Imperial College London
Projects

Environmental Research Group

Initial report relating to fires at Arnolds Field on Launders Lane in Rainham, Havering

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Contents

1 Introduction

Arnolds Field on Launders Lane, a former gravel pit near Rainham in the London Borough of Havering, was used as a landfill site from 1967 to 1971. Although planning permission was granted to convert the site to community woodland in 2000, waste has continued to be dumped illegally. The build-up of a variety of types of materials, in an uncontrolled manner, some of which are not fully known, has resulted in the waste igniting on a number of occasions, particularly since 2018. The fires have resulted in complaints from local residents who are concerned about the effects on their health of the smoke from the fires.

The Environmental Research Group at Imperial College London was commissioned to measure and analyse ambient air pollution in the area to provide further evidence about the possible effects on local residents. The analysis will make use of existing measurement resources as well as monitors specifically located to assess this issue. It will also identify areas where additional information or monitoring is required to gain a better understanding of the problem and effects on ambient air quality. Additional monitoring and analysis are being carried out by TRL to identify any hazardous and toxic substances being emitted.

This initial report details preliminary analysis of the currently available air quality and wind directional information from the Launders Lane area to assess the likely impact from the fires already seen by local residents and inform potential additional monitoring and locations.

2 Details and location of fires

The Arnolds Field site and approximate area affected by the fires is shown in Figure 1.

Figure 1: Location of Arnolds Field fires and residential areas to the north-west, west and south-east

The location is south of a quarry and aggregates works and to the north of a golf course. Residential housing is located mainly to the north-west and west. The closest homes are around 600m away from

the former landfill site. There is also a residential area to the south-east but at a greater distance (approx. 2km) from where the fires are occurring.

London Fire Brigade has provided records of callouts to incidents in the Launders Lane area. Only a small number of events that may relate to the waste site were recorded before 2018 so information has been considered after this date. The records currently received by ERG finish in October 2022. Details of the fires include the time of the call, the end time of Fire Brigade involvement, whether the fire is primary or secondary, the location and the type of land or property affected. For the purpose of this report, any fires described as affecting landfill site, wasteland, scrub land or heathland have been considered as possibly relating to the Arnolds Field waste site. The number of days each year affected by such events are shown in Table 1.

Year	Days affected by fires
2018	1
2019	16
2020	18
2021	14
2022	37

Table 1: Number of days affected by fires that may relate to the Arnolds Field waste site in each year between 1st January 2018 and 12th October 2022.

3 Methods

3.1 Meteorological data

Reliable, publicly available meteorological measurements have not been found in the vicinity of Launders Lane for the time period being considered. However, high quality meteorological data is available from the National Oceanic and Atmospheric Administration (NOAA) Integrated Surface Database. This was accessed using the worldmet package in R. The closest location of available data from this source to Arnolds Field was London City Airport. The locations of City Airport and Arnolds Field fires are shown in Figure 2. This data can be considered representative of overall conditions over a wide area but localised differences are possible. Local meteorological measurements will be included in the additional monitoring being set up in the Launders Lane area.

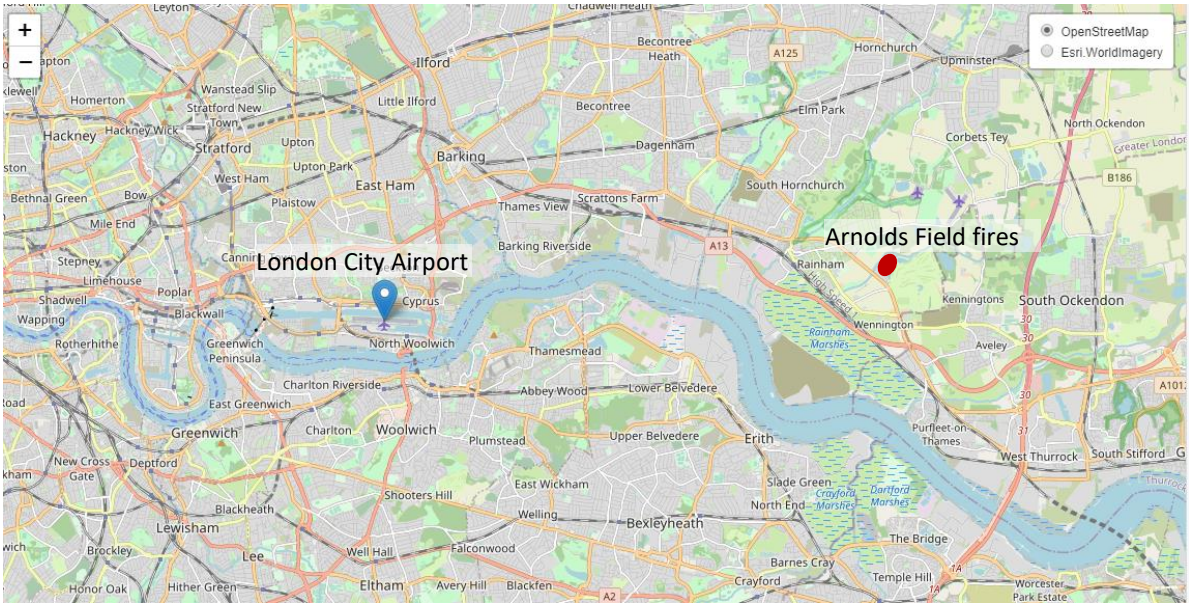

Figure 2: Location of City Airport relative to Arnolds Field

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3.2 Air quality

3.2.1 Reference measurements

Havering Council has two long term reference standard air quality monitoring sites, one of which is located in Rainham, close to Launders Lane and is relevant to this analysis. It is located around 1.25 km to the north-west of the Arnolds Field site, as shown in Figure 4.

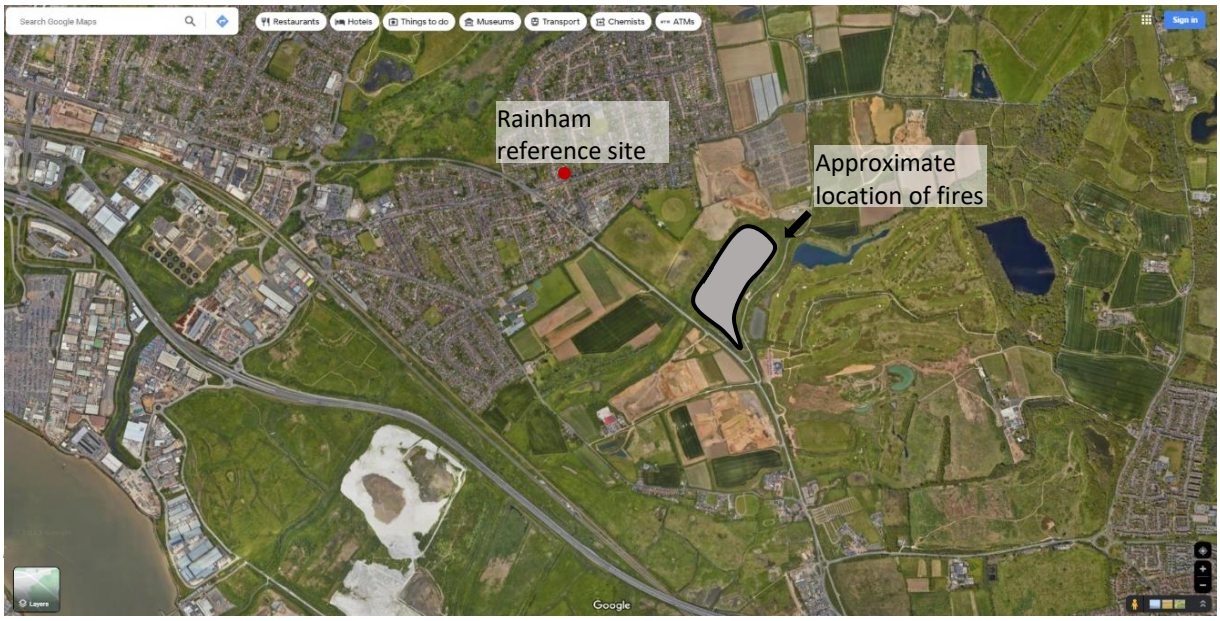

Figure 4: Location of Rainham reference site relative to the Arnolds Field fires

In the UK, outdoor air pollutants are regulated by the Air Quality Standards Regulations, 2010. These are based on the EU Air Quality Directive 2008/50/EC[1] and the amending Directive (EU) 2015/1480 which were enshrined into UK law following the UK's departure from the EU in 2020. The Directive defines the measurement methods and includes guidance on appropriate siting.

The Rainham site was installed in 1995. NOx is measured by chemiluminescence according to the requirements of the Directive. Particulate matter must be measured using methods that have demonstrated equivalence to the reference method. At Rainham PM_{10} and $PM_{2.5}$ are measured by TEOM 1405-DF FDMS which meets this requirement.

Data management and ratification is carried out by Imperial ERG as part of the London Air Quality Network (LAQN)[2]. The equipment is calibrated monthly and is operated and maintained in accordance with the requirements of Directive 2008/50/EC, including UKAS accredited audits by the

[1] European Commission (EC) 2008. Directive 2008/50/EC of the European Parliament and of the Council on ambient air quality and cleaner air for Europe. Commission of the European Community, Brussels.

[2] www.londonair.org.uk

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National Physical Laboratory. These procedures also meet the requirements of London Local Air Quality Management Technical Guidance (GLA, 2019) [3].

3.2.2 Breathe London measurements

The Breathe London sensor network measures NO_2 and $PM_{2.5}$ at around 400 locations across London and is operated by Imperial ERG, in collaboration with the Greater London Authority (GLA). The network provides measurements at local and hyperlocal scales using a unique network scaling approach based on the relationship between each Clarity sensor and reference site measurements, applied on a continuous basis. This provides an increased density of air quality measurements compared to the availability of reference measurements.

The London Borough of Havering currently has seven Breathe London nodes, two of which have been installed to increase measurement coverage in the area where residents are concerned about pollution from the fires. These are at Acer Avenue and King Edwards Avenue in Rainham. There is also a node co-located at the Rainham reference site which can be used as a cross-check to ensure that increased pollution concentrations at the reference measurement site are also detected by the Breathe London node. The locations of Breathe London nodes in the borough are shown in Figure 5.

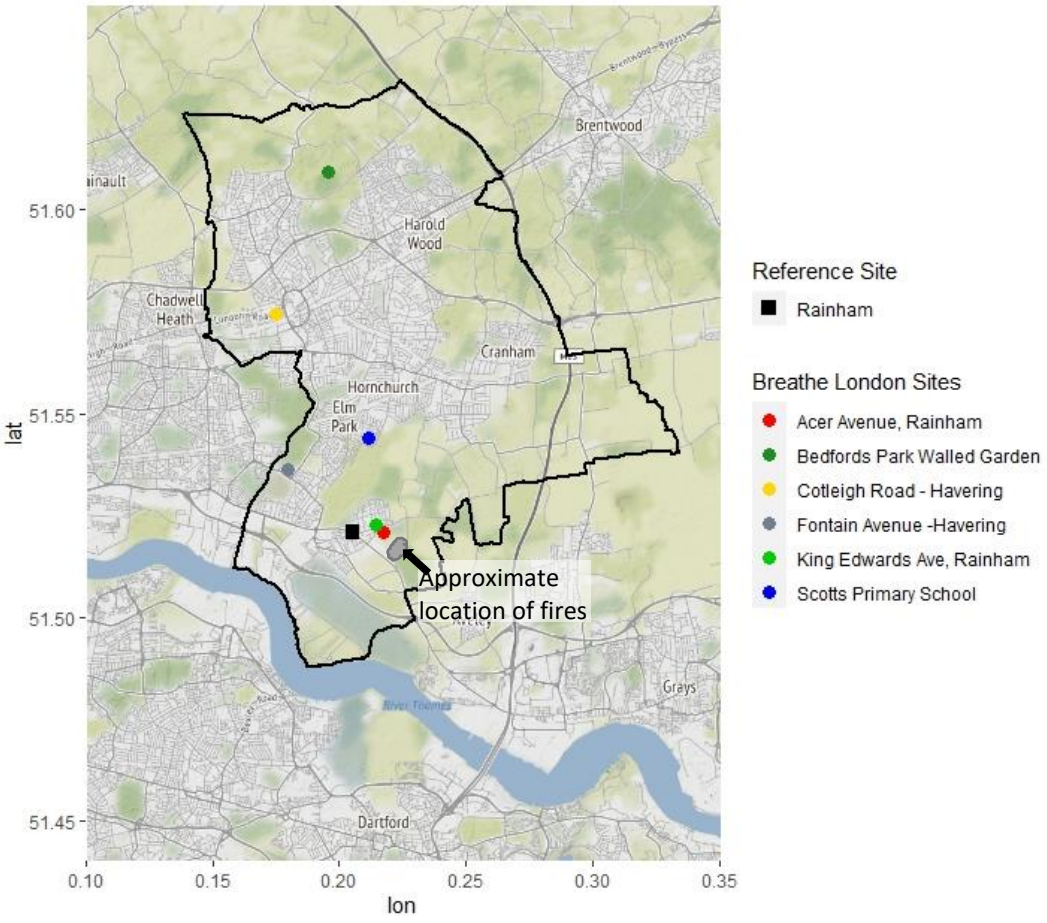

Figure 5: Locations of LB Havering's Breathe London nodes. The black outline shows the borough boundary.

[3] https://www.london.gov.uk/sites/default/files/llaqm_technical_guidance_2019.pdf

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There is also the option to install additional nodes in areas without air quality measurements that may be affected by the smoke from the fires near Launders Lane or to provide further information that will be useful to the analysis. The analysis in this preliminary report will be used to inform potential additional locations where measurements may be needed.

