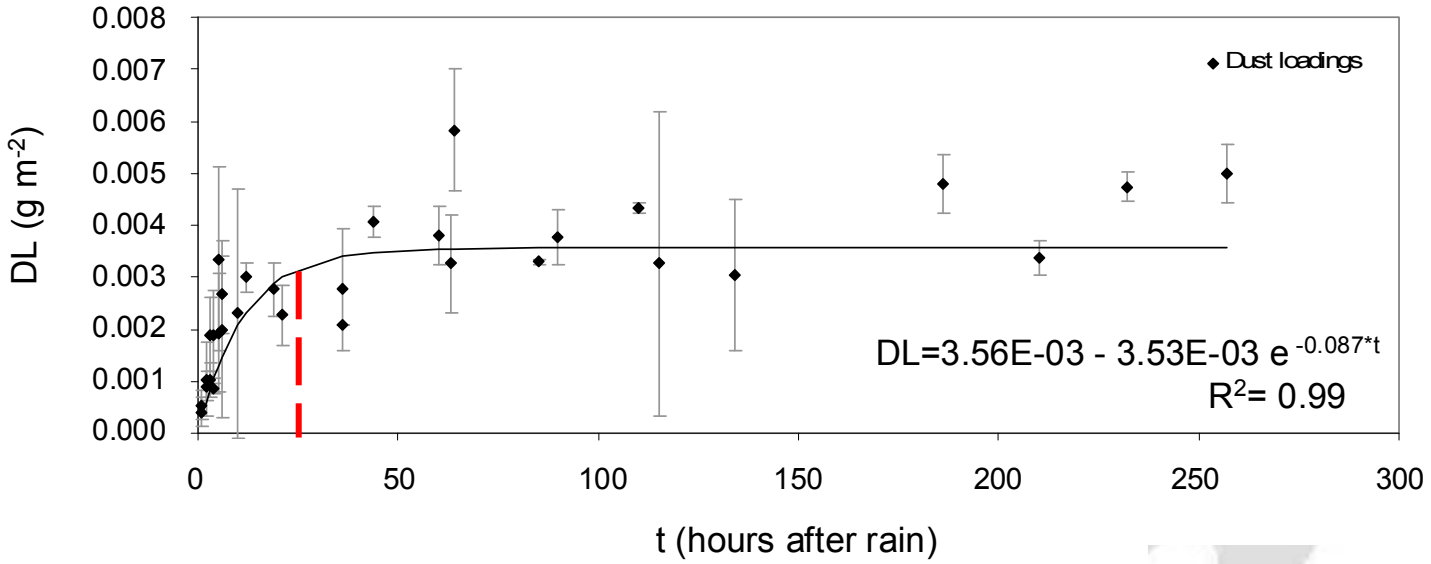
Diputació Barcelona

Ajuntament de Barcelona

Duración del efecto de baldeo sobre el potencial de emisión

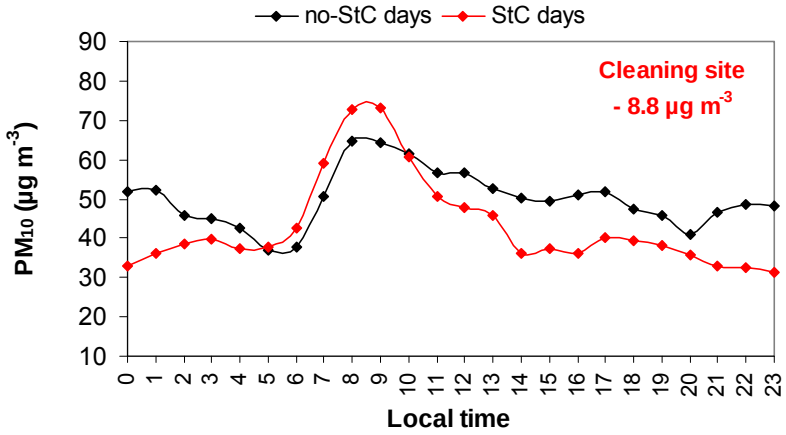


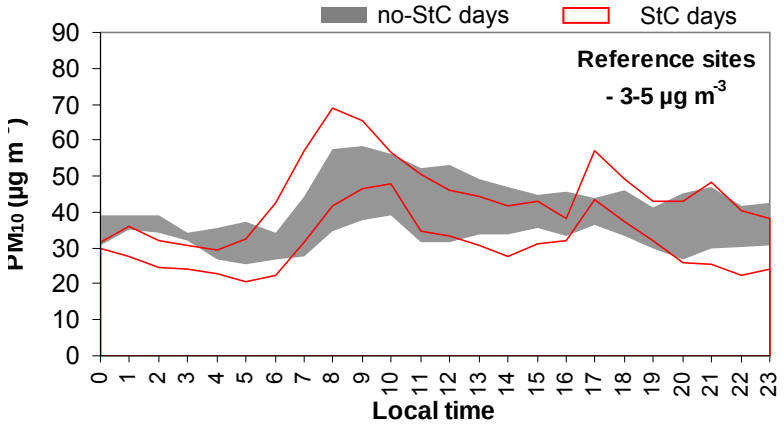
En 8 horas se restablece el 50% potencial de emisión
En 24 horas se restablece el 90% potencial de emisión

Amato et al., 2012.

Efecto en aire ambiente PM_{10} 2008

Cabinas de monitorización		Con baldeo ($\mu g\ m^{-3}$)	Sin baldeo ($\mu g\ m^{-3}$)
Tráfico	Prueba baldeo	44.4	53.2
Tráfico	Control	50.3	54.0
Fondo urbano	Control	38.9	43.8
Fondo urbano	Control	38.6	42.3
Fondo urbano	Control	42.2	44.3
Fondo urbano	Control	38.1	38.2

