Emerging inorganic pollutants in atmospheric PM: inhalable metal aerosols

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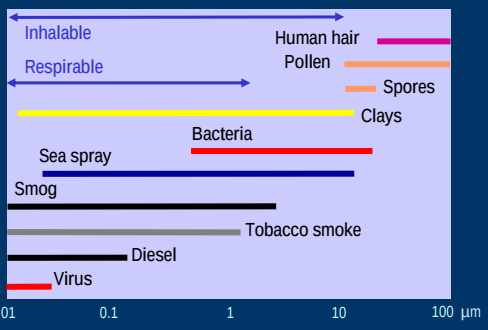
Acc.V Spot Magn Det WD 5 µm
20.0 kV 4.0 5000x SE 9.7

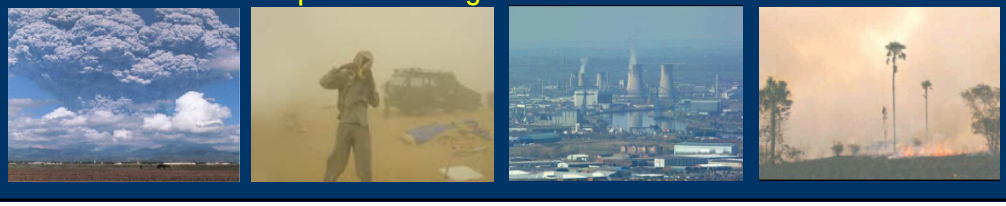
Atmospheric aerosols are solids or liquids suspended in the atmosphere and are typically much less than 100 µm in size

Dust, smoke, smog, are common terms we use to refer to atmospheric aerosols.



Toxicological studies are still striving to identify which aerosol component or group of components are most responsible for the effects on human health proven by epidemiological studies.

Metalliferous particles are emerging as one of the groups of PM components most implicated in negative human health effects.



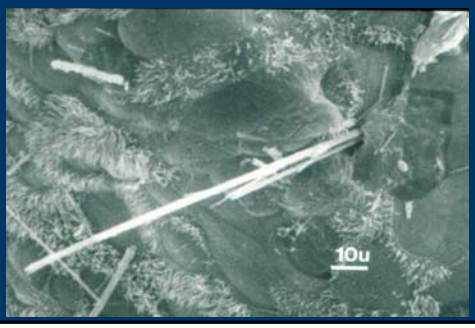
CHARACTERISTICS TO OBSERVE IN PATHOGENIC PARTICLES

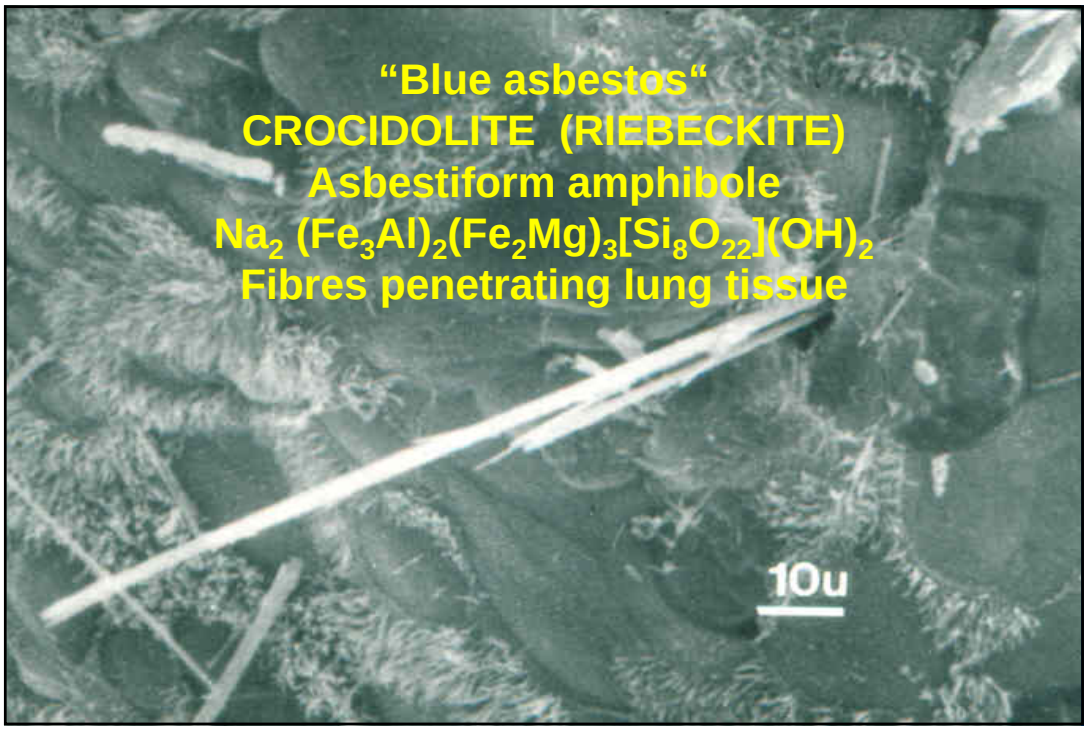
- Number / mass
- Size / morphology
- Surface chemistry