The Breathe London network is a relatively new air quality measurement resource. The majority of Breathe London nodes have been installed since the start of 2021, including the Rainham reference co-location node. The Acer Avenue and King Edwards Avenue sites were installed in October 2022. Therefore, data from these locations can only be used for analysis from this point and not for historical fire events, details of which have been provided up to October 2022 (see section 2). Data from the Rainham reference co-location will be examined for events since February 2021.

4 Results

4.1 Wind direction analysis

Meteorological data from London City Airport from 2018 to 2023 was examined. Wind speed and direction data shows that the most common wind direction is from the south-west. The highest wind speeds also occur from this direction. This is the case in all seasons, as shown in Figure 6. Winds from this direction would blow smoke from the fires in the direction of industrial areas, towards the quarry and aggregates works and not towards residential areas.

Easterly and south-easterly winds would be most likely to bring smoke from the Launders Lane fires towards the main residential area to the north-west and west. This is not a common wind direction in any season but particularly in summer when the fires have been more common. Therefore, on most occasions, the wind is unlikely to blow smoke from the fires towards the main and closest residential areas.

Easterly winds are more common than south-easterly and occur more in spring and summer. This could blow smoke towards the residential areas to the west. Local variations in wind direction or low wind speeds also have the potential to transport smoke towards residential areas.

Additional meteorological measurement equipment is being installed at four locations in conjunction with additional air quality monitors to provide a local perspective on wind conditions and when this is likely to result in pollution from the fires affecting residents. The measurement locations have been chosen with the aim of being representative of the conditions in the Launders Lane and surrounding area.

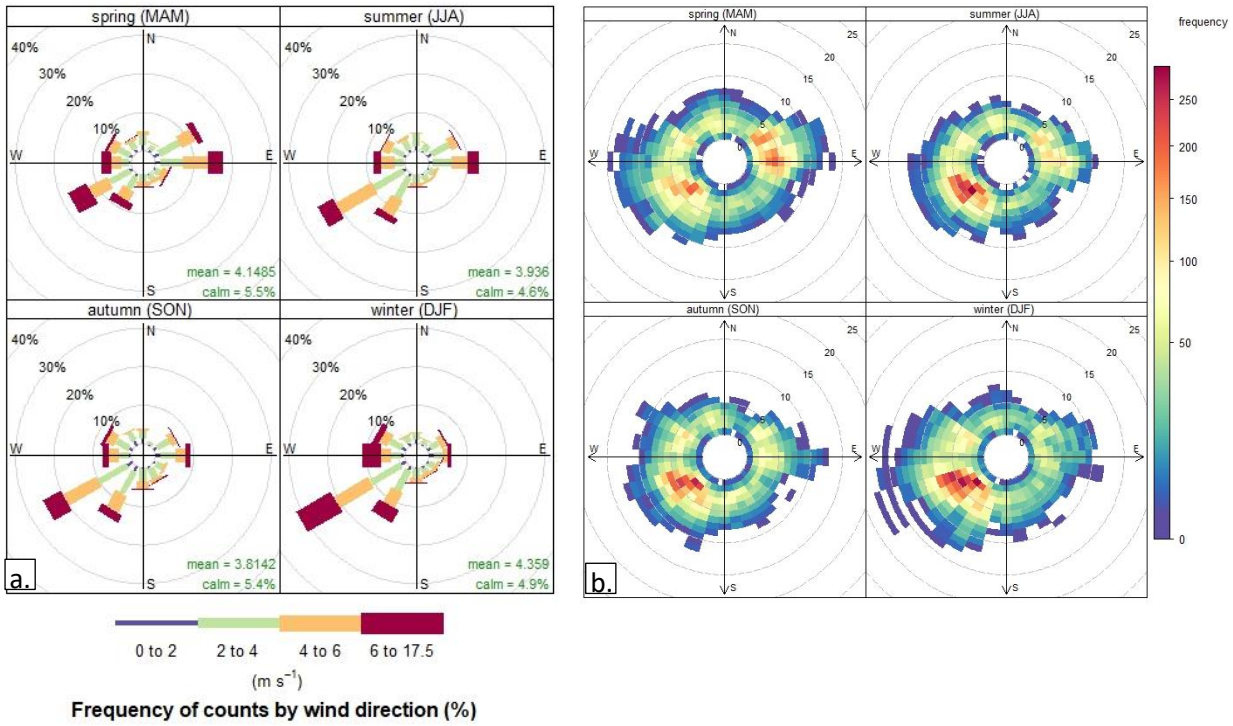

Figure 6: Wind speed and direction by season at London City Airport. Panel a shows wind roses and panel b shows more detailed wind speed and direction frequency plots.

Figure 7 and Figure 8 show that there was no significant variation in wind conditions between different years for the time period considered.

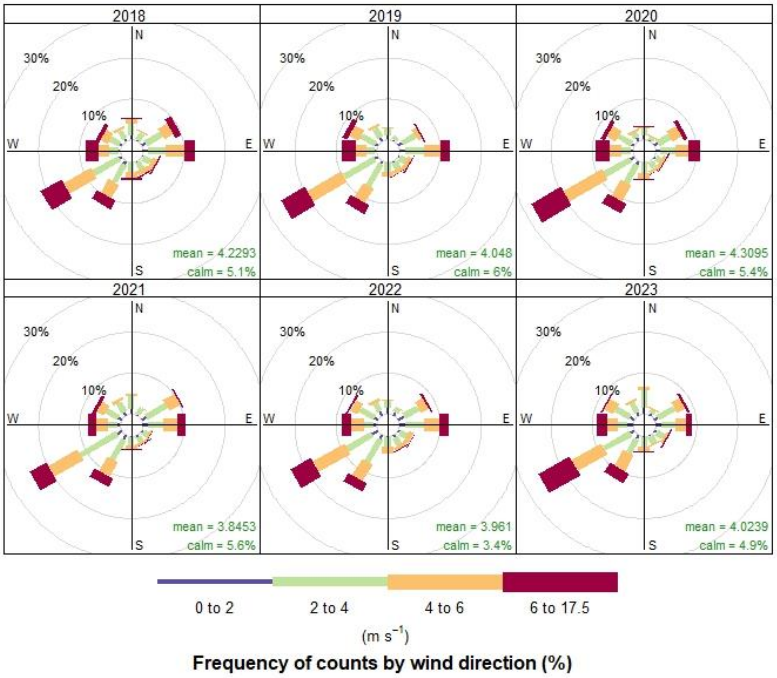

Figure 7: Wind speed and direction by year at London City Airport

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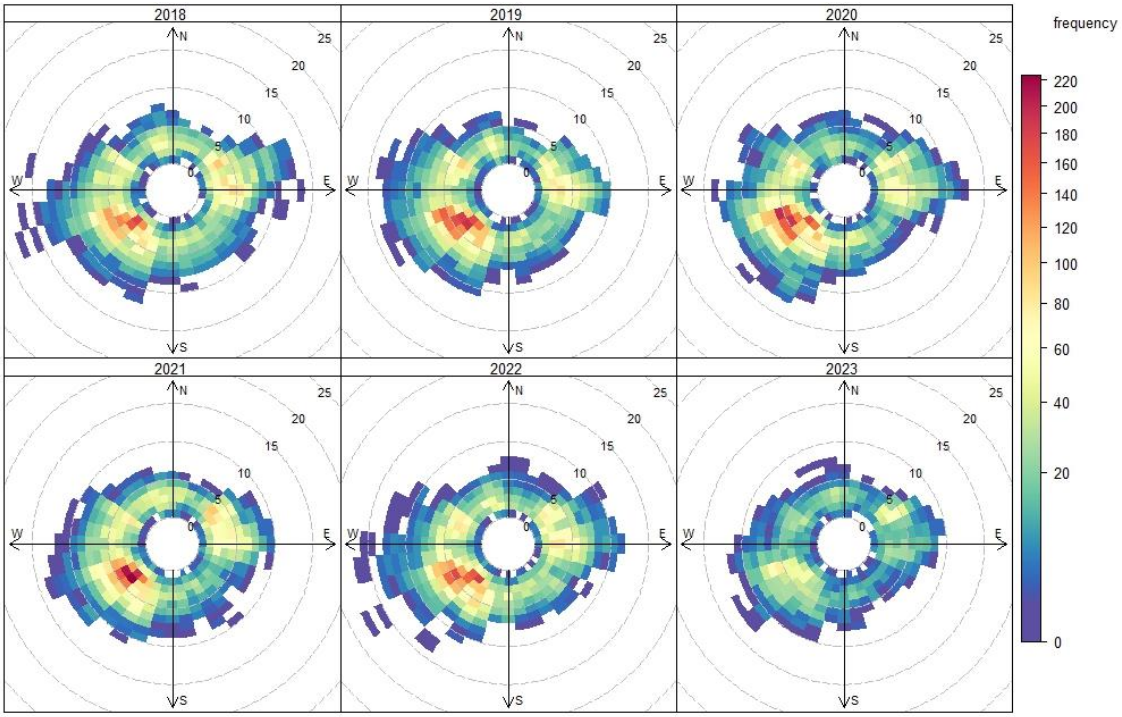

Figure 8: Frequency plots of wind speed and direction by year at London City Airport

4.2 Air quality data analysis

4.2.1 Reference measurements

Air quality measurements from the reference site in Rainham were examined for evidence of smoke from the Arnolds Field fires being detected at the measurement site. Smoke would be expected to cause increased concentrations of particulate matter, both PM_{10} and $PM_{2.5}$, with a high proportion of $PM_{2.5}$.

$PM_{2.5}$ concentrations were examined in the first instance.

2018

Table 2 shows the dates when a fire was recorded by London Fire Brigade at Launders during 2018. Figure 9 shows the daily mean $PM_{2.5}$ concentration at Rainham for each date in 2018. Days when a fire was recorded are circled. The top panel shows the day of month and the lower panel is annotated with wind speed and direction. Only one fire was recorded in 2018 and on this day the wind from a direction which could bring smoke towards the measurement site. The $PM_{2.5}$ concentration on this day was elevated at 22.0 μgm^{-3} which could suggest detection of smoke from the fire.

Due to the small number of incidents, the measurements from 2018 were not examined in more detail.

Date	Fire
11/12/2018 00:57 to 11/12/2018 07:56	Primary Fire, Wasteland, Launders Lane

Table 2: Fires at Launders Lane in 2018, provided by London Fire Brigade

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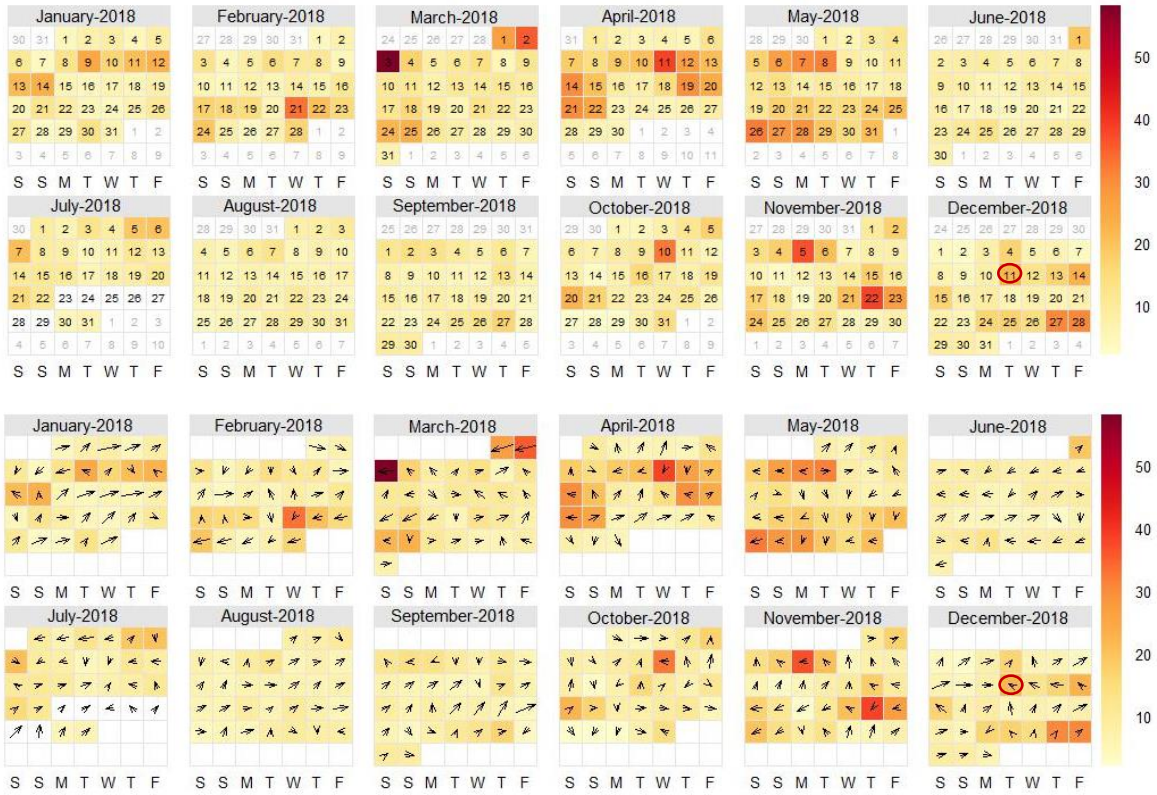

Figure 9: $PM_{2.5}$ daily mean concentrations at Rainham site during 2018. Top panel shows dates, bottom panel is annotated to show wind direction, with the length of the arrow scaled for wind speed. Dates when a fire was recorded at Launders Lane are circled. The plots were produced using the openair package in R [4,5]

2019

The analysis was repeated for 2019. Details of the fires recorded in the Launders Lane area by London Fire Brigade in 2019 are shown in Table 3. 16 days were affected by fires in 2018

Date	Fire
30/06/2019 15:08 to 30/06/2019 21:30	Primary Fire, Heathland, Launders Lane
02/07/2019 13:37 to 02/07/2019 13:37	Secondary Fire, Wasteland, Launders Lane
05/07/2019 13:18 to 11/07/2019 12:26	Primary Fire, Wasteland, Launders Lane
31/07/2019 14:31 to 31/07/2019 15:09	Secondary Fire, Scrub land, Launders Lane
12/08/2019 07:49 to 12/08/2019 08:35	Secondary Fire, Scrub land, Launders Lane
12/09/2019 07:56 to 12/09/2019 08:30	Secondary Fire, Scrub land, Launders Lane
16/09/2019 10:13 to 16/09/2019 11:02	Secondary Fire, Loose refuse, Launders Lane
07/10/2019 08:20 to 07/10/2019 14:48	Primary Fire, Grassland, pasture, grazing etc,

[4] Carslaw, D.C. and K. Ropkins, (2012). openair — an R package for air quality data analysis. Environmental Modelling & Software. Volume27-28,pp. 52–61.