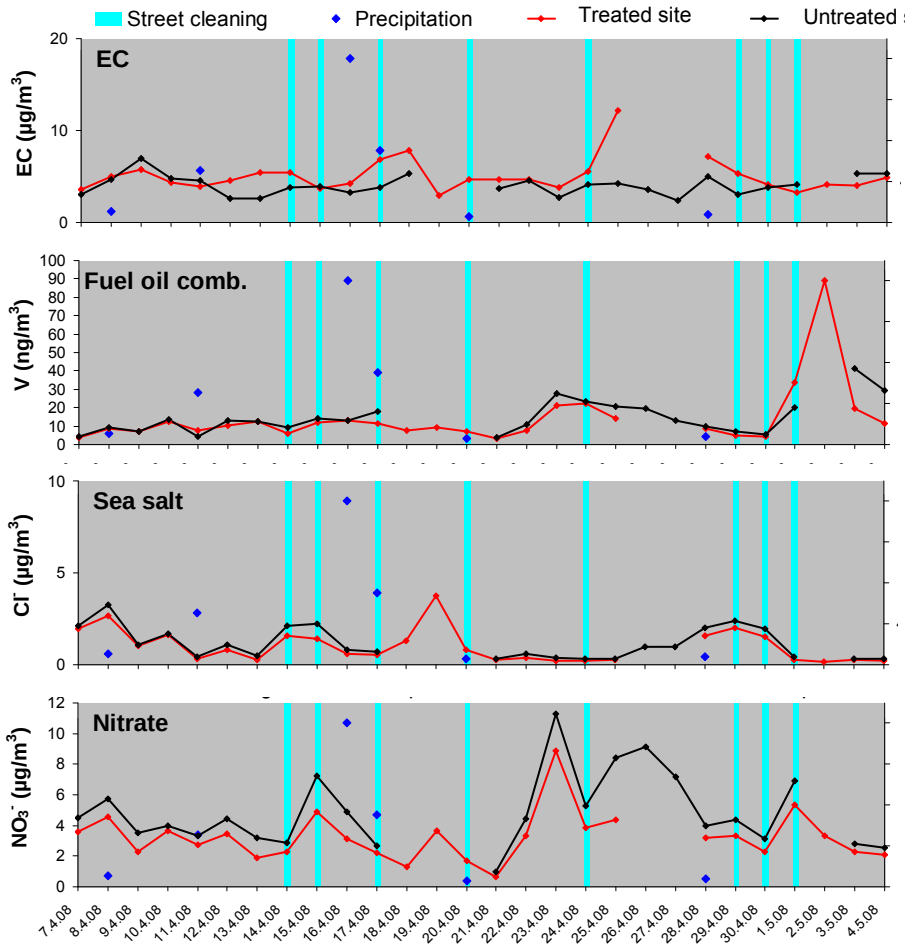


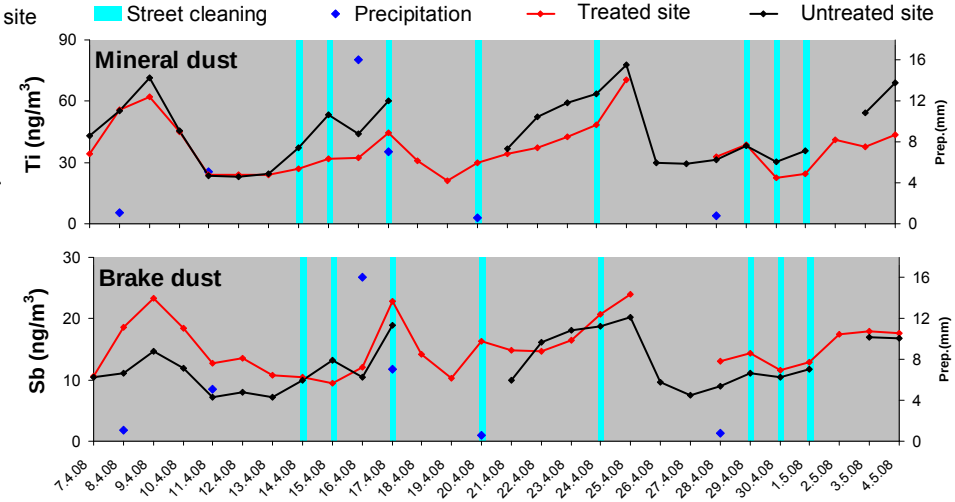


Reducción media diaria

Prueba baldeo:	- 8.8 $\mu g\ m^{-3}$
Sitios de control:	- 3.7-4.9 $\mu g\ m^{-3}$
Reducción neta:	*- 4-5 $\mu g\ m^{-3}$ (7-10%)*