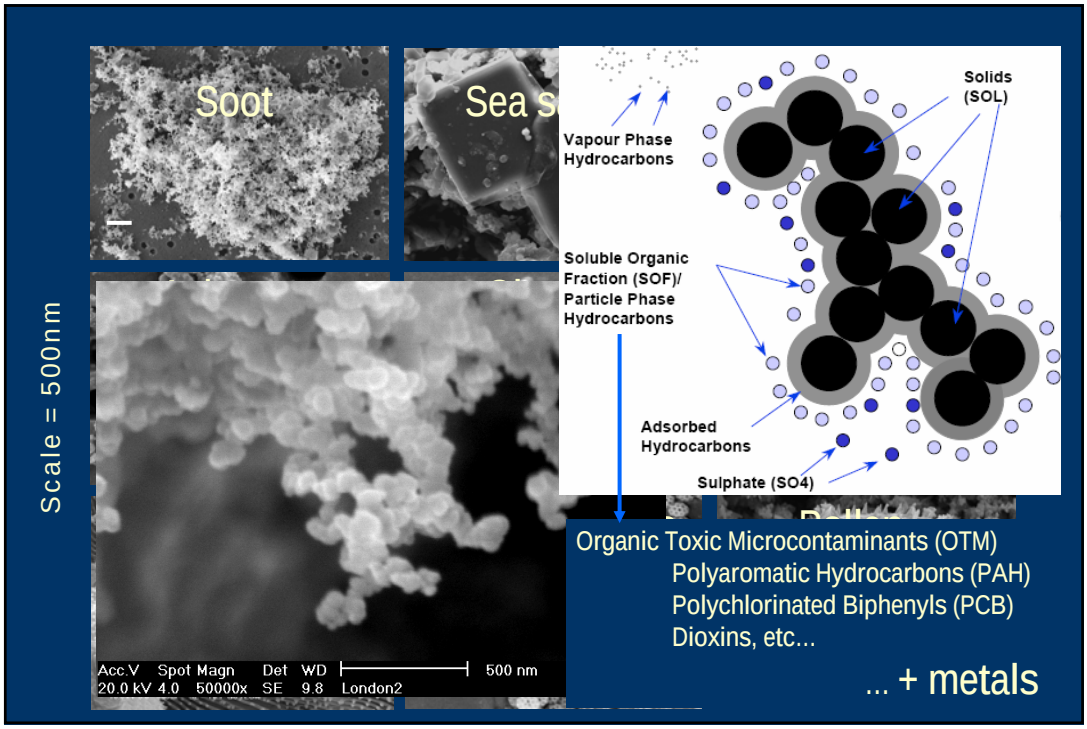
Contact surface

Lung location

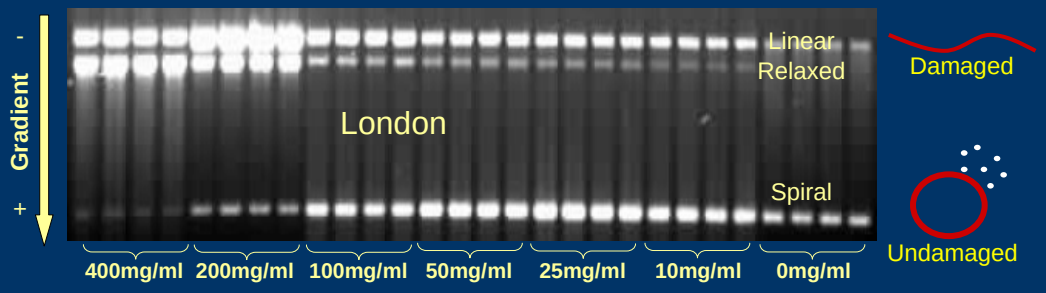
Bioreactivity with cells & fluids ("oxidative stress")