[5] Carslaw, D.C. (2019). The openair manual — open-source tools for analysing air pollution data. Manual for version 2.6-6, University of York.

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27/10/2019 16:55 to 27/10/2019 20:57	Secondary Fire, Wasteland, Launders Lane
05/11/2019 23:27 to 05/11/2019 23:41	Secondary Fire, Scrub land, Launders Lane

Table 3: Fires at Launders Lane in 2019, provided by London Fire Brigade

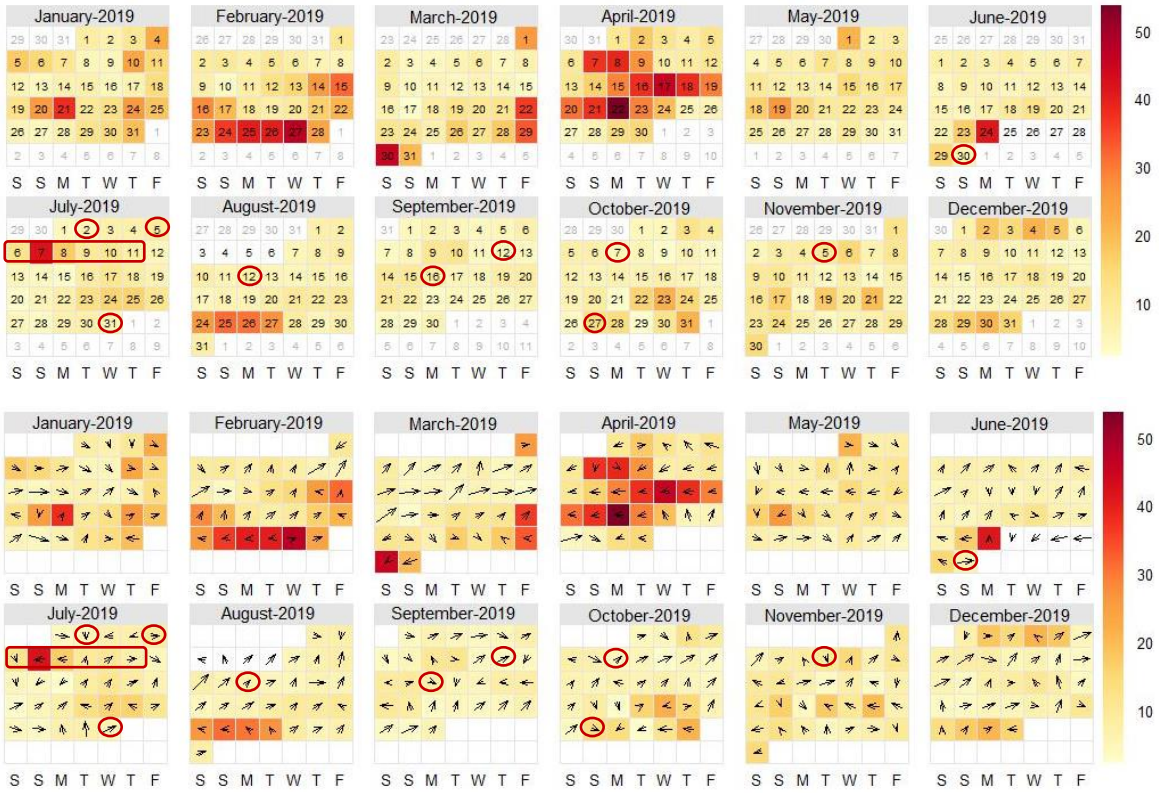

Figure 10: $PM_{2.5}$ daily mean concentrations at Rainham site during 2019. Top panel shows dates, bottom panel is annotated to show wind direction, with the length of the arrow scaled for wind speed. Dates when a fire was recorded at Launders Lane are circled.

Although there were considerably more fires recorded during 2019 than 2018, most of these occurred when the wind was not blowing from Launders Lane towards the measurement site. However, a large and sustained fire occurred over seven days in July, which was reported by BBC London News and by the London Fire Brigade[6,7]. It was reported as starting as a grass fire, then spreading to affect mixed waste and ten fire engines were needed to bring the fire under control. Diggers were used to turn over waste to expose and access deeper pockets of fire which caused a lot of smoke. Local residents were advised to keep their doors and windows closed to prevent smoke ingress. For most of the period, the wind was not blowing towards the measurement site but on 6th, 7th and 8th July, increased $PM_{2.5}$ concentrations were measured that were likely related to the fire.

[6] https://www.bbc.co.uk/news/uk-england-london-48908926

[7] https://www.london-fire.gov.uk/incidents/2019/july/grass-fire-rainham/

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Other fires recorded during 2019 did not have a noticeable effect on daily mean $PM_{2.5}$ concentrations, most likely due to wind direction.

Other periods during 2019 with increased $PM_{2.5}$ concentrations tended to relate to conditions that led to widespread pollution episodes that affected much of south-east England, such as in February, March, April and August. These are described in the episodes section of the Londonair website [8,9,10].

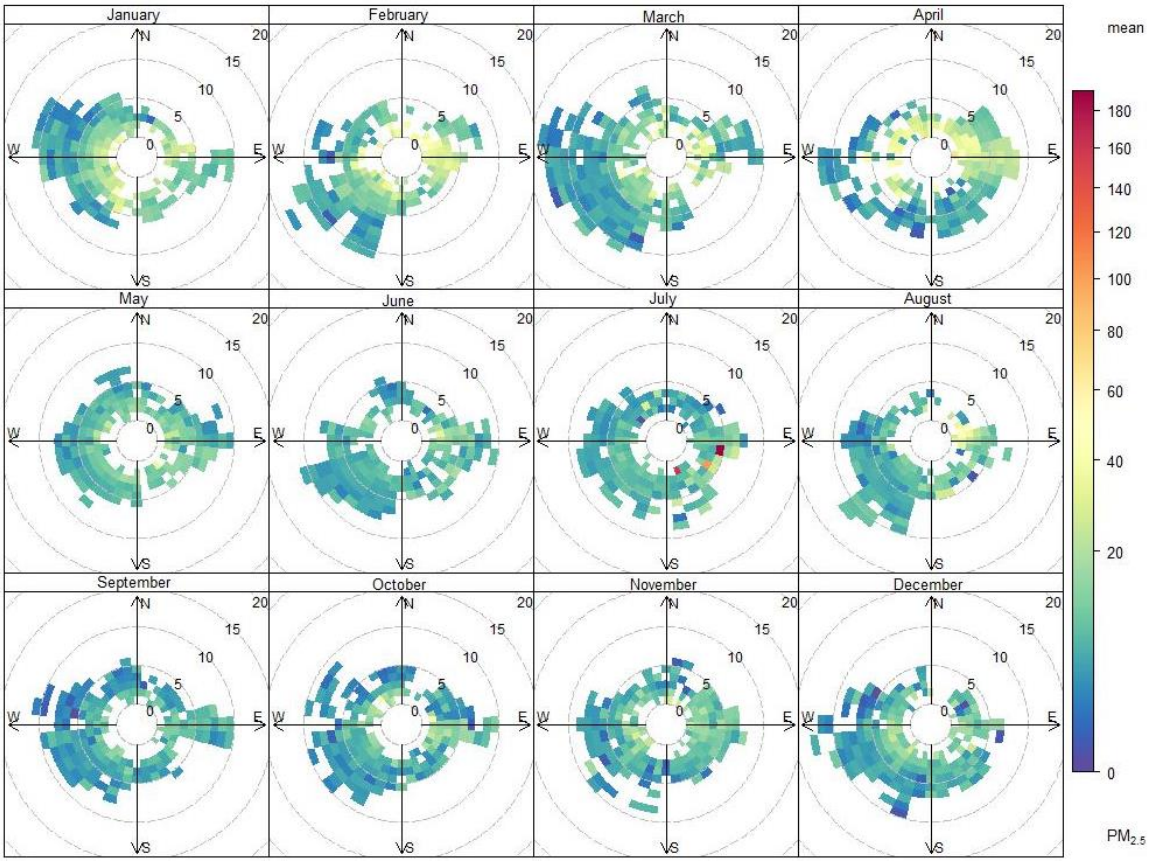

Figure 11: Polar frequency plots showing mean $PM_{2.5}$ concentrations by wind speed and direction and by month, during 2019.

8 https://www.londonair.org.uk/london/asp/PublicEpisodes.asp?species=All&region=0&site=&postcode=&la_id=&level=All&bulletindate=23%2F02%2F2019&MapType=Google&zoom=9&lat=51.4750&lon=-0.119824&VenueCode=&bulletin=explanation&episodeID=pm10pm25feb2519&cm-djitdk-djitdk=

9 https://www.londonair.org.uk/london/asp/PublicEpisodes.asp?region=0&site=&postcode=&la_id=&level=All&bulletindate=23%2F02%2F2019&MapType=Google&zoom=&lat=51.4750&lon=-0.119824&VenueCode=&bulletin=explanation&episodeID=pm10pm25modmarch2019&pageID=page1&cm-djitdk-djitdk=

10 https://www.londonair.org.uk/london/asp/PublicEpisodes.asp?region=0&site=&postcode=&la_id=&level=All&bulletindate=29%2F03%2F2019&MapType=Google&zoom=&lat=51.4750&lon=-0.119824&VenueCode=&bulletin=explanation&episodeID=pm10pm25modhighapril2019&pageID=page1&cm-djitdk-djitdk=

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Figure 11 shows the mean hourly $PM_{2.5}$ concentrations aggregated by wind speed and direction. The increased concentrations during July are evident. These plots are based on hourly wind data which shows a closer correlation with the direction of the measurement site from Launders Lane compared with the calendar plots which show daily mean concentrations. Hourly $PM_{2.5}$ concentrations during the July event were greater than those seen during the pollution episodes during February, March, April and August. These episodes can be observed in Figure 11 by a larger number of points with raised mean concentrations but lower than those in July. This suggests that fires may be detected by looking for a higher concentration but more short-lived pollution signal.

An absence of winds from the east and south-east during June, August, September and October when other fires occurred mean that it was unlikely the smoke would have been detected at the measurement site. Winds from these directions did occur more frequently in November but not at the same time as the fire on the 5th.

Time series plots of $PM_{2.5}$ are shown in Figure 12 and Figure 13. Figure 12 shows measurements from the whole of 2019. Measurements from Slade Green reference site in the London Borough of Bexley are shown for comparison. The July fire caused a large spike on 7th July when the greatest 6 hour mean concentration for the year was measured at 139 μgm^{-3}. The daily mean concentration was 42 μgm^{-3} which exceeds the 'moderate' threshold of the Daily Air Quality Index[11]. This would cause significant exposure for local residents. However, the shorter duration of this event can again be seen when compared with the lower but longer duration pollution episodes in March and April. The close agreement with measurements from Slade Green during these periods indicates the more widespread nature of these events.

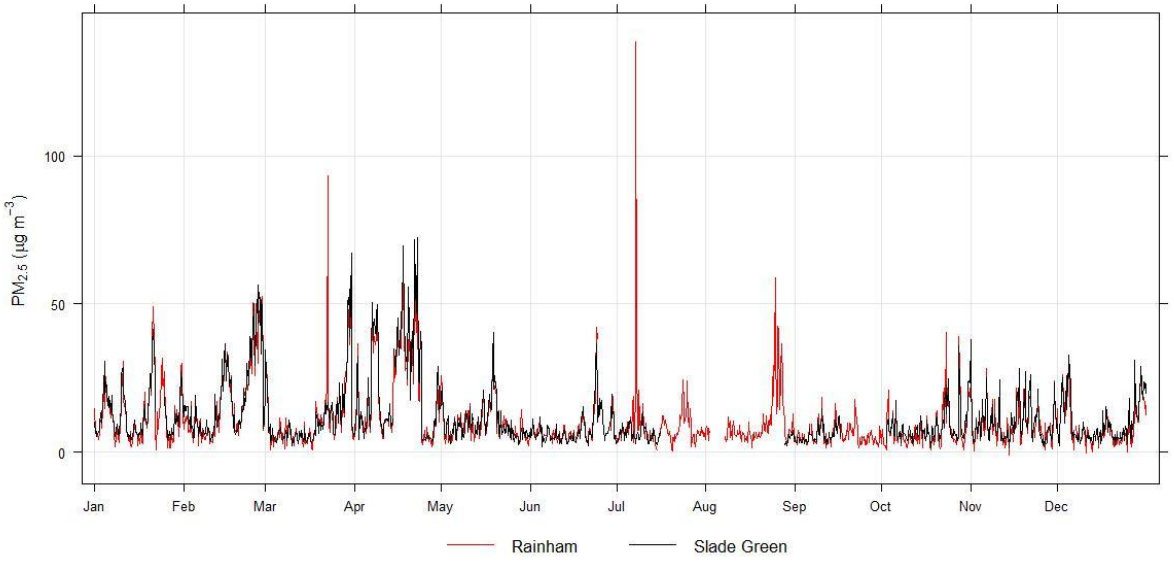

Figure 12: Time series plot of $PM_{2.5}$ in 2019. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison. Measurements are aggregated to six hourly means.

