El problema de la calidad del aire urbano en el sur de Europa: resultados de MAGRAMA y de AIRUSE-LIFE

X. Querol[1], F. Amato[1], A. Karanasiou[1], A. Alastuey[1], F. Lucarelli[2], S. Nava[2], G. Calzolai[2], R. Udisti[2], S. Becagli[2], R. Traversi[2], M. Severi[2], S. Borselli[2], C. Alves[3], C. Pio[3], T. Nunes[3], L. Tarelho[3], M. Duarte[3], M. Cerqueira[3], E. Vicente[3], D. Custódio[3], H. Pinto[3], E. Montfort[4], I.Celades[4], V. Sanfelix[4], R. Harrison[5], C. Holman[5], K. Eleftheriadis[6], L. Diapouli[6], V.L. Gianelle[7], C. Colombi[7]

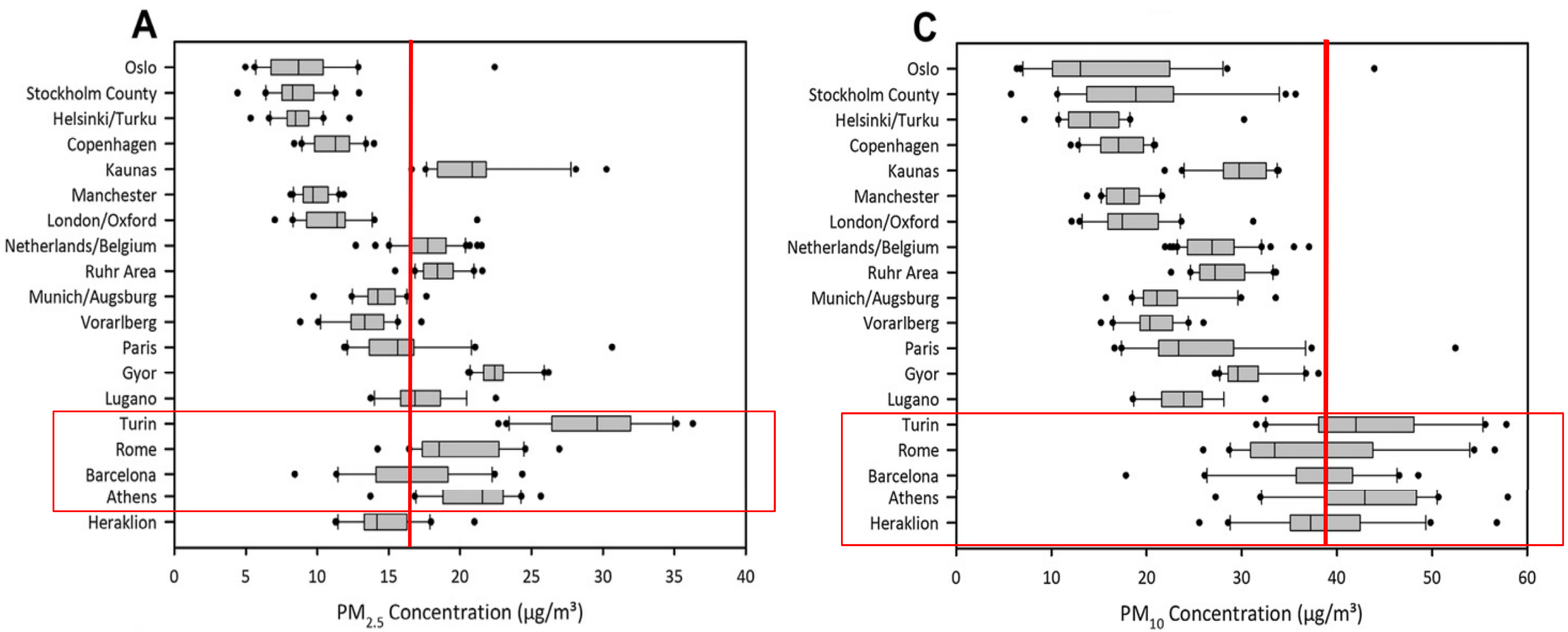
1 idæa CSIC Consejo Superior de Investigaciones Científicas
2 Università degli Studi Firenze Dipartimento di Fisica e Astronomia
3 universidade de aveiro
4 AICE itc Universitat Jaume I
5 University of Birmingham
6 Demokritos National Centre for Scientific Research
7 ARPA Lombardia Agenzia Regionale per la Protezione dell'Ambiente Settore Monitoraggi Ambientali

UIMP, Palacio de la Magdalena, Santander 20-21/07/2015

Bases Científico-Técnicas para mejorar la calidad del aire en España

AIRUSE

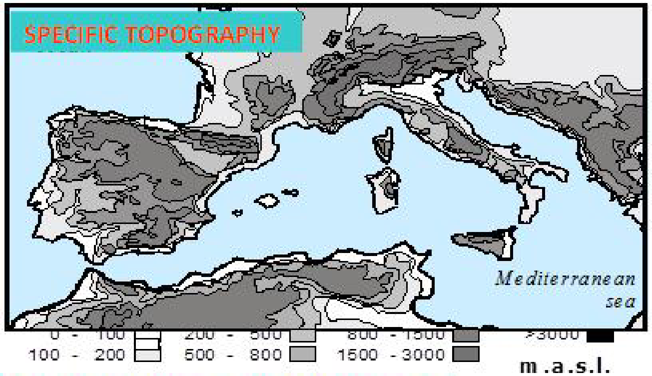
MEAN PM10 & PM2.5 LEVELS IN EUROPE



ESCAPE

Eeftens et al. (2012) Atmospheric Environment

PARTICULATE MATTER IN URBAN AREAS OF SOTHERN EUROPE



HIGH ANTHROPOGENIC EMISSIONS

PARTICULATE MATTER AND HEALTH EFFECTS IN BARCELONA

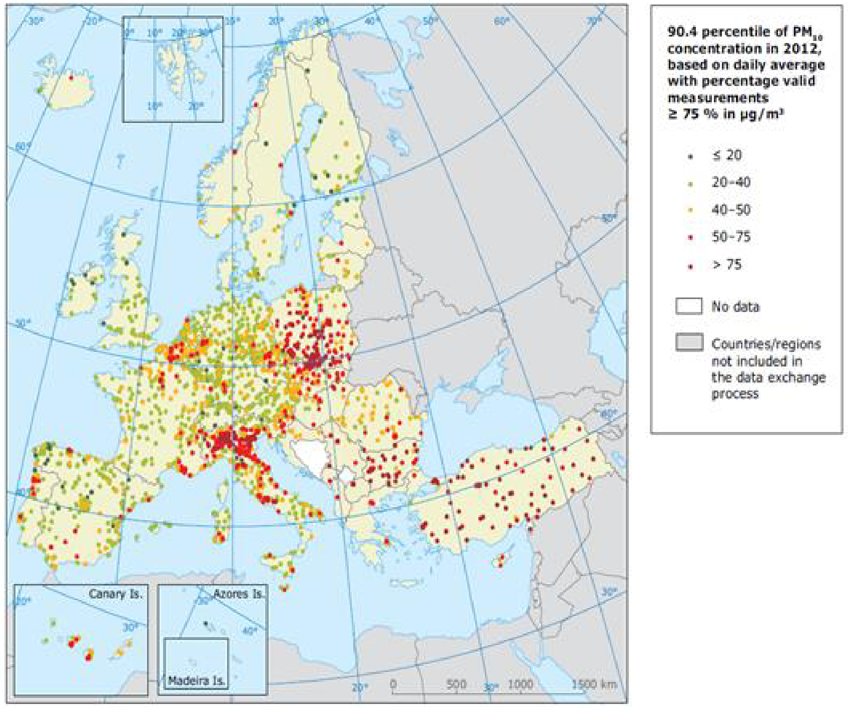
Perez et al., 2009 ES&T

Selected results

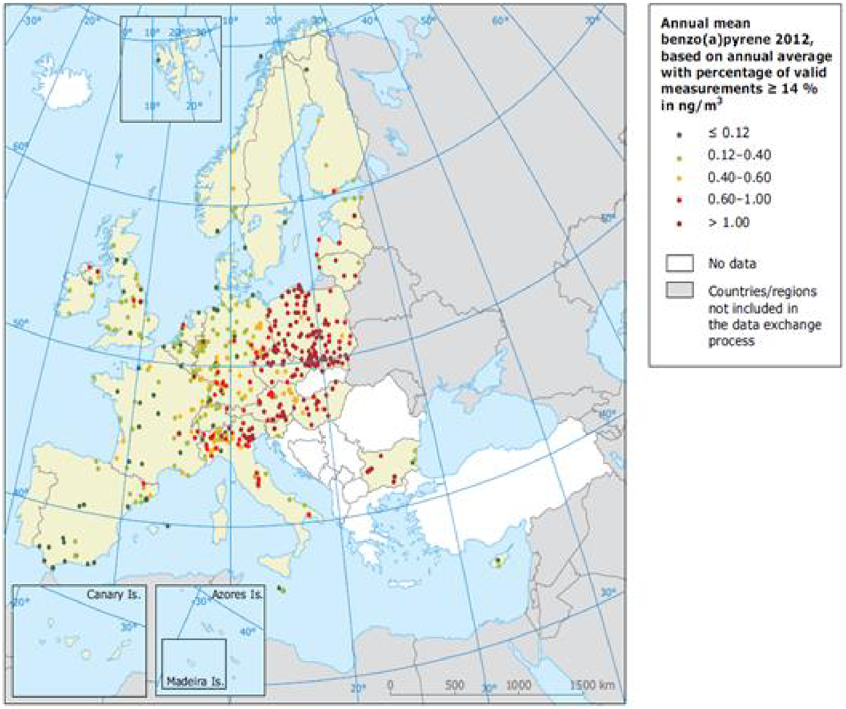
Fraction	Respiratory mortality (Lag2)	Cardiovascular mortality (Lag1)	Cerebrovascular mortality (Lag1)
$PM_{10-2.5}$	1.033 (0.980-1.089)	**1.059 (1.026-1.094)**	**1.098 (1.030-1.171)**
$PM_{2.5-1}$	**1.206 (1.028-1.416)**	0.984 (0.892-1.086)	0.905 (0.743-1.102)
PM_1	1.010 (0.963-1.059)	**1.028 (1.000-1.058)**	**1.063 (1.004-1.124)**

