Particle Characterisation in London Paddington Station

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Introduction

Enclosed train stations with diesel-powered trains are a health risk because of the close proximity to passengers and workers. One such station is London Paddington Station, which is the 8^{th} busiest train station in Great Britain, serving 30 million passengers in 2010.[1] Of the 14 rail tracks in Paddington, 12 are used for diesel powered trains. The rest are used by electric trains to Heathrow Airport. Locomotive PM mass emissions standards were lowered by 88% in January 2012 from 0.200 g/kWh to 0.025 g/kWh.[2] PM emissions are also influenced by EU Directive 2009/30/EC, which lowered fuel sulphur content of locomotives from 1000ppm to 10ppm in 2011.[3] The purpose of this study is to characterise particles in Paddington Station and apportion the sources of emissions.

Methodology

A measurement campaign was carried out based upon the following methods:

- Aerosol monitors (TSI AM510) and pumps with filters were placed a 5 locations to take measurements on a daily basis.
- A suite of larger equipment (SMPS, gas analysers, CPCs) was rotated daily between 3 locations. Table 1 describes the equipment used and the corresponding species measured. Table 2 describes the locations of the equipment.

Table 1: List of equipment and species measured

Species Measured	Equipment Used
PM mass	TSI AM510 Personal Aerosol Monitor
PM size distribution	TSI SMPS and CPC
SO_2	Environmental Technologies UV Fluorescence M100A Analyser
NO_x	Environmental Technologies Chemiluminescence M200A Analyser
PAH and Cholesterol	Quartz Filters and ELF Personal Pump
Metals	Mixed Cellulose Filters and ELF Personal Pump
Anions	PTFE Filters and ELF Personal Pump

Table 2: List of equipment locations and potential PM sources

Location	Purpose
A (Bridge)	Directly above Platform 1 where large intercity locomotives pass.
B (Platform 13)	Underneath a bridge where small regional trains pass.
C (Burger King)	Adjacent to a Burger King where grilling is a source of PM.
D (Praed Ramp)	Entrance where cigarette smoke, outside, and inside air mix.
E (Platform 1)	Adjacent to Platform 1 where large intercity locomotives pass.
F (Food Court)	Isolated area where restaurant cooking occurs.
G (Outdoors)	Outdoor ambient measurements.

Results

An initial survey was conducted with mobile measurement instruments from TSI, Inc. A P-TRAK 8525 Ultrafine Particle Counter was used to measure number concentration of PM below 0.1µm. Figure 1 shows the averaged results of these measurements:

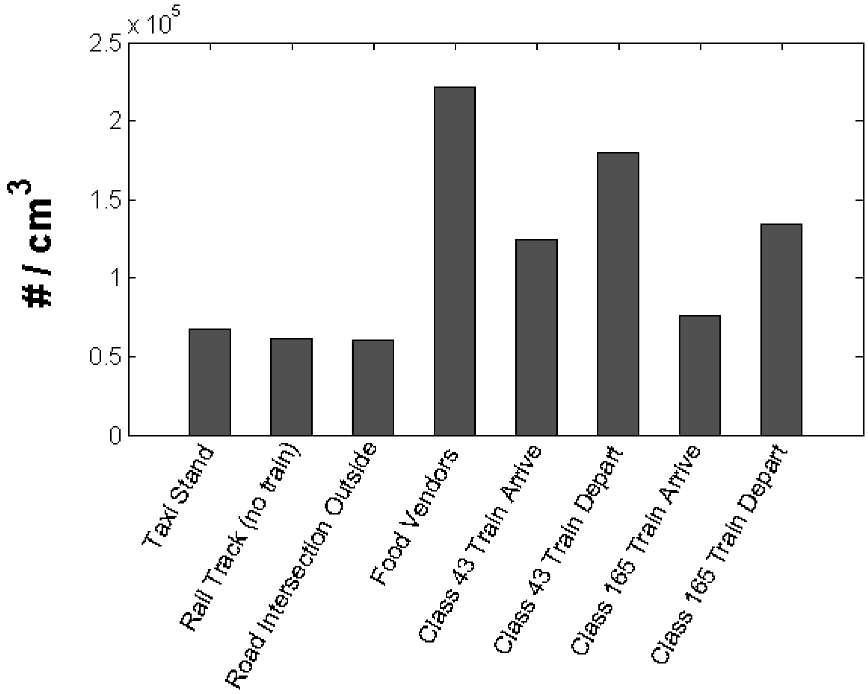

Figure 1: PM Results (initial survey)

Elevated levels of PM were observed during departing and arriving train activity, with departing engine acceleration causing higher levels of PM than braking from arriving trains. Beyond the trains, it was determined that other activities, such as food vendors, can contribute to elevated PM.

