

The UK Clean Air Act at 70: An interdisciplinary analysis of historical air quality change

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Britain's historic smoke-fog problem

Poor outdoor air quality has been an issue in British towns and cities since the thirteenth century (Heidorn, 1978; Fowler *et al.*, 2020). Air pollution in connection to coal use in London can be traced back over 700 years (Brimblecombe, 1976; Cavert, 2016). The city was the focus of the first published work on smoke emissions, *Fumifugium: The inconveniencie of the aer and smoak of London*, by John Evelyn (Evelyn, 1661). Three centuries later during the industrial revolution, London became known as 'The Big Smoke' (Brimblecombe, 1987). Edinburgh was similarly referred to as 'Auld Reekie' (Scots for 'Old Smoky'), a phrase propagated by Robert Fergusson's poem of the same name published in 1773 (e.g. Fergusson, 2000). Industrial expansion, population growth and mounting energy demands in the late eighteenth and nineteenth century led to a dramatic increase in smoke and soot emissions from coal combustion across the UK (Kander *et al.*, 2013; Mosley, 2013). By the

twentieth century, chronic air pollution and episodic smoke-fog events caused by coal burning were a regular, recognised and largely accepted feature of urban life (Cavert, 2016; Fowler *et al.*, 2020).

Outdoor air pollution was especially visible in winter. High levels of smoke from coal fires combined with cold, still and moist weather conditions caused pollution to linger like fog rather than dissipate into the atmosphere (Brimblecombe, 2006). Hence, the term smog (smoke-fog) was coined in 1905 to differentiate between normal fog and coal smoke that became trapped at low levels because of the weather (Stradling and Thorsheim, 1999). As one contemporary commentator explained, fog was a normal atmospheric condition that did little harm, while smog caused by pollution from chimneys was dangerous and preventable (Figure 1). Nevertheless, air pollution was so closely linked to foggy weather that the terms fog and smog were often used interchangeably. Even the first scientists to analyse the Great London Smog of 1952, a monumental event in UK air pollution history, used the term fog (Wilkins, 1954).

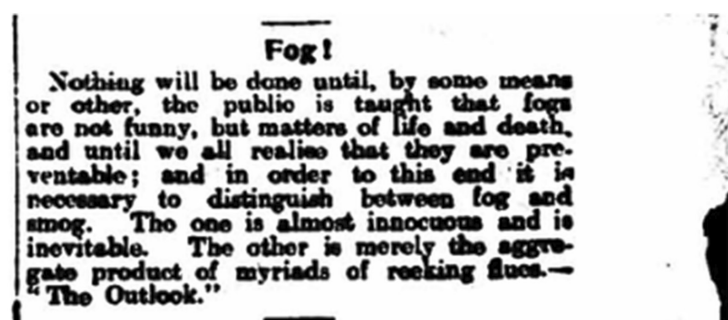
This article explores Britain's air pollution problem from the acceleration of coal smoke emissions in the nineteenth century to the eventual decline of smog after the Clean Air Act 1956, by combining research using historical documentary evidence (archival sources) and data-modelling methodologies. The article outlines the London Smog 1952 and the subsequent Clean Air Act as two pivotal moments in air quality history. The discussion then moves beyond London to address air pollution in three other major UK cities: Glasgow, Sheffield and Cardiff. These cities were chosen

because of their historically industrialised economies, their geographical spread across the UK and their individual air quality histories that spotlight different aspects of the wider national and temporal view. By traversing these three case studies through an interdisciplinary lens over different periods in time, this article reveals the wider chronology and geography of historical air quality change in Britain.

The Great Smog of London 1952

In November 1952, the UK Met Office recorded the weather in the UK as '*cold; considerable snowfall towards the end of the month*' with mean air temperatures of -7°C , the coldest on record in over 25 years (Met Office, 1952a). These conditions persisted into the first week of December, with a low maximum temperature of -1.6°C in London and extreme lows of -9°C in the South East (Met Office, 1952b). An anticyclone in the London area also created a strong temperature inversion, which pushed the cold air towards ground level and produced prime conditions for low-lying fog. Meanwhile, outdoor smoke emissions mounted as people burned more coal to stay warm during the cold temperatures (Met Office, 2025).

