



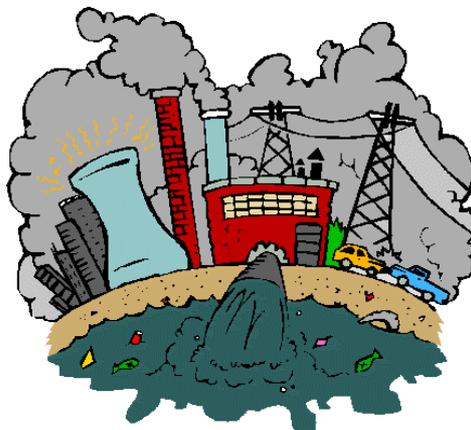
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# **URBAN AIR QUALITY**

## **Teaching Pack for Key Stages 3, 4 & A-Level**

*Sue Hare*

*1999 (updated 2002)*



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# ***Introductory Notes For Teachers***

## AIM:

To highlight and investigate the quality of urban air in the UK.

## OBJECTIVE:

To increase awareness and understanding of the sources and effects of the main urban pollutants and to identify possible responses to improve air quality.

## TARGET AUDIENCE:

Teachers of students aged 12 - 18 years studying geography, science and environmental studies/ science for Key Stages 3 to 4 of the National Curriculum (GCSE), and A-level.

## SKILLS ENHANCEMENT:

Students will develop an awareness and understanding of the current environmental issue of air quality in urban areas. The historical perspective and changes in air quality to the present day will be appreciated through the use of this pack. Students will also gain an up to date appreciation of air quality in urban areas, and the importance of the contribution of vehicular pollution in particular as a major source of urban air pollution today. Students will also increase their knowledge and understanding of the effects of urban air pollution and gain an insight into the responses that can be taken to improve the quality of air in towns and cities of the UK.

THE USE OF THIS PACK:

- ★ Teachers are strongly encouraged to read this pack thoroughly before embarking upon its use.
- ★ Students will gain maximum benefit if all of the lessons are covered in the order set out in this pack. However, lessons may be used in isolation if teaching time does not permit, or if certain lessons prove relevant for a particular syllabus.
- ★ The optional exercises at the end of each lesson are designed to aid students in understanding the topic covered in each section. Usually the exercises require students to draw on information supplied with each lesson topic, or to investigate the issue by their own personal research. These exercises may be most useful for Key Stage 3 & 4 students.
- ★ Sheets for photocopying as OHPs have been included at the end of the pack to help teachers convey factual and graphical information to their students.

# ***Lesson 1: The History of Urban Air Pollution***

## ***A Brief Summary of Air Pollution History***

Urban air pollution is certainly not a new problem. Back in the days of the Middle Ages the use of coal in cities such as London was beginning to escalate. By the end of the 16th century the problems of urban air pollution are well documented.

The Industrial Revolution in the 18th and 19th centuries was based on the use of coal. Industries were often located in towns and cities, and together with the burning of coal in homes for domestic heat, urban air pollution levels often reached devastating levels. During foggy conditions, pollution levels escalated and urban smogs (smoke and fog) were formed. These often brought cities to a halt, disrupting traffic but more dangerously causing death rates to dramatically rise. The effects of this pollution on buildings and vegetation also became obvious. The 1875 Public Health Act contained a smoke abatement section to try and reduce smoke pollution in urban areas.

The 1926 Smoke Abatement Act was aimed at reducing smoke emissions from industrial sources, but the remaining problem that was not being tackled was pollution from domestic sources.

The Great London Smog of 1952 which resulted in around 4,000 extra deaths in the city, led to the introduction of the Clean Air Acts of 1956 and 1968. These introduced smokeless zones in urban areas, with a tall chimney policy to help disperse industrial air pollutants away from built up areas into the atmosphere.

Following the Clean Air Acts, air quality improvements continued throughout the 1970s and further regulations were required through the *1974 Control of Air Pollution Act*. This included regulations for the composition of motor fuel and limits for the sulphur content of industrial fuel oil.

However, during the 1980s the number of motor vehicles in urban areas steadily increased and air quality problems associated with motor vehicles became more prevalent. In the early 1980s, the main interest was the effects of lead pollution on human health, but by the late 1980s and early 1990s, the effects of other motor vehicle pollutants became a major concern. The 1990s have seen the occurrence of wintertime and summertime smogs. These are not caused by smoke and sulphur dioxide pollution but by chemical reactions occurring between motor vehicle pollutants and sunlight. These are known as 'photochemical smogs'.

### ***Key Dates for the History of Air Pollution in the UK***

The following key dates identify some of the major facts relating to urban air pollution in the UK over recent centuries.

*1661 British scientists John Evelyn & John Graunt found that polluted air from industry could affect vegetation and people. They suggested that industries be located in the countryside to minimise effects on health.*

*1852 Robert Angus Smith identifies acid rain in Manchester.*

*1872 Robert Angus Smith became the first air pollution inspector in Britain.*

*1875 The Public Health Act. This contained a smoke abatement section; legislation to the present day has been based on this.*

- 1890 *Sulphurous smogs had been reported for over 100 years in many British cities. 'Smog' became the term to describe severe air pollution conditions, derived from a combination of smoke and fog.*
- 1926 *Public Health (Smoke Abatement) Act. This amended and extended the previous Public Health Acts of 1875 and 1891.*
- 1930/1 *Additional deaths occurred in a smog in Manchester & Salford. This began a campaign which ultimately led to the introduction of smoke control.*
- 1952 *The famous London Smog occurred in December 1952 and resulted in thousands of premature deaths.*
- 1956 & 1968 *Clean Air Acts. These had a dramatic effect on air quality and eliminated the occurrence of the types of smogs of previous decades.*
- 1974 *Control of Pollution Act. Regulations concerning lead content in fuel and sulphur content in fuel were made. Also, local authorities were given power to obtain and publish information about air pollution emissions.*
- 1990 *Environmental Protection Act. This Act was introduced to ensure acceptable standards of pollution prevention and control in industry.*
- 1995 *Environment Act. This introduces local air quality management, requiring local authorities to meet air quality standards set by central government.*
- 1997 *National Air Quality Strategy. This defines standards and objectives for the key urban pollutants to help improve UK air quality. It was updated in 2000.*

## ***Historical Smogs***

In 1905 Dr. HA Des Voeux used the term smog to describe the conditions of fuliginous or sooty / smoky fogs but they were also known as “*pea soupers*” and “*great stinking fogs*”.

Back in the 1600s, the writer and scientist John Evelyn reported industries to be the obvious cause of pollution in London; he noted that pollution almost vanished on Sundays. However, Rollo Russell observed in the mid nineteenth century that there were more fogs on Sundays and holidays than on working days. He therefore concluded that the main cause of the problem was the domestic burning of coal. The reason for this change was that some industrial smoke control had been achieved. However, domestic and industrial sources were still both contributing to urban air pollution.

Smogs occurred as a result of particular meteorological conditions. November was often the worst month for fogs, especially long lasting thick fogs. Many people described the days as “*gloomy*”. Of course, during the winter months emissions of smoke and sulphur dioxide pollution were much greater in urban areas than during the summer months due to the burning of fossil fuels (mainly coal) for heat. Smoke particles trapped in the fog gave it a yellow / black colour and these smogs often settled over cities for many days. Wind speeds would be low at these times causing the smoke and fog to stagnate; hence pollution levels would increase near ground level.



SMOKE  
+  
FOG  
=  
SMOG

During smog periods the effects on human health were very evident particularly when smogs persisted for several days. Many people suffered respiratory problems and increased deaths were recorded, notably those relating to bronchial causes. One of the major London smogs occurred in December 1892. It lasted for 3 days and resulted in approximately 1000 excess deaths.

London became quite famous for its smogs. By the nineteenth century, many visitors to London came to see the capital in the fog. For some the fogs were not all gloom. As an excerpt from a letter in 1888 reveals:

*“today we are having a yellow fog, and that always enlivens me, it has such a knack of transfiguring things...It is very picturesque also...Even the grey, even the black fogs make a new and unexplored world not unpleasing to one who is getting palled with familiar landscapes” (Brimblecombe, 1987).*

## ***The Pollutants of Historical Smogs***

Smoke and sulphur dioxide were the main pollutants that caused smogs to form. Compared to the values that we find in air today, levels of these pollutants were very high indeed. Air pollutants in towns and cities were not measured on a regular basis using standardised techniques until the 1960s. However, writings and measurements taken by some scientists give us an indication of the levels of air pollution in history (see fact File One on the next page).

## ***Sources of Pollution***

The burning of coal in industries and homes was the main source of smoke and sulphur dioxide pollution. Industries were located amongst housing estates which caused urban air to be considerably more polluted than in the countryside. City smoke concentrations occasionally exceeded  $4000\mu\text{g}\text{m}^{-3}$  when fog was intense. (The mean UK concentration of smoke in 1990 was about  $15\mu\text{g}\text{m}^{-3}$ ). Many paintings by the famous artist Lowry in the 1930s illustrate the density of smoke that was regularly emitted into the atmosphere.

**FACT FILE ONE**

<b>City:</b>	Manchester
<b>Period:</b>	1850s
<b>Industries:</b>	Cotton, engineering, metal working, chemicals
<b>Air Pollution Facts:</b>	Manchester Smoke Inspector visited 500 factory premises; 300 of these were issued with notices or cautions. A Manchester cotton mill was observed to emit black smoke for 8 hours 52 minutes out of a 9 hour period. Robert Angus Smith, the first air pollution inspector described the polluted atmosphere of Manchester.
<b>Air Pollution Levels:</b>	Sulphur dioxide levels were not routinely monitored. Estimates for Manchester in the late nineteenth century were 2930 $\mu\text{g m}^{-3}$ (micro grams per cubic metre of air).
<b>Sources:</b>	Brimblecombe, 1989; Longhurst & Mann, 1994

***Further Information***

There are various sources of literature and art which can help to identify what air pollution was like in previous centuries. The art work of L.S. Lowry is one of these. Details of how to obtain resources to support this section are given below:

**L. S. Lowry (1887 - 1976)**

Lowry was a British painter, born in Manchester. He worked as a clerk until his retirement at 65, painting during his spare time. From the 1920s he exhibited regularly in Manchester. His work is characterised by bleak industrial landscapes and towns dotted with matchstick figures. Many of his paintings are now exhibited in the Lowry Centre in Salford, the city where many of his paintings were created.



For further information on Lowry you can visit the following website:

- <http://www.thelowry.com/>

or visit the Lowry Centre

The Lowry,

Pier 8,

Salford Quays,

M5 2AZ

Tel:0161 876 2000

Fax: 0161 876 2001

Email: [info@thelowry.com](mailto:info@thelowry.com)

The Lowry Centre contains the world's largest public collection by the City's most famous painter, L.S. Lowry. There is also a shop from which you can buy Lowry prints, postcards and other goods.

### **Questions**

1. What does the term 'smog' mean?
2. Who was the first air pollution inspector and where did he work?
3. Identify three terms which describe smog.
4. What were the main sources of urban air pollution before the 1956 & 1968 Clean Air Acts?
5. Identify one weather condition associated with the formation of smog.
6. Why did air pollution levels build up when it was foggy?

7. How many excess deaths occurred in the December 1892 London smog?
8. Re-write the 1888 excerpt from a letter in your own words.
9. Which pollutants were the main ones found in historical smogs?
10. What was the estimated sulphur dioxide level for Manchester in the late 1800s?

## ***Lesson 2: Changing Patterns of Air Pollution***

### ***The Early 1900s***

Fog and smog frequencies began to reduce in UK urban areas during the early 1900s, compared with the latter half of the nineteenth century. Air pollution was still a severe problem but the number of major smogs began to decrease. Several changes helped to contribute to this situation, including:

- changing social conditions;
- tighter industrial controls;
- declining importance of coal as a domestic fuel;
- changes in fuel type - gas and electricity became alternatives to coal.

The famous London smogs seemed to have become a thing of the past.

