Levels and geochemistry of PM2.5 in an urban subway system

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This study assesses indoor air quality and passenger exposure in the Barcelona (BCN, NE Spain) subway system, focusing on PM levels, and their metal contents and sources. The impact on indoor air quality of platform screen door and ventilation systems in reducing PM levels were evaluated considering also the influence of the piston effect for ventilation and abatement of PM concentrations on platforms.

To this end a number of sampling and measurement campaigns were performed on the platforms of a number of subway stations with different ventilation conditions as well as inside trains in a number of travels along different lines.

In the BCN subway PM levels inside the trains are amongst the lowest reported for worldwide subway systems (11–32 µg m^3 PM2.5). This is mainly due to the air conditioning system that is working the whole year in all carriages of the trains. However, PM levels are considerably higher on platforms (mean of 46 and 125 µg m^3 in the new (L9, with platform screen doors) and old conventional (L3) lines, respectively) due to high emissions from train and rail wear.

Fe_2O_3 is the major constituent of PM2.5, accounting for most of the mass. However, there is a number of elements or components present also in high concentrations arising from rail, while, brake and catenary wear emissions. Furthermore, on highly ventilated platforms levels of outdoor pollutants such as sulfate, nitrate or sea spray are higher than in platforms with more stagnant conditions.

L3 platform levels show enrichment in most of elements, especially in Ba, Cu, Mn, Cr, As, Mo, Co and Sr (most of those are usual components of brake pads but also are present in steel as impurities), whereas L9 is enriched in Fe and Sb (also a frequent brake pad component). The enrichment in Ba and Sb on L3 and L9 platforms agrees with the composition of L3 and L9 train brake pads, respectively, indicating this as a major source of these metals. The enrichment in the remaining elements is not in agreement with the composition of L3 and L9 train brake pads suggesting other PM sources, such as catenary (Cu-rich material), wheels and railways (Fe and steel-rich materials). A detailed analysis of the different chemical and mineral composition of different brake pads was carried out to trace source origins. Results show that by regulating the brake pad composition an important abatement of levels of trace pollutants may be reached.

Results also evidenced that by combining platform screen door systems and advanced ventilation systems in platforms and tunnels PM exposure levels on the platforms may be reduced by a factor of 5 with respect old subway lines in Barcelona.