

# Air Pollution – Past, Present and Future

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In preparing this paper I have assumed that what is wanted is a general survey of the situation, with a philosophical rather than a technical atmosphere. So I am not going to attempt to deal with the progress in chemical understanding of the many pollutants in the air, or of the development of instruments for chemical analysis.

Instead I will attempt to consider the human and sociological issues, which have been raised in the past by the existence of air pollutants, which are developing and changing even as we pass from 1977 to the speculative scientific victory, or world collapse of 2000 AD.

One of the first issues which I place before you is this: while the words 'air pollution' are easily said, and while they are capable of rousing extremely strong emotions in the minds of some, but little emotion in the minds of others, they are extremely vague and imprecise. This, of course, is one reason why they can rouse such a variety of emotions — the emotion depends upon the interpretation given to the words by the emoter.

The second issue is that of emission to the atmosphere. Technology started with the discovery of how to make fire, and, fire, getting even hotter as more developed techniques were invented, has emitted an ever-increasing quantity and variety of materials into the atmosphere. A third issue is that of population. It is illustrated by a graph of world population. **Figure 1.** In the year 5000 BC it is probable that some ten million people lived on the earth. **Now** the same number of persons forms the population of Tokyo. In the year 1 AD the world population was about 200 million; in the year 1500 it had risen to 400 million; by 1900 it had become 1 500 million.

Combine this graph with a statement by Dr J. Bronowski that hunting, as practised by early man, or by the bushmen of the Kalahari, cannot support more than two people to the square mile, and you can see that the growth of world population was possible only by a steady development in technology — for the production of food, of clothing, of protected dwelling places and of all the multifarious articles which enable large numbers of people to live on small areas of ground.

I travelled from Pretoria to Cape Town recently, sitting next to a highly educated lady who was returning from a visit to Botswana. The talk turned to air pollution and she said sadly, that while the air of Botswana was so clear, as soon as she approached Johannesburg she found that the air was polluted and she felt that she was being choked. There you have the three issues in one sentence.

She was very vague about air pollution, she was emotional about it in the sense that she felt choked: she failed to see that a large country with a very small population could not produce a large total emission to the atmosphere because it could not produce the technology to enable a large population to live there.

## Air Pollution in the Past

If we use what I have been saying about the factors of population, technology, and emissions to the atmosphere, to look at air pollution in the distant past, we reach the conclusion that the people of any period BC did not notice man-made air pollution and had no conception as to what was involved. The first thousand years AD may well have had periods where, in some places, the atmosphere was contaminated by smoke or the smells of the tanning trade, but it is unlikely that 'Air Pollution' was a subject for conversation. Five hundred years later towns had grown to the size which caused townsmen to be unhappily conscious of their neighbours' activities and soon after this coal was marked down as an undesirable fuel in a Capital City: Air Pollution had arrived.

In England technology developed where fuel and minerals were available and, as a result, emissions to the atmosphere were intense in some places and very slight

in others. When iron was smelted charcoal was used. This process was therefore carried on in forests with the result that the people of the small towns of the time were not particularly conscious of a polluted atmosphere.

The story of the attempts to eliminate smoke, from coal burning, in the city of Westminster (as distinct from the city of London), has often been told and the moral of the story seems to be that just as one man's food is another man's poison, one man's income from technology is another man's air pollution.

The struggle of the Smoke Abatement Society, working largely in London, was a long and frustrating one, for it was not until 1952 when the citizens received a profound fright from the realisation that a black London fog could kill a few thousand people, that public opinion came to an agreement that smoke must be abated by legislation.

So much for smoke in London, but long before 1951, some of the northern countries of England were in agreement that hydrochloric acid and chlorine, emitted during the production of caustic soda and of sulphuric acid, were gases which they could not tolerate in the local atmosphere. A parliamentary commission came to the conclusion that one man's income was another man's poison. They also agreed that while the law could not allow people to be poisoned, it also could not remove the livelihood of very many people working in the alkali process.

In addition, said they, the law should not shut down an industry which was a source of a large exporting trade and of large National profits. It was then that they devised the very 'English' phrase, that the 'Best Practicable Means' should be employed to minimise the emissions to the atmosphere. The net result was the passage of the Alkali Act of 1836 which brought chemical technology under legal control years before control of combustion processes was achieved.