Figure 2 shows the results of PM from the AM510. These were corrected by corresponding gravimetric filter measurements. Comparisons were also made to nearby outdoor measurement stations, such as a car park in North Kensington, and a roadside station, in Marylebone Road.

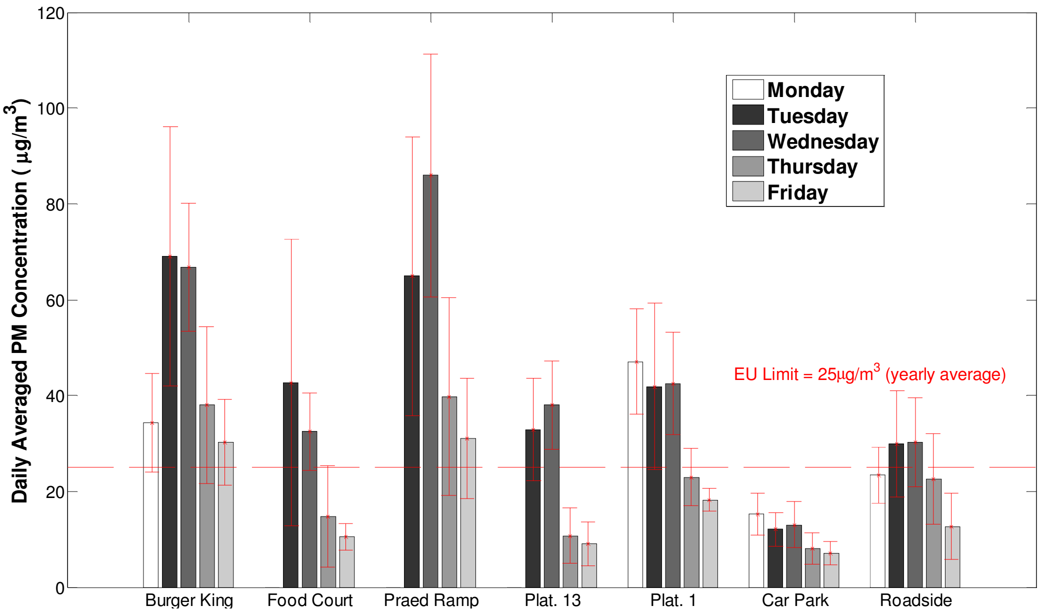

Figure 2: PM results

PM was also collected on quartz filters and analysed for EC/OC composition with the EUSAAR2 method. Measurements were corrected by the results of a blank filter EC/OC analysis. The results of EC/OC analysis are shown in Figure 3:

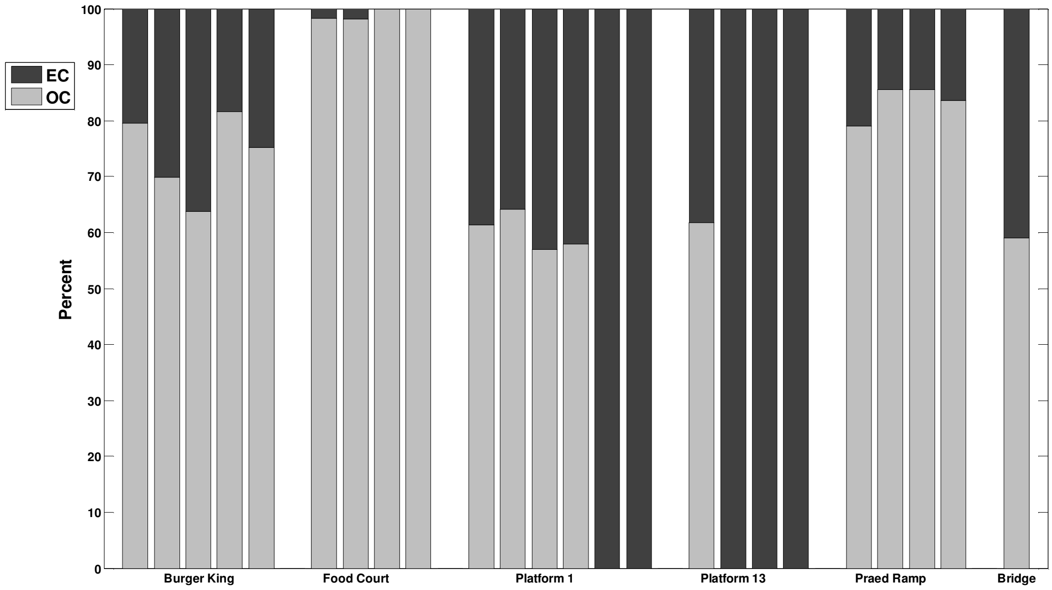

Figure 3: Results of the EC/OC analysis

Teflon (PTFE) filters were used to collect air samples and subsequently analysed for anions. They were also corrected by the results of a blank filter analysis. Figure 4 shows the anion results:

