Estimation of the road dust contribution in the urban aerosol

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Equipment

Two aerosol mobile units were placed at two traffic sites (Alcala and Maldonado) in Madrid (Spain). They were equipped with instruments for the continuous measurements of levels of NO, NO_2, NO_x, O_3 and CO. For the monitoring of particulate matter in each mobile unit were installed:

•One MCV high volume sampler (30 $m^3 h^{-1}$) with DIGITEL PM_{10} inlet for the determination of PM_{10}.

•One Light scattering particle counter (Grimm) using 30 minutes time intervals for the continuous monitoring of PM_{10}, mass concentrations.

For the collection of a satisfactory number of 24h samples intended for source apportionment, another traffic site that belongs to the local monitoring network was used, named Esc.Aguirre (Figure 1) where a MCV high volume sampler was also placed.

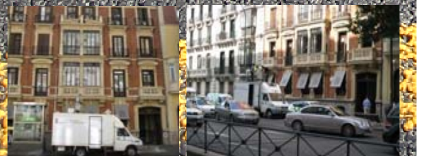

Figure 2. Mobile unit equipped with MCV sampler and Grimm optical counter

Methodology

During the one month campaign the followed procedure was: For one week the road surface was washed daily with high-pressure water systems to prevent suspension of road dust and the next week the road was left untreated to observe any potential increase in PM ambient concentrations and particle loading of the road surface. This was repeated for another two weeks period.

Road dust sampling was conducted in ALCALA site (Figure 2) where the road surface was untreated and at one reference site with daily street washing. Road dust samples were collected on quartz filters with the device (Figure 3) described in Amato et al., 2009.

The road dust sampling protocol included two samplings per day in the morning and evening hours when the traffic peaks. This procedure focused on examining the diurnal trends of road dust loadings and the source strength of resuspension.

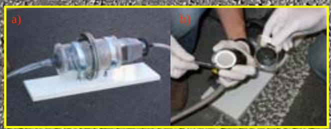

Figure 3: a) PM_{10} resuspension sampler; b) Sampled filter

References

Amato F. , Pandolfi M., Viana M. , Querol X., Alastuey A. and T. Moreno 2009. Atmospheric Environment, 43(9), 1650-1659.

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Background

Several studies in Spanish urban areas have shown high concentrations of aerosol particles. These air pollution problems are in most cases attributed to traffic. Traffic emissions include exhaust origin particles, as well as particulate matter from abrasion sources like tire and brake wear debris and particles resuspended by the road surface. Street washing is one of the methods that might reduce the occurrence of dust re-entrainment by reducing the amount of dust on the road. In recent years, street washing and sweeping are being used by local authorities, mainly for aesthetic reasons. The environmental protection authorities promote street cleaning work, but the effect of this method in the urban air quality is not yet clear.

Since 2007 the local authorities implement street washing in a major part of the urban region of Madrid. However, an exhaustive study in order to examine the effect of this method to the air quality has not yet being conducted.

The aim of this study was to quantify the contribution of road dust to particulate matter, and evaluate the effects of street washing on the strength of resuspension.

Study Area

An intensive sampling campaign was conducted during summer 2009 in central Madrid. Aerosol monitoring included air quality measurements at two traffic sites, ALCALA and MALDONADO along one busy street placed 1.5 km apart and at one fixed site, named ESCUELAS AGUIRRE monitored by the Madrid City Hall authorities. The urban background monitoring site, CASA DE CAMPO was used as a reference site, Figure 1.

Figure 1. Madrid urban area with the sampling sites marked. The arrow indicates the direction of the traffic flow

PM_{10} gravimetric mass concentrations

Table 1. Average daily concentrations for the StW days and for no StW days for the sampling sites

PM_{10}, µg m^{-3}	MALDONADO average (sd)	ALCALA average (sd)	ESCUELAS AGUIRRE average (sd)	CASA DE CAMPO average (sd)
All samples	36.3 (7.2)	45.5 (11.3)	40.3 (9.1)	23.2 (4.0)
StW*	36.1 (7.4)	45.2 (6.3)	39.5 (7.0)	22.9 (4.3)
No StW*	38.8 (5.5)	47.4 (8.5)	41.5 (7.7)	20.6 (4.4)

** weekend data excluded*

❑A reduction in the 24h PM_{10} levels was observed during StW days that corresponds to 5-7% of the average mass concentrations in the three traffic sites (Maldonado, Alcala, Escuelas Aguirre).

❑For the urban background site (Casa de Campo) a different pattern was observed in the 24h PM_{10} average concentrations, these being higher during the StW days.