Odds ratio per 10 ug/m3

PM10 daily limit value 2012



BaP target annual value, 2012



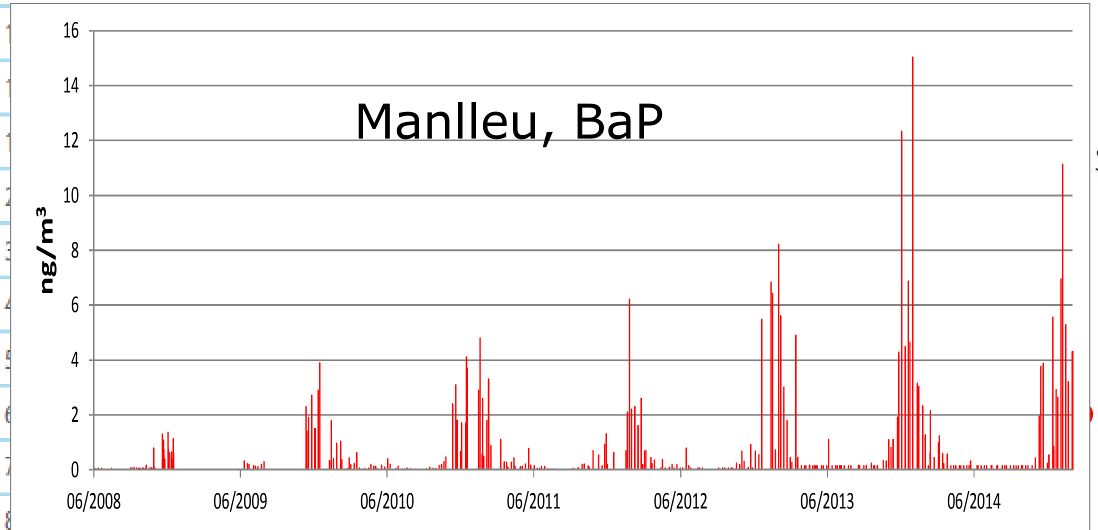
EEA Report | No 5/2014
European Environment Agency
19/11/2014

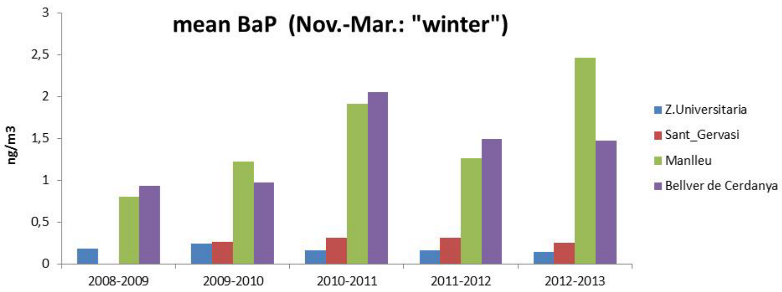
AIRUSE

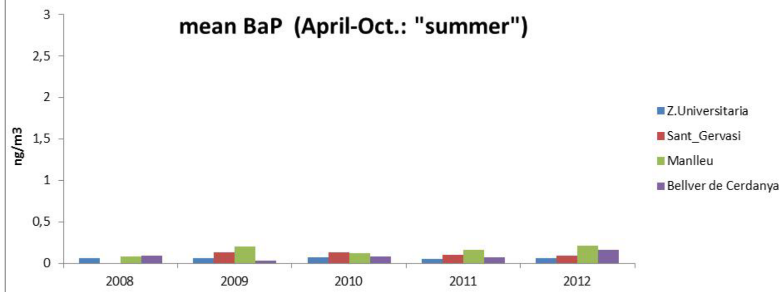
BaP 2013, Catalonia, NE Spain

Generalitat de Catalunya
Departament de Territori i Sostenibilitat

ZQA	Punt de mesurament	Tipus* d'àrea	Tipus** d'avaluació	% dades	Mitjana anual [1] (ng/m^3)
1	Barcelona (el Poblenou)	UT	F	97	0,14
1	Barcelona (Gràcia - Sant Gervasi)	UT	F	96	0,16
1	Barcelona (IES Goya)	UF	F	68	0,07
1	Barcelona (IES Verdaguer)	UF	F	84	0,11
1	Barcelona (l'Eixample)	UT	F	97	0,19
1	Barcelona (parc de la Vall d'Hebron)	UF	F	96	0,08
9	La Bisbal d'Empordà (Ajuntament)	SF	F	14	0,28







AIRUSE

OBJETIVOS

- Identificar similitudes y diferencias en contribución de fuentes a PM en el S-EU (**5 ciudades)**
- Una vez identificadas fuentes clave de PM10 and PM2.5 el objetivo estratégico de AIRUSE es **el desarrollo, pruebas y propuestas de medidas específicas y no específicas para entornos urbanos del S-EU que permitan alcanzar los valores guía y límite OMS-UE**

Medidas de PM específicas

- Lavado y aspiración vías de tráfico y aplicación supresores de polvo de rodadura y polvo africano
- Reducción de emisiones de quema de biomasa
- Reducción de emisiones canalizadas y fugitivas del sector industrial
- Evaluar estrategias de otra regiones europeas

ESTRUCTURA: ACCIONES Y TAREAS

ACTION A. Acciones preparatorias

- A.1 Consultas a la administración competente

ACTION B. Implementation actions

- B1. Documentación del estado actual y tendencias
- B2. Contribución de fuentes a PM de manera homogénea en las 5 ciudades:
  - B3. Fuentes Naturales
  - B4. Quema de biomasa
  - B5. Fuentes industriales
  - B6. Tráfico rodado

  Trabajo adicional intenso en inventarios de emisión, perfiles químicos y factores emisión
- B7. Desarrollo y pruebas de medidas de bajo coste y alta eficiencia para PM
- B8. Evaluación y posibles adaptaciones de medidas aplicadas en el N y C de EU

Se expone esta tarde

Se expone en la presentación

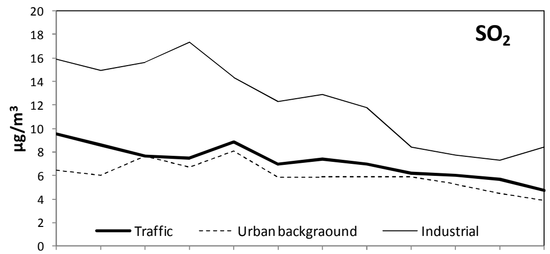
ESTRUCTURA: SOCIOS Y COORDINACIÓN

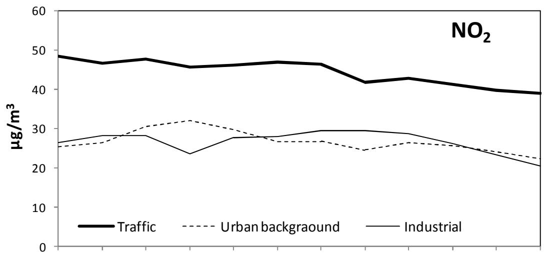
Coordinador
Project Manager
Spain

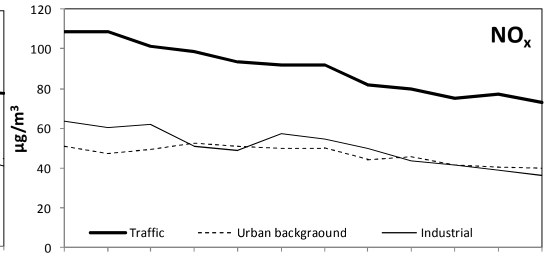
Socios

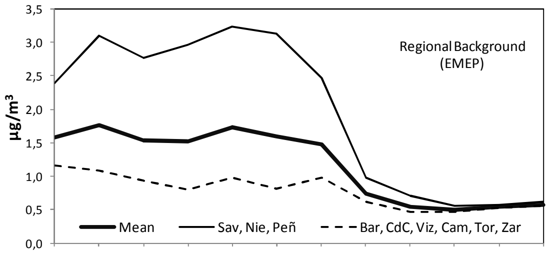
Leader B5 D5 Spain	Leader B8 UK	Leader B3 D2 Greece	Leader B2 Italy	Leader B4 Portugal	Milan Italy

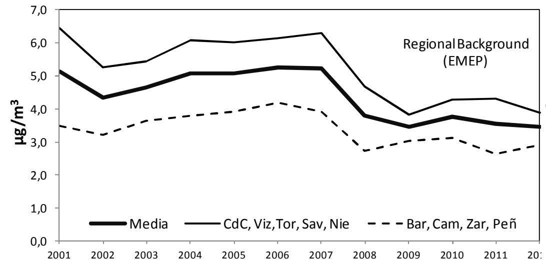
B1: TENDENCIAS 2001-2012 CALIDAD AIRE EN ESPAÑA