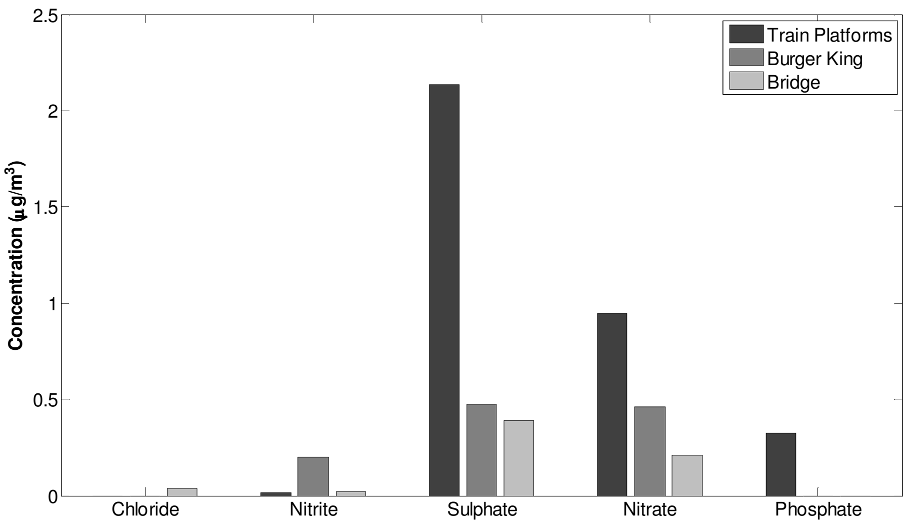

Figure 4: Results of the anion analysis

Discussion

PM mass concentration inside Paddington can be higher than concentrations in nearby outdoor environments. During certain times, EU Air Quality limits are breached. EC/OC speciation shows that PM compositions nearer to train platforms have higher EC proportions and PM compositions near restaurants have higher OC proportions. Finally, anion analysis shows higher sulphate and nitrate concentrations next to the train platforms than in other areas in the station.

Further Work

Uncertainties in the PM mass measurements must be quantified with comparative results between the AM510, gravimetric filters, SMPS, and EC/OC filter measurements. EC/OC filter results can also be further analysed so that source apportionment of PM can be quantified. Source apportionment can also be analysed based upon the SMPS size characterisations.

References

1. ORR (2010) *2009-2010 Station Usage Report and Data*. UK Office of Rail Regulation
2. EU (2004) *Directive 2004/26/EC of the European Parliament and of the Council*. Official Journal of the European Union L-146.
3. EU (2009) *Directive 2009/30/EC of the European Parliament and of the Council*. Official Journal of the European Union L-140

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Introduction

- Enclosed train stations with diesel-powered trains are a health risk because of the close proximity to passengers and workers.
- London Paddington Station is the 8th busiest train station in Great Britain, serving 30 million passengers in 2010.[1]
- Of the 14 rail tracks in Paddington, 12 are used for diesel powered trains. The rest are used by electric trains to Heathrow Airport.
- Locomotive PM mass emissions standards were lowered by 88% in January 2012 from 0.200 g/kWh to 0.025 g/kWh.[2]
- Fuel sulphur content was lowered from 1000 ppm to 10 ppm in January 2011.[3]
- The purpose of this study is to characterise particle emissions in London Paddington Station and apportion the sources of emissions.

Methodology

- Personal aerosol monitors and pumps/filters at 5 locations.
- Suite of SMPS, gas analysers, and CPCs rotated daily between 3 locations.

Table 1: Species measured and equipment used

Species Measured	Equipment Used
PM mass	TSI AM510 Personal Aerosol Monitor
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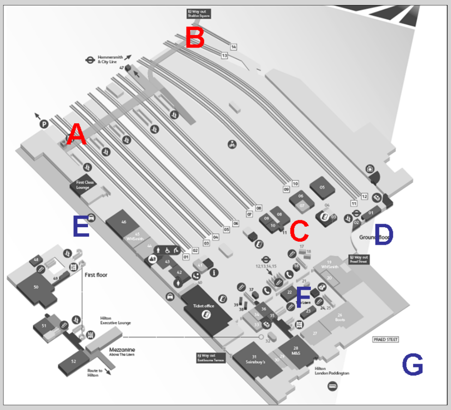

Figure 1: Measurement locations

Table 2: Measurement location purposes

Location	Purpose
A (Bridge)	Directly above Platform 1 where large intercity locomotives pass.
B (Platform 13)	Underneath a bridge where small regional trains pass.
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G (Outdoors)	Outdoor ambient measurements.