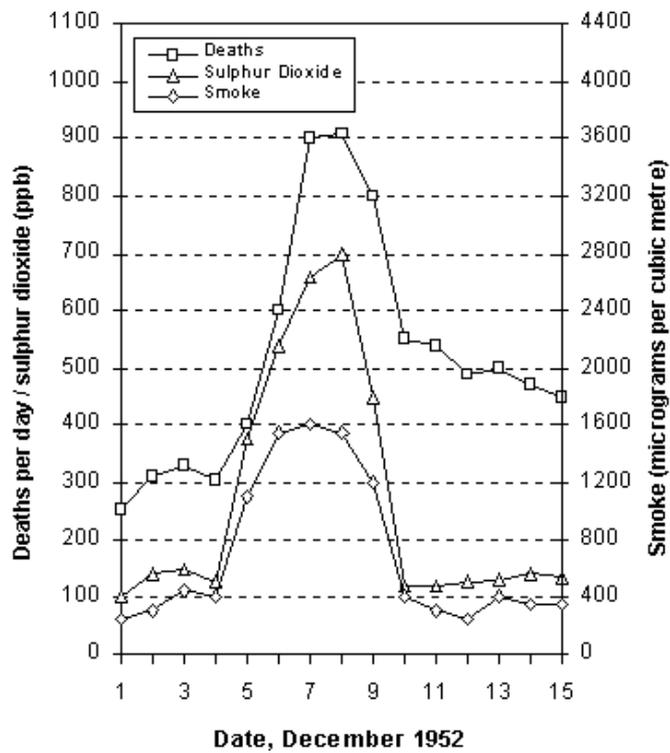
### ***The Great London Smog***

On December 4th 1952, however, an anticyclone settled over London. The wind dropped and the air grew damp; a thick fog began to form. The Great London Smog lasted for five days and led to around four thousand more deaths than usual.

Figure 2.1 shows the average smoke and sulphur dioxide levels for 12 London sites and the relationship with deaths recorded during the smog period in December 1952. The peak in the number of deaths coincided with the peak in both smoke and sulphur dioxide pollution levels.



**Figure 2.1: The Relationship Between Smoke And Sulphur Dioxide Pollution And Deaths During The London Smog, December 1952**  
 Source: Wilkins, 1954



## ***Air Pollution During The Great London Smog, 1952***

Smoke and sulphur dioxide pollution was monitored at various sites in London at the time of the December 1952 smog. The daily average measurements for 10 of these sites are given in Table 2.1.

**Table 2.1: Pollution Concentrations, London, December 1951 & 1952**

Site and distance from Charing Cross (miles)	Mean	Smoke (milligrams per cubic metre)									
	Dec. 1952	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	
1. Lambeth (0.5)	0.43	0.49	0.61	0.49	2.64	3.45	4.46	4.46	1.22	1.22	
2. Westminster (0.8)	0.34	0.38	0.38	0.52	1.93	2.40	1.20	1.20	1.44	0.48	
3. Southwark (1.8)	0.44	0.78	0.85	0.49	1.44	3.95	2.66	2.66	3.95	0.68	
4. City (2.0)	0.20	0.21	0.26	0.26	1.00	1.02	1.06	1.06	1.10	0.22	
5. Greenwich (5.5)	0.34	0.18	0.36	0.36	0.99	1.09	2.06	2.06	0.95	0.19	
6. Chiswick (6.0)	0.20	0.21	0.22	0.66	0.64	0.42	0.35	0.35	0.50	0.09	
7. Leyton (6.3)	0.49	0.35	0.57	0.43	1.12	1.55	1.66	1.66	2.05	0.46	
8. Woolwich (9.0)	0.43	0.27	0.79	0.41	1.47	1.62	3.28	3.28	0.92	0.26	
9. Twickenham (11.3)	0.15	0.30	0.31	0.24	0.63	1.44	0.67	0.67	0.48	0.06	
10. Hornchurch (15.5)	0.12	0.03	0.18	0.03	0.03	0.34	0.56	0.56	0.37	0.07	
Sulphur dioxide (ppm)											
1. Lambeth (0.5)	0.22	0.16	0.22	0.14	0.75	0.86	1.34	1.34	0.47	0.47	
2. Westminster (0.8)	0.16	0.15		0.24		0.99	0.63	0.63	1.23	0.99	
3. Southwark (1.8)	0.11	0.19	0.26	0.18	0.41	0.95	1.14	1.14	0.80	0.14	
4. City (2.0)	0.17	0.12	0.19	0.19	0.62	0.72	0.80	1.22	1.21	0.22	
5. Greenwich (5.5)	0.10	0.09	0.27	0.27	0.33	0.42	0.72	0.72	0.36	0.03	
6. Chiswick (6.0)	0.09	0.05	0.02	0.07	0.34	0.85	0.31	0.31	0.17	0.02	
7. Leyton (6.3)	0.11	0.06	0.12	0.09	0.25	0.29	0.62	0.62	0.64	0.17	
8. Woolwich (9.0)	0.23	0.02	0.20	0.08	0.33	0.23	0.67	0.67	0.21	0.11	
9. Twickenham (11.3)	0.07	0.66	0.21	0.23	0.32	0.89	0.57	0.57	0.14	0.02	
10. Hornchurch (15.5)	0.07	0.02	0.08	0.03	0.17	0.14	0.34	0.34	0.19	0.05	

Source: Wilkins, 1954

Table 2.1 and Figure 2.1 show the dramatic increase in smoke and sulphur dioxide levels during the smog which occurred between 5th and 9th December. The mean levels for December 1951, when there was no fog, are given in Table 2.1 for comparison.

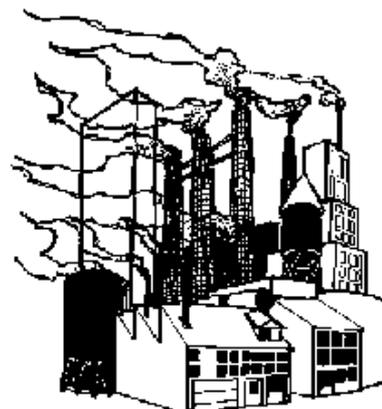
### ***The Clean Air Acts, 1956 & 1968***

The Government could not ignore the Great London Smog. The Clean Air Act was eventually introduced in 1956 following the Beaver Committee Report. This Act aimed to control domestic sources of smoke pollution by introducing smokeless zones. In these areas, smokeless fuels had to be burnt. The Clean Air Act focussed on reducing smoke pollution but the measures taken actually helped to reduce sulphur dioxide levels at the same time. Air pollution in cities dramatically reduced in the following ways:

- domestic emissions reduced because of smoke control areas;
- electricity and gas useage increased and the use of solid fuels decreased;
- cleaner coals were burnt which had a lower sulphur content;
- use of tall chimney stacks on power stations;
- relocation of power stations to more rural areas;
- continuing decline in heavy industry.

### ***Tall Chimneys***

The Clean Air Act of 1968 brought in the basic principle for the use of tall chimneys for industries burning coal, liquid or gaseous fuels. At the time of this legislation it was recognised that smoke pollution could be controlled but that sulphur dioxide removal was generally impracticable. Hence, the higher the



chimney, the better the dispersal of the air pollution.

## ***Urban Air Quality After The Clean Air Acts***

Urban air quality improved following the Clean Air Acts. In particular, the smoke, grit and dust that arose from industrial and domestic sources due to coal burning had been controlled through the introduction of smokeless zones and the controls imposed on industries to reduce their particulate emissions. Fact File 2 provides an insight into air pollution in Manchester during the 1960s.

<u>FACT FILE TWO</u>	
<b>City:</b>	Manchester
<b>Period:</b>	1960s
<b>Industries:</b>	Chemicals, light engineering
<b>Air Pollution Facts:</b>	<p>A survey of air pollution was carried out in Manchester between 1961 and 1971, as part of a national survey.</p> <p>In 1962 it was noted that on the hills to the east of Manchester 'at times the smoke can be seen crossing the summits in a shallow layer at ground level, and a fresh fall of snow may be heavily soiled in 2 hours'.</p>
<b>Air Pollution Levels:</b>	<p>Smoke and sulphur dioxide levels in central areas of Manchester were falling but were still higher than all other regions in the North West. The average smoke concentration during the winter of 1964/65 for Manchester city centre was <math>248\mu\text{gm}^{-3}</math> (micro grams per cubic metre of air) and for <math>\text{SO}_2</math> was <math>436\mu\text{gm}^{-3}</math>.</p>
<b>Sources:</b>	Longhurst & Mann, 1994 & Lewis, 1995

Levels of smoke and sulphur dioxide fell considerably in towns and cities during the 1960s and 1970s and levelled off during the 1980s. The success in reducing urban air pollution and the smogs of the

past was due to the introduction of the legislation, particularly the Clean Air Acts. Figures for smoke and sulphur dioxide for Manchester for the winters (October - March) between 1960 and 1990 are shown in Table 2.2.

**Table 2.2. Winter Smoke And Sulphur Dioxide Concentrations, Manchester 1960-1990**

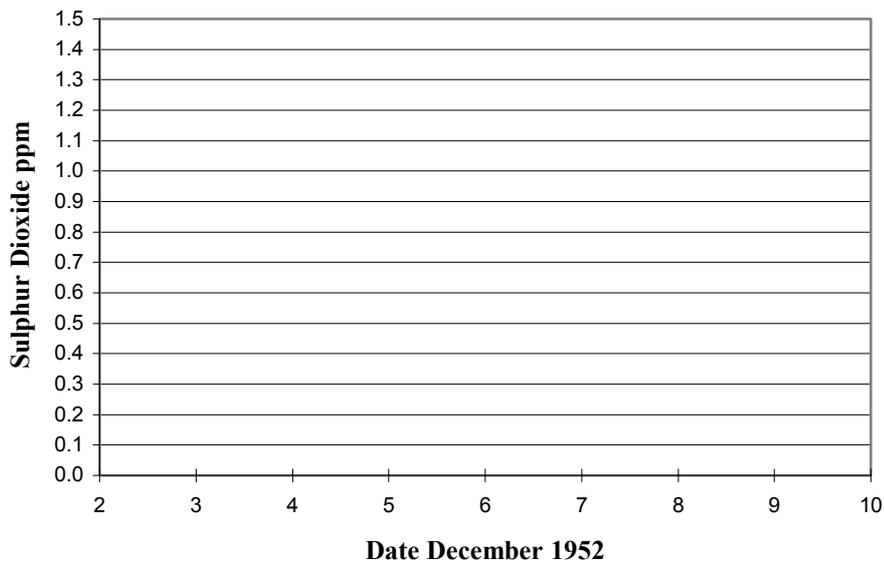
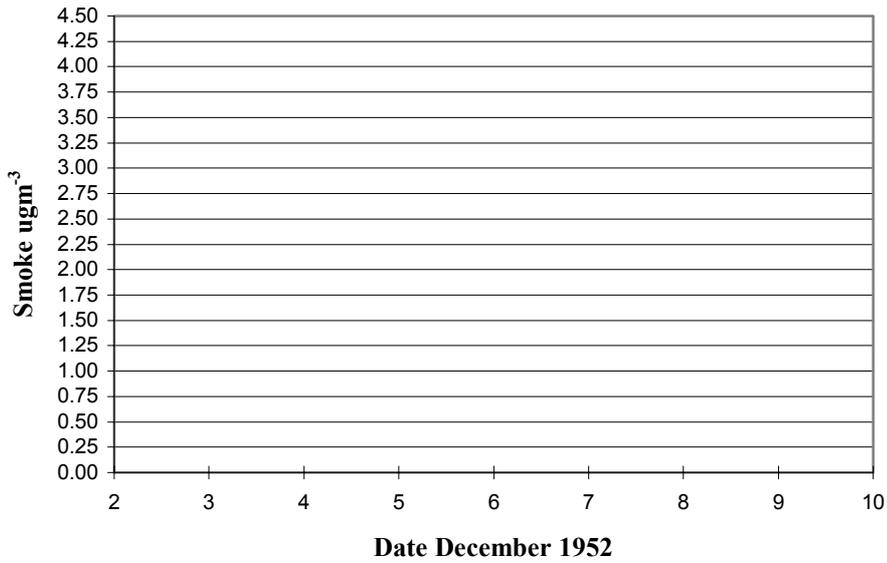
Winter (Oct-Mar) Year	Manchester Centre		North Manchester <sup>†</sup>		South Manchester <sup>‡</sup>	
	Smoke	SO <sub>2</sub>	Smoke	SO <sub>2</sub>	Smoke	SO <sub>2</sub>
	All figures in microgrammes per cubic metre of air ( $\mu\text{gm}^{-3}$ )					
1960/61	326	481	n/a	n/a	n/a	n/a
1961/62	443	587	n/a	n/a	n/a	n/a
1962/63	401	543	628	576	423	384
1963/64	294	385	341	269	236	218
1964/65	248	436	386	351	199	248
1965/66	161	344	174	267	118	210
1966/67	140	345	129	243	95	183
1967/68	135	395	90	252	95	192
1968/69	156	391	178	271	98	187
1969/70	116	307	152	235	67	149
1970/71	142	312	158	240	91	167
1971/72	86	244	84	195	45	118
1972/73	83	232	84	178	41	130
1973/74	80	177	75	131	44	109
1974/75	71	167	53	123	40	118
1975/76	56	179	21	151	19	119
1976/77	56	199	44	162	16	116
1977/78	44	163	42	159	26	116
1978/79	47	153	33	130	31	113
1979/80	42	126	28	97	26	72
1980/81	24	91	17	88	17	77
1981/82	40	122	31	104	32	100
1982/83	28	80	11	72	8	59
1983/84	32	78	25	67	27	66
1984/85	29	76	31	74	23	58
1985/86	26	59	23	60	21	56
1986/87	29	57	20	75	19	54
1987/88	24	59	15	71	13	57
1988/89	32	63	20	42	21	41
1989/90	25	58	17	43	19	51

<sup>†</sup> Crumpsall, approximately 3 miles north of city centre, <sup>‡</sup>Withington, approximately 4 miles south of the city centre.