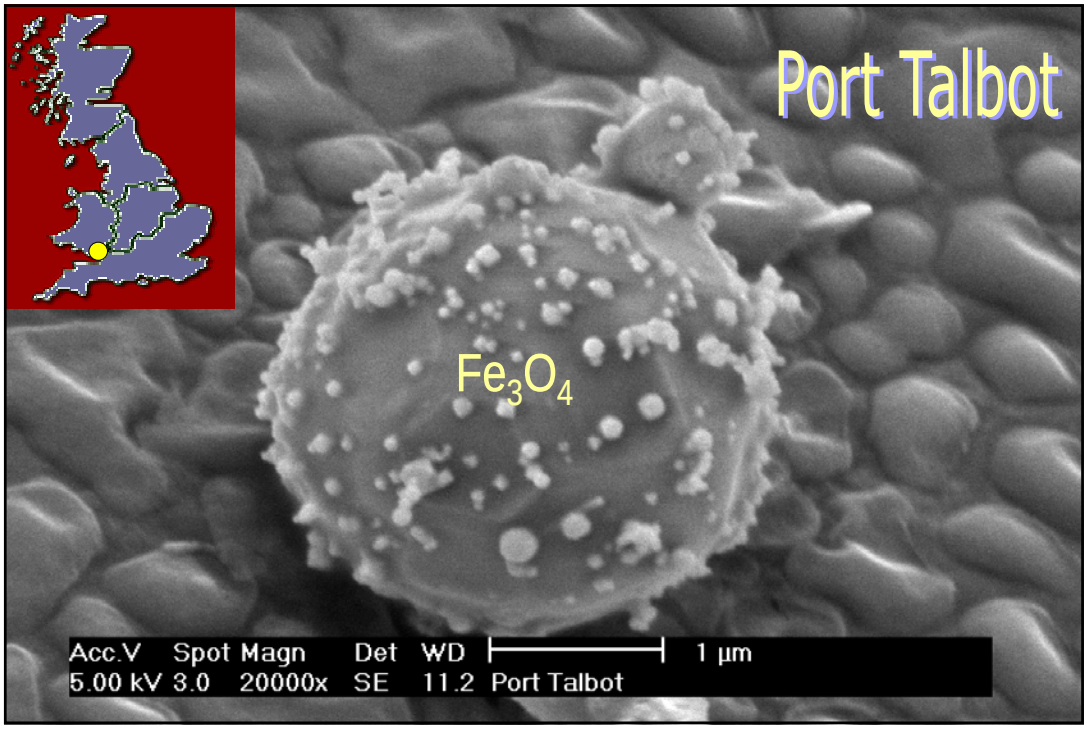


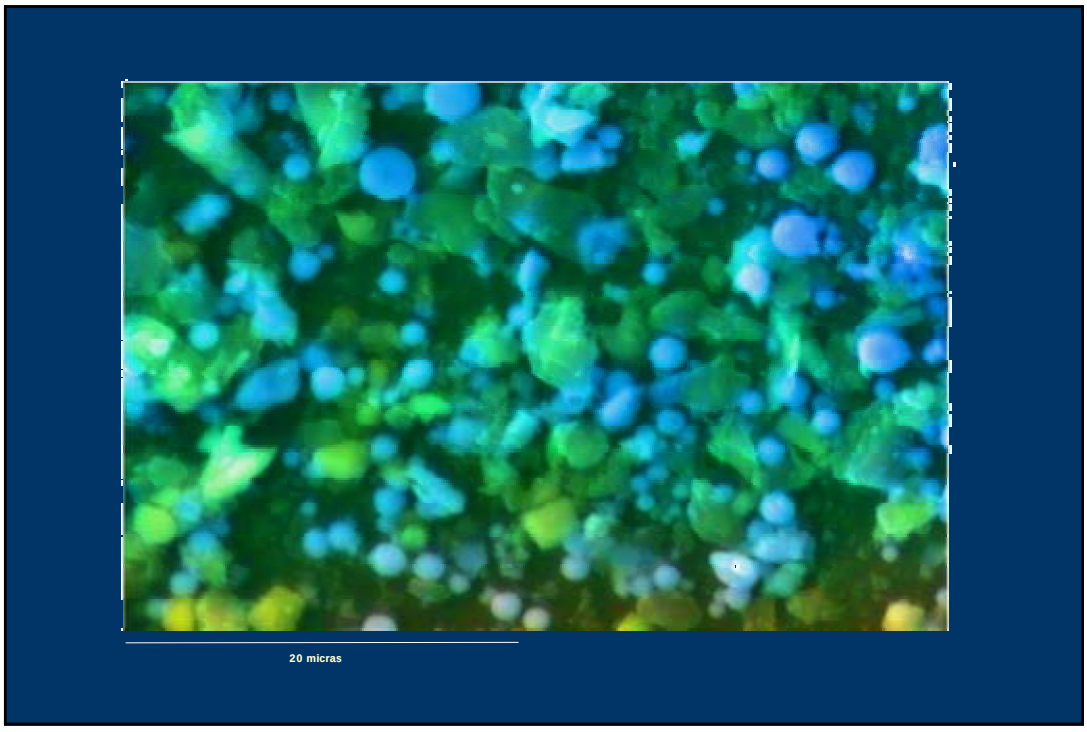


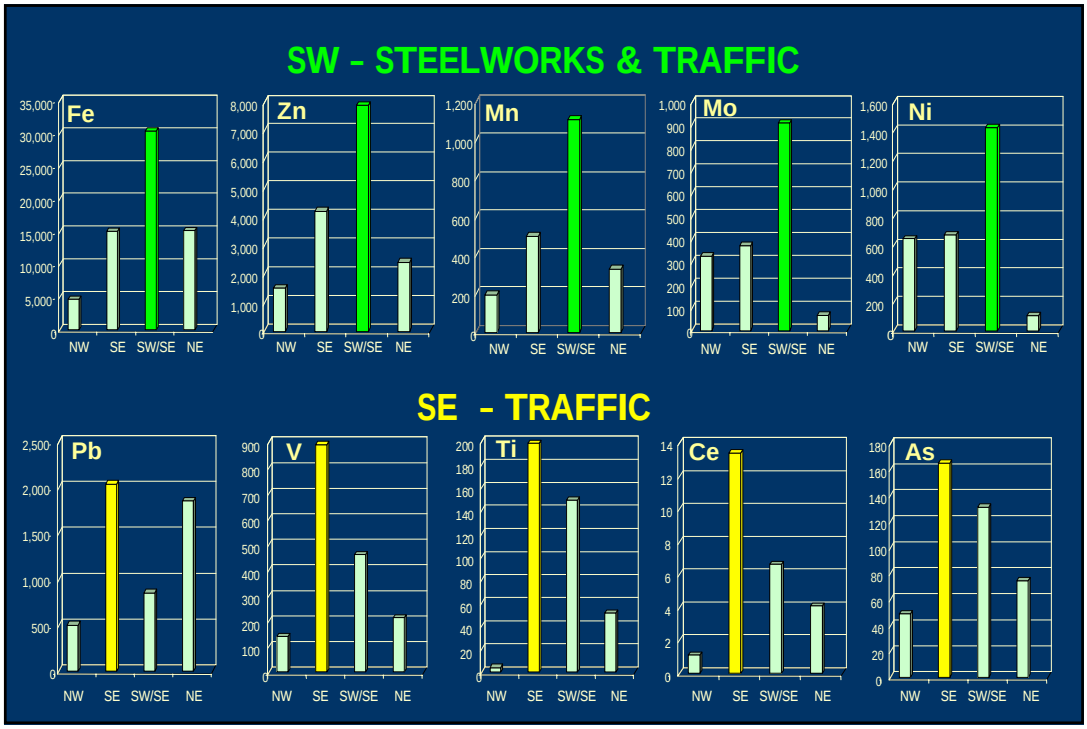
DNA oxidative damage caused by metalliferous particulate matter

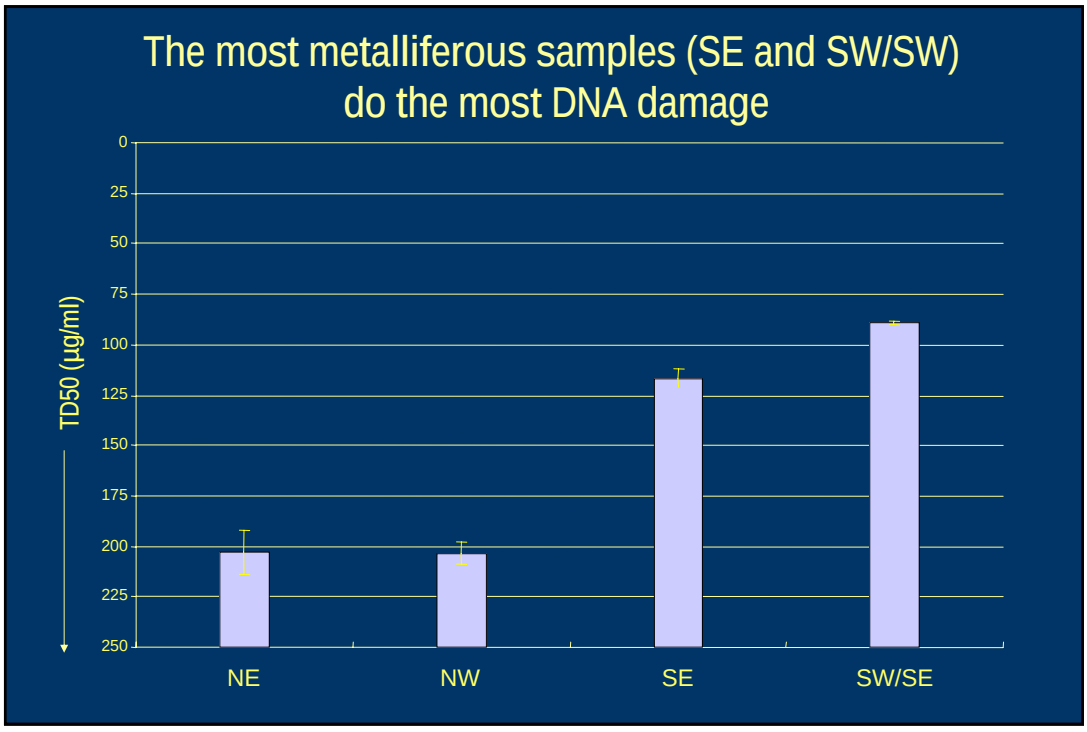


DNA Plasmid Assay: TD50


Port Talbot
Fe_3O_4
Acc.V Spot Magn Det WD 1 µm
5.00 kV 3.0 20000x SE 11.2 Port Talbot


