

## Appendix

### 1. BAQS location:



Figure 1: Map and the appearance of the Birmingham air quality supersite (BAQS, 52.46 N, 1.93 W)

### 2. List of instruments for the parameters used in the report

Table 1: List of instruments for the parameters used in the report

Parameter	Instrument	Manufacturer	Resolution
Temperature	WS300-UMB	Lufft GmbH	1 second
Wind speed	Windmaster	Gill	1 second
Ozone	Thermo 49i	Thermos scientific	1 minute
Nitrogen dioxide	T500U CAPS	Teledyne	1 minute
PM <sub>2.5</sub>	FIDAS 200E	PALAS	1 minute

### 3. Definition of Daily Air Quality Index (DAQI) and low, moderate, high level of air pollutants

DAQI is used to describe the levels of air pollution(<https://uk-air.defra.gov.uk/air-pollution/daq?view=more-info>), The index is numbered 1-10 and divided into four bands, low (1) to very high (10), to provide detail about air pollution levels in a simple way.

## PM<sub>2.5</sub> Particles

Based on the daily mean concentration for historical data, latest 24 hour running mean for the current day.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µgm <sup>-3</sup>	0-11	12-23	24-35	36-41	42-47	48-53	54-58	59-64	65-70	71 or more

## Nitrogen Dioxide

Based on the hourly mean concentration.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µg/m <sup>3</sup>	0-67	68-134	135-200	201-267	268-334	335-400	401-467	468-534	535-600	601 or more

## Ozone

Based on the running 8-hourly mean.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µg/m <sup>3</sup>	0-33	34-66	67-100	101-120	121-140	141-160	161-187	188-213	214-240	241 or more

## 4. Composition of PM<sub>2.5</sub>

The compositions of PM<sub>2.5</sub> in the report are categorized into four groups: black carbon, organic carbon, inorganic elements, and inorganic aerosols, based on the observation methods used in BAQS.

The instruments used in the measurement are as follows:

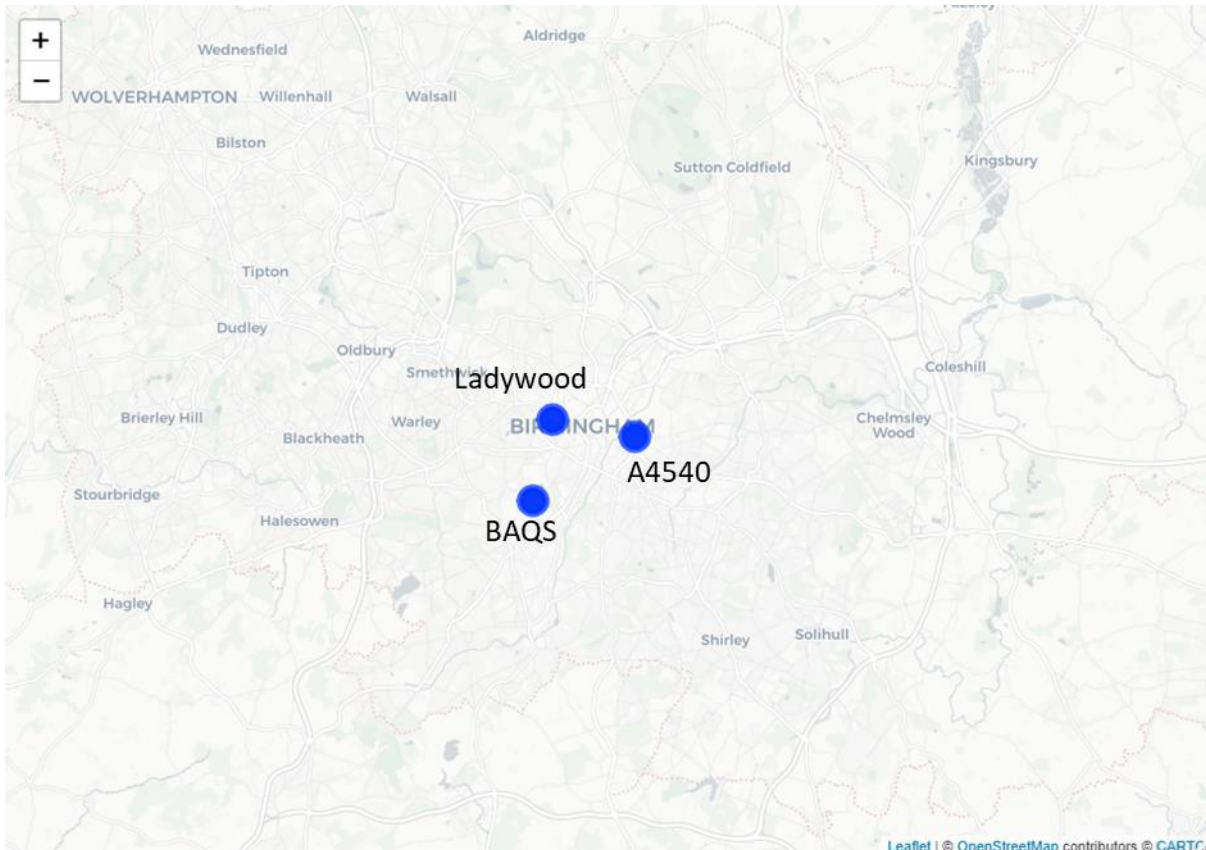
Table 2 instrument used to measure the PM<sub>2.5</sub> composition

