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AIR QUALITY IN THE UK

Air quality in the UK has improved significantly since the time of the Great Smog in London 50 years ago. This POSTnote explores the major steps contributing to that process, examines current air quality issues, mainly related to traffic emissions, and considers trends, developments in policy and future research requirements in air quality.

A brief history of air pollution

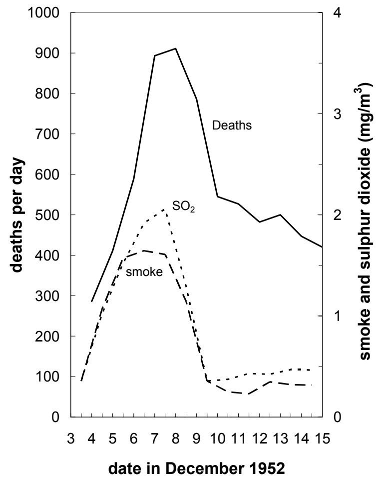
Accounts of air pollution in the UK date back to the 13th century. Early occurrences resulted from rapid population growth, urbanisation and changes in fuel use – in particular the medieval switch from wood to coal, especially in brick kilns and domestic fireplaces. Coal combustion in industrial furnaces, boilers and, above all, in domestic fireplaces, was the main source of air pollution until the 1950s, with smoke and sulphur dioxide (SO_2) the main pollutants.

During calm, cold winter weather, pollutant concentrations could cause severe pollution episodes, termed smogs (smoke + fog), where the combination of smoke and SO_2 emissions forms a thick fog, leading to serious health problems. Such pollution episodes occurred as early as the 17th century but, with rapid industrialisation, became more frequent and more severe towards the end of the 19th century. Legislation at this time focused only on smoke abatement from industry, and difficulties in implementation led to little improvement in air quality until the early 20th century.

Across the UK, episodes of extremely poor urban air quality occurred less frequent from around 1900, as industry and residential areas moved from the centre of cities. A trend towards using town gas and electricity also contributed although the use of coal in their production inevitably involved emissions somewhere. However, pollution episodes such as the Great Smog still occurred (see box opposite) – and not only in London. This caused severe and widespread health impacts and great public concern leading to the Clean Air Acts of 1956 and 1968.

The London smogs

Between 1948 and 1962 eight air pollution episodes occurred in London, but the Great Smog between 5th and 9th December 1952 was the most significant. Smoke concentrations reached 56 times the 'normal' level at the National Gallery and visibility was so bad that people could not see their own feet! Within 12 hours of the beginning of the smog some people showed respiratory problems and hospital admissions increased dramatically. At least 4,000 people above the normal mortality figures are believed to have died during the smog and in the following weeks (see figure below).



Death rate, smoke and SO_2 concentration (daily average) during the Great Smog in December 1952[1].

These acts regulated domestic sources for the first time and introduced 'smoke control areas'. The focus was purely on smoke from coal; SO_2 emissions were not directly regulated, although subsequently, these dropped in parallel with smoke levels. Since the 1960s, the burning of cleaner fuels (especially natural gas), the decline in heavy industry and the location of power stations with high stacks outside cities has led to an over 90% decrease in national average smoke and SO_2 levels.

Air quality today

Air pollutants and their sources

Emissions causing air pollution have changed considerably since the 1950s. With smoke and SO_2 now regulated and a six-fold increase in road traffic between 1955 and 2001, coal combustion is no longer the main cause. Instead, motor vehicle emissions have had an increasing impact on urban air quality.

The main pollutants of concern are nitrogen oxides (NO_x)[2], volatile organic compounds (VOCs), particles (especially PM_{10}, which are particles with a diameter of less than one hundredths of a millimetre, i.e. 10 μm) and carbon monoxide (CO). All of these are mainly emitted by road transport, but also arise from fossil fuel power generation and domestic and industrial sources. Solvent and petrol vaporisation is a major source of VOCs. The figure opposite shows trends in total emissions of the main substances over the last 30 years. While some pollutants such as CO and PM_{10} have declined, nitrogen dioxide (NO_2) and VOCs increased until 1990, but have decreased since then.

Other pollutants of interest

Other routinely monitored pollutants include lead and complex molecules such as 1,3-butadiene, benzene and polycyclic aromatic hydrocarbons (PAHs). Road transport is the predominant source of many of these substances. Lead was widely used as an additive in petrol, but since 1970 emissions have declined by 93%.

