ATMOSPHERIC POLLUTION IN CAPE TOWN

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Dealing With a Bad Past:

In the late sixties and early seventies Cape Town, its mountain and amphitheatre providing a perfect trap for pollution, had dirty air with thick black smog a frequent occurrence.

The three power stations in the area, (one converted to oil); the many coal burning locomotives operating on the foreshore (some thirty of those parking overnight in the harbour area); the coal burning tugs (including the infamous Smokey Sue); industrial and commercial establishments with incinerators, heavy fuel burning appliances and even coal-fired hot water boilers, posed a difficult problem for air pollution control. Pollutants at that time included mainly sulphur dioxide (SO_2) and soot.

In 1968 Council initiated a programme of air pollution control and within a decade the situation had improved to the stage where Cape Town could be considered one of the cleanest major cities in the world.

Reservations about Motor Vehicle Emissions:

Despite the success of those early years and the subsequent decade of relative cleanliness a note of caution has been expressed in respect of motor vehicles and their potential for photochemical smog.[1] This is the name given to the brown haze formed as a result of sunlight acting on petrol driven vehicle emissions.

The main precursors of photochemical smog (primary pollutants) are nitric oxide (NO) and non-methane hydrocarbons (NMHC). The ultraviolet (UV) component of sunlight acts on these precursors to form the secondary pollutants nitrogen dioxide (NO_2), ozone (O_3) and peroxyacetyl nitrates (PAN).

Although each of these pollutants has a health risk of its own if sufficiently high in concentration the synergistic effect at lower concentrations is equally important. The resultant photochemical smog, apart from its unwelcome appearance and odour, attacks vegetation, building materials, metals and rubber and causes smarting eyes, running noses and impaired lung function.

Early measurement in the city of Cape Town of the important precursors of photochemical smog began with nitrogen oxides (NOx) in 1975. The original instrument was followed in 1984 by a considerably more sophisticated system for monitoring such motor vehicle emissions. Readings on these well calibrated instruments indicated that a potential photochemical smog problem existed. This opinion was confirmed by a visiting Australian expert, Dr Martin Smith who, in his report for the University of Cape Town[2] made recommendations for increased research by the University. Only some of these have been implemented.

Other Sources of Air Pollution:

"The source strength of the precursors can vary in different countries and places but, in urban areas, motor vehicle exhausts appear to be the largest contributors to oxides of nitrogen and hydrocarbon emissions."[3]

The generally invisible vapours escaping during transfer of petrol between storage tanks/bowsers/garage tanks/vehicles, and the solvents that escape to atmosphere from paints and the printing industries, also contribute to the total load of photochemical smog precursors. High temperature combustion of solid or liquid fuels in industry also produces NOx.

Relationship of Local Meteorology and Pollution:

The autumn period of April, May and June each year is normally a period of lovely weather in the Cape with clear skies and little wind. It is generally much cooler and the ultraviolet power of sunlight about half that measured at the height of summer.

Research overseas up to 1984 had indicated that photochemical smog was developed under strong sunlight and it was deduced that perhaps because of its reduced autumn ultraviolet Cape Town would escape the scourge besetting coastal cities with large vehicle populations such as Los Angeles and Sydney.

The theory was also advanced that the measurement of large amounts of ozone was a necessary concomitant to photochemical smog. PAN can be developed in cold atmospheres with little ultraviolet and with measurably low ozone.

When in 1984 high levels of photochemical smog precursors were measured in Cape Town it was postulated that this was an unusual year because of the large number of calm days. The weather over the next few years seemed to confirm this in that there were fewer calm days and reduced pollution levels compared with 1984.

In 1989 however the situation was similar to 1984 and levels were higher. This time the visibility was perceived to be worse as indicated by statements from complainants and observations by control staff.

By now Council had acquired an instrument to measure another precursor of photochemical smog, non-methane hydrocarbons (NMHC) but owning to air supply and maintenance problems the equipment was only fully commissioned in 1990.

1990 Smogs: Cause for Concern:

1990 followed the 1989 pattern and as anticipated in previous reports there is now evidence of a situation which gives cause for concern.

On 17th April 1990 the first smog of the season occurred which prompted many enquiries from the press and public and resulted in a question to the Minister for National Health and Population Development in parliament.

