AIR QUALITY IN HELSBY

2023 Annual Report

Report for: Peel NRE Limited

Ricardo ref. ED12299 | Issue: 1 | 21/08/2024

Customer:
Peel NRE Limited

Customer reference:
Helsby 2023 Annual Report

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ED12299

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EXECUTIVE SUMMARY

This report provides details and results of the air quality monitoring programme which took place in Helsby, Cheshire from 1st January 2023 – 31st December 2023.

The work was carried out by Ricardo on behalf of Peel NRE Limited. The monitoring programme includes measurements of particulates (PM_{10} and $PM_{2.5}$), heavy metals, and Toxic Organic Micro Pollutants (dioxins, furans, dioxin like polychlorinated biphenyls, and polycyclic aromatic hydrocarbons), to assess their concentrations against the relevant air quality objectives.

Hourly PM_{10} and $PM_{2.5}$ monitoring was carried out using a Fine Dust Analysis System (FIDAS). The data capture rate for both PM_{10} and $PM_{2.5}$ in 2023 was 78.9%. The annual means measured for PM_{10} and $PM_{2.5}$ were 9.9 μgm^{-3} and 6.1 μgm^{-3}, respectively. The annual mean AQS objectives are >40 μgm^{-3} for PM_{10} and >20 μgm^{-3} for $PM_{2.5}$, therefore, the annual means are below the limit values. The 24-hour mean PM_{10} limit is 50 μgm^{-3} which may not be exceeded more than 35 times per year to meet the objective. There were no exceedances of this limit in 2023, therefore the objective was met.

Monthly collated filter samples of PM_{10} were analysed for a number of heavy metals. The 2023 annual mean concentrations were compared to the UK AQS Objective for lead and Ambient Air Directive target values or Environment Assessment Levels for other compounds where applicable. No metals exceeded their associated target values or levels.

Dioxins, furans, dioxin like polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) were extracted from samples collected and collated every three months from a High-Volume sampler. Benzo(a)pyrene (B[a]P) is used as a marker for PAHs in ambient air. The annual mean concentration of B[a]P in 2023 was 0.055 ngm^{-3}, which is well below the annual mean European target value of 1 ngm^{-3} and the UK objective of 0.25 ngm^{-3}.

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1. INTRODUCTION

This report produced on behalf of Peel NRE Limited, relates to the period 1st January 2023 to 31st December 2023 during which time air quality monitoring of dioxins, furans, particulates, PAHs and heavy metals were undertaken in Helsby, Cheshire.

The monitoring, commissioned on behalf of Peel NRE, followed on from an original contract with the Bioenergy Infrastructure Group (B.I.G) acting on behalf of Ince Bio Power Ltd. The original contract, which was completed in July 2020, was to monitor pollutants prior to and post construction and commissioning of a new biomass renewable energy power plant in Cheshire (Plot 9, Ince Resource Recovery Park). Further information on the air quality monitoring which took place during this initial survey can be found in a report located on the Protos website[1].

Monitoring continued without a break following the initial survey and will be ongoing to provide members of the local and wider community with air quality data on an annual basis. It will also provide monitoring required by businesses operating at Protos to ensure compliance with planning conditions.

During the period 1st January 2023 to 31st December 2023, activity on site at Protos included:

1. Operational biomass energy plant on plot 9a.
2. Operational timber recycling facility on plot 3.
3. Construction of the Energy Recovery Facility (ERF) on plot 8.
4. Construction of two electricity substations.
5. Construction of the plastics to hydrogen facility on plot 10b.
6. Construction of work on plot 13.

In addition there has been Phase 2 infrastructure works and the development of three additional ecology areas.

For more information on any of these activities, please visit www.protos.co.uk/community or email community@protos.co.uk.

2. MONITORING SITE AND METHODS

2.1 MONITORING STATION

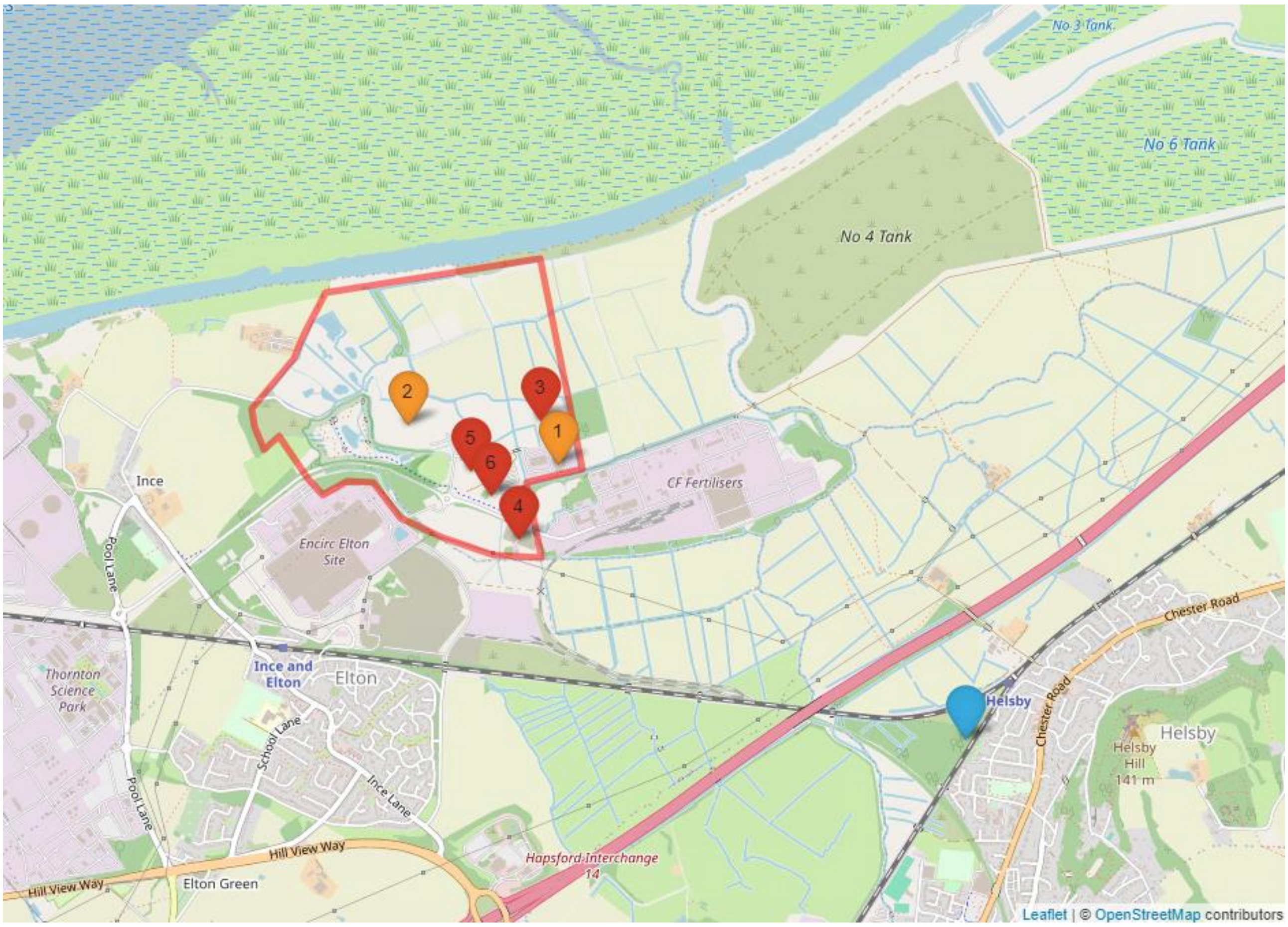
The monitoring station was set up in 2016 on land owned by Helsby Parish Council adjacent to an office building accessed from Mountain View, Helsby. The site was previously used by Ince Bio Power Ltd and will continue to be used for the purposes of ongoing monitoring for current and future facilities located at Protos.

Protos is an energy and resource site of 54ha, currently under development by Peel NRE. During 2023 two plots within Protos were fully occupied at the site and two further sites under construction. Figure 1 shows the location of the monitoring station (blue marker) with respect to the Protos development (as shown by the red line), the operational Ince Bio Power Plant and Ince Park Renewables Ltd (orange markers) and sites under construction (red markers).

This plan will be updated each year to show facilities at Protos which have been under construction, under commissioning, or operational during the reporting year.

[1] https://www.protos.co.uk/media-centre/community-downloads/#air-quality-documents.

Figure 1 Location of Helsby monitoring station (blue marker) and the Protos development. Operational facilities within the Protos development are shown as orange markers and facilities under construction are shown as red markers.



2.2 POLLUTANTS MONITORED

The monitoring station set up in Helsby is shown in Figure 2. The following sections provide an overview of the pollutants that Ricardo were contracted to measure at the site in Helsby, firstly by B.I.G., then since July 3rd 2020, by Peel NRE. In addition, hourly meteorological data from Liverpool John Lennon Airport (located 9 km NW of the monitoring station) were sourced from the NOAA Integrated Surface Databased [1] and accessed using the worldmet R package [2].

Figure 2 Monitoring station located on land adjacent to RSK offices accessed from Mountain View in Helsby.

2.2.1 Particulate Matter

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. The terms PM_{10} and $PM_{2.5}$ are used to describe particles with an effective size with a median aerodynamic diameter of 10 and 2.5 µm respectively. These are of greatest concern with regard to human health, as they are small enough to penetrate deep into the lungs. They can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface absorbed carcinogenic compounds into the lungs. Particles with a median aerodynamic diameter greater than 10 µm are less likely to travel as far into the respiratory system. These larger particles are also removed more readily from the air by sedimentation.

The main source of airborne particulate matter in the UK is combustion (industrial, commercial and residential fuel use). Other large sources include production processes, agriculture and road transport. PM and its precursors can also be transported long distances, and transboundary pollution from the continent can result in increased PM in the UK.

PM_{10} and $PM_{2.5}$ were measured using an MCERTS approved Fine Dust Analysis System (FIDAS). The FIDAS analyser utilises a light emitting diode (LED) to determine particle numbers and particle size distribution through light scattering of individual particles.

The output is recorded and stored every 10 seconds and averaged to 15 minute average values by an on-site data logger. This logger is connected to a modem to download the data to Ricardo. The data are then converted to concentration units and averaged to hourly mean concentrations. Data were processed according to the rigorous quality assurance and quality control procedures used by Ricardo, and ratified every six months, to produce the final dataset reported here.

2.2.2 Heavy Metals

Heavy metals are toxic metallic elements that can result in adverse health effects. Anthropogenic sources of heavy metals include emissions from industrial processes and fuel combustion.

A Partisol 2025 sampler was used to collect particulates in the PM_{10} fraction on a weekly schedule. The weekly filters were collated into monthly samples and sent to an analytical laboratory to be analysed for heavy metals including: Arsenic, Cadmium, Cobalt, Chromium, Mercury, Manganese, Nickel, Lead, Antimony, Thallium, Vanadium, Zinc, via UKAS accredited procedures, and Chromium VI (not accredited).

2.2.3 Toxic Organic Micro Pollutants (TOMPs)

Toxic Organic Micro Pollutants include a range of persistent organic pollutants (POPs), such as polychlorinated-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). Exposure to POPs can have an adverse impact on human health and the environment. The main source of POPs in recent years in the UK are unintentional by-products from the incomplete combustion of fuels.

A High Volume sampler was used to collect samples for analysis of dioxins, furans, dioxin like PCBs and PAHs. Samples were collected every 2 weeks and collated into 3 monthly samples (Table 1). Sample blanks were also obtained and analysed and found to be within acceptable limits. The method used for the analytical measurement complies with US EPA 1613B for the PCBs, dioxins and furans, and EPA-TO-13A for PAHs.

Table 1 Start and end dates of 3-monthly periods for TOMPs sampling in 2023.

Period	Start Date	End Date
Period 1	27/12/2022	05/04/2023
Period 2	05/04/2023	28/06/2023
Period 3	28/06/2023	05/10/2023
Period 4	05/10/2023	27/12/2023

2.3 AIR QUALITY LIMIT VALUES

Table 2 shows the current UK objectives (included in the Air Quality Standards Regulations [3] and subsequent Amendments for the purpose of Local Air Quality Management), for the pollutants monitored at Helsby for this report. These regulations are based on those in the European Commission Directive on Ambient Air Quality and Cleaner Air for Europe [4], [5] (referred to as the Air Quality Directive) when the UK was a member of the European Union. Since Brexit, the UK is no longer tied to the EU limits, however, current objectives in the UK have been adopted from those stated in the Air Quality Directive, as shown in Table 2.