Barcelona: efecto en la composición química de PM_{10}





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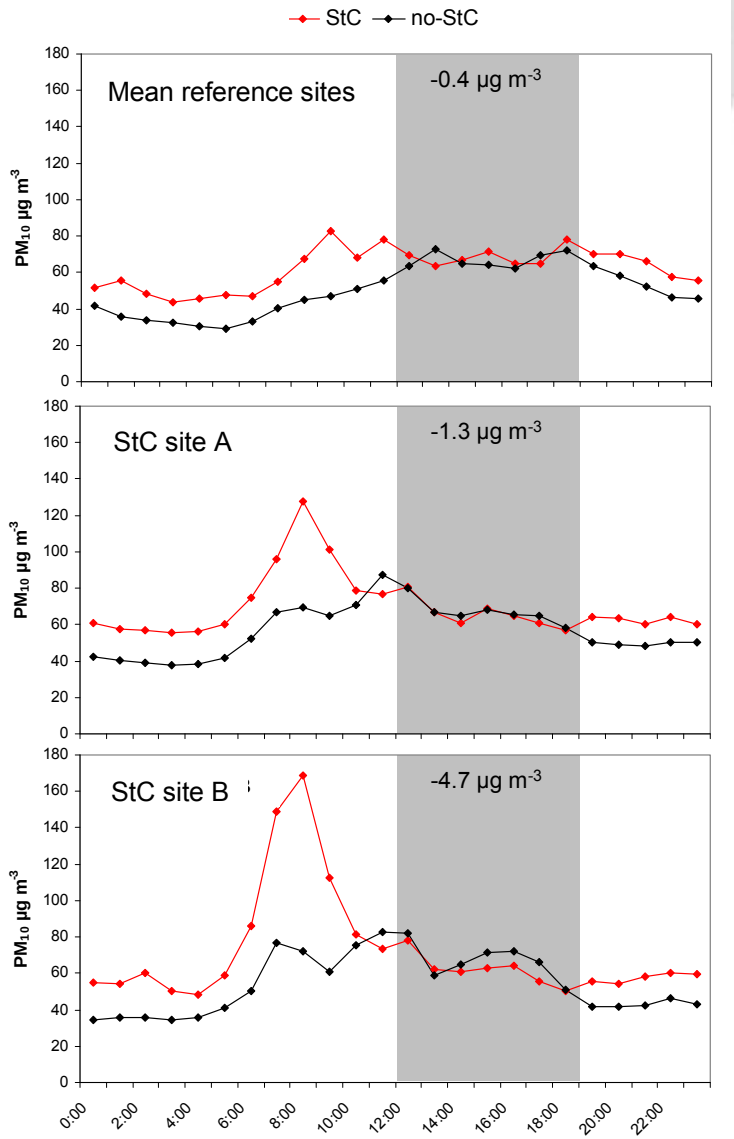
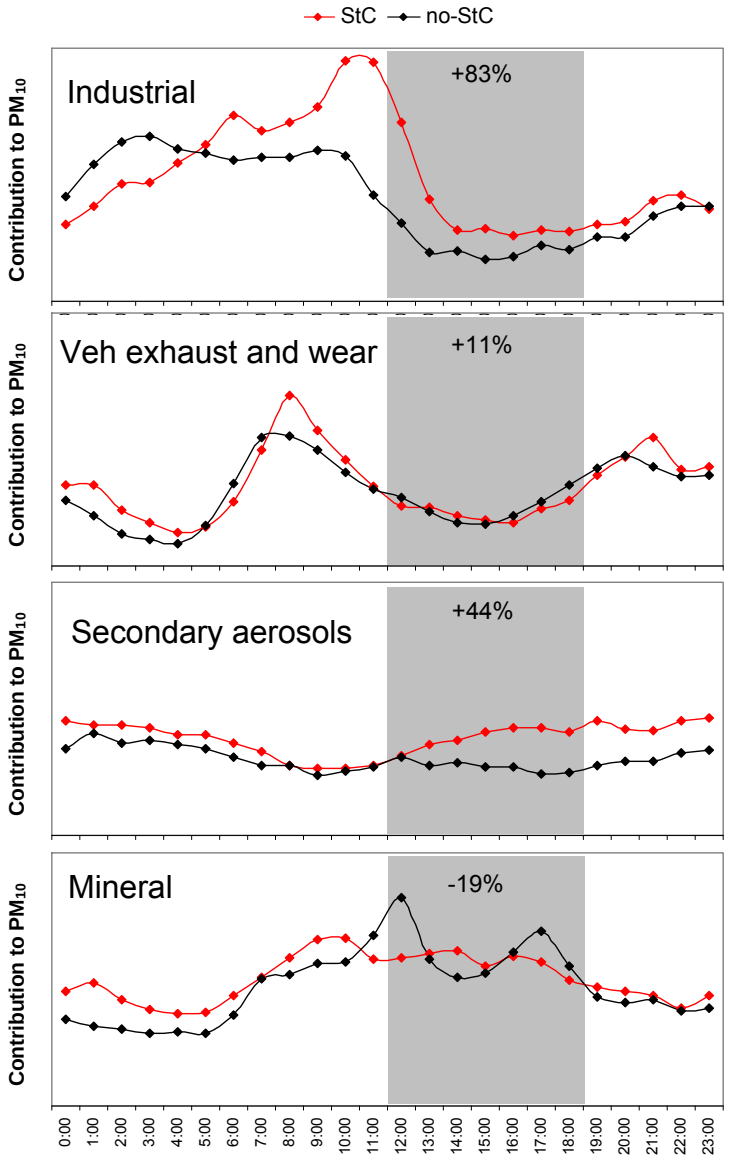
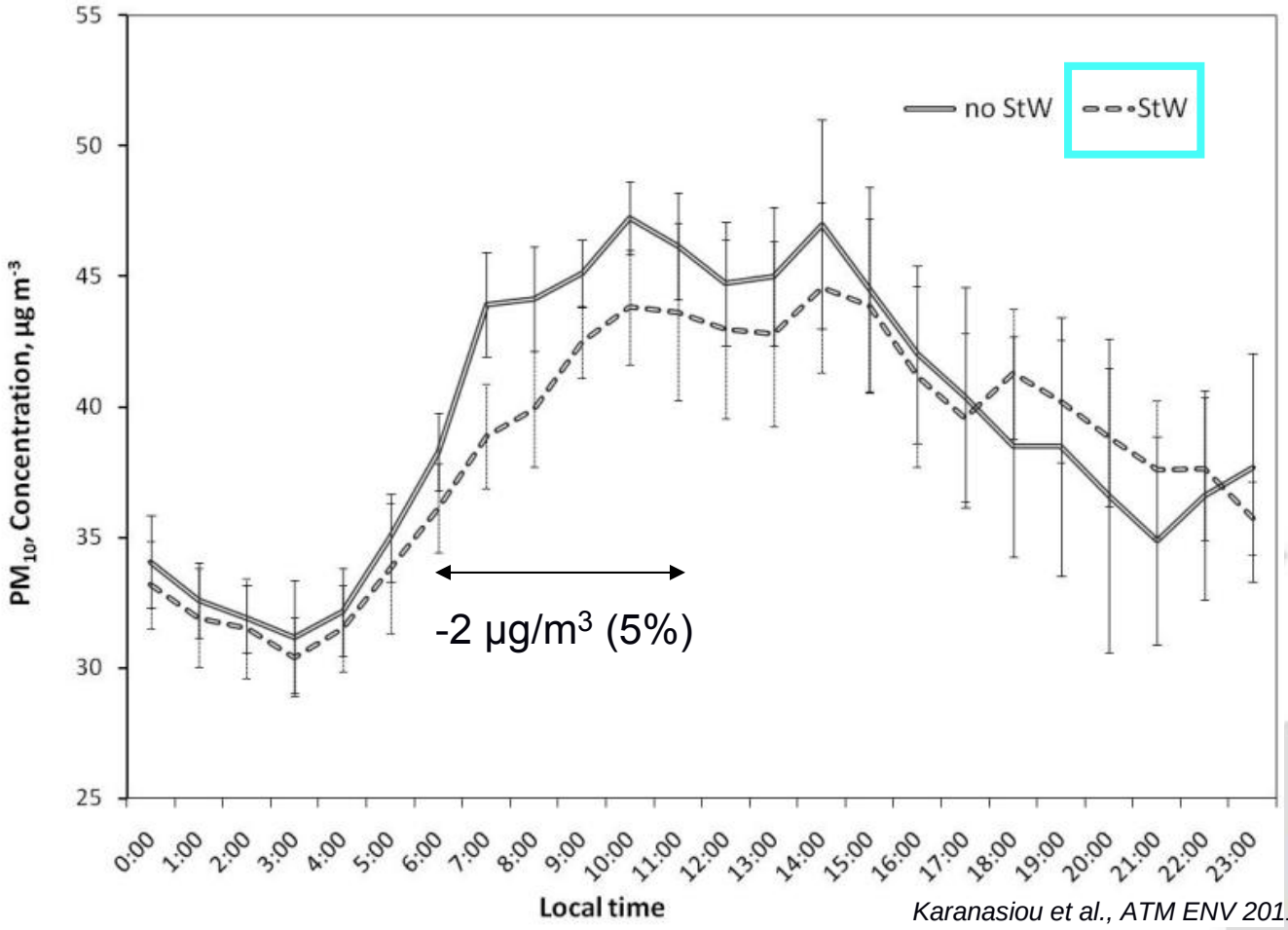
En 2009: resolución horaria





Madrid : Calle Velazquez

Madrid: efecto en aire ambiente (PM_{10})