From 5 to 9 December 1952, pollution in London rose to unprecedented levels (Wilkins, 1954). The pollution was exacerbated by the extensive burning of high-sulphur, low-grade fuels necessitated by the post-war fuel crisis and rationing, urban poverty and the exportation of higher-grade coal to service war debts (Wilkins, 1954; Thorsheim, 2006). The high-pressure



Fog!
Nothing will be done until, by some means or other, the public is taught that fogs are not funny, but matters of life and death, and until we all realise that they are preventable; and in order to this end it is necessary to distinguish between fog and smog. The one is almost innocuous and is inevitable. The other is merely the aggregate product of myriads of reeking flues. —
"The Outlook."

Figure 1. Commentary on 'Fog!' published in the Daily Record, 29 December 1905 (The Outlook, 1905, reproduced with permission from REACH PLC).

weather system over the city trapped vast quantities of coal smoke beneath the inversion layer (Brimblecombe, 2006). With little wind or atmospheric disturbance, this formed a dense and dangerous smog. There were 1000 tonnes (t) of smoke particles, 2000t of carbon dioxide, 140t of hydrochloric acid, 14t of fluorine compounds and 370t of sulphur dioxide, that converted into 800t of sulphuric acid, being added to the atmosphere each day during the 5-day smog event (e.g. Fenger, 2009; Met Office, 2025).

Smog was so normalised in 1950s Britain that there was little immediate concern, despite visibility declining to almost nil. The Met Office weather report for December recorded the 'long spell of smoke laden fog in the London area' as a notable feature that month, but the extent of the damage was only realised later (Met Office, 1952b). Undertakers, for example, were accustomed to rising demand from smog-related mortality in the winter months, especially in relation to the elderly and chronically ill (Berridge and Taylor, 2005). But when coffin stores depleted and florists ran out of flowers, the full impact of the crisis became increasingly clear (BBC News, 2002). Over 4000 people were killed during the 5-day emergency and up to 12000 people died in the longer term due to injury to health caused by the pollution (Mosley, 2017).

The Great London Smog led to a public inquiry by the Beaver Committee on Air Pollution, whose final report was published in November 1954. The report, alongside mounting public pressure, finally forced the government to adopt far-reaching legislation to improve air quality. The first UK Clean Air Act received royal assent on 5 July 1956 and came into effect in December that year, 4 years after the Great Smog in London (Ashby and Anderson, 1981).

The Clean Air Act 1956

The Clean Air Act 1956 was the first national legislation to directly address the endemic, centuries-old problem of air pollution in Britain. Scientific research on air quality and smoke abatement campaigning date back to the nineteenth century, but Britain's coal dependency and popular acceptance of industrial and domestic smoke was a persistent barrier to serious change. Local authorities, such as Coventry Council, introduced smokeless zones as part of their reconstruction plans after the Second World War, but the Great Smog forced a leap in public discourse on the politics and policy around how and why Britain should clean up its air (Davies, 2025).

Significantly, the Act restricted the burning of bituminous coal in domestic hearths for the first time and set national air quality standards. The government also provided

funding for 40% of the costs to support the conversion of traditional coal grates to smokeless solid fuels such as coke and anthracite, and later, gas and electric systems. The remaining costs were funded equally by local authorities and households (Mosley, 2017). This legislative shift was reinforced by broader changes in the UK's energy system, most notably the discovery of North Sea gas in 1965, which propelled the transition from coal to cleaner-burning fuels (Davies, 2025).

The impact of the Clean Air Act, which was implemented within a wider context of deindustrialisation and energy transition in the late twentieth century, can be seen in the associated decline in air pollution in London (Figure 2). Fine particulate matter (PM_{2.5}) is used here as a proxy for overall air pollution, given its strong association with the combustion of solid fuels, particularly coal, which was the dominant source of fuel for homes and industry in Britain until the 1970s.