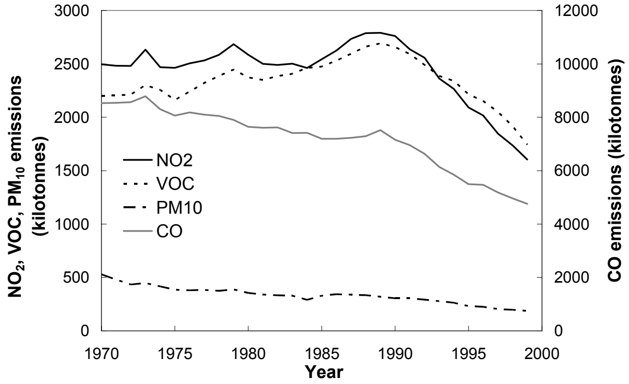
Secondary pollutants

Secondary pollutants are those formed in the atmosphere from emissions of 'precursors'. The most significant is ground-level ozone, which is formed by a series of chemical reactions between NO_x, VOCs and oxygen in the presence of sunlight. Ozone may remain in the atmosphere for several days before breaking down and can be transported downwind, thereby causing high concentrations to build up in rural areas. In urban areas ozone is broken down rapidly by other pollutants. Ozone concentrations had been increasing in line with rising NO_x and VOC emissions but recent reductions in these precursors have resulted in lower maximum ozone levels throughout the last decade. Nevertheless, yearly average concentrations are slowly increasing partly due to pollutants generated outside the UK – mainly in Europe, but also possibly in North America and Asia.

Air pollution episodes

Indicators show that overall levels of pollution have improved significantly since the 1950s. Nevertheless, smog episodes still occur during calm winter days, although the main pollutants are now oxides of nitrogen. Several winter smogs occurred in London during the 1990s. One in 1991 caused 100 to 180 excess deaths[3]. Photochemical smog – air pollution that occurs on hot summer days – results from ground-level ozone formed from its precursors[4], which are mainly emitted by vehicles. Such a summer pollution episode occurred in 1976 (increasing mortality in London by about 7%) and 1995 is also regarded a high ozone year[5].

UK annual emissions of NO_2, VOCs, PM_{10} and CO



Source: National Atmospheric Emissions Inventory (http://www.naei.org.uk)

Health problems

Air pollution legislation has mainly been and still remains focused on reducing the adverse human health effects of air pollutants, although during the 1980s acid rain and ecosystem damage were a principal concern. The levels of air pollutants measured today can still give rise to significant health impacts. In 1992, the Department of Health (DH) set up a Committee on the Medical Effects of Air Pollutants (COMEAP) to examine the potential toxicity and effects on health of air pollutants. In their 1998 report COMEAP concluded that up to 24,000 deaths were 'brought forward' in the UK in 1995/1996 due to the short term effects of air pollution[5,6]. Research indicates that long-term exposure could have an even greater impact, although this has been difficult to quantify. The box on the next page gives an overview of health problems for which there is moderately consistent evidence that a causal link with air pollution exists. Poor air quality, however, not only affects humans, but also plants, animals, buildings and materials, for example blackening and corrosion of historic buildings.

Legislation and policy responses

European and UK strategy

While the Clean Air Acts focused on the sources of emissions, today's legislation has a different approach by setting standards or targets for specific pollutants in ambient air. While standards are based on health effects, targets take costs and benefits into account and have achievement dates specified.

The Government and the devolved assemblies have developed statutory[7] Air Quality Strategies and a system of local air quality management. The UK Air Quality Strategy (AQS), first published in 1997, sets targets for eight air pollutants: benzene, 1,3-butadiene, CO, lead, NO_2, ozone, PM_{10}, and SO_2, to be achieved between 2003 and 2008. It includes European Union (EU) targets set through 'Daughter Directives' of the Air Quality Framework Directive[8], as well as more stringent national targets. A review of the AQS in 2000 tightened some targets and introduced new ones to protect vegetation and ecosystems. However, targets for particles were relaxed because it became clear that national measures alone would not be sufficient to achieve the 1997 PM_{10} target. Emissions in mainland Europe can contribute up to 20% to annual mean particle levels.

Health effects of air pollutants
Mostly elderly and young people and those with respiratory diseases such as asthma or bronchitis are affected.

