Air Quality in London Paddington Train Station

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Exposure to airborne particles from diesel railcars and locomotives in semi-enclosed train stations could present a major health risk for frequent travellers and station employees. While the EU and UK government have recently enacted PM emissions standards on rail traction diesel engines, these regulations only apply to engines that are post-2006 type approved (EU 2004). PM concentrations inside semi-enclosed environments are not regulated by EU air quality standards that apply to outdoor air quality. This presents a strong motivation to evaluate the air quality and emissions inside a station that has diesel trains, such as London Paddington.

Paddington Station is the 8th busiest train station in Great Britain (ORR 2010). Train schedule data indicate that approximately 70% of journeys in Paddington are diesel fuelled. In the context of Paddington, the goals of this study are (a) to quantify the indoor air quality and diesel emissions and (b) to assess the impacts of diesel train emissions on air quality. The methodology of this study is based upon a theoretical air quality model and an experimental measurement campaign.

In the measurement campaign, PM mass was measured at 5 locations using TSI AM510 monitors. Particle size distributions and number concentrations were measured at 2 locations using a TSI CPC and SMPS. Measurements were taken with and without a catalytic stripper to quantify the semi-volatile content of PM. Air samples were also collected on filters for analysis of metals, ions, and elemental/organic carbon (EC/OC) particle composition. Real time measurements of CO_2, NO_x, and SO_2 were also measured at the same 2 locations. Using anemometers, wind speed and direction data were collected at the 2 largest openings into the station so that a simplified mixed box model of particle mass concentrations in the station could be derived.

A theoretical mixed box model was developed based upon Nazaroff (2004) and solved with Euler's method. The model calculated particle mass concentration as a function of indoor emissions rate, natural ventilation, and air leak infiltration. Idle and acceleration emissions factors were developed for train types and traffic schedules specific to Paddington station. Natural ventilation was calculated from an air flow rate that was measured at the 2 largest openings in the building. Air leak infiltration was calculated based upon Gowri et al. (2009).

Measured results include total particle number, mass, and size distribution. Generally, results showed that respirable PM concentrations in the station were similar to concentrations on a typical London roadside (Marylebone Road). However, during some peak rush hours, concentrations of PM and NO_2 exceeded outdoor EU limits. EC/OC measurements shown in Fig. 1 indicate that the organic fraction of PM depend on the location in the station with highest concentrations near Praed Ramp, furthest from the trains. Similar conclusions drawn from concentration metrics are also discussed in the presentation.

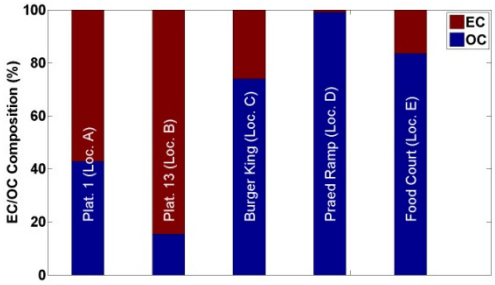

Figure 1: EC/OC ratio variation by location

Modelled PM concentrations tracked closely with measured concentrations. The results from 1 day of analysis (Thursday) are shown in Fig. 2.

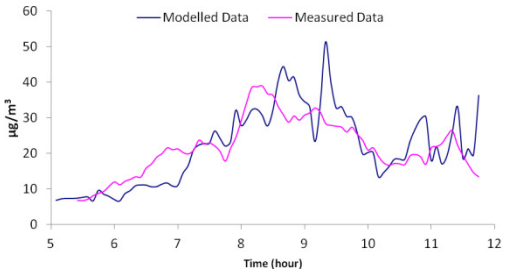

Figure 2: Modelled versus measured PM concentrations

The coefficient of determination between modelled and measured results was R^2=0.24. The daily averaged modelled concentration was also calculated to be within 2% of the measured concentration.

The measured PM mass concentrations in the station are close to London roadside levels. Speciation measurements show that diesel trains constitute a significant portion of PM. A mixed box model was developed to simulate PM mass concentrations. Further research could result in a more precise mixed box model that can assess the air quality impact of emissions abatement technologies on the diesel trains in the context of impending rail traction emissions regulations.

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