Karanasiou et al., ATM ENV 2011

- Otros estudios
  - Canada: 2-3 $\mu g/m^3$ reducción en estación de tráfico (Dobroff et al., 1999)
  - Suecia: 6% reducción en estación de tráfico (Norman and Johansson, 2006)
  - Taiwan: hasta 30% reducción en TSP (Chang et al., 2005)
  - Alemania: 2 $\mu g/m^3$ reducción (John et al., 2006)
  - No se ha observado reducción en Noruega e Italia (Amato et al., 2010)

- Aglomerantes:
  - Ca-Mg acetato (CMA)
  - $CaCl_2$, $MgCl_2$
  - Polimeros

Carrer Industria (Abril-Mayo 2013)

Ajuntament de Barcelona

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AIRUSE
www.airuse.eu

Estudios previos con CMA

- Suecia: 35% reducción diaria (Norman and Johansson, 2006).
- Austria: 20-30% reducción diaria (10% annual)

  www.life-cma.at

- Stuttgart, no hubo reducción
- Londres:
  - No se registró reducción significativas en vías urbanas
  - Reducción hasta 40% en zonas industriales

- Asfalto poroso
  - Generalmente utilizado para reducir ruido y mejorar drenaje
  - Puede retener particulas respirables
  - Ensayos prometedores en Suecia (http://www.slb.nu/elvf/) y Suiza (Gehrig et al., 2010)

Conclusiones

- El barrido en seco no ha mostrado beneficios en PM10 a corto plazo
- La efectividad del baldeo parece más ligada al factor humedad, que a la remoción de partículas del firme

	Reducción PM10 en estaciones de tráfico	Duración
Barcelona (2008)	7-10%	≤24 horas
Barcelona (2009)	20%	6 horas
Madrid (2009)	5%	5 horas

- A la espera de nuevos resultados sobre aglomerantes en Barcelona
- La mitigación es necesaria, pero es solo una ficha del puzle. Las medidas no-tecnologicas son las más eficaces

Agradecimientos

Agència de Salut Pública

Generalitat de Catalunya
Departament de Territori i Sostenibilitat

Ajuntament de Barcelona
Intervenció, Innovació i Qualitat Mediambiental

Diputació Barcelona
Àrea de Territori i Sostenibilitat

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MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

Life AIRUSE

Gracias por su atención!

fulvio.amato@idaea.csic.es

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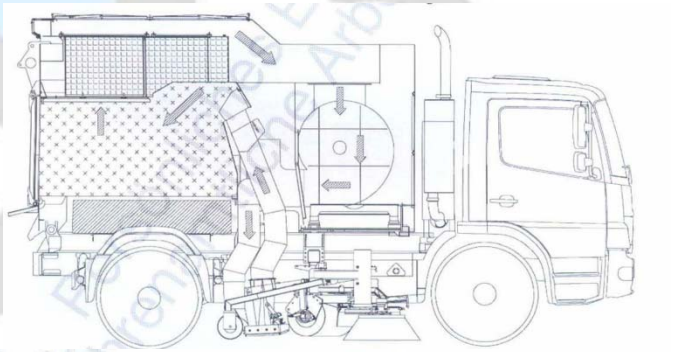
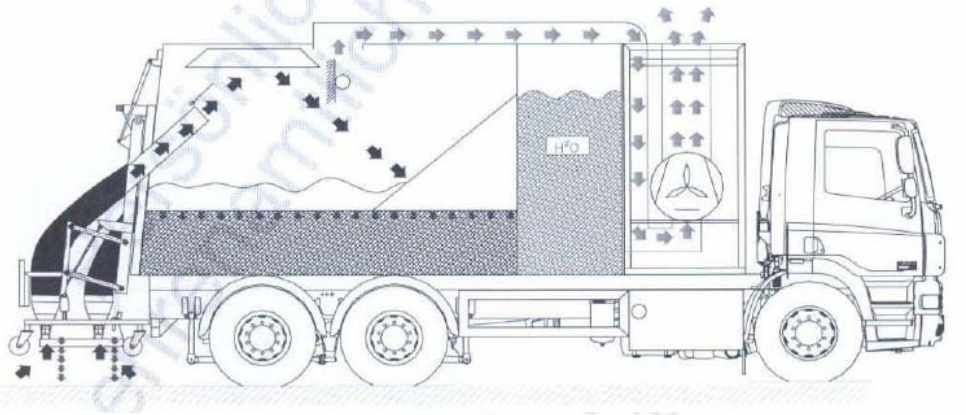
2014. Test de diferentes tecnologías de vehículos

