sulphur dioxide

INTRODUCTION

Of all the gaseous pollutants affecting air quality, sulphur compounds are the most widespread. Sulphur is an essential nutrient for all forms of life yet some compounds can be directly toxic. Of all the sulphur compounds present in the atmosphere sulphur dioxide (SO_2) usually has the highest concentration at ground level in urban areas.

Sulphur dioxide is a colourless non-flammable acidic inorganic gas with a choking taste. It is the main product of the combustion of sulphur contained in fuels.

Much of the sulphur dioxide in the atmosphere comes from natural sources but in industrialised and densely populated areas most derives from the combustion of sulphur containing fossil fuels (coal and oil). Sulphur dioxide oxidises in air to sulphur trioxide (SO_3) which can also be formed directly from sulphur combustion in the presence of excess air.

Sulphur dioxide is extremely soluble in water and is readily adsorbed onto a variety of surfaces especially small airborne particles. It is for this reason that sulphur dioxide is commonly associated with particulate matter (smoke).

With moisture, sulphur trioxide forms sulphuric acid (H_2SO_4) which is a corrosive acid. Because SO_2 concentrations are readily measured (by their acidity) it was often used as an indicator of the likely level of other common air pollutants that could affect human health. The correlation however is neither absolute nor consistent and SO_2 concentrations cannot therefore be used as a reliable means of predicting levels of other pollutants.

HEALTH EFFECTS

Sulphur dioxide and sulphuric acid act as irritants to the mucous membranes of the respiratory tract and promote the development of chronic respiratory diseases, particularly bronchitis and pulmonary emphysema. The effects are dependent on the concentrations in ambient air and act synergistically with other common pollutants, such as particulate matter.

Both sulphur dioxide and sulphuric acid molecules paralyse the hairlike cilia lining the respiratory tract. Without the action of the cilia particulates are able to penetrate the lungs and settle there. This can lead to a direct, prolonged contact with delicate lung tissues. The SO_2-particulate combination has been cited as the primary cause of excess deaths in several air pollution episodes.

Figure 2.1 The London smog of 1952 when SO_2 caused a number of excess deaths.

OTHER EFFECTS

Some plants are sensitive to SO_2, particularly in the growing season. Injury to vegetation may be acute resulting in damage characterised by clearly marked dead tissue between veins or on the margins of leaves. Chronic injury results in brownish-red or bleached areas on leaves.

Sulphuric acid aerosols in contact with building materials cause corrosion especially to those containing carbonates such as limestone, roofing slates and mortar. Excessive exposure to SO_2 accelerates the corrosion of metals such as iron, steel and copper.

SO_2 is also the major contributor to acid deposition (acid rain) which impacts on terrestrial and aquatic ecosystems.

Figure 2.2 Leaning chimney stack and perished mortar pointing typical of sulphur attack.

SOURCES

The amount of sulphur released annually from natural sources is up to five times greater than that from human activity with aerosols produced by the evaporation of sea spray contributing the largest single consistent source.

The burning of solid and fossil fuel contributes more than 80% of anthropogenic sulphur dioxide emissions with most deriving from stationary sources such as industrial processes and power generation. With the decline in the use of such fuels in domestic premises and the low level of industry in Southwark sulphur dioxide is no longer one of the main pollutants as was the case in the 1950's and 1960's.

The UK however discharges a disproportionate amount of the worldwide annual total and is one of the 'hot spots' where relatively large quantities of sulphur oxides are released from concentrated urban and industrial areas. Meteorological mechanisms transport such pollution throughout the world and Southwark is equally affected by such trans-boundary pollution.

The overall SO_2 emissions from motor vehicles are relatively small although diesel contains marginally larger amounts of sulphur than petrol. The origins of sulphur are occasionally noted by the smell of hydrogen sulphide (rotten eggs) from vehicles fitted with catalytic converters.

AIR AWARE

sulphur dioxide

STANDARDS

The air quality standard for sulphur dioxide is set by EU Directive 80/779/EEC (as amended by 89/427/EEC) which has been implemented in the UK by the Air Quality Standards Regulations 1989.

Limit and Guide Values are specified and summarised in table 2.1. Limit Values are mandatory maximums and Guide Values are the criteria for environmental improvement.

The Directive contains standards for SO_2 in relation to levels of suspended particulates and is further complicated by reference to the sampling method. Southwark has utilised the 'black-smoke' method and the corresponding values are therefore the only standards included in the table.

In addition sulphur dioxide is included in the Department of the Environment protocol for determining air quality categories. These air quality bands are shown in table 2.2.

The World Health Organisation has also set health and vegetation guidelines for sulphur dioxide as shown in table 2.3.