On this and subsequent smog occasions this year a strong low-level inversion with mist was apparent at sunrise. As the mist disappeared it left behind a brown haze. During these episodes of visible brown haze reports have been received of smells, variously described as "hot-radiator", "sweetly - acid" or "burning electrical insulation". Inversion refers to a meteorological condition where the normal situation of reducing temperature with height of atmosphere above ground level is reversed and warmer air sits above cooler air and prevents upward convection. A strong inversion indicates a greater temperature differential and a low-level inversion means close to the ground, sometimes as low as 30 m. Obviously the stronger and lower the inversion level the smaller the volume of air trapped beneath it and the higher the concentration of pollutants.

Air Quality Standards and Guidelines:

The South African air pollution legislation does not include air quality standards but guidelines are set and issued by the directorate, Air Pollution Control of the Department of National Health and Population Development. Those for NOx, NO and NMHC have been exceeded locally on several occasions while that for NO_2, less often.

These guidelines are designed to give wide health and safety margins and do not necessarily identify levels at which photochemical reactions will definitely occur.

As a rule when the guidelines have been exceeded a breeze has occurred by about noon and carried pollutants around the peninsula and out to sea. Sometimes the inversion and calm conditions prevail into the afternoon and evening.

Air pollution was evident on 15 days this autumn (April to June 1990). Measurements indicated that on 9 of these days photochemical smog had occurred.

Photochemical smog can thus develop on a sufficient number of occasions to warrant concern. PAN has been measured as a special event on some such occasions.[4] It is reasonable to assume that they are present on other, unmeasured, occasions.

Cause for Concern - Quo vadis?

The abatement policies developed in countries that have experienced photochemical air pollution have been dependent on the degree and frequency of adverse effects, the major sources of precursor emissions and the period of time that had elapsed since effects were first observed.

In all cases adverse effects have occurred before control measures have been introduced but the increased awareness of the problem that has developed since incidents were first experienced in Los Angeles has resulted in the progressive shortening of the time between the onset of adverse effects and the development of abatement policies.[5]

The early warning signals of a deteriorating quality to Cape Town's air is an indication that planning should now be initiated to avoid serious environmental damage and health hazards developing. The institution of control measures will be a lengthy process and so planning should not be delayed.

" ... if a control decision is made that is wrong or ineffective it will be five years or more before this is realised. Therefore, early identification of the oxidant problem, the correct selection of the control strategy, and quick implementation of the controls, are vital."[6]

Once pollutants have entered the atmosphere there are no effective control measures available for use by the authorities. Only natural meteorological events ensure dispersal of the pollution. Hence control measures must be directed towards reducing production and emission of pollutants, a major source of which is the petrol driven motor vehicle engine.

Reducing the number of vehicles operating in the region would reduce the pollutant level but poses practical problems. The improvement of public transport to achieve this end is a long term and costly exercise which would also need disincentives to discourage private usage (high tolls, parking fees, etc.).

"Given the current status of car technology, the Commission believes that the standards will have to be met by catalytic converters and that European manufacturers can adapt themselves to meet them." (EEC Commission).

In Cape Town too, introduction of catalytic oxidation of exhaust emissions to reduce the quantity of photochemical smog precursors emitted to atmosphere is likely to prove the most feasible solution. The use of catalytic convertors presupposes the removal of lead from petrol since lead poisons the catalyst.

There are many ramifications of such a decision and all interested parties should be able to make submissions before adoption of a control policy.

This report and the recommendations contained therein were submitted to Council and adopted without change.

The recommendations are listed below with reaction from the Minister for Health.

1. That Council acknowledges that the potential for a photochemical smog problem in the city gives cause for concern.

2. That Council requests the Minister of National Health and Population Development to fund

additional research into photochemical smog and brown haze.

"It is realised that little is known about the constitutents of your "brown haze" so that research in identifying them is warranted. It is anticipated that funds for such research will shortly be made available".

3. That the Medical Officer of Health expand Council's monitoring programme (to include, inter alia, ozone and PAN) and provide for this on the 1991/1992 budget.

"I am pleased to note that you intend extending, your monitoring programme. It is esential that both the magnitude and the extent of the problem be determined before any plan of action can be finalised. Much is known throughout the world about the mechanism of photochemical pollution formation. It is therefore considered that money would be better spent on monitoring than on basic research at this stage".

4. That Council recommends to the Minister of National Health and Population Development that a Commission of Enquiry be appointed at the appropriate time to hear evidence from all affected parties regarding the introduction of control measures.