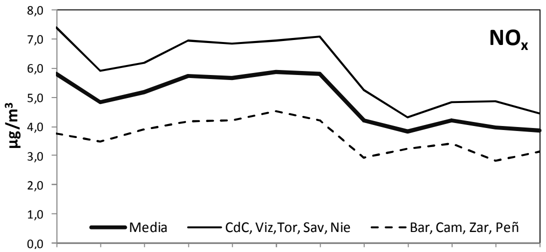


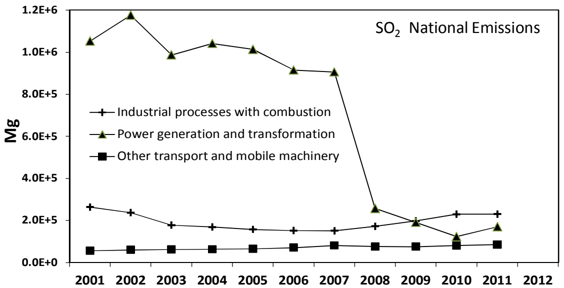


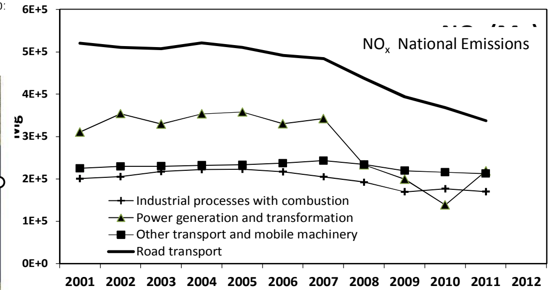






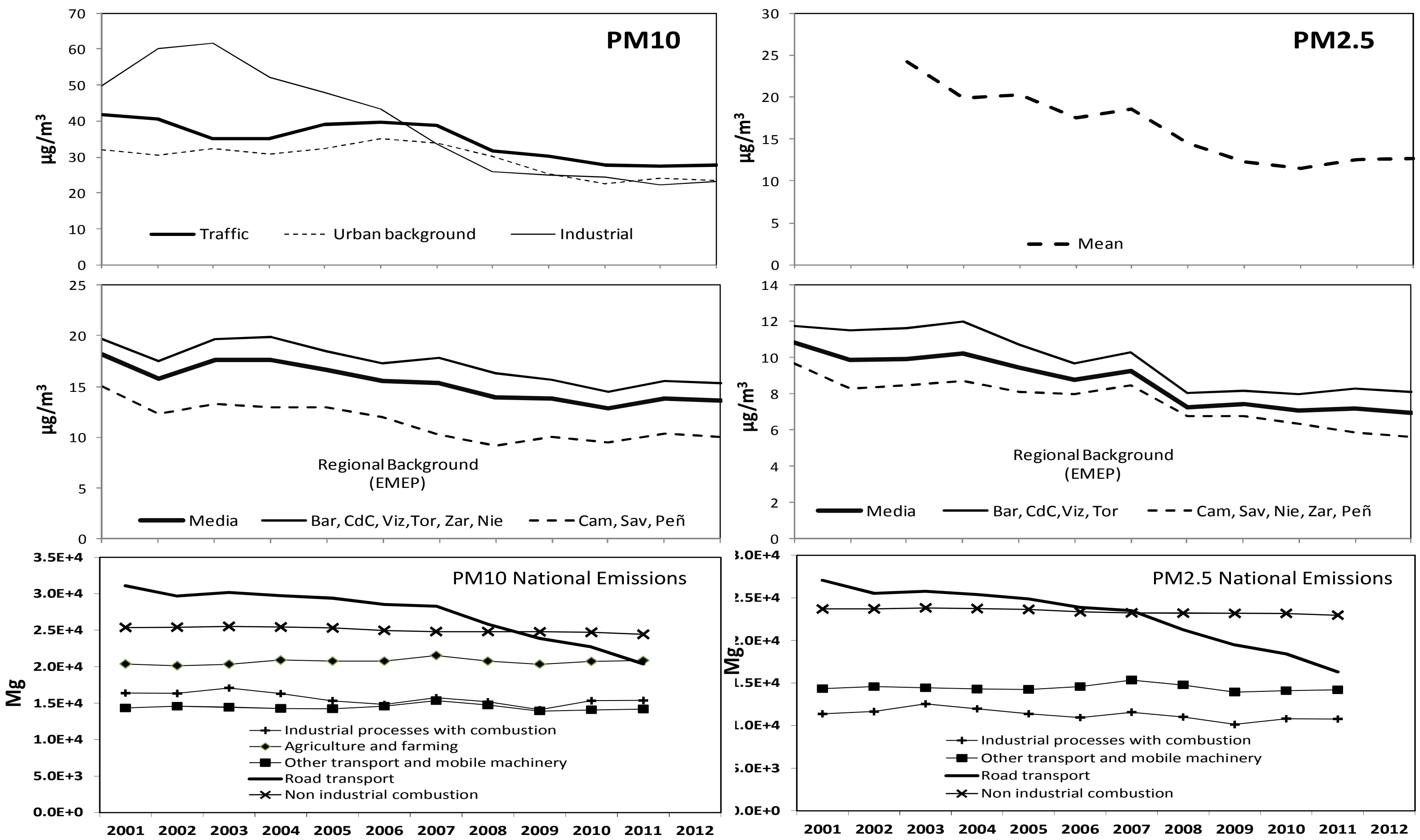






Querol et al., 2014. Science of Total Environment

B1: TENDENCIAS 2001-2012 CALIDAD AIRE EN ESPAÑA



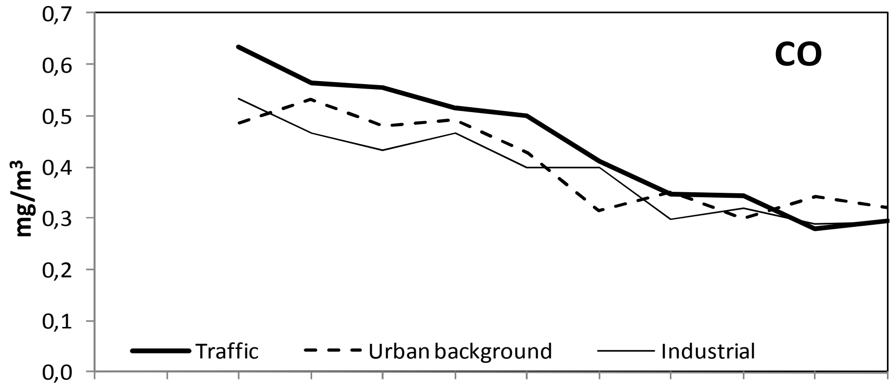
GOBIERNO DE ESPAÑA

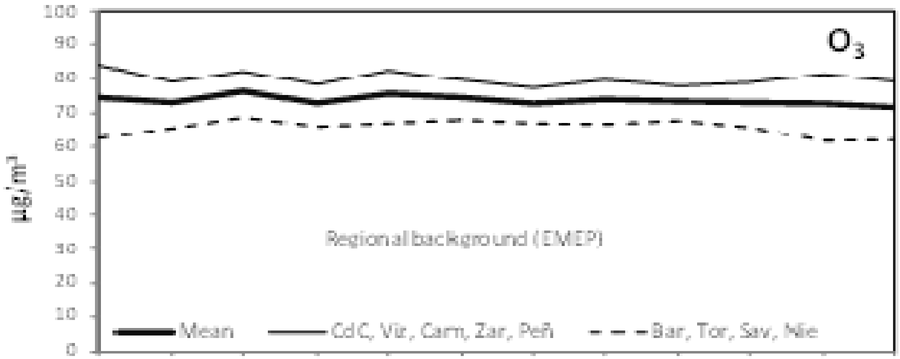
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

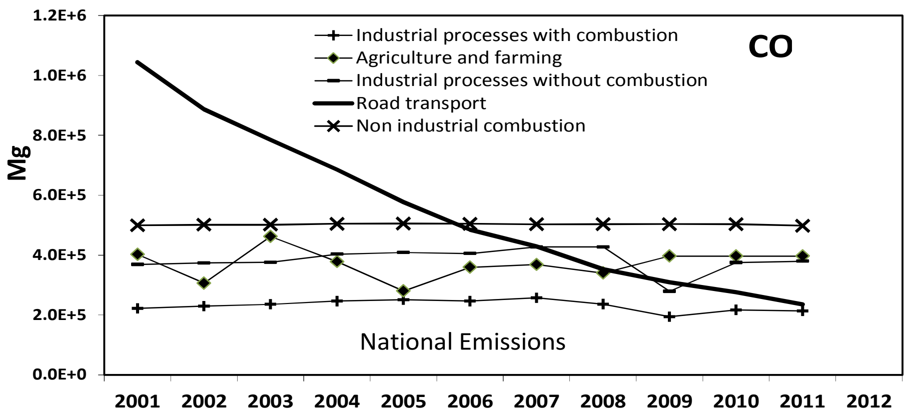
Querol et al., 2014. Science of Total Environment

