Article:

Marsden, G.R. and Bell, M.C. (2001) Road traffic pollution monitoring and modelling tools and the UK national air quality strategy. Local Environment, 6 (2). pp. 181-197. ISSN: 1469-6711

https://doi.org/10.1080/13549830120052818

Published paper
Marsden, G.R.; Bell, M.C. (2001) *Road traffic pollution monitoring and modelling tools and the UK national air quality strategy.* Local Environment, 6(2), pp.181-197.

Road Traffic Pollution Monitoring and Modelling Tools and the UK National Air Quality Strategy

Dr Greg Marsden[*] and Dr Margaret Bell[$]

[*]Transportation Research Group, Department of Civil and Environmental Engineering, University of Southampton, Highfield, Southampton. SO17 1BJ.
Tel: 023 8059 2175 Fax 023 8059 3152 E-mail: grm@soton.ac.uk

[$]Institute for Transport Studies, University of Leeds, Leeds. LS2 9JT
Tel: 0113 233 5330 Fax: 0113 233 5334 E-mail: mbell@its.leeds.ac.uk

Abstract

This paper provides an assessment of the tools required to fulfil the air quality management role now expected of local authorities within the UK. The use of a range of pollution monitoring tools in assessing air quality is discussed and illustrated with evidence from a number of previous studies of urban background and roadside pollution monitoring in Leicester. A number of approaches to pollution modelling currently available for deployment are examined. Subsequently, the modelling and monitoring tools are assessed against the requirements of Local Authorities establishing Air Quality Management Areas. Whilst the paper examines UK based policy, the study is of wider international interest.

Introduction

Air and noise pollution is estimated to cost the European Union (EU) some 0.6% of gross domestic product every year. This is equivalent to 37 Billion Euro per year to which road transport is responsible for over 90% (European Union Parliament, 1995). In the UK, poor air quality is estimated to be responsible for approximately four times the number of premature deaths each year than road traffic accidents (Department of the Environment, Transport and Regions, 1998).

Road traffic is a major contributor to pollutant emissions on a national and local level. Table 1 lists estimates of the contribution road traffic makes to pollutant emissions as defined by Cloke et al. (1998) from the most important UK studies to date.

Table 1: Percentage contrbution that road traffic makes to pollutant emissions on a national, regional and urban scale (from Cloke et al., 1998)

Area	CO	NO_x	PM_{10}	VOC	1,3 butadiene	Benzene
UK	88.8	49.4	56.1	29.4	N/A	77
North-West England	86.1	61.8	40.5*	38.3	N/A	N/A
Gloucester	87	89	N/A	71	N/A	N/A
Leeds	N/A	N/A	N/A	48.5	N/A	N/A
West Midlands	96	85	55.9	46**	96.5	99.5
Greater Manchester	95	63	31	20**	96	93

N/A – not available * black smoke ** non methane VOC

As a result of the growing societal impacts of air quality, the UK Government established the Environment Act (HMSO, 1995). The act has, amongst other things, set out the following requirements:

1. The Government and devolved administrations prepare a National Air Quality Strategy (NAQS) which is reviewed periodically
2. Local Authorities review air quality within their boundaries
3. Air Quality Management Areas (AQMA) are established where air quality standards fall or are likely to fall below national standards.

Traditionally, information regarding air quality has been collected by national and some local authorities using low cost monitoring systems capable of providing coarse averages. During the last decade, the UK Government has implemented and expanded a national network of high precision monitoring stations. The previously fragmented nature of the local monitoring networks has meant that in many cases, Local Authorities have only recently begun to develop new monitoring capabilities to assess the quality of air within their boundaries. In addition to monitoring the current state of the network, many Local Authorities are looking to implement new modelling tools to help forecast future scenarios of air quality.

This paper addresses the suitability for deployment of such models and monitoring equipment and investigates how the current tools match the current needs with a particular emphasis on the contribution of road transport. After a description of UK air quality standards, a discussion of the pollution monitoring tools that are available and their relative merits is provided. This is further illustrated with some examples from case studies in Leicester. The role and availability of emission and air quality modelling tools is then discussed before conclusions are drawn about how the tools meet the requirements.

Air Quality Standards

In March 1997, the UK Government published a National Air Quality Strategy (Department of the Environment et al., 1997) to formalise standards for ambient air quality, establish objectives for when the standards should be met and to set out a national programme for achieving this. The standards, which have since been updated (Department of the Environment Transport and the Regions et al., 2000) (Table 2) are compatible with EU Air Quality Directives. Where EU limits have not yet been agreed, or where a more stringent standard is deemed achievable without imposing unjustifiable costs on the parties involved, the guidelines are those proposed by reports and recommendations from the Expert Panels on Air Quality Standards.

The framework and stages of an air quality review (Department of the Environment, Transport and the Regions and National Assembly for Wales, 2000a) have been established by the Government as part of their statutory duty to develop the NAQS. The review can take up to three stages depending on the seriousness of the air quality problem in an area. The depth of understanding and therefore monitoring and modelling analysis increases as the review progresses through stage one to three.

Table 2: UK Standards and Objectives in the UK National Air Quality Strategy (Department of the Environment et al., 2000)

United Kingdom Pollutant	Standard Concentration	Measured as	Date to be achieved by
Benzene	16.25 μg/m^3 5 ppb	running annual mean	31 December 2003
1,3 - Butadiene	2.25 μg/m^3 1 ppb	running annual mean	31 December 2003
Carbon monoxide CO	11.6 mg/m^3 10 ppm	running 8-hour mean	31 December 2003
Lead	0.5 μg/m^3	annual mean	31 December 2004
Pb	0.25 μg/m^3	annual mean	31 December 2008
Nitrogen dioxide NO_2	200 μg/m^3 105 ppb	1-hour mean*	31 December 2005
	40 μg/m^3	annual mean	31 December 2004
Particles (PM_{10})	50 μg/m^3	24 hour mean$	31 December 2004
	40 μg/m^3	annual mean	31 December 2004
Sulphur dioxide	350 μg/m^3 132 ppb	1 hour mean+	31 December 2004
	125 μg/m^3 47 ppb	24 hour mean&	31 December 2004
	266 μg/m^3 100 ppb	15 minute mean$	31 December 2005

* not to be exceeded more than 18 times a year
$ not to be exceeded more than 35 times a year
+ not to be exceeded more than 24 times a year
& not to be exceeded more than 3 times a year
There is also a national standard for ozone however, due to the complex nature of ozone formation this is not a target for consideration at a local level.

