AIR POLLUTION – SAFE GROUND LEVEL CONCENTRATIONS

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SINOPSIS:

Die probleem met die daarstelling van perke vir die grondvlakkonsentrasie van besoedelstowwe wat algemeen in 'n stadsatmosfeer voorkom, word bespreek en die redes vir die probleem word uitgewys. In die lig hiervan word die luggehalte standaarde soos deur die VSA se 'Environment Protection Agency' voorgeskryf, uiteengesit vir swaweldioksied, koolstofmonoksied, osoon, stikstofokside en lood.

SYNOPSIS:

The difficulty of setting limits to ground level concentrations of the pollutants commonly occurring in the urban atmosphere is discussed and the causes of this difficulty are indicated. In the light of this discussion the standards adopted by the EPA are set out for, sulphur dioxide, carbon monoxide, ozone, oxides of nitrogen and lead.

We all appreciate that concern about air pollution has two aspects; firstly that it may affect the well being of persons, and secondly that it may cause damage to property. A discussion of safe ground level concentrations would therefore have to take into account both of these aspects. However since I am a doctor I will be pardoned if I place more emphasis on the health aspects of air pollution.

Aside from a few specific but dramatic instances there is a lack of scientific evidence that air pollution seriously injures health. Yet there are concentrations which, while not being a serious threat to health, are nevertheless intolerably annoying and disagreeable. A health hazard would therefore not necessarily have to be demonstrated to establish the need for control of air pollution.

It must also be accepted that a modern industrial and scientific community is inseparably associated with pollution but that air pollution should be reduced – and modern science and technology have the means to do it – to that practical level which strikes a balance between industry's right to reasonable operation and the community's demand for a decent living environment.

When it comes to effects on health critical evaluation convinces one that there are four basic groups of air pollutants which could become a threat. These are:–

1. irritants – or substances which irritate mucous membranes and the respiratory tract,
2. asthmagens – or substances which cause asthma,
3. carcinogens – or substances which cause cancer,
4. heavy metals, mainly lead, derived from motor car fuel additives

Regarding the first two categories, their action is essentially related to their respective concentrations in the ambient atmosphere while the effect of the other two is dependant on the total uptake or body burden of the pollutant.

The approach when it comes to the setting up of safe levels is completely different in the two categories. In the first case the amount or concentration of asthmagens and irritants together with the time exposed are the crucial factors. Generally the effects on children and the aged have been studied because these are the most sensitive groups. What is bad for them is taken as bad for everybody.

The study of adverse effects of low level toxic substances such as air pollutants generally consists of long term epidemiological surveillance entailing collection and analysis of large amounts of data. But this is usually very difficult and time consuming, so recourse is also had to studying adverse effects in colonies of test animals whose life span is shorter and metabolism faster than that of man. But this induces a grave complicating factor. All experimental findings in the first instance, apply only to the specific species of test animal. Great care is necessary and often gross misconceptions arise when these findings are extrapolated to human beings.

A further problem is that of synergism where one pollutant enhances the effect of the other and both in relatively innocuous concentrations individually have a combined deleterious effect far in excess of either one alone. This is especially marked in the case of sulphur dioxide and ozone, two common irritating pollutants.

In the other category of pollutants where effect is a function of body burden additional considerations come into play. Air, water and food may all contribute to the daily intake of pollutants. This fact greatly complicates the study of air pollution. Often the primary toxicant derives from the air which we inhale. It may however also be dissolved in the water that we drink. It may be absorbed from the air and water by plants which we eat directly, or else which pass through a food cycle which concentrates it in the bodies of animals and fish before it reaches the plates on our tables.

Another important factor is individual susceptibility. Children at the one end of the life span and the old and frail at the other end are particularly sensitive to toxic materials. In addition, because of their smaller size and often greater physical activity, young children may take in greater amounts of a pollutant per kilogram of body weight. Adult males who are more often employed in occupations involving physical labour are more likely to inhale larger volumes of air thereby influencing pollutant exposure.

To derive a standard for an air pollutant, information on several aspects is essential. Firstly one must be able to estimate the total daily intake of a pollutant. You must know how much of this is retained and how much is immediately exhaled again. You must know how much additionally enters the body daily with food and water. Then there must be reliable knowledge of the level at which a specific body burden became hazardous. The body is quite capable of handling or detoxifying a specific amount of hazardous material each day and a body burden up to a certain level need not be a hazard to health. Only when this is exceeded does the material became dangerous.