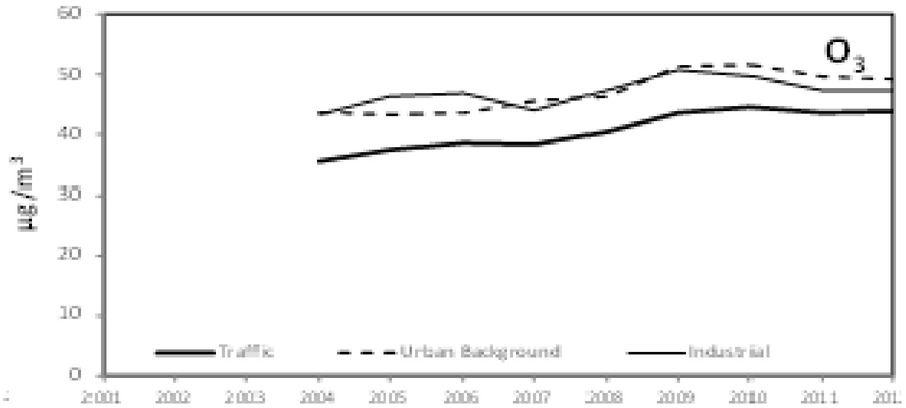
AIRUSE

B1: TENDENCIAS 2001-2012 CALIDAD AIRE EN ESPAÑA









GOBIERNO DE ESPAÑA

MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

Querol et al., 2014. Science of Total Environment

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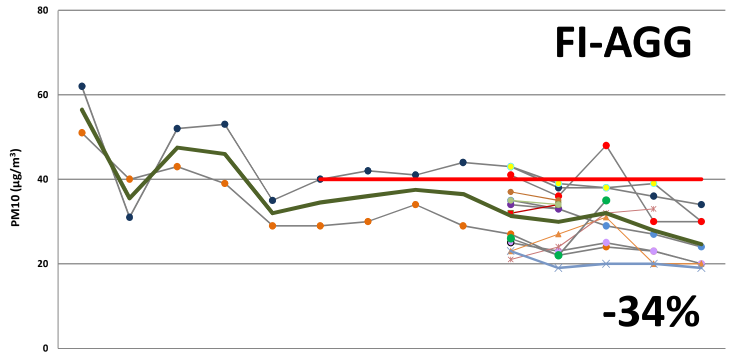
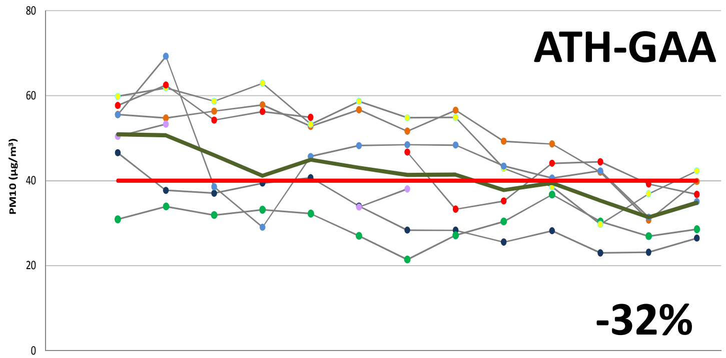
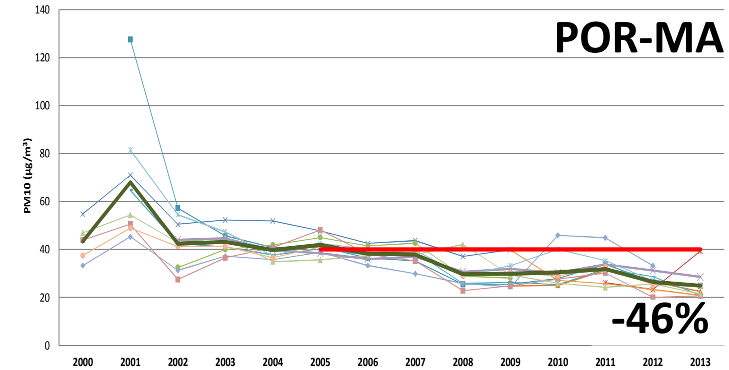
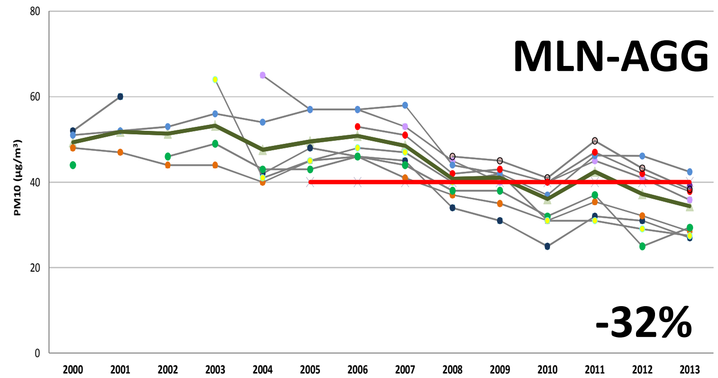
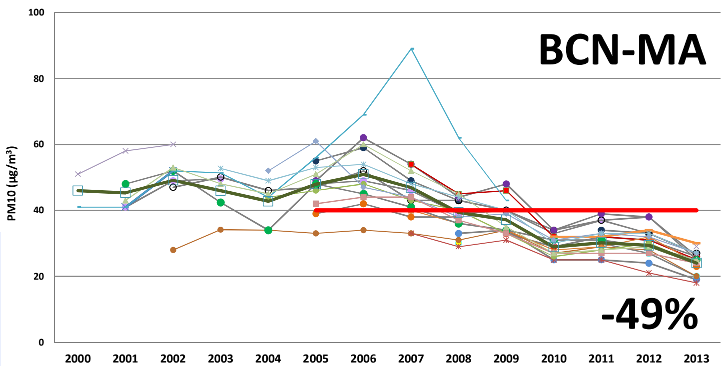
B1: 5 CIUDADES TENDENCIAS 2001-2013 PM10 ANUAL











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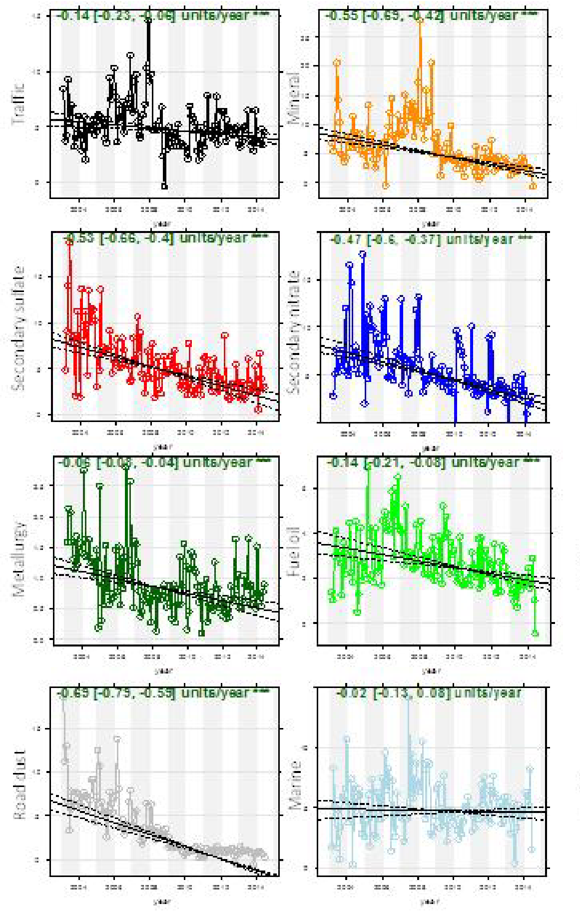
B1: BARCELONA TENDENCIAS 2004-2014 PM10 Y PM2.5 CONTRIBUCIÓN FUENTES

PM10



Generalitat de Catalunya
Departament de Cultura

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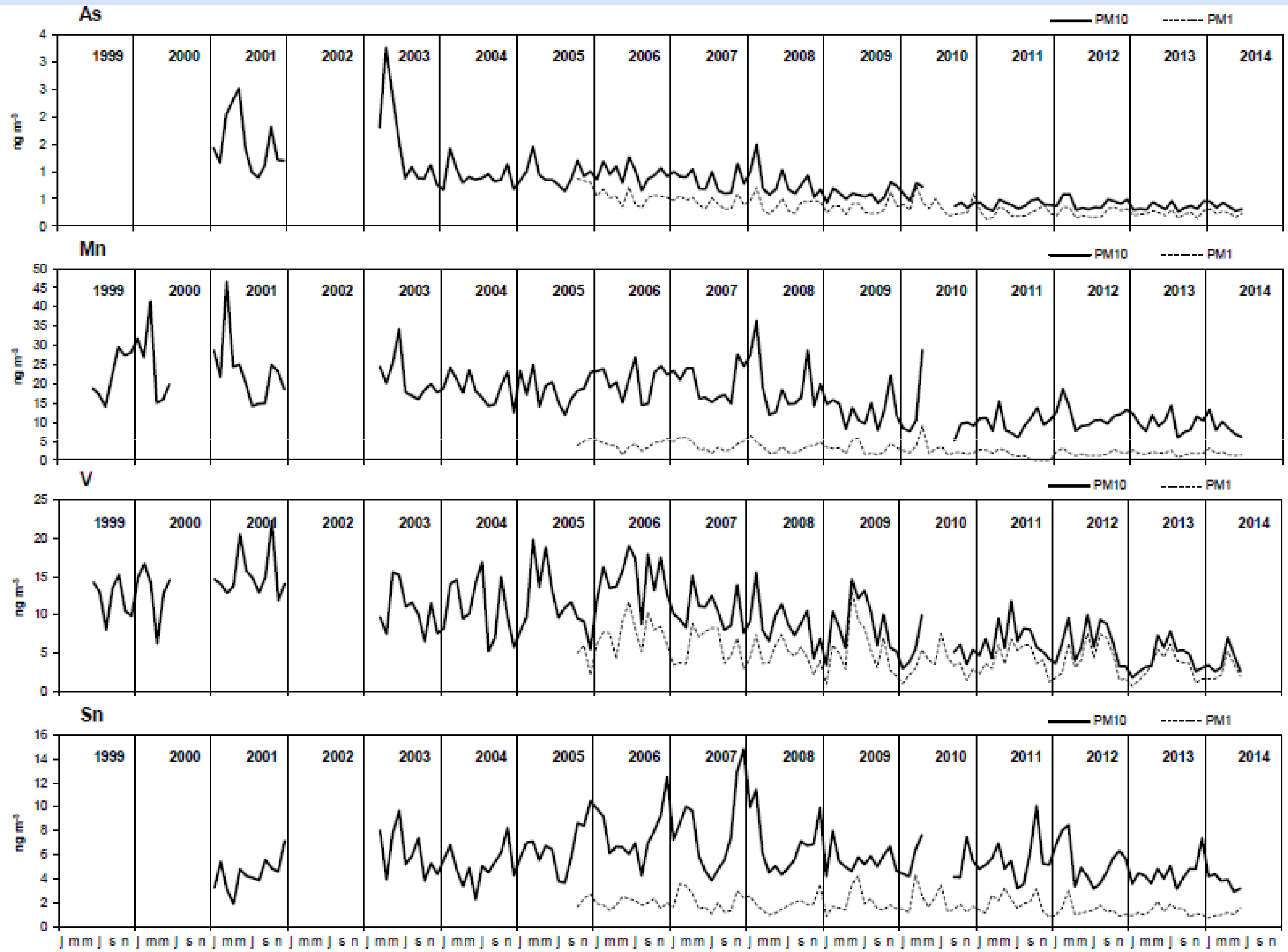

As
Mn
V
Sn
PM10
PM1
ng m-3
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
j mm j s n

B2. CONTRIBUCIÓN DE FUENTES 2013 PM10 & PM2.5

Long term measurements			BCN-UB	FI-UB	MLN-UB	POR-TR	ATH-SUB
Daily	PM10	Mass	122	226	379	123	197
		Elements	122	226	241[§]	123*	197‡
		Ions	122	226	337	123	197
		ECOC	122	226	348	123	197
		CC	122	226	89	123	197
		Levoglucosan			324		243
	PM2.5	Mass	126	243	378	126	243
		Elements	126	243	361[§]	126	243
		Ions	126	243	374	126	243
		ECOC	126	243	370	126	243
		Levoglucosan	126	243	356	126	888
Hourly	PM2.5-10	Elements	716	504		504	888
	PM2.5	Elements	714	504		504	197

*intercomparison between PIXE and ICP on Teflon filters
‡intercomparison between Teflon (PIXE) and quartz (ICP) filters
§ intercomparison between PIXE and XRF on Teflon and MCE filters