Figure 1: Equipment used

Results—PM mass measurements

- PM mass concentration was taken from 5 locations daily.
- AM510 PM data was calibrated with gravimetric filter measurements.
- Comparisons were made to KCL outdoor measurements in a nearby car park and roadside station.
- Uncertainty bounds are given as the standard deviation of the set of data collected over the course of daily measurements.

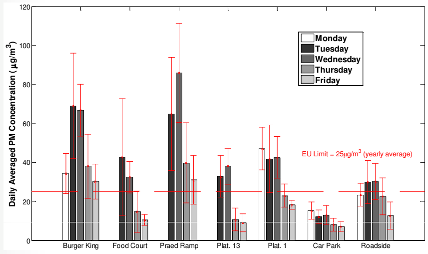

Figure 3: PM measurements by location.

Results—EC/OC speciation

- EC-OC was determined by quartz filter collection using a EUSAAR 2 method.
- Data were corrected by results from a blank filter test.

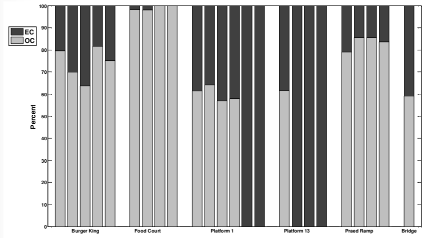

Figure 4: EC-OC results by location.

$$\text{Total EC} = EC_{TRAIN} + EC_{FOOD}$$
$$\text{Total OC} = OC_{TRAIN} + OC_{FOOD}$$
$$EC_{FOOD}/OC_{FOOD}=0.19^{4}$$
$$EC_{TRAIN}/OC_{TRAIN}=3.95^{5}$$

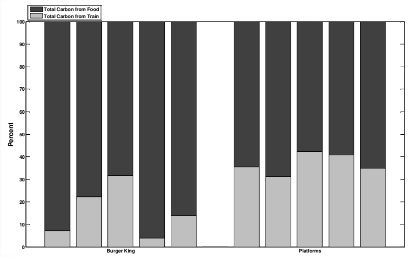

Figure 5: Preliminary source apportionment

Results—PM size distribution

- Data was collected with an SMPS.
- PM was measured with and without a catalytic stripper.

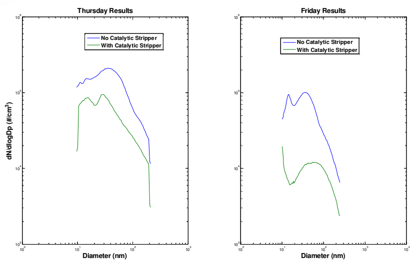

Figure 6: Daily averaged PM distributions

Results—NO_2 measurements

- Mass concentration was taken with an analyser based on chemiluminescence.
- Uncertainty bounds are taken from zero calibration conducted during the measurement campaign.

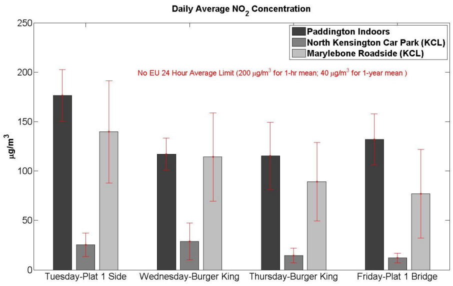

Figure 7: NO_2 measurements by location

Results—Anions

- Anion analysis was done with Teflon (PTFE) filters using ion chromatography.
- Data were corrected by results from a blank filter test.

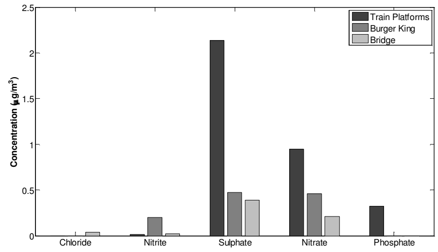

Figure 8: Location results of anion analysis

Discussion

- PM mass concentration inside Paddington can be higher than concentrations in nearby outdoor environments. During certain times, the EU Air Quality limits are breached.
- EC-OC values are uncertain because of low overall carbon concentrations relative to the blank filter values.
- OC proportions are higher in food cooking and cigarette smoking locations. EC proportions are higher in areas of close proximity to trains.
- NO_2 concentrations within the station can be higher than concentrations in nearby outdoor environments.
- Sulphate and nitrate values are higher on train platforms than when next to food cooking areas.
- SO_2 measured concentrations are not shown because of the uncertainty in the results.

Further Work

- Uncertainty quantification
- Further quantification of emissions sources for other species.
- Correlate SMPS size distributions with filter mass data.
- Correlate gravimetric data with filter mass data.

Acknowledgements

- Engineering and Physical Sciences Research Council
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References

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