The first stage of the air quality review, required by all Local Authorities through the Environment Act, draws together knowledge about the local area pollution sources into a report. The review identifies whether it is likely that significant exposure to emissions may occur and where the principal sources are located. No monitoring is required at this stage although it can be included.

A second stage review, where required, concentrates on those pollutants identified of being of concern and attempts to define whether or not there is a significant risk of an air quality objective not being met. In order to achieve this, the local authority has to provide an assessment of the ground level concentrations of the pollutants being considered on a similar temporal level to that of the air quality objective being addressed. If, after the second stage review, it seems likely that an air quality objective will not be met, a further and more in depth review of air quality (stage three) must be conducted to identify the problems and to enable an AQMA to be established which will address the problem.

Pollution Monitoring Tools

There are four different categories of pollution monitoring techniques:
1. passive sampling;
2. active sampling;
3. automatic or continuous; and

4. remote sensing.

When preparing an assessment of air quality within an area, it is possible that a number of these monitoring tools will be used. Each monitoring tool has its advantages and disadvantages and careful selection of the tools is required although the NAQS does not require local authorities to purchase extra equipment. However, where potential exceedences of standards are identified within the second stage of the review process, it is in the interest of the local authority to provide a more comprehensive monitoring review. In the first instance, this makes a clearer case for whether or not to proceed to the third stage of the review and secondly, if an AQMA is established following a stage three review, it allows the development and monitoring of a more effective action plan. This section describes each of the tools and provides some evidence of their practical application.

Passive Monitoring

Passive pollution monitoring has been used to determine trends in long term pollution levels. The UK has had a network of SO_2 passive monitors in operation for over 30 years. Passive monitoring is usually undertaken using diffusion tubes. The tubes are left open for a period of one week to one month before being analysed in a laboratory to determine average pollutant concentrations. The tubes are inexpensive (under £50 per tube) and are well established as a monitoring tool for trend analysis. However, if sampling is only taken at one month intervals, the effects of a short term pollution episode where air quality standards were exceeded would be masked by the overall average figures. In addition, diffusion tubes are not available for all pollutants, nor would they be suitable in assessing exceedences of hourly or 15 minute limit guidelines.

Active Sampling

Active sampling uses a pump, usually battery driven, to draw air over the sensor. Again, samples are collected over a period of time (daily to monthly) and the information can be used for long-term trend analysis. The equipment is more expensive than diffusion tubes e.g. £1000 to £3000 (Cloke et al., 1998) and is less easy to hide. The use of this sort of monitoring is reducing as it is labour intensive and the equipment needs to be supervised and batteries replaced. Observer fatigue and exposure to pollution can also limit such surveys (Reynolds and Bell, 1992). Reynolds and Bell also concluded that the relationships between traffic characteristics and roadside pollution measurements were complex and required much larger databases of measurements over long periods to obtain any statistical significance.

Automatic or Continuous

Since the early 1990's significant advances have been made in automatic monitoring techniques. As mentioned previously, long-term trend analysis has been developed through the centrally funded automatic network. The automatic network consists of a number of high precision quality assured monitoring stations located around the UK. The information from monitoring stations is recorded in real-time and provided to the public via a Government funded World Wide Web site[1] that is updated every three hours. The monitoring equipment is expensive and requires regular calibration but is the accepted standard against which air quality models should be validated. Figure 1

[1] www.aeat.co.uk/netcen/airqual/index.html

shows the location of monitors accredited as part of the automatic network, currently numbering over 100 of which 84 are urban monitors (Department of the Environment, Transport and the Regions and National Assembly for Wales, 2000a).