Parameter	Instrument	Manufacturer	Resolution
<b>Black carbon</b>	Aethalometer AE33	Magee Scientific	1 minute
<b>Total carbon aerosol</b>	Total Carbon TCA08	Magee Scientific	1 hour
<b>Inorganic elements</b>	Xact 635i	Cooper environmental	1 hour

Black carbon is the sooty material from the incomplete combustion. Organic carbon is the organic carbonaceous compounds originating from anthropogenic and biogenic sources, as well as secondary organic aerosols (SOA). The inorganic elements include elements such as S, Cl, P, Br, Si, K, Ca, Fe, Mn, Cu, Pb, primarily sourced from soil, traffic emissions, wood burning, and industrial activities. chlorine

(Cl) is the dominant element in the measurement obtained at BAQS, which can be seen as a tracer of sea salt. Black carbon and inorganic elements are directly observed by measuring instruments. Organic carbon was determined by subtracting BC from the measured total carbon aerosol. Inorganic aerosols are obtained by subtracting black carbon, organic carbon, and inorganic elements from the total concentration of  $PM_{2.5}$ . This fraction mainly includes components such as sulphate, nitrate, ammonium, and inorganic oxides.

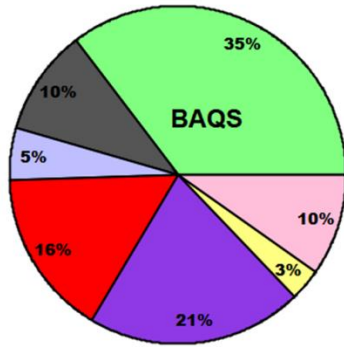
## 5. site of Ladywood and A4540



Ladywood site is an urban background sites in Birmingham. And “A4540” is an air quality monitoring site situated on the A4540 ring road around Birmingham city centre, which is a typical traffic sites. Both sites information and data can be found <https://uk-air.defra.gov.uk/data/>

## 6. Offline $PM_{2.5}$ composition analysis and source apportionment (preliminary: not published)

A one-year filter sampling was conducted in 2021 at the BAQS site, source apportionment was performed using a PMF model. It resulted in the identification of six  $PM_{2.5}$  sources: biomass burning, resuspended dust and traffic-related emissions, fuel oil combustion, sea salt, secondary aerosols from power generation and agriculture, and biogenic aerosols. Their contributions were estimated at 25%, 22%, 9%, 9%, 25%, and 10%, respectively.



OM EC Sea salt  $(\text{NH}_4)_2\text{SO}_4$   $\text{NH}_4\text{NO}_3$  Calcium salts Dust

Figure 2: pie chart of the  $\text{PM}_{2.5}$  composition determined in the offline filter sampling

Identified components	% Contribution to PM mass	Concentration ( $\mu\text{g m}^{-3}$ )
Biomass burning 1	19	1.5
Biomass burning 2	6	0.5
Resuspended dust-and traffic-related	22	1.7
Fuel oil combustion	9	0.7
Sea salt	9	0.7
*Secondary aerosols	25	1.9
Biogenic SOA	10	0.7