Beyond London: a tale of three cities

The Great London Smog of 1952 and the subsequent Clean Air Act 1956 were both landmark events that have been the focus of previous historical research (Ashby and Anderson, 1981; Brimblecombe, 1987; Thorsheim, 2006; Mosley, 2013, 2017). These

moments had shock factor and have had illustrative value for scientists in the contemporary context. But it is important to remember that air pollution was not confined to London, and it did not immediately disappear after the Clean Air Act. While national legislation delivered an important framework for the transition to smokeless fuels, experiences of air quality within local communities varied, and improvements took time. Looking beyond London to three other UK cities, Glasgow, Sheffield and Cardiff, illuminates the bigger picture.

Glasgow, Southwest Scotland

The industrial revolution in Glasgow transformed the city into a global economic powerhouse built on coal mines and iron foundries. By the late-nineteenth century, the city was a centre of British shipbuilding and heavy engineering. This had a major impact on air quality, which was recognised and resisted by people who lived there (Mosley, 2013). But smoke in the Victorian age was also considered a necessary by-product of industrial wealth (Brimblecombe, 1987). As one popular song (quoted in Mosley, 2013) exclaimed:

*There's coal underground,
There's coal in the air,
There's coal in folk's faces,
There's coal everywhere;
But – there's money in Glasgow!*

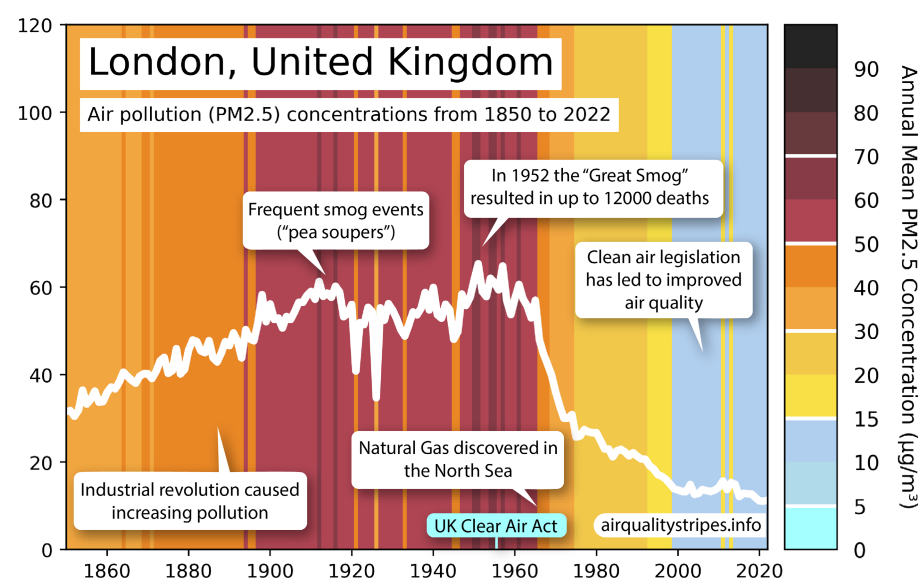


Figure 2. Annual mean, historical particulate matter air pollution (PM_{2.5}) concentrations for London, UK, displayed as Air Quality Stripes (airqualitystripes.info, Pringle et al., 2025). Recent values (2000–2022) use the satellite dataset of Van Donkelaar et al. (2021). Values prior to 2000 are derived from atmospheric model simulations (Turnock et al., 2020) driven by CMIP6 emission inventories (Hoesly et al., 2018). Model values are bias-corrected to the satellite record following Pringle et al. (2025). The white trend line shows the same data as the coloured stripes (PM_{2.5}, $\mu\text{g m}^{-3}$) but allows clearer identification of short-term variability. Colour bar sections are grouped by a subjective health category (e.g. <https://airqualitystripes.info/stripes/?continent=Europe&country=United%20Kingdom&city=London&plot=stripes>), from the bottom (from blue through yellow, orange, red, brown and finally black): 'Good', 'Fair', 'Moderate', 'Poor', 'Very Poor' and 'Extremely Poor'; Pringle, 2025). The model is not nudged to meteorological observations; it captures historical trends but cannot reproduce specific short-term weather events.

In autumn 1909, severe smog overwhelmed the city and killed at least 1000 people (Evening Dispatch, 1911). It was reported that 'the weather in Glasgow is the most severe that has been experienced for a generation', and that reduced visibility had also caused deaths by collisions with trams and accidental drowning in the River Clyde (Birmingham Daily Gazette, 1909). Mortality rates rose by 82% that November with deaths from respiratory disease increasing from 25% to 40% of the total (Mosley, 2013).