❑The diurnal variation of PM_{10} revealed that this reduction was noticeable during the morning hours

PM_{10} Chemical components

With regards to the chemical composition of PM_{10} samples, the concentrations of trace elements like Pb, Sn, Zn, Cu and Sb which are considered to be emitted from non-exhaust traffic sources were reduced during street washing in all three sites Alcala, Maldonado and Escuelas Aguirre with the reduction being higher at Alcala site.

Table 2: Average concentrations of major and trace elements in daily PM_{10} samples

Average	MALDONADO		ALCALA		ESCUELAS AGUIRRE	
µg/m³	StW	no StW	StW	no StW	StW	no StW
OC	3.59	5.12	4.14	4.73	4.68	5.23
EC	3.95	7.64	5.48	6.72	3.99	5.18
NO_3	1.95	1.42	0.63	0.94	0.65	0.79
SO_4	1.79	1.80	0.86	1.18	1.11	1.13
Al	2.14	2.23	1.39	2.76	2.40	2.97
Ca	1.83	1.66	2.32	3.31	3.09	3.34
Fe	1.58	1.64	1.43	2.04	1.48	1.65
K	0.36	0.41	0.27	0.47	0.43	0.47
Na	0.45	0.47	0.37	0.71	0.46	0.54
Mg	0.28	0.29	0.22	0.37	0.27	0.29
ng/m³	StW	no StW	StW	no StW	StW	no StW
Ti	64.73	60.79	41.82	63.57	53.93	58.52
V	2.33	2.03	1.63	2.33	1.77	1.97
Cr	12.28	12.96	8.80	15.62	8.46	9.77
Mn	22.00	22.90	19.29	30.47	20.99	23.87
Co	0.42	0.39	0.32	0.47	0.31	0.35
Ni	5.04	3.90	2.19	6.55	2.40	3.02
Cu	77.99	86.85	87.56	122.13	66.24	75.06
Zn	51.90	56.02	54.04	76.45	45.62	48.93
As	0.54	0.70	0.44	0.72	0.51	0.60
Se	0.30	0.25	0.20	0.27	0.24	0.31
Rb	1.76	2.10	1.57	2.44	2.45	2.64
Sr	7.74	6.47	5.88	8.94	10.43	7.45
Mo	24.93	24.59	13.10	46.61	22.80	24.27
Sn	17.09	18.02	15.81	21.74	12.48	14.60
Sb	12.42	12.89	12.75	17.25	9.44	10.78
Ba	48.48	52.66	46.94	64.95	44.10	43.85
La	0.64	0.58	0.34	0.56	0.86	0.59
Pb	6.36	9.40	6.53	12.10	5.22	8.41

PM_{10} continuous mass concentrations

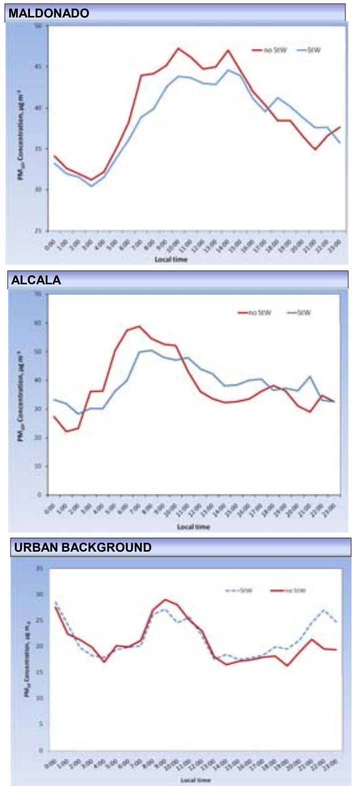

Figure 4. Daily variability of PM_{10} between StW days and no StW days

Source Apportionment

PMF identified four sources: vehicles emissions, secondary aerosol, road dust and soil. Vehicles emissions along with road dust were the major contributors in PM_{10} particle mass, Figure 5.

The effect of street washing was evaluated by examining the daily variation of the road dust contribution between StW days and no StW days. The results revealed a reduction in the contribution of road dust about 26%, Table 3. The vehicles emissions contribution was also reduced during StW days around 16%.

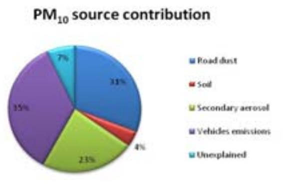

Figure 5. Source contribution (%) calculated by PMF for the urban area of Madrid

Table 3. Source contribution between StW days and no StW days

Average contribution, µg m^{-3}	Road dust	Soil	Secondary aerosol	Vehicles emissions
StW	10.6	1.5	13.1	14.2
no StW	14.6	1.9	9.6	16.9

Though it merits further inquiry in future work, for the purpose of adopting strategies for the reduction of PM levels, we conclude that street washing has a positive effect. The results of the present study indicate that resuspension and street washing activities correlate positively.

Future work

The future work will incorporate the road dust chemical analysis results and the calculation of the emission factors

Acknowledgments

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