What we can learn from the past is that this principle, protection of the general public **and at the same time** protection of the producer of the goods which the public need and want, is completely basic to the consideration of the control of air pollution.

In the past I have seen air pollution controllers in large cities in the United States, attempting to apply laws which had been written in somewhat draconian fashion, but finding that in the end they had to recognise that the two aspects of protection of the public and of protection of the viability of the industry, had to be recognised by some form of compromise.

## The Position in the 1930's

In the 1930's the British were minimising the emission of 'off-gases' from chemical and metallurgical industries by use of the 'Best Practicable Means' concept. This could involve a battle of wits between the Alkali Inspector and the factory manager, but usually it happened that the Inspector, who had gained much more experience in the limitation of emissions to atmosphere through his country-wide activities, than the manager, concerned with a single factory, had been able to gain, was able to give the manager valuable advice which the manager was very ready to take.

On the other hand the British were doing nothing about smoke emissions, mainly because of lack of knowledge concerning ways to control combustion and make it efficient.

In America, emissions from furnaces, boilers and also from chemical processes, were the subject of 'city laws', each large city making its own regulations and having its own fights with management. As a result the level of control was uneven resulting in a tendency for industries to locate where they knew that the control activity was the least intense.

Elsewhere in the world very little attention was being paid to the control of pollutants so that it was well known that the industrial regions of Germany and Belgium had very murky atmospheres.

During the years just before 1940 a population change was taking place in America; many thousands of people moving from the cities of the eastern seaboard to Los Angeles and San Francisco on the west coast. The move was prompted to a considerable extent by a desire to

escape from the cold, the snows and the grime of the cities of the Atlantic coast, and the people who moved were determined to have more free life in the open spaces. The net result amongst others, was that they filled up the open spaces with people and that, because there was no coal on the west coast but magic oil, they began to experience a new type of 'thing' in the air of Los Angeles, the photochemical smog which gave them headaches and running eyes.

In many ways the arrival of Los Angeles Smog is the great divide in the story of air pollution. Before LAS interest was focussed upon the emissions of the industrialist, but after LAS interest was switched to the general populace, every one of whom, in LA, had a car or perhaps two.

This is an interesting feature in the history of Air Pollution Control. Up to then the controller endeavoured to deal with relatively small numbers of industries so that in England six inspectors were able to control the activities of all the scheduled industries in the country. But now attention was being turned to many thousands of home owners, car owners, flat dwellers, all of whom were discovered to be emitters to the atmosphere.

In England it was not yet recognised that the operation of every coal-burning stove and fire-place would have to be controlled but the time was not far off when such actions would have to be taken. The other interesting feature of the LAS situation was the tremendous amount of emotion which was engendered by a pollutant whose main effect was sore eyes. The populace demanded that this objectionable thing should be removed at once, and at whatever cost. The city responded and brought in advisers from all over the country. By 1945 the city was spending over three million dollars a year on research into the subject and another very large sum on controlling the emission of everything that could be thought to be a contributory cause of the smog.

If you consider the position of cigarette smoke, a form of self-administered air pollution, which after years of study, is considered to be a contributory cause of bronchitis and of lung cancer, it is strange that a material which caused a headache and sore eyes, could rouse such intense emotion.

It would seem that the people of Los Angeles were the up-and-coming ones, who had escaped from the toils of the eastern cities and desired to enjoy the really happy life of California, and were knocked off balance by this unexpected assault on their senses. This indicates the degree to which emotional shock has a controlling effect in setting the degree to which a particular pollutant is not tolerated.

## The Engineer, the Scientist, and Air Pollution

During the years 1930 to 1940 or even 1945 the accent was heavily on the prevention of emissions to the atmosphere and in this work the task fell mainly on the engineer and the manufacturing chemist. However, the physicist and the analytical chemist slowly began to take an interest in a study which really demanded a multidiscipline outlook. The first purely physical study took place in Leicester in the English midlands, where scientists measured sulphur dioxide concentrations at a number of sites in different parts of this small town which happened to have most of its industry in the centre of the town, instead of round the outskirts as is the more modern tendency. Their results demonstrated that when movements of the atmosphere carried a pollutant with it, it also diluted the pollutant. **Figure 2.**—As a result, in Leicester, the highest concentrations were always in the centre of the town, while the lines of equal concentration closed up towards the centre of the town on the windward side and opened upon the down-wind side. This was a very simple experiment but it corrected erroneous opinions, generally held, concerning the movement of pollutants from a compact source. It was virtually the beginning of the science of 'boundary layer atmospheric physics' which has grown to a very large subject in recent years.