Where target analytes do not have a UK objective limit value, Ambient Air Directive (AAD) target values or Environmental Assessment Levels (EALS) used for Environmental Permit Risk assessments [6] were adopted for the purpose of this study, as shown in Table 3.

Table 2 UK and European air quality objectives for pollutants measured at Helsby.

Pollutant	UK Objective	European Objective	Measured as
PM_{10}	50 µgm^{-3} not to be exceeded more than 35 times a year	50 µgm^{-3} not to be exceeded more than 35 times a year	24 hour mean
PM_{10}	40 µgm^{-3}	40 µgm^{-3}	annual mean
$PM_{2.5}$	20 µgm^{-3}	20 µgm^{-3}	annual mean
Polycyclic Aromatic Hydrocarbons (PAH)	0.25 ngm^{-3} B[a]P	1 ngm^{-3} B[a]P	annual mean
Lead	0.25 µgm^{-3}	0.5 µgm^{-3}	annual mean

Table 3 UK and European air quality objectives for pollutants measured at Helsby.

Pollutant	Adopted limit (ngm^{-3})	Standard	Measured as
Arsenic (As)	6	AAD Target Value	annual mean
Cadmium (Cd)	5	AAD Target Value	annual mean
Copper (Cu)	10000	Environmental Assessment levels	annual mean
Mercury (Hg)	250	Environmental Assessment levels	annual mean
Manganese (Mn)	150	Environmental Assessment levels	annual mean
Nickel (Ni)	20	AAD Target Value	annual mean
Antimony (Sb)	5000	Environmental Assessment levels	annual mean

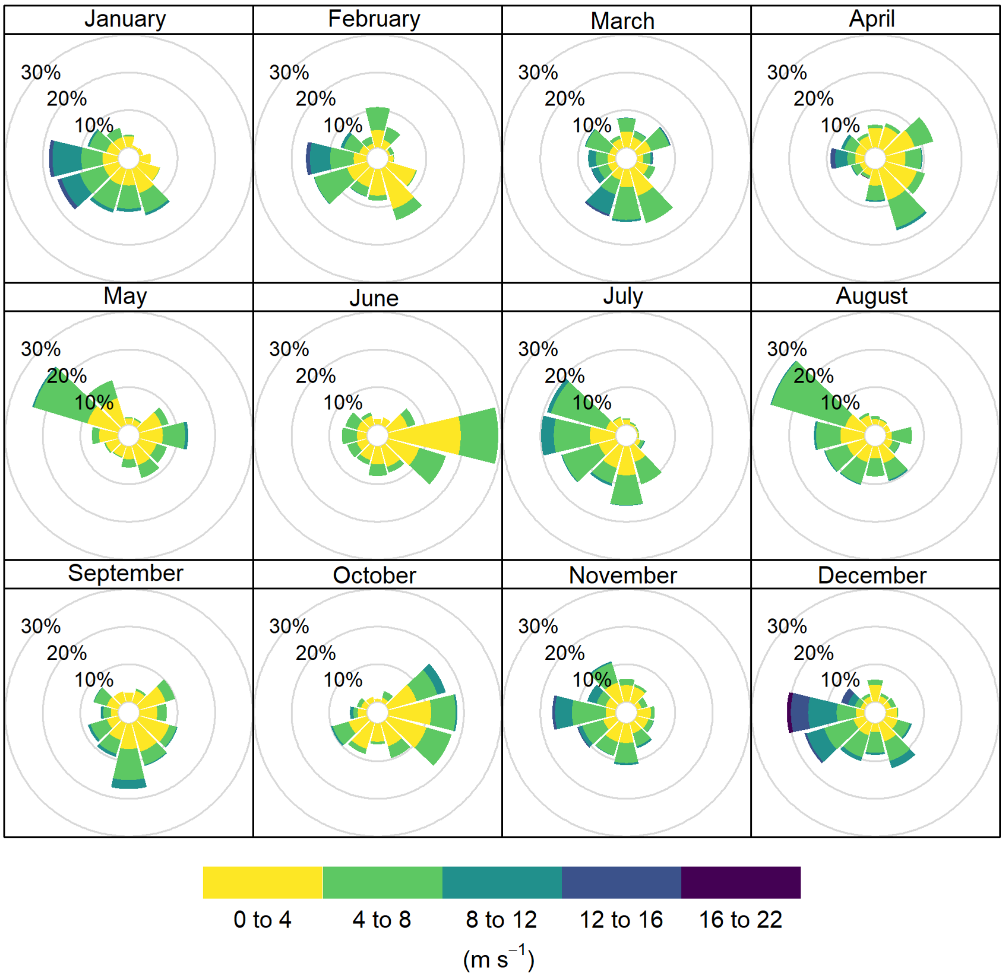
3. RESULTS AND DISCUSSION

The pollutant data measured at Helsby during 2023 have been analysed and where applicable measurements have also been assessed with respect to current Air Quality Objectives.

3.1 METEOROLOGICAL CONDITIONS

Figure 3 shows the distribution of wind speed and wind direction (wind rose) for each month at Liverpool John Lennon Airport. The “spokes” show the direction the wind is coming from, a longer spoke means a higher frequency of wind from that direction and the colours represent the wind speed (purple= high winds, yellow = calm winds). The highest winds were observed in December 2023, as a result of two storms (Elin and Fergus) arriving one after the other from the west between 9 and 10 December.

Figure 3 Monthly wind roses in 2023 for Liverpool John Lennon Airport. Data source: NOAA Integrated Surface Database (ISD) [1].



3.2 PM DATA ANALYSIS

3.2.1 Summary Statistics

Table 4 shows a summary of the PM data for 2023. The period mean concentrations are below the annual mean air quality objectives for PM_{10} and $PM_{2.5}$. There were no exceedances of the PM_{10} daily mean objective during 2023, therefore the objective was met. The data capture rates in 2023 for both PM fractions is 78.9%. The lower capture rate compared to previous years was due to an intermittent fault with the FIDAS analyser, which occurring during the summer months. Servicing was undertaken on the analyser in October to fix the issue.

Table 4 Summary statistics and exceedances for particulate matter measured at Helsby in 2023.

Statistic	PM_{10}	$PM_{2.5}$
Annual Mean (μgm^{-3})	9.9	6.1
Hourly Maximum (μgm^{-3})	86.1	58.2
Daily Maximum (μgm^{-3})	41.0	25.7
Data Capture rate (%)	78.9	78.9
Period mean > annual mean objective	No	No
Exceedances (daily mean > 50 μgm^{-3})	0	0

3.2.2 AQ Index Distribution

The plots below illustrate the distribution of AQ index values for Helsby for PM_{10} and $PM_{2.5}$. The AQIs are based on the daily mean for PM and each plot shows the number of days that concentrations measured are in each index. The index ranges from 1 to 10 and separated into four different bands: 1-3 = Low, 4-6 = Moderate, 7-9 = High, and 10 = Very High. Further information on the AQ Index is available in Table A1 in the appendix and from UK-Air [7]. During 2023, there were no days recorded when the PM_{10} or $PM_{2.5}$ AQI went above the "Low" banding (Index 1-3).

Figure 4 Distribution of AQI for PM_{10}.

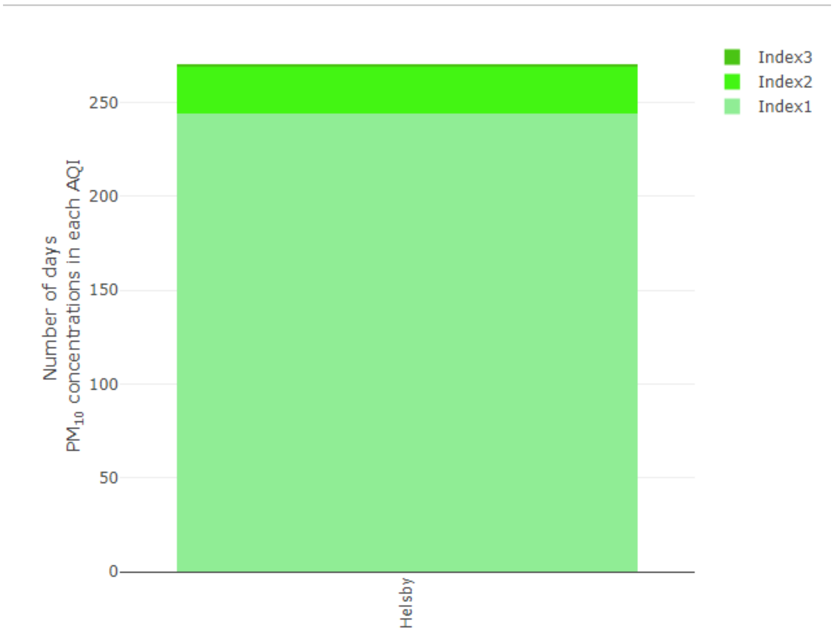
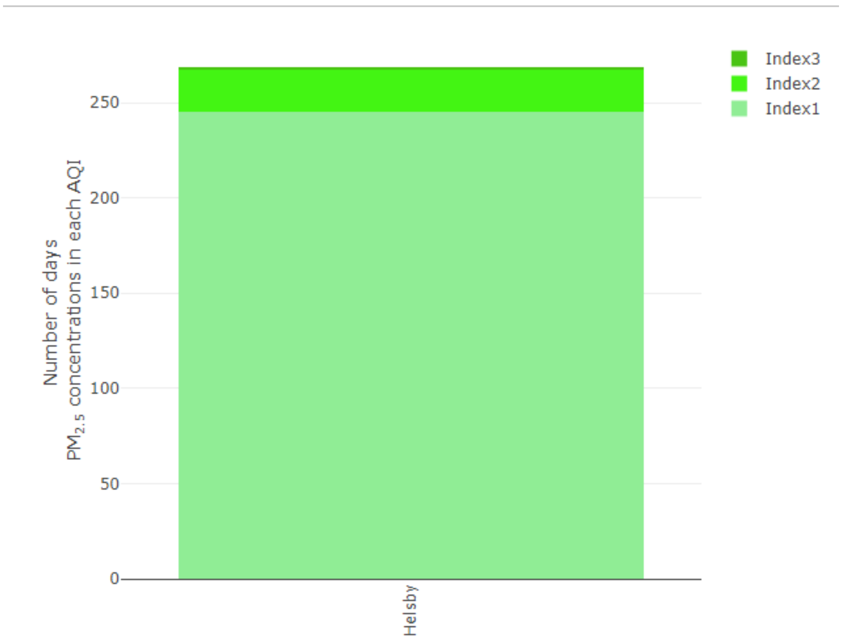


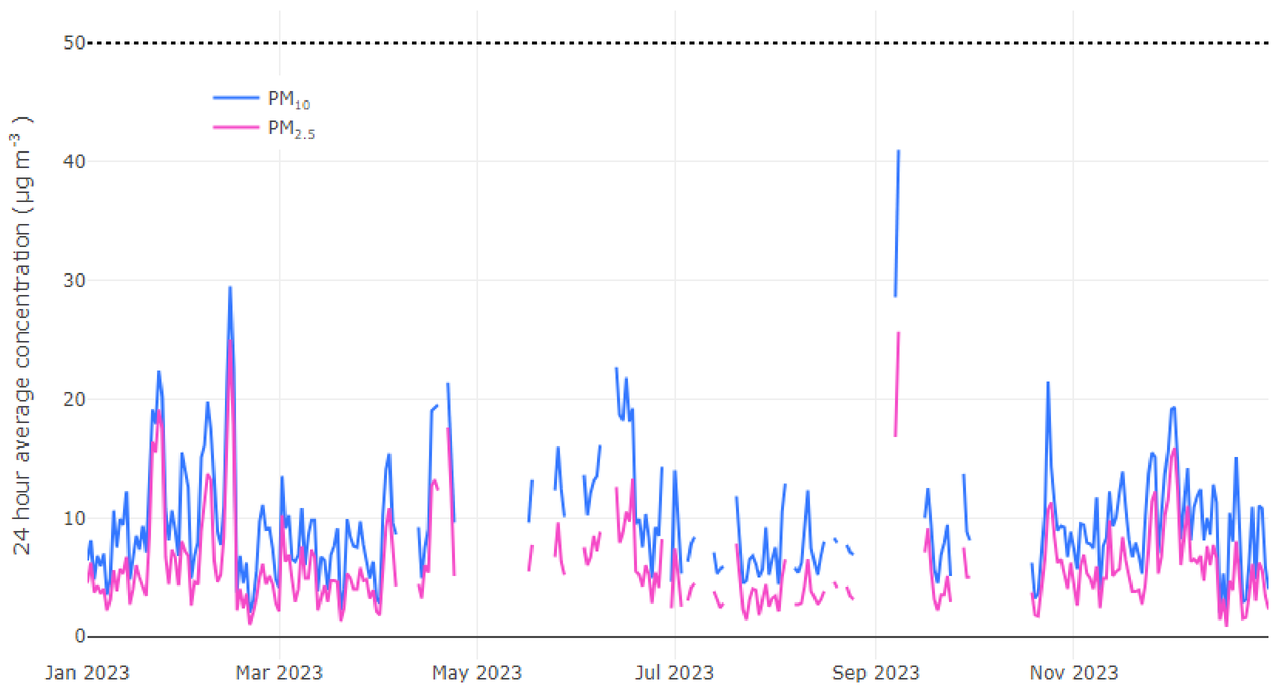
Figure 5 Distribution of AQI for $PM_{2.5}$.



