Subway platform air quality: assessing the influences of tunnel ventilation, train "piston effect" and station design

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It is known that air quality in underground rail transport systems, especially with regard to inhalable particulate matter (PM) concentrations, is highly variable but commonly extremely poor. There are, however, few specific data investigating potentially controlling influences on PM levels in subways, such as the effects of underground ventilation, train movement, and different station designs. With this in mind, an intensive, high resolution air quality measurement campaign was conducted in 10 stations along Line 2 of the Barcelona metro system under (a) normal ventilation conditions, and (b) with daytime tunnel ventilation systems shut down. Fifteen different PM size ranges (0.3-20 µm) were measured at 6-second intervals for one hour in four different sampling sites along each of the 10 platforms, together with concentrations of CO and CO_2. The data confirm that subway air quality is extremely variable, with average PM_{10} platform concentrations ranging from 11 to 95 µg/m^3 and transient peaks in several stations regularly rising into the 100-200 µg/m^3 range. The stations with poorest air quality were those with only a single platform and narrow tunnel containing a single line, and with lateral (rather than end) exit points, and there was always a notable spatial increase in PM_{10} levels at the end of the station furthest from the entrance (in those stations with only one exit). In these stations with the poorest air quality, average levels of PM_{10} rose when tunnel ventilation was turned off, in some cases doubling in concentration. This increase was despite the fact that outside air background concentrations in Barcelona were 30% lower during this phase of the experiment: clearly outside conditions were not significantly affecting air quality underground. The ratio of fine to coarse PM recorded by PM_3/PM_{10} (ranging between 0.6-0.7) was unaffected by the presence or absence of tunnel ventilation. Levels of CO and CO_2 under normal ventilation conditions were unexceptional (typically c.0.4ppm and 400-550ppm respectively), in most cases staying similar or falling when the ventilation was turned off. The main conclusion of the study is that the various combinations of station design and tunnel ventilation are the dominant factors controlling underground air quality in the Barcelona metro, with the "piston effect" induced by trains producing a perceptible through-draught but having less influence on actual air quality in terms of PM concentrations.

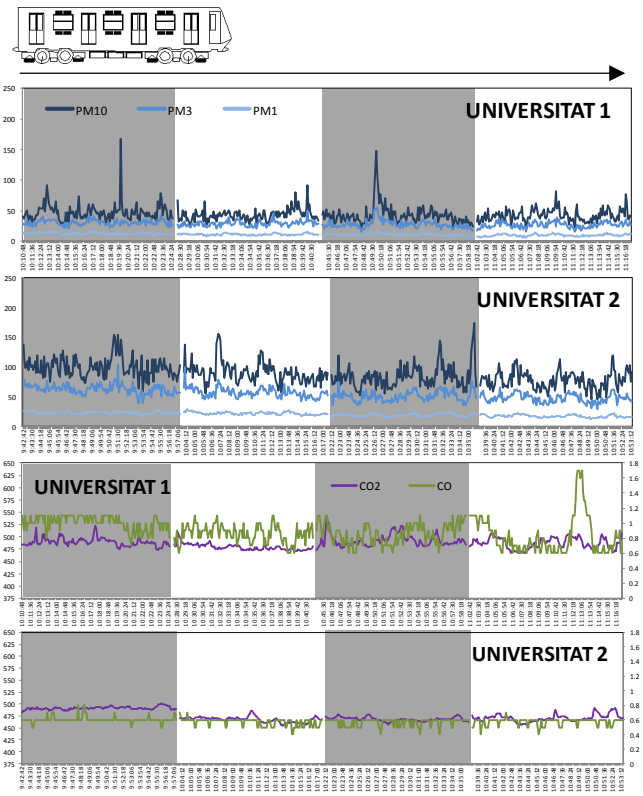

Figure 1. Example of PM concentrations in µg/m^3, and CO2 (left axes) and CO (right axes) in ppm, measured every 6 seconds in 4 different points along the subway platform. Data are shown for the Universitat station (with single train line and single platform) in the week 1 with tunnel ventilation (Universitat 1), and week 2 without tunnel ventilation (Universitat 2).

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