Significantly, this event gained the attention of Dr Henry des Voeux, the scientist and campaigner that coined the portmanteau, smog, a few years before. There was already some public awareness of the connection between pollution and poor respiratory health by the early twentieth century, hence the market for 'medicines' claiming to combat the effects of smog that were frequently advertised in the local press (Figure 3). However, des Voeux's analysis of the 1909 Glasgow smog directly connected episodic air pollution disasters with mortality statistics in the city. These death rates were subsequently used by the Coal Smoke Abatement Society in London to raise awareness of the impacts of air pollution on human life (Simmons, 2009, 2019). The local experience of Glasgow informed the national picture.

Half a century later in 1959, it was reported that a 47-day smog in the city had cost Clydeside £20 million (Sunday Post, 1959). Smog was recorded as 'the most notable influence on Glasgow's health' that year (The Scotsman, 1960). The 1959 smog, which occurred 3 years after the Clean Air Act, was indicative of the gradual rather than the immediate effect of legislative change.

Figure 4 shows the estimated annual mean PM_{2.5} concentrations in Glasgow. The model used to reconstruct historical data was not 'nudged' to observe meteorological conditions and, therefore, it can capture trends but not specific short-term weather-driven pollution events. Episodic air pollution disasters were also typically short-lived and may be obscured within annual mean values. Nevertheless, the 1909 and 1959 Glasgow smogs occurred during periods of persistently elevated PM_{2.5} concentrations, representing some of the most prolonged episodes of poor air quality in the city since 1850.

Sheffield, South Yorkshire

Sheffield was one of the first local authorities to introduce bylaws against smoke in 1853; it hosted the Smoke Abatement Exhibition in 1909 and, with Glasgow and Manchester, established the Smoke Abatement League of Great Britain. The 'Steel City' had a long tradition of campaigning against air pollution but, like Glasgow, heavy industry was cen-

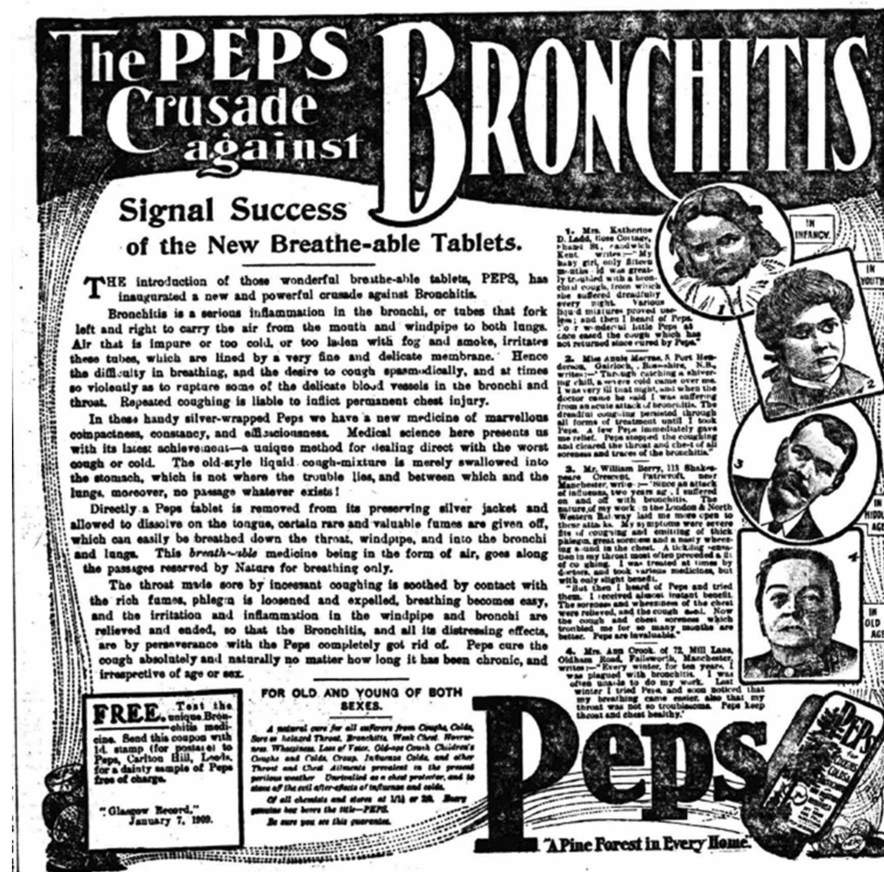


Figure 3. Advertisement for PEPS breathable tablets featured in the Daily Record and Mail, 1909 (PEPs, 1909, reproduced with permission from REACH PLC).

