Effects of maintenance works and ventilation settings on the PM concentrations in subway platforms

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Factors controlling PM concentrations in underground systems include type of ventilation, station design, wheels/rails/brakes composition, train speed/frequency, passenger density, and the presence/absence of platform screen doors. It is important to know the effect of these variables to produce a strategic plan to improve air quality in subways worldwide. As part of the IMPROVE LIFE project in the Barcelona subway, experiments are investigating the impact on passenger's exposure to air pollutants attributed to: 1) tunnel renewal works (ballast, sleepers, rails); 2) addition of ballast with/without a dust suppressant polymer; 3) changes in ventilation settings; 4) use of different brake pads; and 5) use of pantographs with different compositions. Monitoring equipment is located at the train entry point in each platform including: i) DustTrak (8533, TSI) for $PM_{2.5}$ mass concentrations; ii) OPS (3330, TSI) for number distributions in the 0.3–10µm size range; iii) high volume sampler (CAV-A/MSb, MCV) for $PM_{2.5}$ gravimetric and chemical analysis; and iv) IAQ-Calc (7545, TSI) for CO, CO_2, T, RH values. Campaigns carried out so far have yielded the following results:

1. An increment of mean levels in the platform associated with tunnel night renewal works was detected. These works increased $PM_{2.5}$, $N_{0.3\text{-}10}$ and CO levels up to 90% (Table 1), although duration was always less than 30 min. Welding and railway replacement activities had a more lasting effect on $PM_{2.5}$ and $N_{0.3\text{-}10}$ concentrations, extending into passenger occupancy hours.

Table 1. Summary of statistics in days with or without renewal works in progress.

	Before works		Works period	
	Mean	St. Dev.	Mean	St. Dev.
$PM_{2.5}$ (µg m^{-3})	34.2	15.4	42.6	21.5
$N_{0.3\text{-}10}$ (# cm^{-3})	1129	570	1211	774
CO_2 (ppm)	479	49	501	51
CO (ppm)	0.03	0.08	0.1	0.4
T (°C)	16.9	1.4	19.7	1.2
HR (%)	34	6	41	8

2. The addition of ballast treated with a dust suppressant at first did not seem to reduce the emission of particles more than the standard method (using just water) during the process (Fig.1). However, an effect was observed later during subway operation hours, PM being lower when applying the dust suppressant method. Further research is needed to evaluate the reproducibility of these results.

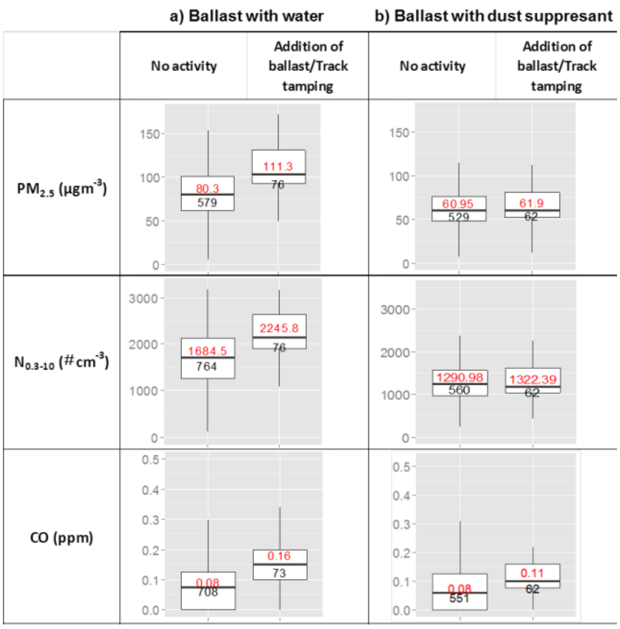

Figure 1. Box plot of $PM_{2.5}$, $N_{0.3\text{-}10}$ and CO levels during subway operation hours, after ballast addition with and without dust suppressant. Data points in black, mean concentrations in red.

3. Better air quality was achieved by forceful introduction of outdoor air (impulsion) in tunnels rather than by the extraction of indoor air. $PM_{2.5}$ and $N_{0.3\text{-}10}$ mean levels were 18-22% higher when extraction was operating ($PM_{2.5}$: 77 vs 62µg m^{-3}; $N_{0.3\text{-}10}$: 1713 vs 1340#cm^{-3}), while CO_2 levels were 10% higher (480 vs 530ppm). The increases were observed immediately after the change of ventilation setting, but did not increase further with time.

The relationship between the composition of platform PM and that of particles generated by maintenance works, as well as the chemistry of different pieces used in each subway line (brakes, pantographs, ballast) will now be studied, and the contribution of each pollutant source will be estimated to develop protocols aimed at producing discernible improvements to rail subway air quality.

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