Nitrogen dioxide

Guidelines

NO_2:	**40 μg/m³ annual mean**
	200 μg/m³ 1-hour mean

Rationale

As an air pollutant, nitrogen dioxide (NO_2) has multiple roles, which are often difficult or sometimes impossible to separate from one another:

i. Animal and human experimental studies indicate that NO_2 – at short-term concentrations exceeding 200 μg/m³ – is a toxic gas with significant health effects. Animal toxicological studies also suggest that long-term exposure to NO_2 at concentrations above current ambient concentrations has adverse effects.

ii. Numerous epidemiological studies have used NO_2 as a marker for the cocktail of combustion-related pollutants, in particular, those emitted by road traffic or indoor combustion sources. In these studies, any observed health effects could also have been associated with other combustion products, such as ultrafine particles, nitrous oxide (NO), particulate matter or benzene. Although several studies – both outdoors and indoors – have attempted to focus on the health risks of NO_2, the contributing effects of these other, highly correlated co-pollutants were often difficult to rule out.

iii. Most atmospheric NO_2 is emitted as NO, which is rapidly oxidized by ozone to NO_2. Nitrogen dioxide, in the presence of hydrocarbons and ultraviolet light, is the main source of tropospheric ozone and of nitrate aerosols, which form an important fraction of the ambient air $PM_{2.5}$ mass.

The current WHO guideline value of 40 μg/m³ (annual mean) was set to protect the public from the health effects of gaseous NO_2. The rationale for this was that because most abatement methods are specific to NO_x, they are not designed to control other co-pollutants, and may even increase their emissions. If, however, NO_2 is monitored as a marker for complex combustion-generated pollution mixtures, a lower annual guideline value should be used (WHO, 2000).

Long-term exposures

There is still no robust basis for setting an annual average guideline value for NO_2 through any direct toxic effect. Evidence has emerged, however, that increases the concern over health effects associated with outdoor air pollution mixtures that include NO_2. For instance, epidemiological studies have shown that bronchitic symptoms of asthmatic children increase in association with annual NO_2 concentration, and that reduced lung function growth in children is linked to elevated NO_2 concentrations within communities already at current North American and European urban ambient air levels. A number of recently published studies have demonstrated that NO_2 can have a higher spatial variation than other traffic-related air pollutants, for example, particle mass. These studies also found adverse effects on the health of children living in metropolitan areas characterized by higher levels of NO_2 even in cases where the overall city-wide NO_2 level was fairly low.

Recent indoor studies have provided evidence of effects on respiratory symptoms among infants at NO_2 concentrations below 40 μg/m³. These associations cannot be completely explained by co-exposure to PM, but it has been suggested that other components in the mixture (such as organic carbon and nitrous acid vapour) might explain part of the observed association.

Taken together, the above findings provide some support for a lowering of the current annual NO_2 guideline value. However, it is unclear to what extent the health effects observed in epidemiological studies are attributable to NO_2 itself or to the other primary and secondary combustion-related products with which it is typically correlated. Thus it can be argued that the available scientific literature has not accumulated sufficient evidence to justify revising the existing WHO AQG for annual NO_2 concentrations. Nevertheless, since NO_2 concentrations in ambient air are routinely measured but those of other correlated combustion-derived pollutants are not, it seems reasonable to retain a prudent annual average limit value for NO_2. Such a limit allows for the fact that there may be direct toxic effects of chronic NO_2 exposure at low levels. In addition, maintaining the annual guideline value may help to control complex mixtures of combustion-related pollution (mainly from road traffic)

Short-term exposures

A number of short-term experimental human toxicology studies have reported acute health effects following exposure to 1-hour NO_2 concentrations in excess of 500 $\mu g/m^3$. Although the lowest level of NO_2 exposure to show a direct effect on pulmonary function in asthmatics in more than one laboratory is 560 $\mu g/m^3$, studies of bronchial responsiveness among asthmatics suggest an increase in responsiveness at levels upwards from 200 $\mu g/m^3$.

Since the existing WHO AQG short-term NO_2 guideline value of 200 $\mu g/m^3$ (1-hour) has not been challenged by more recent studies, it is retained.

In conclusion, the guideline values for NO_2 remain unchanged in comparison to the existing WHO AQG levels, i.e. 40 $\mu g/m^3$ for annual mean and 200 $\mu g/m^3$ for 1-hour mean.