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# Assessment of the relationship between industrial and traffic sources contributing to air quality objective exceedences: a theoretical modelling exercise

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**Abstract**

In the UK, local government is under a statutory duty to undertake scientific review and assessment of air quality and designate Air Quality Management Areas (AQMAs) in locations with identified air quality problems. This paper investigates, from a theoretical perspective, a situation where traffic is not the sole cause of an AQMA declaration. It presents air quality assessments in different scenarios, which are modelled using ADMS-Urban to predict concentrations of nitrogen dioxide. Modelling is carried out using simple scenarios with a combination of traffic and industrial emissions, different type of roads, meteorological data and approaches to derive nitrogen dioxide from oxides of nitrogen. The modelling results have shown the significance of the $NO_x$:$NO_2$ relationship and meteorological data as parameters inputted into the model. The results are discussed and compared with the guidance provided by Department for Environment, Food and Rural Affairs (Defra). Examples of local authorities' source apportionment studies are presented.


*Keywords:* Air quality management; $NO_x$:$NO_2$ relationship; Traffic pollution; Industrial pollution; ADMS-Urban; Theoretical modelling

## 1. Introduction

The Environment Act 1995 requires UK local government to undertake air quality review and assessment in order to achieve air quality objectives for seven pollutants. An Air Quality Management Area (AQMA) is then declared when an objective is exceeded in a location where public exposure exists. On completion of the first round of the review and assessment, 122 local authorities declared AQMAs while a further 9 authorities anticipate declaring in due course (Air Quality Management Resource Centre, 2003). After declaration, the next step is to prepare an Air Quality Action Plan (AQAP), setting out how the local authority intends to work towards the air quality objectives. Development of an AQAP begins with the identification of areas of exceedences and contribution of air pollution sources, from where the authorities can start to identify their options by considering the cost effectiveness and proportionality of different emission reduction strategies.

The air quality objectives that will be exceeded in the UK are $NO_2$ (annual and 1-h means), $PM_{10}$ (annual and

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24-h means) and $SO_2$ (15-min mean). Over 95% of AQMAs are designated as a result of traffic emissions (Longhurst et al., 2003). However, a small number of local authorities located near major industrial sources have air quality problems that arise from both traffic and a contribution of industrial sources (Leksmono et al., 2002).

The annual objective for nitrogen dioxide is 40 $\mu g\, m^{-3}$ to be achieved by the end of 2005 (HM Government, 2000) whilst the first EU Daughter Directive has the same limit value for the $NO_2$ annual objective but a target date of 1 January 2010 (Council of the European Union, 1999). In the UK, this objective will be exceeded by a large majority of local authorities. A survey of 105 local authorities in England and Wales conducted in 2002 has shown that this objective is exceeded by 91% of respondents (Leksmono, 2003).

Nitrogen dioxide is formed in the atmosphere in complex reactions between oxides of nitrogen, $NO_x$, and ozone. The principal sources of $NO_x$ in the UK are road transport, the electricity supply industry and other industrial and commercial sectors, which accounted for 49, 21 and 16% of total UK emissions in 2000, respectively. The contribution of road transport is much greater in urban areas. In London, road transport is estimated to account for more than 75% of $NO_x$ emissions (Defra et al., 2003). It is essential for local authorities to have knowledge of the primary emission source(s) in their AQMAs so that AQAPs can be properly targeted (Defra and National Assembly for Wales, 2001).

This study investigates the relationship between traffic and industrial emissions of $NO_x$ from a theoretical perspective using a dispersion model ADMS-Urban. It is intended to investigate how different data sources affect the modelled $NO_2$ concentrations and to identify the significance of each input parameter. The model is used to predict concentrations of annual nitrogen dioxide at a hypothetical urban location. This location has one major industrial source and a major road, and therefore air pollution arises from industrial and road traffic. Although the location in this research is hypothetical, the traffic and industrial scenario data entered into the model are real data.

## 2. Local air quality management in the UK

With the establishment of the Environment Act 1995 (HM Government, 1995), local government has the statutory powers to conduct a review and assessment of air quality and to declare an AQMA where necessary. With this Act, the UK moved from an air pollution control system that was almost exclusively based on emission standards to a system that placed greater emphasis on ambient air quality standards (NSCA, 1993). The Act requires preparation of a national air quality strategy and regulations for implementing the strategy. The Secretary of State for the Environment published the first strategy and led regulations before Parliament in 1997, which was then revised in 2000. Local government in England, Wales and Scotland have to work towards achieving air quality objectives for seven pollutants, as regulated by the Air Quality (England), Regulations 2000 and their equivalents for Wales and Scotland (HM Government, 2000, 2002). The air quality objectives for these pollutants are presented in Table 1.

European requirements for air quality management came under the EC Framework Directive 96/62/EEC on Ambient Air Quality Assessment and Management (Council of the European Union, 1996a). This Directive defines the policy framework within which limit values for 12 air pollutants are set. Limit values for the specific pollutants have progressively been set through a series of Daughter Directives. The first Daughter Directive is Directive 1999/30/EC (Council of the European Union, 1999), which sets limit values for sulphur dioxide, nitrogen dioxide, particulate matter and lead in ambient air. The second Daughter Directive is Directive 2000/69/EC (Council of the European Union, 1996b) which sets limit values for benzene and carbon monoxide. The latest Daughter Directive published is on ozone 2002/3/EC (Council of the European Union, 2002) and must be transposed by Member States by 9 September 2003. The Commission is still working on the remaining five pollutants, i.e. polycyclic aromatic hydrocarbons (PAHs), cadmium, arsenic, nickel and mercury.

In the UK, local authorities have finished the first round of air quality assessment. Those authorities, containing areas where air quality objective(s) are predicted to be exceeded, have designated air quality management area(s) and are currently preparing their action plans. In the first round, the UK government recommended a three-stage approach. The first stage involved data gathering on any significant existing or proposed sources, i.e. transport, industrial, other significant sources, and background concentrations within a local authority's area and its neighbouring authorities. This was followed by a second stage of assessment using simple screening models and available monitoring data. Stage 3 involved the use of complex dispersion modelling tools and detail monitoring to predict whether the air quality objectives will be met on specific target dates at a relevant location with exposure to the public (DETR and National Assembly for Wales, 2000). Where this is not the case, AQMAs are declared and AQAPs must be prepared to identify how the authorities are planning to achieve the objectives. Another requirement of the 1995 Act is to carry out further air quality assessment in AQMAs (known as stage 4 assessment) in order to verify the findings of