Source: Lewis, 1995

## Exercises

1. Refer to Table 2.1. Choose 3 of the 10 sites and using different colours plot the values for smoke on graph 1 and sulphur dioxide on graph 2 below for your 3 chosen sites.



2. Charing Cross is in central London. List below the names of the 3 sites that you have chosen for your graphs in Exercise 1 and their distance from Charing Cross (see Table 2.1).

Site Name	Distance from Charing Cross

Refer to the graphs in exercise 1. Describe what the graphs show in terms of highest pollution levels, occurrence of fog (5th - 9th December) and distance from central London.

3. Use a computer spreadsheet to produce a graph of the mean smoke and sulphur dioxide levels for all of the 10 sites given in Table 2.1.

**4. You require an A4 sheet of graph paper for this exercise.**

Plot a graph to show the changes in smoke and sulphur dioxide levels between 1960 and 1990 for one of the Manchester sites given in Table 2.2. Write some comments about your graph and identify the reasons for the change in air quality for this period.

## Lesson 3: Urban Air Pollution Today

### Major Sources

Urban air pollutants arise from a wide variety of sources although they are mainly a result of combustion processes. The largest source in most urban areas is motor vehicles and industry. The impact of transport on urban air quality will be looked at in more detail in Section 4, whilst the impact of industry will be studied in Section 5. Fact File 3 identifies some of the urban air quality issues today. These contrast quite significantly from those identified in Fact Files 1 & 2 in previous sections.

#### FACT FILE THREE

<b>City:</b>	Manchester
<b>Period:</b>	1990s
<b>Industries:</b>	Light engineering, commerce and financial enterprises.
<b>Air Pollution Facts:</b>	Several monitoring networks operate in Greater Manchester to provide air quality data. A national monitoring site for urban pollutants is located in the city centre. The main source of air pollution in Manchester is road transport.
<b>Air Pollution Levels:</b>	Manchester city centre smoke and sulphur dioxide concentrations for winter 1993/4 were 27 and 38 $\mu\text{g m}^{-3}$ (microgrammes per cubic metre of air) respectively. The mean nitrogen dioxide (NO <sub>2</sub> ) concentration for Manchester in 1993 was 26ppb (parts per billion) and for carbon monoxide (CO) was 0.6 ppm (parts per million).
<b>Sources:</b>	Longhurst & Mann, 1994; DOE, 1995 & Lewis, 1995

## Major Urban Pollutants

In most urban areas of the UK, traffic generated pollutants have become the most common pollutants; primarily nitrogen oxides, carbon monoxide, hydrocarbons and particulates. Some of these are emitted directly into the atmosphere (primary pollutants) whilst others are formed in the air as a result of chemical reactions (secondary pollutants). The main urban air pollutants and their sources are shown in Table 3.1.

**Table 3.1. The Main Urban Air Pollutants.** Source: DEFRA, 2001

Pollutant	Main Sources	UK (1996) Figures
Nitrogen oxides	Combustion of motor spirit and other fuel, combustion for domestic heating, power stations, industrial boilers, chemical processes etc.	Road transport 44% Power stations 21% Other industry 9%
Sulphur dioxide	Fuel combustion for power stations, domestic heating, industrial boilers, diesel vehicles, waste incinerators.	Power stations 65% Other industry 10% Refineries 8%
Carbon monoxide	Combustion of motor spirit and other combustion processes.	Road transport 69% Off-road sources 9% Domestic 5%
Ozone	Secondary pollutant resulting from chemical reactions with nitrogen oxides and VOCs.	See NO <sub>x</sub> & VOCs.
Particulates	Fuel combustion for power stations, transport, heating, other industrial processes.	Construction, mining, quarrying 13% Road transport 20% Power stations 10% Domestic 20%
Volatile Organic Compounds (VOCs)	Transport, oil combustion, chemical processes, solvent use, waste incinerators.	Road transport 27% Solvent use 27% Extraction & distribution of fossil fuels 15% Production processes 12%
Benzene	Combustion of motor spirit, evaporation from petrol pumps and fuel tanks.	Road transport 71%
Lead	Combustion of leaded petrol, coal combustion, metal production.	

There are over 1500 sites across the UK which monitor air quality. They are organised into networks that gather a particular kind of information, using a particular method. The pollutants measured and method used by each network depend on the reason for setting up the network, and what the data is to be used for. There are two major types - automatic and non-automatic networks.

Automatic Networks produce hourly pollutant concentrations, with data being collected continuously from individual sites by computer. The data go back as far as 1972 at some sites. Non-automatic Networks measure less frequently - either daily, weekly or monthly - and samples are collected by some physical means (such as diffusion tube or filter). These samples are then subjected to chemical analysis, and final pollutant concentrations calculated from these results.

All the following pollutants are now automatically monitored at many urban sites across the UK.

### ***Oxides of Nitrogen (NO<sub>x</sub>)***

NO<sub>x</sub> is a term used to refer to two species of oxides of nitrogen: nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). The major sources of NO<sub>x</sub> in the UK are vehicles and power stations. Levels of NO<sub>x</sub> in urban areas vary significantly during the day, with peaks generally occurring with 'rush hour' traffic.

### ***Sulphur Dioxide (SO<sub>2</sub>)***

Sulphur dioxide is a colourless gas and is the principal pollutant associated with the problem of acid deposition. Power stations and industries are the main source of SO<sub>2</sub> pollution in the UK. Sulphur dioxide monitoring is relatively extensive in the UK. A national monitoring survey for smoke and sulphur dioxide was set up in 1961. In 1982, the sites were reorganised to form the Basic Urban and EC Directive networks.

## ***Carbon Monoxide (CO)***

Carbon monoxide is a gas which slowly oxidises in the atmosphere to CO<sub>2</sub>. The main source of CO in the UK is vehicles.

## ***Ozone (O<sub>3</sub>)***

Ozone is a secondary pollutant; there are no direct emissions of O<sub>3</sub> to the atmosphere. Most ozone in the troposphere (lower atmosphere) is formed directly by the action of sunlight on nitrogen dioxide. As a result of the various reactions that take place, O<sub>3</sub> tends to build up downwind of urban centres where most of the NO<sub>x</sub> is emitted from vehicles.

## ***Particulate Matter***

Particulate matter is a mixture of coarse and fine organic and inorganic substances, present in the atmosphere as both solids and liquids. Coarse particles have a diameter of more than 2.5 µm and fine particles less than 2.5 µm. Particles are often referred to as PM<sub>10</sub> which means they have a diameter of less than 10µm. The main sources of particulates are industry, vehicles and domestic coal burning.

## ***Volatile Organic Compounds (VOCs)***

VOCs include a very wide range of individual substances, such as hydrocarbons, halocarbons and oxygenates. All VOCs are compounds of carbon and exist as atmospheric vapours.

In comparison to other pollutants, the monitoring of VOCs is not yet well developed and there is no long term database of information. In June 1992 the Department of the Environment began to develop a small network known as the UK Hydrocarbon Monitoring Network. Hydrocarbons measured include benzene, xylene and toluene.

***Benzene***

Benzene is a volatile organic compound, i.e. it readily evaporates. About 80% of human made emissions come from petrol fuelled vehicles. Benzene is monitored as part of the UK Government's Hydrocarbon Monitoring Network.

***Lead (Pb)***

Lead is a bluish or silver-grey soft metal. In the context of air pollution, two of its most important compounds are used as 'anti knock' additives in leaded petrol. The concentration of lead emitted in the UK has fallen over recent years due to increasing use of unleaded petrol. Leaded petrol is no longer sold in the UK. Lead is monitored under five different networks in the UK. Lead has also been widely studied in the UK due to concern over health implications.

## ***A Case Study of Air Pollution in London Today***

### **GEOGRAPHY**

**Location:** Situated in the south east of England on the banks of the River Thames, 65 km west of its estuary on the North Sea.

**Area:** 1 579 km<sup>2</sup>

**Altitude:** 5m above sea level.

### **DEMOGRAPHY**

**Population:** (1998) 7.2 million - Greater London.

### **CLIMATE**

**Rainfall:** Mean annual precipitation is 597mm.

**Temperature range:** 5.5 - 18.1°C. London causes a noticeable urban heat island effect, showing typical temperatures of 2-3°C higher than in the surrounding rural areas.

### **TRANSPORT**

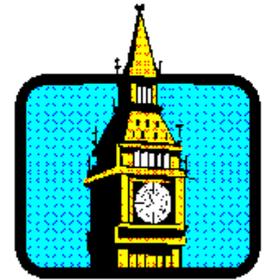
**Motor Vehicle Registrations:** 2,845,700 (2001).

**Air Transport:** There are two airports located within the Greater London area and a number of heliports, the largest and busiest being at Battersea. Total number of passengers (2000):

Heathrow: 64,279,000

### **INDUSTRY**

London is one of the most important banking and commercial



centres in the world. Until the 1960s it was also an important port. However, changes in working practices and a decrease in Britain's manufacturing base led to the closure of most of the docks, although a few wharves remain in operation. The industries which were associated with the docks have tended to relocate out of London. Some major industrial areas still exist in the east, along the Thames, whilst smaller industrial areas are located to the north along the River Lea, in the west along the Grand Union Canal and to the south in Croydon.

Power generation is mainly from gas and oil fired power stations located in the outer area of Greater London.

During the second half of the 20th century emissions from motor vehicles have become increasingly important in terms of affecting air quality in London.

It is estimated that road traffic in London has roughly doubled over the past 25 years, yet the road area has increased by only 10 percent over the same period. Such growth in traffic has resulted in increased emissions of CO, NO and secondary pollutants such as NO<sub>2</sub> and O<sub>3</sub>. The increasing level of traffic is also likely to offset any reductions in NO<sub>x</sub> and CO emissions brought about by the introduction of MOT exhaust emission tests and catalytic converters.

Petrol engined vehicles already account for the vast majority of CO emissions into London's atmosphere, and under certain weather conditions London-wide episodes of elevated CO levels occur. Indeed, in 1989 the WHO eight-hour guideline for CO was exceeded on 27 days at the central London background air quality monitoring station (Bell, 1993). More recently, however, concentrations of CO in London have fallen due to improved engine technology and lower emissions.

Air transport also has a small impact on air quality in London. The most significant pollutant emissions from London's airports are CO, NO<sub>x</sub> and hydrocarbons. Heathrow airport accounts for 6%

of the total NO<sub>x</sub> emissions in Greater London and 2% of Greater London's total CO emissions.

London's enormous size and energy use mean that it still experiences sulphur levels higher than many European cities, the main source of sulphur pollution in London being from power stations. These emissions often descend on London with light easterly winds; conditions usually responsible for the worst SO<sub>2</sub> episodes in Greater London.

The main sources of air pollutants in London are shown in Table 3.2, clearly identifying transport as the principle polluter in the city.

Smoke levels have decreased dramatically in London over the past century. This has led to increased sunlight levels resulting in the photo-oxidation of urban air pollutants known as photochemical smog. The NO<sub>x</sub> and VOC gases that contribute to these smogs mainly arise from motor vehicles.

Ground level ozone has become an increasing problem in London in recent years. In hot, sunny conditions ozone concentrations in excess of WHO guidelines

frequently occur in central London (Brimblecombe, 1987).

The highest pollutant levels in London are most commonly experienced during the autumn months. This is due to the typical high pressure over the south-east of England, which results in light winds and thus less dilution of air pollution (WHO, 1992). Temperature inversions also cause a problem in the city, trapping emissions and preventing them from dispersing into the upper atmosphere.

In the early 1990s the London Air Quality Network was set up - see website at:

<http://www.erg.kcl.ac.uk/london/asp/home.asp>

The UK Government also improved access to air quality information by setting up a freephone number, and providing details on teletext and the Internet at:

<http://www.airquality.co.uk/>

A comparison of emissions at a kerbside and a background monitoring site are shown in Tables 3.3 and 3.4. In general, higher concentrations are recorded at the kerbside site,

whilst background levels are more representative of the average levels of human exposure in the city.

The introduction of the UK National Air Quality Strategy in 1997 (DETR, 1997) is aimed at improving air quality in the UK. Standards and objectives for all of the main urban pollutants have been set to ensure that urban air quality improves in future years.