3.2.3 Time Series

Figure 6 shows the 24 hour averaged time series of PM_{10} and $PM_{2.5}$ measured at Helsby during 2023.

Figure 6 24 hour average PM_{10} and $PM_{2.5}$ concentrations measured at Helsby during 2023. The dashed line represents the PM_{10} 24 hour objective.



3.2.4 Time Variations

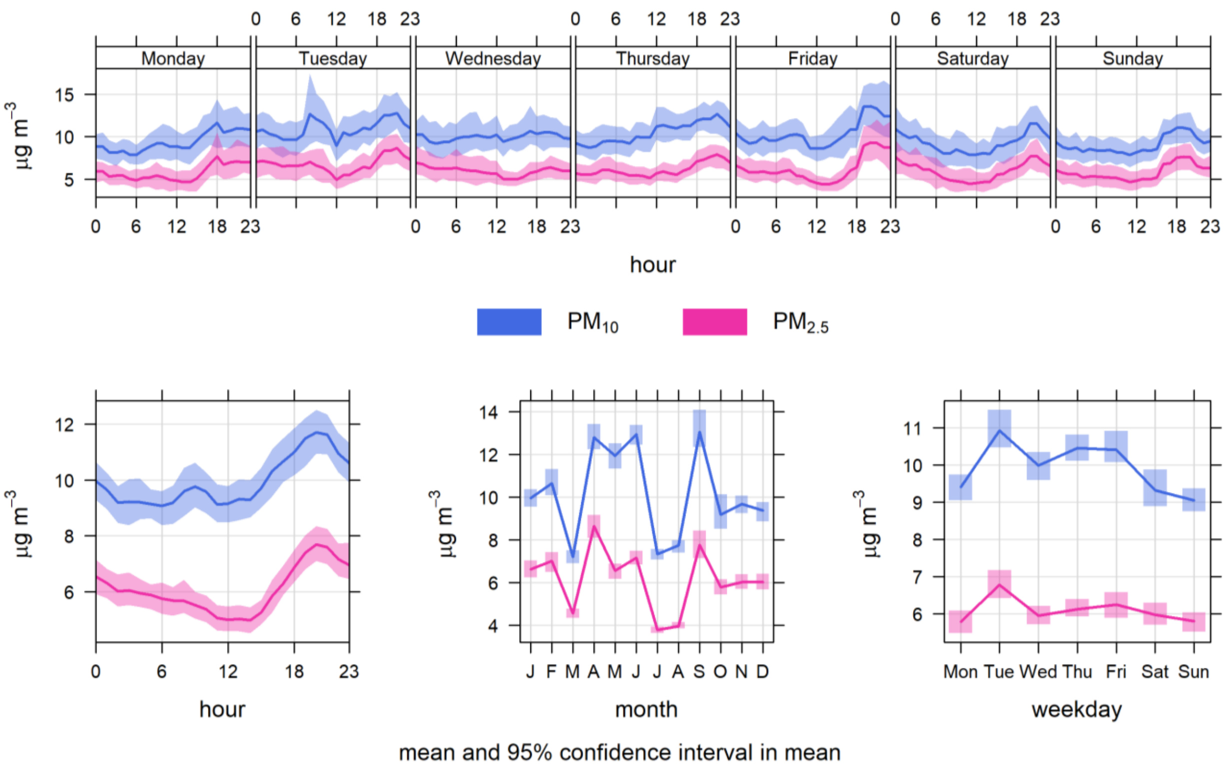
As PM_{10} and $PM_{2.5}$ are continuously measured on an hourly time period, the variability over short and long time periods can be assessed. Figure 7 shows the daily, weekly, and monthly variability in concentrations for 2023.

Seasonal: Variations in the PM concentrations across seasons can be seen in the “month” plot in Figure 7. PM concentrations were elevated during, April, May and June 2023. This may be due to easterly wind bringing polluted air masses from the continent to the UK. The wind roses in Figure 3 show a large proportion of wind coming from the east during June. The highest PM levels were observed in September 2023. Further information on the elevated levels during September is provided in section 3.2.5

Weekly: The weekly cycles for PM_{10} and $PM_{2.5}$ are very similar with the lowest concentrations observed on Saturday, Sunday and Monday. The weekly cycle varies from year to year which may, in part, be related to changes in traffic patterns, however, this cannot be concluded without additional information on traffic volumes in the area.

Diurnal: The diurnal cycle, as seen in the “hour” plot in Figure 7 shows a minimum in PM_{10} and $PM_{2.5}$ around noon, with a smaller peak in the morning (for PM_{10}) and a higher peak in the evening. Concentrations remain high during the night-time, this might be due to a reduced surface boundary layer height during the night-time, rather than higher emissions of PM at night compared to midday. The surface boundary layer is the turbulent lower layer of the atmosphere that is influenced by the Earth’s surface, where vertical mixing of pollutants can occur. When the sun sets a lower stable nocturnal boundary layer forms which can trap pollutants near the ground, resulting in elevated concentrations compared to the daytime.

Figure 7 Temporal variations in PM_{10} and $PM_{2.5}$ concentrations measured at Helsby during 2023.



3.2.5 Calendar Plots

The plots in Figure 8 and 9 show daily variation in concentrations by pollutant for each month in 2023. The colours shown for each day relate to the concentration. The highest daily mean PM_{10} and $PM_{2.5}$ concentrations were observed on 8th September, with average daily concentrations of 41.0 µgm^{-3} and 25.7 µgm^{-3}, respectively.

The elevated levels of PM in September coincided with a heatwave across the UK. The Daily Air Quality Index (DAQI) from 6th to 9th September indicate Moderate levels of ozone and PM across many regions of the UK[2]. Therefore it is likely that widespread pollution contributed to the elevated PM levels observed in Helsby. The wind direction on 8th September was from an easterly direction, which can often bring polluted air from the continent to the UK, which can result in elevated levels of pollutants.

Elevated PM_{10} and $PM_{2.5}$ was also observed from 13th to 15th February at Helsby and across much of the east and north of England. The cause of the high PM concentrations in February was due to a widespread Saharan dust event.

[2] https://uk-air.defra.gov.uk/latest/measurement-summary-map

Figure 8 Calendar plot for PM_{10} measured at Helsby during 2023.

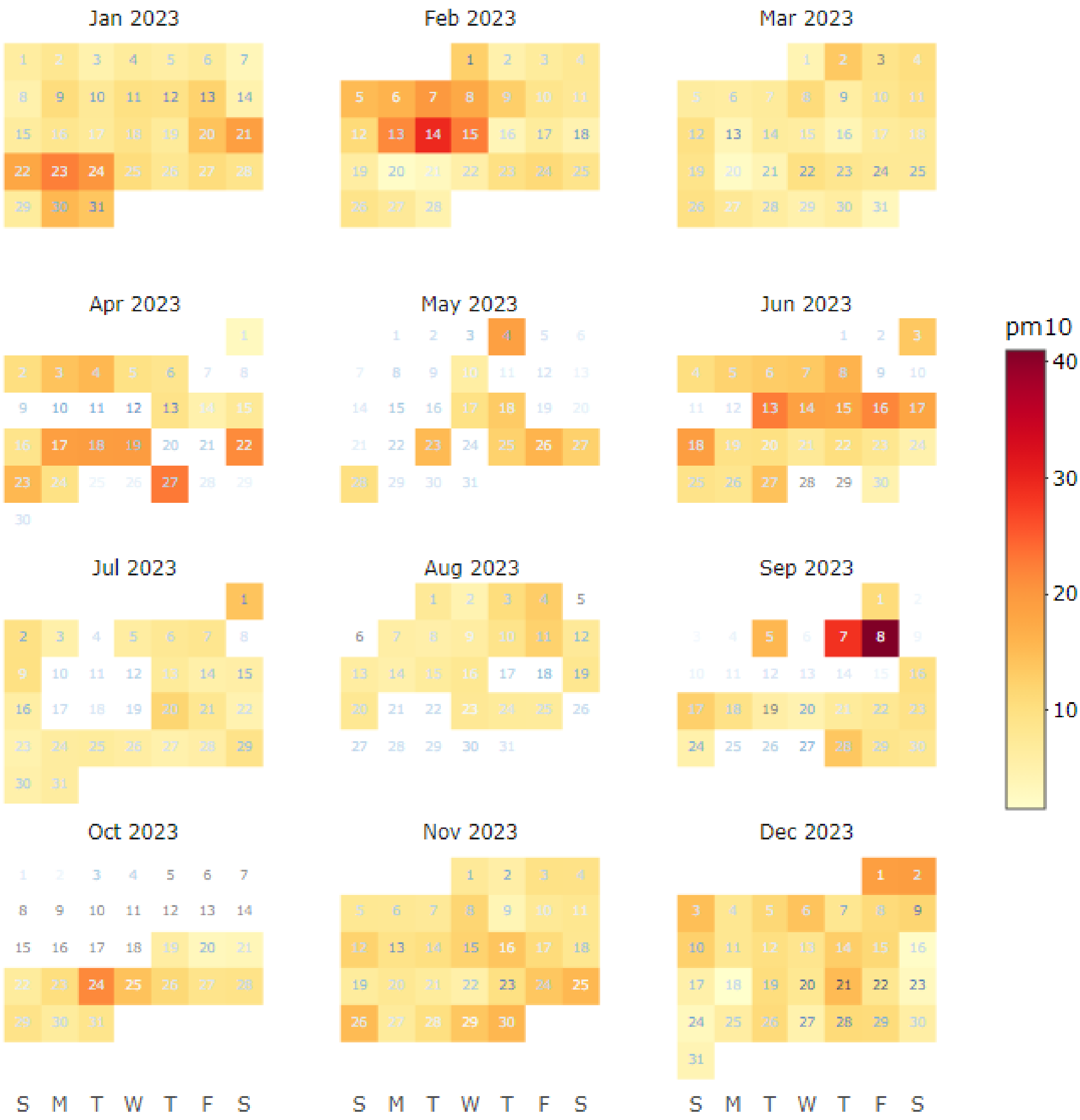
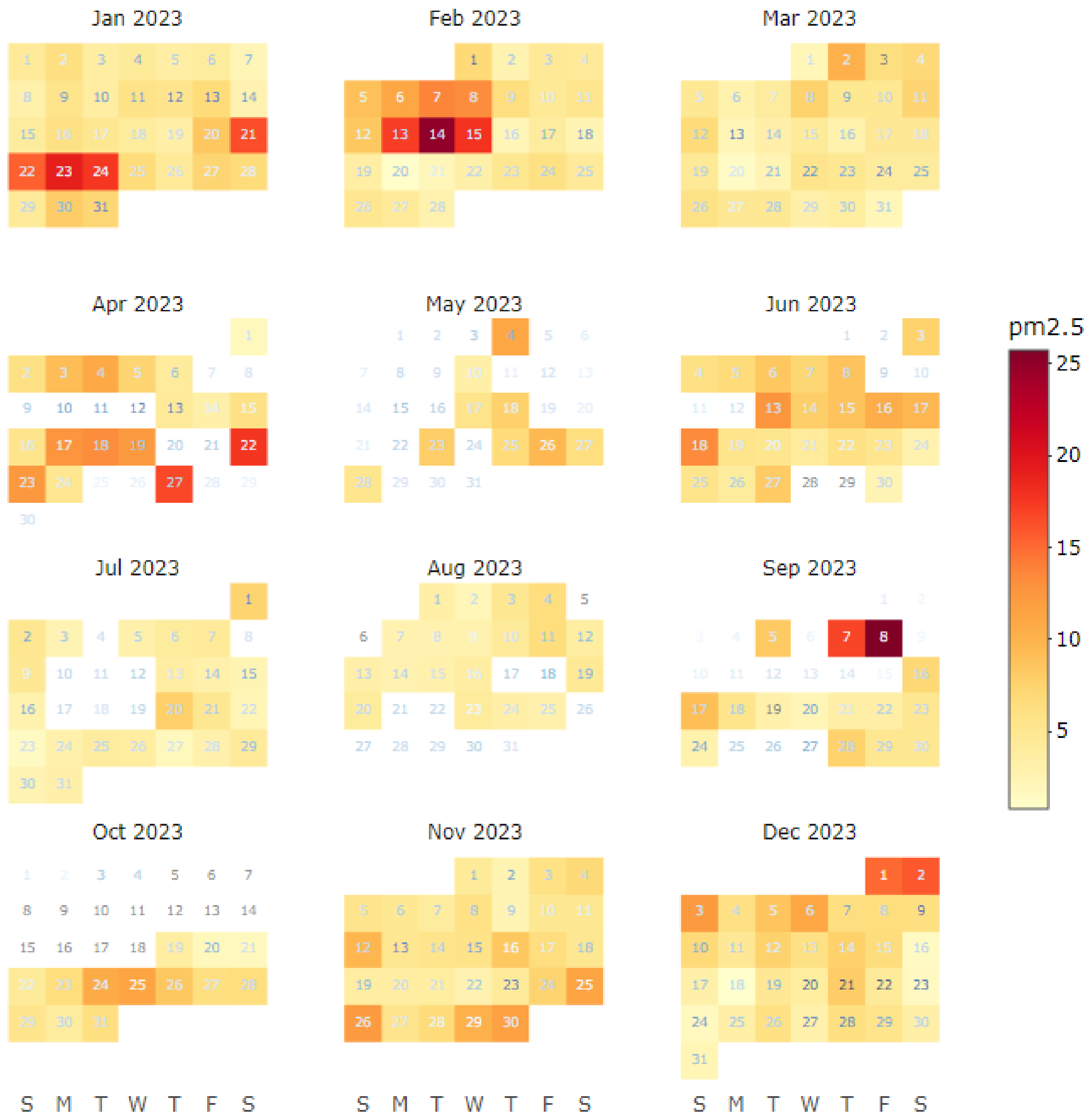