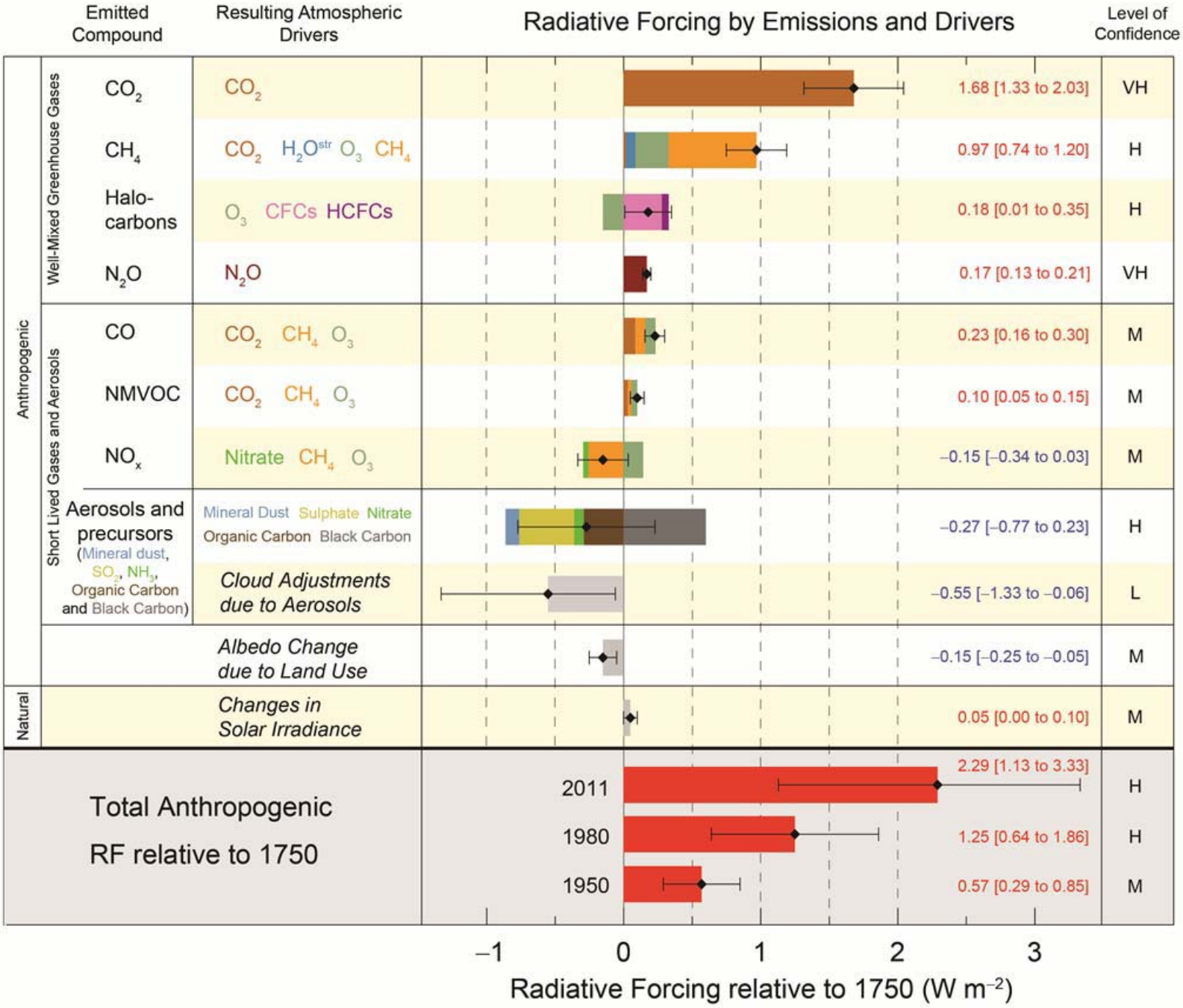


Pure suction



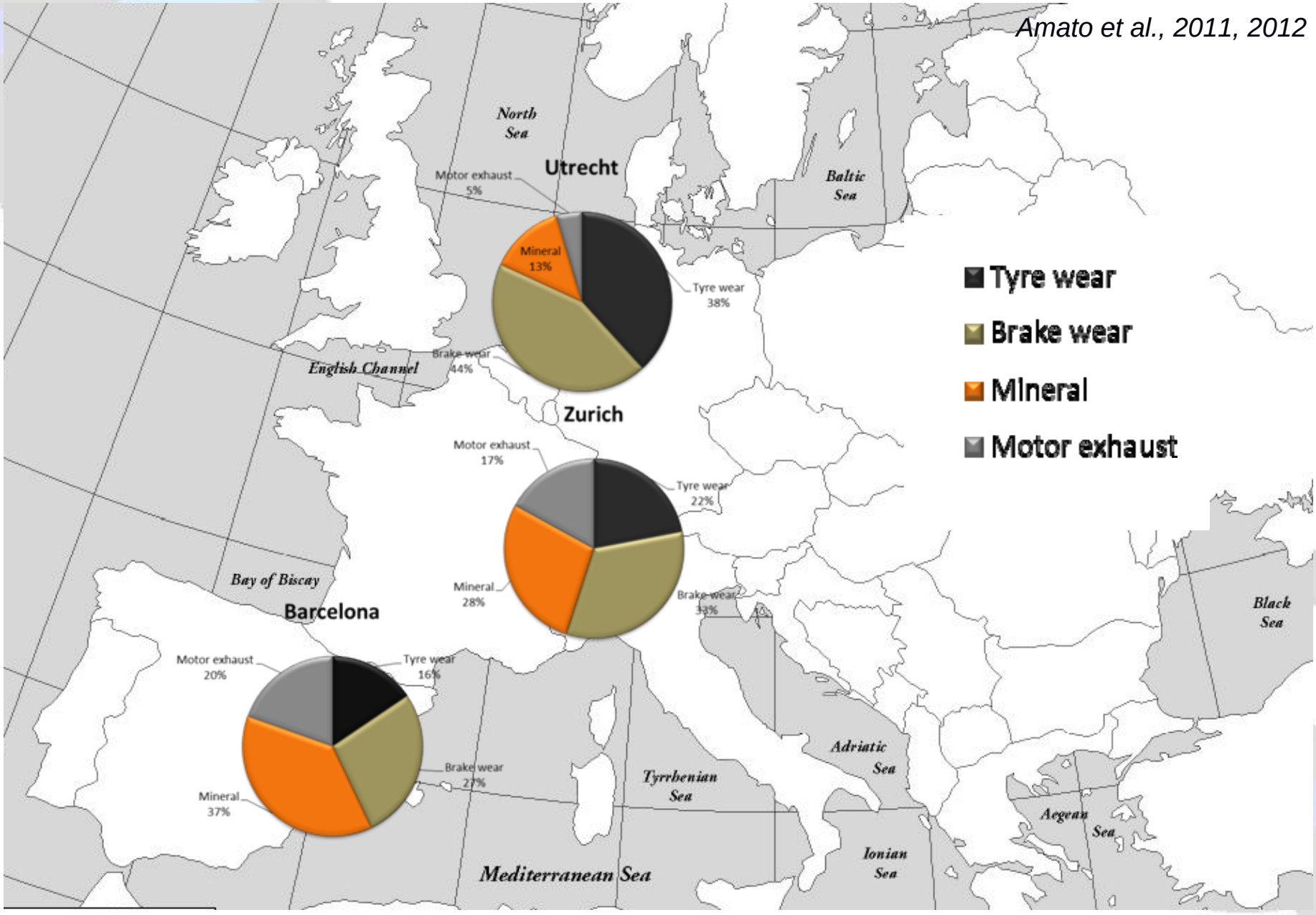
High pressure water

Mechanical suction sweeper


Emitted Compound
Resulting Atmospheric Drivers
Radiative Forcing by Emissions and Drivers
Level of Confidence
Anthropogenic
Natural
Well-Mixed Greenhouse Gases
Short Lived Gases and Aerosols
CO2
CH4
Halo-carbons
N2O
CO
NMVOC
NOx
Aerosols and precursors (Mineral dust, SO2, NH3, Organic Carbon and Black Carbon)
CO2
CO2 H2Ostr O3 CH4
O3 CFCs HCFCs
N2O
CO2 CH4 O3
CO2 CH4 O3
Nitrate CH4 O3
Mineral Dust Sulphate Nitrate
Organic Carbon Black Carbon
Cloud Adjustments due to Aerosols
Albedo Change due to Land Use
Changes in Solar Irradiance
1.68 [1.33 to 2.03]
0.97 [0.74 to 1.20]
0.18 [0.01 to 0.35]
0.17 [0.13 to 0.21]
0.23 [0.16 to 0.30]
0.10 [0.05 to 0.15]
–0.15 [–0.34 to 0.03]
–0.27 [–0.77 to 0.23]
–0.55 [–1.33 to –0.06]
–0.15 [–0.25 to –0.05]
0.05 [0.00 to 0.10]
VH
H
H
VH
M
M
M
H
L
M
M
Total Anthropogenic RF relative to 1750
2011
1980
1950
2.29 [1.13 to 3.33]
1.25 [0.64 to 1.86]
0.57 [0.29 to 0.85]
H
H
M
–1
0
1
2
3
Radiative Forcing relative to 1750 (W m–2)