"It is considered premature to appoint a commission of enquiry into photochemical pollution in view of the paucity of information on the extent of the problem both locally and nationally. There is no doubt that in common with most of the large cities of the world, our cities are suffering increasing vehicle pollution and decisions will have to made as soon as sufficient evidence is available".

5. That Council requests the Minister of National Health and Population Development to initiate action designed to ensure control of the developing problem as outlined in this report bearing in mind the delay between decision to implement controls and the implementation thereof.

"As you are no doubt aware, considerable attention is presently being given to lead in petrol and this topic is intimately connected to the control of other vehicle emissions. The complete removal of lead from petrol is required before vehicle exhaust emission devices can be used and this is expected to cost the country several thousands of millions of Rands. Such vast expenditure can only be justified if the health effects of the additional lead in the environment or photochemical pollution is sufficient to warrant it.

Please be assured that this important topic will continue to be addressed and action will be taken timeously to ensure that our environment is not allowed to deteriorate to the extent of some of the major cities in the world".

Update for 1991

In previous years the most critical period for vehicle emissions were the months of April, May and June. This previous report to Council in 1990 dealt only with that period.

It has now become necessary to look at the whole winter period of April to September since episodes are occurring through the winter.

The guidelines for air quality both for the 1 hr average and the 24 hr avrage were exceeded more in 1991 than in other years (See figure 1 and 2).

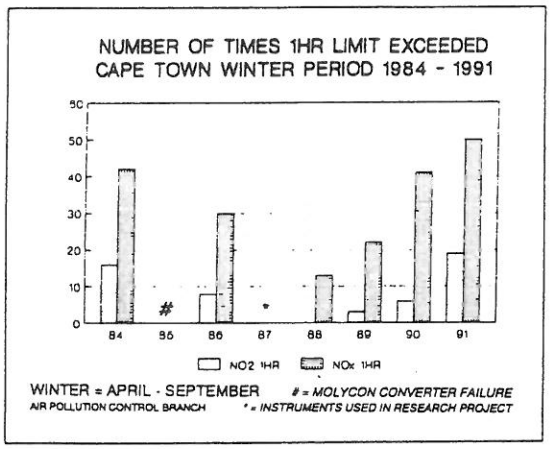


Figure 1

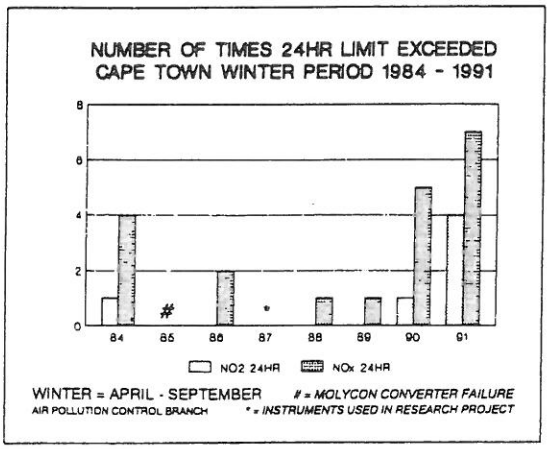
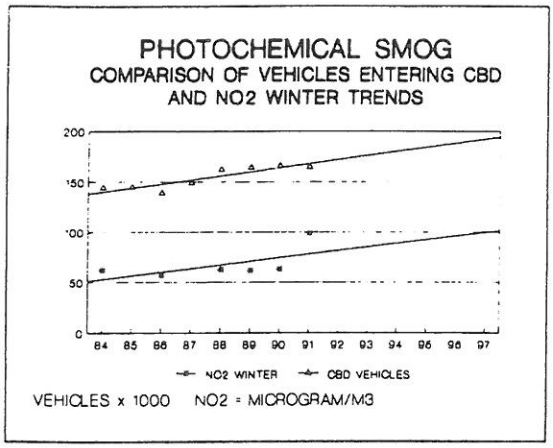


Figure 2

The guideline for hydrocarbons is exceeded on most days of the year and for most of the day. Doubt has thus been expressed as to the aptness of the guideline. These results are therefore not included.

The graph of Nitrogen Dioxide (NO_2) which is the indicator that photochemical reaction is taking place is shown in comparison with the number of vehicles entering the central business district (CBD) together with their trends. (Figure 3)

Fig. 3



Of interest is that if both trends continue at the same rate then for an increase of 36% in the number of vehicles (140 000 to 190 000) doubling of photochemical smog will occur.

This means that more and more days would be subject to visible pollution.