## **CONCLUSIONS**

The air quality in London has undergone changes in the last few decades, due mainly to the decline in industrial and domestic sources of pollution in the city and the increase in vehicular pollution. The consequence of this is the move from thick, dense smogs to photochemical smogs.

The introduction of the UK National Air Quality Strategy and greatly increased access to information on air quality in the late 1990s should lead to an improvement in urban air quality in London. However, to achieve the air quality objectives set in the Strategy, there will be a need to be a dramatic shift in transport use in London, from cars to public transport.

**Table 3.2. Sources of the Main Air Pollutants in London, 1991**

SOURCE	Carbon dioxide (as carbon)	Sulphur dioxide	Black smoke	Carbon monoxide	Nitrogen oxides
Road Transport	33	22	96	99	76
Other Transport	3	1	2	1	4
Electricity Gen.	2	0	0	0	1
Other Industry	13	43	1	0	5
Domestic	30	1	0	0	6
Other	19	32	2	0	8
<b>Total emissions (000 tonnes)</b>	<b>8503</b>	<b>26</b>	<b>19</b>	<b>648</b>	<b>137</b>

Source: London Research Centre, 1993

**Table 3.3. Concentrations of Major Air Pollutants in London, (Cromwell Road Kerbside Site), 2001**

POLLUTANT	Annual mean	Max. hour concentration	Air Quality Strategy objectives
Ozone	n/a	n/a	50ppb (8 hour mean)
Nitrogen dioxide	39.8 ppb	107 ppb	105ppb (hourly mean) Exceeded once in 2001, max allowed 18.
Carbon monoxide	1.0 ppm	4.7ppm (max 8hr 3.5 ppm)	10ppm (8 hour mean)
Sulphur dioxide	2.7 ppb	25 ppb	132 ppb (1 hour mean)

Source: NETCEN

**Table 3.4. Concentrations Of Major Pollutants in London, (London Brent Background Monitoring Site), 2001**

POLLUTANT	Annual mean	Max. hour concentration	Air Quality Strategy objectives
Ozone	18.6 ppb	91 ppb (max 8hr 76 ppb)	50ppb (8 hour mean) Exceeded on 21 days (max. allowed 10 days)
Nitrogen dioxide	19.1 ppb	79 ppb	105ppb (hourly mean)
Carbon monoxide	0.3 ppm	6.1 ppm (max 8hr 3.5 ppm)	10ppm (8 hour mean)
Sulphur dioxide	1.6 ppb	27 ppb	132 ppb (1 hour mean)

Source: NETCEN

**NB** In tables 3.3 and 3.4, concentrations are given in parts per billion (ppb) and parts per million (ppm). If you wish to compare these with others given in this pack, you can use the conversion figures below:

Pollutant gas	ppb to $\mu\text{g m}^{-3}$ multiply by
Ozone	2.00
Nitrogen Dioxide	1.91
Nitric Oxide	1.25
Carbon Monoxide	1.16 (ppm to $\text{mgm}^{-3}$ )
Sulphur Dioxide	2.66

## ***Exercises***

1. In your own words write a summary of the air quality in London today.

2. Telephone the Department for Environment, Food & Rural Affairs' freephone number:

0800 556677

Find out what levels of pollutants have been monitored in London today. Alternatively, this information is available on:

TELETEXT pages 155 & 169  
or the Internet:  
<http://www.airquality.co.uk/>

How was the air quality described for London?

Low

Moderate

High

Very High

What levels of nitrogen dioxide (NO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>), ozone (O<sub>3</sub>) and carbon monoxide (CO) were recorded? (All in parts per billion - ppb except CO in parts per million - ppm).

Site	NO <sub>2</sub>	SO <sub>2</sub>	O <sub>3</sub>
London Bexley			
London Southwark			
Sutton roadside			

## Lesson 4: Transport & Urban Air Pollution

### Introduction

In most urban areas of the UK transport is the largest source of air pollution, particularly for emissions of carbon monoxide, particulates (including black smoke), nitrogen oxides and hydrocarbons. The emissions of pollutants from road traffic in the UK for 1999 are summarised in Table 4.1.

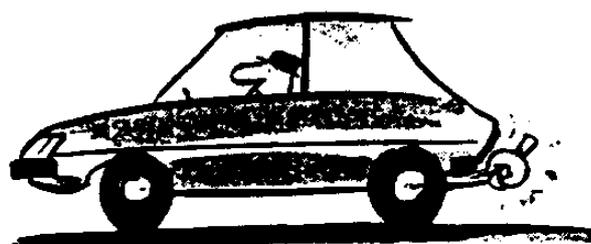
**Table 4.1. Emissions From Road Traffic in the UK, 1999**

Pollutant	Emissions (000 tonnes)	% of total UK Emissions
Carbon Monoxide (CO)	3,293	69
Black Smoke	130	48
Nitrogen Oxides (NO <sub>x</sub> )	714	44
Volatile Organic Compounds (VOCs)	473	27
Carbon Dioxide (CO <sub>2</sub> )	31,200	22
Sulphur Dioxide (SO <sub>2</sub> )	12	1

Source: DEFRA, 2001

Road transport is an important source of the precursor pollutants that lead to the formation of ground level ozone. This is particularly problematic during periods with long hours of bright sunlight, temperatures above 20°C and light winds.

Recently there has been concern over emissions of benzene (a hydrocarbon) as it can cause cancer. The major source of benzene in the atmosphere is the combustion and distribution of

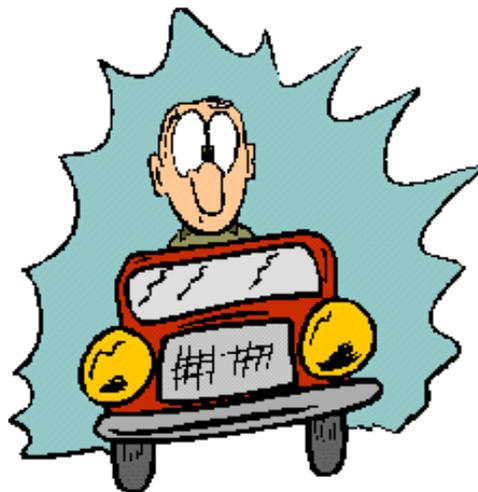


**Bengt Good**

petrol; approximately 70% of benzene emissions are from petrol fuelled cars.

In recent years there has been a large increase in the number of vehicles in the UK which has been overshadowed by the even greater increase in vehicle usage. For example, between 1980 - 2000, vehicle ownership in the UK increased by about a third to approximately 29 million vehicles. However, vehicle usage during the same period increased by 70% to 460 billion vehicle kilometres. This was reflected in increases in vehicle related pollutant emissions.

Transport related pollution is likely to become increasingly important in the future as vehicle numbers and usage are expected to continue to rise.



### ***Reducing Air Pollution From Road Traffic***

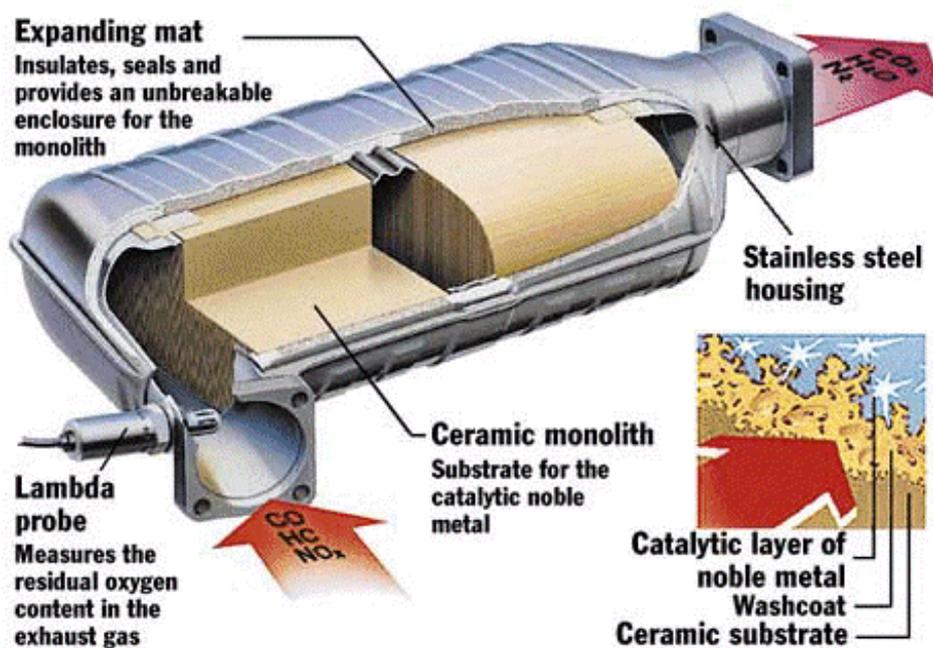
There are many ways in which road traffic pollution can be reduced, including restriction of traffic, technological solutions and changes in people's travelling behaviour. Many of these measures are only effective if they are carried out alongside other methods of pollution reduction. Therefore it is important that a balanced plan is made for reducing air pollution which includes several actions.

In recent years there have been substantial developments in the technology and design of cars which are aimed at reducing the emissions of air pollutants. Some of these are outlined below.

### ***Catalytic Converters***

Since January 1993 all new cars sold in the European Union (EU) have to be fitted with a catalytic converter. This is made up of a very thin layer of platinum group metals on a honeycomb structure (see Figure 4.1). As the exhaust gases pass through the catalyst a chemical reaction occurs which converts carbon monoxide (CO), hydrocarbons (HC) and oxides of nitrogen (NO<sub>x</sub>) to less harmful compounds (water, nitrogen and carbon dioxide). To work most effectively a catalytic converter needs to reach an optimum temperature. It may not reach this in a short journey. Devices to pre warm the catalyst are being developed which will improve the overall performance of catalytic converters.

***Figure 4.1. A Catalytic Converter***



The use of catalytic converters leads to a dramatic reduction in the emissions of CO, HC and NO<sub>x</sub>. However, they also result in an increase of CO<sub>2</sub> emissions which do not cause a problem for urban air quality but do contribute to global warming.

### ***Lean Burn Engines***

Lean burn engines are more fuel efficient than other engines and produce less NO<sub>x</sub> and CO, but they do emit higher levels of hydrocarbons. At the present time they are still under development and have not yet been able to meet EU emission standards, especially at high speeds.

### ***Exhaust Gas Recirculation***

This involves returning exhaust air to the air fuel inlet, which results in a reduction in peak engine temperatures and emissions of NO<sub>x</sub> gases from petrol vehicles. Levels of CO and HC are also reduced.

### ***Alternative Fuels***

Fuels to replace the more polluting traditional fuels are also being promoted as a method for reducing emissions from road transport. The main alternative fuels that have been developed to date include, natural gas, liquefied petroleum gas, hydrogen, alcohol fuels and battery operated vehicles.

Whilst technical fixes such as those outlined above may provide cleaner air for the next 10 - 15 years, they do not represent a long term solution to transport related urban air pollution. They need to be combined with planning and policy measures which balance the need for people to travel with a reduction in urban air pollution. These measures will be discussed in the role play that follows. (They are also examined in lesson 7, which may provide useful background information for the role play.)

## ***Role Play Exercise***

The aim of this exercise is to promote a discussion of the various issues that arise when planning decisions need to be made. The emphasis of the discussion should focus on the effects of the transport plan on the quality of the air. A teacher will therefore need to chair the role play discussion to ensure that each group has opportunity to put forward their opinions and that an orderly discussion follows.

### ***Instructions:***

1. Divide the class into 6 groups and give each group a role play card:
  - Group 1) Suburban Commuters
  - Group 2) Friends of the Environment
  - Group 3) Northshire Retailers Association
  - Group 4) Northshire City Centre Residents Group
  - Group 5) Health Protection Society
  - Group 6) Goods R Us
2. Each group should be given a copy of the background information (pages 38-41). These should be read by all participants along with the role card and any extra information.
3. Each group should discuss the proposed measures in the transport plan and decide their views on each of the proposals, choosing which measures (if any) they wish to support. Groups may also suggest ideas of their own to be included in the plan. Notes should be made by each group on their support or rejection of the proposed transport plan, stating alternative proposals where appropriate.

4. Each group should present their case to the meeting, explaining the reason for their decision.
5. After each group has presented their views the other groups should raise questions about their decisions and discuss opposing views in the transport debate. The teacher should chair this debate.
6. Once the discussion has ended the class should vote on the measures that have been proposed, to reach agreement on what the Council's transport plan should include.

### ***Role Play Exercise Background Information***

#### *Northshire City*

*Population:* 300 000

#### *Industry:*

There is a small industrial area to the north of the city. The other main area of employment is the business district, which contains many service related businesses and commercial ventures, located to the west of the city.