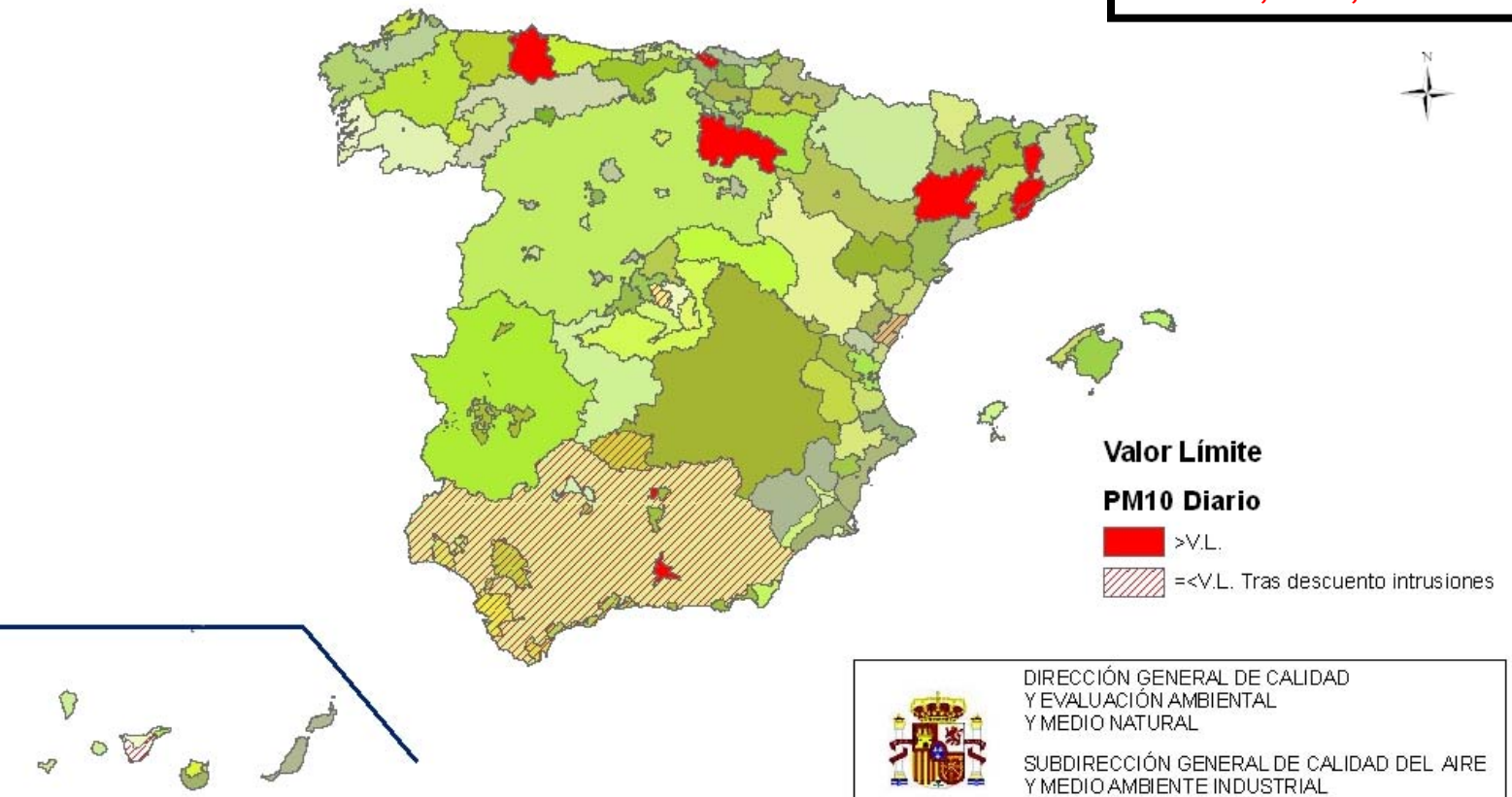
Fuentes de road dust

Amato et al., 2011, 2012



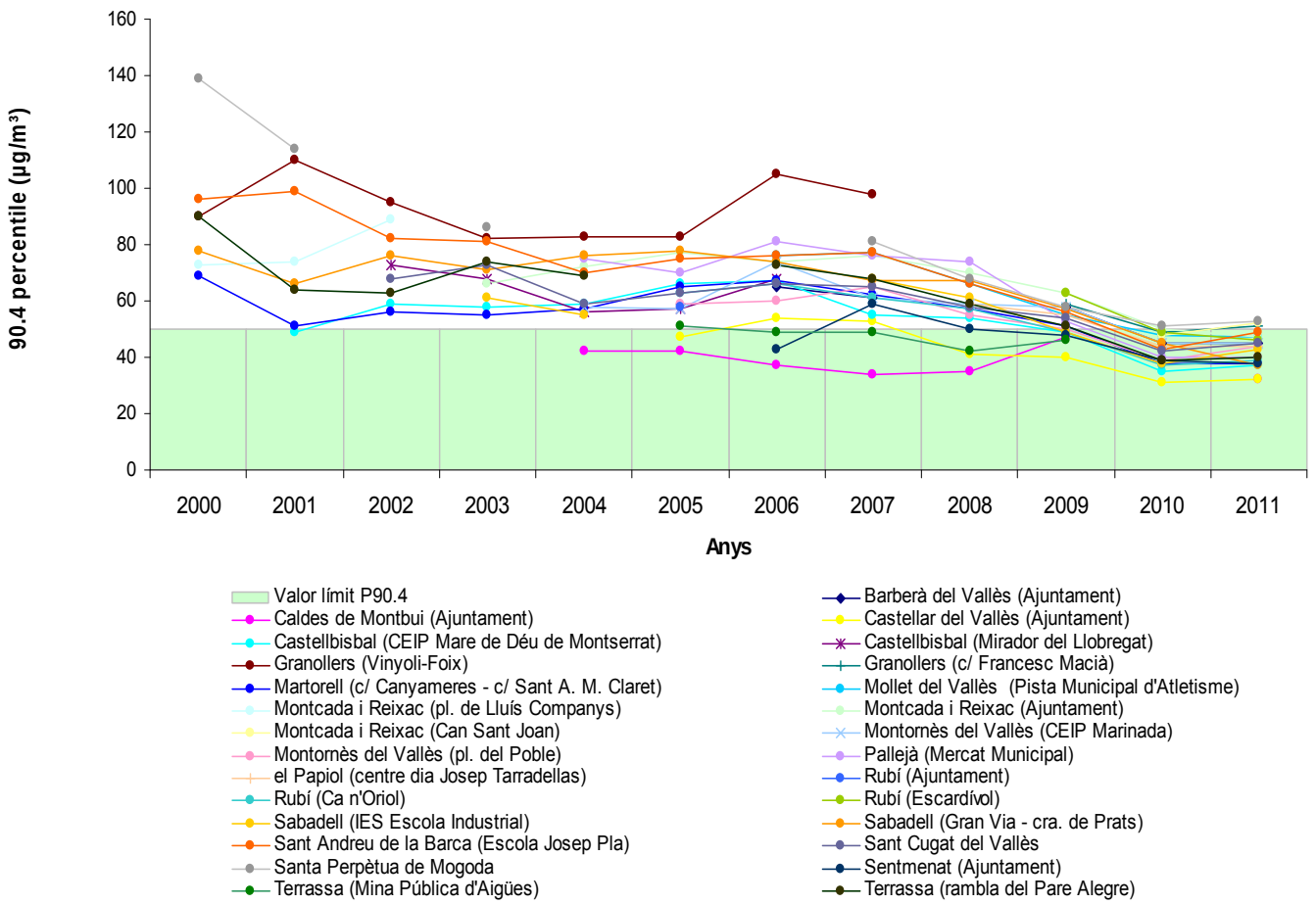
Superacions al 2011

VLA: Avilés2
VLD: Sevilla, Granada, Córdoba, Villanueva del Arz., Huelva, Bailén, Alfaro, Bilbao, Puertollano, Avilés, Gijón, St. Vicenç Horts, Sta