In the 1960's and later there was a tremendous growth

in various aspects of atmospheric chemistry, and intensive studies resulted in the development of a very wide range of instruments for measuring concentrations of a wide range of gaseous pollutants. Recording equipment was set up in profusion in many cities, and, while the bare measurements served to keep a tally of the materials in the atmosphere, they also served to give valuable and sometimes surprising information concerning the travel of pollutants and the changes which took place during the period of travel. In fact such measurements **must** be used for the increase of scientific knowledge, or else the monitoring programme (as it is called), can degenerate into a futile collecting of disjointed items.

## Air Pollution in South Africa

In 1946 there was no thought about Air Pollution in South Africa except for a couple of articles on smoke by Dr Quass of the Fuel Research Institute. Some people knew about the smoke and the fogs of London and saw them as nuisances, but did not know about sulphur dioxide as a hazard. It must be remembered that our city populations were not great. Johannesburg had about 200 000 whites, Cape Town about 150 000 and Pretoria about 60 000.

This, however, does not entirely explain the lack of interest.

One must accept that the general public do not notice things outside their immediate points of interest and that though they saw smoke in the winter evenings and the early mornings they did not **notice** or rather, they did not reach any conclusions concerning what they had noticed. The newspapers reported the existence of Los Angeles smog and the excitement about it in America, but people in Pretoria and Johannesburg thought it was just something that 'those Americans' were shouting about.

By 1956, when the CSIR had been running experiments in Pretoria for six years and had shown the seasonal variations in smoke and in sulphur dioxide in different parts of the city, interest was more lively in this case on the part of the industrial organisations. The Federated Chamber of Industries devoted a part of one of its annual meetings to a discussion of the situation as it might affect industries in general and, partly as a result of these discussions and partly following on my visit to America to study the situation at first hand, a national committee made up of civil servants, municipal authorities, industrialists and scientists from the CSIR, met to study the situation in South Africa. This committee drew up a proposal for a bill to be presented to Parliament and finally the Atmospheric Pollution Prevention Act was passed in 1965. The next move was to appoint a Chief Air Pollution Control Officer and start organising industry into adopting the best practicable means for minimising emissions to the atmosphere. Nothing was done about smoke emissions from dwelling houses because at that time nothing practicable could be done until suitable household stoves, to burn coal without smoke emission, could be developed.

During the past six years it has been possible to declare smokeless or 'smoke control' zones in residential areas, and local authorities have been steadily taking advantage of such a facility. Thus chemical and metallurgical industries are controlled by the Chief Air Pollution Officer, while smoke from industries and also from dwelling houses is controlled by the local authorities.

The present position therefore is as follows:

1. All the industries which are scheduled as needing emission controls are making use of one or other of the devices for removing solid or gaseous pollutants from their discharge stacks. There are, of course, occasions when equipment fails due to electrical or other failure and there are industries whose emissions have proved rather resistant to treatment by the usual air-cleaning techniques. In these cases emissions may be intermittently unsatisfactory or may be unsatisfactory for a considerable time before a suitable technique is finally developed.

In addition of course, industrial activity in South Africa is expanding steadily, as other papers at this

symposium will show, and every new industry has to go through the process of bringing its activities regarding emission control up to the required level of performance so that there are always stacks whose emissions need to be worked on and reduced.

It must be made clear, however, that it is almost never possible to have no emission. An emission can be reduced to 5% of what it was formerly, and by extra effort and expenditure it may be reduced to 0,5% but the costs tend to rise rapidly with the rise in the number of zeros after the decimal point. So it comes about that to produce a zero emission is not practicable because it amounts to closing the industry down.