#### *Transport:*

- ★ car ownership is high (many households have one or more cars);
- ★ commuting from the residential areas is very common (most commuters live in the suburbs of Northshire);
- ★ cycle routes exist to the south of the city;
- ★ local rail services operate to some parts of the suburbs;
- ★ car parking in the city centre is heavily subsidised.

The Northshire City Council is preparing a transport plan for the city. They are holding a public meeting to get ideas from local people and interest groups that will be affected by the plan.

Details have been produced to introduce each of the possible measures which could be included in the transport plan. These include pedestrian areas in the city centre, improving public transport, a park and ride scheme, a parking policy and road pricing, details of which are as follows:

### ***Pedestrianisation Of The City Centre***

- ★ all vehicles to be banned from the central area of the city between 11am and 4pm, with exemptions for disabled people (permits to be issued) and certain delivery services;
- ★ areas surrounding the pedestrianised zone are to have widened pavements and reduced road area, with lower speed limits to discourage through traffic;
- ★ bus corridors will be introduced to allow access for public transport;
- ★ lighting, security cameras and seating are to be improved.

### ***Improving The Public Transport Network***

- ★ Improvement of information about services;
- ★ improvement of facilities at stations to provide a clean, safe and attractive environment;
- ★ bus lanes to the city centre to be introduced with strict enforcement of parking / driving restrictions in the lanes;
- ★ bus only corridors through pedestrianised areas;
- ★ improvement of links between bus and train services;

- ★ increased frequency and reliability of services;
- ★ extension of network to areas currently lacking public transport;
- ★ improved night services;
- ★ increased range of saver tickets;
- ★ improved facilities for disabled persons.

### ***Park and Ride Scheme***

- ★ 4 000 free parking spaces to be provided at two bus terminals and two train stations in different parts of the suburban area;
- ★ fixed low cost fares to the city centre;
- ★ bus routes to the city centre from various suburban locations every 5 minutes (peak times) and 10 minutes (other times);
- ★ bus routes to the business park as above (same frequency);
- ★ services stop at railway stations, bus stations, major employment areas in city centre and city tourist attractions.

### ***Parking Policy***

- ★ number of parking spaces in city centre to be reduced and concentrated in car parks;
- ★ parking costs to be increased;
- ★ all street parking to be scrapped;

- ★ strict enforcement of parking restrictions on bus and cycle lanes.

### ***Cycling Policy***

- ★ new developments must provide on site parking for cycles;
- ★ increase in the number of cycle parking spaces in the city, especially outside large businesses, railway and bus stations, public amenities etc.;
- ★ more cycle lanes in the city centre to be introduced, space to be taken from the road, not the pavement;
- ★ extra time to be allowed at traffic signals for cyclists;
- ★ public awareness campaign to provide information about cycling in the city.

### ***Road Pricing***

- ★ drivers to be charged using pre-paid cards (similar to phone cards) for travel in the city zone between 0600 and 1700 hours, Monday to Saturday;
- ★ exemptions for disabled drivers, taxis and public transport;
- ★ the funds collected will be used to finance improvements to the transport networks, public transport and other transport related schemes. Charges will be higher at peak periods of the day and will be different for various types of vehicle. Charges will also be increased during periods of poor air quality.

**ROLE CARD: GROUP 1****SUBURBAN COMMUTERS**

You are a group of people who work in the business park and drive into the city centre in your cars. You enjoy the freedom that you get from driving and think that buses / trains are crowded, uncomfortable, dirty and inefficient, You also think that something should be done to reduce the congestion on the roads into the city.

Points to consider:

- cost of travelling;
- changes that would make you use public transport;
- personal freedom;
- door to door driving;
- journey time.

**ROLE CARD: GROUP 2****FRIENDS OF THE ENVIRONMENT**

Friends of the Environment are an international pressure group who campaign on a wide range of environmental issues. Air pollution from transport is one of their major campaign areas. Friends of the Environment are a non-governmental organisation..

**Supplementary notes**

Motor vehicle emissions have an impact on various areas of the environment: vegetation, freshwater, buildings, etc. The principle pollutants emitted from vehicles which cause damage to the environment are oxides of nitrogen and sulphur dioxide. Other exhaust gases called hydrocarbons can react with nitrogen oxides to form ozone. This process results in photochemical smog.

Motor vehicle emissions can contribute to the erosion and soiling of buildings. Air pollution from vehicles also affects health; some of the pollutants are known to be carcinogenic. The number of private cars in Great Britain continues to rise each year at a very fast rate.

**ROLE CARD: GROUP 3****NORTHSHIRE RETAILERS ASSOCIATION**

The Northshire Retailers Association campaign about issues that affect shop owners in the city. They represent the views of a range of retailers, both large and small. They want to see a reduction in air pollution in the city but are worried that preventing traffic from entering the city centre will lead to a decline in trade.

Points to consider:

- how a reduction in traffic could have an impact on city centre businesses
- would pedestrianisation be beneficial?
- the impact of a restriction on delivery times
- would travel by public transport encourage or discourage shoppers, e.g. those with young children, the elderly, weekend shoppers (weekday workers), those with heavy / bulky items to purchase?

**ROLE CARD: GROUP 4****NORTHSHIRE CITY CENTRE RESIDENTS GROUP**

The Northshire City Centre Residents Group provide a forum for residents of the city centre to discuss issues that affect them in the city. They are campaigning for cleaner air in the city and want safe, traffic-free pedestrian / cycle routes which provide access to shops, employment, schools and local amenities.

Points to consider:

- which proposals would be of most benefit for local residents?
- other ideas to improve the environment of the city?

**ROLE CARD: GROUP 5****HEALTH PROTECTION SOCIETY**

The Health Protection Society is a local group that aims to promote information about the impacts of pollution on health and campaigns for the introduction of measures to reduce air pollution in towns and cities.

**Supplementary notes**

Air pollution can affect human health, ranging from slight feelings of discomfort to major respiratory problems. This may be caused by a single pollutant or the combined effect of a number of pollutants. People most at risk from air pollution are children up to and including the age of 14 (with children under 5 most at risk), asthma sufferers, the elderly, pregnant women and unborn babies, as well as those taking vigorous exercise and people suffering from pre-existing conditions such as heart or circulatory disease and reduced breathing capacity. The effects of various air pollutants on human health are outlined in Table 6.1 in Lesson 6 of this pack.

Concentrations of pollutants such as carbon monoxide, nitrogen oxides and lead are higher inside cars than background levels. Emissions of carbon monoxide and hydrocarbons are higher in congested slow moving traffic and peak during the morning and evening rush hours.

**ROLE CARD: GROUP 6****GOODS R US**

You are a goods distribution / courier firm who are based in the outskirts of Northshire and deliver to businesses throughout the city. Heavy traffic at peak times often causes delays to urgent deliveries. You believe that it is important for you to be able to reach any address in the city at any time of the day and therefore have access to all customers.

Points to consider:

- how would road closure and road pricing affect business?

***Follow Up Work***

- ★ Look out for reports about air pollution and transport in your local newspaper.
- ★ Does your local town or city have any of the measures discussed in the role play? If so, do you think they are effective?
- ★ Do you think that transport causes an air pollution problem in your nearest town / city?
- ★ How do the people in your family travel into your local town? Could this way of travelling be changed to reduce the emissions of air pollutants from this mode of travel?

# Lesson 5: Industries & Urban Air Pollution

## ***Air Pollution from Industries in the UK***

Industries contribute significantly to the air pollution problem in the UK. Lessons 1 and 2 have identified that during the Industrial Revolution industries were often located in urban areas. Following the Clean Air Acts and with the decline of heavy industry, few large industries are located in towns and cities today. Many large industries and power stations are now located in more rural areas of the UK. However, most urban areas have some smaller industries and possibly a power station. The larger industrial sources, even though located out of town, also have an impact on urban air quality.

## ***Industrial Smoke Pollution***

Smoke pollution can be defined as particulate material smaller than  $15\mu\text{m}$  in diameter which arises from the incomplete combustion of fuel. Estimates for emissions of smoke in the UK for 1999 identify that power stations account for 5% of UK emissions and other industries for 3%. The significant sources of smoke pollution are therefore not industries but rather vehicles (48%) and domestic sources (29%).

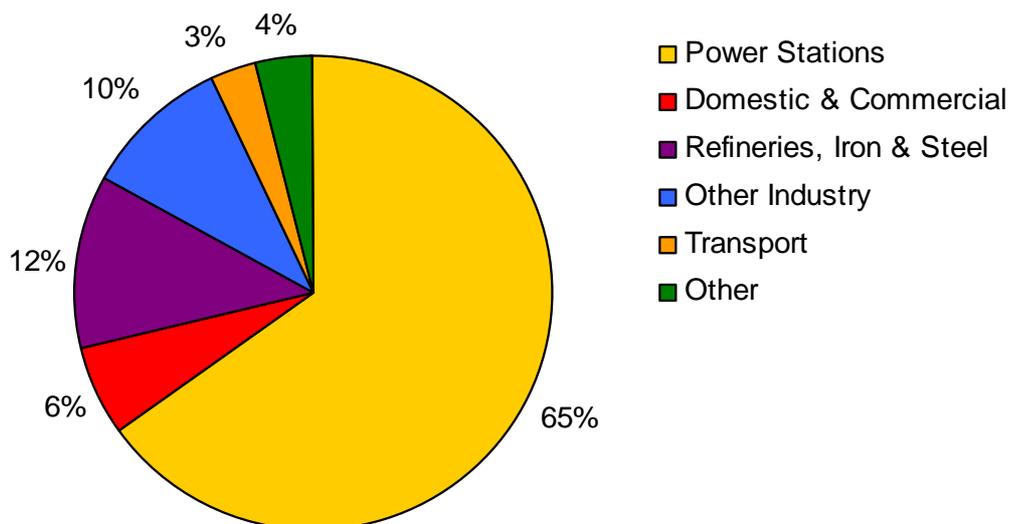
In the past, urban air pollution was dominated by thick black smoke which was emitted from industries and power plants burning coal. Levels of smoke in cities and towns during the wintertime in particular were at much higher concentrations than those measured today. Table 2.2 in Lesson 2 shows that in the early 1960s, winter smoke concentrations in central Manchester averaged at more than  $250\mu\text{g}\text{m}^{-3}$ . Today, the typical urban annual mean for smoke is  $10\text{-}40\mu\text{g}\text{m}^{-3}$ . The reason for this has been due to technical air pollution control, the decline in the use of coal for domestic purposes and the

general shift of power stations and industries from town and city centres to more rural locations.

### ***Industrial Sulphur Dioxide Pollution***

Industries are the major source of the UK sulphur dioxide pollution, as identified in Figure 5.1. Power stations and all other types of industry account for 90% of all UK SO<sub>2</sub> pollution. Most industries and power stations are now located in rural areas but urban areas often lie in the prevailing wind path of these industries.

**Figure 5.1 Sources of Sulphur Dioxide Pollution in the UK. (1999)**



Source: DETR (2001)

Sulphur dioxide, along with smoke, are both pollutants which have long been associated with urban air pollution. As a consequence of the Clean Air Acts, SO<sub>2</sub> levels have fallen dramatically in urban areas. This gives a misleading picture of SO<sub>2</sub> pollution in the UK because whilst levels in urban areas may have reduced to an annual

mean concentration way below  $100\mu\text{gm}^{-3}$ , coal burning industries and power stations still emit large quantities of  $\text{SO}_2$  into the atmosphere via their tall chimney stacks.

Small industries located within urban areas may greatly affect local  $\text{SO}_2$  levels as their emissions may become trapped by temperature inversions in the urban environment.

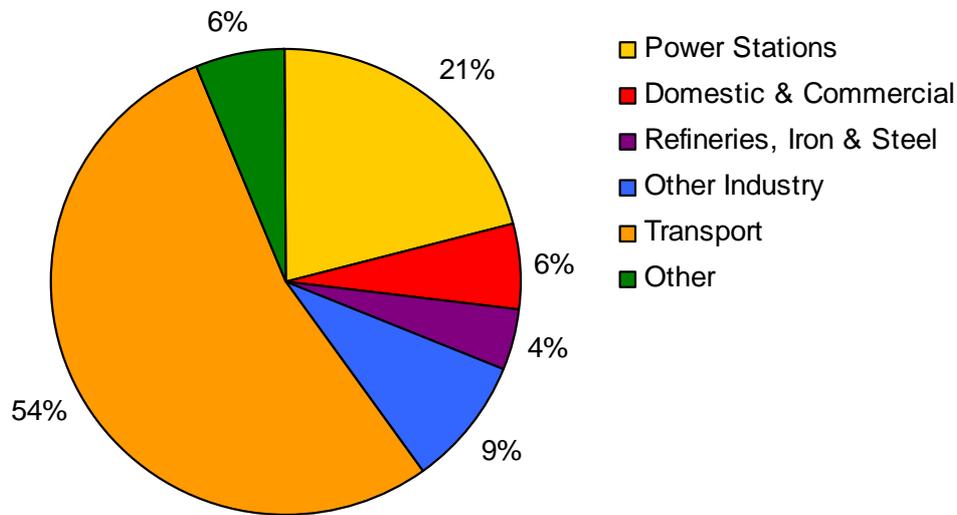
Sulphur dioxide pollution is one of the main pollutants that causes acid rain when it combines with water in the atmosphere to form sulphuric acid. Because the main source of  $\text{SO}_2$  in the UK is industry, industries are therefore major contributors to rainfall acidity. Acid rain affects urban areas by causing faster erosion of certain building materials, and it can cause damage to urban vegetation.

