Industrial Pollution and Health

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In the last twenty years, and especially in the last five, there has been a great and proper increase in concern about all forms of pollution. There are many reasons for this: an increase in population, an increasing standard of living, or at any rate of consumption, with its inevitable increase in domestic waste of all kinds, an increase in public education and greater awareness of amenity, and, finally, the increased industrial activity needed to support our rising standards.

It is the contribution of this industrial activity to the total pollution problem in the U.K. and what effects there may be on the health of the general public, or how the public is protected from these effects, that will be discussed in this article. It offers a good opportunity to put the problem of industrial pollution in perspective because it is chiefly on the possibility of danger from toxic chemicals from industrial processes that public anxiety seems to concentrate when questions of pollution arise.

The general public may be exposed through contamination of the atmosphere or by the persistence of chemicals in the food or water supply, apart from accidents due to careless and irresponsible dumping of small quantities of toxic wastes, an activity recently taken under legal control.

Air pollution presents the greatest problem, and, as it is the only form of pollution that has demonstrable effects on public health, it has received the most attention over the longest period. For more than a century the Alkali and Clean Air Inspectorate has controlled industrial emissions and ensured that industry has fulfilled the requirements of the Clean Air Acts.

What has been achieved in reducing both industrial and domestic smoke pollution in the last eighteen years is shown in the first report of the Royal Commission on Environmental Pollution and in a more recent comparison of air pollution statistics compiled from official figures on total U.K. energy use (Parker, 1974). As Figure 1 shows, total smoke emission amounted to 2·3 million metric tons in 1953, to which domestic smoke contributed 53 per cent, industrial smoke 33 per cent, and the railways 14 per cent. By 1968, as a result of a variety of control measures, the total had fallen below 1 million tons, to which industry contributed 14 per cent and the railways about 3 per cent.

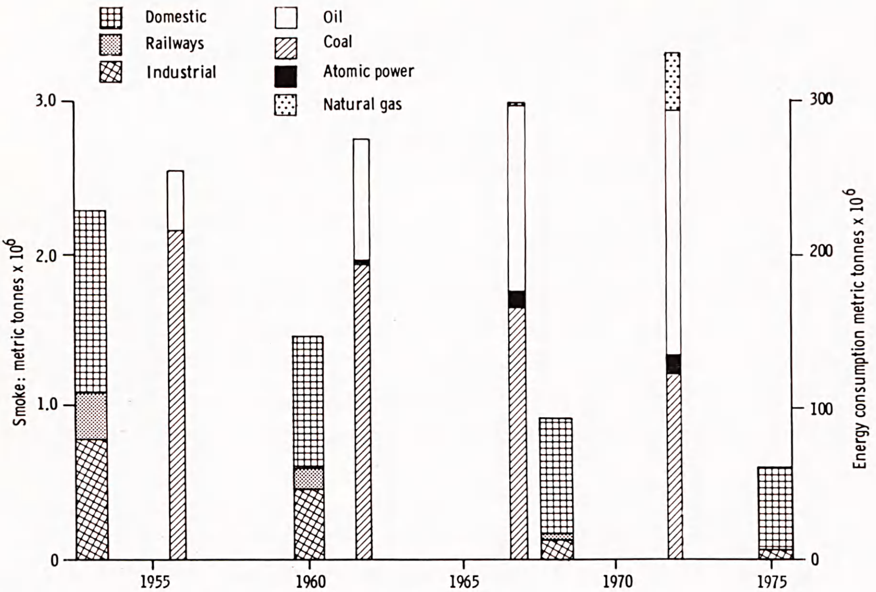

Fig. 1. Smoke emission v. energy consumption.

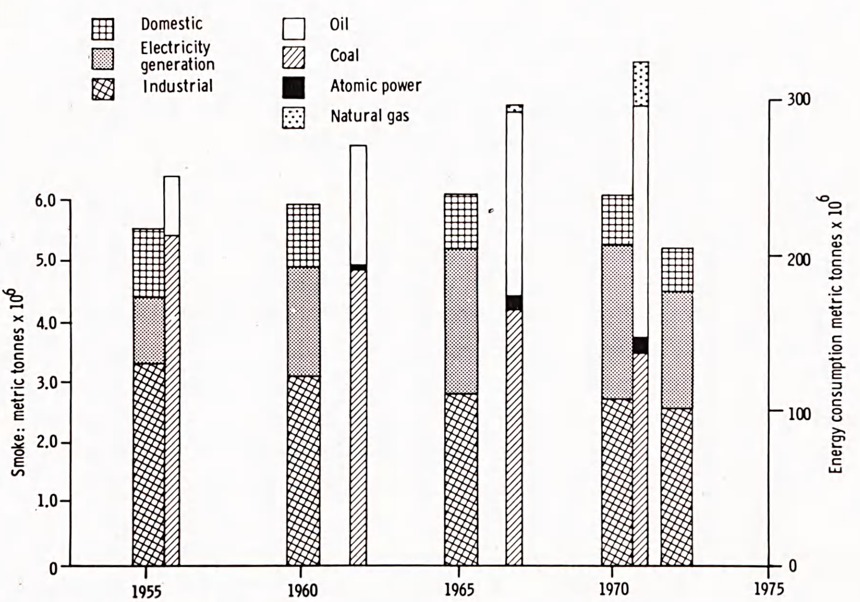

Fig. 2. Emission of sulphur v. energy consumption.