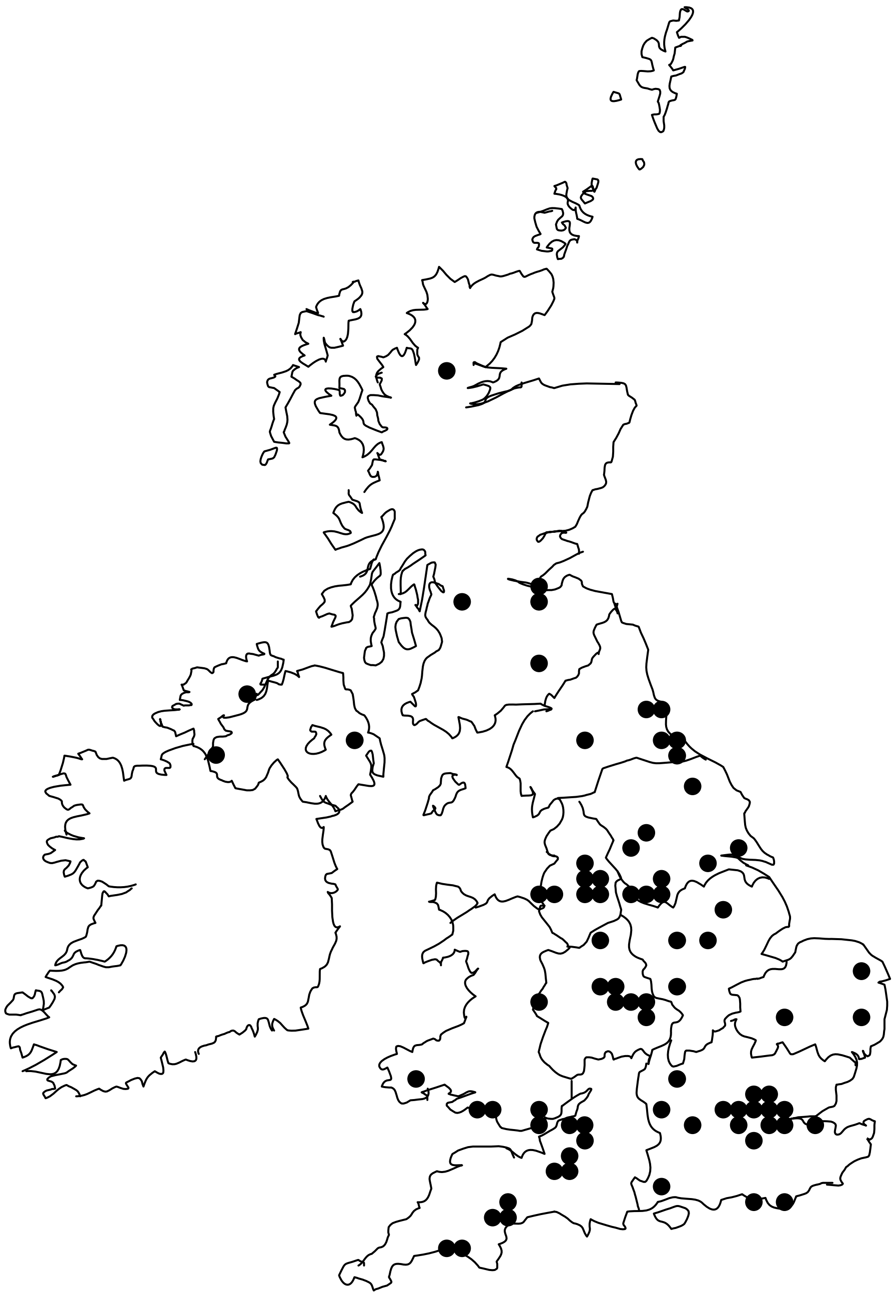

Figure 1: Location of Accredited Automatic Monitoring Stations in the UK

The national site classification for all monitoring stations is shown in Figure 2. It is difficult to install accredited monitoring stations at kerbside (U1) sites or at roadside (U2) sites due to their size and the availability of space in the vicinity of urban roads.

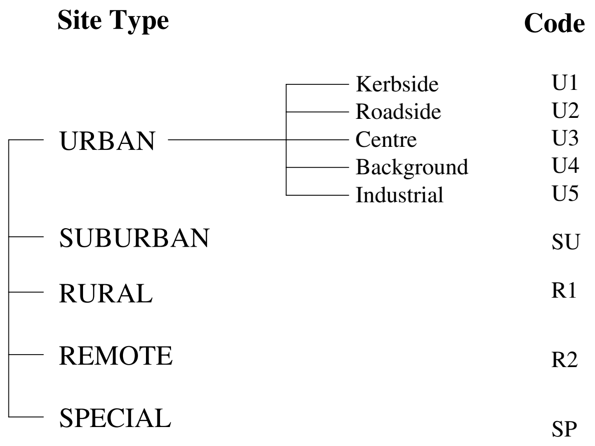

Figure 2: Site Classification in the Automatic Monitoring Networks

Urban background monitoring stations (U4) are typically located in elevated locations, parks and urban residential areas to obtain a broadly representative picture of citywide background conditions. Urban centre sites (U3) are located closer to the kerbside, influenced more by vehicle emissions.

A study performed in Leicester (Dussledorp, 1995) attempted to examine the relationship between background air pollution levels and local traffic characteristics using data respectively from a U3 high precision monitoring station and a nearby road. Pollution monitoring results were examined for a six-month period from January to June. Traffic data from adjacent roads was obtained from the Split, Cycle, and Offset Optimisation Technique (SCOOT) demand-responsive traffic control system (Hunt et. al., 1981).

Dussledorp split the monitoring period up into two periods; January to March (termed "winter") and April to June (termed "summer"). Figures 3 and 4 show the difference between the diurnal variations of CO and SO_2 respectively.

CO levels are more clearly related to the traffic flow with peak pollutant levels at 0800 and 1800 corresponding with the peak-hour traffic. The CO profile is more defined in the period from January to March than from April to June. No significant alterations to the traffic flow profile, through demand management measures, were introduced between the periods. The effect is likely to be weather related. The phenomenon of temperature inversion that prevents pollutants from being dispersed is more prevalent in the winter months. SO_2 is less clearly related to the traffic flow profile – indicative of the fact that the majority of SO_2 pollution comes from industrial sources.

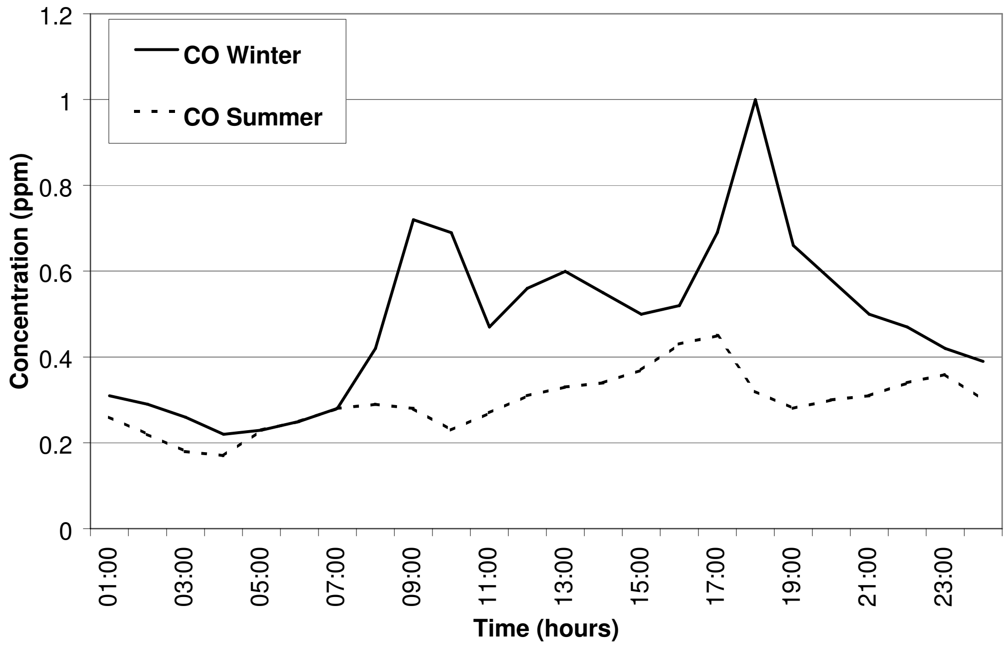

Figure 3: Diurnal variation in Hourly CO levels (From Dusseldorp, 1995)