### ***Industrial Oxides of Nitrogen Pollution***

Power stations contribute significantly to the total emission of nitrogen oxides in the UK. In 1999, 21% of  $\text{NO}_x$  came from this source and a further 13% arose from other industries, iron and steel and refineries. Figure 5.2 shows the major sources of  $\text{NO}_x$  pollution in the UK to be road transport and power stations.

Whilst the majority of  $\text{NO}_x$  emissions arise from road transport, the contribution of industrial  $\text{NO}_x$  pollution is still important. Nitrogen oxides are also converted into nitric acid when combined with water in the atmosphere, hence, like  $\text{SO}_2$ , contributing to acid rain.

**Figure 5.2: Sources of Nitrogen Oxide Pollution in the UK. (1999)**



Source: DEFRA (2001)

### ***Other Industrial Pollutants***

Industries do not emit large quantities of the other major urban air pollutants. The UK contribution of power stations and industries in 1999 for carbon monoxide was 3% and for volatile organic compounds (hydrocarbons) was negligible.

## ***Exercise***

1. Carry out fieldwork in your locality to gain information on possible air pollution problems that may occur in the area around your school / college. Look out for sources of air pollution such as industries and major roads, and for historical buildings, vegetation, densely populated areas which may be subject to the effects of air pollutants.
2. Devise a questionnaire of approximately ten questions in an attempt to discover how local residents feel about the quality of air where you live. You could include questions based on your fieldwork, which may include:
  - particular industries or busy roads that are located in your area;
  - concerns about the effects of air pollution on health, buildings, vegetation;
  - attitudes on increasing use of vehicles.
3. Conduct as many questionnaires as you can on members of your family, friends or neighbours.
4. Write a short report on the general conclusions that you have obtained from your questionnaire surveys.

# ***Lesson 6: The Effects of Urban Air Pollution***

## ***Human Health & Air Pollution***

As individuals we all depend on clean air and there is little doubt that polluted air is detrimental to health, especially to the respiratory system. The effects of air pollution can range from slight feelings of discomfort to major breathing difficulties and even death. For example, high concentrations of SO<sub>2</sub> and smoke were responsible for increased mortality rates during the smogs of the 1950s as described in lessons 1 & 2.

Individual responses to a given concentration of air pollution are dependant upon a number of factors:

- **age & general health of the individual;**
- **type of pollutant;**
- **activity being undertaken when exposed to air pollution;**
- **concentration and length of exposure to the pollutant.**

## ***Age & Health***

Children up to the age of 14, and particularly children under 5 years old, are susceptible as pollutants are quickly absorbed into the body. Also the elderly and those with respiratory ailments are more at risk. Asthma sufferers are especially sensitive and attacks may be triggered by raised pollution levels.

## ***Type of Pollutant***

Adverse human health effects may be caused by a single pollutant or the synergistic effect, the acting together, of a number of pollutants.

Individual pollutants have differing effects on human health, for example carbon monoxide, when entering the body, displaces the oxygen in the bloodstream and thus reduces the oxygen carrying capacity of the blood. This leads to oxygen starvation which can result in headaches and vomiting, can cause an individual to collapse and ultimately can lead to death. Table 6.1 summarises the main effects of air pollutants on health. There are also concerns about the 'cocktail' or mix of pollutants in urban air although little is known to date about the health effects of a combination of pollutants.

## ***Activity and Exposure to Pollutants***

Individuals taking vigorous exercise, especially close to sources of pollution (e.g. jogging along a main road), may also be at risk from pollution. When taking exercise increased amounts of inhaled air enters the body and as a result pollutants are inhaled deep into the lungs.



## ***Concentration and Length of Exposure to Pollutants***

Effects of pollution on human health are dependent upon both the duration of exposure and the concentration of the pollutant. In order to protect human health there are different air quality standards and guidelines for differing averaging times. For those pollutants for which long term exposure is significant, air quality guidelines and standards are based on pollution concentrations over long time periods *i.e.* annually, while those pollutants for which short term exposure is important guidelines and standards are based on between 10 minutes exposure to 24 hours.

***Table 6.1: The Effects of Air Pollution on Human Health***

<b><u>Pollutant</u></b>	<b><u>Effects on human health</u></b>
Sulphur dioxide (SO <sub>2</sub> )	Can cause respiratory problems, leading to chronic bronchitis, can cause narrowing of the airways and can affect asthmatics.
Carbon monoxide (CO)	Interferes with blood's capacity to absorb and circulate oxygen. Worsens emphysema, chronic bronchitis and other lung disease. Can affect those suffering from heart disease and can have impacts on the central nervous system.
Nitrogen dioxide (NO <sub>2</sub> )	Can cause respiratory disorders such as altered lung function, lung tissue damage, increased prevalence of acute respiratory illness. Young children and asthmatics are most at risk.
Ozone (O <sub>3</sub> )	Can aggravate chronic respiratory diseases and can cause permanent lung damage. Can affect the eyes, nose and throat, as well as causing chest discomfort, coughing and headaches.

Benzene (C <sub>6</sub> H <sub>6</sub> )	Can cause cancer, anaemia and injury to bone marrow.
Lead (Pb)	Can cause mental retardation, drowsiness and problems with the kidneys and reproduction system. Long term exposure interferes with normal development and functioning of the brain.
Particulates (PM <sub>10</sub> )	Can cause acute respiratory disorders and decrements in lung function and can lead to premature death.
Volatile organic compounds (VOCs)	Health effects are dependent upon the specific VOC, however a number of VOCs are known or suspected to cause cancer.

## ***Buildings & Air Pollution***

It is widely acknowledged that high concentrations of sulphur dioxide pose a threat to building materials. However, despite the reduced levels of SO<sub>2</sub>, damage to buildings is still evident. This could be caused by increased concentrations of ozone and nitrogen compounds within the urban environment. Experiments carried out have shown that a combination of pollutants, *i.e.* ozone, nitrogen dioxide and sulphur dioxide corrode stone faster than they would separately.

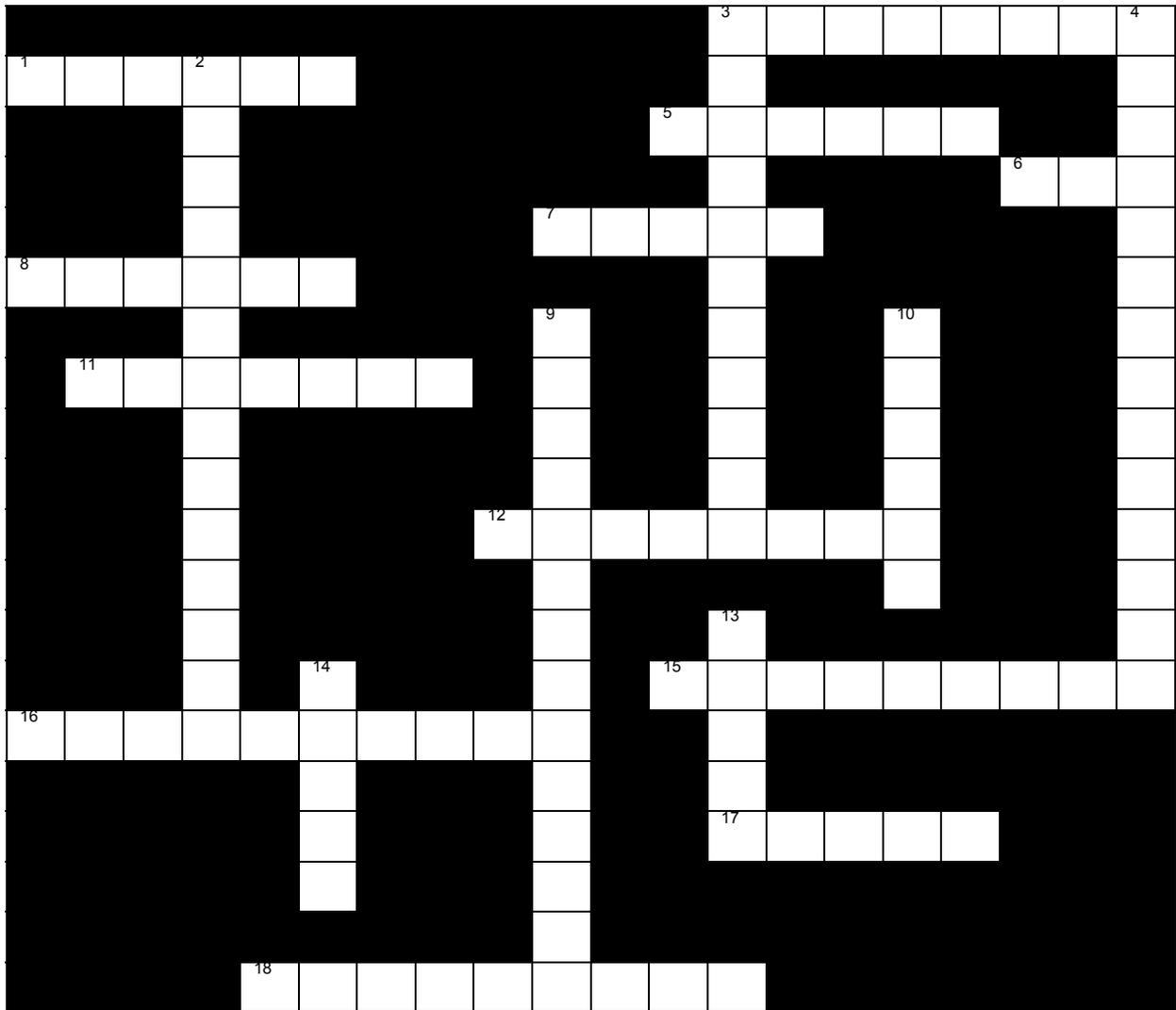
An important issue associated with urban air pollution is the soiling of buildings. Urban areas are increasingly becoming congested, and as such smoke and other airborne particles from predominantly diesel-engined vehicles have now taken over from coal smoke as the major cause of blackening of building surfaces. Soot and other airborne particles can also combine with pollutants to increase the erosion damage to buildings.

## ***Urban Vegetation***

Within the urban environment there are trees, hedgerows and herbaceous plant species found in public parks, along roadsides, in private gardens and allotments. Prior to the Clean Air Act of 1956 few species were able to grow and thrive within towns and cities. However, today a greater diversity of species can be found, although this diversity is being threatened by pollutants predominantly from motor vehicles.

Air quality in urban areas is a major factor influencing growth of urban vegetation. Some studies have shown that crops and plants which have been planted along major routes from suburban areas to city centres show poor growth rates nearer they city. It is however, difficult to single out the effect from any one single pollutant, and plant deterioration is probably a result of a mixture of airborne pollutants. However, high ozone levels have shown deterioration of plant species in a number of studies.

A number of plant species, particularly those with short leaves such as spinach and clover, are sensitive to ozone, and visible damage may become evident after a short exposure. Whilst there is no detailed knowledge of the effects of ozone on plant species, it has been assumed that the damage to the cell structure is a result of ozone penetrating into the stomata. This can also disturb the functioning of the stomata and thus upset the plant's moisture balance.