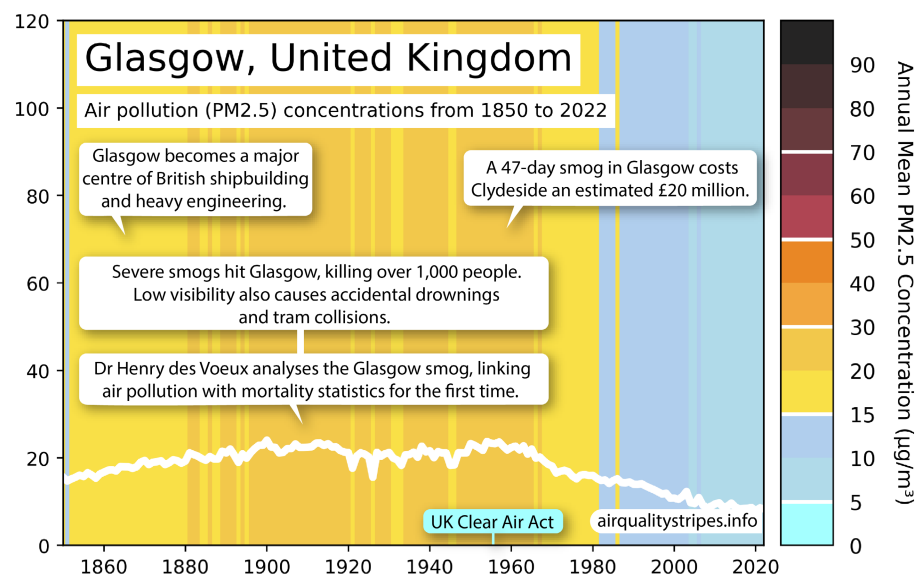


Figure 4. Historical annual PM_{2.5} concentrations in Glasgow were significantly lower than in London, Sheffield or Cardiff, likely due to stronger atmospheric removal (from strong Atlantic winds and high rainfall) and possibly also because major industrial emission sources were concentrated in the docklands rather than distributed across the city. Despite this, episodic weather conditions still lead to short-term buildups with high concentrations.

tral to the local economy and impacted air quality. The extent of the pollution from factories on the banks of the River Don during the interwar years, for example, is visible in Figure 5. As the Chief Smoke Abatement Officer for Sheffield insisted decades later in

1952 (the same year as the Great London Smog), the city was 'as dirty as it's ever been' (Davies, 2025).

Following the Clean Air Act 1956, Sheffield was one of many 'black areas' across the country that were slow to implement change.