Figure 9 Calendar plot for $PM_{2.5}$ measured at Helsby during 2023.



3.2.6 Polar Plots

To investigate possible sources of PM in 2023, meteorological data measured at Liverpool John Lennon Airport was used to assess the hourly mean PM_{10} and $PM_{2.5}$ concentrations with wind speed and wind direction.

Figure 10 and Figure 11 show bivariate polar plots or “pollution roses” of PM_{10} and $PM_{2.5}$, respectively. The plots indicate how the PM concentration varies with wind direction and wind speed, with blue colours representing lower PM levels, and red colours higher PM levels.

PM_{10}: In 2023, the highest concentrations of PM_{10} were observed when the wind was from the east, or from the northwest under high (>10 ms^{-1}) wind speeds. There is also evidence of higher concentrations when the wind was from the east under calmer wind speeds (< 5 ms^{-1}).

$PM_{2.5}$: $PM_{2.5}$ shows a similar pattern with wind direction to PM_{10}.

Elevated PM_{10} and $PM_{2.5}$ at low wind speeds is typically associated with local sources. The high PM at high wind speeds from the northwest may be related to pollution from the M56 and farther afield – potentially including the Protos site.

Figure 10 Bivariate polar plot of PM_{10} for 2023.

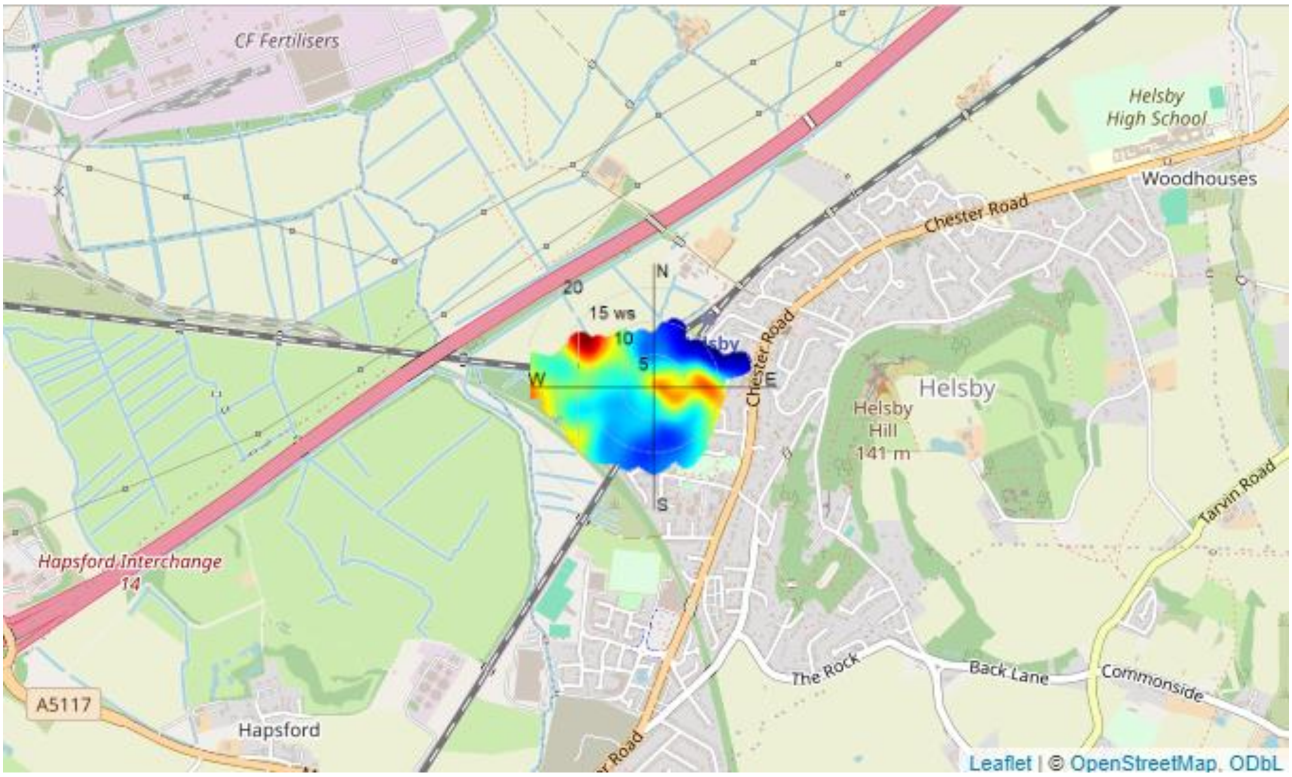
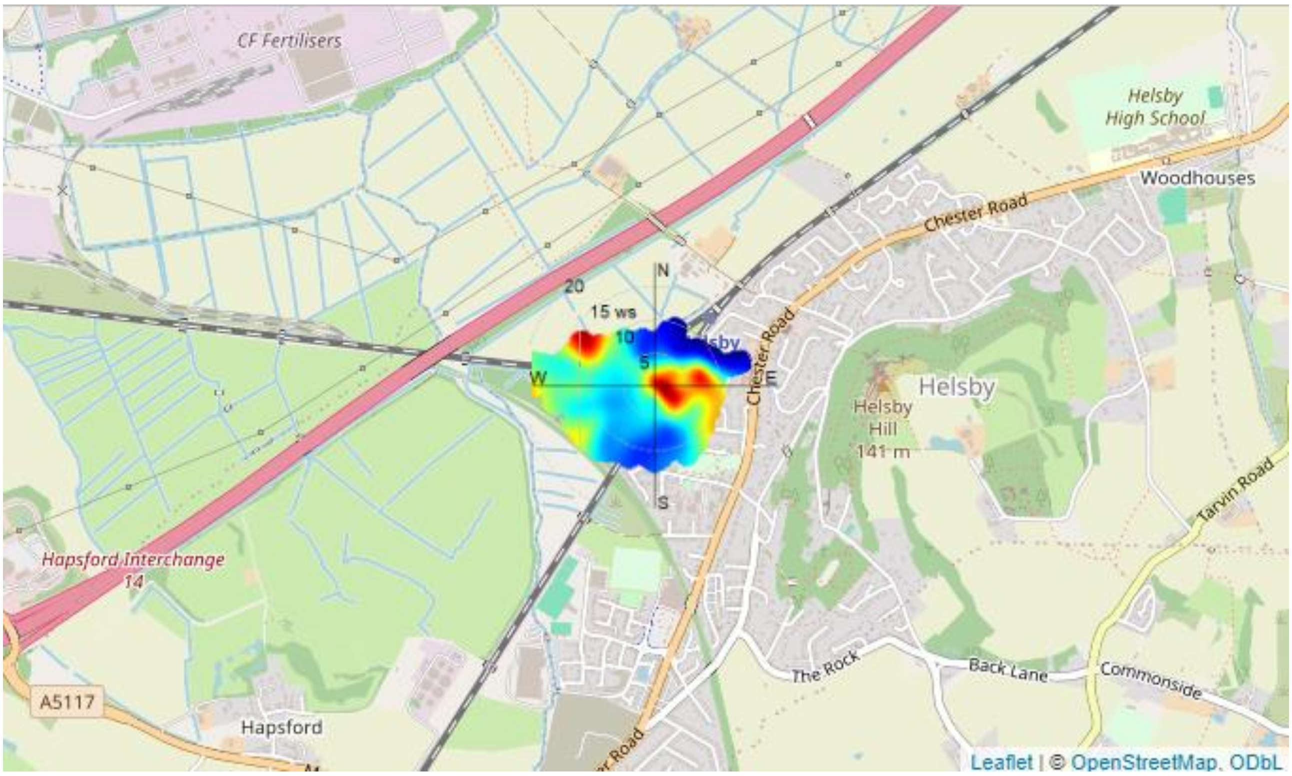


Figure 11 Bivariate polar plot of $PM_{2.5}$ for 2023.

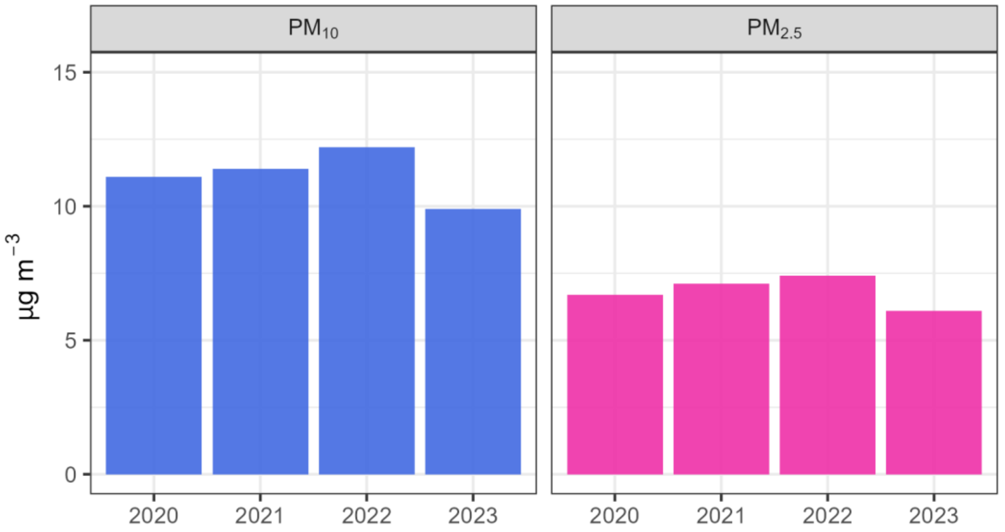


3.2.7 Annual Variation

Figure 12 shows the annual mean PM_{10} and $PM_{2.5}$ concentrations measured at Helsby from 2020 to 2023. The measured concentrations in all years are well below the annual mean air quality objectives for PM_{10} and $PM_{2.5}$.

From 2020 to 2022 a small increase is observed each year, however, in 2023, the concentrations decreased. PM can be transported long distances in the atmosphere, therefore, variations in concentrations year-on-year can be caused by changes in meteorological conditions, in addition to variations in local emissions.

Figure 12 PM_{10} and $PM_{2.5}$ annual mean concentrations from 2020 to 2023.