\*Secondary aerosols – including from power generation, agriculture, traffic

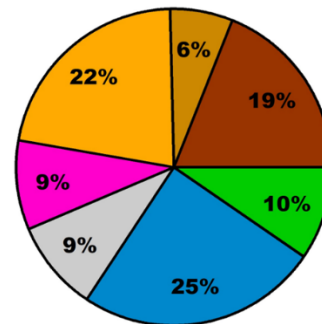


Figure 3: list and pie chart of the  $\text{PM}_{2.5}$  sources resolved by the PMF model

## 7. Glossary of abbreviations and definitions of terms used

**A4540 site:** Roadside monitoring station beside the A4540 (Watery Lane Middleway) which forms part of Birmingham's ring road. Located at the end of Keeley Street. The monitoring station is located approximately 6.5 metres from the kerb. Latitude/Longitude: 52.476145, -1.874978. [https://uk-air.defra.gov.uk/networks/site-info?site\\_id=BIRR](https://uk-air.defra.gov.uk/networks/site-info?site_id=BIRR)

**Aerosol:** a suspension of small size (generally under one micron) liquid or solid particles in air gas.

**Ammonium ( $\text{NH}_4^+$ ):** a reduced form of nitrogen most often indicative of agricultural emissions.

**Back trajectory analysis:** is a way to provide important information on air mass origins, often used to filter air mass origins to allow for more refined analyses of air pollution — for example trends in concentration by air mass origin. HYSPLIT trajectory model is the most extensively used model. <https://www.arl.noaa.gov/hysplit/>

**BAQS:** Birmingham air quality supersite

**BC:** Black Carbon, is the sooty black material emitted from gas and diesel engines, coal-fired power plants, and other sources that burn fossil fuel. It comprises a significant portion of particulate matter or PM, which is an air pollutant.

**CH<sub>4</sub>:** Methane, is a colourless, non-poisonous, flammable gas emitted by marshes and dumps undergoing anaerobic decomposition.

**CO:** Carbon Monoxide, is a colourless, odourless gas resulting from the incomplete combustion of hydrocarbon fuels. CO interferes with the blood's ability to carry oxygen to the body's tissues and results in adverse health effects.

**DAQI:** Daily Air Quality Index, shows levels of air pollution and provides recommended actions and health advice, <https://uk-air.defra.gov.uk/air-pollution/daq>

**Inorganic aerosols:** in this report the inorganic aerosols refer to the aerosols obtained by subtracting concentrations of black carbon, organic carbon, and inorganic elements from the total concentration of PM<sub>2.5</sub>. They are mainly sulphate, nitrate and ammonium.

**Inorganic elements:** in this report the inorganic elements refer to the elements detected by the Xact625i instrument, include such as S, Cl, P, Br, Si, K, Ca, Fe, Mn, Cu, Pb... in total of 65 elements. They are primarily sourced from soil, traffic emissions, wood burning, and industrial activities.

**Ladywood site:** an urban background site at St Marks Crescent Birmingham, Latitude/Longitude: 52.481346, -1.918235. [https://uk-air.defra.gov.uk/networks/site-info?site\\_id=BMLD](https://uk-air.defra.gov.uk/networks/site-info?site_id=BMLD)

**NH<sub>3</sub>:** ammonia, a pungent, colourless, gaseous pollutants formed mainly from volatilisation of decomposing excreta or fertilisers. NH<sub>3</sub> is alkaline, but may be acidifying if oxidised to nitrate in soils.

**Nitrates (NO<sub>3</sub><sup>-</sup>):** an oxidized form of nitrogen most often indicative of mobile source or power plant emissions. Those gases and aerosols that have origins in the gas-to-aerosol conversion of nitrogen oxides.

**NO<sub>2</sub>:** Nitrogen Dioxide, a gas consisting of one nitrogen and two oxygen atoms. It absorbs blue light and therefore has a reddish-brown colour associated with it.

**O<sub>3</sub>:** ozone, is not emitted directly into the atmosphere, but is a secondary pollutant generated following the reaction between nitrogen dioxide (NO<sub>2</sub>), hydrocarbons and sunlight. Whereas nitrogen dioxide acts as a source of ozone, nitric oxide (NO) destroys ozone and acts as a local sink (NOX-titration). For this reason, O<sub>3</sub> concentrations are not as high in urban areas (where high levels of NO are emitted from vehicles) as in rural areas. Ambient concentrations are usually highest in rural areas, particularly in hot, still and sunny weather conditions which give rise to summer "smogs".