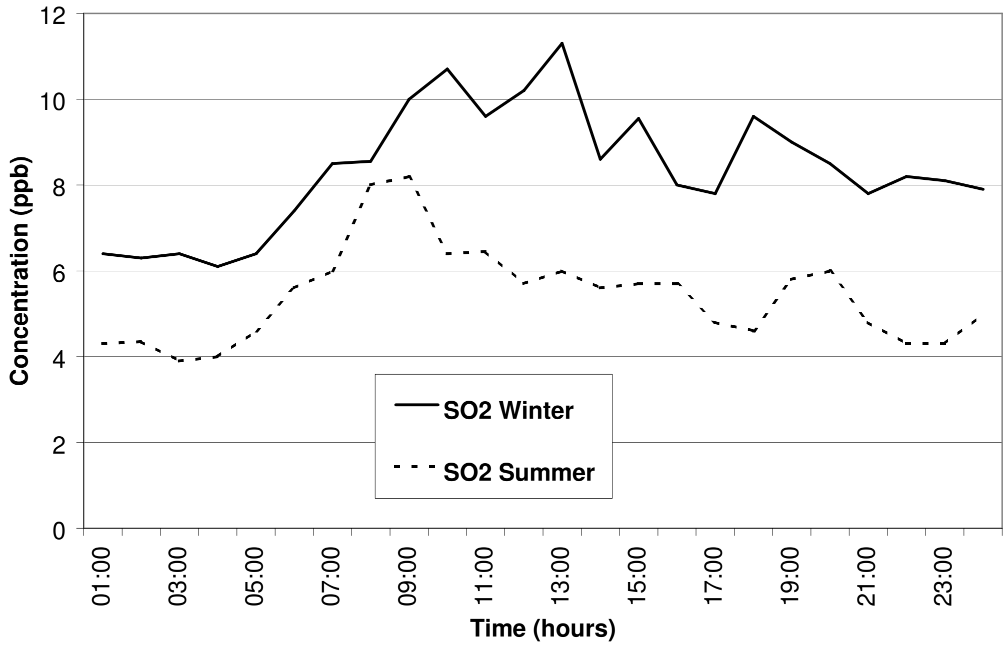

Figure 4: Diurnal variation in hourly SO_2 levels (From Dusseldorp, 1995)

No correlation was found between the traffic characteristics collected from SCOOT and pollutant levels. A large number of factors affect both the emissions from exhaust tailpipes and the transport of the pollution to the monitoring station some metres away. Whilst the studies highlighted in Table 1 show that traffic is the dominant source of most urban pollution, the link between traffic and measured concentrations is not simple.

The AUN sites are suitable for detailed long-term trend analysis of overall air quality and adherence to standards, a fundamental part of all parts of the air quality review. However, such systems are not necessarily suitable for assessing the direct air quality effects of new traffic demand management schemes for example.

Whilst background monitoring is an essential tool for informing the public and examining long term trends in pollutant concentrations there are certain areas within cities that are pollution “hot spots”, with localised high levels of pollutants. The hot spots can be present for a variety of reasons such as topography, static sources and road traffic. Extended individual exposure to high levels of pollutants in such areas could exacerbate breathing problems when the air quality is generally poor.

Bell et al. (1996) describe the development and testing of a new Roadside Pollution Monitor (RPM) . The RPM units measure CO and NO_2 by drawing air across a series of electrochemical cells. The chemical reaction within each cell produces a small electrical current that is related to the pollutant concentration measured. Data from the units is produced every minute as an average of the second-by-second readings taken over that minute. The monitors have been developed so that information can be sent via existing traffic system control communication lines to the Urban Traffic Control centre or by dial up modem. The units are permanently fixed to the pavement, vandal proof and are usually sited five metres upstream of the stop-line with the pollution intake 1.5m from the floor level (approximating at face height for an average human).

Such systems are particularly useful in the study of the effects of traffic on local air quality. The sensors are not as precise or expensive as those used for the AUN stations and are suited to a roadside application where they will measure a greater range of pollutant concentrations. However, only in the very centre of cities where people spend a significant amount of time by the roadside, can the roadside pollutant concentrations be taken to be representative of personal exposure levels for a significant period of time.

A study of CO concentrations at seven locations on a busy single lane road in Leicester City Centre was performed as part of a larger traffic emissions study (Marsden, 1997) in July 1997. Two portable research RPM units were used in combination with CO monitoring using two Golden River Marksman M660 units. The M660 produces an average CO concentration for each five-minute period. Readings from the RPM units were aggregated to the synchronised five-minute averages for direct comparison.

Figure 5 shows a comparison of the pollution levels measured 5m from the stop-line by an RPM unit (air intake 1.5m from kerb-level) and an M660 unit (air inlet 10 cms from kerb level) on one day. The data clearly shows that there is a high degree of variation between the kerb-level emissions and those measured at 1.5m.