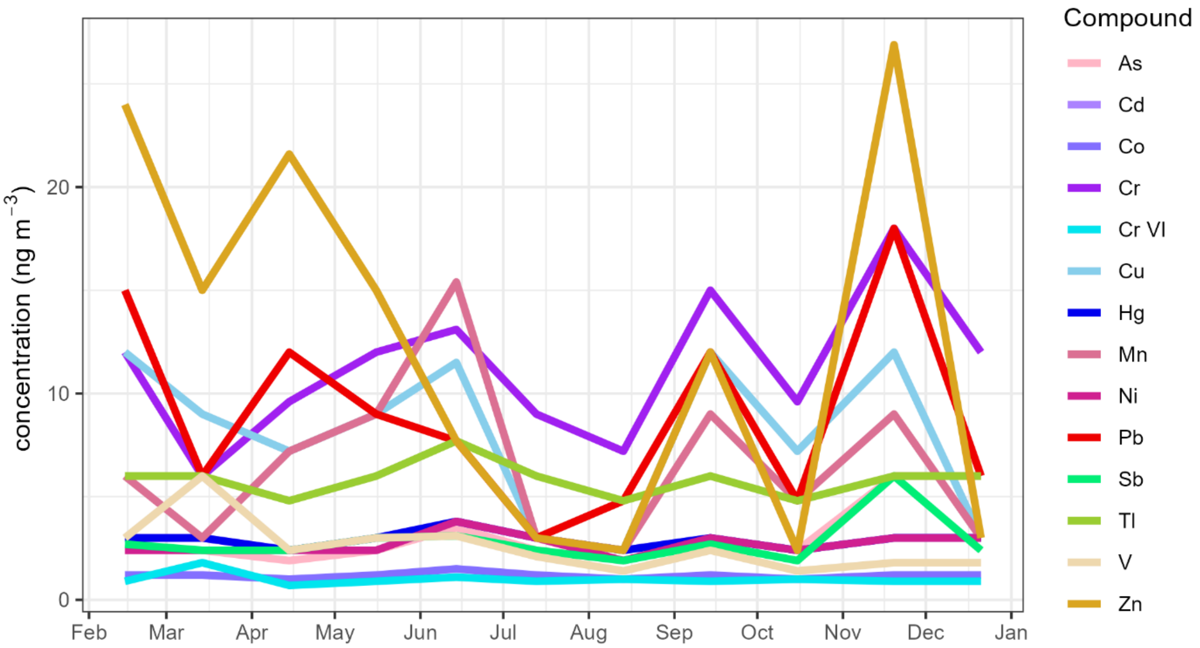


3.3 HEAVY METALS ANALYSIS

Figure 13 shows a time series of the metal concentrations for each month, during 2023. Data from the analysis of the monthly samples are provided in Table C1 in Appendix 3.

As highlighted in previous years, zinc concentrations are highly variable throughout the year. In 2023 concentrations dropped below the limit of detection in June and July and then increased again over autumn/winter, before dropping below the limit of detection again in December.

Figure 13 Heavy metal concentrations measured at Helsby during 2023. Points shown at mid-point of 4-week period.



To assess the concentrations of heavy metals measured in Helsby, a comparison of annual means against UK AQS Objective, Ambient Air Directive target values or Environment Assessment Levels (outlined in Table 3) has been performed.

Annual averages for heavy metal concentrations measured during 2023 are shown in Table 5. The annual averages with and without measurements below detectable limits are provided. For some heavy metals concentrations were below the LOD for each sampling period during the year. In these cases period averages calculated without measurements below detectable limits are blank.

Table 5 Summary statistics for heavy metals during 2023.

Adopted limits ($ng.m^{-3}$)	**As** **6**	**Cd** **5**	**Co** **-**	**Cr** **-**	**Cu** **10000**	**Hg** **250**	**Mn** **150**	**Ni** **20**	**Pb** **250**	**Sb** **5000**	**Tl** **-**	**V** **-**	**Zn** **-**	**Cr VI** **-**
Annual Average	3.1	2.9	1.2	11	8	2.9	6.5	2.7	8.9	2.8	5.8	2.6	12	1.00
% of limit	52%	58%			0.08%	1.2%	4.3%	14%	3.6%	0.056%				
Annual Average (without < LOD)	4.2			11	8		6.5	2.9	9.6	3.6		2.7	16	0.96
% of limit (without < LOD)	69%				0.08%		4.3%	14%	3.8%	0.067%				

To assess how concentrations of heavy metals have varied over time, annual mean concentrations for each heavy metal species for 2020, 2021, and 2023 were calculated (see Figure 14). Annual means could not be calculated for 2022, as data is only available for the final five months of 2022 (further information is provided in the 2022 annual report). However a comparison was also undertaken of the data from August to December for all four years of measurements (Figure 15). The results show that for many species, the concentrations are very similar across the four years. This is expected for those metals that are around or below the LOD (e.g. As, Cd, Co, Hg, Tl, Cr VI). Copper (Cu) shows a clear decrease over time, in both the annual and period mean data. Other metals whose concentrations are typically above the LOD (Cr, Mn, Pb, V, Zn) vary from year to year. Data over a longer time period is required to provide further information on whether there is an ongoing long-term trend in these species.

Figure 14 Annual average of heavy metal concentrations measured at Helsby from 2020 to 2023. Error bars represent the maximum and minimum values recorded. Note that annual means were not available for 2022.

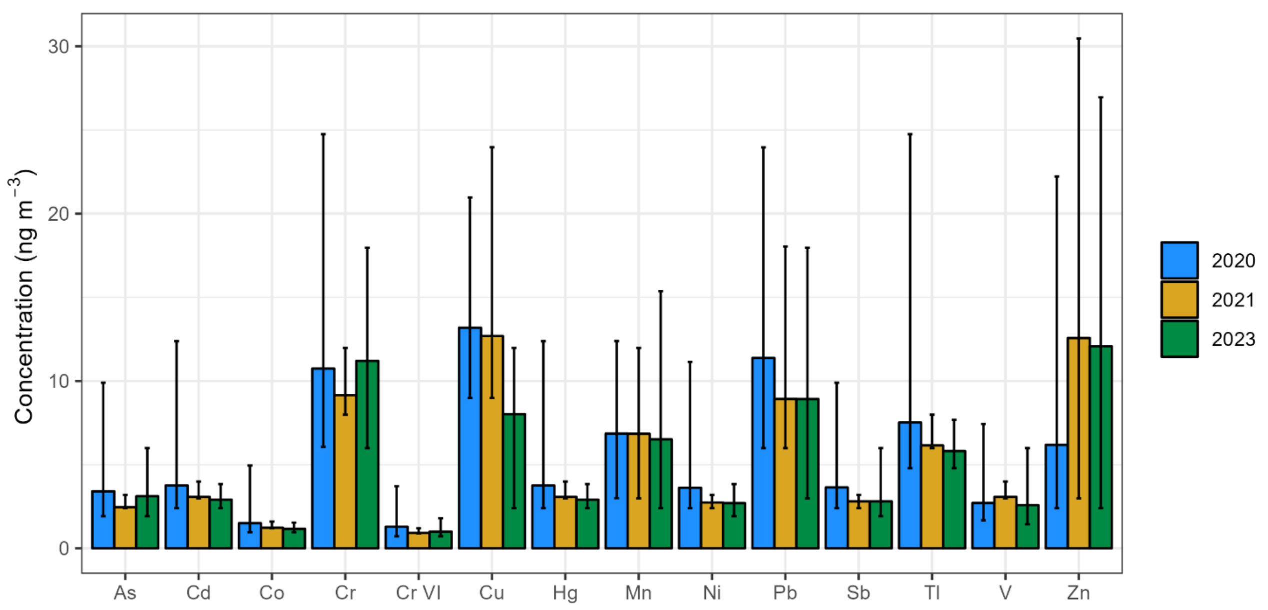
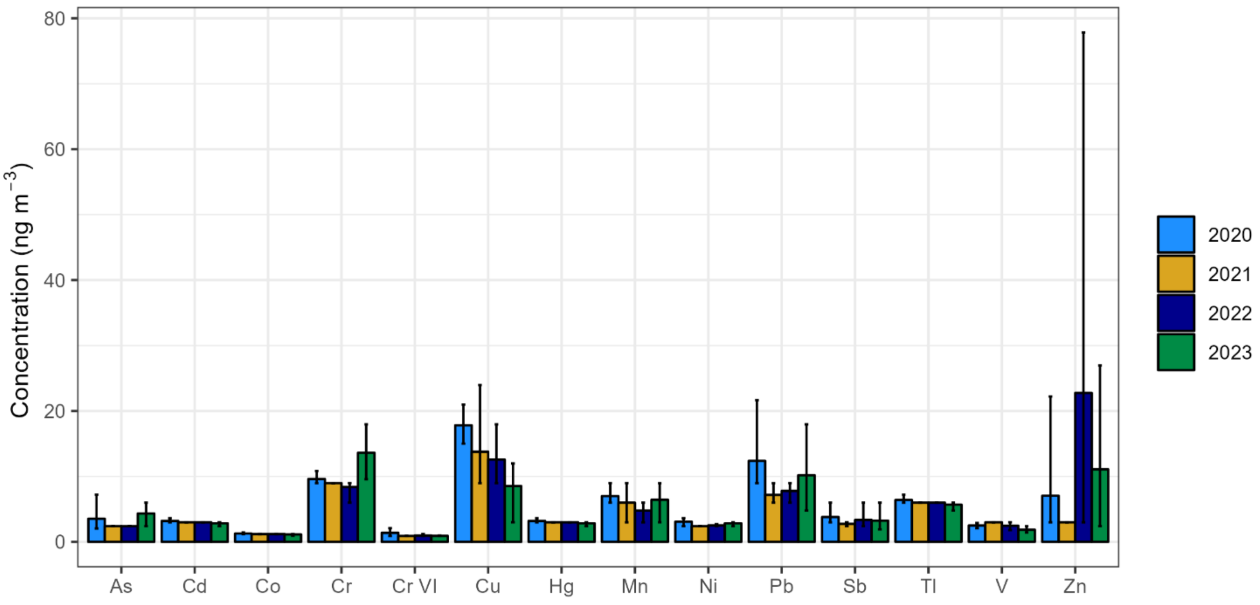


Figure 15 Average of heavy metal concentrations measured at Helsby from August to December for the years 2020 to 2023. Error bars represent the maximum and minimum values recorded.



3.4 PAH ANALYSIS

Table 6 shows the period mean of the measured PAHs in PM_{10} calculated from the 3-monthly samples in 2023. All compounds sampled were above the LOD. Benzo(a)pyrene (B[a]P) is used as a marker for assessment of PAHs against UK and European objectives. The annual mean concentration of B[a]P in 2023 was 0.055 ngm^{-3}, which is well below the European target value of 1 ngm^{-3} and below the stricter UK objective of 0.25 ngm^{-3}. To assess the use of B[a]P as a marker for PAHs, additional PAHs are required to be measured as per the Fourth Daughter Directive (DD4). These additional compounds should include at a minimum: benz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene and dibenz[a,h]anthracene. All these compounds were measured at Helsby, along with other PAHs. Please note, however, as for previous years, the naphthalene concentrations reported are highly uncertain due to potential breakthrough on the sampling media at the flow rates used.

Table 6: Summary statistics for PAHs during 2023. Benzo(a)pyrene is used for assessment of PAHs against air quality objectives.

Compound	Annual Mean (ngm^{-3})	Compound	Annual Mean (ngm^{-3})
Naphthalene	0.023	Chrysene	0.107
Acenaphthylene	0.004	Benzo(b)fluoranthene	0.099
Acenaphthene	0.027	Benzo(k)fluoranthene	0.034
Fluorene	0.149	Benzo(a)pyrene	0.055
Phenanthrene	1.569	Indeno(1,2,3-cd)pyrene	0.058
Anthracene	0.066	Dibenzo(ah)anthracene	0.006
Fluoranthene	0.654	Benzo(ghi)perylene	0.063
Pyrene	0.449	Benzo(j)fluoranthene	0.044
Benzo(a)anthracene	0.061	Dibenzo(ac)anthracene	0.006

Concentrations of PAHs for each of the four periods in 2023 are shown in Figure 16. The data for each period are provided in Table C2 in Appendix A3.

Figure 16: PAH concentrations measured at Helsby during 2023.