Graphs of Winter and Summer trends in NO_x and NO_2 (figures 4 and 5) indicate increasing levels though the winter trends presently indicate a faster increase. How soon will the visible pollution be a summer phenomenon too?

Fig. 4

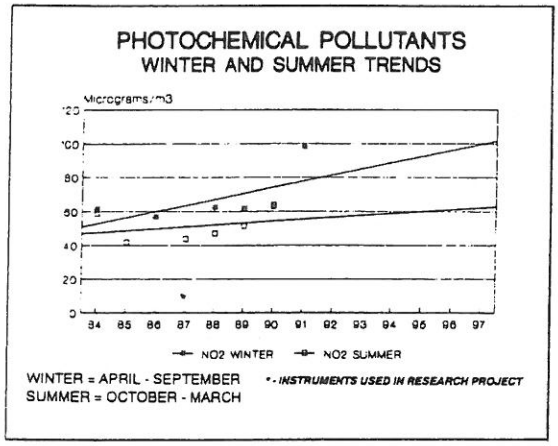
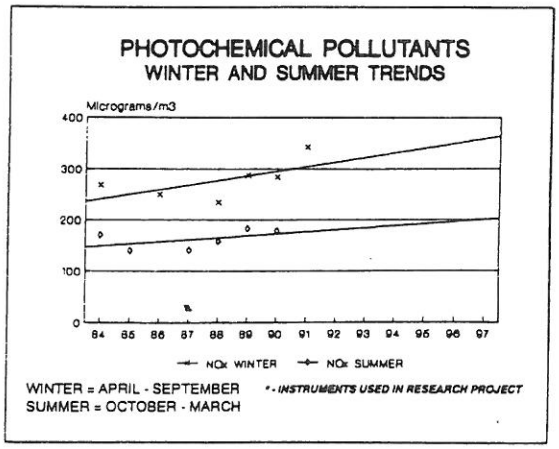


Fig. 5



Media Reports

As a result of the increasing visible pollution the public and the media have demonstrated concern.

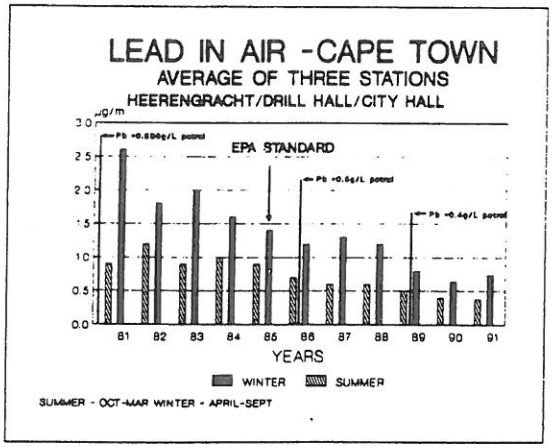
The Cape Times publishes the figures of pollution daily in the weather report section.

High levels always provoke some comment.

Lead In Air

Of further interest is that despite the increase in the number of vehicles entering the city the figures for lead in air have decreased, no doubt due to the reduction in prermissible lead in petrol. (Figure 6)

Fig. 6



Peryoxyacetyl Nitrates (PAN)

The PAN Oxidant recorder was installed in late June 1992 and is operating in a mobile trailer with an ozone analyser and data handling p.c.

It is functioning well and is readily calibrated with NO_2 permeation tube and is also capable of producing NO_2 analysis in addition to PAN.

We now await a further smog episode.

References:

1. Annual & Monthly Reports of the Medical Officer of Health, City of Cape Town, 1974 to 1988/1989.

2. A survey of Photochemical (and other) Air Pollution Problems in South Africa with special emphasis on Cape Town", M Smith CSIRO Australia; Report No 80 Energy Research Institute, University of Cape Town; November 1984.

3. Photochemical Oxidant Air Pollution - Peroxyacetyl Nitrate (PAN) As an Indicator of Photochemical Activity - E Grosser March 1990 MSc thesis.

4. I Baunok and E Grosser - Pretoria March 1990 - Measurement of Atmospheric Peroxyacetyl Nitrate [PAN] in Johannesburg, Cape Town and Long Tom Pass [E Tvl] during 1988-1989 and Pretoria during 1987 and 1989.

5. [Source - Photochemical Oxidant Air Pollution - Organisation for Economic Co-operation and Development, Paris 1975 - p43]

6. [Source - Photochemcial Oxidant Air Pollution - Organisation for Economic Co-operation and Development, Paris 1975 - p13]