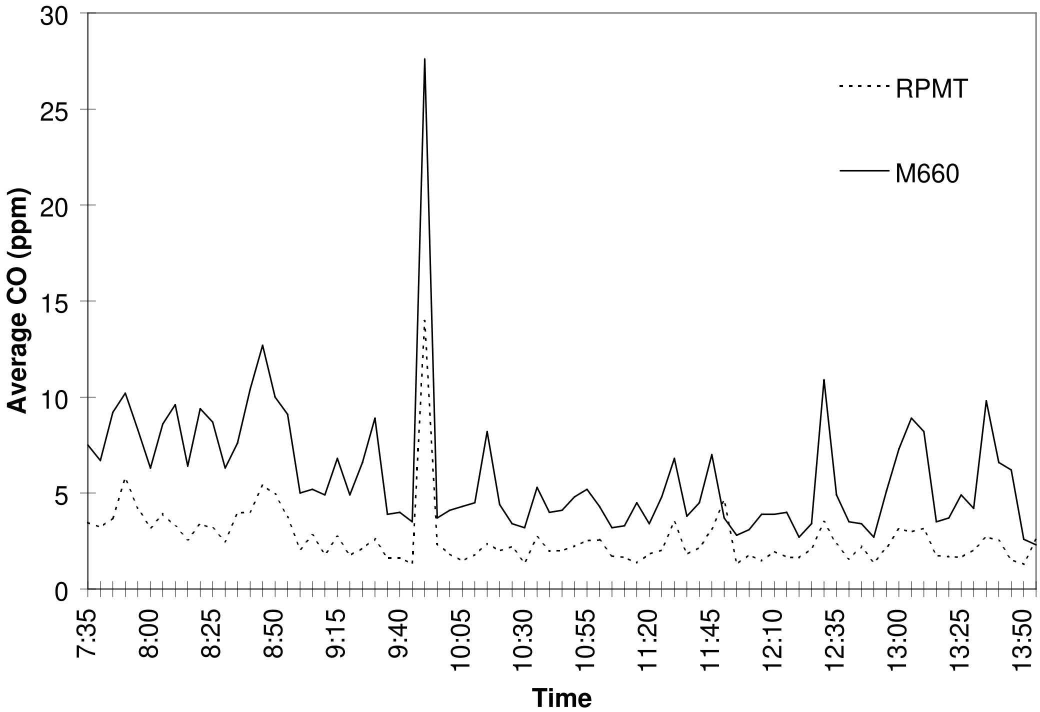

Figure 5: Comparison of CO concentrations measured at kerb level and 1.5m above kerb level

An analysis of the video data revealed an old van (with considerable smoke emissions from the exhaust) stopped at the traffic lights at 9:45AM. It is likely therefore that the engine was in bad condition and the general emissions were high, causing the peak.

A further survey two days later, plotted in Figure 6, that showed significant differences between the CO profiles of the same sensors used for Figure 5. It is clear that the CO pollution profile at 1.5m from kerb level has almost completely disappeared. Initially, it was believed to be due to equipment malfunction but a similar trend was exhibited by pollution measurements at a distance 35m from the stop-line. The weather on Regent Road on this day was warm, overcast and dry with blustery wind. It is possible that the wind was responsible for the flattening of the profile between kerb level and face level. However, the average wind speed measured at the Leicester City automatic network monitoring site did not show a higher wind speed on this day compared with the previous survey days.

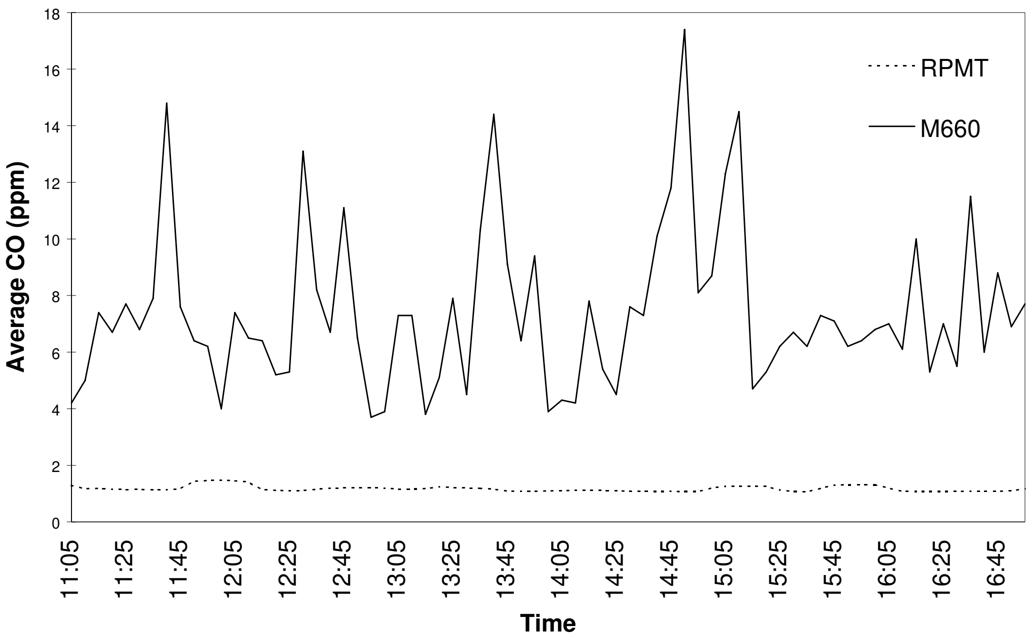

Figure 6: Stop-line kerb and 1.5m level comparison (1st August 1997)

These results indicate that kerb level pollution monitoring studies are a better tool to assess the benefits of emission management strategies and corridor pollutant concentration levels than monitoring at 1.5m from kerb level although they do not represent personal exposure. In addition, these surveys have highlighted the importance of monitoring local climate conditions simultaneously with pollutant concentration measurements.

Remote Monitoring

Direct measurement of emissions from the tailpipe can be made using remote sensing equipment. Remote monitoring works by transmitting light of a wavelength known to be absorbed by a molecule of the pollutant of interest (Bishop and Stedman, 1996). The absorption of light causes a voltage drop in the detector related to the percentage concentrations of CO, HC and NO and the air/fuel ratio.

Remote sensing has primarily been used to monitor gross emitting vehicles. In the UK, research has shown that 10% of vehicles produce up to 50% of vehicle emissions (Muncaster et al., 1994).

Remote sensing technology is beginning to mature as a technology (Cadle et al., 1999) and it is possible that it could become an integral part of the emissions management strategy of UK local authorities (Stationary Office 1999). Such systems are not suited to air quality monitoring but are rather, emissions sensing devices with application for both the measurement of transport and industrial emissions.

Monitoring Summary

Table 3 below summarises the main application of each of the different pollution sensors within the context of the UK NAQS.