- *SO_2* - coughing, tightening of chest, irritation of lungs
- *NO_2* - irritation and inflammation of lungs
- *PM_{10}* - inflammation of lungs, worsening of symptoms of people with heart and lung conditions, linkage of long-term exposure to coronary heart disease and lung cancer
- *CO* - prevention of normal transport of oxygen by blood, resulting in the reduction of oxygen supply to the heart
- *ozone* - pain on deep breathing, coughing, irritation and inflammation of lungs
- *benzene* - cause of cancer
- *1,3-butadiene* - cause of cancer
- *polycyclic aromatic hydrocarbons (PAHs)* - toxicity and cause of cancer
- *lead* - linkage of exposure to impaired mental function and neurological damage in children

Implementation

National and European measures such as vehicle emission regulations, industrial air pollution control and fuel regulations are the key mechanisms for achieving the AQS targets. In areas where targets are unlikely to be met, local authorities have to take action through a system of Local Air Quality Management (LAQM). They are required to review and assess air quality in their areas and, if AQS targets are not likely to be met, to declare an Air Quality Management Area (AQMA). Despite steadily improving national trends in air quality, there are already over 100 such AQMAs in the UK. An action plan to reduce pollutant concentrations can include measures on industry, traffic management, in-use vehicle emission testing, land-use planning and charges for road use and parking.

Industrial emissions are regulated by the Environment Agency in England and Wales, the Scottish Environment Protection Agency and local authorities under the Integrated Pollution Control (IPC) regime. This is progressively being replaced by the Pollution Prevention and Control (PPC) regime, which implements the EU Directive on Integrated Pollution Prevention and Control (IPPC). PPC involves consideration of a wider range of issues, such as energy efficiency and industrial sectors not previously regulated under IPC.

Land-use planning is another instrument to control air pollution, especially the construction of new, or alterations to existing, industrial plants. Planning policy guidance for England complements the new PPC regulations and encourages local authorities to apply for planning and PPC permits in parallel. Such an integrated approach is seen as necessary to minimise the impacts of potentially polluting developments.

London's size means that its air pollution problem is unique in Britain. Due to the high levels of pollutants experienced in the city, cost-benefit calculations led to a less stringent PM_{10} AQS target for the capital being announced in August 2002. The Mayor's Air Quality Strategy to improve air quality in London was launched in September 2002. The strategy states that road traffic in London contributes more to air pollution than in any other UK city and thus is the main target for reductions.

Monitoring

Today air quality across the UK is measured at more than 1,600 monitoring sites - over 100 of these being integrated into an automated urban monitoring network to measure AQS pollutants. Up to date air pollution information is available free of charge to the general public giving also advice on health problems (http://www.airquality.co.uk).

Future developments and issues

Trends in air quality

Monitoring data from across the UK show improvements in air quality. Looking towards 2025, mathematical models predict that most pollutant levels will continue to fall, but targets for NO_2, PM_{10} and ozone may be breached in some areas. Thus, adverse health effects will continue, especially with long term exposure. This raises questions over whether and how air quality can be further improved, taking costs and benefits into account.

Despite years of research, the ways in which particles cause deaths and adverse health effects remain unclear. They are a mixture of many different compounds and occur in a wide range of sizes. Evidence is emerging that numerous very small particles ($PM_{2.5}$)[9] can penetrate right inside the lungs and cause significant health effects. COMEAP recently concluded that if $PM_{2.5}$ concentrations fell by one millionth of a gramme per cubic metre, a person could gain 1.5 to 3.5 additional days on their lifespan[10]. However, as this is an average, some vulnerable people may benefit more. DH considers this to be a significant impact and acknowledges the need for further reduction measures. However, a national target for $PM_{2.5}$ was not seen to be necessary, since $PM_{2.5}$ particles are included in PM_{10} and measures to reduce PM_{10} in fact reduce mainly $PM_{2.5}$.

DH also recognises that improving health significantly in the future requires understanding of the potentially toxic components of particles. The DH budget for research into health effects of air pollution is currently £1.1m over three years. Given the impact of particles on health a question arises over the adequacy of funding in this area.

Currently ozone is the only pollutant whose yearly average concentration is predicted to increase. While its effects on human health and vegetation are known, it remains unclear whether there is a 'threshold' – a concentration below which no adverse health effects occur. Moreover, as a secondary pollutant, ozone (and its precursors) can travel thousands of kilometres.

Potential new air quality issues

As the levels of some pollutants continue to fall, others may become more significant. Ammonia, produced by livestock farming, is increasingly recognised as an air pollutant, as it can damage ecosystems. Metals such as mercury, arsenic and nickel from industrial processes can persist in the atmosphere and may become an issue.