The results for 1972 indicate that the 1975 target of a reduction in total smoke emission to 0·6 million tons, with the industrial contribution reduced to around 12 per cent and the railways' contribution eliminated, is likely to be achieved. Energy requirements have grown by 30 per cent over the same period. The decline in other pollutants has been less rapid: Figure 2 shows the sulphur dioxide levels over the same period and indicates that later measures to reduce the sulphur content of fuels have been slower to take effect. Despite the actual increase in total sulphur dioxide production over the period 1958 to 1968, there was a decline of about 50 per cent in the average ground level concentrations recorded, indicating improved means of dispersion by industrial plant and illustrating the truism that pollution occurs only when production of the pollutant exceeds the capacity of the environment to absorb and degrade it. The results also illustrate how much easier it is to control industrial emissions than domestic, as the points to be controlled are fewer and effective machinery has long existed.

In contrast, the contribution, particularly to urban pollution, from diesel and petrol engines has increased, adding carbon monoxide, lead, oxides of nitrogen, olefines and polycyclic hydrocarbons to the atmosphere; but as this is not pollution related to industrial production, and studies of groups heavily exposed—policemen, bus-drivers, and garage workers—have so far shown no effect on mortality or morbidity (Lawther, 1971), this source of pollution will not be considered further, but it will obviously become necessary to review the effect of these pollutants as pollution from other sources is reduced.

Given the degree of complexity and steadily changing pattern of air pollution, it is not surprising that, despite intensive and large-scale epidemiological studies for over twenty years, it is not yet possible to relate effects on health to any particular pollutant or interaction of pollutants. The difficulty is to identify the nature of exposures that cause effects which, with present methods of study, can only be detected long afterwards and are concerned in disease processes affected by many other factors, including recurring infections and smoking habits. It is largely due to the work of Professor Reid and Dr Charles Fletcher and their collaborators and the M.R.C. Air Pollution Research Unit under Dr Lawther that the picture of the respiratory diseases related to pollution has been built up. To determine how the incidence of respiratory disease in Britain compares with that of some other industrial countries has needed several years of careful work to establish the comparability of clinical diagnoses (Reid and Fletcher, 1971). The main conclusions are well known and were summarised in the R.C.P. monograph *Air Pollution and Health* (Royal College of Physicians, 1970). The results of some key

TABLE 1. Differences in morbidity and death rates from bronchitis in middle age and childhood between rural and urban areas

Index	Location							
	Rural		Urban < 100,000		Urban > 100,000		Conurbation	
	♂	♀	♂	♀	♂	♀	♂	♀
Annual death rate per 100,000 Age 45–64 (1959–63)	71	15	106	20	122	23	133	25
Age 0–4 yrs (♂ + ♀) (1960–63)	11		13		16			
Standardised morbidity ratio % national level = 100	S	NS	S	NS	S	NS	S	NS
Age 35–59 (1966)	121	41	131	52	159	67	209	71
S = smokers; NS = non-smokers								

TABLE 2. Differences between U.K. and other countries in death rates from chronic lung diseases, 1965–67.

	Annual death rates per 100,000			
	Age 45–54	Age 55–64		Age 45–64
		♂	♀	
England and Wales	41	202	37	143·5*
U.S.A.	18	77	15	39·9*
Japan	4	16	8	
The Netherlands		101	13	
Norway		20	8	
*Figures for 1963				

studies are recorded in Tables 1 and 2. They show an increase in death rates from chronic bronchitis in the middle-aged with a gradient of effect between urban and rural dwellers; an urban/rural gradient can also be shown in infant deaths before complicating factors such as smoking or the exchange of infections that occurs on beginning school intervene, a much more pronounced urban/rural gradient between smokers, and a striking difference in national incidence. Already the figures shown for the death rate from bronchitis are out of date and in the London area the rate is declining towards the rural rate (M.R.C. Annual Report, 1973–74). With lung cancer the role of pollution is much more difficult to disentangle because of the overwhelming effect of cigarette smoking on incidence and, although an urban/rural gradient can be shown, it appears as a minor factor (Waller, 1972). Even in an occupational study involving exposures of gas workers to atmospheric concentrations of benz-pyrene 100 to 10,000 times greater than those in London streets in the early 1960s, the death rate from lung cancer in the group with the highest exposure was only 69 per cent higher than the national average (Doll *et al.*, 1965; Lawther *et al.*, 1965). It is clear that it will take many more years of work to identify by this epidemiological approach the factors concerned in the effects of pollution, although international comparisons may give important clues. The Japanese situation may be especially interesting because over 80 per cent of their energy (and pollution) is derived from oil.