Table 3: Application of pollution monitoring tools for air quality assessments

Monitor	Personal Exposure	Episode Monitoring	Traffic Scheme Assessment	Individual Vehicle	Suitability for NAQS assessment
Passive	✓✓	✗	✗	✗	2
Automatic High Precision	✓✓	✓✓	✓	✗	1
Automatic Roadside	✓	✓	✓✓	✗	3
Remote Sensing	✗	✗	✓	✓✓	4

✓✓ Recommended
✓ Can be applied
✗ Not suitable

Further advice and guidance on the selection of monitoring tools can be found through Government guidance notes (Department of the Environment, transport and the Regions and Welsh National Assembly, 2000b).

Modelling Tools

Pollution monitoring forms an essential part of an assessment of air quality within the UK. Modelling the dispersion of emissions from transport, industry and domestic sources can augment monitoring. Modelling provides estimates of pollutant concentration levels across and urban area or region rather than at a single location of a monitoring system. National forecasts of air quality are produced every afternoon for the Department of Transport, Environment and the Regions using a variety of national pollution monitoring and modelling tools and weather forecasts. The modelling techniques, outlined in Stedman et al. (1998), use data from the National Atmospheric Emissions Inventory to produce estimates of pollutant concentrations over a 10km by 10km grid of the United Kingdom. The information is relayed to the public through television, radio, teletext, newspapers, the World Wide Web[2] and through a free telephone information service. Rather than producing a detailed estimation of the pollutant concentrations by grid square, the values are reported according to a system of thresholds which indicate if the pollutant levels are forecast to be Low, Moderate, High or Very High.

The DETR provides forecasts so that individuals who may be affected by episodes of high pollution can take preventative measures. In addition, local authorities can use the forecasts to implement further public awareness measures and traffic management strategies to reduce the severity and duration of such an episode.

Whilst such models are used for short-term episode forecasting, they can also be used to examine long term strategies such as the air quality impacts of a new power station or car park. Whilst the national air quality forecasting service 10 km by 10km resolution warns of the area of a city to be affected, when and for how long, it provides no support for traffic demand strategy generation e.g. to alleviate congestion or reduce exhaust emissions. For the assessment of traffic demand management strategies a traffic assignment model is required to predict the changes in traffic levels and characteristics and much smaller scale air quality models are needed to assess

[2] www.aeat.co.uk/netcen/airqual/forecast

impact. This section reviews the main categories of models and their relative benefits over a range of potential applications.

State-of-art reviews performed by Negrenti (1998), Cloke et al. (1998) and Algers et al. (1997) have identified over forty vehicle emission estimation models. It is difficult to assess the relative merits of each model, particularly as they were developed to fulfill different objectives. However, the models can be divided up according to the level of detail they use to estimate vehicle emissions. This section reviews the three main levels of model detail and provides a summary of their suitability for application within an air quality review.

Disaggregated modelling

Disaggregated modelling is the finest resolution emissions modelling that is undertaken. Disaggregated modelling uses vehicle speed and acceleration characteristics at a small time scale combined with a known emissions performance by an engine to estimate the emissions for a given speed profile.

Vehicle emissions depend on a complex number of variables (Heywood, 1988) such as of age, maintenance, load, fuel and variety of engine type. On-street measurement studies have been carried out by several researchers using high precision sensors mounted in the vehicle exhaust system. The common finding from real-world measurements is that harsh acceleration can produce significantly higher levels of exhaust emissions than driving which does not require extra power. DeVlieger (1997) states that CO emissions were up to three times higher with aggressive stop-start driving than with moderate acceleration and deceleration. Similar effects are found for HC but not for NO_x, which is related more to the speed of the vehicle.

For this reason, the use of disaggregated models should be considered for the assessment of schemes that could have a significant impact in the driving profile within an area. For example, when considering the installation of speed humps as a traffic calming measure, failure to take account of the impacts of the extra periods of deceleration and acceleration will underestimate the emission impacts of such a scheme.

Work is currently on going within the European Union (Joumard et al., 1999) to improve the database of engine emissions available from the various testing stations throughout Europe. However, the current scarcity of data for a wide range of vehicles of different ages and maintenance levels means that this type of modelling will primarily be carried out in recognised research institutes.

Average Speed Modelling

Average speed based models are commonly used in assessing the impacts of new traffic systems on vehicle emissions and air quality. The models simplify the discussions regarding the effects of acceleration by applying an emission factor to a vehicle assumed to have a constant speed over a link or a journey. The emission factor applied can take some account of whether the vehicle experienced stop-start conditions or travelled uninterrupted by the use of a variety of driving cycles that describe typical vehicle behaviour within a city (Jost et al., 1992).

One example of a model that applies the average speed methodology is included in the latest version of the traffic signal optimisation software SCOOT (Bretherton et al., 1998). The SCOOT traffic model gives the average delay per vehicle travelling on a road and, together with the unimpeded journey time average link speed is estimated. Emission factors are then applied to the volume of traffic on each link for each signal cycle based on the average speed.

The UROPOL model (Matzoros, 1990) has been used to estimate vehicle emissions using the SATURN (Van Vliet, 1982) traffic assignment model. Estimates of the total emissions due to vehicles cruising, accelerating, idling and decelerating on a link are based on the proxy measures of delay, stops and queues produced from the traffic assignment model. Whilst this model takes some account of the effects of acceleration on vehicle emissions, the approach is aggregated for all vehicles on a link over the period of the simulation rather than calculated for individual vehicles at small time increments. The UROPOL model has been used within the Environmental Forecasting For the Effective Control of Traffic (EFFECT) DGXIII funded Fourth Framework project (Bell and Hodges, 1999) to compare the potential emissions impacts of a range of traffic strategies in Maidstone (Cox, 1999).

The SCOOT and UROPOL models described above are tools for examining the impact on emissions of traffic management and control strategies. They take no account of the overall contribution of transport to the total emissions and, in the absence of a dispersion model, do not estimate their contribution to the concentration levels within a region. The emissions from transport should remain the focus of the traffic engineer. However, to fulfil the requirements of the national air quality strategy, models that also take into account industrial and domestic emissions are required. An atmospheric dispersion sub model is essential to forecast the impacts on air quality of changes in emissions from any source.