[11] https://www.londonair.org.uk/london/asp/airpollutionindex.asp

A more detailed view of the July event is shown in Figure 13. The greatest hourly mean concentration reached 370 µgm^{-3}. Four hours recorded concentrations over 100 µgm^{-3}. Smaller pollution spikes can be seen late on 6th and 8th July, either side of the largest spike on the evening of 7th July. The localised nature of this event is clear from the comparison with measurements from Slade Green where $PM_{2.5}$ concentrations remained low for the duration of the event.

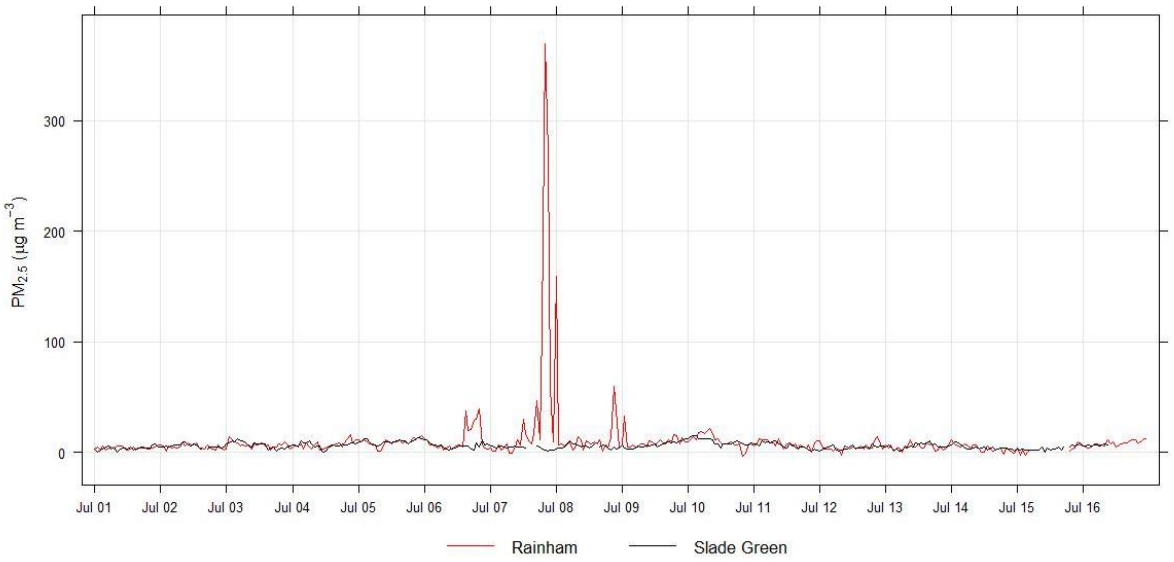

Figure 13: Time series plot of hourly mean $PM_{2.5}$ in July 2019. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison.

2020

Details of the fires recorded in the Launders Lane area by London Fire Brigade in 2020 are shown in Table 4. 18 days were affected by fires in 2020.

Date	Fire
23/04/2020 13:02 to 23/04/2020 17:01	Primary Fire, Scrub land, Launders Lane
06/08/2020 05:31 to 11/08/2020 13:03	Primary and Secondary Fire, Wasteland, tree scrub, Launders Lane
16/08/2020 20:17 to 17/08/2020 07:09	Secondary Fire, Heathland, Landfill site, Launders Lane
02/09/2020 06:25 to 02/09/2020 06:49	Secondary Fire, Landfill site, Launders Lane
07/09/2020 17:20 to 07/09/2020 17:25	Secondary Fire, Landfill site, Launders Lane
09/09/2020 19:38 to 09/09/2020 20:18	Secondary Fire, Landfill site, Launders Lane
11/09/2020 07:17 to 11/09/2020 11:23	Primary Fire, Landfill site, Launders Lane
21/09/2020 20:47 to 22/09/2020 09:39	Secondary Fire, Landfill site, Launders Lane
29/09/2020 19:40 to 30/09/2020 08:02	Secondary Fire, Scrub land, Launders Lane
16/10/2020 08:41 to 16/10/2020 09:31	Secondary Fire, Waste land, Launders Lane

Table 4: Fires at Launders Lane in 2020, provided by London Fire Brigade

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Calendar plots of daily mean $PM_{2.5}$ concentrations in 2020 are shown in Figure 14. Fires at Launders Lane occurred on eight days in August and some of these days measured increased concentrations of $PM_{2.5}$. The wind direction was from the east for much of this period which could bring smoke towards the measurement site. However, increased pollution concentrations were widespread at this time due to a pollution episode during hot weather[12]. Seven days in September were affected by fires at Launders Lane and slightly increased daily mean $PM_{2.5}$ concentrations were measured on some of these days. However, the wind direction was not towards the measurement site for most of these days.

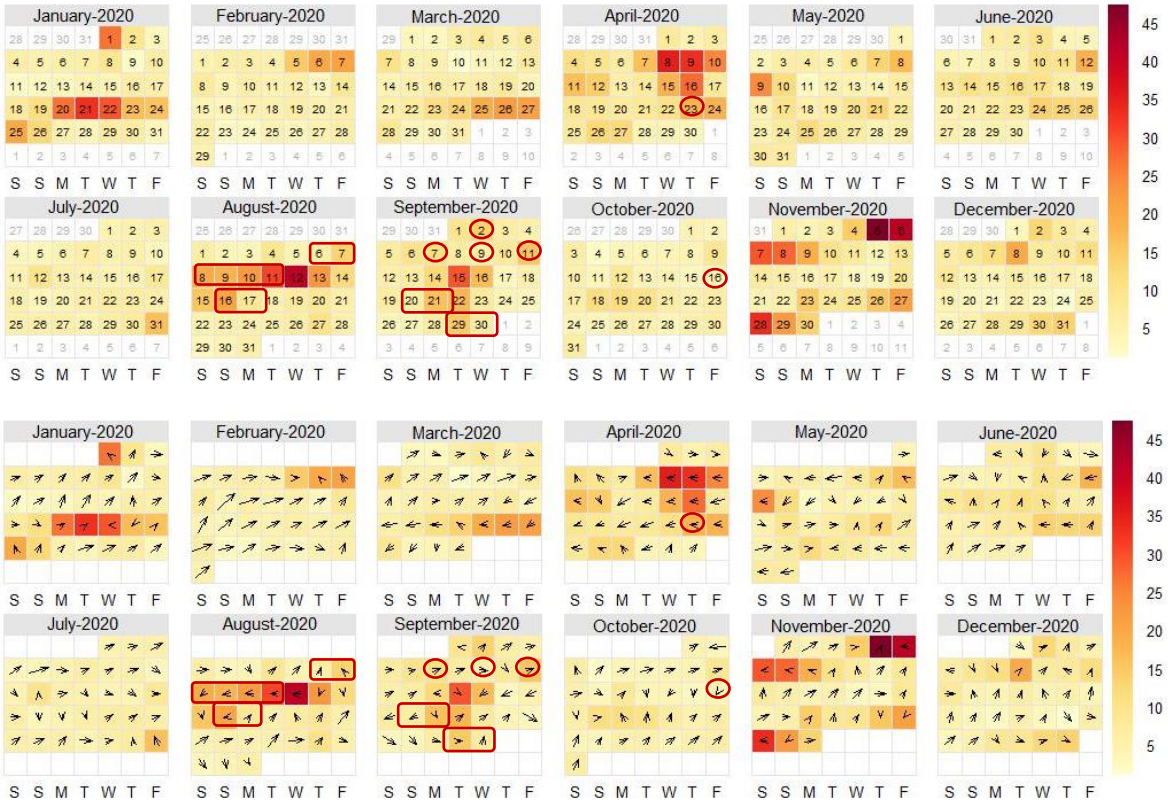

Figure 14: $PM_{2.5}$ daily mean concentrations at Rainham site during 2020. Top panel shows dates, bottom panel is annotated to show wind direction, with the length of the arrow scaled for wind speed. Dates when a fire was recorded at Launders Lane are circled.

The polar frequency plots in Figure 15 show increased $PM_{2.5}$ concentrations with wind from the south-east in several months, including those with and without recorded fire events at Launders Lane. Some of these elevated concentrations may relate to the fires but this also highlights a difficulty with distinguishing the signal from the fires from other sources at this location: south-easterly winds often bring pollution to south-east England from the continent and this is a common cause of

12 https://www.londonair.org.uk/london/asp/publicepisodes.asp?species=All&region=0&site=&postcode=&la_id=&level=All&bulletindate=07%2F08%2F2020&MapType=Google&zoom=9&lat=51.4750&lon=-0.119824&VenueCode=&bulletin=explanation&episodeID=o3pm10August2020&cm-djitdk-djitdk=

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increased $PM_{2.5}$ concentrations and the locations of additional monitoring should take this into account to enable the separation of the signal from the fires from other sources.

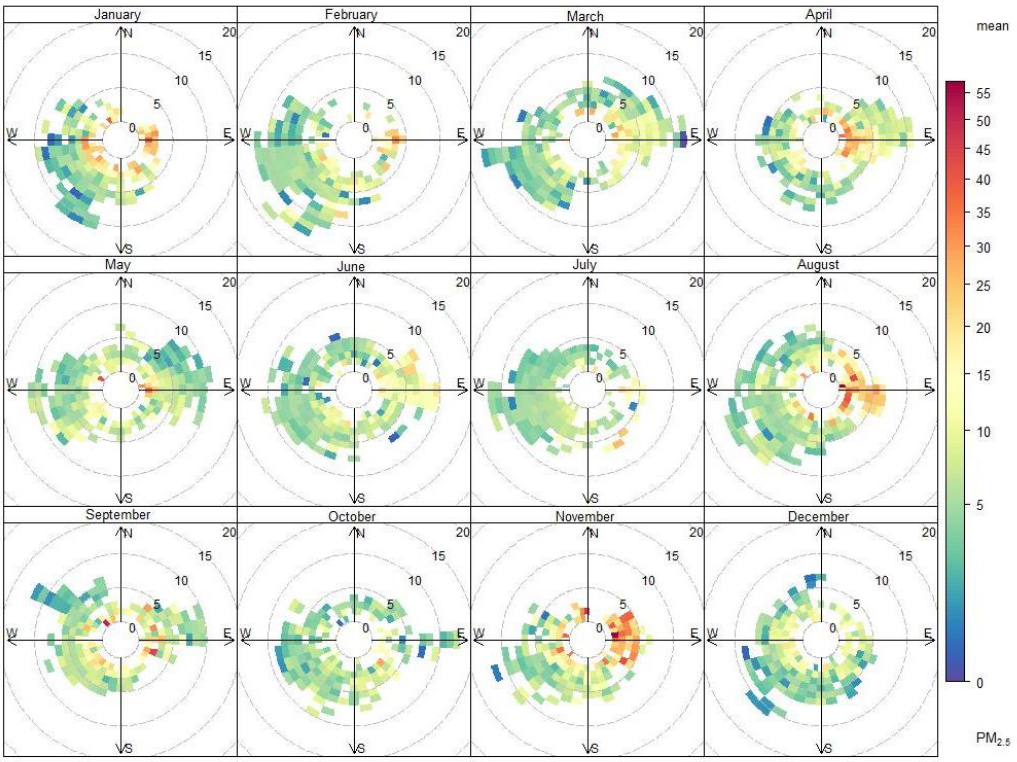

Figure 15: Polar frequency plots showing mean $PM_{2.5}$ concentrations by wind speed and direction and by month, during 2020.

The time series plots in Figure 16, Figure 17 and Figure 18 can help to distinguish local from widespread pollution events by comparing $PM_{2.5}$ concentrations at Rainham with concentrations at Slade Green.

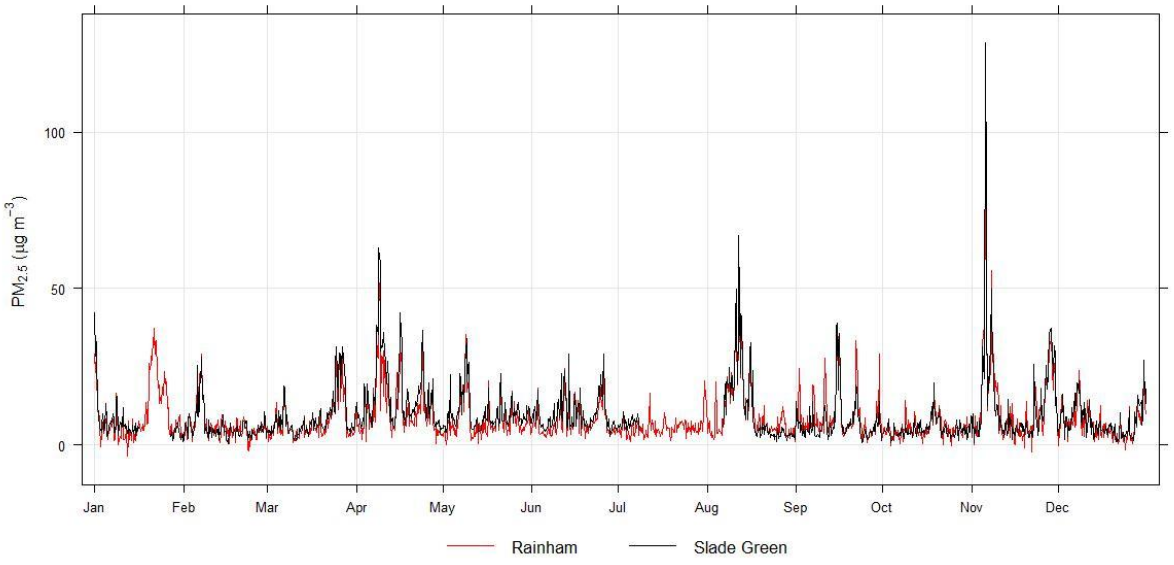

Figure 16: Time series plot of $PM_{2.5}$ in 2020. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison. Measurements are aggregated to a six hourly means.