Assurance on the absence of effects on health from industrial pollution is more likely to be derived from considering the systems of control and monitoring of industrial processes that operate and the arrangements for monitoring potential pollution of water and food. In referring to the success so far achieved by the Alkali and Clean Air Inspectorate in reducing smoke and sulphur dioxide pollution, it is perhaps helpful to recall that the Inspectorate's responsibilities extend across a wide range of industries, as the categories of registered works show (Table 3).

TABLE 3. Alkali and Clean Air Inspectorate categories of registered works

Chemical and allied industries:	e.g. chlorine and bromine works, HCN, arsenic and selenium works, acrylates and di-isocyanates works
Metal industries:	smelting, aluminium, beryllium, cadmium, chromium, copper, iron and steel, lead, uranium and zinc works
Fuel industries:	electricity, gas and coke works, petroleum works
Other industries:	cement, lime, carbide and magnesium works ceramic works caustic soda and sulphate reduction works metal recovery works mineral works

For works in these categories there is a statutory duty to ensure that emissions are controlled to safe levels. The report of activities for 1972 contains many examples of the influence that the Inspectorate exerts on industry, both in the development of environmental controls and in ensuring that new plant is designed to operate to higher standards than the plant it replaces. An outstanding example quoted from one industrial site was of the effect of a change from coal to oil in reducing sulphur dioxide production from 36,000 tons per annum to 1,000 tons, and many examples were given in the third report of the Royal Commission of plant brought into operation in the last five years where, despite a considerable planned increase in output, the total production of pollutants was reduced.

Since 1969 there has been the most extensive review ever undertaken of the machinery for the control of health and safety at work and for the monitoring and protection of the environment. This has already led to considerable rationalisation and reorganisation, and there are many examples of how the existing machinery has operated to identify and protect the general public from chemical pollution in the U.K.

The relatively benign warning provided by DDT and the other organochlorine pesticides about the combination of properties (high lipid solubility, chemical stability and resistance to biological degradation) liable to give rise to environmental problems, and the likelihood of accumulation and concentration through food chains, led to the setting up of a monitoring service by the Laboratory of the Government Chemist to examine the amounts of organochlorine residues in 'total diet' studies and to monitor their occurrence in human tissues. At the same time, regular analytical monitoring of wild-life specimens as part of a nature conservancy survey was instituted. Apart from producing evidence that the measures to restrict the uses of DDT and organochlorines from the mid-1960s onwards are having an effect on the dietary levels, the computed daily intake of DDT and metabolites fell from a level of 44 μg in 1966–67 to 15 μg in 1970–71, and this was reflected in the lower levels of DDT found in human fat in 1971, which showed a decline of 30 per cent (Report of the Government Chemist, 1971 and 1972).

The existence of arrangements for regular food monitoring gave reassurance when a sombre warning of the dangers to health of inadequate disposal of industrial effluent came, in the late 1960s, from Japan in the outbreak of obscure and frequently fatal neurological illnesses ultimately traced to high concentrations of methyl mercury in shellfish, caused by the methylation of inorganic mercury in spent catalyst residues discharged from an industrial plant into a relatively land-locked bay, Minamata. It was readily shown that there were no significant concentrations of mercury in U.K. food samples, and surveys of estuarial life have also failed to show abnormal concentrations (Ministry of Agriculture, Fisheries and Food report, 1971).

A notable piece of detection by the Government Chemist's survey began in 1963 with the finding, in gas chromatograms of wild bird tissues and eggs, of trace amounts of organochlorine compounds not identifiable as any of the known organochlorine pesticides. Similar chromatographic peaks were found in some fish extracts in subsequent years, and after workers in Sweden had identified polychlorobiphenyls (PCBs) in fish in 1966, the Government Chemist's Laboratory was able to show that components of industrial PCBs had the same chromatographic behaviour as the unknown compounds previously found. As these materials, which are mixtures of biphenyls with varying degrees of chlorination, have much the same lipid solubility and chemical inertness as the organochlorine pesticides, it was not surprising that they were being similarly distributed in the environment. These materials, manufactured since 1929, are mainly used in closed systems as heat-exchange fluids, though they have had other applications, particularly in the U.S.A., as plasticisers, hydraulic fluids and lubricants, adhesives, and in carbonless copying paper, which have led to their escape into the environment. In the 1970–71 diet survey, traces of PCBs were found in a small proportion (3 per cent) of samples examined, and just detectable amounts were found in most of the human fat samples examined in 1969–71. As, however, all the PCBs are produced by a single manufacturer, there has been a voluntary restriction of sales in the U.K. since 1971 to controllable uses in sealed systems. This is a further illustration of the value of a dietary monitoring programme which since 1971 has also monitored the occurrence of heavy metals—mercury, lead and cadmium—in controlling exposure to pollution.