Table 2.1 Air Quality Standards for sulphur dioxide

EU Limit values		
Year	smoke ≤ 34μg/m^3	120μg/m^3
	smoke > 34μg/m^3	80μg/m^3
(Median of daily values)		
Winter	smoke ≤ 51μg/m^3	180μg/m^3
	smoke > 51μg/m^3	130μg/m^3
(1 October to 31 March)		
Year	smoke ≤ 128μg/m^3	350μg/m^3
(Peak)	smoke > 128μg/m^3	250μg/m^3
(98th percentile of all daily mean values)		
EU Guide values		
Year	smoke 34 - 51μg/m^3	40 - 60μg/m^3
24-hour	smoke 85 - 128μg/m^3	100 - 150μg/m^3

Table 2.2 DoE Air Quality categories for SO_2

Very good	≤ 59ppb	[≤ 160μg/m^3]
Good	60 - 124ppb	[162 - 335μg/m^3]
Poor	125 - 399ppb	[338 - 1079μg/m^3]
Very poor	≥ 400ppb	[≥ 1082μg/m^3]

Table 2.3 WHO sulphur dioxide guidelines

1-hour average	350μg/m^3	(health)
10-minute average	500μg/m^3	(health)
24-hour average	125μg/m^3	(vegetation)
Annual average	30μg/m^3	(vegetation)

AIR AWARE

MONITORING SITES

The locations of sites monitored for SO_2 are shown in figure 2.3 below.

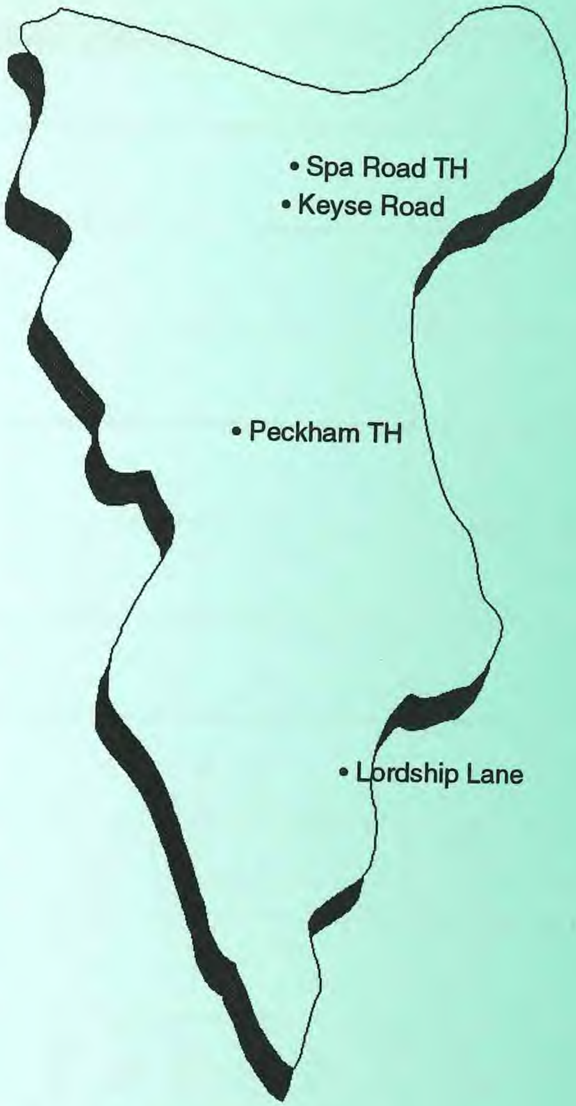

Figure 2.3 SO_2 monitoring sites.

COMMENTARY

Of all the pollutants covered by this report sulphur dioxide shows the most dramatic decrease over the last 40 years.

Levels in the late 50's and early 60's were notably high particularly in the most densely populated areas in the north of the borough with a peak of over $700\mu g/m^3$ in Bermondsey compared to a peak of nearly $400\mu g/m^3$ in Camberwell.

The main source of sulphur dioxide, domestic coal burning, is clearly illustrated by the graphs of seasonal averages showing considerably higher levels during the winter months and in some cases it is possible to identify unusually cold winters.

The effect of smoke control through the application of the Clean Air Acts is readily identified by the dramatic fall in levels in the late 60's and a steadily decreasing level thereafter. In the most polluted areas the reduction over twenty years can be seen to be about 90%.

Comparison against the standards (although not applicable until 1989) shows that annual Limit Values were consistently exceeded up to 1967-68 and, where data is available, annual Guide Values were rarely breached in the last 10 years.

The most recent data presented for both Bermondsey and Camberwell show similar levels within or below the annual Guide Values indicating a borough wide improvement.

Further evidence of the origins of this pollutant and its decline is given by the convergence of the seasonal averages.

sulphur dioxide

AIR AWARE