2. It can be said that a very high proportion of the stacks from industrial boilers are now operating with no smoke emission except when flues are cleaned or when fires are started up from cold. However, the price to be paid for this is constant vigilance on the part of the smoke inspectors of the local authorities and it would be an unwise thought for city administrators to think that they can now relax their efforts and save some money. It is extremely easy for a control organisation to lose control of a situation through loss of staff or a cutting down of staff on the assumption that everything is going fine.
3. All new houses being built in any town of 20 000 houses or more are supplied with heating and cooking equipment which operates without smoke emission and a very high proportion of older houses are in a similar condition. Here again vigilance is necessary for houses can change hands and new owners do not always follow the policies of the previous owners. When a housing district changes its character from a high income to a lower income-group ownership strange things can happen in the interests of reducing expenditure, and inspectors need to be wide and diplomatic in explaining that smoke means waste and can lead to rising instead of falling costs.
4. Part 4 of the Act which deals with dust from industrial operations has been used in the Transvaal to reduce by a very large fraction, the dust blown from mine dumps and into the towns. This has been achieved by growing grass on the dumps, but two comments must be made. Once again the achievement has to be maintained by constant vigilance, for anti-social, or just thoughtless, persons have been destroying the grass, by burning it, by riding motor cycles over the dumps, by tearing out the grass for various purposes. It has been realised that the grassing is a rapid-results cure (only five or ten years), but for a permanent solution to the dust problem it will be necessary to landscape the dumps down to fairly low elevations over enlarged bases and then to apply a permanent covering on which industrial buildings may be erected so that the cost of transforming the dump shape will be more than covered by the increased value of the land so formed. This type of activity has been successful elsewhere and should be successful on the Witwatersrand. The ERGO project which has attracted such oversubscribing of shares, is of course a slightly different scheme and really should appear in the section on the future.
5. The fifth part of the Act, dealing with motor vehicles, has been invoked so far only to reduce the smokiness of the exhausts of diesel-engined vehicles. Here again users of the roads will observe that there are still diesel vehicles which emit dark-coloured gases, but what they will not know is that the operators of the roadside checks have reported that the ratio of dark-smoke exhausts to light-smoke exhausts has steadily fallen with time. Here again, any failing in the roadside check programme will cause the mass of smoke being emitted per day in the streets of South African cities, to increase once again. Smoke emission means loss of efficiency but increase of power, so that an operator is often willing to face extra fuel costs in order to increase the pay-load of the vehicle. The public who complain about smoking exhausts are not the public who operate the emitters, hence the need for

vigilance. From time to time questions have been asked about the control of unburned petrol and other materials in the exhausts of petrol engines. At the present time, the financial stringency makes any control authority wary about embarking on a full-scale task of that type. In addition, regular measurements of these substances in the five largest cities of South Africa show that the pollutants originating from petrol engines are not found in quantities which could be called even moderate air pollution. Thus, with a pull back on the use of petrol because of short supplies, it is unlikely that concentrations will grow much in the next few years.

## A Look at the Future

When writing an article for the New Year issue of a commercial magazine, Joel Mervis, retired editor of the Sunday Times, said that as it was more easy to predict the past than the future, he intended to write about the past.

Predicting the future of Air Pollution is also a difficult task. One can start by saying that Air Pollution has a future and go on to say that, as emissions to atmosphere result from technology, there will always be emissions and always the need to apply technical controls and to seek for new techniques which will improve the 'best practicable means'.

Also, because populations will continue to increase, the technology for supplying the needs of the growing multitude will increase so that, even if the same efficiency of emission control is maintained, the total emission rate must increase. You should consider, however, that levels of pollution sufficient to cause community concern are not uniformly scattered over the surface of the earth, but tend to be associated with the high population densities. It is therefore possible to consider a future in which new industry is spread out into areas where pollution levels are low and where physical studies have indicated that dispersion of residual emissions will be, high. This, however, will immediately cause those who at present live in such regions, to complain about the 'contamination of our beautiful environment'. This situation already exists in the United States and will presently be found in other parts of the world. Note that the objectors will not be saying that their air will be made unendurable. They will be saying that they have very clean air, that they like it that way and they do not want any change to take place in it. It can be said to the objectors, 'You want to keep your air clean at the expense of the people who are suffering from air pollutants in over-populated regions, yet you wish to have the benefits of the goods which are manufactured in those regions'. However, the emotions of people who have been sensitised to react to polluted air are very strong and it will be very difficult to alter them.