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The annual time series in Figure 16 shows that in many cases, $PM_{2.5}$ concentrations at Slade Green in 2020 were elevated at the same time as $PM_{2.5}$ concentrations at Rainham. A closer examination of concentrations in August suggests that increased $PM_{2.5}$ concentrations were mostly related to widespread pollution events, such as the episode described above, rather than to the fires that occurred from 6th to 11th August and 16th to 17th August. Later in August, $PM_{2.5}$ concentrations at Rainham tended to be slightly higher than at Slade Green although no fires were recorded during this time. Therefore, this is likely to be due to a different local source, an unreported fire event or smouldering at the former landfill site.

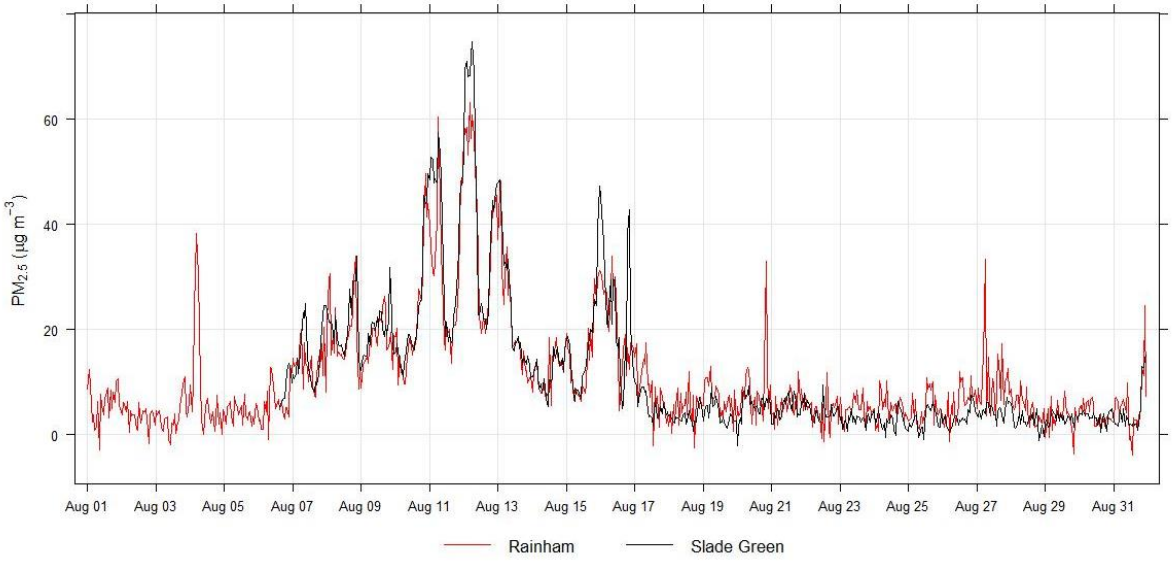

Figure 17: Time series plot of hourly mean $PM_{2.5}$ in August 2020. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison.

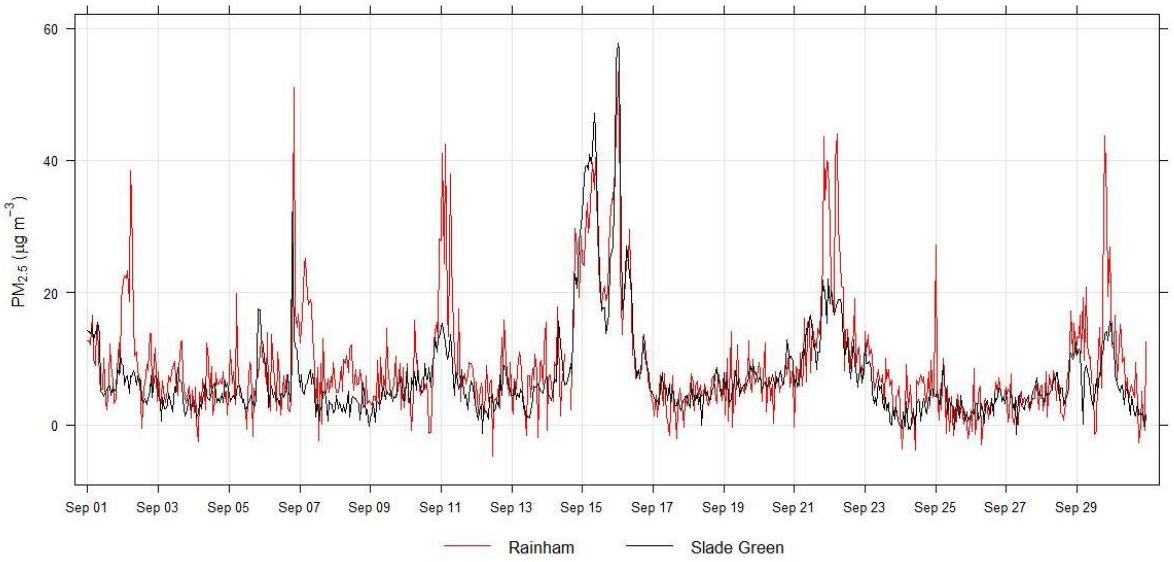

Figure 18: Time series plot of hourly mean $PM_{2.5}$ in September 2020. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison.

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In September 2020, some of the days when fires occurred had increased $PM_{2.5}$ concentrations at Rainham that were not measured at Slade Green. Although the wind direction plotted in Figure 14 did not appear conducive to bringing smoke from Launders Lane to the Rainham measurement site, the wind speed was low which could allow spreading of the plume or short-term or local variations in wind direction. This could result in smoke detection at the measurement site. The $PM_{2.5}$ concentration spikes were lower than those seen in July 2019, with maximum hourly concentrations around 40-50 μgm^{-3}. Again, the spikes are short-lived compared to the longer pollution episodes seen in August in Figure 17.

2021

Details of the fires recorded in the Launders Lane area by London Fire Brigade in 2021 are shown in Table 5. 14 days were affected by fires in 2021.

Date	Fire
27/05/2021 06:15 to 27/05/2021 18:06	Secondary Fire, Landfill site, Scrub land, Launders Lane
29/05/2021 13:59 to 29/05/2021 15:03	Secondary Fire, Landfill site, Launders Lane
31/05/2021 23:40 to 02/06/2021 12:49	Primary Fire, Scrub land, Launders Lane
04/06/2021 07:42 to 04/06/2021 09:02	Secondary Fire, Landfill site, Launders Lane
12/10/2021 06:26 to 12/10/2021 13:57	Secondary Fire, Landfill site, Scrub land, Launders Lane
13/10/2021 06:17 to 13/10/2021 15:48	Secondary Fire, Landfill site, Scrub land, Launders Lane
14/10/2021 11:18 to 14/10/2021 13:19	Secondary Fire, Scrub land, Launders Lane
16/10/2021 07:09 to 16/10/2021 11:57	Primary Fire, Landfill site, Launders Lane
17/10/2021 21:53 to 17/10/2021 22:53	Secondary Fire, Waste land, Launders Lane
18/12/2021 04:12 to 18/12/2021 23:06	Secondary Fire, Waste land, Launders Lane
25/12/2021 21:50 to 25/12/2021 22:05	Secondary Fire, Waste land, Launders Lane
26/12/2021 15:26 to 26/12/2021 16:25	Secondary Fire, Landfill site, Launders Lane

Table 5: Fires at Launders Lane in 2021, provided by London Fire Brigade

Calendar plots of daily mean $PM_{2.5}$ concentrations in 2020 are shown in Figure 19. Unfortunately, a fault with the monitor from 10th October 2021 to 4th January 2022 means that measurements are not available for this period. Several of the fires recorded in 2021 occurring in October and December so it was not possible to detect these in the air quality measurements. In May and June 2021 some days when fires occurred had increased concentrations of $PM_{2.5}$ and the wind direction was from the east. This may indicate some detection of smoke from the fires which will be examined further in subsequent plots.

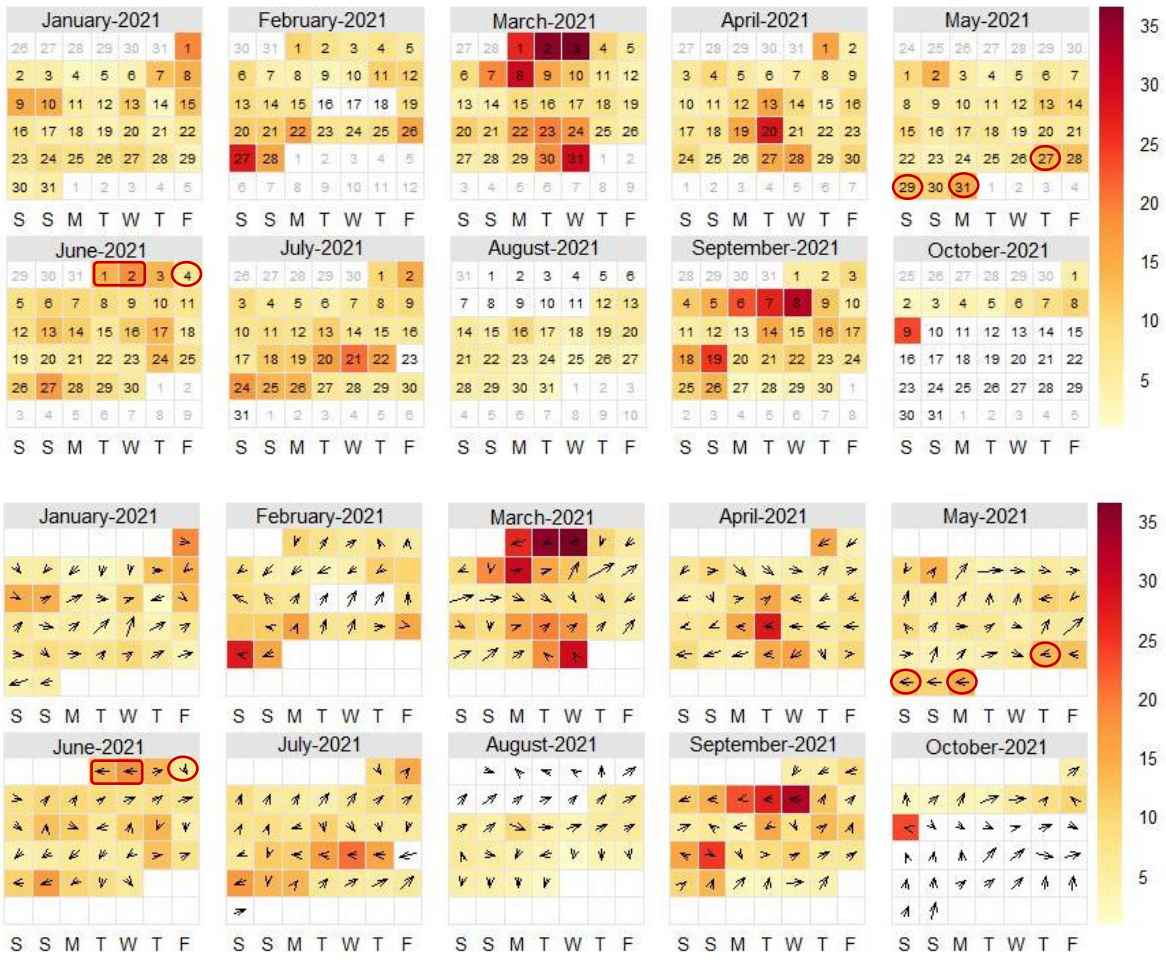

Figure 19: $PM_{2.5}$ daily mean concentrations at Rainham site during 2021. Top panel shows dates, bottom panel is annotated to show wind direction, with the length of the arrow scaled for wind speed. Dates when a fire was recorded at Launders Lane are circled.

Figure 20 shows that there was relatively small amount of measurements when wind direction was from the south-east. Some of these points on the polar frequency plots do have elevated $PM_{2.5}$ concentrations which could relate to the fires. Although some elevated $PM_{2.5}$ concentrations occurred in early October when the wind was from the south-east, the first recorded fire was not until 12th October so these are unlikely to relate to fires at Launders Lane.