20 micras

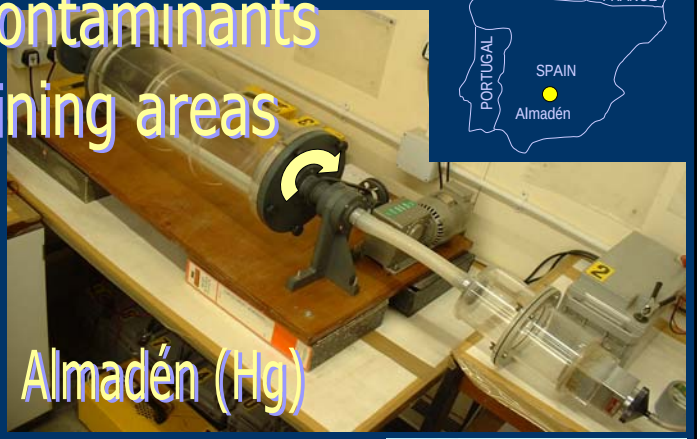

SW – STEELWORKS & TRAFFIC
Fe
Zn
Mn
Mo
Ni
NW SE SW/SE NE
SE – TRAFFIC
Pb
V
Ti
Ce
As
NW SE SW/SE NE

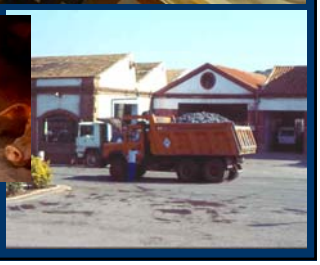

The most metalliferous samples (SE and SW/SW)
do the most DNA damage
TD50 (µg/ml)
0
25
50
75
100
125
150
175
200
225
250
NE
NW
SE
SW/SE

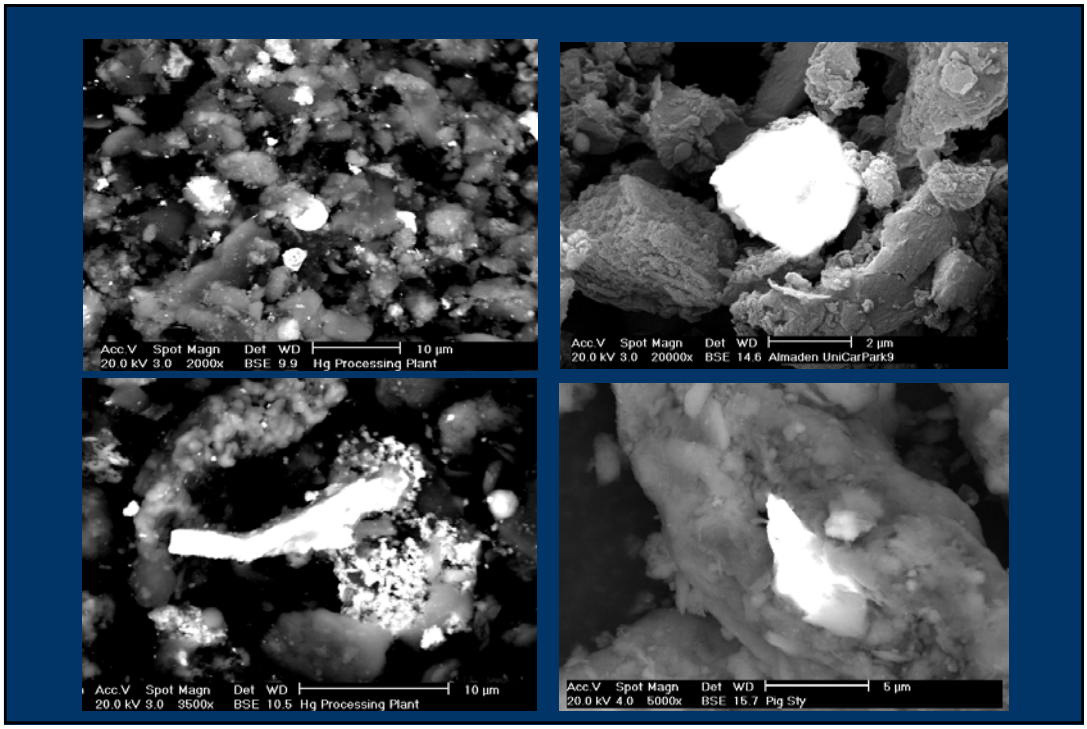
PM metal hotspots: four examples from Spain

