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APICE intensive air pollution monitoring campaign at the port of Barcelona

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Introduction

A one year monitoring campaign (February 2011 to January 2012) was performed, mostly in the harbour area, but also covering (for a number of atmospheric pollutants) the whole metropolis of Barcelona, and focusing on Particulate Matter (PM_{10} and $PM_{2.5}$ mass concentration of particles under 10 and 2.5 micron, respectively) and NO_2. The main goal was the characterization of pollution sources and their possible link with harbour activities.

Methodology

PM_{10} and $PM_{2.5}$ levels were monitored in all monitoring sites both by sampling on proper collecting media and by automatic monitors. Levels of gaseous pollutants were also monitored at the port and the urban background.

- NO, NO_2, SO_2 and H_2S at the port monitoring site
- NO, NO_2, O_3, SO_2 and CO at the urban monitoring site Palau Reial

Data on gaseous pollutants and particles were supplied by the Autonomous Government of Catalonia (*Departament de Territori i Sostenibilitat*) in the case of the metropolitan region, and the *Autoritat Portuaria de Barcelona*, in the case of the harbour area.

In addition, at the Barcelona port area, measurements of NO_2 and NH_3 were carried out at 8 different places, using passive dosimeters, in order to identify possible emission sources of these gaseous pollutants in the port area.

Furthermore, a detailed chemical characterization of PM_{10} and $PM_{2.5}$, both in the harbour and the urban background of Barcelona was performed with the objective to evaluate the levels of major and trace elements at both sites, aiming to identify harbour-sources affecting the city and vice versa. From these results, a source apportionment analysis was carried out to identify sources and quantify their contributions to ambient PM_{10} and $PM_{2.5}$.

Simultaneous PM_{10} and $PM_{2.5}$ sampling was performed from February 2011 to January 2012 at the port and an urban background site (Palau Reial) by collecting 24 hour samples on quartz fibre filters every four days with high volume samplers. In total, 303 PM_{10} + $PM_{2.5}$ samples were collected.

PM_{10} and $PM_{2.5}$ concentration levels were obtained following standard gravimetric procedures. Subsequently, filters were treated and analyzed by diverse techniques following the methodology by Querol et al. (2008) to determine the concentrations of

- Carbonaceous compounds: organic and elemental carbon (OC and EC): Sunset thermo-optical carbon analyser.
- Soluble ions from water leaching of filters:
  - Cl^-, NO_3^-, SO_4^{2-}: ion chromatography
  - NH_4^+ : ammonium selective electrode
- Major and trace elements from acid digestion of filters.
  - Al, Ca, K, Na, Mg, Fe, P, S, Ti, Mn: ICP-AES

- Li ,Ti, V, Cr, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Y, Zr, Cd, Sn, Sb, Cs, Ba, Pb, Bi, Th, U, rare earths: ICP-MS

In order to identify chemical tracers of harbour activities, a number of additional studies have been done, including

- sampling of road dust;
- characterization of bulk materials (scrap, coal, soy)
- fresh shipping emissions

Results

In Figure 1 a summary of the mean PM_{10} and $PM_{2.5}$ concentrations (µg/m^3) across the metropolitan area of Barcelona is shown. Higher PM_{10} concentrations are observed in the harbour area (40-50 µg/m^3), probably due to the intense truck traffic and the construction activities that are taking place nearby in order to enlarge the harbour surface, whereas those of $PM_{2.5}$ are more elevated in the city centre, at traffic hotspots (22-25 µg/m^3). Out of the harbour area, PM_{10} levels are relatively homogeneous (25-33 µg/m^3), slightly higher at traffic sites.