PIXE	
ICP	
SUNSET	
XRF	
Infrared	
IC	
GC	

1047 PM10 samples
1116 PM2.5 samples

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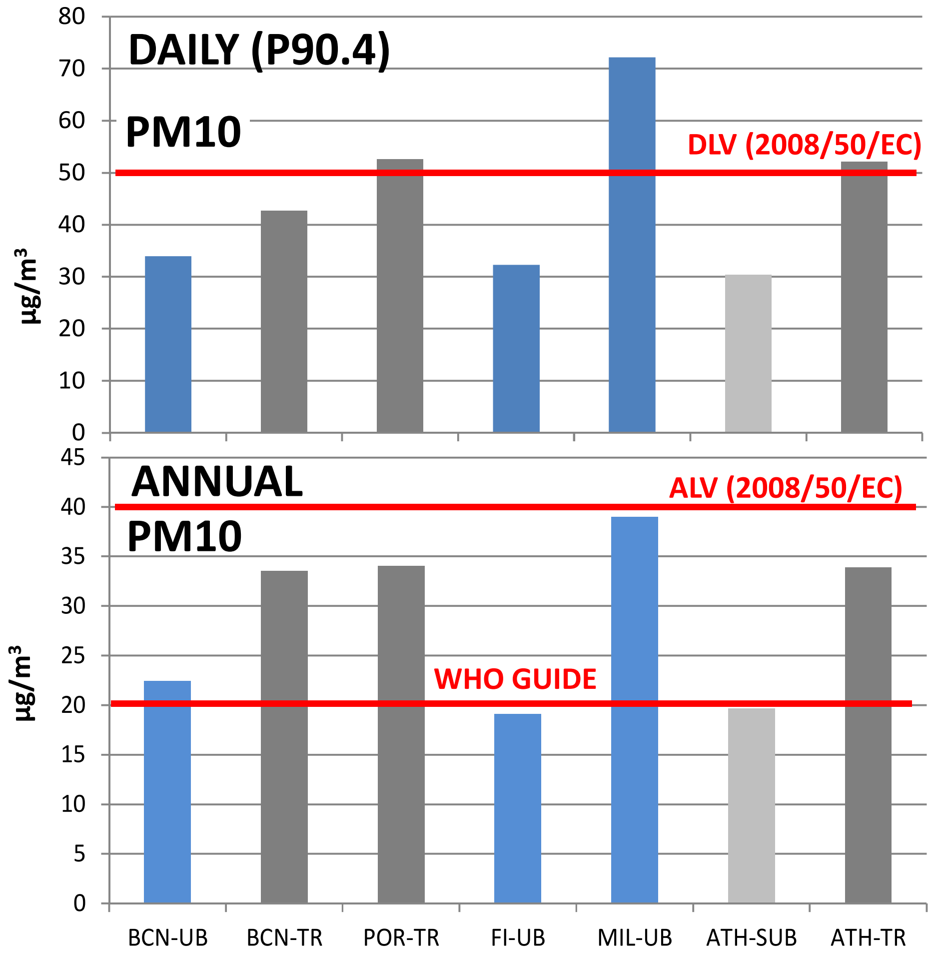
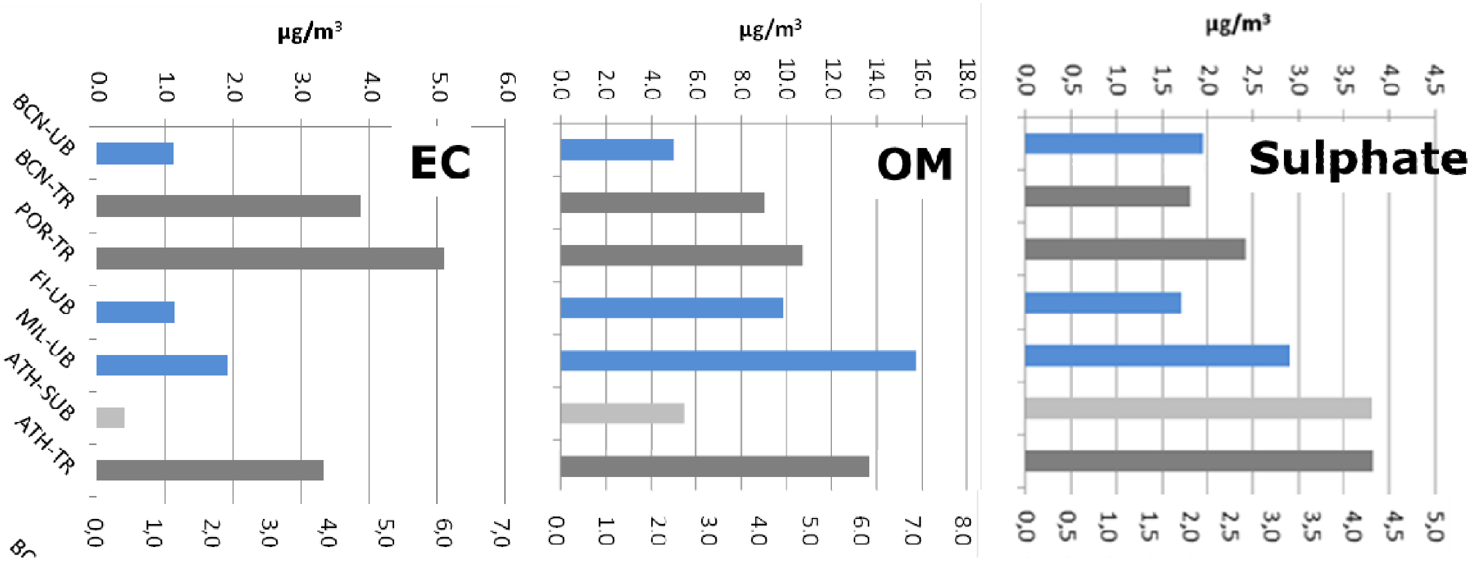
B2. CONTRIBUCIÓN DE FUENTES 2013 PM10 & PM2.5

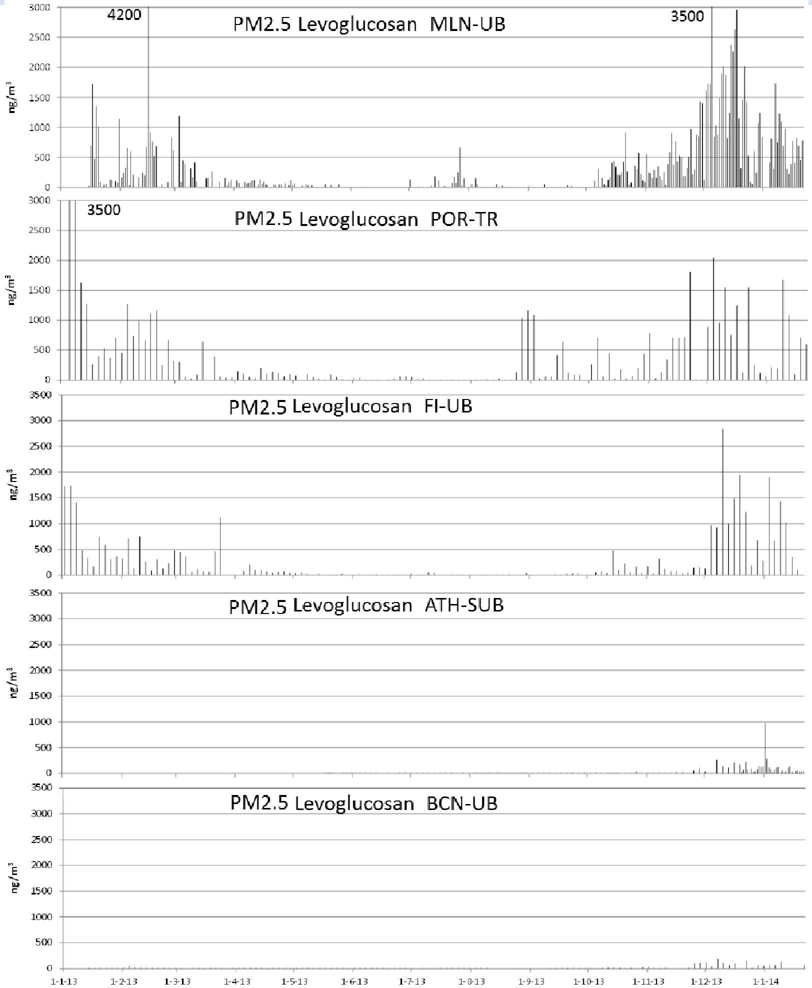


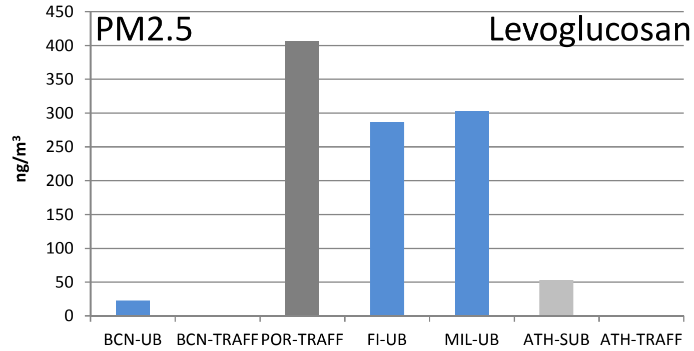
B2. HARMONIZED 2013 PM10 & PM2.5 SOURCE APPORTIONMENT

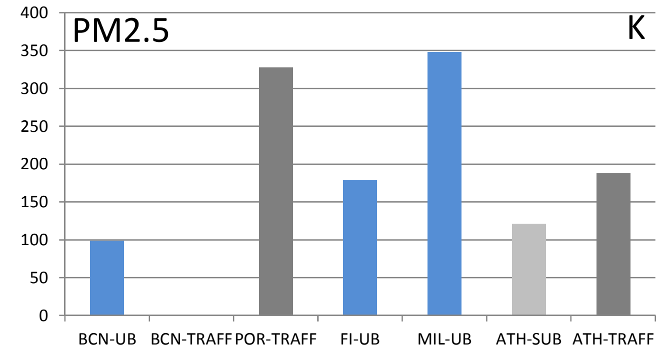
Example PM10



B2. CONTRIBUCIÓN DE FUENTES 2013 PM10 & PM2.5







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B2. CONTRIBUCIÓN DE FUENTES 2013 PM10 & PM2.5

Primary: 62%
Secondary: 38%

PM2.5

PM10 (media anual)	PM10 (días de superación)
1. **Road Traffic** is the main source contributing to PM10: **31-38%** (ATH 23%)	**36-45%** (ATH 15%)
1.1. Vehicle exhaust + traffic related NO_3^- are the main causes: **21-29%** (ATH 15%)	**30-34%** (ATH 6%)
1.2. Non-exhaust vehicle emissions are also relevant: **8-11%**	**18-29%** (ATH 3%, POR 6%)
2. **Regional OC and/or SO_4^{2-}** dominated pollution: **20-26%** (POR-**TR** 10%)	BCN **19%,** 2-6%
3. **Local dust** : **10-19%**	POR **27%,** 1-4%
4. **Biomass burning** very relevant in POR & FI (**14-16%**), less in ATH (**7%**) and negligible in BCN	POR & FI (**25-30%**), ATH 1%, negligible in BCN
5. **Industry** BCN **11%, 4-5%,** ATH <1%	BCN **17%,** <1-3%
6. **Non traffic-NO_3^-** **6-8%** (2% POR)	BCN & FI 7-9% (1-2% POR & ATH)
7. **Shipping** **4%** in coastal sites	3-4% in coastal sites
8. **African dust** ATH **14%,** 1-4%	ATH **52%,** 1%
9. **Sea salt** POR **13%, 4-8%**	ATH **7%,** 1-3%
10. **Anthropogenic dust** (Local dust + Non exhaust) reaches **19-25%**	**11-33%**, ATH 4%