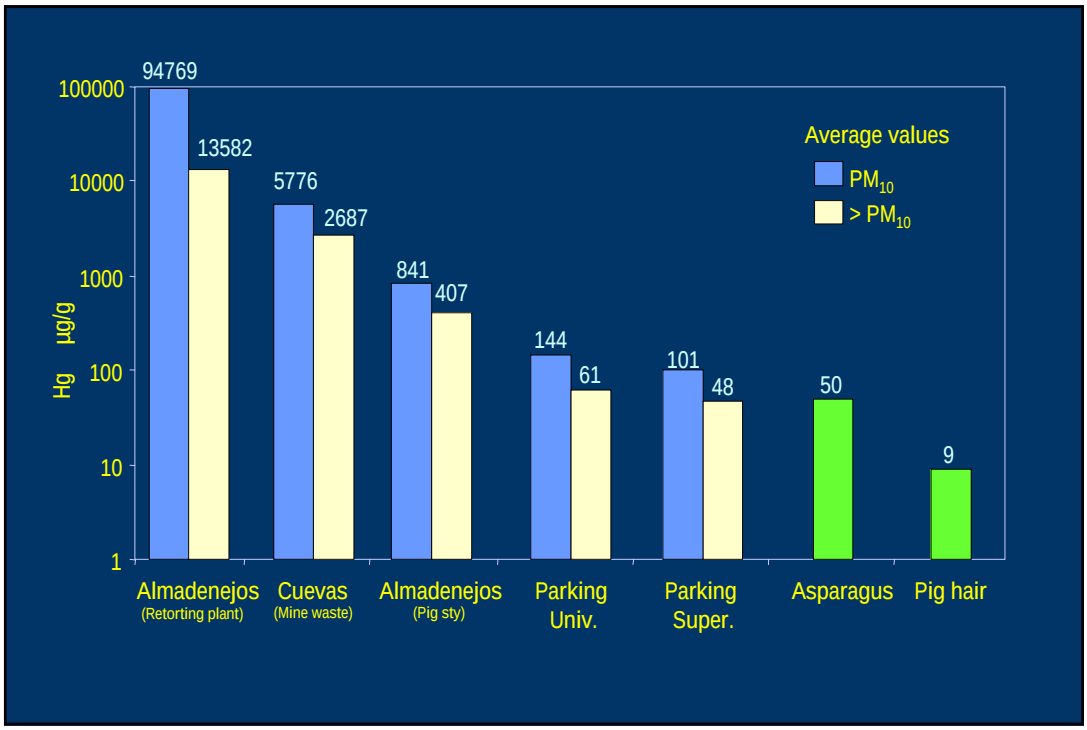
1. Former mining areas e.g. Almadén
2. Heavy industry e.g. Puertollano
3. Recreational e.g. *Las Fallas* fireworks
4. Modern urban cocktail

1. PM metal contaminants in former mining areas






Acc.V Spot Magn Det WD 10 µm
20.0 kV 3.0 2000x BSE 9.9 Hg Processing Plant
Acc.V Spot Magn Det WD 2 µm
20.0 kV 3.0 20000x BSE 14.6 Almaden UniCarPark9
Acc.V Spot Magn Det WD 10 µm
20.0 kV 3.0 3500x BSE 10.5 Hg Processing Plant
Acc.V Spot Magn Det WD 5 µm
20.0 kV 4.0 5000x BSE 15.7 Pig Sty


Hg µg/g
100000
10000
1000
100
10
1
94769
13582
5776
2687
841
407
144
61
101
48
50
9
Average values
PM10
> PM10
Almadenejos (Retorting plant)
Cuevas (Mine waste)
Almadenejos (Pig sty)
Parking Univ.
Parking Super.
Asparagus
Pig hair

2. Industrial hotspot PM metal contaminants revealed from source apportionment studies

Puertollano

SOURCE APPORTIONMENT

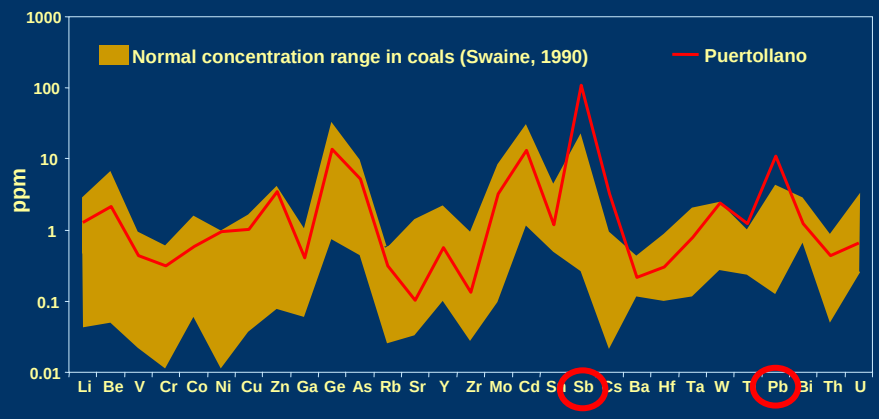
PM_{10}

Factor 1		Factor 2		Factor 3		Factor 4	
Ti	0.98	NH_4^+	0.93	Sb	0.93	Cl	0.80
Rb	0.97	SO_4^{2-}	0.84	Pb	0.89	Na	0.77
Al_2O_3	0.97	NO_3	0.80	As	0.70	Mg	0.41
Mn	0.94	PM_{10}	0.74	Zn	0.62	Co	0.29
Fe	0.93	OM-EC	0.67	Co	0.53	Zn	0.28
Li	0.91	Ni	0.58	Cl	0.41		
Sr	0.87	V	0.52	OM-EC	0.34		
Cr	0.84	Ca	0.30				
Ca	0.83	K	0.30				
K	0.78	Ba	0.29				
P	0.77						
Ba	0.70						
Mg	0.62						
PM_{10}	0.61						

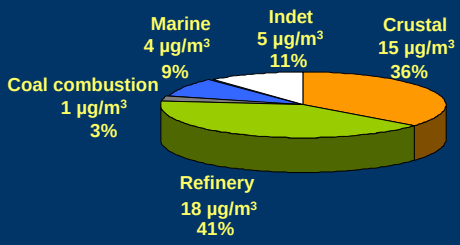
$PM_{2.5}$

Factor 1		Factor 2		Factor 3	
Ti	0.96	SO_4^{2-}	0.90	Sb	0.90
Al_2O_3	0.95	NH_4^+	0.80	Pb	0.87
Fe	0.95	Ni	0.77	Zn	0.79
Sr	0.92	V	0.75	Co	0.72
Ca	0.85	$PM_{2.5}$	0.69	As	0.69
Rb	0.81	NO_3	0.50	Cl	0.61
Mn	0.79	Co	0.49		
Mg	0.70	Zn	0.41		
K	0.29	OM-EC	0.40		

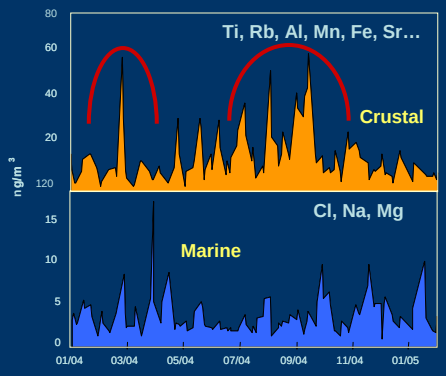
CHEMICAL COMPOSITION OF PUERTOLLANO COALS