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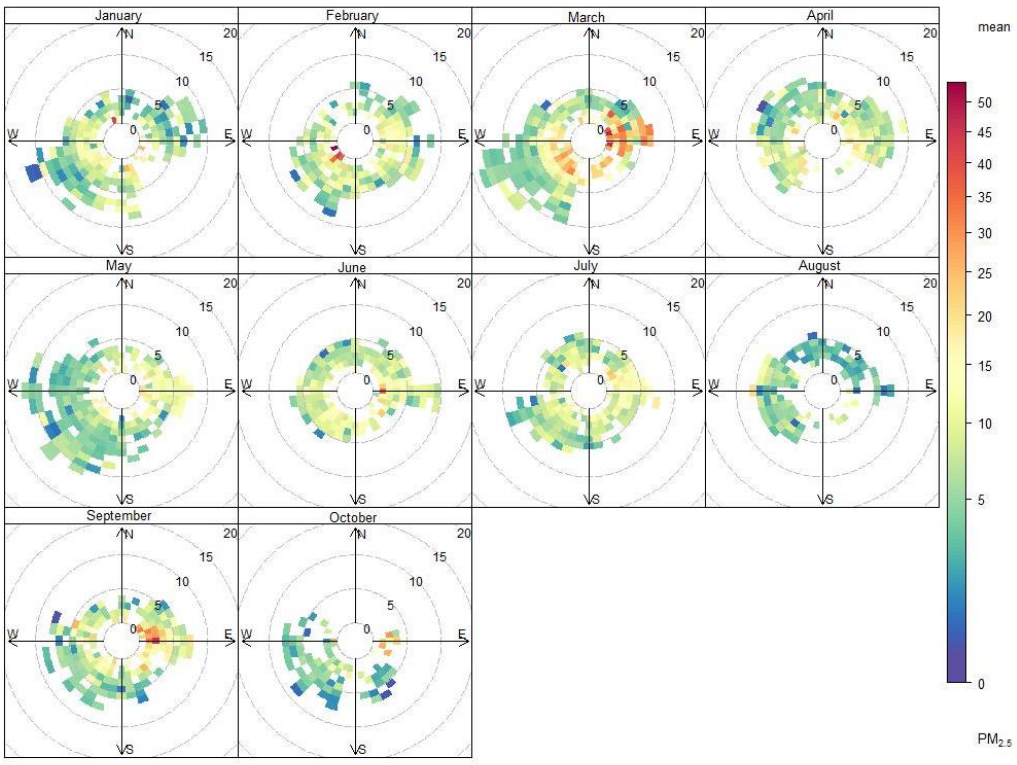

Figure 20: Polar frequency plots showing mean $PM_{2.5}$ concentrations by wind speed and direction and by month, during 2021.

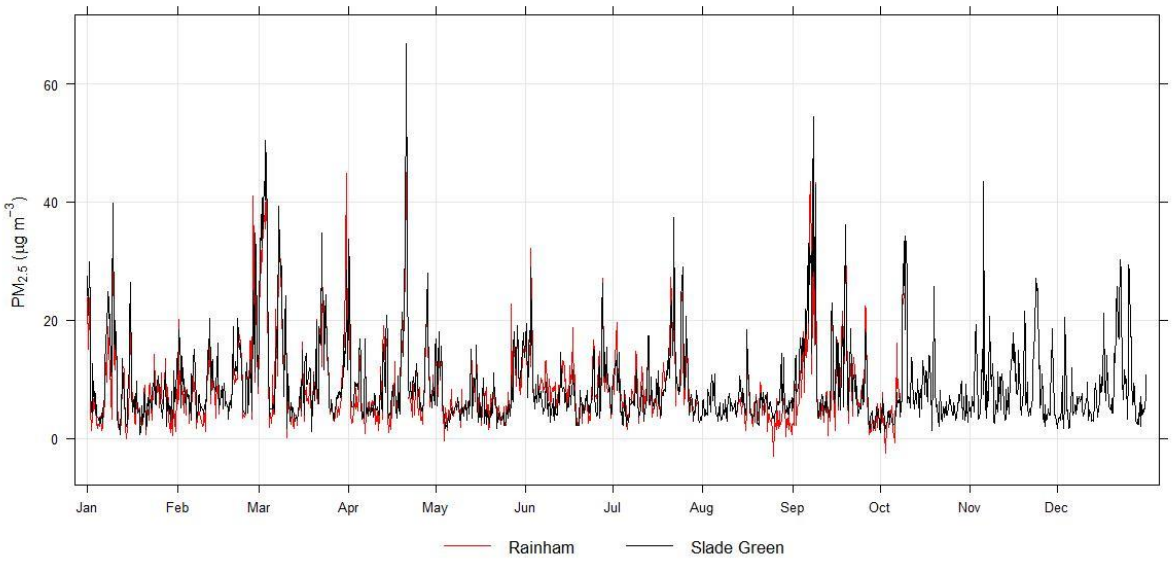

Figure 21: Time series plot of $PM_{2.5}$ in 2021. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison. Measurements are aggregated to a six hourly means.

The time series plot of the full year for 2021 in Figure 21 shows a few occasions when $PM_{2.5}$ concentrations were higher at Rainham than Slade Green. The main period with air quality data available when fires occurred in 2021 was May to June. A time series covering this period is shown in Figure 22. The spike in $PM_{2.5}$ concentrations on 27th May at Rainham that did not occur at Slade Green

coincides with a fire incident at Launders Lane. This day had light winds so it is possible that smoke drifted towards the measurement site. On 1st to 2nd June another small spike occurred at Rainham but not at Slade Green. A larger spike occurred at Rainham at the end of the day on 2nd June but a similar concentration increase was seen at Slade Green. The increased concentrations that may be a result of the fires at Launders Lane were relatively small and short-lived. For the remainder of the period shown in the time series, $PM_{2.5}$ concentrations were slightly increased compared to Slade Green but there were no fires recorded at this time. This could indicate a different local source or unrecorded fires. However, overall concentrations during this period were relatively low.

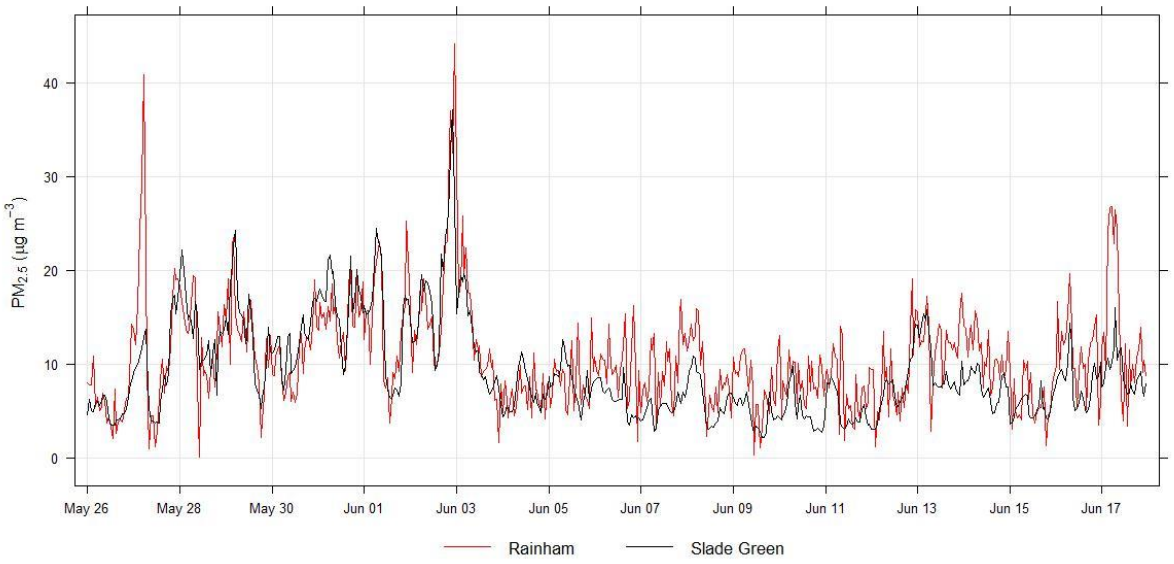

Figure 22: Time series plot of hourly mean $PM_{2.5}$ in May to June 2021. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison.

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2022

Details of the fires recorded in the Launders Lane area by London Fire Brigade in 2022 are shown in Table 6. This year had the greatest number of fires compared during the analysis period. 37 days were affected by fires at Launders Lane during 2022. There was also a major fire in the area on 19th July 2022 during a prolonged heat-wave when the UK's maximum temperature to date was measured. This fire occurred in Wennington and did not affect the Launders Lane site. Smoke from this fire was detected at the Rainham measurement site. This period of very hot weather may also have increased the risk of fires at the Arnolds Field site.

Date	Fire
17/04/2022 19:25 to 22/04/2022 19:35	Primary Fire, Secondary Fire, Landfill site, Wasteland, Heathland, Launders Lane
24/04/2022 20:11 to 24/04/2022 20:56	Secondary Fire, Landfill site, Launders Lane
27/04/2022 02:36 to 27/04/2022 03:04	Secondary Fire, Landfill site, Launders Lane
05/05/2022 15:30 to 06/05/2022 06:31	Primary Fire, Secondary Fire, Landfill site, Launders Lane
09/05/2022 13:19 to 09/05/2022 13:47	Secondary Fire, Landfill site, Launders Lane
04/06/2022 13:03 to 04/06/2022 14:22	Primary Fire, Landfill site, Launders Lane
07/06/2022 17:31 to 07/06/2022 19:38	Secondary Fire, Landfill site, Launders Lane
11/06/2022 12:44 to 11/06/2022 13:52	Secondary Fire, Landfill site, Launders Lane
15/06/2022 04:36 to 15/06/2022 05:24	Secondary Fire, Landfill site, Launders Lane
19/06/2022 16:55 to 21/06/2022 22:32	Primary Fire, Secondary Fire, Landfill site, Scrub land, Launders Lane
25/06/2022 19:10 to 28/06/2022 00:36	Secondary Fire, Landfill site, Scrub land, Launders Lane
30/06/2022 07:24 to 01/07/2022 11:42	Secondary Fire, Landfill site, Launders Lane
05/07/2022 21:32 to 10/07/2022 06:55	Primary Fire, Secondary Fire, Landfill site, Heathland, Launders Lane
14/07/2022 04:54 to 14/07/2022 05:28	Secondary Fire, Landfill site, Launders Lane
16/07/2022 17:39 to 18/07/2022 21:46	Secondary Fire, Landfill site, Scrub land, Launders Lane
26/07/2022 07:06 to 26/07/2022 13:31	Secondary Fire, Landfill site, Launders Lane
06/08/2022 20:38 to 06/08/2022 20:57	Secondary Fire, Wasteland, Launders Lane
08/08/2022 13:32 to 08/08/2022 16:31	Primary Fire, Wasteland, Launders Lane

Table 6: Fires at Launders Lane in 2022, provided by London Fire Brigade

Daily mean $PM_{2.5}$ concentrations during 2022 are shown in Figure 23. The first fires of 2022 occurred between 17th and 27th April. Although some increased $PM_{2.5}$ concentrations occurred at this time, the wind was mostly from the north-east during this period so this may not be due to the fires. The polar frequency plot in Figure 24 shows that there was very little wind from the south-east in April. The calendar plots indicate the possibility of smoke being detected at the measurement site on some days in June and July when the wind was blowing from approximate direction of Launders Lane. These are investigated further in the time series plots that follow.

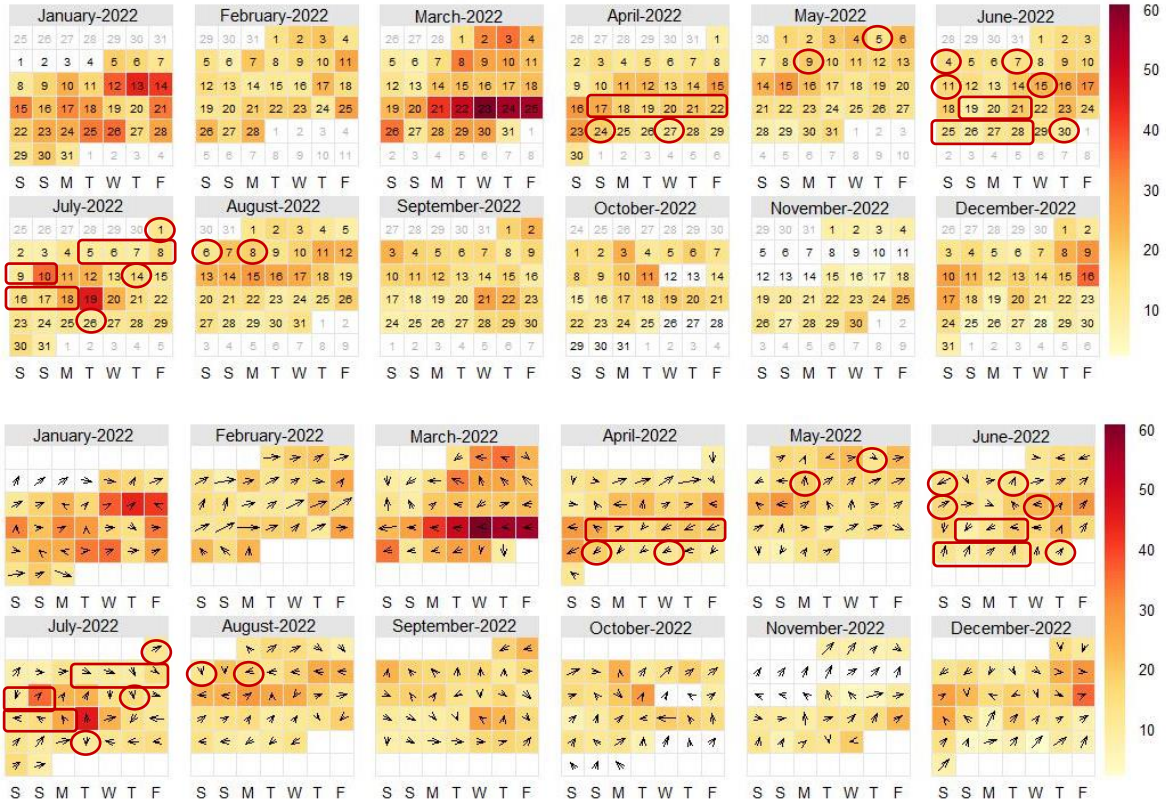

Figure 23: $PM_{2.5}$ daily mean concentrations at Rainham site during 2022. Top panel shows dates, bottom panel is annotated to show wind direction, with the length of the arrow scaled for wind speed. Dates when a fire was recorded at Launders Lane are circled.