Perpètua de la M., Granollers, Lleida, Vic, Barcelona, A Coruña

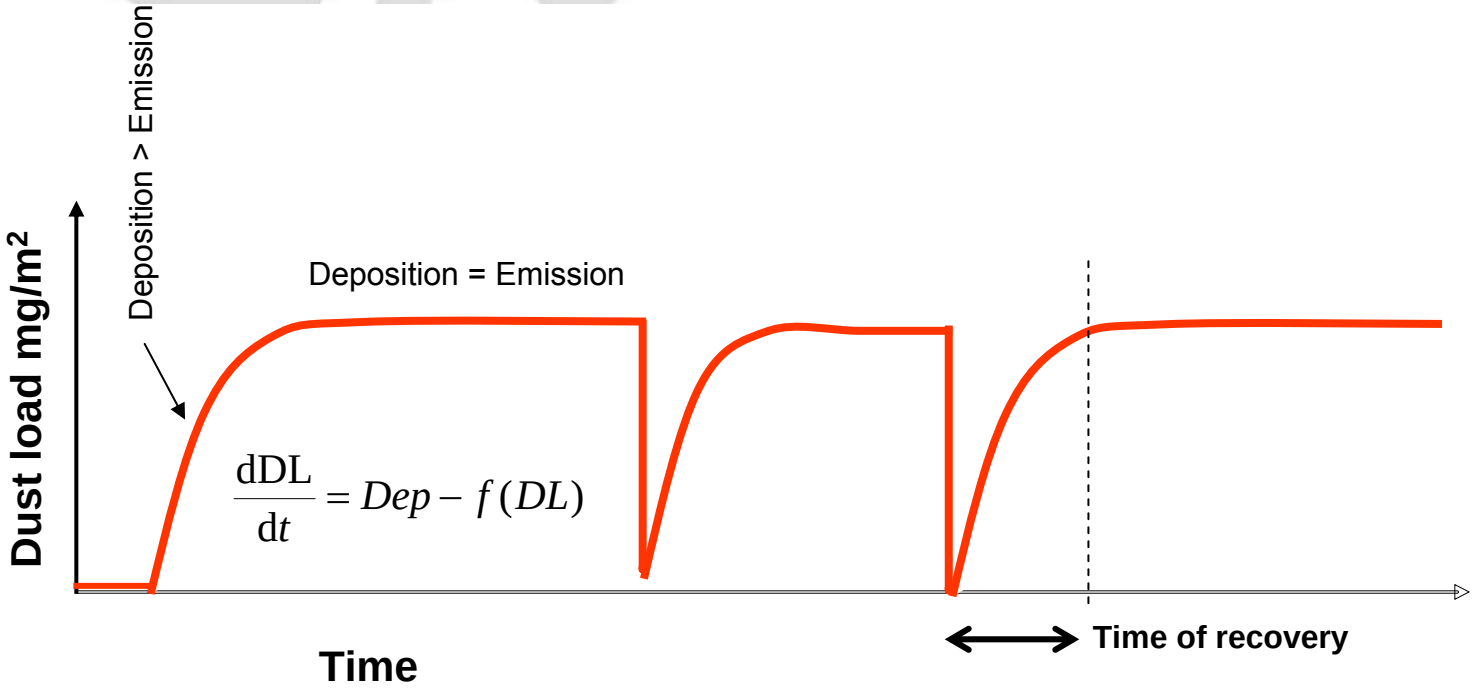


EVOLUCIÓ DE NIVELLS MITJANS DE QUALITAT DE L'AIRE
Últims 11 anys ZONA METROPOLITANA 1 & 2

Generalitat de Catalunya
Government of Catalonia
Departament de Territori i Sostenibilitat