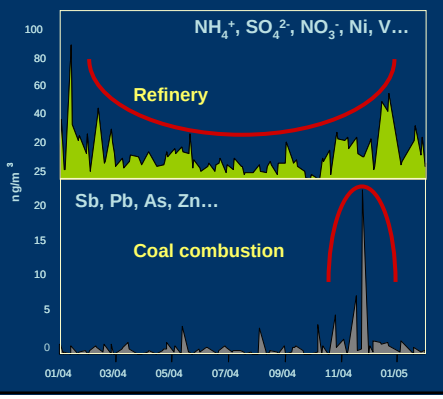
PM_{10} SOURCE MASS CONTRIBUTION



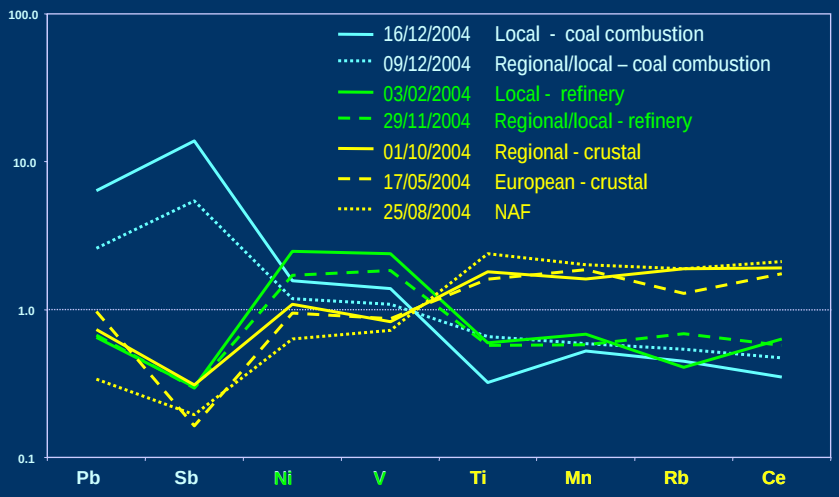
NATURAL



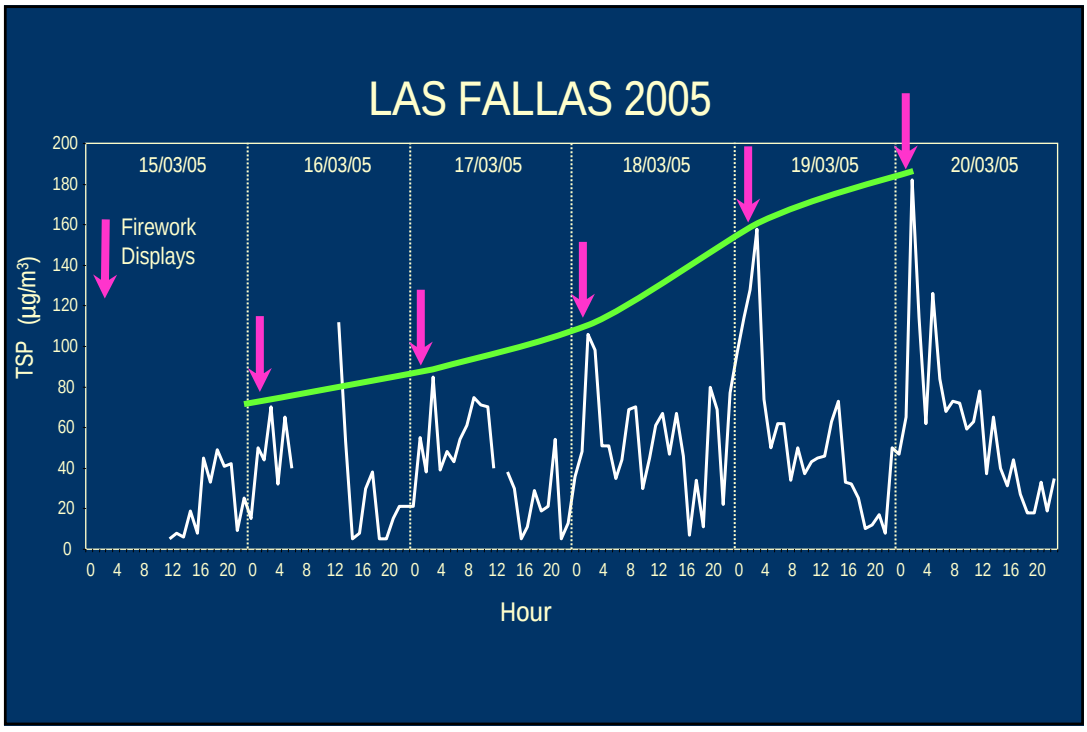
ANTHROPOGENIC

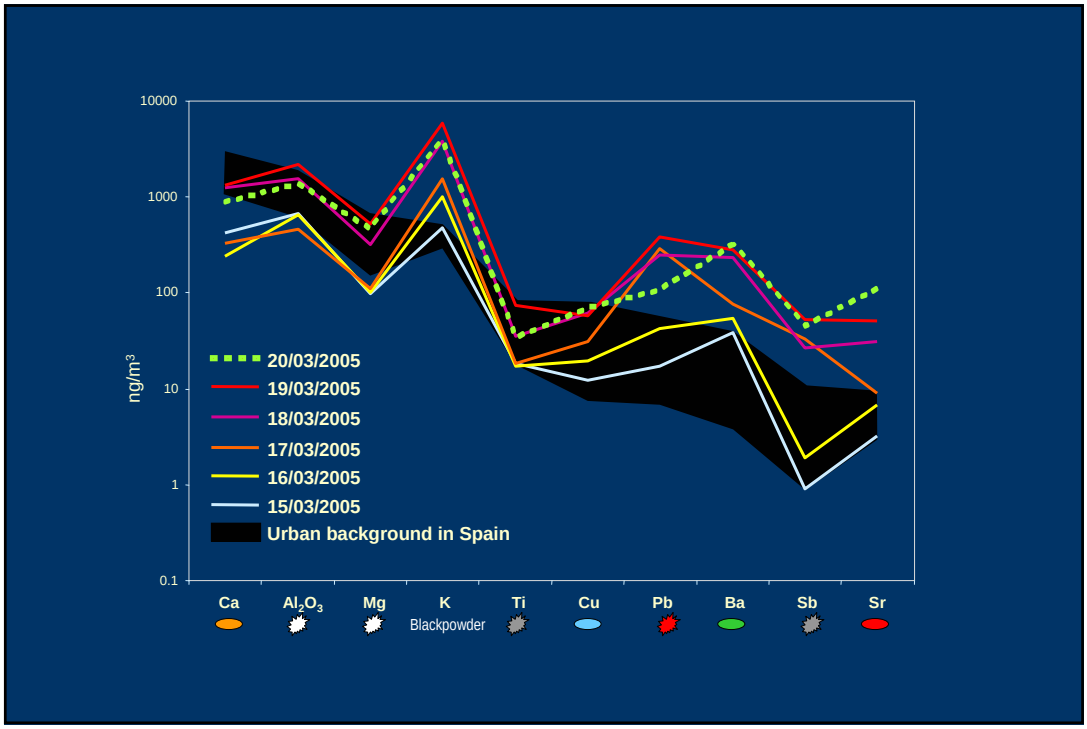


EMERGING TRACE METAL SIGNATURES CHARACTERISING DIFFERENT POLLUTION EPISODES