Also platinum group metals emitted from catalytic converters in vehicle exhausts have been identified as potentially harmful to health, although more work is needed to characterise the risk. Persistent organic pollutants (POPs) from industrial processes, waste disposal and fuel combustion stay in the environment for a long time and are thought to cause health effects such as cancer from exposure at low levels.

Measures such as traffic reduction and improvements in energy efficiency have a beneficial impact on both local air quality and climate change. However, some measures to improve air quality conflict with reducing emissions of greenhouse gases. For example, meeting emission standards by using catalytic converters can decrease fuel economy and so increase carbon dioxide emissions.

Traffic

Despite advances in emission control technology, the downward trend in air pollution from road transport could be partly offset by the increasing number of road vehicles. In particular, unless technology continues to improve, more diesel vehicles could limit the rate at which PM_{10} and NO_x emissions are forecast to fall.

Use of cleaner fuels, emission controls and advanced engine technologies, e.g. electric vehicles, have already proved to be effective in reducing air pollution and are promoted with Government grants, but there is still considerable scope for further improvements. For instance, the Greater London Authority (GLA) is currently undertaking a feasibility study for the introduction of a Low Emissions Zone in London, which would restrict access by polluting vehicles. Such zones have already been successfully introduced in Sweden. In addition, the GLA is planning a pilot programme to introduce a small number of buses powered by hydrogen fuel cells with zero air pollutant emissions[11] at the point of use.

Policy responses

Because air pollution is often transboundary, UK policy has developed in cooperation with other EU and UNECE[12] countries. EU limit values are now in place for NO_2, PM_{10}, SO_2, lead, CO, benzene and ozone. Controls on arsenic, nickel, cadmium, mercury, and PAHs are in preparation. In countries where air pollution is less significant than in the UK, the targets do not present a challenge. However, NO_2 is likely to be a problem in most European countries. Also, increasing background ozone concentrations remain of concern.

Following consultation to update the UK AQS, stricter targets for some pollutants were announced in August 2002, with PAHs being included for the first time. While London has a separate, less stringent, PM_{10} target, which is widely criticised by the GLA, London Boroughs and environmental groups such as the National Society for Clean Air and Environmental Protection (NSCA), Scotland adopted an even stricter PM_{10} target.

Historically, government policy has focused on the specific values of the AQS targets, but the GLA has suggested that the AQS should include more specific measures, such as promoting clean fuel infrastructure and increasing awareness of incentives to reduce air pollution by local authorities and the public. In the meantime, success of the AQS depends on constant review of air quality targets together with continuous efforts to improve local air quality by local authorities. Here, they face the difficult issue of whether they can tackle air pollution transported into their area from neighbouring authorities, elsewhere in the UK or from mainland Europe.

Overview

Air quality in the UK has improved significantly since the 1950s, but adverse health effects continue – with nitrogen dioxide, particles and ground-level ozone as today's main problem pollutants mostly stemming from road traffic.

National air quality policy does not set out clear reduction measures and has been criticised for not promoting widespread awareness of incentives to reduce emissions. Nonetheless, the National Audit Office regards the UK's air quality strategy as effective and NSCA sees it as among the best in Europe.

However, research indicates that up to 24,000 vulnerable people a year may have their deaths 'brought forward' by air pollution, so UK air quality is likely to remain on the political agenda. Developing strategies and reduction measures will require consideration of economic and social as well as environmental issues.

Endnotes

1 Quart. J. Roy. Met. Soc. (1954), vol. 80, pp. 267-71.
2 Nitrogen oxides are commonly referred to as NO_x, which includes nitric oxide (NO) and nitrogen dioxide (NO_2).
3 COMEAP (1997), *Handbook on air pollution and health*.
4 Ozone episodes occur more often in summer, in the southern UK and are more likely in rural than in urban areas.
5 In 1995 around 12,500 deaths were 'brought forward', which means vulnerable people might have lived longer if air pollution was not a factor.
6 COMEAP (1998), *Quantification of the effects of air pollution on health in the UK*.
7 Environment Act 1995
8 Framework Directive (96/62/EC) on Ambient Air Quality Assessment and Management and Daughter Directives.
9 Particles with diameters less than 2.5 thousandths of a millimetre (μm)
10 Based on the population alive in 2000 and followed for 105 years. COMEAP (2002), *Statement and report on long-term effects of particles on mortality*.
11 POST (2002), *Prospects for a hydrogen economy*, POSTnote 186.
12 United Nations Economic Commission for Europe

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