

Nitrogen Dioxide Concentrations in the Atmosphere

Purpose

This Policy Position Statement outlines the technical challenges involved in the assessment and management of future concentrations of nitrogen dioxide (NO₂) in the atmosphere. It notes that NO₂ is the pollutant responsible for most breaches in European standards for air quality in the UK and that, as a result, a robust evidence based approach is required to assess future concentrations of this pollutant to allow good policy making.

CIWEM's Position on Nitrogen Dioxide in the Atmosphere:

1. The main cause of the exceedance of the annual mean air quality objective for NO₂ is emissions from road vehicles. These contribute directly to local concentrations of pollutants but also to the general background concentrations of this pollutant. As a result, most Air Quality Management Areas (AQMAs) have been declared in large urban areas where there are high levels of traffic, or where there are 'street canyons' together with congested traffic.
2. Considerable progress has been made to reduce emissions of nitrogen oxides (typically nitric oxide and NO₂) from motor vehicles, but the increasing proportion of NO₂ in vehicle exhaust means the UK is likely fail to comply with the European limit values.
3. CIWEM notes that there are numerous small towns that have recorded high concentrations of NO₂ that are not easily explained by our current understanding of vehicle emissions and dispersion of pollutants. This is a topic that needs further research so that we can assess the measures needed to reduce concentrations in these areas.
4. Forecasting of NO₂ concentrations in the future relies on good information regarding vehicle emissions and robust air quality monitoring. CIWEM is concerned that the emission information used to derive current emission factors does not include sufficient information on the most recent vehicle types. The emissions of NO₂ directly from vehicles (known as "primary NO₂") requires further research to be able to assess future concentrations of this pollutant more accurately.
5. A new approach is required, that may require giving local authorities new powers to introduce low-emission strategies, to ensure that the EU limit values are achieved by 2015. This will be necessary to ensure that the EU grants the UK government a time extension from the current requirement for compliance by 2010.

CIWEM is the leading independent Chartered professional body for water and environmental professionals, promoting excellence within the sector.

Context

Exposure to NO₂ can decrease lung function and increase a person's susceptibility to allergens and affect asthmatics. Air quality standards were set to protect vulnerable members of the community.

Nitrogen dioxide (NO₂) is a gas formed by the reaction of nitrogen and oxygen in combustion and also by various chemical processes in the atmosphere. Combustion of fuels such as petrol and diesel produce a mixture of nitrogen oxides, principally nitric oxide (NO) and a smaller amount of NO₂ known as primary NO₂. Once emitted into the atmosphere, nitric oxide reacts with ozone and other oxidants to form NO₂. Further reactions can create and destroy NO₂ but it is the initial reaction of nitric oxide with ozone and the primary emissions of NO₂ that are most important contribution to total NO₂ concentrations. The amount of conversion of NO to NO₂ is a key factor in the assessment of future concentrations of NO₂ and a range of concentrations are observed at various monitoring sites in the UK.

European standards have been set for concentrations of NO₂ in the atmosphere. These set an annual mean limit value of 40µg/m³ and an hourly mean concentration of 200µg/m³ that can be exceeded up to 18 times a year. A date for compliance with these regulations of 1 January 2010 was set for the European Standards.

The UK introduced a system of air quality management through its National Air Quality Strategy. The Strategy has set air quality objectives based on the European limit values. The air quality objectives are normally the same concentrations as the European limit values but sometimes with earlier target years. For NO₂ the objectives were set at the same values as the European limit values but the target year for compliance was 31 December 2005.

The UK Air Quality Strategy requires that local authorities review air quality in their area and assess whether they will meet air quality objectives by the relevant target years. If there is a risk of exceedance then the local authority must declare an Air Quality management Area (AQMA). By February 2009 208 local authorities had declared at least one AQMA for exceedance of the NO₂ objective.

The air quality objectives and the EU limit values are widely exceeded. A 2008 EU Directive allows an extension for the compliance date for achieving the EU limit values from 2010 to 2015 provided an action plan is provided. Department for Environment, Food and Rural Affairs (Defra) modelling predicts that in 2010 exceedences of the annual mean objective will occur along nearly 2,500 km of roads, and the one hour objective along about 330 km, and by 2015 that exceedences will still occur along 850 km and 25 km of roads respectively. Even by 2020 exceedences are predicted to continue in some places. This modelling assumes an "average" year in meteorological terms, and therefore these predictions may be optimistic.

Emissions of nitrogen oxides result in local increases in concentrations but the pollutant is also transported further resulting in an increase in background concentrations at distant locations. All combustion of fossil fuels results in some emissions of nitrogen oxides but in urban areas that main source of this pollutant is road vehicles. For instance in London it is currently estimated that 42% of the emissions are from motor vehicles.