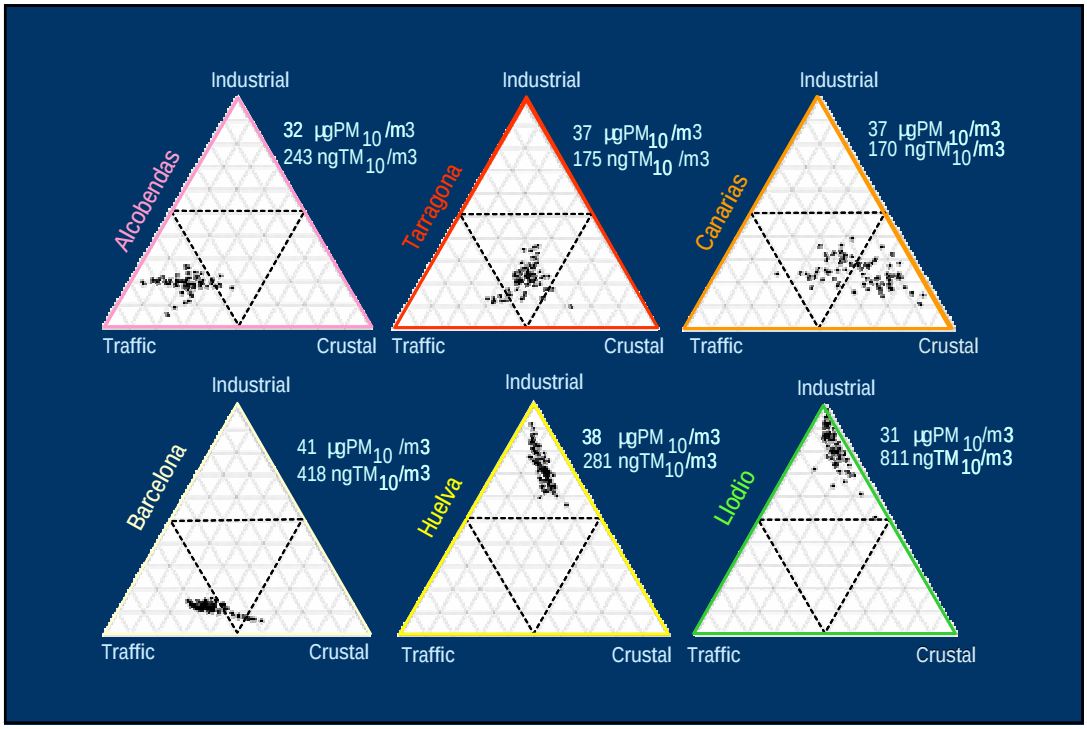

Las Fallas
Valencia
3. PM metal contaminants in fireworks

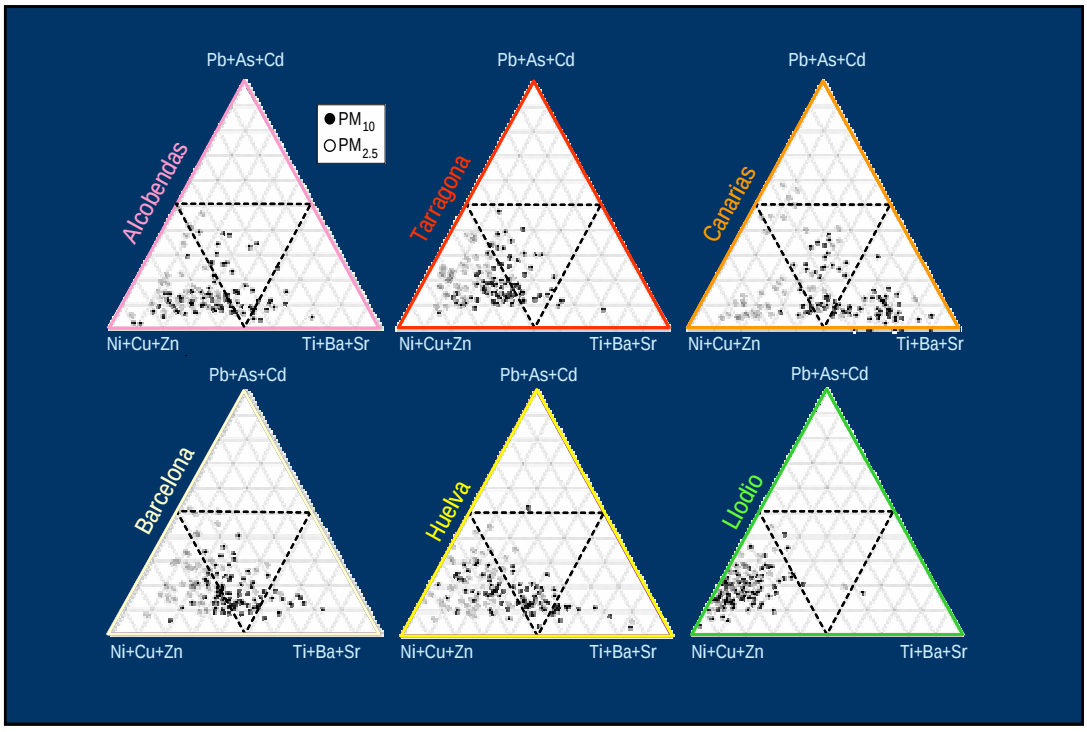

LAS FALLAS 2005
15/03/05
16/03/05
17/03/05
18/03/05
19/03/05
20/03/05
Firework Displays
TSP (µg/m³)
0
20
40
60
80
100
120
140
160
180
200
0 4 8 12 16 20
Hour