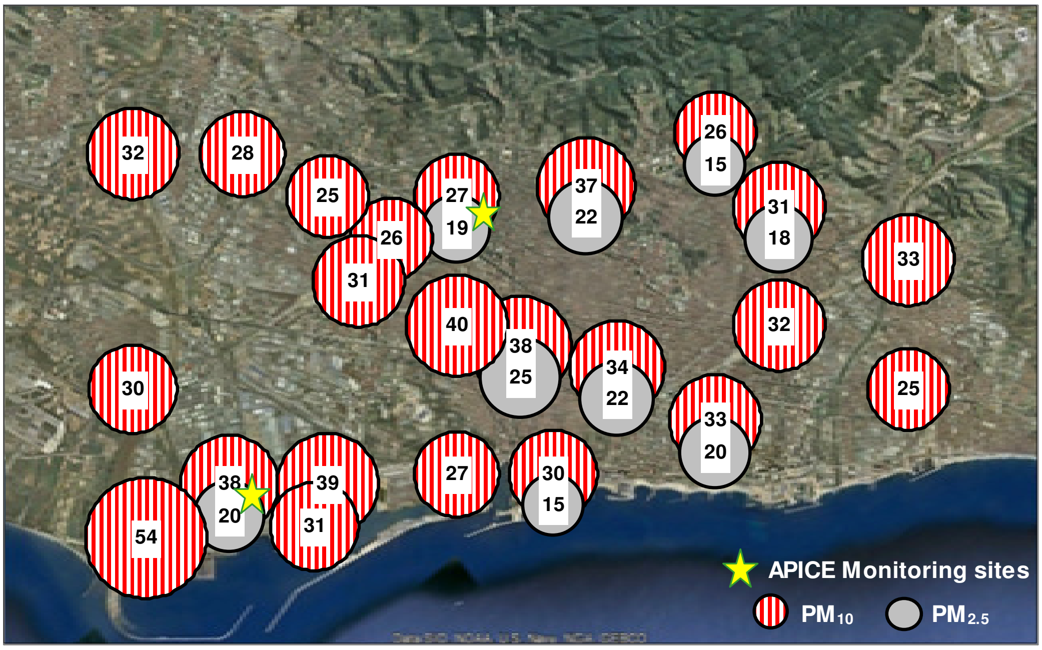

Figure 1. PM_{10} and $PM_{2.5}$ (µg/m^3) spatial concentrations during the campaign.

Regarding NO_2 concentrations (only shown for the harbour area) these are clearly parallel to traffic influence. Thus, the highest levels are observed in specific areas in the harbour. As far as we are away from road traffic lines, NO_2 levels decrease drastically.

A different pattern is observed for NH_3, clearly higher in two specific sectors inside the harbour: where dusty materials are handled, and close to the water waste treatment plant of the Barcelona metropolitan area.

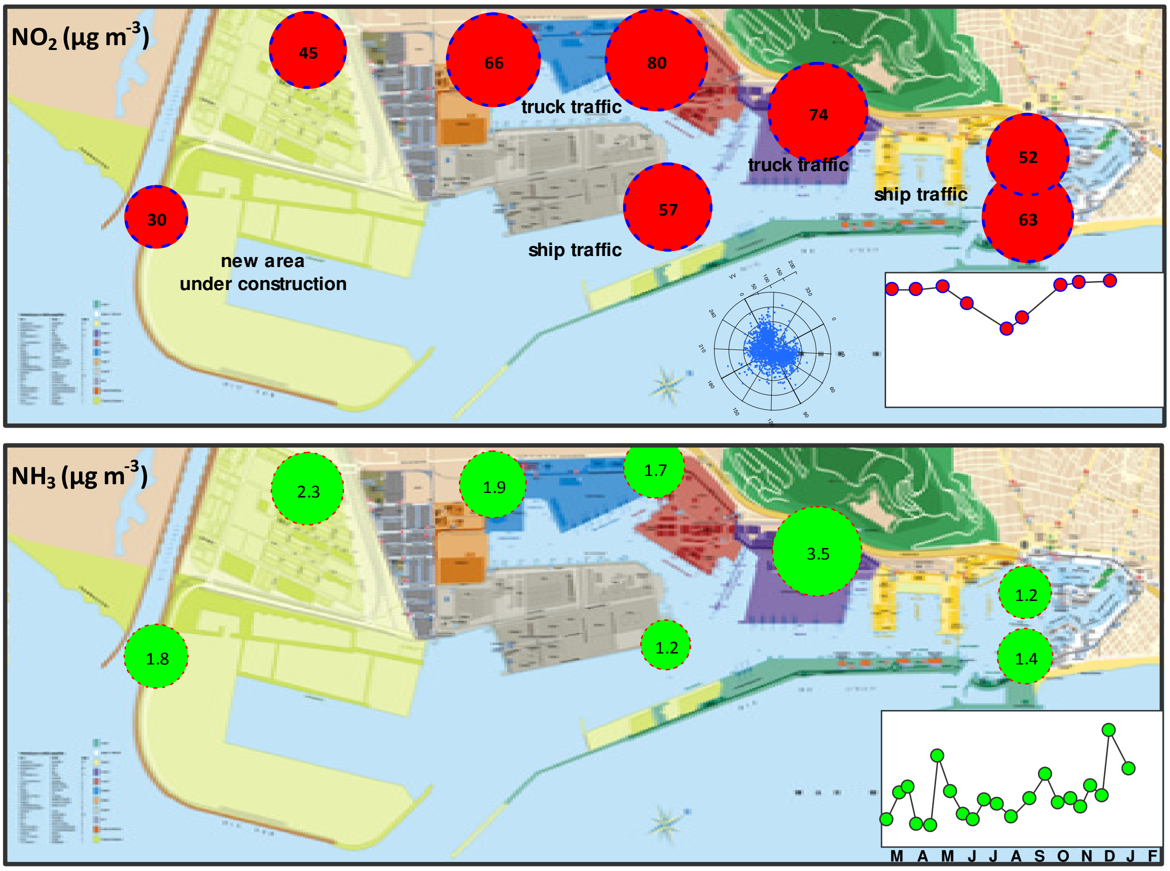

Figure 2. NO_2 and NH_3 ($\mu g/m^3$) spatial concentrations during the campaign.