The AIRVIRO model (now developed by the Swedish Meteorology and Hydrology Institute) and the UK Meteorological Office NAME model (Ryall and Maryon 1998) are two examples currently being applied in major cities in the UK and world-wide. The vehicle emission modules for these models are simpler than those described above. Traffic activity including flow, delay and congestion effects is estimated for grid squares of 500m by 500m (or greater) and emission factors applied for these areas based on the activity calculations and the vehicle fleet composition for the area. Nesting of models can also occur where a larger area model provides background pollution data and a more detailed model superimposes local area effects. Government guidance on the selection and application of dispersion models is also available (Department of the Environment, Transport and the Regions and National Assembly for Wales, 2000c).

Modelling air quality in this manner allows forecasting of poor air quality and assessment of the impacts of local policies on air quality. However, pollution does not respect local boundaries and care should be taken to acknowledge incidences of imported pollution when local action may have limited effect. Episodes of exceedence of the Ozone standards have been attributed to other European emission sources (Department of the Environment et al., 1997) and within Kent, short term elevated emissions of PM_{10} originated from the Continent (Street and Ireland 1997).

Aggregated Modelling

Aggregated modelling has been used for the development of national emissions inventories and for the study of the macroscopic effects of new policy measures. Vehicle usage statistics, fleet age, characteristic average speeds, road classification, cold starts and evaporative emissions are typically included.

The DETR's Vehicle Market Model (Kirby and Seiker, 1998) has been developed using this methodology to assess the impacts of new vehicle and fuel taxation policies on UK transport emissions. The London Transport Emissions Model (London Transport Buses, 1999) has also been developed using London travel statistics to examine the contribution of buses to vehicle emissions in London.

The application of aggregated models to the study of local air quality is limited given that, by their nature, they use aggregate statistics for large areas. Whilst they provide a useful indicator of how the overall emissions might change under a certain policy environment, there is little spatial resolution to enable dispersion modelling and therefore air quality forecasting.

Modelling Summary

Table 4 below summarises the compatibility of the various types of emission modelling tools described with different levels of spatial resolution that might be required for an assessment of the effects of transport policy.

Table 4: Application of pollution modelling tools for air quality assessments

Model Type	National	Area	Scheme	Main Use
Diasaggregated	✗	✗	✓✓	Research
Average Speed	✗	✓✓	✓	Local action
Aggregated	✓✓	✓	✗	National policy

✓✓ Recommended
✓ Can be applied
✗ Not suitable

It is essential to understand and select the correct level of detail required for modelling emission changes. Emission modelling defines the quality of the input to the dispersion model, which ultimately determines the likely impacts on local air quality.

Conclusions

Long-term monitoring of urban centre and urban background pollution levels will be the backbone of air quality assessments. Whilst the UK Government is expanding the network, it is possible for Local Authorities to augment the national network with sites of their own. The cost of purchasing and the running costs of such systems are significant. However, strategically locating the systems around a city can provide an indication of personal exposure profiles in the centre and in key residential areas. The understanding of personal exposure to pollution forms the basis of an NAQS assessment.

Passive sampling techniques have some drawbacks relating to the assessment of air quality due to the fact that they are normally left on street to measure pollution over a period of one week to a month. They are only suitable for the assessment of yearly average guidelines. However, due to their low cost, a wider area assessment of such guidelines can often be achieved.

Cheap automatic pollution concentration measurement systems are now available. The monitors, typically located near a traffic intersection stop-line, are dominated by the effects of acceleration and idling emissions and so are not representative of the overall link. Pollutant concentrations also decrease sharply away from the roadside. These factors mean that such systems do not provide a general personal exposure profile unless the road is in an area of dense and continuous pedestrian activity such as a city centre shopping area. However, as pollution hot spots are often associated with roads with high vehicle flows, they are likely to find application in local air quality management.

Remote sensing will find increasing use for monitoring gross emitting vehicles and targetting standard roadside compliance tests. Perhaps the greatest short-term application of remote sensing for local air quality management will be through monitoring industrial chimney stack emissions.

A number of different modelling techniques have been discussed for estimating transport emissions. The most suitable level of detail for most Local Authorities to work at with regards to transport is usually based on average vehicle speed. In addition, the estimation of industrial, domestic and other important local emission sources should also be undertaken and combined with a pollution dispersion model to estimate air quality. Whilst the UK government provides such a tool on a 10km by 10km basis, the understanding of the dynamics on a much more local basis is necessary, particularly in areas where air quality is near or above the limit guidelines.

The quality of such models is linked strongly to the quality of the input data provided. Not only are the physical locations of all roads, domestic areas and industrial sources required, but a good indication of the levels of emissions from each source. This is a time-consuming and costly process and one that needs continuous updating to take account of changes in vehicle mix or industrial plant performance for example. It is likely therefore that only large towns and cities will have the resource and need to develop such models. In addition, weather conditions can differ significantly from the forecast and so no prediction gives 100% confidence.

Other forms of modelling of transport emissions are likely to be used more as part of research and national policy making studies. Such programmes will produce national guidance documents for implementation.

The UK Government pollution monitoring network and air quality forecasting model serve as an excellent base line of information for providing information about air quality. In areas, particularly urban centres, where there is a risk of air quality guidelines being exceeded, it is good practice to supplement some of the national monitoring and modelling activities to provide a greater understanding of the sources and spatial distribution of the effects. In this way, a more effective action plan to reduce pollution levels can be drawn up. This article has described the major types of monitoring and modelling tools available to fulfil these roles.

References

Algers, S., Bernauer, E., Boero, M., Breheret, L., DiTaranto, C., Dougherty, M., Fox, K. and Gabard, J. (1997) Review of Micro-simulation models, SMARTEST EU Fourth Framework Project Deliverable D3, Contract N^{o}: RO-97-SC.1059, Institute for Transport Studies, University of Leeds.

Bell, M.C. and Hodges, N. (1999) Managing Traffic to Improve Air Quality. *Proceedings of 8th International Symposium on Transport and Air Pollution including COST 319* Final Conference, Gratz, Austria 31st May to 1st June

Bell, M.C., Reynolds, S., Gillam, W.J., Berry, R. And Bywaters, I. (1996) Integration of Traffic and Environmental Monitoring and Management Systems. *Proceedings of the 8th International Conference on Road Traffic Monitoring and Control*. pp 33-37. IEE conference publication 422, London.