There is an important exception to this general statement and concerns carcinogens, that is, substances capable of causing cancer. The scientific world is still arguing the question of whether there exists a threshold below which a carcinogenic material has no effect. If not, any exposure, regardless how low, may result in an eventual adverse effect. However if a threshold does exist, there is a level below which no adverse effect occurs. My own view is that there does exist a non-effect level below which the human body repairs damage faster than it occurs.

From all the above it should be clear that to derive a standard for a pollutant based on body burden is by no means a simple exercise having regard to the various routes by which a pollutant reaches the body. Extensive studies in many countries have been carried out on concentrations of pollutants in the air, in the "average" food basket and in the "average" drinking water of the "average" man. If the rates of absorption via the lung and digestive tract and the rate of excretion are known, the resulting body burden for cumulative toxicants can be estimated.

One can then determine that amount of pollutant which can be inhaled without exceeding a predetermined or safe level.

The following is an example how all this is applied in practice:

P = pollutant

Say:	190 ug	= daily intake of P via food
	10 ug	= daily intake of P via water
	0,10	= absorption rate of P in the gastro-intestinal tract
	25 ug	= acceptable total daily absorbed intake of P for the highest-risk portion of the population
	0,50	= absorption rate of P in lung
	$20\ m^3$	= amount of air inhaled per day.

P taken up by food and water = (190 + 10) x 0,10
= 20 ug.

Additional amount which can be taken up via the lungs
= 25 – 20 ug
= 5 ug per day.

Amount which can be breathed in $20\ m^3$

$$= \frac{5}{0{,}50} = 10\ ug$$

$$\text{Ambient air standard: } = \frac{10}{20}\ 0{,}5\ ug\ P/m^3$$

Considering all these problems, great progress has been made in evaluating the hazards of air pollution and determining safe ground level concentrations.

A question which continually recurs is what elements of pollution should be determined. Thousands of chemical substances are blown out by chimneys and motor car exhausts. Which of these should be chosen as a yard stick?

In South Africa we are in the main guided by work done in the United Kingdom and the United States of America. The Clean Air Acts in these countries were greatly influenced by severe and well documented episodes of short term heavy pollution which led to much illness and many deaths. From these experiences evolved many long term studies and the eventual setting of ambient standards.

Before discussing the problem in South Africa it may be worthwhile to look at particular overseas standards. The most representative are those of the American Environmental Protection Agency (EPA).

In 1971 the EPA promulgated two types of ambient air standards namely primary standards designed to protect human health and secondary standards designed to protect human welfare, which includes those things which humans value, like buildings, materials, plants and so on. These standards cover the following:

(1) Sulphur dioxide
(2) Particular matter
(3) Carbon monoxide
(4) Oxidants (measured as ozone)
(5) Nitrogen oxides
(6) Hydrocarbons
(7) Lead (a standard proposed in 1977)

Common logic confirmed by experience proved that if these seven indicators of pollution were controlled, the problem as a whole was well in hand.

(1) *Sulphur Dioxide:*

This compound is one of the main pollutants formed when fossil fuels are burnt. There is a considerable body of informed thought which ascribes the hazards of sulphur dioxide not to the gas itself but rather to the formed sulphates which appear in the atmosphere together with other particulate matter as smoke or smog. There exists an interesting anomaly. In many studies increased mortality and morbidity have been associated with increased SO_2 levels, yet reducing the SO_2 levels does not automatically bring about improved health. SO_2 must therefore only be seen as an indicator and preferably in association with particulate matter concentration. The Americans have set the following ambient primary and secondary standards for these two items:

	Primary	*Secondary*
Sulphur Dioxide – ug/m^3 (ppm)		
Annual arithmetic mean	80 (0,03 ppm)	60 (0,023 ppm)
24 hr max) only once per		
3 hr max) year	365 (0,14)	260 (0,01)
		1300 (0,05)
Particulate matter – ug/m^3		
Annual geometric mean	75	60
24 hr max	260	150

An interesting point emerges from these figures namely that SO_2 and particulates damage the environment before they damage human health.