Daily average PM_{10} levels during this period were higher at the port (35 $\mu g/m^3$) than at the urban site (27 $\mu g/m^3$, Figure 3). For $PM_{2.5}$, similar levels were obtained (18 $\mu g/m^3$). Emissions from construction of a new port extension are probably responsible of the high PM_{10} levels measured.

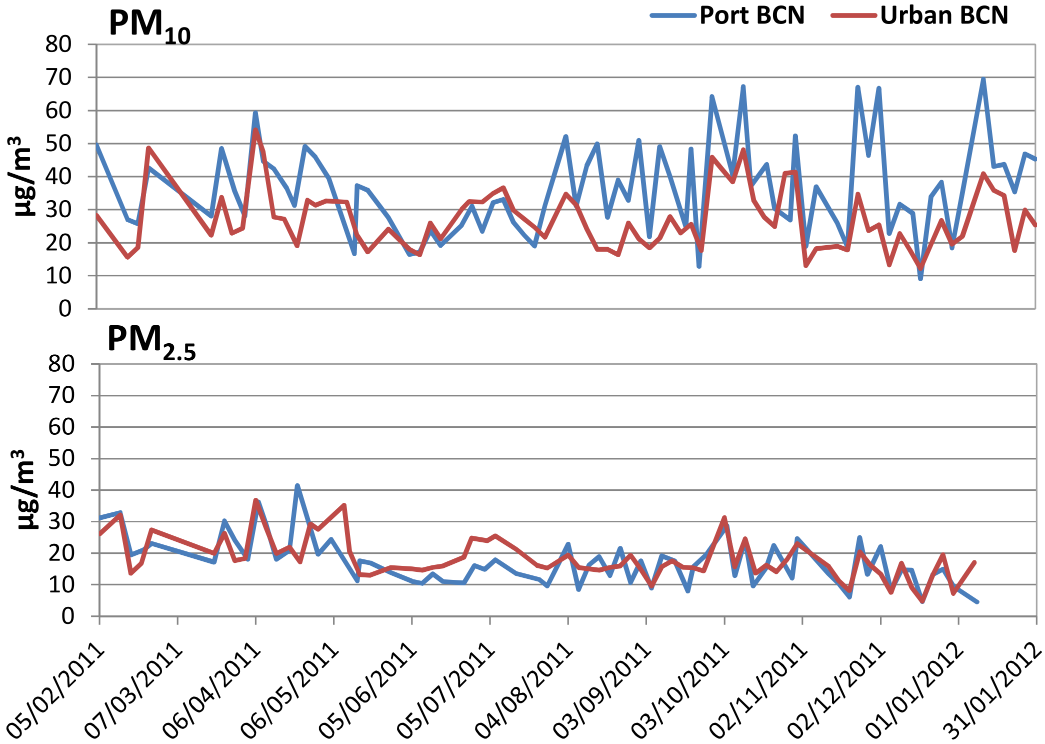

Figure 3. Levels of PM_{10} and $PM_{2.5}$ measured at the Port and the urban background of Barcelona during the campaign.

Regarding the chemical composition of $PM_{2.5}$ and the coarse PM fraction ($PM_{2.5\text{-}10}$, calculated as the difference between PM_{10} and $PM_{2.5}$) (Figure 4), the main difference was found for mineral matter, being more than 50% higher at the port in both the coarse fraction and $PM_{2.5}$ (8.6 vs. 3.5 µg/m^3 in $PM_{2.5\text{-}10}$), probably reflecting emissions from the new port extension works, but also handling of materials and dust resuspension by road traffic. Elemental carbon (EC) was almost 50% higher at the port in $PM_{2.5}$ (2.8 vs.1.5 µg/m^3), probably due to the heavy truck transport. Sulphate was more than 50% higher at the port in the coarse fraction (1.3 vs. 0.4 µg/m^3), while the differences in $PM_{2.5}$ were lower, reflecting coarse sulphate formation at the port.