The polar frequency plots in Figure 24 show increased $PM_{2.5}$ concentrations with south-easterly winds in July. However, these could relate to the Wennington fire so further examination is necessary.

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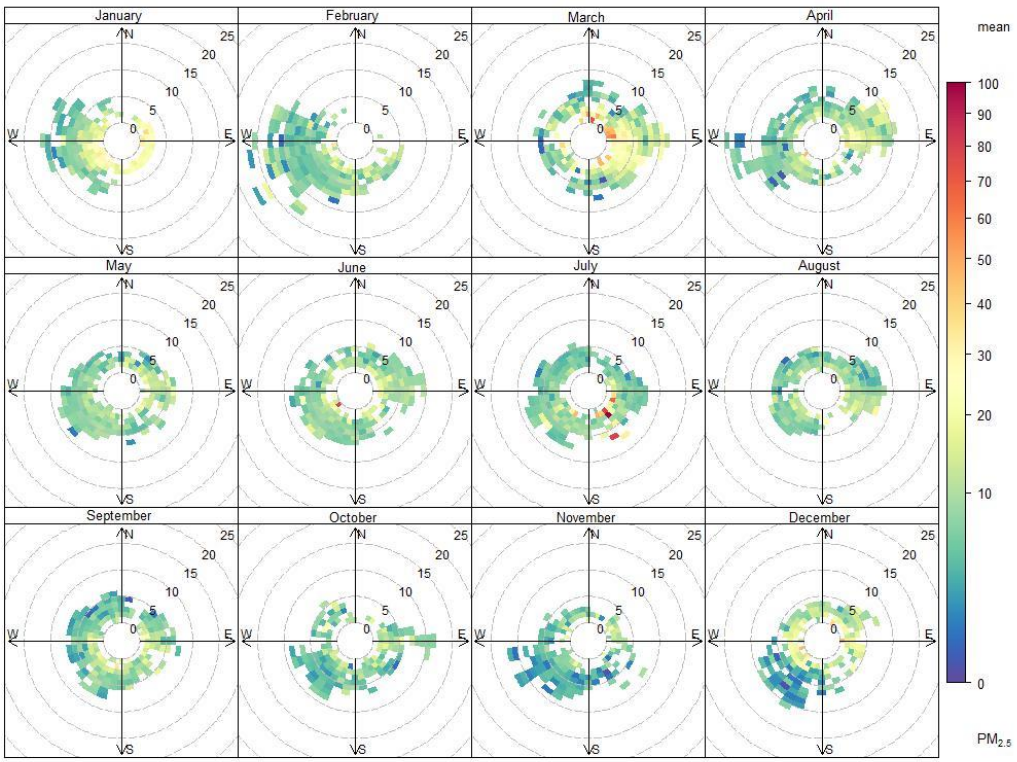

Figure 24: Polar frequency plots showing mean $PM_{2.5}$ concentrations by wind speed and direction and by month, during 2022.

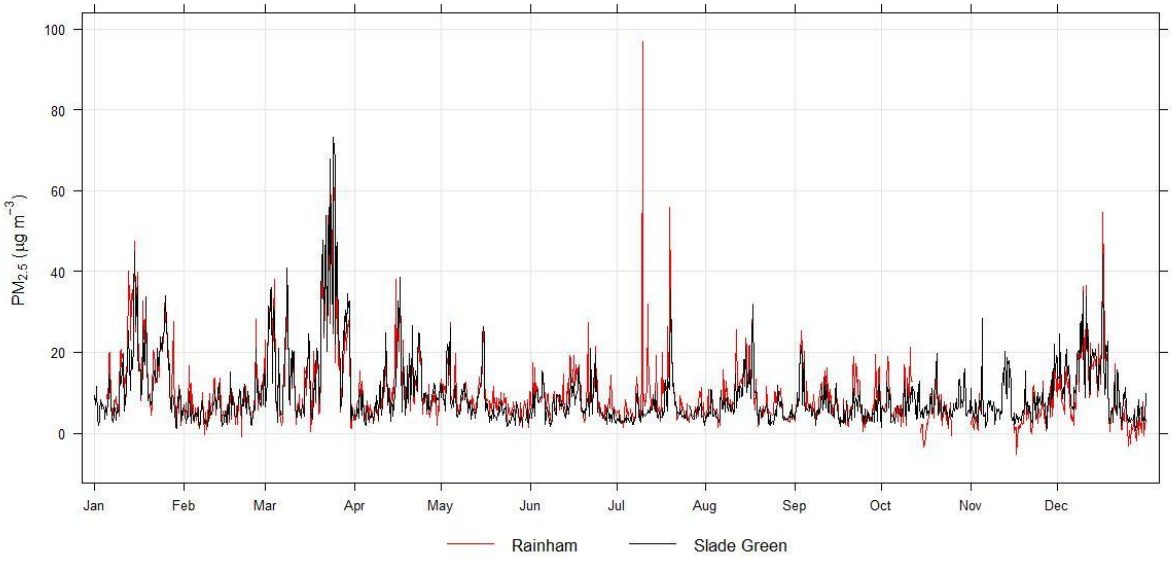

Figure 25: Time series plot of $PM_{2.5}$ in 2022. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison. Measurements are aggregated to a six hourly means.

The time series plot for 2022 in Figure 25 shows increased $PM_{2.5}$ concentrations at Rainham compared with Slade Green for much of June and July. This is also the case in August and September although few fires were recorded at Launders Lane during this period.

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A more detailed view of $PM_{2.5}$ concentrations covering the period when fires occurred in April 2022 is shown in Figure 26. There is little indication that smoke from fires at Launders Lane affected the $PM_{2.5}$ concentrations during this period as there was little difference compared with $PM_{2.5}$ concentrations at Slade Green. Any increased concentrations are more likely due to more widespread meteorological and pollution conditions.

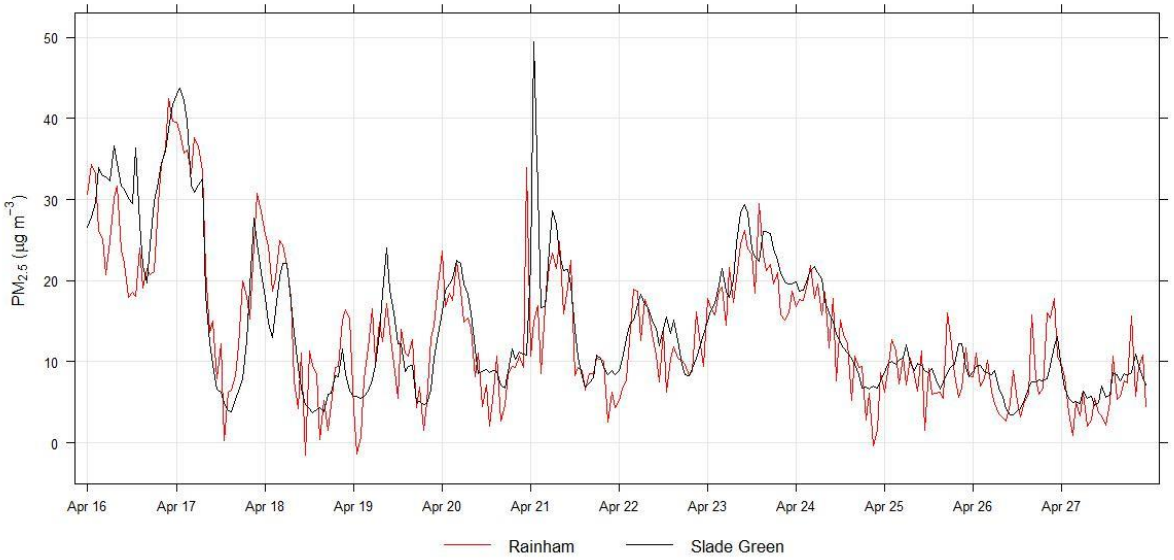

Figure 26: Time series plot of hourly mean $PM_{2.5}$ in April 2022. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison.

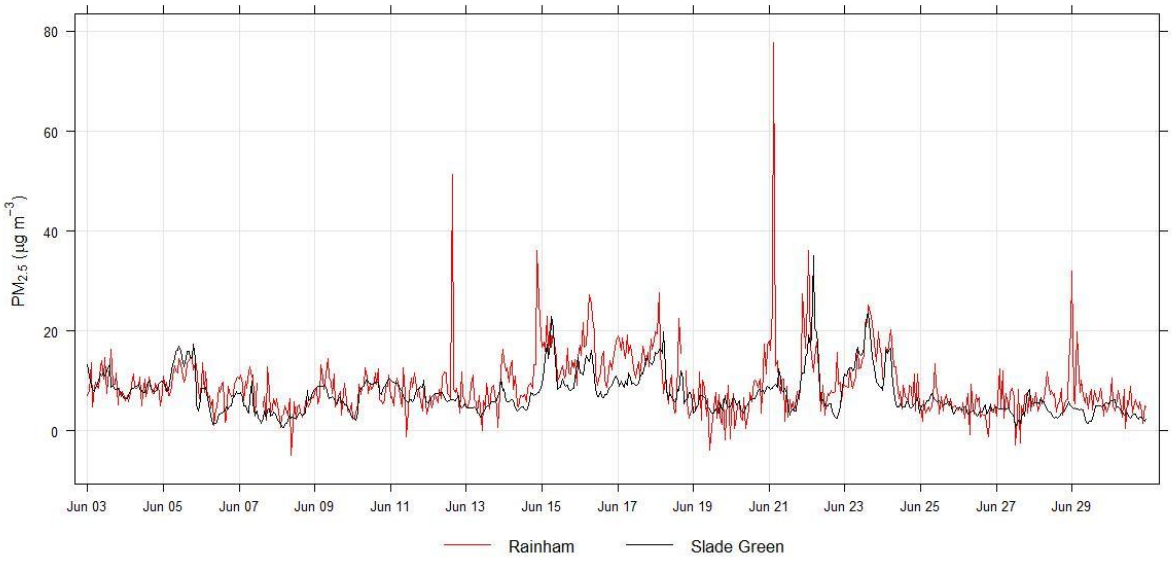

Figure 27: Time series plot of hourly mean $PM_{2.5}$ in June 2022. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison.

Figure 27 shows the $PM_{2.5}$ concentrations at Rainham and Slade Green during June 2022. During this period there were times when $PM_{2.5}$ concentrations at Rainham were greater than those at Slade Green. There are also some relatively large short-lived spikes similar to the signal previously considered to be a result of the fires at Launders Lane. The maximum hourly concentration was on

21st June was 77.7 µgm^{-3}. At this time, the wind direction went from east to south and the wind speed was low (1 ms^{-1}) which could have allowed smoke to accumulate in the area.

The time series for July 2022 is shown in Figure 28. Several $PM_{2.5}$ spikes occurred at Rainham that were not measured at Slade Green. The greatest hourly mean concentration was measured on 10th July at 169 µgm^{-3}. Although the daily average wind direction was south-westerly as seen on the calendar plot, Figure 23, the wind direction when this $PM_{2.5}$ spike occurred was south-easterly with wind speed around 2 ms^{-1} which suggests a high possibility that this relates to the fires recorded at Launders Lane. Another spike occurred late on 11th July when wind was from the south-east. The fire brigade records on this date are not clear. There are two incidents recorded as false alarms at this time although the description mentions smoke issuing at the landfill site. Further $PM_{2.5}$ spikes similar to the signal previously associated with fires at Launders Lane were seen at Rainham on 14th, 16th, 17th and 18th July when fires. The longer $PM_{2.5}$ increase measured at Rainham and Slade Green on 19th to 20th July likely relates to the Wennington fire caused by the heat-wave.

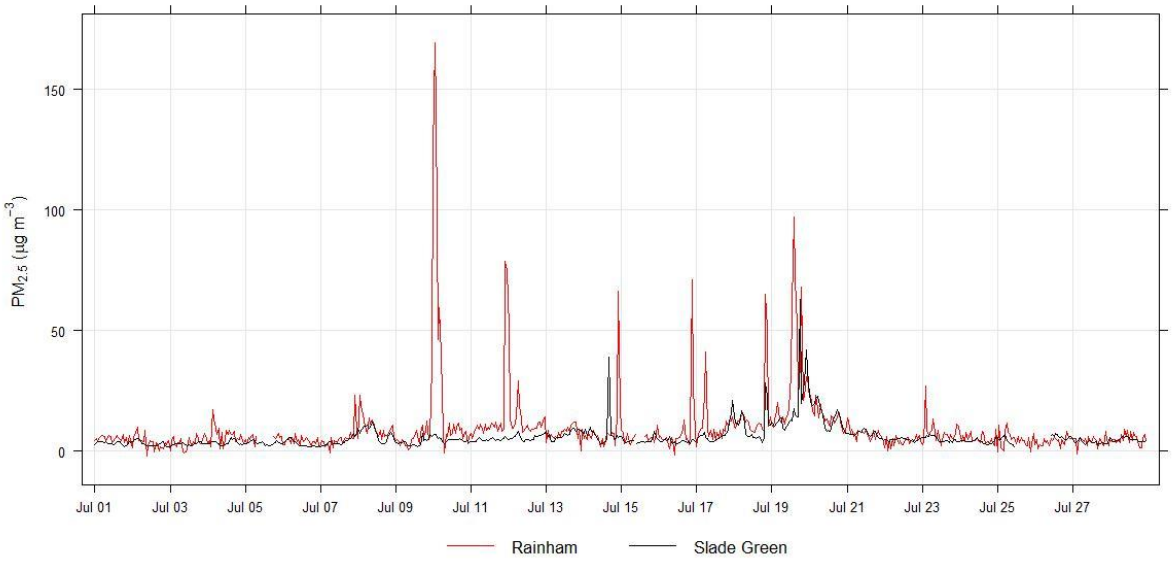

Figure 28: Time series plot of hourly mean $PM_{2.5}$ in July 2022. The red line shows measurements from Rainham and the black line shows measurements from Slade Green in Bexley for comparison.