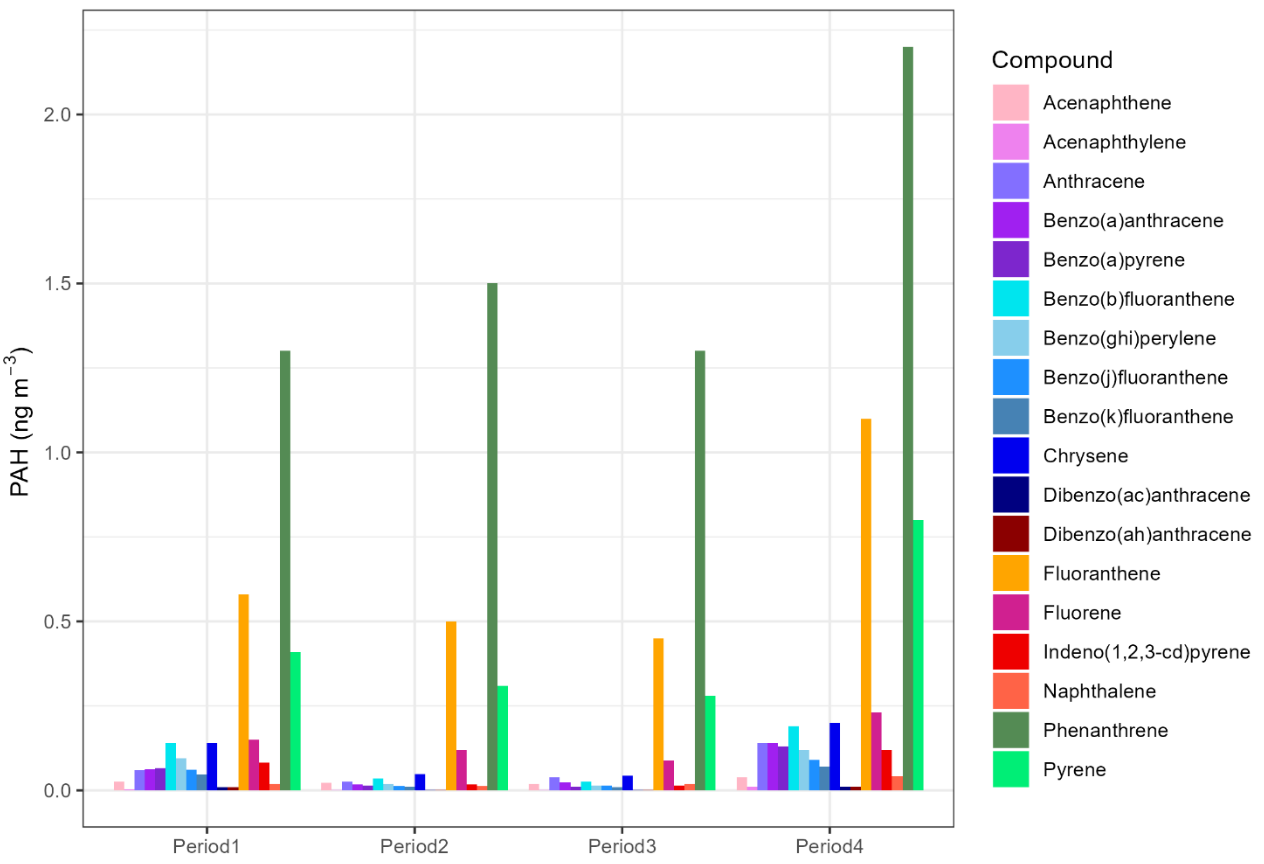
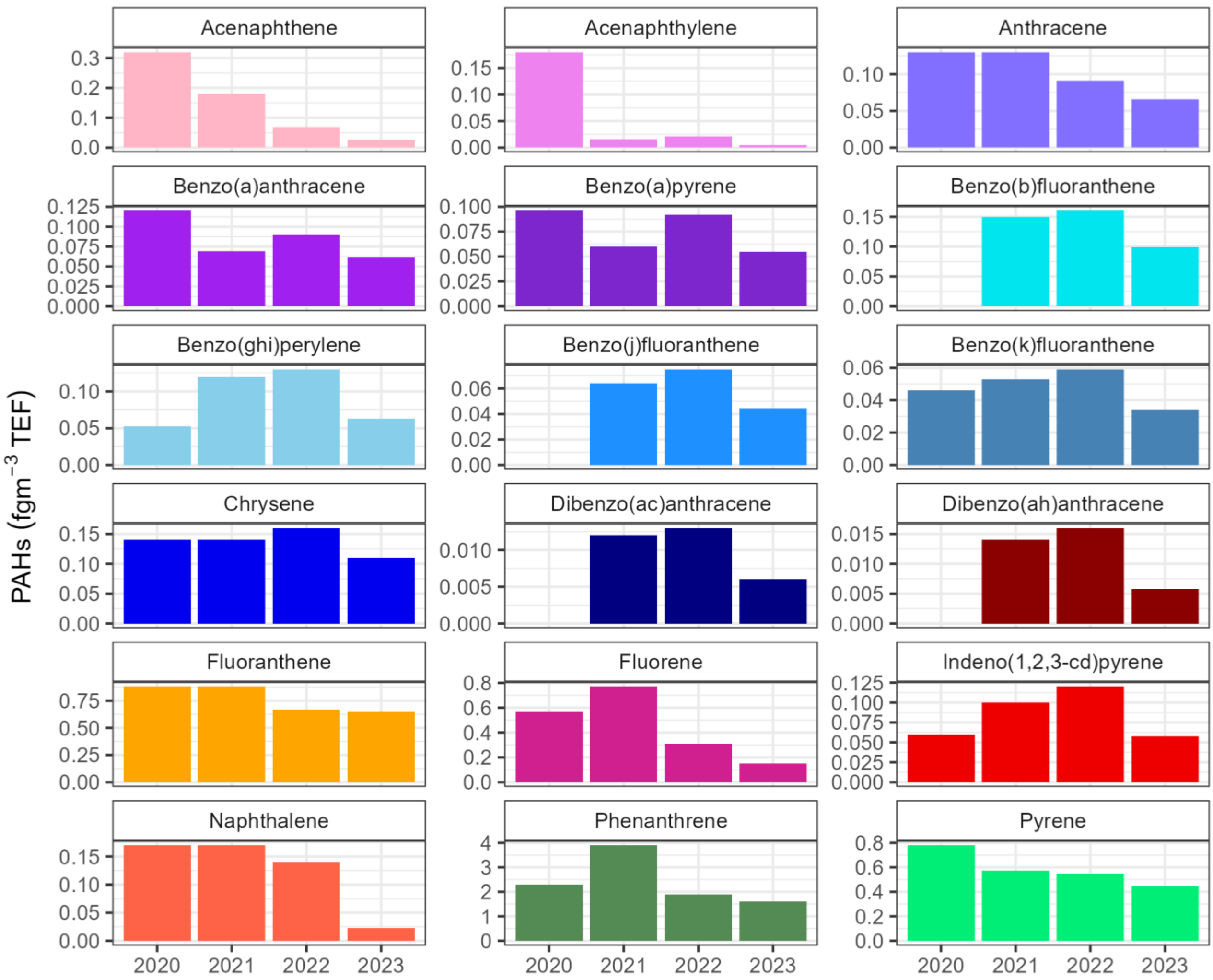


Figure 17 shows a comparison of annual mean PAH concentrations from 2020 to 2023. The analysis shows some variation across years, however concentrations in 2023 are lower than in previous years for all compounds. For B[a]P the measured concentrations were well below the UK objective of 0.25 ngm^{-3} for all years. The annual mean B[a]P concentrations will continue to be reported in future years, to assess the long-term changes in this PAH.

Figure 17: Annual mean concentrations of PAHs from 2020 to 2023



3.5 DIOXINS, FURANS AND PCB ANALYSIS

The TOMPs data (Dioxins, Furans and PCBs) for Helsby have been converted to Toxic Equivalency using the World Health Organization Toxic Equivalency Factors (see Appendix A2). The annual mean concentrations for each set of compounds measured at Helsby in 2023 are provided in the tables below.

Table 7: Summary statistics for Dioxins at Helsby during 2023.

Compound	Annual Mean (fgm^{-3} TEF)
2378 Tetra CDD	4.625
12378 Penta CDD	5.150
123478 Hexa CDD	0.613
123678 Hexa CDD	0.633
123789 Hexa CDD	0.230
1234678 Hepta CDD	0.202
OCDD Octa CDD	0.007

Table 8: Summary statistics for Furans at Helsby during 2023.

Compound	Annual Mean (fgm^{-3} TEF)
2378 Tetra CDF	0.462
12378 Penta CDF	0.260
23478 Penta CDF	3.925
123478 Hexa CDF	0.613
123678 Hexa CDF	0.633
234678 Hexa CDF	0.780
123789 Hexa CDF	0.230
1234678 Hepta CDF	0.202
1234789 Hepta CDF	0.024
OCDF Octa CDF	0.001

Table 9: Summary statistics for PCBs at Helsby during 2023.

Compound	Annual Mean (fgm^{-3} TEF)
PCB-81	0.0017
PCB-77	0.0054
PCB-123	0.0003
PCB-118	0.0134
PCB-114	0.0004
PCB-105	0.0040
PCB-126	0.6825
PCB-167	0.0004
PCB-156	0.0006
PCB-157	0.0002
PCB-169	0.0045
PCB-189	0.0001

Bar plots showing the concentrations of Dioxins, Furans and PCBs measured at Helsby for each of the four periods in 2023 are shown in Figure 18 to Figure 20, below. The data for each period and compound are provided in Table C3 in Appendix A3.

Figure 18: Dioxin concentrations measured at Helsby during 2023.

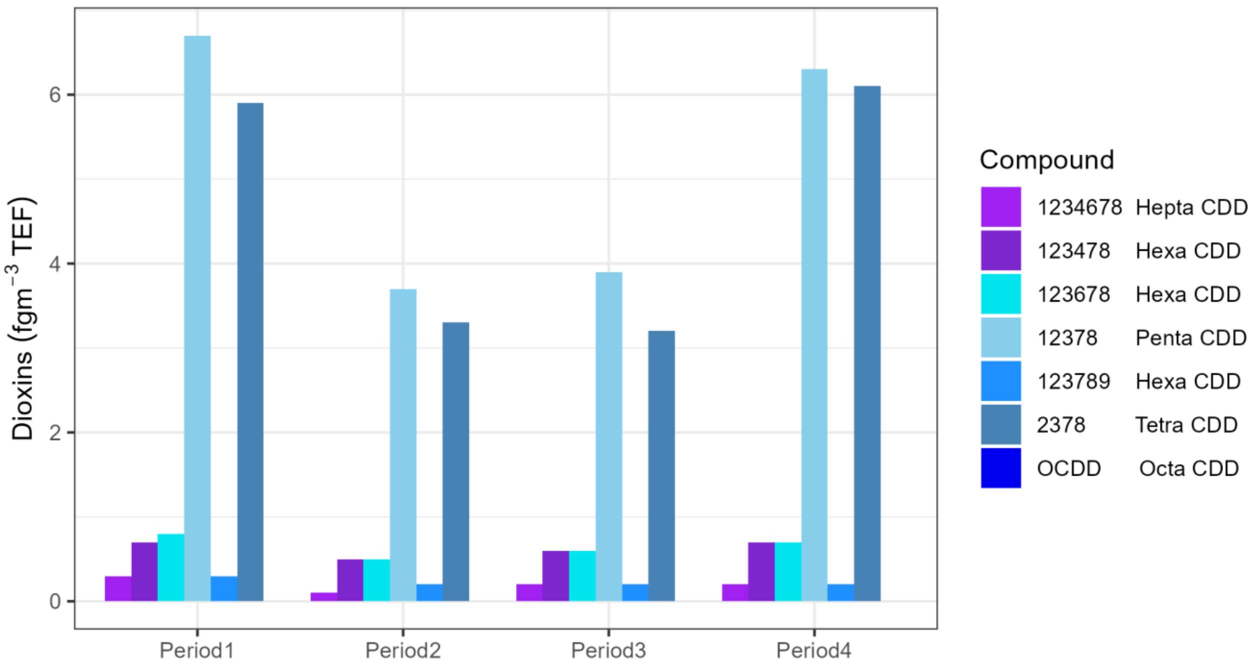


Figure 19: Furan concentrations measured at Helsby during 2023.