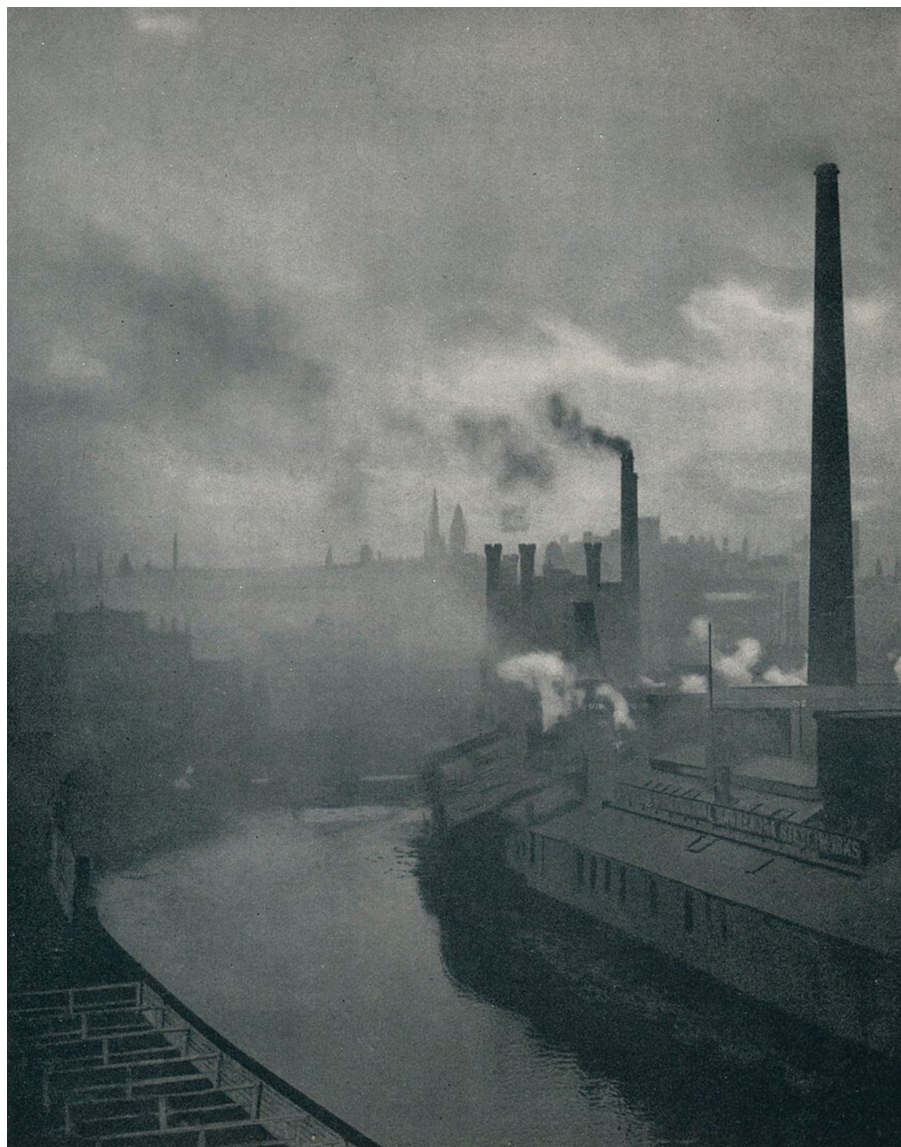


Figure 5. Reginald Belfield, 'Where the shells came from' (Sheffield), (Belfield, 1927, Public domain.)

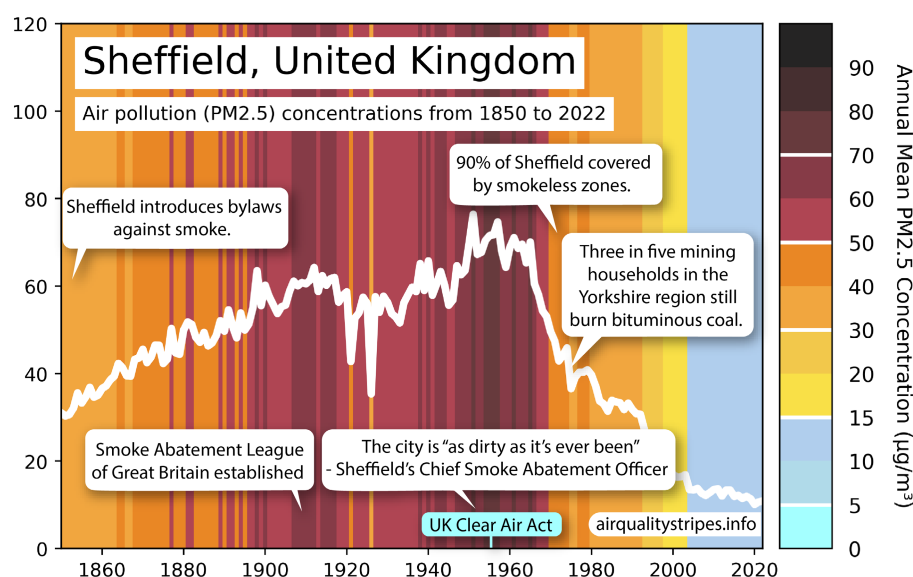


Figure 6. Historical annual PM_{2.5} concentrations in Sheffield, overall higher than most other UK cities due to significant use of coal in steel industry.