There is a concern in the developed part of the world which has little to do with the production of clean air, but which may in the end help to solve the clean-air problem, and this brings me back to the beginning of my paper. Because of the exponential rise in population, it is expected that the 3 000 million people of today is likely to become 7 000 million by the fabled year 2000. This will place an unbearable burden on the task of the suppliers of food and many other necessities of life, so that there is a strong move at a world level to cause population increase to level off. At the Air Pollution level of thinking it is obvious that, if populations and particularly city populations, were to be reduced, the general effect on the atmosphere would be one of improvement. Teilhard deChardin, the Jesuit paleontologist, said quite forty years ago, that the human race was suffering from planetisation, the pressure produced by the finite size of the earth. He said that physical evolution, such as paleontologists study, had given place to mental and spiritual evolution — evolution in the thinking of groups of human beings, and that the pressure of excess population could possibly force human groups to make tremendous mental changes in the process of adjustment to this pressure. He was optimistic that men would react constructively to this physical constriction, but he recognised that there was always the possibility that the

FIGURE 1. Graph of world population

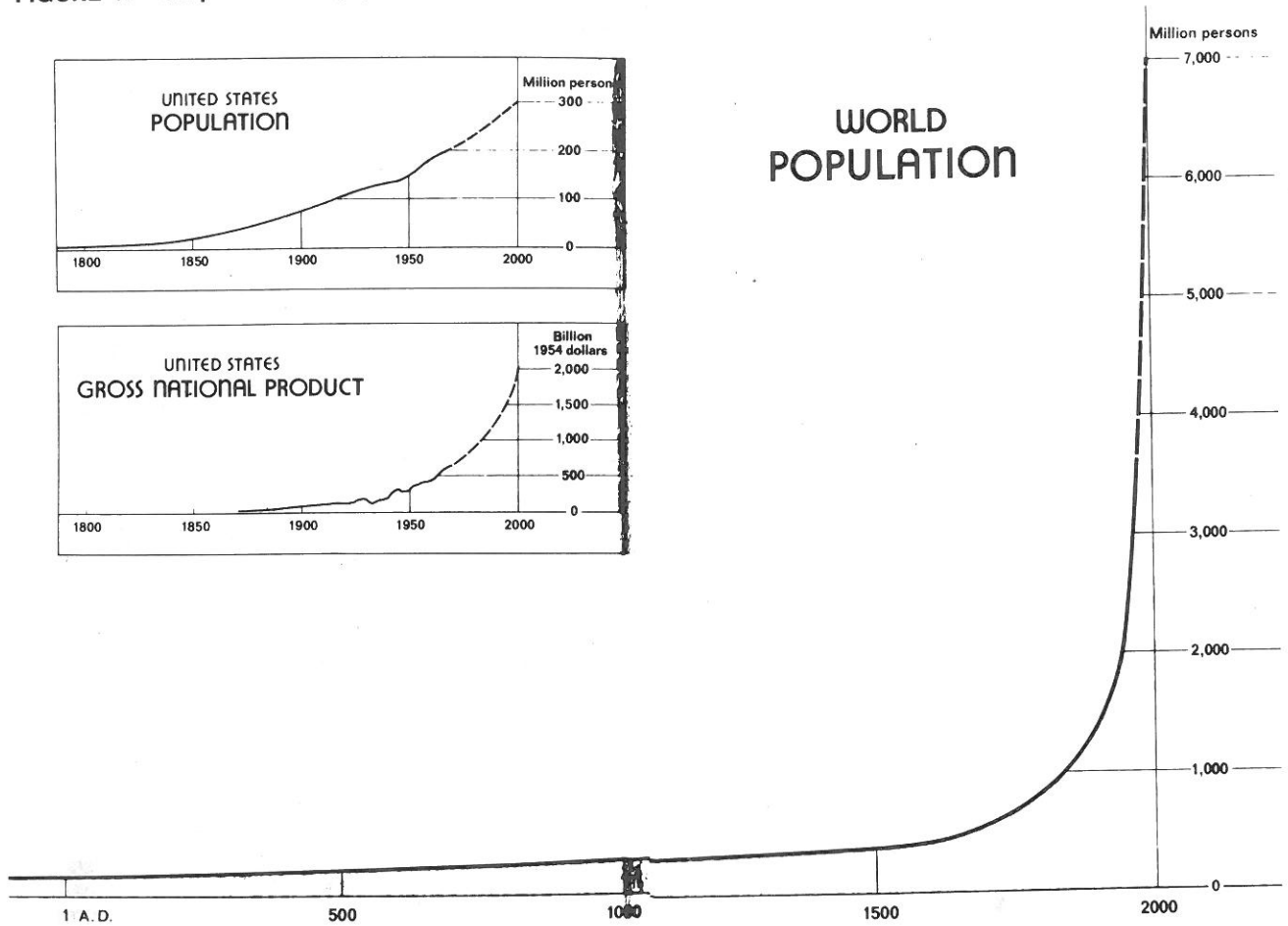
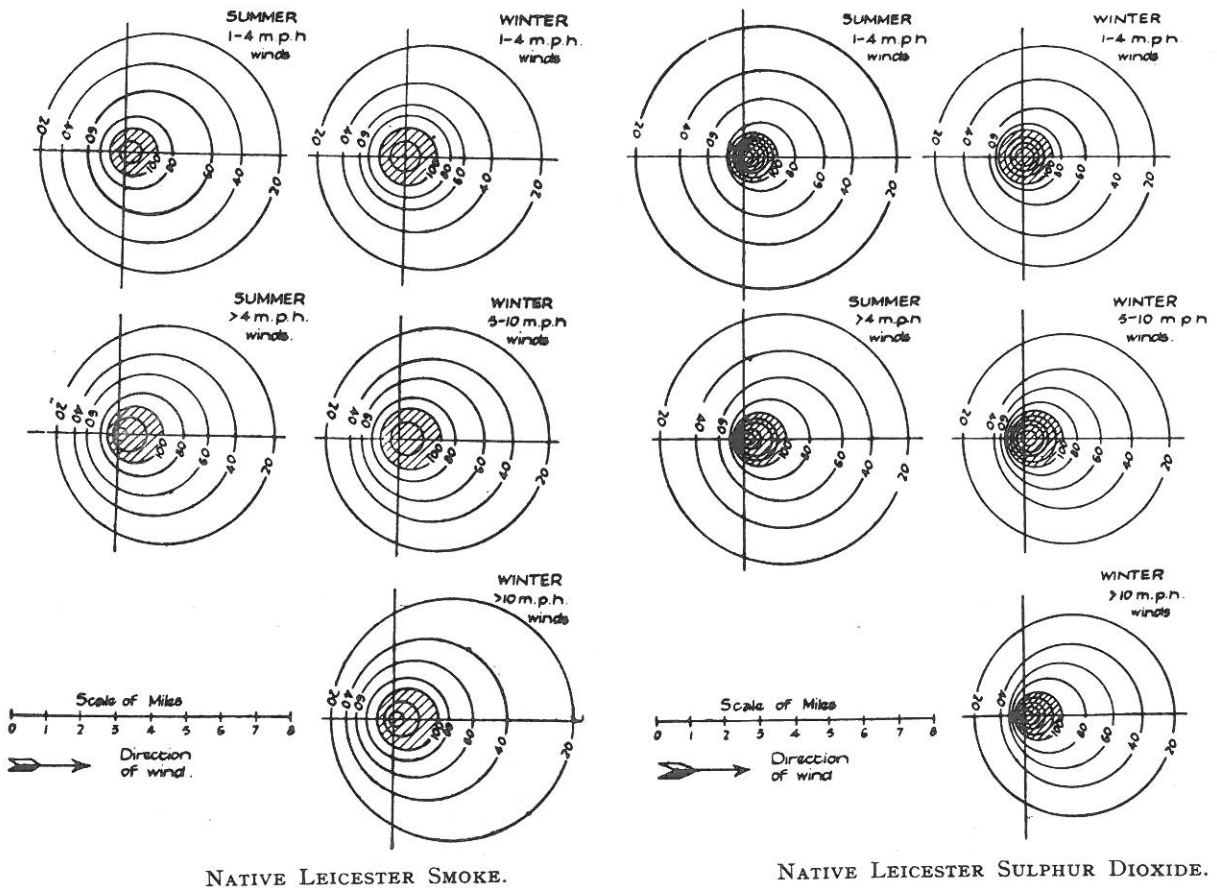


FIGURE 2. Effect of air movement on pollutant concentration



reaction would be negative and self-seeking and take the form of war and destruction rather than co-operation and the control of the birth rate.

You can see how far we can get from air pollution when we try to look into the future. The future of the control of air quality is overshadowed by the future of the control of the human being. If human beings can learn to control themselves, the problem of air quality control will become a minor issue on the world scene.

Now to turn to possible changes of a more physical and mechanical nature, while still remembering that population overshadows the whole scene.