PM2.5 (media anual)	PM2.5 (días de superación PM10)
1. **Road Traffic** is the main source contributing to PM2.5: **28-39%** (ATH **22%**)	**32-42%** (ATH 11%)
1.1. Vehicle exhaust + traffic related NO_3^- are the main causes: **25-34%** (ATH 17%)	**31-40%** (ATH 10%)
1.2. Non-exhaust vehicle emissions are also relevant: **5-9%** (BCN&FI 1-2%)	1-7%
2. **Regional OC and/or SO_4^{2-}** dominated pollution: **19-37%** (POR **13%**)	BCN & MLN **11-22%,** 2-6%
3. **Local dust**: POR **16%**, **2-6%**	POR **22%,** 1-2%
4. **Biomass burning** very relevant in MLN, FI & POR (**18-21%**), less in ATH (**10%**) and negligible in BCN	POR, FI & MLN (**26-33%**), <2%
5. **Industry** **5-12%**, ATH <1%	BCN **18%,** <1-3%
6. **Non traffic-NO_3^-** **3-6%** (POR **1%**)	BCN, FI & MLN **6-9%** (1-3% POR & ATH)
7. **Shipping** **5-7%** in coastal sites	**6-10%** in coastal sites
8. **African dust:** ATH **6%,** <1%	ATH **45%,** 1%
9. **Sea salt** POR **5%,** <1-3%,	<1%-1%
10. **Anthropogenic dust** (Local dust + Non exhaust) reaches **10-21%**, BCN **7%**, FI **4%**	**POR 15, 3-9%**

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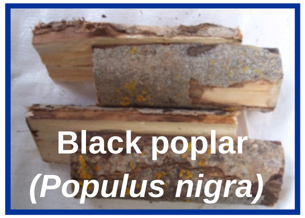
B4. QUEMA DE BIOMASA

Biomass fuels: Based on forest inventories and information provided by the AIRUSE partners, wood species widely used as biofuels in residential combustion in Southern European



agro-fuels

Biomass burning appliances

1

Traditional brick fireplace

2

Traditional cast iron wood stove

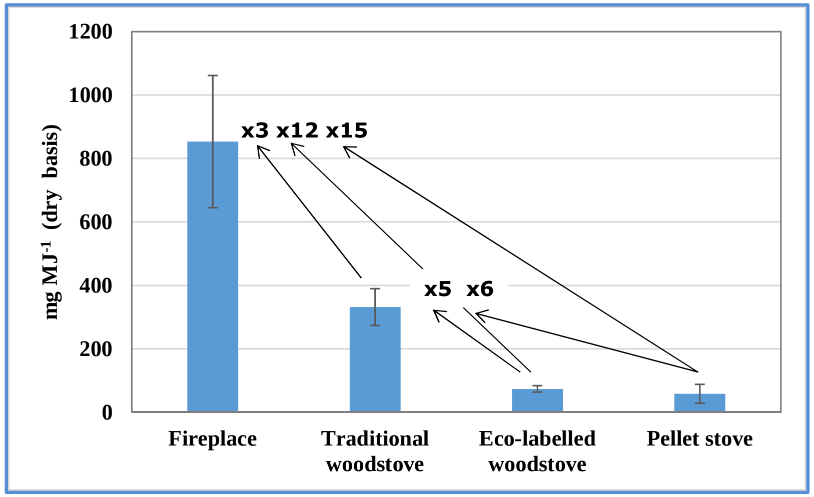
3

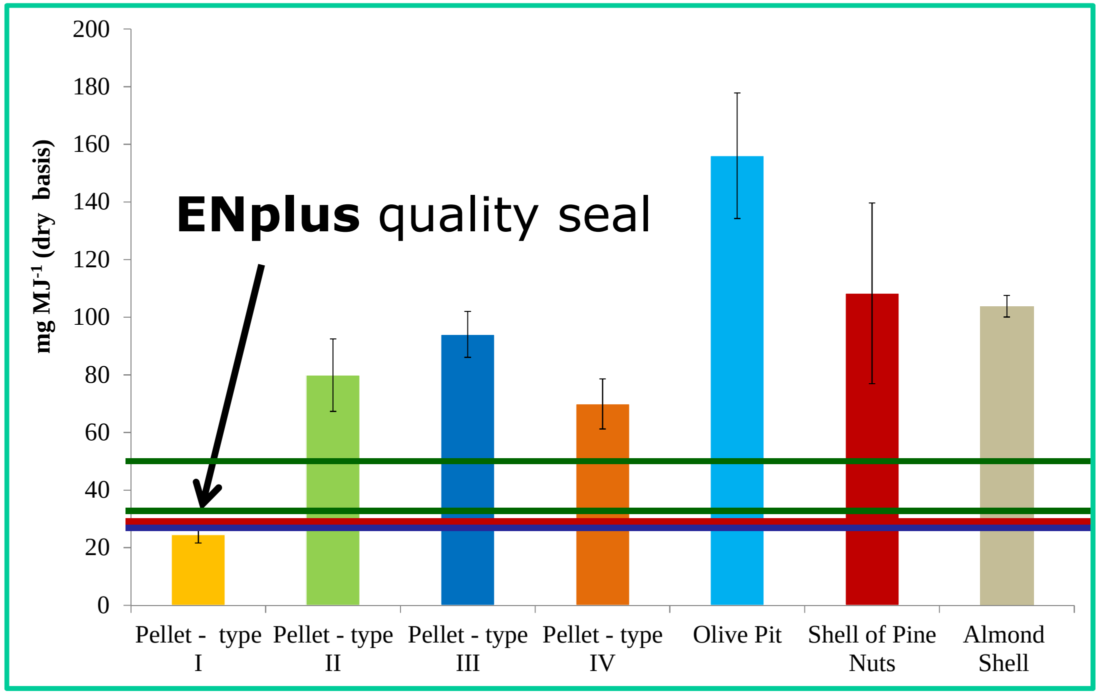
Eco-labelled chimney-type wood stove

4

Pellet stove

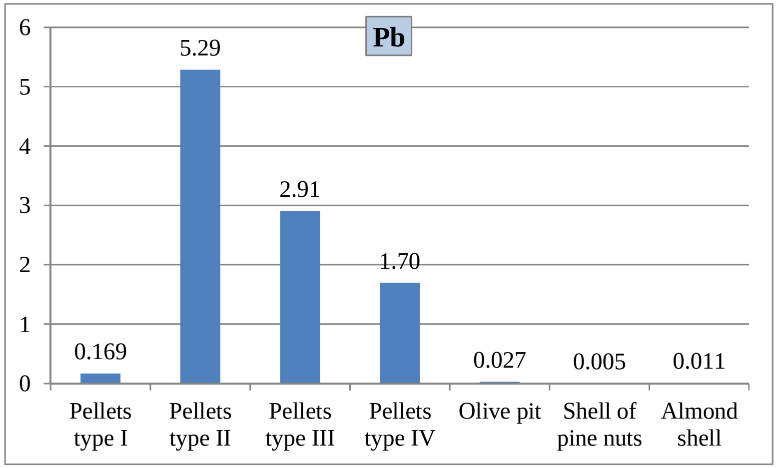
PM emission factors

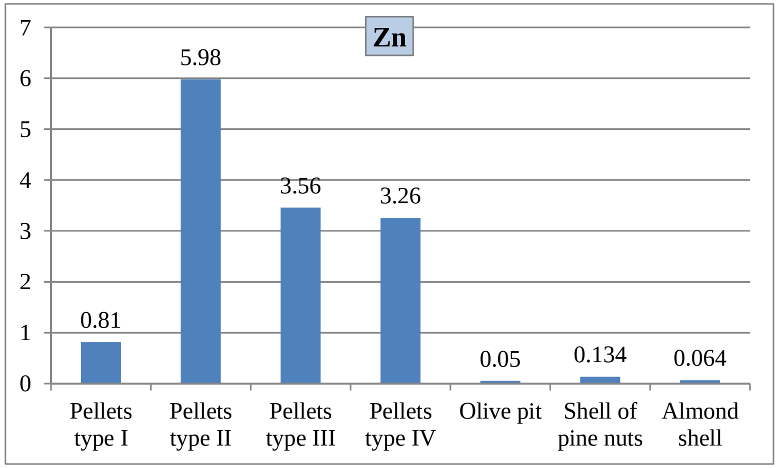


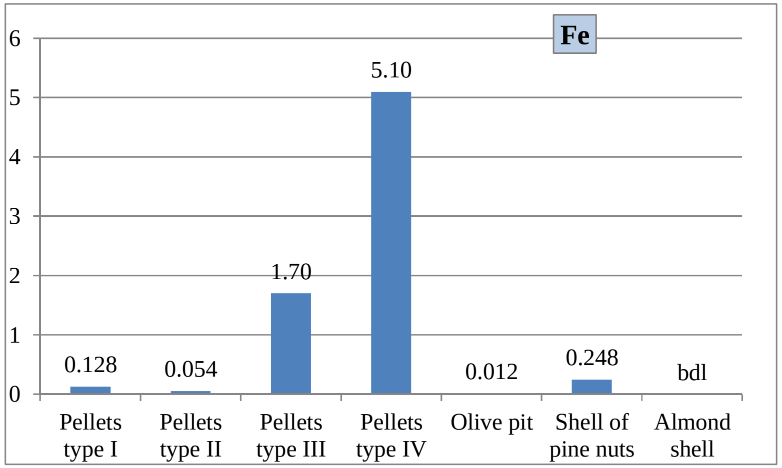


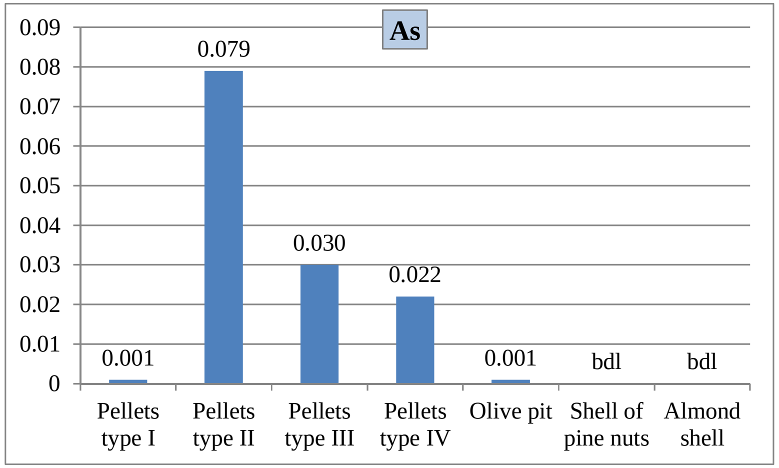
50 mg MJ^{-1} in Denmark & Switzerland
35 mg MJ^{-1} wood fuels & 25 mg MJ^{-1} for pellets in Austria
27 mg MJ^{-1} in Germany

B4. QUEMA DE BIOMASA









Standards need to be established in the EU for elemental composition of commercial wood pellets and chips to avoid the inclusion of extraneous materials. Only Germany has standards containing extensive trace element limits.