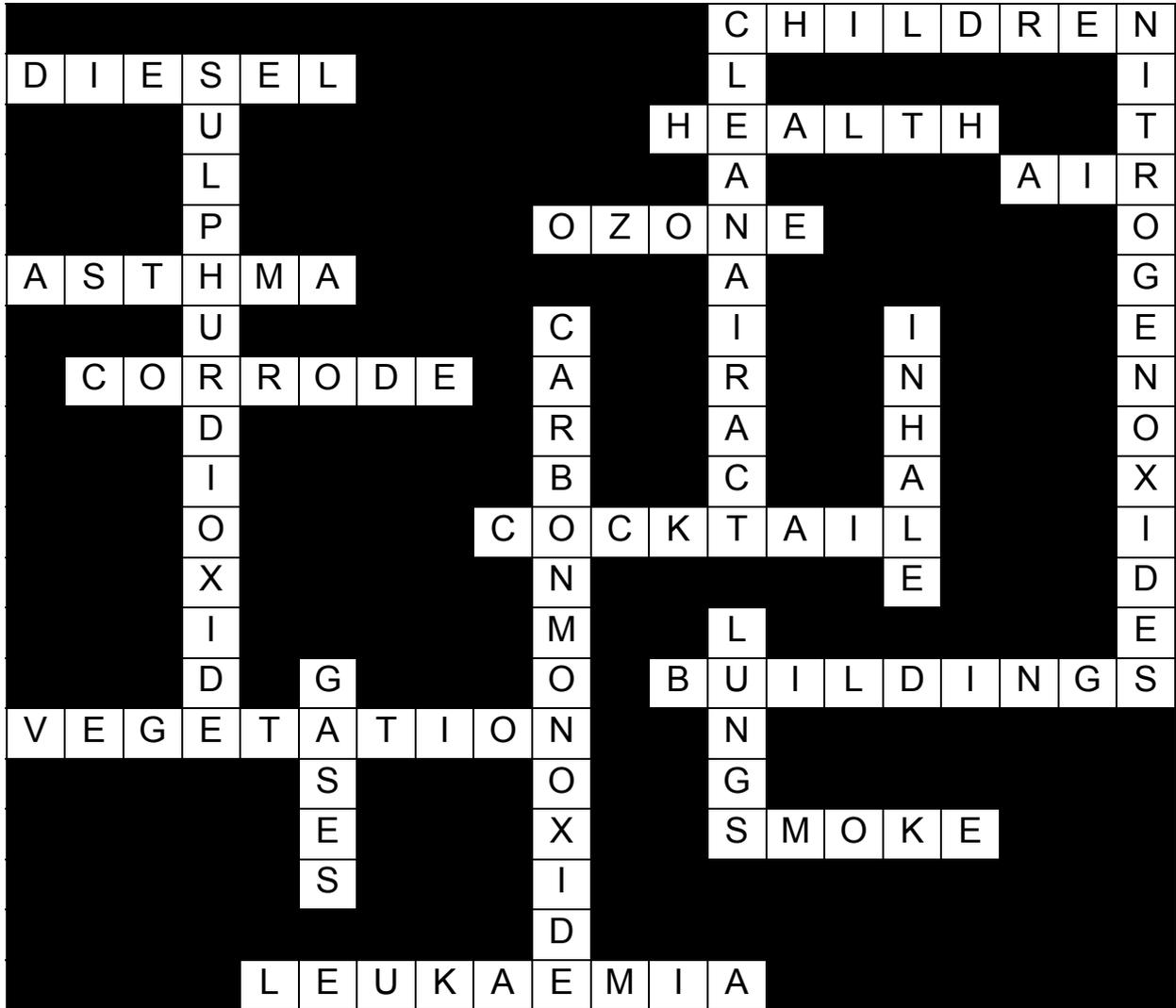
**Exercise: Crossword****Crossword Clues****Across**

- 1) Type of fuel - not petrol (6)
- 3) Young humans affected by pollution (8)
- 5) Pollution damages this and makes you ill (6)
- 6) Mixture of gases essential for life (3)
- 7) This gas is created during photochemical smogs (5)
- 8) A disease which causes breathing difficulties (6)
- 11) Certain air pollutants do this to buildings and metals (7)
- 12) Mix of pollutants (8)
- 15) Pollutants corrode these (9)
- 16) Shrubs, plants and trees make up this (10)
- 17) Airborne particles (5)
- 18) Type of cancer caused by benzene (9)

**Down**

- 2) Major chemical which causes acid rain (7,7)
- 3) Legislation to prevent smog (5,3,3)
- 4) NO<sub>2</sub> and NO are these (8,6)
- 9) A chemical which displaces oxygen in the blood (6,8)
- 10) Opposite of exhale (6)
- 13) Respiratory organs (5)
- 14) Invisible constituents of air (5)

**Answers to Crossword**



# Lesson 7: Responses To Urban Air Pollution

## *The Government's Response*

The UK National Air Quality Strategy published by the Government in 1997 (and updated in 2000) sets air quality standards and guidelines for key pollutants:

- sulphur dioxide
- nitrogen dioxide
- carbon monoxide
  - benzene
- 1,3-Butadiene
  - particles
    - lead
    - ozone

The standards and objectives set in the Strategy are based on the effects on human health and have been set at levels similar to those adopted by the World Health Organisation and the European Union.

Through the Environment Act 1995, the Government has legislated a new framework for local air quality management, based on local air quality management areas. As a result the responsibility of meeting the new standards and targets will fall with the local authorities.

The local authorities will therefore be required to:

- periodically review air quality in their local area;
- establish air quality management areas in sectors of their authority where air quality targets are unlikely to be met;
- prepare plans for remedying air quality problems in the identified air quality management areas;
- co-ordinate activities which will influence air quality improvement, *i.e.* planning and transport policies.

In addition, the local authority will be expected to provide day to day information to the public on the air quality situation within the management areas.

### ***The Domestic Sector***

Since 1956 the smoke control policy has provided an effective system for the regulation of smoke and sulphur dioxide from domestic sources. This system has proved to be effective, and domestic emissions now represent negligible problems in most cities.

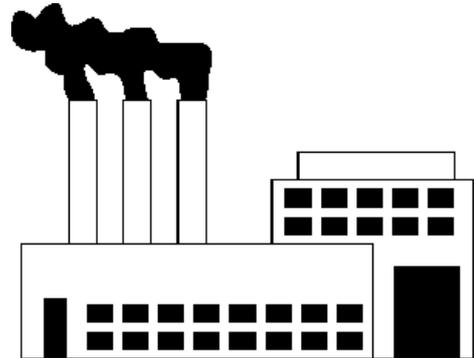
There are, however, parts of the UK where smoke and sulphur dioxide are still a problem.

#### ***EXAMPLE: NORTHERN IRELAND***

*In Northern Ireland domestic heating still relies heavily on coal burning, as natural gas has not been widely available there. Regulations are being implemented to limit the sulphur content of domestic coal. Natural gas however will be made available more widely in future years in Northern Ireland which should help to reduce urban air pollution in the Belfast area. For other parts of the UK the Government has no plans to implement further controls as emissions are continuing to decline.*

## ***The Industrial Sector***

Emissions from a range of industrial processes are controlled by Her Majesty's Inspectorate of Pollution (HMIP), or by the local authority. The local authority is required to use the **Best Available Technique Not Entailing Excessive Cost (BATNEEC)** to prevent or reduce emissions.



## ***The Transport Sector***

Road transport is the single greatest source of many air pollutants within the urban environment. Therefore, the future quality of urban air will be largely determined by the future pattern of motor vehicle emissions. Technical solutions such as catalytic converters and tighter MOT emission tests will result in a reduction of emissions on a per vehicle basis, but increasing vehicles on the road will, if not restrained, counteract these measures.

A combination of measures need to be put in place to achieve good air quality, such as balancing motor traffic restraint with increased use of public transport, walking and cycling and effective land use planning to avoid the need to travel, plus technical solutions from the motor vehicle industry.

## ***Land Use Planning***

The land use planning system has an important role to play in seeking to reduce pollution from vehicles. The location of new developments relative to a transport provision and vice versa can influence the need to travel. For example, new developments that attract large numbers of people, *i.e.* shopping centres and

educational establishments should be encouraged to locate in towns which have good public transport links and are easily accessible by foot or cycle.

## ***Pedestrians & Cyclists***

Pedestrians and cyclists can be encouraged to make short journeys by providing purpose built paths and rights of way, pavement improvements and cycle parking.

## ***Public Transport***

A well-used public transport system is energy efficient compared to the use of the private car. However, for public transport to be an attractive alternative, it needs to be reliable, efficient, cheap, convenient and attractive to use. This can be achieved by:

- ★ subsidising public transport to reduce the cost to the traveller;
- ★ providing good facilities at rail and bus stations;
- ★ developing bus priority measures to prevent traffic hold-up;
- ★ developing good interchange facilities so passengers can reach their destinations quickly and efficiently;
- ★ providing park-and-ride facilities;
- ★ upgrading local networks;
- ★ supplying good information services;
- ★ extending transport systems;
- ★ restraining car access on roads and increasing car parking charges to make buses / trains / trams more attractive.

**EXAMPLE: MANCHESTER**

*Manchester has introduced the MetroLink system, which is accessible to all travellers; it improves access to Manchester city centre and reduces congestion and pollution.*

**Traffic Restraint**

Towns and cities cannot take unrestricted traffic growth, therefore plans have to be put in place to restrain growth. Methods to restrain traffic include:

- ★ traffic calming;
- ★ parking policies;
- ★ road pricing;
- ★ traffic-free areas;
- ★ planned congestion.

**Traffic Calming**

Traffic calming uses physical barriers such as road humps and legal measures to reduce traffic speed.

**Parking Policy**

Parking policies can reduce the amount of parking space available and increase the cost of parking in an attempt to reduce the volume of traffic entering the urban area. This can be achieved by the removal of parking meters and short-stay car parking.

## ***Road Pricing***

This method aims to charge road users directly for the road space they use. A major problem associated with this method is that it can cause congestion due to the fact that cars have to stop and queue to pay road tolls. New techniques, however, such as the 'smart card' can reduce congestion. This card is used like a phone card at a roadside toll station where payment is automatically debited from a pre-paid card.

### ***EXAMPLE: HONG KONG***

*A road-pricing scheme was developed and tested during the 1980s in Hong Kong. Many people were angered at what they saw as an invasion of their privacy as vehicles were recorded by computer and bills produced individually. Therefore the system failed.*

## ***Traffic Free Areas***

These include pedestrianised zones which are generally put into action in small sections of towns and cities. Some European countries have taken this further.

### ***EXAMPLE: AMSTERDAM***

*Amsterdam has excluded cars from a large area around its main tourist areas; bicycles and trams provide non-pedestrian access but the car and delivery vehicles are restricted to small time periods at the beginning of the day.*

## ***Planned Congestion***

Congestion exists at certain times of the day, *i.e.* rush hour. The congestion can be planned or managed to enhance movement of selected modes of transport, whilst making it less attractive to other modes, *i.e.* bus or tram priority lanes. Further advances could include priority signals for public transport and bus activated signals.

No one traffic restraint can be considered in isolation. Transport and land use planners need to implement a balance portfolio of measures to:

- ★ restrain motor traffic;
- ★ encourage use of public transport and
- ★ provide incentives to walk or cycle.

## ***Traffic Bans & Poor Air Quality***

Summertime smogs in urban areas are the result of vehicular exhausts. Some countries operate a policy of banning all vehicles, or those without a catalytic converter, from urban roads when the air quality is considered poor. Los Angeles is the most famous of these smog cities and such traffic bans are common in this city. Many other European cities have adopted such measures including Rome and Athens.



## **Exercise**

The average car driver has little knowledge of the damage to the environment being caused by their vehicle. Find out about the effects of motor vehicle exhaust on the environment by contacting the information providers below:

### **Atmospheric Research & Information Centre (aric)**

*Manchester Metropolitan University  
Chester Street, Manchester M1 5GD  
Tel: 0161 247 1590/3  
Fax: 0161 247 6332  
E-mail: [aric@mmu.ac.uk](mailto:aric@mmu.ac.uk)  
Internet: <http://www.ace.mmu.ac.uk/>*

### **Department for Environment, Food & Rural Affairs**

*Air Quality  
Ashdown House  
123 Victoria Street  
London SW1E 6DE  
Internet: <http://www.defra.gov.uk/>*

### **National Society for Clean Air & Environmental Protection**

*44 Grand Parade  
Brighton BN2 2QA  
Tel: 01273 878770  
E-Mail: [info@nsca.org.uk](mailto:info@nsca.org.uk)  
Internet: <http://www.nsca.org.uk/>*

### **Transport 2000**

*The Impact Centre  
12-18 Hoxton Street  
London N1 6NG  
Tel: 0020 7613 0743  
E-Mail: [info@transport2000.org.uk](mailto:info@transport2000.org.uk)  
Internet: <http://www.transport2000.org.uk/>*

Design a leaflet to inform car owners using the information that you have received.

# Glossary

- **air pollution:** term to describe anything which contaminates the air that we breathe.
- **atmosphere:** the envelope of gases which surrounds the Earth.
- **benzene:** a colourless, flammable, aromatic liquid; a volatile organic compound which readily evaporates.
- **carbon monoxide:** a highly poisonous gas produced when fuel is burnt in insufficient air.
- **catalytic converter:** a device fitted to the exhaust system of a vehicle which converts the majority of harmful vehicle exhaust gases into less harmful ones.
- **combustion:** burning.
- **emissions:** the discharge of waste gases into the atmosphere.
- **emphysema:** a medical condition in which the air sacs become grossly enlarged causing breathlessness and wheezing.
- **Expert Panel on Air Quality Standards:** a group of scientists who recommend standards and guidelines for air pollutants to the UK Government.
- **fossil fuel:** any naturally occurring carbon or hydrocarbon fuel such as coal, petroleum, peat and natural gas, formed from the decomposition of organic matter.
- **fuliginous:** sooty or smoky.