Bishop, G.A. and Stedman, D.H. (1996). Measuring the emissions of passing cars. *Acc. Chem. Res.* **Vol. 29**, pp 489-495.

Bretherton, D. Wood, K. and Bowen, G. (1998) SCOOT version 4. *9th International Conference on Road Transport Information and Control*, IEE Conference Publication 454, London, pp 104-108.

Cadle, S.H., Gorse, R.A., Belian, T.C. and Lawson, D.R. (1999) Real World vehicle Emissions: A summary of the 8th Co-ordinating Research Council On-Road Vehicle Emissions Workshop. *Journal of the Air and Waste Management Assoc.* **49**, pp 242-255.

Cloke, J., Boulter, P., Davies, G.P., Hickman, A.J., Layfield, R.E., McCrae, I.S. and Nelson, P.M. (1998) Traffic Management and Air Quality Research Programme. TRL Report 327, Crowthorne, Berkshire.

Cox, R. (1999) Kent Demonstrator. *Presentation at EFFECT Project Launch Seminar*. Leicester City Council, January 15th.

Department of the Environment, Transport and the Regions (1998) *A New Deal for Transport: Better for Everyone*. The Stationary Office, London. 0-10-139502-7.

Department of the Environment, Scottish Office and Welsh Office (1997*). The United Kingdom Air Quality Strategy*. The Stationary Office, London. 0-10-135872-5

Department of the Environment Transport and the Regions and National Assembly for Wales (2000a) Framework for Review and Assessment of Air Quality. *Local Air Quality Guidance Note LAQM.G1(00)*, Rotherham. ISBN 1 85112 369 5.

Department of the Environment Transport and the Regions and National Assembly for Wales (2000b) *Monitoring for Reviews and Air Quality Assessments. Local Air Quality Guidance Note LAQM.TG1(00)*, Rotherham.

Department of the Environment Transport and the Regions and National Assembly for Wales (2000c) *Selection and Use of Dispersion Models. Local Air Quality Guidance Note LAQM.TG3(00)*, Rotherham.

Department of the Environment Transport and the Regions, the Scottish Executive, the National Assembly for Wales and the Department of the Environment in Northern Ireland (2000). *The Air Quality Strategy*. The Stationary Office, London. Cm 4858, SE 2000/3, NIA 7 0-10-145482-1.

DeVlieger, I. (1997) On-board emission and fuel consumption measurement campaign on petrol-driven passenger cars. *Atmospheric Environment*. Vol 31, **22** pp 3753-3761.

Dussledorp, A. (1995). Background Air Pollution Levels and Traffic Characteristics in Urban Areas. *MSc Thesis*, Department of Civil Engineering, University of Nottingham.

European Union Parliament (1995) *Towards Fair and Efficient Pricing in Transport: Policy Options for Internalising the External Costs of Transport in the European Union*. COM(95)691/Provisional. Directorate General for Transport DGVII, Brussels.

Heywood, J. B. (1988) *Internal Combustion Engine Fundamentals*. (New York, McGraw-Hill Inc.). ISBN 0-07-028637-X.

HMSO (1995) The Environment Act. HMSO, London.

Hunt, P.B., D.I. Robertson, R.D. Bretherton and R.I. Winton (1981) *SCOOT - a traffic responsive method of co-ordinating signals*. TRRL Laboratory Report 1014, Transport and Road Research Laboratory, Crowthorne, Berkshire.

Jost, P, Hassel, D., Weber, F.J. and Sonnborn, K.S. (1992) *Emission and fuel consumption modelling based on continuous measurements*. Deliverable. No. 7, EU DRIVE project V 1053. Modelling of emissions and consumption in urban areas - MODEM.

Joumard, R. et al. (1999) *Methods of estimation of atmospheric emissions from transport: European scientist network and scientific state-of-the-art*. Action COST 319 Final Report (LTE 9901), INRETS, Lyon, France.

Kirby H, and Seiker, A. (1998) Transport Research Institute Napier University: Annual Report 1997/98. *Traffic Engineering and Control* **39** No 11 pp 608-616.

London Transport Buses (1999) Buses: a Cleaner Future. Bus emissions and air quality in London. Report, London Transport Buses.

Marsden, G.R. (1997) Towards a real-time road traffic pollution estimator. *PhD. Thesis*, Department of Civil Engineering, University of Nottingham.

Matzoros, A. (1990) Results from a model of road traffic air pollution, featuring junction effects and vehicle operating modes. *Traffic Engineering and Control* Vol. 31, **1**, pp24-37.

Muncaster, G.M., Hamilton, R., Revitt, D.M., Stedman, D.H. and Vanke, J. (1994) Individual emissions from on-road vehicles. *International. Symposium on Advanced Transportation Telematics Applications: The Motor Vehicle and the Environment - Demands of the Nineties and Beyond.*

Negrenti, E (1998*): Consumption and emission models: results from action COST 319*. ENEA report RTI-ERG-SIRE-98/19, Rome.

Reynolds, S.A. and Bell, M.C. (1992) *Carbon Monoxide and traffic congested urban areas*. Final report to SERC, Department of Civil Engineering, University of Nottingham, Report TR930001

Ryall, D.B. and Maryon, R.H. (1998) Validation of the UK Met. Office's NAME model against the ETEX dataset. *Atmospheric Environment* **32** N^{o} 24 pp 4265-4276.

Stationary Office (1999). *Vehicle emissions testing*. Report by the Comptroller and Auditer General. London. ISBN 0-10-265899-4.

Stedman, J., Espenhalm, S. and Willis, P.G. (1998) *Air Pollution Forecasting in the United Kingdom: 1997*. Department of the Environment, Transport and the Regions. Contract EPG 1/3/59.

Street, E. and Ireland, M. (1997) *Local Air Quality Management in Kent – A Partnership Approach*. Working paper to Kent Air Quality Partnership.

Van Vliet, D. (1982) SATURN - a modern assignment model. *Traffic Engineering and Control*, **23**, pp 578-581.