PM2.5 & BaP emission factors

FIREPLACE			
	Softwood	Hardwood	Briquettes
g $PM_{2.5}$ kg^{-1} biofuel	7.02	16.9	13.8
µg BaP kg^{-1} biofuel	260	475	31.4
TRADITIONAL WOODSTOVE			
	Softwood	Hardwood	Briquettes
g $PM_{2.5}$ kg^{-1} biofuel	3.64	13.5	9.02
µg BaP kg^{-1} biofuel	46.7	322	85.3
ECO-LABELLED STOVE			
	Softwood	Hardwood	Briquettes
g PM_{10} kg^{-1} biofuel	1.12	2.06	---
µg BaP kg^{-1} biofuel	1543	146	---

PELLET STOVE							
	Pellets I	Pellets II	Pellets III	Pellets IV	Olive pit	Shell of pine nuts	Almond shell
g PM_{10} kg^{-1} biofuel	0.49	1.51	1.77	1.35	3.12	2.19	2.07
µg BaP kg^{-1} biofuel	4.43	nd	nd	4.61	nd	17.2	9.19

Es necesario certificar no solo el tipo de caldera, sino:
el tipo de pellet y su transporte y almacenamiento

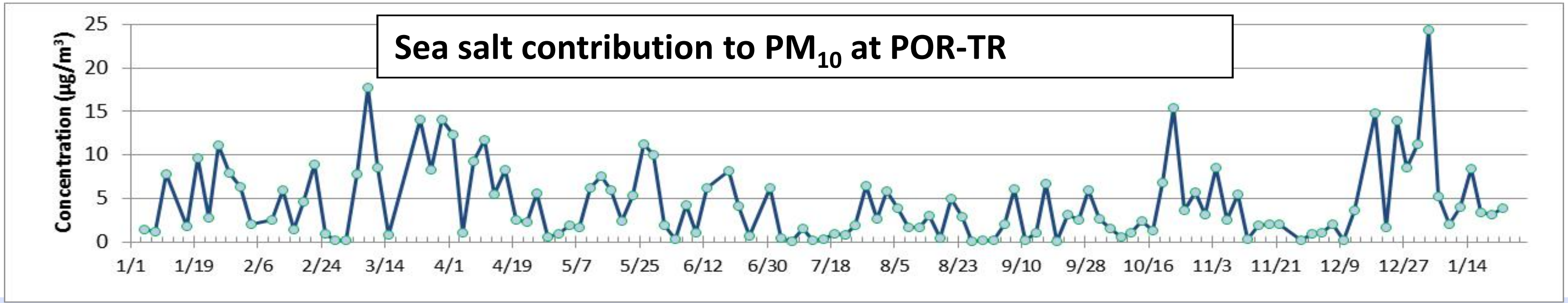
NATURAL CONTRIBUTIONS are considered from 3 types of sources:

Estimation of sea salt contribution

Sea salt concentration was calculated **based on chemical composition data** collected at each city:

$$\textbf{Sea salt} = Cl^- + ssNa + ssMg + ssK + ssCa + ssSO_4^{-2}$$

- $ssMg$, ssK, $ssCa$ and $ssSO_4^{-2}$ were calculated based on ssNa and typical sea water composition ratios for Mg/Na, K/Na, Ca/Na and SO_4^{2-}/Na
- $ssNa = Na^+ - nssNa$
- nssNa was attributed to Na present in soil and was calculated based on Al concentration and typical Na/Al ratio for soil.



Estimation of Saharan dust contribution

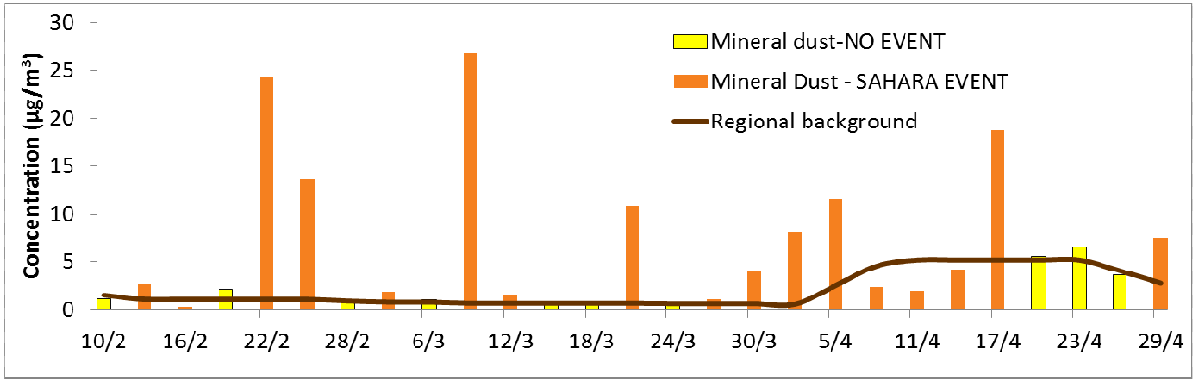
Otherwise, Saharan dust contribution was estimated from the mineral dust PMx component from SA analysis. Assuming

*Mineral dust = local dust contribution + **Saharan dust***

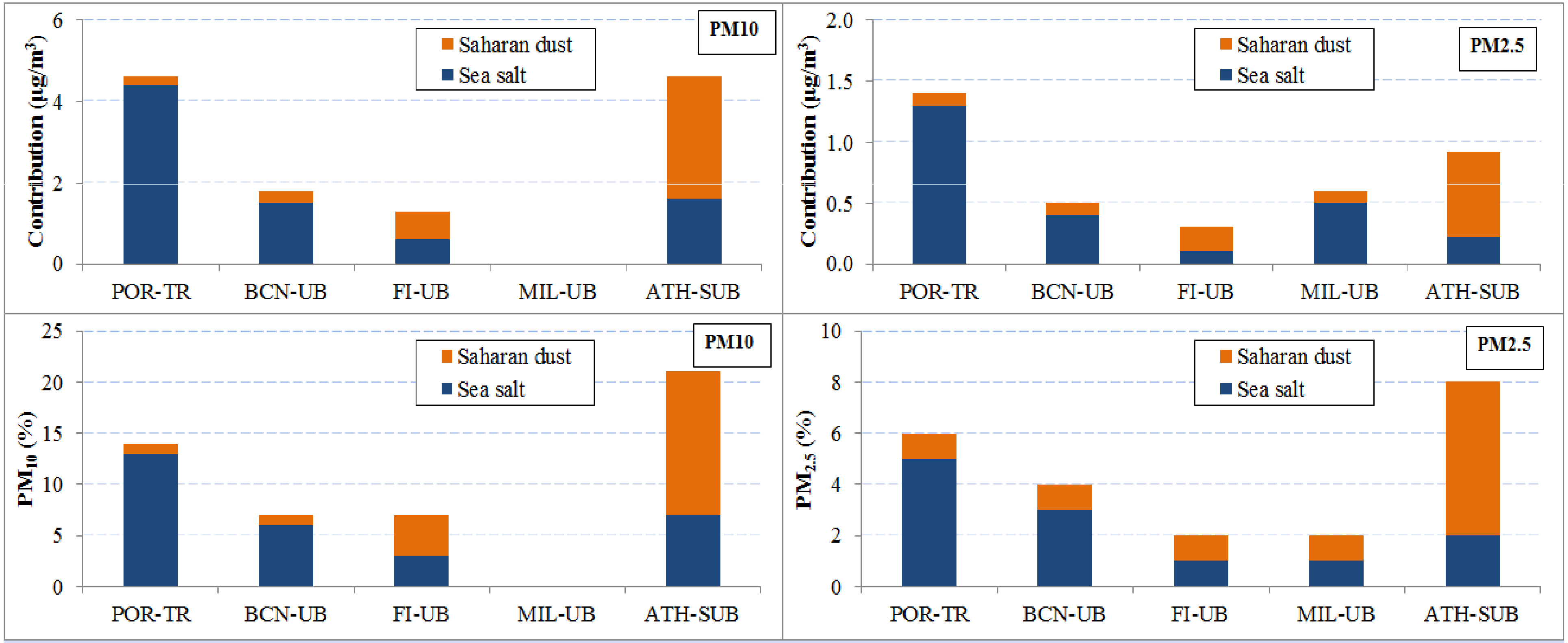
Saharan dust event days identified from a suite of air mass/dust transport modelling tools

methodology for **net dust calculation** (Escudero et al., 2007) is applied to the mineral dust PMx component

Estimation of Saharan dust contribution to PM_{10} at ATH-SUB



Sea salt and African dust mean contribution normalized over an annual basis for the AIRUSE cities



Mitigation measures with respect to Natural contributions

Two distinct aspects of control strategies may be identified:

• Measures to reduce the potential of dust particles deposited, to resuspend:

- Systematically clean streets and pavements after intense African transport events, to remove heavy load of dust available for resuspension;

- Increase urban vegetation and reduce the free surfaces where particles may accumulate and easily resuspend;

Measures to protect human health,
emergency action plan for forecasted extreme dust events:

1) An **alert system** easily accessible to the general public that wil :

- provide forecasts on intense African dust events,
- inform on potential exposure symptoms and
- suggest relevant preventive actions, such as staying indoors, avoiding physical activities outdoors or possible need for extra use of asthma medication.

System should focus on **sensitive population subgroups**,
(asthmatics or other respiratory or cardiovascular disease, elderly and children)
Should include different **communication channels** (such as internet, radio and television announcements, information boards located in selected central locations).

CONSIDERACIONES FINALES

Informes individuales en www.airuse.eu

1. Contribución de fuentes a PM
2. Condiciones de lavado y aspiración polvo rodadura
3. Uso de supresores de polvo
4. Uso de organo nanopolimeros
5. Quema de biomasa
6. Emisiones industriales
7. Medidas del norte y centro de Europa (10 informes)
8. Fuentes naturales

Déjenos su dirección y le remitiremos los informes

AGRADECIMIENTOS

LIFE+ AIRUSE & MAGRAMA

Spain	**GenCat, Barcelona and Madrid City Councils**
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**

¡GRACIAS POR SU ATENCIÓN!