The discoveries about the behaviour of these chemicals in the environment have provided a stimulus to investigating the fate of other materials in large-scale use, since the best safeguard of the public health is a thorough knowledge of their distribution and ultimate disposal. The results of a study, begun in 1971, of the environmental fate of some chlorinated aliphatic hydrocarbons in large-scale use, either as intermediates in manufacture or as industrial solvents in dry-cleaning or metal degreasing plants, were recently published by Pearson and McConnell (1974). As shown in Table 4, these

TABLE 4. Persistence in the atmosphere of some organochlorine compounds. Data from Pearson and McConnell (1974).

	World production (1973) 1,000 tpa	Air concentration (10^{-9}) Urban	Rural	Half-life in troposphere (weeks)
Trichloroethylene	1,010	1–20	1–9	6
Perchloroethylene	1,050	<0·1–10	<0·1–2·5	12
Trichloroethane	480	<0·1–6	2–4	26
Chloroform	245	3–8	<0·1–0·4	23
Carbon tetrachloride	1,000	1–20	0·7–3	10

compounds are produced on a scale two to ten times greater than the highest annual production of DDT (probably around 100,000 tons in the mid-1960s) and are degraded at various rates in the atmosphere, ultimately to carbon dioxide and hydrochloric acid. Since they are present in the atmosphere and all have appreciable water solubility, they also occur in rain and surface waters, but in concentrations of $2–6 \times 10^{-9}$ for chloroform and trichlorethylene, and $3–4 \times 10^{-10}$ for the remainder. Like DDT, none could be found in water from underground aquifers, suggesting that they are adsorbed during percolation through the soil.

These are illustrative of the trends in monitoring, in which there is considerable activity in the U.K. A recent report of the Department of the Environment (1974) reviews all the 101 projects in hand in government laboratories, research associations, water authorities, etc. As there is at present no central collection and co-ordination of the information, the Department of the Environment's Central Unit on Environmental Pollution proposes to undertake this activity.

It is appropriate to conclude by looking at some of the studies during the past five years (Table 5) which are now resulting in legislation that should

TABLE 5. Government reports and legislation on environmental control

1969	Ministry of Housing and Local Government Working Party on Sewage Disposal Report: *Taken for Granted*, 1970
1971	Department of the Environment Central Advisory Water Committee Report: *The Future Management of Water*, 1971
1970–72	Department of Employment Committee on Safety and Health at Work Report: *Safety and Health at Work*, 1972
1970–	Department of the Environment Royal Commission on Environmental Pollution, 1st Report: *The Problem Examined*, 1971 2nd Report: *Three Issues in Industrial Pollution*, 1972 3rd Report: *Pollution in Some British Estuaries and Coastal Waters*, 1972 Currently reviewing problems of atmospheric pollution.
Legislation	
1973	Water Act
1974	Control of Pollution Act
1974	Health and Safety at Work Act

bring better co-ordination to the whole field of environmental control. Especially relevant to the control of industrial pollution are the studies on sewage disposal and water resources, which revealed the anomaly of separate authorities responsible in the same river area for the provision of water and the disposal of sewage and effluent. This anomaly was corrected by the establishment of the enlarged Regional Water Authorities created by the Water Act, 1973, which should result in more uniform standards of effluent control and water quality.

Among other controls, the Control of Pollution Act consolidates the Deposit of Poisonous Waste Act, 1972, which was introduced with some urgency to stop the abuse of uncontrolled dumping, particularly of cyanide wastes. Control over waste disposal will be extended under the Act, but will probably not be enforced before mid-1975, when the statutory survey provisions of the Act should have been implemented.

The Safety and Health at Work Act is expected to provide more stringent control over the introduction of toxic new materials into industrial processes, and it aims at establishing greater uniformity of practice in the handling of new materials. Establishing a single Health and Safety Inspectorate under the Act, in place of the existing inspectorates for factories, mines, agriculture, explosives and nuclear installations, and the Alkali and Clean Air Inspectorate, should improve co-ordination of action on environmental control inside and outside industrial premises. The current review of the problems of atmospheric pollution is intended to ensure further improvement. When fully implemented, the measures, taken together, should provide better systems to protect public health and the environment from new pollution hazards that may arise from a constantly changing technology.

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