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Sources of fine particles ($PM_{2.5}$) in the West Midlands

A report from the WM-Air project team

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Microscopic airborne particles ($PM_{2.5}$) are the air pollutants with the greatest impact upon health in the West Midlands, responsible for up to 2070 early deaths each year. $PM_{2.5}$ concentrations are 2-3 times higher than World Health Organisation guideline levels. Identifying the sources of $PM_{2.5}$ is key to designing effective policies for cleaner air. Through the application of state-of-the-science methods, the major sources of $PM_{2.5}$ in the West Midlands have been identified as: biomass burning (25%), secondary inorganic aerosol (25%), primary traffic related emissions (22%), secondary biogenic aerosol (10%), industrial activity (9%) and sea salt (9%). Reducing emissions from biomass (wood) burning and road traffic exhaust, should be policy priorities for local, regional and national government to reduce the health impacts of air pollution.

Air quality in the West Midlands

Air quality is the largest environmental threat to human health in the UK [1] with the burden of long-term exposure to air pollution equivalent to 29,000 – 43,000 early deaths a year [2]. In the West Midlands the ambient pollutants of greatest concern are nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$; particles with a diameter of 2.5 µm or below). Of these pollutants, $PM_{2.5}$ has the greatest impact on health with up to 2,070 early deaths attributable to long term $PM_{2.5}$ exposure[3] each year in the region.

Following the Environment Act, 2021, an annual average $PM_{2.5}$ target level for England of 10 µg m^{-3} was set, to be achieved by 2040, with an interim target of 12 µg m^{-3} to be achieved by January 2028. The World Health Organisation issues non-binding guideline levels of air pollutants for the protection of human health with a guideline level for $PM_{2.5}$ of 5 µg m^{-3}.

Unlike NO_x which is primarily emitted by road traffic, $PM_{2.5}$ has a broad range of both primary (particles emitted directly into the atmosphere) and secondary (particles formed in the atmosphere) sources of natural and human origin. $PM_{2.5}$ also has a long atmospheric lifetime, meaning that local concentrations are impacted both by local emission sources and a regional background. The impact of this background on $PM_{2.5}$ concentrations is dependent on the prevailing weather conditions and pollution sources in the surrounding region. Understanding the contribution of both primary and secondary sources to total $PM_{2.5}$ concentrations is necessary when designing policy interventions to control concentrations of $PM_{2.5}$.

Sources of $PM_{2.5}$ in the West Midlands

In order to identify the factors contributing to $PM_{2.5}$ concentrations in the West Midlands region, filter samples were collected from January 2021 to February 2022 at two urban background sites: Birmingham Air Quality Supersite (BAQS) and the AURN sampling site at Birmingham Ladywood (LW)[4].

Filters were analysed for Organic Carbon (OC), Elemental Carbon (EC), Ions, Metals and Organic compounds. These species were then used to

[1] Public Health England: Health matters: air pollution. Guidance. London: PHE, 2018.

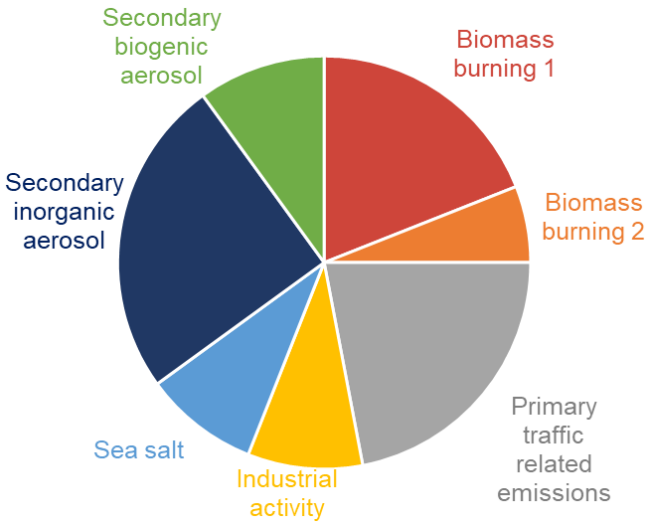
[2] Mitsakou C., et al.: Updated mortality burden estimates attributable to air pollution. Chemical Hazards and Poisons Report, 28, 2022

[3] Hall J., et al.: Regional impact assessment of air quality improvement: The air quality lifecourse assessment tool (AQ-LAT) for the West Midlands combined authority (WMCA) area. Environ Pollut., 356, 2024

[4] Srivastava D., et al..: Comparative receptor modelling for the sources of fine particulate matter ($PM_{2.5}$) at urban sites in the UK. Atmos. Environ., 343, 2025

identify the factors contributing to total $PM_{2.5}$ concentrations using positive matrix factorisation, an extensively used receptor modelling approach. For a full method description see Srivastava et al., 2025[4].

Seven factors were identified: two Biomass burning factors, primary traffic related emissions, industrial activity, sea salt, secondary inorganic aerosol and secondary biogenic aerosol.



Biomass burning

The first biomass burning factor, Biomass burning 1, accounted for 19% of $PM_{2.5}$. This factor followed the profile expected of wood burning for heating with concentrations higher in the winter than in the summer. The contribution of this source to total $PM_{2.5}$ mass was higher at BAQS than at LW which is consistent with the older houses present in Selly Oak and Edgbaston being more likely to have chimneys and fireplaces than the more modern estates around the Ladywood site.

A second biomass burning factor, Biomass burning 2, did not show a seasonal pattern and the contribution of this factor to total $PM_{2.5}$ mass was similar at both sites. This suggests that this source could be linked to other activities such as garden waste burning, barbecues or commercial biomass combustion. This factor accounted for 6% of annual average $PM_{2.5}$ mass across the two sites.

Primary traffic related emissions

Primary traffic related emissions are made up of tyre and brake abrasion as well as resuspension of road dust and particles emitted from the exhaust (many of the gases emitted from vehicle exhausts react in the atmosphere to form secondary inorganic aerosol). This factor made up 22% of $PM_{2.5}$ mass annually.

Industrial activity

Industrial activity, characterised by sulfate (SO_4^{2-}) and metal ions made up 9% of total $PM_{2.5}$ annual average mass concentration.

Sea salt

Sea salt is emitted from the sea as salt spray and from road de-icing salt and is observed throughout the UK. This factor accounted for 9% of total $PM_{2.5}$ mass which is consistent with other sites in the central UK.

Secondary inorganic aerosol

Secondary inorganic aerosol is dominated by nitrate (NO^{3-}), sulphate (SO_4^{2-}) and ammonium (NH^{4+}) ions. These species are formed in the atmosphere from the emission of gaseous pollutants from traffic, industrial and agricultural sources. This factor accounted for 25% of $PM_{2.5}$ mass across the 2 sites.

Secondary biogenic aerosol

Biogenic volatile organic compounds are emitted from plants; many of these are familiar, for example, pine scent and the smell of cut grass. In polluted environments these compounds can be oxidised to form particulates. This factor contributed to 10% of $PM_{2.5}$ mass concentration at both sites.

Table 1. Sources of $PM_{2.5}$ averaged across the Birmingham Air Quality Supersite (BAQS) and the Ladywood AURN sampling (LW) in 2021/2022.

Identified Sources	Contribution to PM mass (%)	Concentration (µg m^{-3})
Biomass burning 1	19	1.5
Biomass burning 2	6	0.5
Primary traffic related emissions	22	1.7
Industrial activity	9	0.7
Sea salt	9	0.7
Secondary inorganic aerosol	25	1.9
Secondary biogenic aerosol	10	0.7