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CONTRIBUTIONS TO THE ANNUAL MEAN

PM10	**POR-TR**	**BCN-UB**	**FI-UB**	**MLN-UB**	**ATH-SUB**
TRAFFIC	38%(13)	33%(7)	31%(6)	34%(13)	23%(5)
Exhaust	23%	14%	13%	7%	10%
Non-exhaust	9%	11%	9%	9%	8%
TR-NO_3^-	6%	8%	9%	19%	5%
REG ($OC+SO_4^{2-}$)	10%(4)	26%(6)	21%(4)	19%(6)	20%(4)
L.DUST	19%(6)	11%(3)	12%(2)	5%(2)	10%(2)
BIOMASS BURN.	14%(5)	<2%(<0.5)	16%(3)	24%(9)	7%(1.4)
INDUST	4%(1.2)	11%(3)	5%(0.9)	9%(4)	<1%(<0.2)
nTR-NO_3^-	2%(0.8)	8%(1.8)	6%(1.2)	5%(2)	7%(1.5)
SHIPPING	<1% (<0.2)	4%(0.9)	<1%(<0.2)	<1%(<0.2)	4%(0.8)*
AFR.DUST	<1%(<0.2)	1%(0.3)	4%(0.7)	<1%(<0.2)	14%(3)
S.SALT	13%(4)	6%(1.5)	3%(0.6)	3%(1)	7%(1.6)

CONTRIBUTIONS TO THE MEAN OF DAYS >50µg/m^3 PM10 (BCN >40µg/m^3)

PM10	**POR-TR**	**BCN-UB**	**FI-UB**	**MLN-UB**	**ATH-SUB**
TRAFFIC	36%(24)	45%(22)	43%(31)	41%(33)	9%(6)
	25%	13%	5%	5%	4%
	6%	14%	9%	14%	3%
	5%	18%	29%	22%	2%
REG ($OC+SO_4^{2-}$)	5%(3)	19%(9)	6%(4)	9%(3)	2%(1.7)
L.DUST	27%(17)	4%(1.8)	2%(1.8)	3%(17)	1%(1.1)
BIOMASS BURN.	25%(16)	<2%(<0.5)	30%(22)	35%(16)	1%(0.6)
INDUST	2%(1.2)	17%(8)	3%(2)	4%(1)	<1%(<0.2)
nTR-NO_3^-	2%(1.3)	9%(4)	7%(5)	6%(1)	1%(1.1)
SHIPPING	<1%(<0.2)	4%(2)	<1%(<0.2)	<1%(<0.2)	3%(2.3)*
AFR.DUST	<1%(<0.2)	1%(0.3)	<1%(0.2)	<1%(<0.2)	52%(38)
S.SALT	3%(1.9)	2%(0.8)	1%(0.5)	2%(2)	7%(4.9)

*Shipping in ATH includes also heavy oil combustion from industrial plants and maybe some residential oil combustion for heating as well.

CONTRIBUTIONS TO THE ANNUAL MEAN

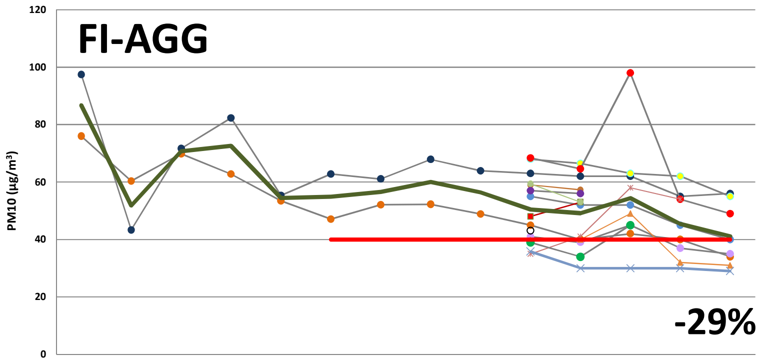
PM2.5	POR-TR	BCN-UB	FI-UB	MLN-UB	ATH-SUB
TRAFFIC	39%(10)	28%(4)	31%(4)	34%(10)	22%(2.5)
Exhaust	31%	20%	18%	6%	15%
Non-exhaust	5%	1%	2%	9%	5%
TR-NO_3^-	3%	7%	11%	19%	2%
REG (OC+SO_4^{2-})	13%(3)	37%(6)	29%(4)	19%(6)	34%(4)
L.DUST	16%(5)	6%(1.0)	2%(0.3)	5%(1.5)	5%(0.5)
BIOMASS BURN.	18%(5)	<3%(<0.5)	21%(3)	21%(6)	10%(1.2)
INDUST	5%(1.3)	12%(1.8)	6%(0.8)	5%(1.5)	<1% (<0.1)
nTR-NO_3^-	1%(0.3)	3%(0.5)	4%(0.5)	6%(1.7)	3%(0.3)
SHIPPING	<1%(<0.2)	5%(0.7)	<1%(<0.2)	<1%(<0.2)	7%(0.8) *
AFR.DUST	<1%(<0.2)	<1%(<0.2)	1%(0.2)	<1%(<0.2)	6%(0.7)
S.SALT	5%(1.3)	3%(0.4)	1%(0.1)	1%(0.5)	2%(0.2)

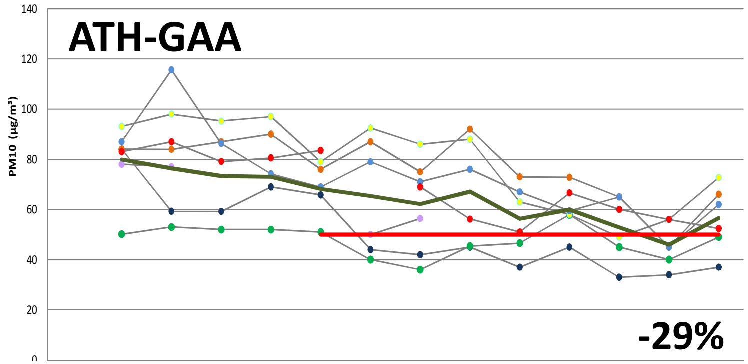
CONTRIBUTIONS TO THE MEAN OF DAYS >50 (40 BCN)µgPM10/m^3 (>35µg/m^3 PM2.5 MLN)

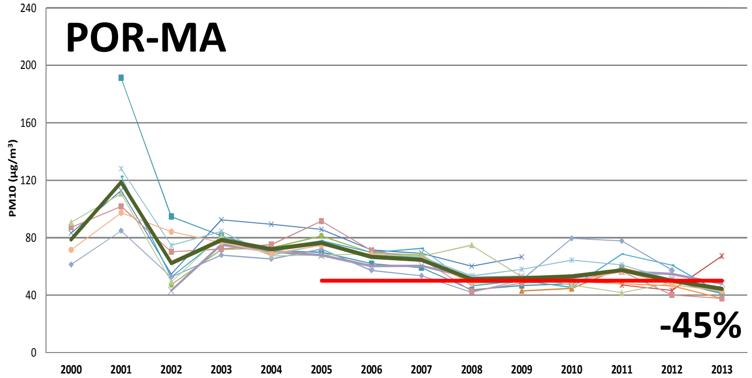
PM2.5	POR-TR	BCN-UB	FI-UB	MLN-UB	ATH-SUB
TRAFFIC	35%(23)	42%(14)	32%(22)	39%(21)	11%(3)
Exhaust	30%	20%	5%	4%	9%
Non-exhaust	3%	2%	1%	7%	1%
TR-NO_3^-	2%	20%	26%	28%	1%
REG (OC+SO_4^{2-})	2%(1.4)	22%(7)	6%(4)	11%(6)	5%(1.2)
L.DUST	22%(14)	2%(0.6)	<1%(0.1)	2%(1.2)	2%(0.4)
BIOMASS BURN.	33%(22)	<3%(<0.5)	33%(23)	26%(14)	2%(0.5)
INDUST	1%(0.9)	18%(6)	3%(2)	3%(1.8)	<1%(<0.2)
nTR-NO_3^-	1%(0.4)	9%(3)	6%(4)	8%(4.3)	3%(0.6)
SHIPPING	<1%(<0.2)	6%(2)	<1%(<0.2)	<1%(<0.2)	10%(2)*
AFR.DUST	<1%(<0.2)	<1%(<0.2)	<1%(0.3)	<1%(<0.2)	45%(10)
S.SALT	<1%(<0.2)	1%(0.3)	<1%(0.4)	1%(0.7)	1%(0.3)

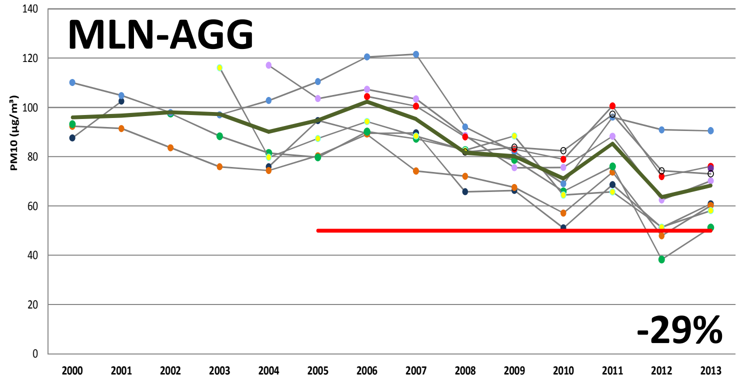
*Shipping in ATH includes also heavy oil combustion from industrial plants and maybe some residential oil combustion for heating as well.

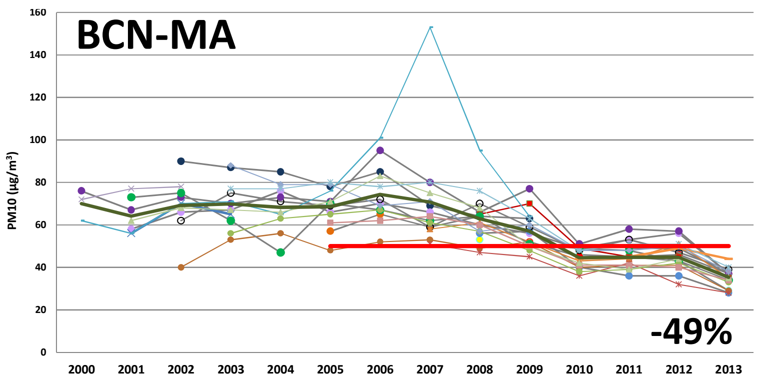
B1: 5 CIUDADES TENDENCIAS 2001-2013 PM10 DIARIO











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