Wherever we look into the future we see opposing trends. Rising population causes a tremendous demand on food supplies and therefore on the limited areas of cultivation. Falling population, **Figure 3**, causes the average age of the population to rise and this is dangerous because it is the younger members of a community who tend to be the productive members and the provision of food and other necessities becomes a burden on the young.

Here is another pair of problems. At one time it was thought that the problems caused by smoke and sulphur dioxide would be solved by replacing coal by oil. However, the smoke-SO<sub>2</sub> problem meets with the NO<sub>x</sub> — Ozone problem and confuses the issue. Recently a further trouble-maker has been discovered, namely sulphates derived from SO<sub>2</sub>, which are said to be more harmful than SO<sub>2</sub>.

Let us look at another see-saw. It is claimed that the greatest polluters of the atmosphere are millions of motor cars, with their hydrocarbons, their oxides of nitrogen and the resulting oxidants (bane of Los Angeles). It is possible that a really massive breakthrough in the form of a lightweight and large capacity storage battery would result in cars being non-polluting and virtually silent. However, this brings us back to the generation of electricity with a choice of thermal stations, hydroelectric stations, nuclear power stations, all of which have undesirable features about which argument has been raging for some time. One can think of esoteric forms of power generation such as solar energy and wave energy, but both of these are very young technologies with an expected growth time of many years.

So what do we see in the future in the atmosphere?

If we look at the past hundred years, we see perhaps sixty years of high pollution, of administrative confusion and of public uncertainty, followed by large efforts which, in twenty years brought about large improvements in the atmospheric quality of large cities. Then we see the law of decreasing returns beginning to operate so that the rate of reduction of emissions to the atmosphere slows down. The situation now is much better than it was in 1937 but change has slowed. It is possible, when we look into the murky depths of the next 22 years to 2000 AD, that mystic figure beloved of the conference organisers, that we can see that the struggle to clean the air will develop into a struggle to 'hold the fort'. And if we can hold the fort we probably can be fairly satisfied.

However, there are other threats said to be caused by pollutants which at present are basically the theories of atmospheric scientists. The accumulation of carbon dioxide will make the world hotter, melt the ice caps and drown the ports of the world. The accumulation of fine particulates in the stratosphere will absorb sunlight, cool the earth and produce an ice age. The accumulation of freon in the stratosphere will partly destroy the ozone layer, increase the intensity of ultraviolet light from the sun and cause fair-skinned people to suffer excessively from skin cancer.

What can we say about these prophesies? Firstly, we can say that the theoretical problems of working out even a simple quantitative estimate of the effect of each of these theories are so great that even with the use of large modern computers, only a simplified form of the theory can be used so that the answers are still an occasion for further argument. Secondly, we can say that the first two theories are in conflict with one another, so that the balancing of the physical effects of two antagonistic processes is also a subject for argument rather than agreement. Thirdly, we can say that a programme for making measurements of the quantities of these pollutants in well-mixed air, very far away from areas of high population density, is probably the only way of obtaining a hint of the true direction in which these processes are going.

This programme, known as global monitoring of the air, has its own problems, for small local emissions have a potential to overbalance the effects of emissions throughout the world, which are thoroughly mixed with the air of, for example, the southern hemisphere. Such a programme will need to continue for twenty years or more, because of the known secular variations which are known to take place in all global quantities.

So the answer to the question, "What will happen in the whole world in twenty to forty years?" is the statement that a global survey of the atmosphere may, perhaps, tell you in twenty to forty years.

## Conclusion

The most important single requirement for any legislation is that it must be capable of being implemented. In the case of air pollution control legislation, fulfilment of this requirement is no easy task. Two basic approaches as applied in the United States of America and South Africa respectively, have been used to illustrate the theoretical and practical difficulties encountered.

The scientific knowledge available today does not yet permit exact quantification of the multitude of input variables required for the implementation of definitive and comprehensive legislation, as proved by the failure of the American air quality management approach over more than two decades.

As an alternative, more than 110 years in England and nine years in South Africa have illustrated the ability of the subjective and piecemeal best practicable means principle to overcome the difficulty. While by no means perfect, it has proved itself as the most workable form of legislation for the present — and the foreseeable future.

**FIGURE 3** Slow growing countries on the left, fast growing countries on the right. East Germany is anomalous because population has been seriously distorted by political unrest.