4. Urban PM metal contaminants

	Longitude	Latitude	Altitude (masl)
Alcobendas	03° 37' 39"W	40° 32' 42"N	667
Barcelona	02° 11' 47"E	41° 25' 30"N	24
Las Palmas	15° 24' 49"W	28° 08' 04"N	20
Huelva	05° 56' 24"W	37° 15' 21"N	10
Llodio	02° 57' 44"W	43° 08' 42"N	122
Tarragona	01° 14' 52"E	41° 07' 29"N	20

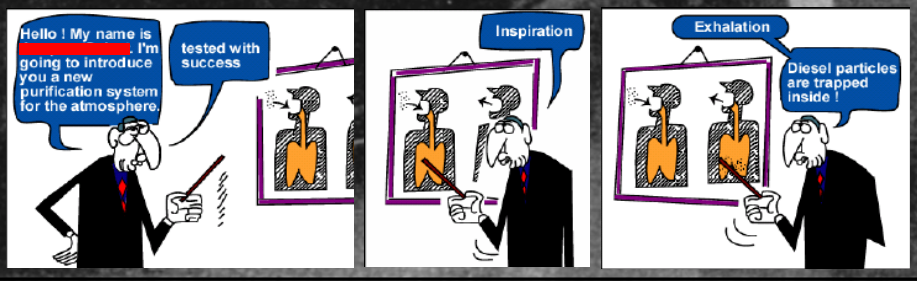

Industrial
Alcobendas
32 µgPM10/m3
243 ngTM10/m3
Traffic
Crustal
Industrial
Tarragona
37 µgPM10/m3
175 ngTM10/m3
Traffic
Crustal
Industrial
Canarias
37 µgPM10/m3
170 ngTM10/m3
Traffic
Crustal
Industrial
Barcelona
41 µgPM10/m3
418 ngTM10/m3
Traffic
Crustal
Industrial
Huelva
38 µgPM10/m3
281 ngTM10/m3
Traffic
Crustal
Industrial
Llodio
31 µgPM10/m3
811 ngTM10/m3
Traffic
Crustal

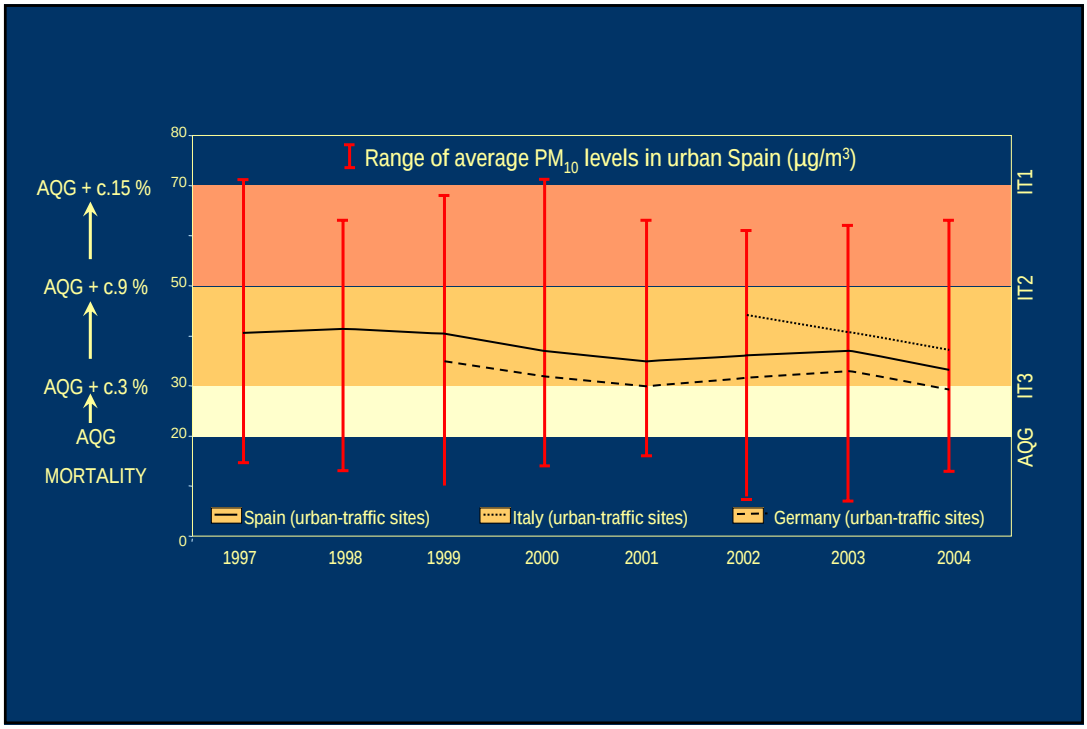

Pb+As+Cd
PM10
PM2.5
Alcobendas
Ni+Cu+Zn
Ti+Ba+Sr
Pb+As+Cd
Tarragona
Ni+Cu+Zn
Ti+Ba+Sr
Pb+As+Cd
Canarias
Ni+Cu+Zn
Ti+Ba+Sr
Pb+As+Cd
Barcelona
Ni+Cu+Zn
Ti+Ba+Sr
Pb+As+Cd
Huelva
Ni+Cu+Zn
Ti+Ba+Sr
Pb+As+Cd
Llodio
Ni+Cu+Zn
Ti+Ba+Sr

London, December 1952
4000 deaths in 4 days

50 years later…..

"Inhalation of atmospheric PM reduces European human life span by 8.6 months" WHO 2000




Range of average PM10 levels in urban Spain (µg/m3)
AQG + c.15 %
AQG + c.9 %
AQG + c.3 %
AQG
MORTALITY
80
70
50
30
20
0
IT1
IT2
IT3
AQG
Spain (urban-traffic sites)
Italy (urban-traffic sites)
Germany (urban-traffic sites)
1997
1998
1999
2000
2001
2002
2003
2004