However, at the urban background, NH_3 levels are much higher than at the Port of Barcelona in both the coarse and $PM_{2.5}$ fractions (0.5 vs 1.0 µg/m^3, at the port and urban site respectively). High NH_3 levels at the urban background of Barcelona have reported recently (Reche et al., 2012), being related to domestic sources.

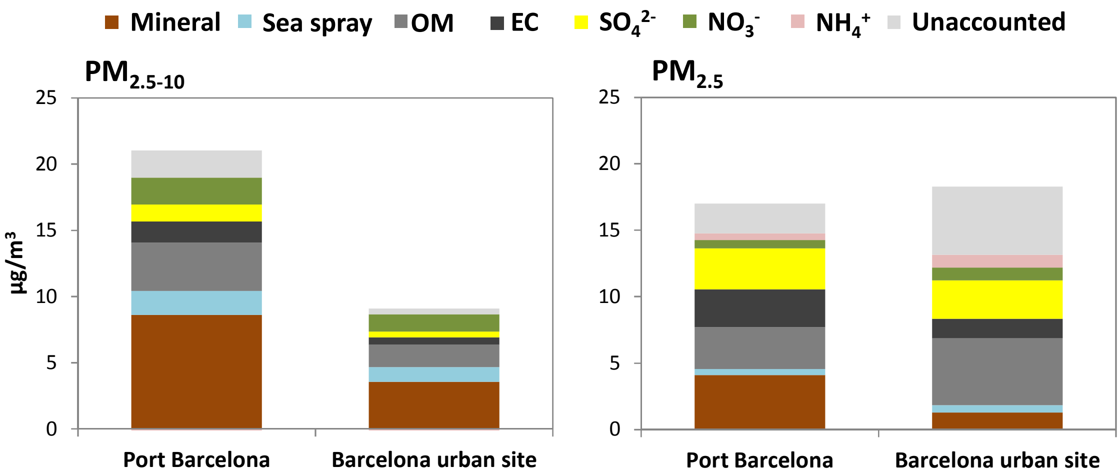

Figure 4. Main $PM_{2.5\text{-}10}$ and $PM_{2.5}$ components measured at the port of Barcelona and Palau Reial urban site during the campaign.

Trace element levels were in general higher at the port for both PM_{10} and $PM_{2.5}$ (Figure 5). Differences higher than 50% were found in PM_{10} for road traffic tracers (Cu, Zn, Sb, Sn) and fuel oil combustion tracers (V, Ni), reflecting emissions from an oil refinery and ship exhausts. Tracers of industrial emissions, such as As, Cd, Pb and Mn, presented also differences higher than 50% in PM_{10} at the port with respect to the urban area.

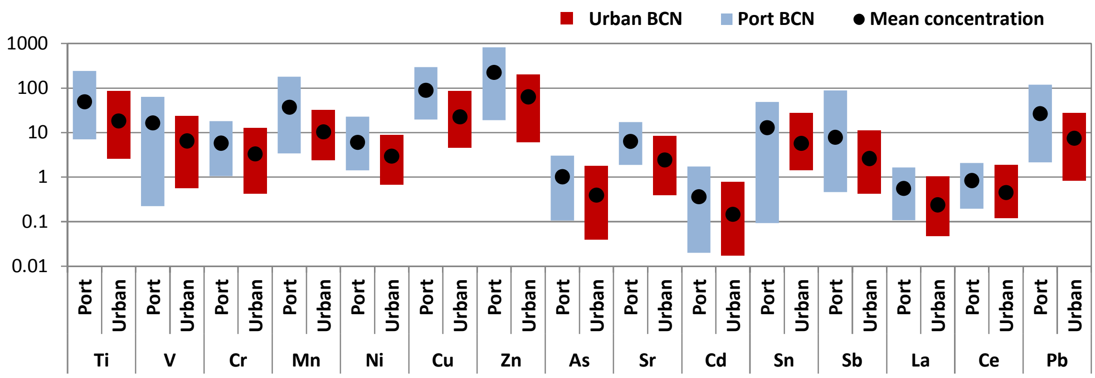

Figure 5. Levels of trace elements measured in PM_{10} at the Port and the urban background of Barcelona during the campaign.

Conclusion

Activities at the port of Barcelona may have an important impact at the urban area, especially to the coarse fraction. The important emissions of mineral dust (due to the port extension works but also to handling of materials and dust resuspension), EC and NO_2 (related to the heavy truck transport) and many road traffic, shipping and industrial tracers are transported to the urban area, owing to the location of the port and the sea breeze patterns. Abatement strategies should be developed and applied for the port of Barcelona.

References

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