Black areas were the most polluted in the UK and were mainly located in the Midlands and northern England. They were also areas that were most economically reliant on the extraction and combustion of coal, and were home to some of the poorest councils and communities. This made change difficult, as the costs of smokeless fuel conversions were part funded by local authorities (30%) and households (30%; Mosley, 2017).

In 1959, following instruction from national government, Sheffield City Council implemented a 10-year clean air plan. Six years later, Sheffield was 'winning the war against smoke' (The Guardian, 1965), and the plan was eventually hailed as a success story nationally (Financial Times, 1968). By 1972, 90% of the city was covered by smokeless zones, and by 1974, most Sheffield residents agreed that smoke control regulations were necessary, compared to just 10% in the 1950s (Mills, 2007).

Within the wider context of southern Yorkshire, however, change was slow due to the significance of coal mining in the region. Economic and logistical complications associated with the coal allowance that was received by mining households as part of wages, alongside political motivations and social and cultural attachments to coal, affected the enforcement of clean air legislation (Davies, 2025). In 1975, three in five mining households in Yorkshire still burned bituminous coal (Thorsheim, 2006) (Figure 6).

Cardiff, South Wales

As in southern Yorkshire, the coal industry was fundamental to the history and communities of South Wales. By the 1890s, Cardiff exported over 7 million tons of coal per year and was the largest coal-exporting port in the world (Minchinton, 2006). It has been long-stated locally that the first million-pound cheque was signed at Cardiff Coal Exchange in 1904. The following year, in 1905, Cardiff was awarded city status in recognition of the expansion of this once small town (Carradice, 2011).

The development of the coal industry and increased coal consumption in the region was reflected in the high concentrations of PM_{2.5} in the atmosphere (Figure 7). Economic decline in the inter-war period was also mirrored in the mean average annual concentrations, as were two periods of significant industrial action in South Wales and across British coalfields nationally: the Miners' Lockout 1921 and the Miners' Strike 1926. Concentrations of PM_{2.5} dropped significantly in Cardiff during these years as the sudden, mass interruption of coal extraction and burning over 3 months in 1921 and 6 months in 1926 translated into a sharp decrease in the annual averages. This contrasts with the rate of decline in fine particulate mat-

ter following the Clean Air Act 1956, which is reflective of a gradual transition away from bituminous coal and toward smokeless fuels over two decades.

The connection between the industrial legacy of Cardiff and annual PM_{2.5} concentrations is reflected again in the continued decline from the 1970s (Figure 7). This was caused by a combination of factors, including the national expansion of Clean Air legislation in 1968, the transition away from coal as the nation's primary fuel and rapid deindustrialisation. But the problem of industrial pollution did not cease completely as other forms of pollution continued. A Letter to the Editor of Wales on Sunday published in 1990, over 30 years after the Clean Air Act, described the smell of Port Talbot on the drive from Cardiff to

Neath (Figure 8). The letter noted that you could 'smell Port Talbot before you see it', and that even industrial cities in Northern England, like Sheffield, had managed to clean up their atmosphere.

Cardiff's experience of a transboundary air pollution episode in March 2015 is a reminder that air pollution is an ongoing challenge in the twenty-first century. Traffic emissions from other major European cities carried in the wind and led to a nationwide health alert for air pollution in the UK. South Wales was one of several regions that were most heavily affected (The Guardian, 2015). This exemplifies that, while coal burning decreased significantly in the late twentieth century, different sources of air pollution including motor vehicles and agriculture remain a threat to air quality. With the right

weather conditions, air pollution from these sources can travel long distances and affect the air we breathe.

Air quality (un)changed?

Interdisciplinary analysis of historical air quality change in Britain illuminates the connection between PM_{2.5} concentrations and local histories, geographies and economies within the longer temporal view. The analysis of three UK cities beyond London confirms the Clean Air Act 1956 as a milestone in British environmental history, while recognising that its impact on air quality was gradual rather than immediate, and achieved within a wider context of transition in the late twentieth century. This analysis also exposes place-based trends in historical annual PM_{2.5} concentrations, localised challenges for implementing clean air policy, and the continuation of air pollution despite the significant improvements realised by this landmark legislation.