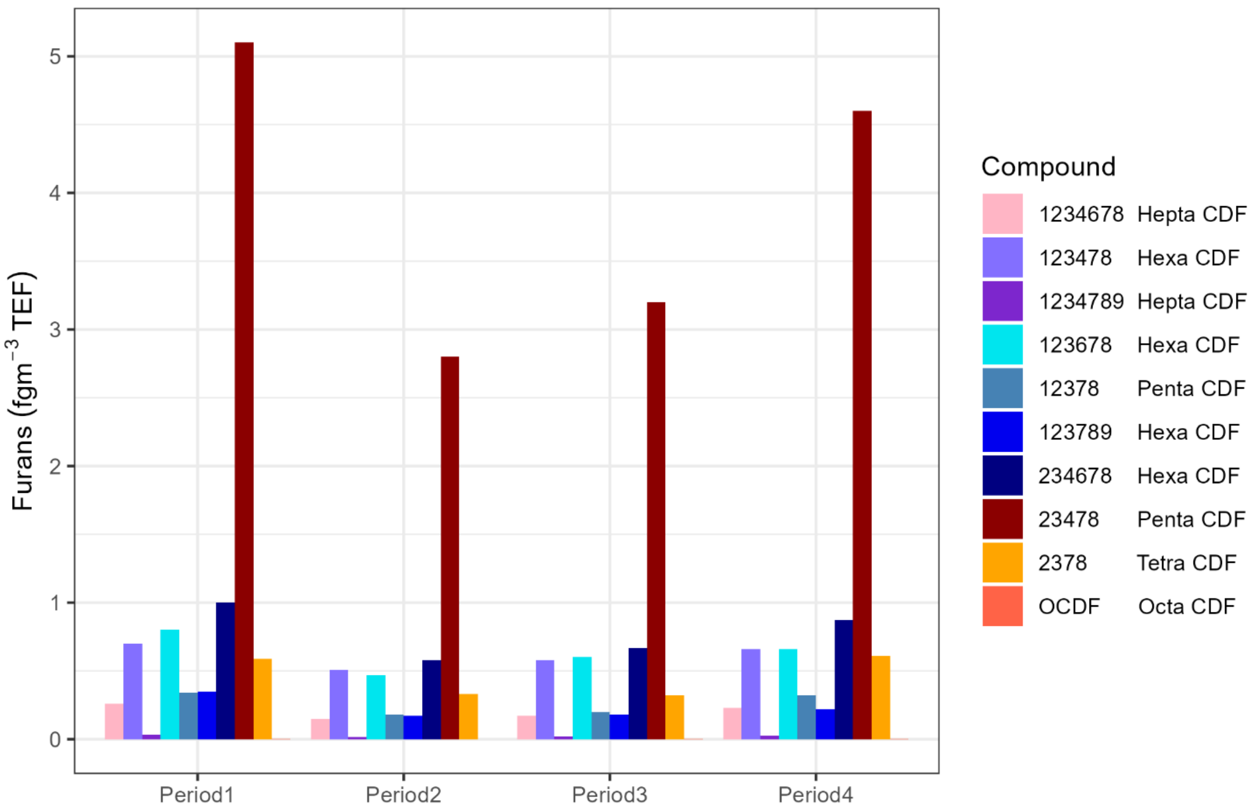


Figure 20: PCB concentrations measured at Helsby during 2023. Note, for PCB-126 actual concentrations are x10.

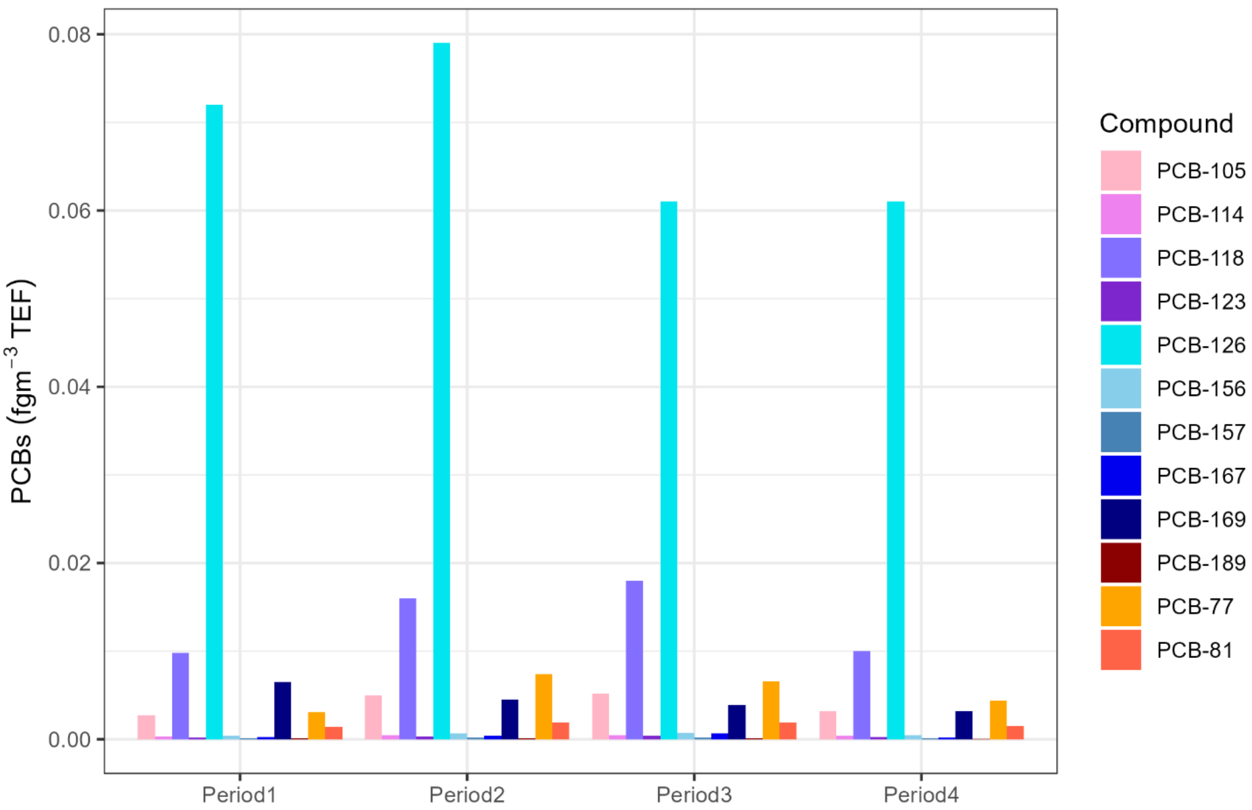


Figure 21 to Figure 23 below show the annual mean concentrations of dioxins, furans and PCBs measured at Helsby from 2020 to 2023. For the dioxins (Figure 21). There is an increase in concentrations in 2023 when compared to previous years for 123478 Hexa CDD, 12378 Penta CDD, and 2378 Tetra CDD, however decreases are observed for the other dioxins measured. Data from future monitoring will help determine if these are ongoing trends or just natural variability in the concentrations.

All furans measured (Figure 22) show similar variability across the four years of measurements, with higher concentrations observed in 2020 and 2022 and lower concentrations in 2021 and 2023. This is in contrast to the PCBs (Figure 23) which are typically higher in 2021. As for the dioxins future monitoring of these species will provide further information on whether consistent trends are present.