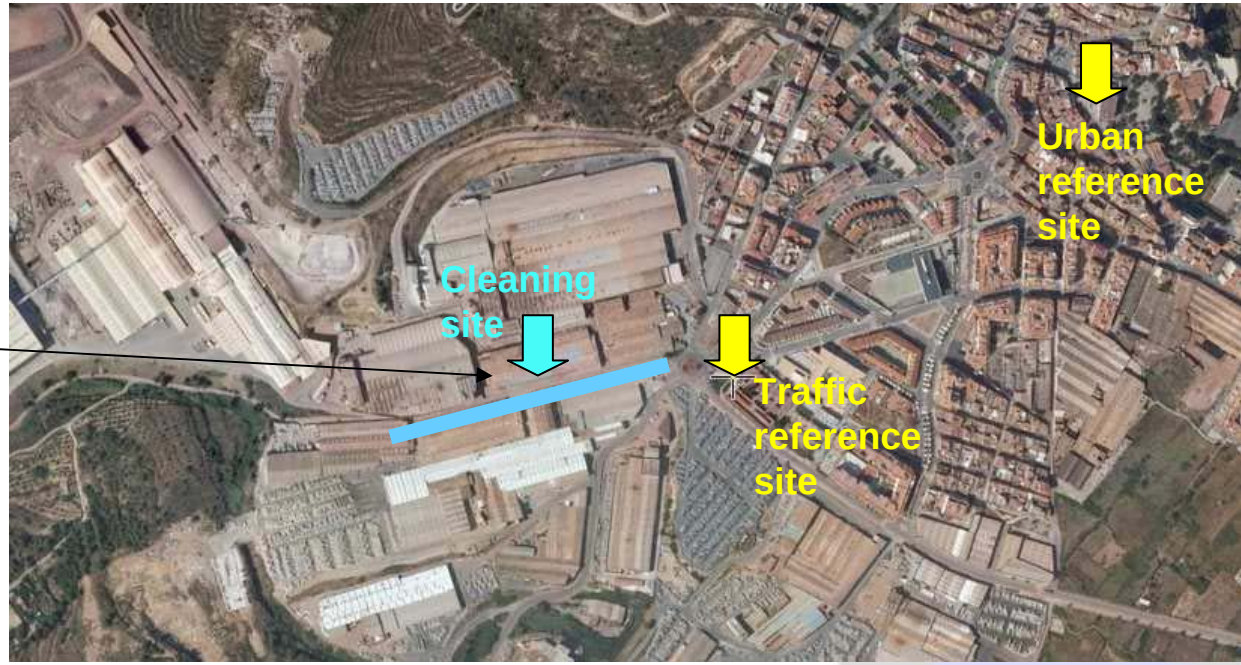


Evolución del road dust

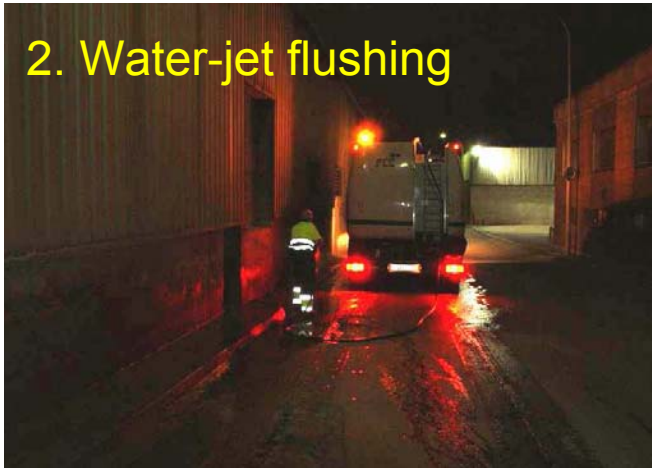


Castellón: industrial ceramic production

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

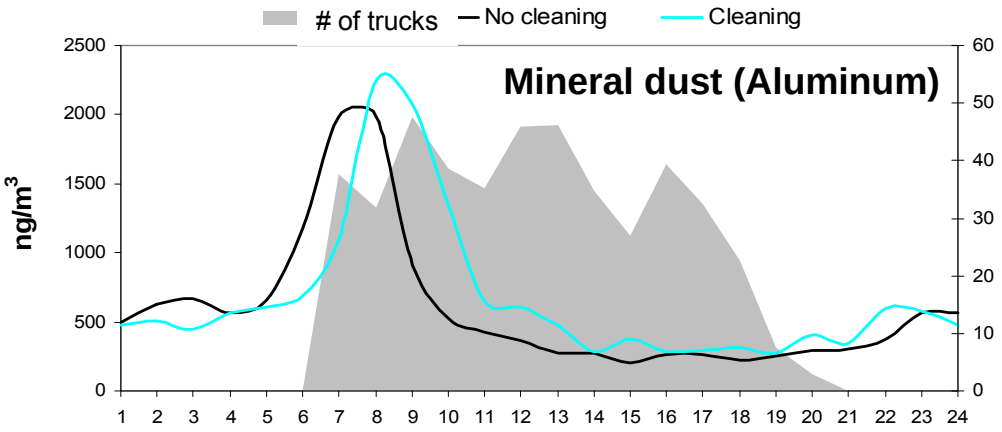


4. Road Cleaning method



Castellón: effect on PM_{10}

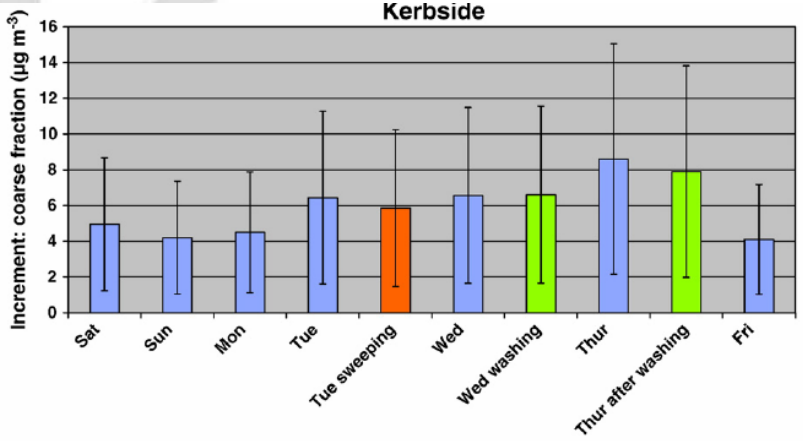
	Cleaning days	No cleaning	Reduction
Cleaned Canyon	43	50	-7
Reference 1	45	53	-8
Reference 2	31	34	-3

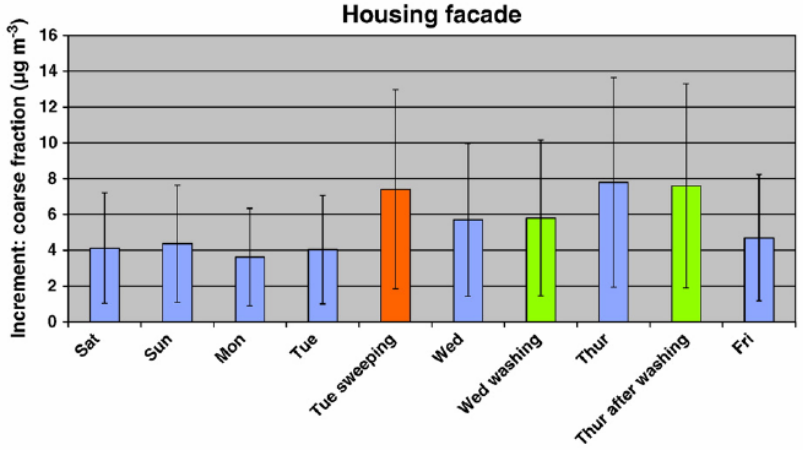


Why no reduction?

- simply not observed (measurements 30 m from the road) ?
- too high deposition rate (46-85 mg m^{-2} h^{-1}) ?

Amsterdam





No significant difference

Keuken et al., 2010.

Type of pavement

•Granite pavement was found to be more prone (70% higher) to PM10 production compared to the quartzite pavements (Gustafsson et al., 2009).

•Total wear of a pavement normally decreases with increasing aggregate size.

•Mafic, volcanic rock is the most resistant while granite is least resistant to wear. (Räisänen et al., 2003)

•Conditions of pavement are also important: fresh abrasion particle emissions from pavements in good condition are quite low. (Gehrig et al., 2010).