- **hydrocarbons:** organic compounds containing carbon and hydrogen.
- **meteorological:** weather.
- **monitoring (air quality) :** scientific equipment is used to measure a particular air pollutant.
- **nitrogen oxides:** collective term for nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>).
- **ozone:** a gas formed when nitrogen oxides and hydrocarbons react in the presence of sunlight; a secondary pollutant (O<sub>3</sub>).
- **particulates:** coarse and fine particles of organic or inorganic substances present in the atmosphere.
- **photochemical smog:** describes the hazy conditions which occur when air pollutants are trapped at ground level. High levels of ozone may be produced as nitrogen oxides and hydrocarbons react in the presence of sunlight. Pollution concentrations may become very high and the air quality may be classed as 'poor' or 'very poor'. In summertime, they usually occur on warm, still, sunny days. In winter, smogs may occur on cold, calm days when air pollutants are trapped in urban areas by a layer of warmer air above.
- **platinum group metals:** group of precious metals which includes ruthenium, rhodium, platinum, palladium, osmium and iridium.
- **sulphur dioxide:** a colourless gas which is given off during fossil fuel combustion.
- **sulphurous:** containing sulphur.

- **urban:** *a built up area with a large population, i.e. town or city*
- **urban smog:** *historical smog in which air pollutants, particularly smoke and sulphur dioxide were trapped at ground level. They usually occurred on cold, calm winter days. The term smog was derived from smoke + fog. Not to be confused with **photochemical smog**.*
- **WHO:** *World Health Organisation. In relation to air quality, WHO recommend guide values for particular pollutants which are considered safe for human health.*

# References & Further Information

## References

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**Bell, S.** (1993) Capital Killer II : Still Fuming Over London's Traffic Pollution, London Boroughs Association.

**Brimblecombe, P.** (1987), The Big Smoke, Routledge, London.

**Department for Environment, Food & Rural Affairs** (2001) The Air Quality Strategy for England, Scotland, Wales & Northern Ireland, The Stationery Office, London.

<http://www.defra.gov.uk/environment/airquality/strategy/index.htm>

**Department for Environment, Food & Rural Affairs** (2001) Digest of Environmental Statistics, The Stationery Office, London.

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**Department of the Environment** (1997) The National Air Quality Strategy, The Stationery Office, London.

**Lewis, R.H.** (1995) Air Quality Monitoring Report, Manchester City Council, Planning & Environmental Health Dept., Manchester City Council.

**London Research Centre** (1993) London Energy Study - Energy Use and the Environment, London Research Centre, London.

**Longhurst, J.W.S. & Mann C. (1994)** Changing Air Quality in Greater Manchester, ARIC, Manchester.

**National Environmental Technology Centre**, National Air Quality Archive, <http://www.airquality.co.uk>

**National Statistics**, StatBase<sup>®</sup> - National Statistics data and references, <http://www.statistics.gov.uk/statbase/mainmenu.asp>

**NSCA (1995)**, NSCA Handbook 1995, NSCA, Brighton.

**QUARG** - Quality of Urban Air Review Group (1993) Urban Air Quality in the UK, DOE, London.

**WHO & UNEP (1992)** Urban Air Pollution in Megacities of the World, Blackwell, Oxford.

**Wilkins, E.T. (1954)** Air Pollution Aspects of the London Fog of December 1952, Quarterly Journal Royal Meteorological society, Vol. 80, pp 267-271.

## **Sources of Further Information**

*The following addresses may be useful contacts for further information on urban air quality:*

### **AEA Technology: The National Environment Technology Centre (NETCEN)**

*Culham*

*Abingdon*

*Oxford OX14 3DB*

*Internet: <http://www.airquality.co.uk>*

### **Atmospheric Research & Information Centre (aric)**

*Manchester Metropolitan University*

*Chester Street, Manchester M1 5GD*

*Tel: 0161 247 1590/3*

*Fax: 0161 247 6332*

*E-mail: [aric@mmu.ac.uk](mailto:aric@mmu.ac.uk)*

*Internet: <http://www.ace.mmu.ac.uk/>*

### **British Lung Foundation**

*78 Hatton Gardens*

*London EC1N 8LD*

*Tel: 020 7831 5831*

*Fax: 020 7831 5832*

*Internet: <http://www.lunguk.org/>*

### **Department for Environment, Food & Rural Affairs**

*Air Quality*

*Ashdown House*

*123 Victoria Street*

*London SW1E 6DE*

*Tel: 0171 890 6295*

*Internet: <http://www.defra.gov.uk/>*

### **Friends of the Earth**

*26-28 Underwood Street*

*London N1 7JQ*

*Tel: 020 7490 0881*

*Internet: <http://www.foe.co.uk/>*

**Greenpeace**

Canonbury Villas

London N1 2PN

Tel: 020 7865 8100

Internet: <http://www.greenpeace.org/>

**Johnson Matthey Catalytic Systems**

Orchard Road

Royston SG8 5HE

Tel: 01763 253000

Fax: 01763 253492

**National Asthma Campaign**

Providence House

Providence Place

London N1 0NT

Tel: 020 7226 2260

Fax: 020 7704 0740

Internet: <http://www.asthma.org.uk/>

**National Society for Clean Air & Environmental Protection**

44 Grand Parade

Brighton BN2 2QA

Tel: 01273 878770

E-Mail: [info@nsca.org.uk](mailto:info@nsca.org.uk)

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**Transport 2000**

The Impact Centre

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Internet: <http://www.transport2000.org.uk/>



*These can be printed out onto transparencies to support teaching, if required.*

***OHP 1:*** *Key dates for the history of air pollution in the UK.*

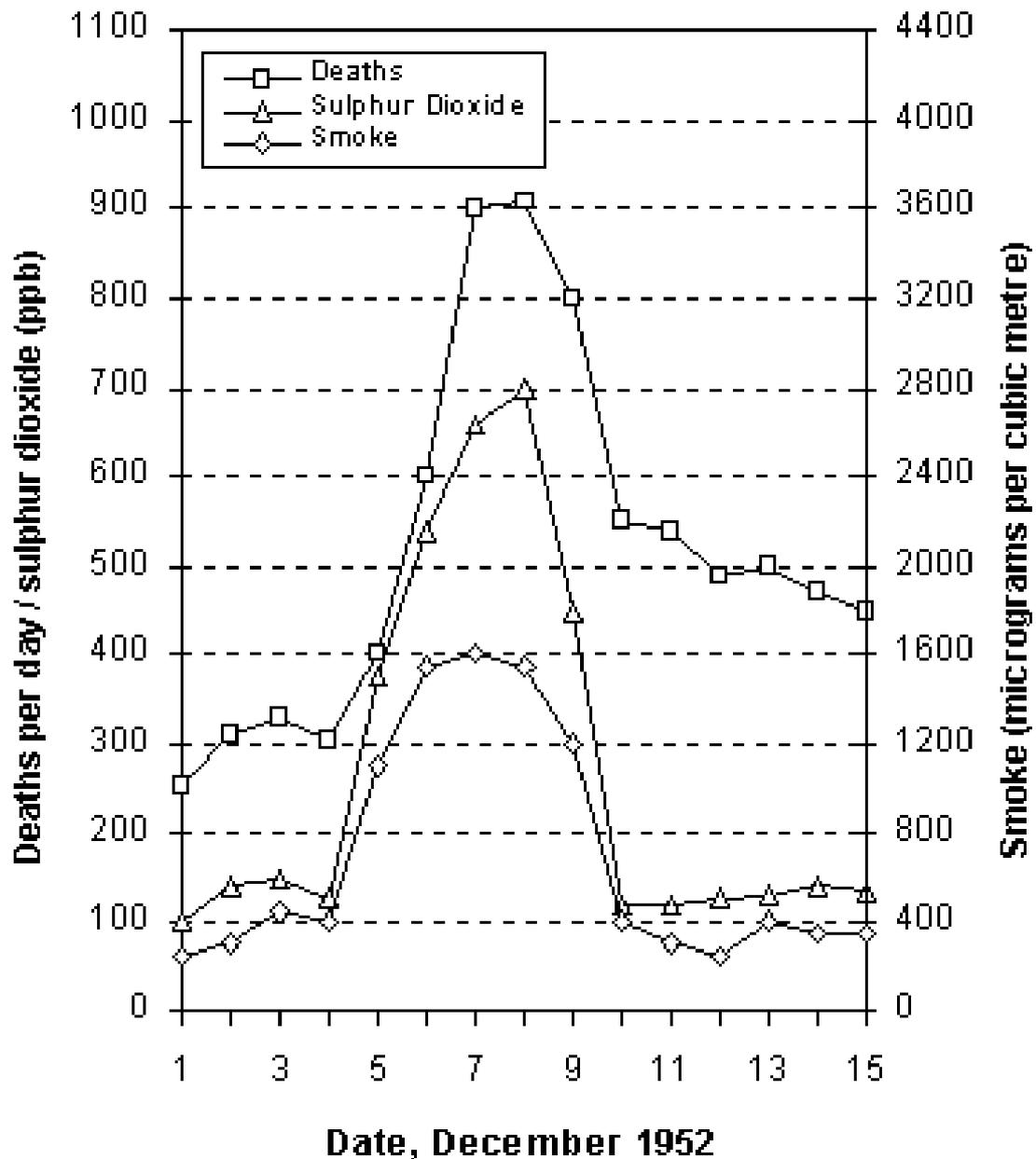
***OHP 2:*** *The relationship between smoke and sulphur dioxide pollution and deaths during the London Smog, December 1952.*

***OHP 3:*** *The main urban air pollutants.*

***OHP 4:*** *The effects of urban air pollution on human health.*

**OHP 1:****KEY DATES FOR THE HISTORY OF  
AIR POLLUTION IN THE UK**

- 1852      *Robert Angus Smith Identifies Acid Rain In Manchester*
- 1872      *Robert A. Smith: First British Air Pollution Inspector*
- 1875      *The Public Health Act*
- 1890      *Sulphurous Smogs Had Been Reported For Over 100 Years In Many British Cities*
- 1926      *Public Health Act (Smoke Abatement)*
- 1952      *The Famous London Smog, (December)*
- 1956      *1<sup>st</sup> Clean Air Act Established*
- 1968      *2<sup>nd</sup> Clean Air Act Established*
- 1974      *Control Of Pollution Act*
- 1990      *Environmental Protection Act*
- 1995      *The Environment Act*
- 1996      *The UK National Air Quality Strategy.*

**OHP 2:*****THE RELATIONSHIP BETWEEN SMOKE AND SULPHUR DIOXIDE POLLUTION AND DEATHS DURING THE LONDON SMOG, DECEMBER 1952***

Source: Wilkins, 1954

**OHP 3:*****THE MAIN URBAN AIR POLLUTANTS***

<b>Pollutant</b>	<b>Main Sources</b>	<b>UK (1996) Figures</b>
Nitrogen oxides	Combustion of motor spirit and other fuel combustion for domestic heating, power stations, industrial boilers, chemical processes etc.	Road transport 47% Power stations 22% Other industry 7%
Sulphur dioxide	Fuel combustion for power stations, domestic heating, industrial boilers, diesel vehicles, waste incinerators.	Power stations 65% Other industry 10% Refineries 6%
Carbon monoxide	Combustion of motor spirit and other combustion processes.	Road transport 71% Off-road sources 16% Domestic 5%
Ozone	Secondary pollutant resulting from chemical reactions with nitrogen oxides and VOCs.	See NO <sub>x</sub> & VOCs.
Particulates	Fuel combustion for power stations, transport, heating, other industrial processes.	Production processes 28% Road transport 25% Power stations 16% Domestic 14%
Volatile Organic Compounds (VOCs)	Transport, oil combustion, chemical processes, solvent use, waste incinerators.	Road transport 30% Solvent use 29% Extraction & distribution of fossil fuels 14% Production processes 13%
Benzene	Combustion of motor spirit, evaporation from petrol pumps and fuel tanks.	Road transport (approximately 80%)
Lead	Combustion of leaded petrol, coal combustion, metal production.	

**OHP 4:*****THE EFFECTS OF AIR POLLUTION ON  
HUMAN HEALTH***

<b>Pollutant</b>	<b>Effects on human health</b>
Sulphur dioxide (SO <sub>2</sub> )	Can cause respiratory problems, leading to chronic bronchitis, can cause narrowing of the airways and can affect asthmatics.
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Volatile organic compounds (VOCs)	Health effects are dependent upon the specific VOC, however a number of VOCs are known or suspected to cause cancer.