(2) *Carbon Monoxide (CO):*

Whereas most other pollutant gases are lung irritants and their effects difficult to measure, CO combines with the haemoglobin in the red cells of the blood and the resultant carboxy-haemoglobin (COHb) can be easily assessed. CO is produced by all internal combustion engines and is an important polluter of urban air. Body metabolism in humans produces CO which results in a natural level of COHb in the blood of 0,4–0,7%. Levels of 2% adversely affect some people with heart disease and peripheral vascular disease. At 2% behavioral changes and changes in psychomotor responses appear. The American standard aims at preventing COHb levels in the blood from exceeding 2%. At the same time it is interesting to note that cigarette smoking causes blood levels of COHb of from 2% to 15%. The EPA primary standard for CO is 10,000 ug/m^3 (9 ppm) for an 8 hour maximum period and 4 times this for 1 hour maximum.

(3) *Ozone:*

This is one of the main photochemical oxidants. These substances are peroxides caused by interaction of hydrocarbon exhaust gases and sunlight in the presence of oxygen. Ozone is a potent irritant and may adversely affect the respiratory system. Levels of ozone vary naturally from 0,01 ppm to 0,05 or 0,06 ppm. The Americans have set a controversial level of 0,08 ppm (160 ug/m^3) as ambient standard. Many large American industrial cities have drawn up complicated procedures for curtailing pollution progressively as ozone rises during adverse atmospheric conditions up to a point where all non-essential traffic ceases and all industrial pollution producing activities are stopped.

(4) *Nitrogen Oxides:*

The EPA ambient standard for nitrogen dioxide is 100 ug/m^3 (0,05 ppm) and is based mainly on epidemiological studies of respiratory infections in young children. Like SO_2 the main source of NO_2 is the burning of fossil fuel and it seems as if the control of SO_2 levels in the atmosphere will automatically take care of the NO_2 as well.

(5) *Hydrocarbons:*

The concentration of Hydrocarbons in the air is closely related to the ozone concentration as the latter depends on hydrocarbons for its formation. Keeping the hydrocarbons low will prevent the buildup of ozone. On this basis a 3 hr maximum average of 160 ug/m^3 (0,24 ppm) has been set.

(6) *Lead:*

The EPA has proposed a standard of 1,5 ug/m^3 for airborne lead. This has proved to be very controversial but it nevertheless is intended to protect children from the lead compounds added to motor fuels as anti-knock agents. This standard has at least served the purpose of accentuating a hazard of motor car pollution which is often played down.

The question now arises whether we in South Africa should follow suit and submit ourselves to the strict dissipline of setting standards and conforming to them. The benefits of such standards, if they can be achieved are obvious. We will breathe clean and fresh air. Man is the only species which pollutes and destroys this environment to agree which already threatens his survival. Conforming to set standards will help to prevent this.

On the debit side large and unwieldy inspectorial facilities will have to be developed to ensure that standards are adhered to. The problem also exists what to do if pollution levels in a city are exceeded.

Control is a long and hazardous process and should start with control at source. Fortunately this is exactly where our own Prevention of Air Pollution Act (No. 45 of 1965) tackled the problem. Pollution from industries, motor traffic, domestic smoke and mine dust is controlled under the various sections of the Act. Wisely no attempt has so far been made to lay down national air quality standards. A pragmatic and practical approach has been to apply a standard, in and around the source, which is related to the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (ACGIH) in so far as that this TLV is further reduced by a factor of 50. This guarantees the safety of the most susceptible sections of the general population.

If pollution can be controlled at source – and it seems as if this is what the Act is achieving – the setting of standards would appear to be unnecessary and known standards like those of the EPA could be used for comparison and evaluation. High values could guide the Air Pollution Control Officer in the application of his wide powers within the context of his specific Act.

In this country we seem to place undue reliance on legislation to control the evils around us. I believe that the stimulation of public opinion to demand clean air is an equal or better deterrent against pollution and this is no doubt one of the laudable aims of the National Association of Clean Air. The Good Lord has provided each of us with a most sensitive monitoring apparatus. We can see smoke issuing from a chimney, we smell and taste many gases and we hear noise. If we bring combined pressure to bear on that which we find physiologically unacceptable much need for the long and arduous processes of statutary enforcement of ambient air standards will disappear.

JULY 1980

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