Figure 21: Annual mean concentrations of Dioxins from 2020 to 2023

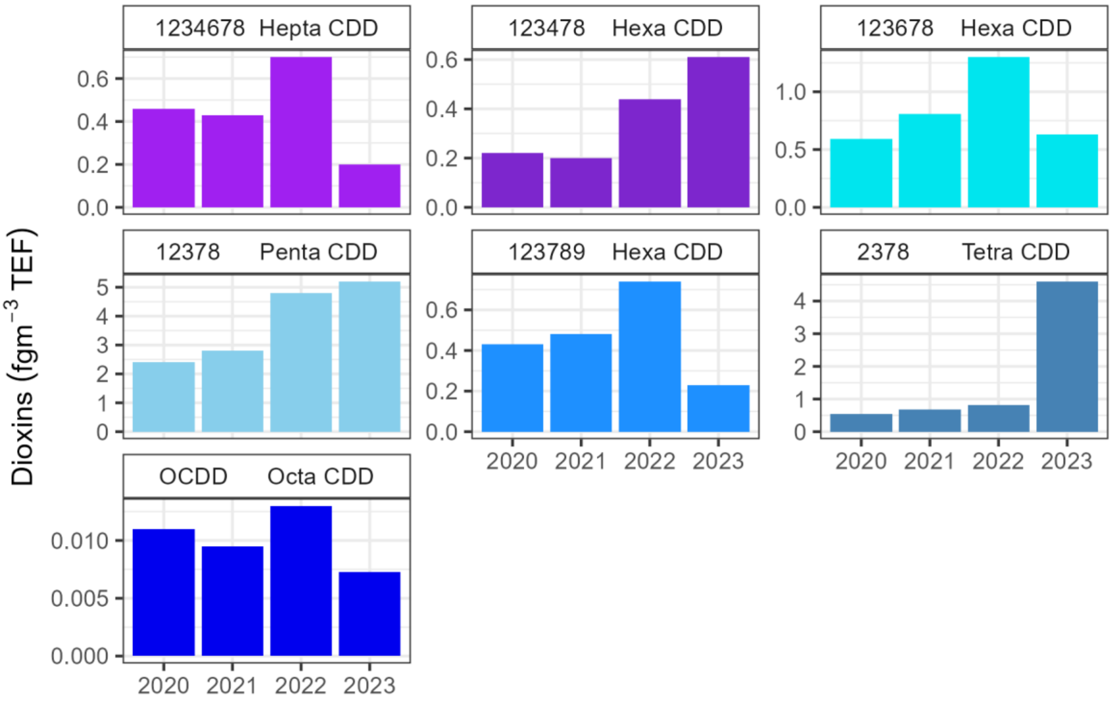


Figure 22: Annual mean concentrations of Furans from 2020 to 2023

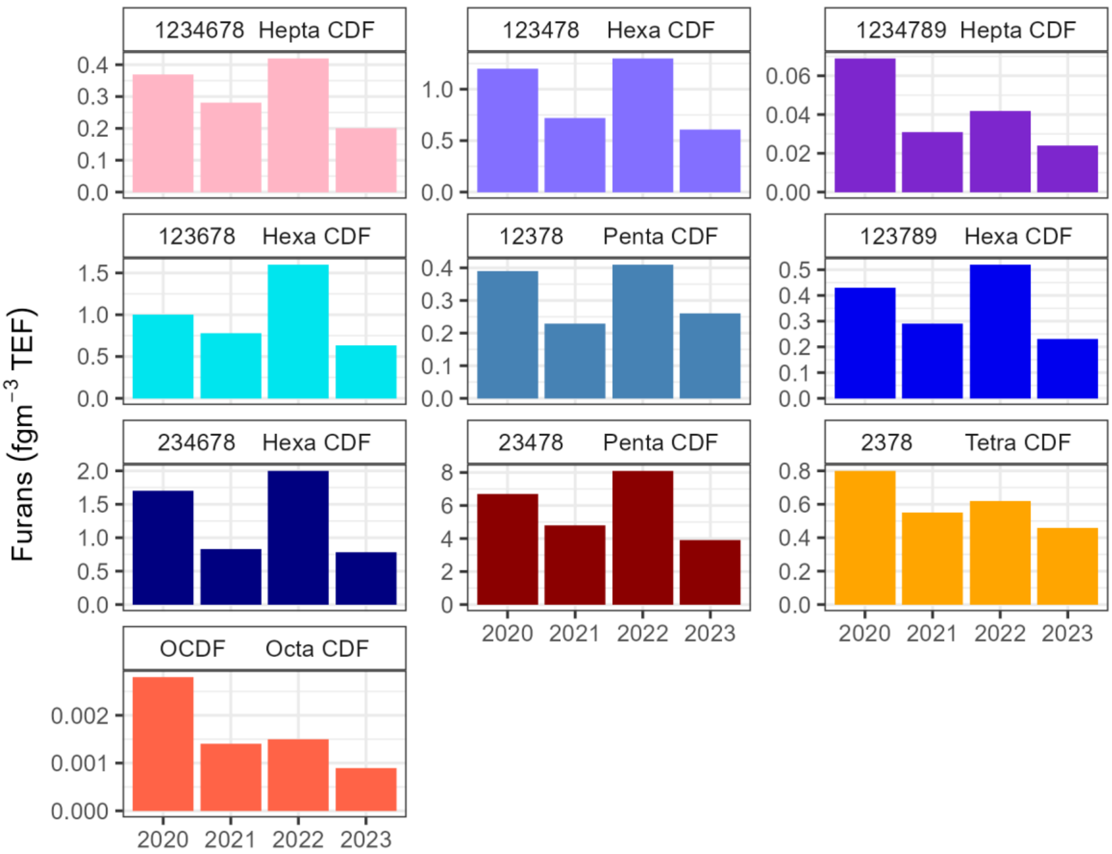
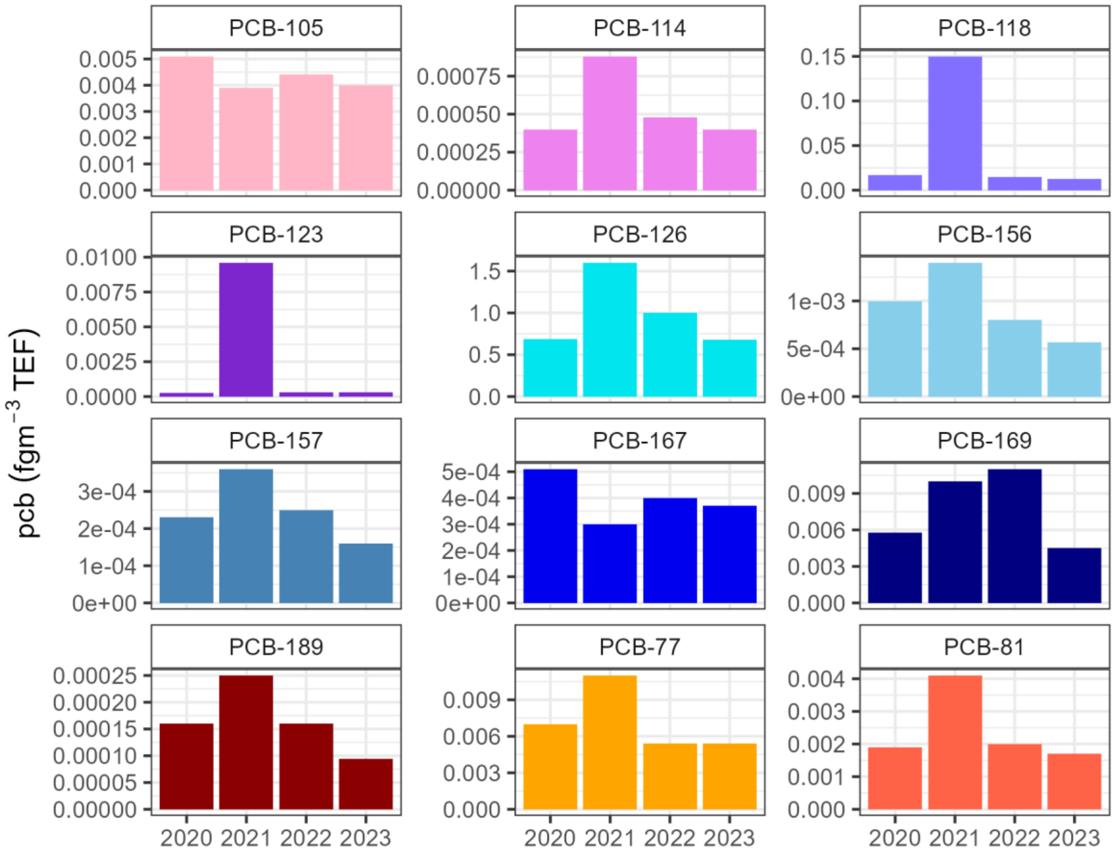


Figure 23: Annual mean concentrations of PCBs from 2020 to 2023



4. CONCLUSIONS

This report provides the results from the analysis of the pollutant data measured at the site in Helsby in 2023.

The results show that both PM_{10} and $PM_{2.5}$ annual means in 2023, were well below the annual mean AQS objective of 40 µgm^{-3} for PM_{10} and 20 µgm^{-3} for $PM_{2.5}$. There were no exceedances of the 24-hour PM_{10} limit of 50 µmg^{-3}.

Variations in hourly PM_{10} and $PM_{2.5}$ concentrations with wind speed and direction were assessed to investigate sources of particulates. Higher concentrations of PM_{10} and $PM_{2.5}$ were associated with high winds from the east or northwest, and from the east under calmer conditions.

Filter samples of PM_{10} were collected every month and heavy metal concentrations extracted. The annual mean concentrations for all metals with assessment levels were below the associated target values. Many of the metals were also below the limit of detection.

Samples were collected and collated every 3 months for analysis of dioxins, furans, PCBs, and PAHs. The annual mean concentration of Benzo(a)pyrene (B[a]P), which is used as a marker compound for PAHs, was 0.055 ngm^{-3} in 2023, which is below the European (1 ngm^{-3}) and UK (0.25 ngm^{-3}) objectives. Measured PAH concentrations decrease in 2023 when compared to the previous three years of measurements. The dioxins, furans, PCBs, were more variable, and increases were observed in some of the dioxins in 2023. However, this may be due to year-on-year fluctuations in concentrations and long-term data is required to make any robust conclusions.

5. REFERENCES

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APPENDICES

Appendix 1 Air Pollution Bandings

Table A1 *Description of air pollution bandings*

Banding	Index	Accompanying health messages for at-risk individuals
Low	1,2,3	Enjoy your usual outdoor activities.
Moderate	4,5,6	Adults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors.
High	7,8,9	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion.
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.

Appendix 2 Toxic Equivalency Factors

The International Toxic Equivalent (ITEQ) values for individual congeners are calculated for each sample using the WHO schemes. The factors are provided in Table B2. Where an isomer has a result less than the LOD a value equivalent to the LOD is used to determine the ITEQ. Therefore, these values represent a worst case assessment. Additional total ITEQ values are also calculated, assuming that where a result is less than the limit of detection then the ITEQ contribution is zero.

Table A2 Toxic equivalency factors for TOMPs

Compound	WHO TEF	Compound	WHO TEF
DIOXINS		**PCBs**	
2378 Tetra CDD	1	PCB-81	0.0003
12378 Penta CDD	1	PCB-77	0.0001
123478 Hexa CDD	0.1	PCB-123	0.00003
123678 Hexa CDD	0.1	PCB-118	0.00003
123789 Hexa CDD	0.1	PCB-114	0.00003
1234678 Hepta CDD	0.01	PCB-105	0.00003
OCDD Octa CDD	0.0001	PCB-126	0.1
FURANS		PCB-167	0.00003
2378 Tetra CDF	0.1	PCB-156	0.00003
12378 Penta CDF	0.05	PCB-157	0.00003
23478 Penta CDF	0.5	PCB-169	0.003
123478 Hexa CDF	0.1	PCB-189	0.00003
123678 Hexa CDF	0.1		
234678 Hexa CDF	0.1		
123789 Hexa CDF	0.1		
1234678 Hepta CDF	0.01		
1234789 Hepta CDF	0.01		
OCDF Octa CDF	0.0001		

Appendix 3 Datasets

Table C1 provides the analysis of heavy, metals for each period during 2023.

Table C1 Analysis of heavy metals for each period. Values with the prefix “<” denote data where the values were below the limit of detection.

start	end	Report ID	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Sb	Tl	V	Zn	Cr VI
31/01/2023	28/02/2023	ASC/58337.001	2.40	2.99	1.20	11.98	11.98	2.99	5.99	2.40	14.97	2.70	5.99	2.99	23.96	0.90
28/02/2023	28/03/2023	ASC/58523.001	2.40	2.99	1.20	5.99	8.98	2.99	2.99	2.40	5.99	2.40	5.99	5.99	14.97	1.80
28/03/2023	02/05/2023	ASC/59468.001	1.92	2.40	0.96	9.58	7.19	2.40	7.19	2.40	11.98	2.40	4.79	2.40	21.56	0.72
02/05/2023	30/05/2023	ASC/59469.001	2.40	3.00	1.20	11.98	8.99	3.00	8.99	2.40	8.99	3.00	5.99	3.00	14.98	0.90
30/05/2023	29/06/2023	ASC/61057.001	3.46	3.84	1.54	13.06	11.53	3.84	15.37	3.84	7.68	3.07	7.68	3.07	7.68	1.15
29/06/2023	27/07/2023	ASC/60133.001	2.40	2.99	1.20	8.98	2.99	2.99	2.99	2.99	2.99	2.40	5.99	2.10	2.99	0.90
27/07/2023	31/08/2023	ASC/60234.001	1.92	2.40	0.96	7.19	2.40	2.40	2.40	1.92	4.79	1.92	4.79	1.44	2.40	0.96
31/08/2023	28/09/2023	ASC/60948.001	2.99	2.99	1.20	14.97	11.98	2.99	8.98	2.99	11.98	2.70	5.99	2.40	11.98	0.90
28/09/2023	02/11/2023	ASC/61346.001	2.40	2.40	0.96	9.58	7.19	2.40	4.79	2.40	4.79	1.92	4.79	1.44	2.40	0.96
02/11/2023	07/12/2023	ASC/61450.001	5.99	2.99	1.20	17.96	11.98	2.99	8.98	2.99	17.96	5.99	5.99	1.80	26.95	0.90
07/12/2023	04/01/2024	ASC/61555.001	5.99	3.00	1.20	11.98	3.00	3.00	3.00	3.00	5.99	2.40	5.99	1.80	3.00	0.90

Table C2 Analysis of PAHs for each period.

Compound	Period 1	Period 2	Period 3	Period 4
Naphthalene	0.019	0.013	0.019	0.042
Acenaphthylene	0.004	0.001	0.001	0.012
Acenaphthene	0.026	0.023	0.020	0.038
Fluorene	0.153	0.123	0.089	0.230
Phenanthrene	1.336	1.505	1.286	2.151
Anthracene	0.059	0.025	0.038	0.143
Fluoranthene	0.582	0.498	0.453	1.083
Pyrene	0.408	0.308	0.281	0.799
Benzo(a)anthracene	0.063	0.018	0.024	0.139
Chrysene	0.137	0.048	0.043	0.200
Benzo(b)fluoranthene	0.140	0.036	0.025	0.193
Benzo(k)fluoranthene	0.046	0.011	0.009	0.071
Benzo(a)pyrene	0.066	0.014	0.011	0.129
Indeno(1,2,3-cd)pyrene	0.082	0.018	0.014	0.118
Dibenzo(ah)anthracene	0.010	0.002	0.001	0.011
Benzo(ghi)perylene	0.095	0.019	0.014	0.124
Benzo(j)fluoranthene	0.061	0.013	0.014	0.090
Dibenzo(ac)anthracene	0.009	0.002	0.001	0.012

Table C3 Analysis of Dioxins, Furans and PCBs, for each period.

Compound	Period 1	Period 2	Period 3	Period 4
DIOXINS				
2378 Tetra CDD	5.9	3.3	3.2	6.1
12378 Penta CDD	6.7	3.7	3.9	6.3
123478 Hexa CDD	0.7	0.51	0.58	0.66
123678 Hexa CDD	0.8	0.47	0.6	0.66
123789 Hexa CDD	0.35	0.17	0.18	0.22
1234678 Hepta CDD	0.26	0.15	0.17	0.23
OCDD Octa CDD	0.012	0.0035	0.0026	0.011
2378 Tetra CDF	0.59	0.33	0.32	0.61
12378 Penta CDF	0.34	0.18	0.2	0.32
23478 Penta CDF	5.1	2.8	3.2	4.6
123478 Hexa CDF	0.7	0.51	0.58	0.66
123678 Hexa CDF	0.8	0.47	0.6	0.66

Compound	Period 1	Period 2	Period 3	Period 4
234678 Hexa CDF	1	0.58	0.67	0.87
123789 Hexa CDF	0.35	0.17	0.18	0.22
1234678 Hepta CDF	0.26	0.15	0.17	0.23
1234789 Hepta CDF	0.035	0.018	0.022	0.023
OCDF Octa CDF	0.0011	0.00066	0.00083	0.00098
PCBs				
PCB-81	0.0014	0.0019	0.0019	0.0015
PCB-77	0.0031	0.0074	0.0066	0.0044
PCB-123	0.00021	0.00032	0.00042	0.00022
PCB-118	0.0098	0.016	0.018	0.01
PCB-114	0.00035	0.00043	0.00046	0.00038
PCB-105	0.0027	0.005	0.0052	0.0032
PCB-126	0.72	0.79	0.61	0.61
PCB-167	0.00024	0.00039	0.00065	0.0002
PCB-156	0.00041	0.00069	0.00073	0.00046
PCB-157	0.00014	0.00019	0.0002	0.00011
PCB-169	0.0065	0.0045	0.0039	0.0032
PCB-189	0.000089	0.00014	0.000083	0.000062

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