**Organic carbon:** organic part in carbonaceous aerosol, may be either primary or secondary. Sources of primary organic carbon are the incomplete combustion of organic materials and the degradation of carbon containing products such as vehicle tyres and of vegetation. Degradation of any material is likely to give rise to particles with larger sizes than those resulting from combustion. Secondary organic carbon is formed through the condensation, or sorption onto other particles of organic carbon gases. Sources of organic carbon gases may be from the combustion of organic material, the evaporation of fuels, or the natural emission of volatile organic compounds from vegetation.

**PM<sub>10</sub>:** Particulate Matter less than 10 microns, tiny solid or liquid particles of soot, dust, smoke, fumes, and aerosols. The size of the particles (10 microns or smaller, about 0.0004 inches or less) allows them to easily enter the air sacs in the lungs where they may be deposited, resulting in adverse health effects. PM<sub>10</sub> also reduces visibility.



**PM<sub>2.5</sub>:** Particulate Matter less than 2.5 microns, tiny solid or liquid particles, generally soot and aerosols. The size of the particles (2.5 microns or smaller, about 0.0001 inches or less) allows them to easily enter the air sacs deep in the lungs where they may cause adverse health effects; PM<sub>2.5</sub> also causes visibility reduction.

**PMF model:** Positive Matrix Factorization Model, is a mathematical receptor model developed to provide scientific support for the development and implementation of air and water quality standards, and environmental forensics. PMF Model reduces the large number of variables in complex analytical data sets to combinations of species called source types and source contributions. The source types are identified by comparing them to measured profiles. Source contributions are used to determine how much each source contributed to a sample. In addition, PMF provides robust uncertainty estimates and diagnostics.  
<https://www.epa.gov/air-research/positive-matrix-factorization-model-environmental-data-analyses>

**Primary aerosols:** Aerosols injected into the atmosphere directly, Sea spray, mineral dust, smoke, and volcanic ash are all primary aerosols.

**Secondary aerosols:** aerosols which were emitted in another form (e.g. gases), then become aerosol particles after going through chemical reactions in the atmosphere.

**SO<sub>2</sub>:** Sulphur Dioxide, is a corrosive, acidic gas which combines with water vapour in the atmosphere to produce acid rain. Both wet and dry deposition have been implicated in the damage and destruction of vegetation and in the degradation of soils, building materials and watercourses. SO<sub>2</sub> in ambient air is also associated with asthma and chronic bronchitis.

**SOA:** secondary organic aerosol, in contrast to primary organic aerosols, which are emitted directly from the biosphere, SOAs are either formed via homogeneous nucleation through the successive oxidation of gas-phase organic compounds, or through condensation on pre-existing particles. These gas-phase species exert high vapor pressures, meaning they are volatile and stable in the gas-phase.

**Sulphate (SO<sub>4</sub><sup>2-</sup>):** a type of particle formed in the atmosphere when gaseous sulphur dioxide (SO<sub>2</sub>) interacts with other oxidants.

**SVOCs:** Semi-volatile organic compounds, are more likely to be liquids or solids at lower temperatures. Some examples of products that include SVOCs are many pesticides, oil-based products, and fire retardants. SVOCs can deposit on outdoor surfaces. VOCs are more likely to be dispersed, and monitored for, in the air.

**µg m<sup>-3</sup>:** micrograms per cubic metre. A concentration of 1 µg m<sup>-3</sup> means that one cubic metre of air contains one microgram (10<sup>-6</sup> grams) of pollutant.

**Urban background site:** Located such that its pollution level is not influenced significantly by any single source or street, but rather by the integrated contribution from all sources upwind of the station e.g. by all traffic, combustion sources etc. upwind of the station in a city. These sampling points shall, as a general rule, be representative for several square kilometres.

**Urban traffic site:** Located such that its pollution level is determined predominantly by the emissions from nearby traffic (roads, motorways, highways). Air sampled at traffic sites must be representative of air quality for a street segment no less than 100 m length. Sampling probes shall be at least 25 m from the edge of major junctions and no more than 10 m from the kerbside.

**VOCs:** Volatile Organic Compounds; family of highly evaporative organic materials used in a variety of industrial applications, such as paints and solvents; VOCs emissions are major pre-cursors of ground-level ozone and smog.

**WHO:** World Health Organization, the United Nations agency working to promote health, keep the world safe and serve the vulnerable.