Furthermore, while the 70th anniversary of the UK Clean Air Act is important to recognise, it is also imperative to remember that air pollution is an ongoing global challenge. Much of the Global North has experienced improvements in air quality (Li *et al.*, 2025) and discourse on this issue understandably celebrates the positive changes made over time. In many parts of Central Asia and Africa, however, air quality is declining (see, e.g. airqualitystrips.info). Several cities, including Delhi (India), Lahore (Pakistan), N'Djamena (Chad), Kinshasa (DRC) and Hanoi (Vietnam), currently have annual mean PM_{2.5} concentrations as high, or higher than, those in the UK in the 1950s (Xu *et al.*, 2025, Pringle, 2025).

The drivers of air quality decline in these regions are complex, but they include the outsourcing of manufacturing to developing economies (Chen *et al.*, 2026), increasing smoke from wildfires linked to land clearing and climate change (Xu *et al.*, 2023), reliance on diesel for power and transport (Lam *et al.*, 2019), and in some cases, high levels of natural PM_{2.5} (e.g. dust; Aboagye-Okyere *et al.*, 2025). Addressing air quality globally demands coordinated national and international policy, targeted regulation, investment in monitoring and enforcement, meaningful public engagement and community action and a deeper understanding of air quality change within much wider chronologies, as place-based factors continue to shape the impacts of Clean Air legislation today.

Author contributions

Kathy Davies: Conceptualization; investigation; writing – original draft; methodology; visualization; writing – review and editing; formal analysis; project administra-

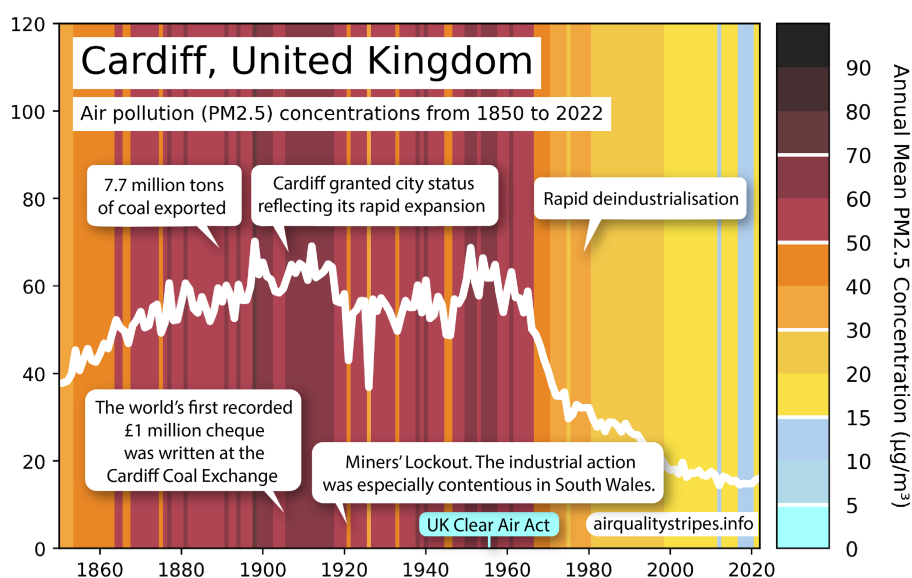


Figure 7. Historical annual PM_{2.5} concentrations in Cardiff. The reduction in PM_{2.5} concentrations during the strikes (1921, 1926) is captured in the emissions inventory and shows clearly in the concentrations.



Figure 8. Letter to the Editor of Wales on Sunday by Peter James, Neath, West Glamorgan, 1990 (James, 1990, reproduced with permission from REACH PLC).

tion. **James B. McQuaid:** Conceptualization; writing – review and editing; formal analysis; project administration; funding acquisition; methodology. **Kirsty J. Pringle:** Conceptualization; writing – review and editing; software; data curation; formal analysis; methodology.

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Data availability statement

Data sharing is not applicable to this article as no new datasets were generated or analysed during the current study.

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