Key Issues

Assessment of NO₂ concentrations

Future trends in NO₂ concentrations are assessed by air quality modelling. This process takes information regarding the quantities of pollutant emitted from each source, the existing background concentrations, the location of the source and local meteorology. This processes this information to predict pollutant concentrations. Modelling air pollution is difficult, and the models themselves contain a number of uncertainties, which are not considered in this PPS. However, of key importance to the accuracy of the models is the emission data used, i.e. the quantities of pollutants emitted from each source and the fact the models first calculate total nitrogen oxides concentrations and then assess the likely conversion to NO₂ using various approaches.

The emission data used for most vehicles is based on emission testing of vehicles. We note with concern that although the emission data provided by Defra/Department for Transport (DfT) is based on tests carried out on over a thousand vehicles, the majority of tests are on older vehicle types that are becoming less common in the current vehicle fleet. Some emission data for recent vehicles have been obtained from very few tests. There is an urgent requirement to work with our European Community partners to obtain a more robust dataset. For vehicles meeting future emission standards it is assumed that emissions will drop in direct proportion to the improvement in the emission limits, which has historically provide to be an over simplistic approach. It is, therefore, hard to have confidence in this information when projecting forward into the future.

One area where there is little information is the quantity of NO₂ directly emitted from vehicles (primary NO₂). As noted above, most nitrogen oxides are emitted in the form of nitric oxide and this converts in the atmosphere to NO₂. It is generally estimated that about 5-10% of the nitric oxides are emitted in the form of NO₂. However, there is increasing evidence that the proportion of primary NO₂ is increasing on more modern vehicles (Air Quality Expert Group, 2007, Trends in Primary NO₂ in the UK) and this will have profound impacts on our estimates of future concentrations. There is an important need to understand this issue further and to commission further research to obtain suitable information.

NO₂ concentrations in smaller towns

Most air quality studies have concentrated on areas where it was expected that air quality objectives would be exceeded i.e. where there are high levels of traffic in our major towns and cities. However, the experience of CIWEM Air Panel members is that there are numerous locations in smaller towns with lower traffic volumes where observed NO₂ concentrations are much higher than expected and often well above the objective level. At present, it is hard to identify the reasons this is occurring. Possible causes are the type of monitoring being carried out, emission factors not accounting for local operating conditions and a change in primary NO₂ emissions in the local area. Given the very high concentrations being observed it is essential that further research is carried out to fully understand why this is occurring and to devise mitigation methods to reduce concentrations.

Meeting the EU Limit value

Defra analysis of the reasons for future exceedences of the EU limit values suggests that different approaches will be needed in different locations to ensure compliance. The main causes of the exceedences are emissions from heavy goods vehicles and buses, and high background concentrations. It is clear that new measures, at both national and local levels, will be required. The high levels of NO₂ measured in small towns must be adequately taken into account when drawing up these new measures.

In deciding the most effective policies and measures to introduce the Government use cost benefit analysis in which the cost of measures are compared to their benefits. Some benefits are difficult to quantify and therefore may not be fully accounted for. There is concern that the approach used by Defra could conclude that it will be cheaper not to achieve compliance but pay any fines imposed by the European Commission.

Discussion

More AQMAs have been declared for exceedence of the NO₂ objectives than for any other pollutants. Concentrations in several parts of the UK still remain well above the relevant objectives and limit values and action is required at a national and local level to improve air quality.

However, there are limitations in the information being used to determine future concentrations of NO₂, particularly in terms of the emission data being used and the level of primary NO₂ emissions where information is based on only a few vehicle emission tests. Action is needed at a national and European level to address these information gaps and to therefore have more confidence in our predictions of future air quality and the effectiveness of mitigation measures.

Although emissions of nitrogen oxides at a national level have declined by almost half since 1990, a corresponding improvement in measured NO₂ concentrations has not been observed. This is because of the complex relationship between nitric oxide, NO₂, ozone and other substances in the air. In some locations concentrations are increasing whereas in others levels appear to be constant or falling. Uncertainties result both from limited understanding of the processes giving rise to high concentrations and the changing nature of emissions of nitrogen oxides. Pollution control technologies such as diesel particulate filters and the increase in the popularity of diesel cars in recent years have both affected the proportion of nitrogen oxides emitted as NO₂. Greater understanding of the in-use emissions from both light and heavy duty diesel vehicles, and how they change as vehicles age, are required.

Although poor air quality is normally associated with highly trafficked large urban areas we are observing several locations in smaller towns with much higher than expected NO₂ concentrations. At present, it is not possible to understand why this is happening, and there is an urgent need to examine these areas in more detail to identify the cause and hence provide appropriate mitigation measures that will improve air quality.

There is concern that the current cost benefit analysis approach used by Defra will conclude that it will be cheaper for the UK to not achieve compliance but pay any fines imposed by the European Commission.

June 2009

Note: CIWEM Policy Position Statements (PPS) represents the Institution's views on issues at a particular point in time. It is accepted that situations change as research provides new evidence. It should be understood, therefore, that CIWEM PPS's are under constant review, that previously held views may alter and lead to revised PPS's. PPSs are produced as a consensus report and do not represent the view of individual members of CIWEM.