Other pollutants

Measurements of other pollutants at the Rainham site were examined for evidence of detection of smoke from fires at Launders Lane. The results for PM_{10} were very similar to those seen for $PM_{2.5}$ since a large proportion of the PM from smoke tends to be in the $PM_{2.5}$ size fraction. However, one of the $PM_{2.5}$ spikes examined previously that occurred on 7th July 2019 did correspond with an exceedance of the PM_{10} daily mean objective of 50 µgm^{-3} which should not be exceeded more than 35 times a year. This is the same as the 'moderate' threshold of the Daily Air Quality Index[13] which was also exceeded for $PM_{2.5}$. There is no daily mean objective for $PM_{2.5}$. The corresponding PM_{10} daily

[13] https://www.londonair.org.uk/london/asp/airpollutionindex.asp

mean concentration at Slade Green was 10 μgm^{-3} which suggests that the fires added around 40 μgm^{-3} of PM_{10} to expected local pollution concentrations over the course of the day.

An example plot of PM_{10} concentrations alongside $PM_{2.5}$ concentrations at Rainham is show in Figure 29. This analysis was not repeated for all periods as it did not add to the evidence already provided by the $PM_{2.5}$ analysis.

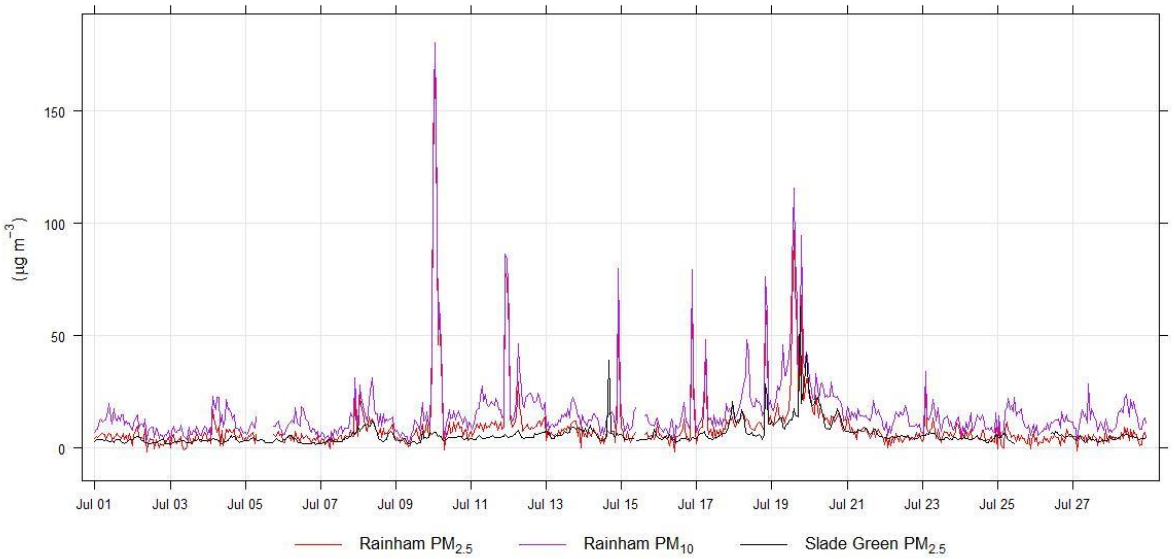

Figure 29: Time series plot of hourly mean $PM_{2.5}$ and PM_{10} in July 2022. The red line shows $PM_{2.5}$ measurements from Rainham, the purple line shows PM_{10} measurements from Rainham and the black line shows $PM_{2.5}$ measurements from Slade Green in Bexley for comparison.

Pollutant ratios, such as PM_{10}:$PM_{2.5}$ ratio and $PM_{2.5}$:NOx ratio were examined to look for a possible signal from the fires at Launders Lane. A consistent result was not found and therefore this method did not improve the evidence for detection of the fires at the Rainham site.

The $PM_{2.5}$:Nox ratio may be expected to be increased for smoke from the fires compared to other sources such as traffic. Therefore, this technique still has the potential to be used for analysis once further measurements are available from targeted measurements in the second stage of the air quality monitoring.

4.2.2 Breathe London measurements

The majority of Havering's Breathe London sites do not have measurements available for the period covering the Fire Brigade records received to date. Therefore, it is not possible to use these to look for evidence of smoke from known fires at Launders Lane. However, the node co-located at the reference site at Rainham was installed in February 2021. These measurements were compared to the measurements from the reference $PM_{2.5}$ instrument for periods when a possible signal was detected from the fires. The main periods since February 2021 when smoke from the Launders Lane fires may have been detected occurred in June and July 2022. Time series plots are shown in Figure 30 and Figure 31. These show that there is a good match between the reference and Breathe London

measurements so Breathe London measurements are appropriate for analysis of the potential impact of the Launders Lane fires.

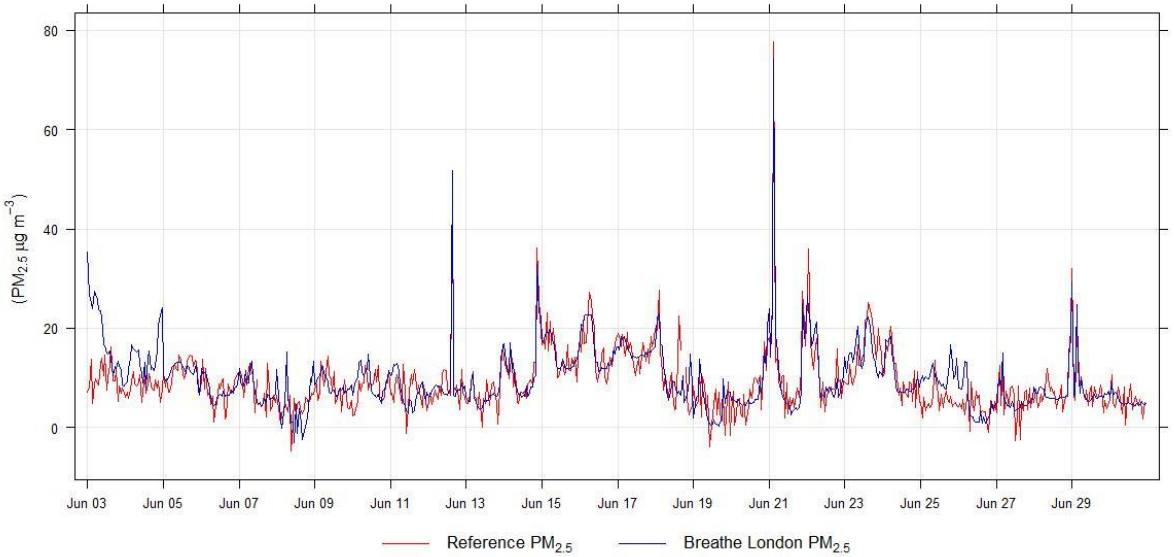

Figure 30: Time series plot of hourly mean $PM_{2.5}$ in June 2022. The red line shows measurements from the Rainham reference $PM_{2.5}$ monitor and the blue line shows $PM_{2.5}$ measurements from the Breathe London node.

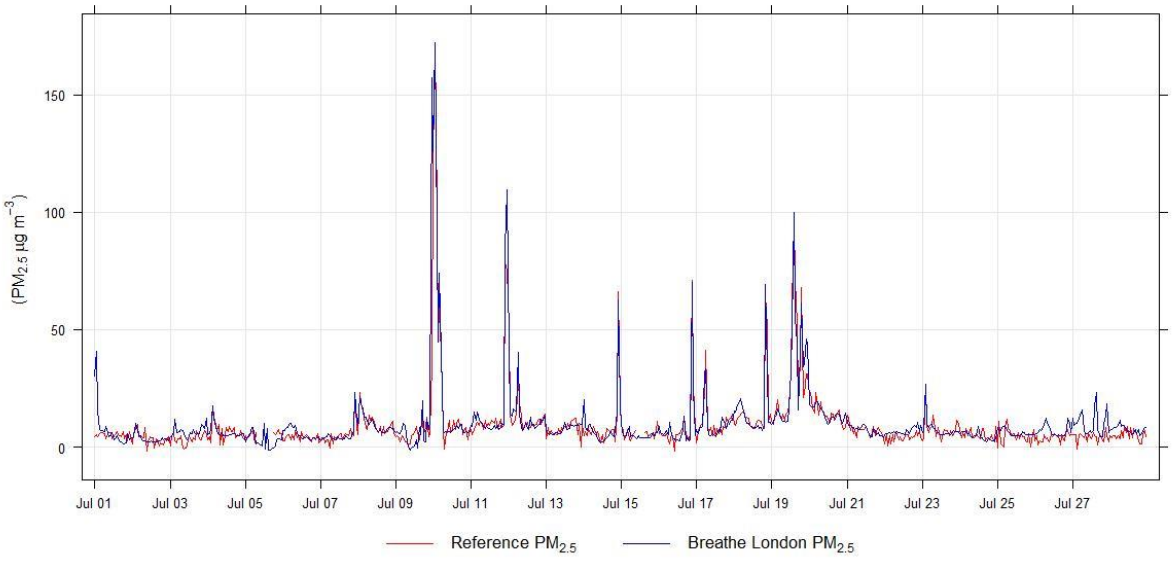

Figure 31: Time series plot of hourly mean $PM_{2.5}$ in July 2022. The red line shows measurements from the Rainham reference $PM_{2.5}$ monitor and the blue line shows $PM_{2.5}$ measurements from the Breathe London node.

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5 Conclusions

- London Fire Brigade records show that 1 to 37 days per year were affected by fires at the Arnolds Field former landfill site on Launders Lane during the years 2018 to 2022, with the largest number (37) occurring in 2022.
- Analysis of wind speed and direction data from London City Airport shows that the most common wind direction at this location was from the south-west. There may be local variations in wind direction. Additional meteorological measurement equipment is being installed in the Launders Lane area in order to provide local meteorological measurements.
- South-westerly winds would transport smoke from fires at Launders Lane towards the north-east. This area does not have any residential housing but does have industrial areas and a cemetery where people could be exposed to smoke.
- The main residential areas close to the Arnolds Field site are to the west and north-west, meaning that winds from the east and south-east would be most likely to blow smoke from the fires towards these areas. South-easterly winds were not frequent, particularly during the summer. Easterly winds occurred more frequently, particularly during spring and summer when fires were also more frequently recorded. Such conditions could expose residents west of Launders Lane to smoke.
- A potential signal from the Launders Lane fires was noted on some occasions in the $PM_{2.5}$ measurements from the air quality reference measurement site in Rainham. The main occurrences were in July 2019, June 2022 and July 2022. Hourly mean $PM_{2.5}$ concentrations up to 169 μgm^{-3} were measured. These spikes in $PM_{2.5}$ were not seen at a comparison site in Slade Green.
- Although short-lived these spikes were the greatest six-hourly mean $PM_{2.5}$ concentrations measured at Rainham reference site in 2019 and 2022. This also resulted in a daily mean concentration of 42 μgm^{-3} on 7th July 2019 which exceeded the 'moderate' threshold of the Daily Air Quality Index. Similar increases were seen in PM_{10} measurements on this day, exceeding the 'moderate' threshold of the Daily Air Quality Index and an exceedence of the daily mean PM_{10} objective. However, the UK Air Quality Strategy Objectives were not exceeded in any year analysed in this study.
- The reference measurement site is located 1.25 km to the north-west of the Arnolds Field site. The nearest residential area is 600 m from the Launders Lane site. Exposure to smoke from the Launders Lane fires is likely to be greater at these locations than at the reference measurement site.
- Breathe London measurements at the Rainham site showed good agreement with the reference measurements, indicating that these measurements are appropriate for monitoring the impact of the fires.
- Breathe London measurements from nodes installed closer to the Arnolds Field site are not available for the period covered by Fire Brigade records received to date but will be informative for the next stage of analysis.
- Longer periods of increased $PM_{2.5}$ concentrations at Rainham were associated with widespread pollution events during the analysis period so the Launders Lane fires are not the main source of exposure to particulate pollution for residents in this area. However, the detection of smoke at the measurement site which is likely to affect the wider area is a

concern due to unknown and potentially toxic components. Compositional analysis will provide further information on this risk.

6 Recommendations

- Additional Breathe London nodes are available to increase coverage of ambient air quality measurements that may improve understanding of the impact of the fires at Launders Lane. Two additional nodes are recommended as a result of this initial analysis:
  - Installation of a node to the north-east of the Arnolds Field site to improve evidence of potential effects in the area most likely to be impacted by smoke, according to the most common wind direction. Although there is not significant public exposure in this location, this monitoring may increase confidence in the measurements if a large impact from the fires is detected compared to other locations where smoke is less likely to be detected due to wind direction.
  - Moving or installation of a node to the west of the Arnolds Filed site. This is a large residential area with potentially significant exposure to smoke from the fires. Easterly winds are more common than south-easterly winds which would bring smoke towards the current air quality measurement locations, particularly in spring and summer when more fires tend to occur.
- Additional PM_{10} monitoring is not recommended on the basis of this analysis. Similar increases in PM_{10} and $PM_{2.5}$ were measured and a large proportion of this PM was noted to be in the $PM_{2.5}$ size fraction. PM_{10}:$PM_{2.5}$ ratios did not improve the evidence for detection of smoke from Launders Lane fires. $PM_{2.5}$ is of greater concern for its effects on health.

Imperial College London
Projects

Environmental Research Group

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