Sub Project 3 – Air Quality

Note: This sub-project will be closely linked to Sustainable Transport; the research groups will meet jointly from time to time.

1. Project Statement

Air pollution dispersion and noise propagation modelling are useful tools for estimating the effectiveness of proposed pollution reduction and of noise abatement strategies in urban districts. In the case of particulate matter (PM) and other vehicle-derived pollutions, this requires source inventories and use of atmospheric dispersion modelling. While the meteorological and physical dispersion models are not perfect, it is generally accepted that the quality of input data available (i.e. the emission inventories) is the weakest link in these models [3.1][4] . Emission factors developed in one country are often utilised in other countries where local vehicle and traffic characteristics, climate and fuel quality may be very different.

This sub-project aims to establish systems for estimation and measurement of PM parameters using low-cost methodologies and to set up procedures for integration of the data with the GIS modelling activities of the wider project.

2. Objectives and Targets

. • To establish methodologies for estimating detailed, site-specific emissions factors for road-transport-derived exhaust emissions (of PM, NOx, CO, CO2 and unburned hydrocarbons), for input to a GIS-based model for atmospheric dispersion of these emissions. These factors will take account of engine and vehicle operating profiles which link to actual traffic flow patterns on the routes of interest. Real-world data will be derived from representative vehicles fitted with low-cost GPS instrumentation, combined with data available from now-standard on-board diagnostic sockets.

. • To study methods of estimating the indoor air pollution associated with different outdoor air quality characteristics, to facilitate modelling of the indoor-outdoor relationship, and subsequent integration into the MOLAND GIS program.

3. Review of State of Knowledge

Air Pollution from Vehicles (Sub-Project 3)

Diesel Particulate Matter (DPM) is a major of road transport particle emissions. In urban areas, DPM constitutes a large proportion of airborne particle pollution. For example, in 2001, the fraction of London's PM10 air pollution resulting from road transport was estimated to be 68% [3.2][5] . In a recent study by Künzli *et al.* [3.3][6] it was found that the traffic share of the total PM10 exposure in Austria, France and Switzerland depended on the mean ambient particle concentration, and ranged from 28% at an annual mean PM10 level of 10-15 µg/m^3, and increasing up to 58% in areas where the total annual mean PM10 concentrations were above 40 µg/m^3. These figures are higher than those reported elsewhere [3.4][7] and highlight how site-specific any reported figure will be.

a. [4] 3.1. Air Quality Expert Group, Particulate Matter in the United Kingdom. 2004, Department for Environment, Food and Rural Affairs; Scottish Executive; Welsh Assembly Government; and Department of the Environment in Northern Ireland.

b. [5] 3.2. Calvert, J.G., Heywood, J.B., Sawyer, R.F., and Seinfeld, J.H., Achieving acceptable air Quality: Some Reflections on Controlling Vehicle Emissions. Science, 1993(Vol 261 2 July 1993).

c. [6] 3.3. Künzli, N., Kaiser, R., Medina, S., Studnicka, M., Chanel, O., Filliger, P., Herry, M., Horak, F., Jr., Puybonnieux-Texier, V., Quénel, P., Schneider, J., Seethaler, R., Vergnaud, J.-C., and Sommer, H., Public-health impact of outdoor and traffic-related air pollution: a European assessment. The Lancet, 2000. 356(9232).

In order to quantify total Irish diesel particulate matter emissions an emissions calculation computer program, COPERT III [3.5][8], is in current use in Ireland. Emissions factors used in average-speed-based models such as COPERT III typically take no account of the details of local traffic flows and have been shown to significantly mis-estimate the emissions. It is for this reason that the current proposal includes plans to record actual vehicle operating characteristics that are more truly representative of the particular route, under a range of traffic conditions. To this end, instrumentation of vehicles using a specific route (on a low cost basis, facilitated by modern GPS and now-standard on-board vehicle diagnostic sockets) is integral to the proposed work.

It is also planned to study the possibility of establishing quantitative links between outdoor pollution, much of which is traffic-derived, with indoor air quality in nearby buildings. Previous PM monitoring studies have shown how particle concentrations in ambient are key contributors to indoor air quality. The extent of this influence is dependent on a number of factors, such as weather patterns and air exchange rates in buildings. These factors will be reviewed in the proposed study and the feasibility of including them in the GIS model investigated. For example, a study in Nottingham, UK [3.6][9] examined the relationship between living near a “main road” and the risk of wheezing illness, which is often an indicator of asthma, in almost 10,000, finding that the risk of wheeze increased by eight percent for the primary schoolchildren, and 16 percent for the secondary schoolchildren, per 30 meters of increasing proximity to the road. The results could give a good indicator to the need for “buffer zones” from major roads for new housing developments.

4. Description of Work

Description of Work: Determination of Vehicle Emissions (Sub-Project 3)

Test vehicles will be equipped with a Global Positioning System (GPS) from which detailed vehicle speed, acceleration and road position information can be derived. Also, using standard Onboard Diagnostics sockets (OBD II), detailed data concerning engine speed, torque, coolant temperature and fuel consumption data can be downloaded into a portable computer. Detailed information about real-world vehicle and driver behaviour will thus be recorded from vehicles will be driven along specified routes both during and outside peak traffic hours.

Vehicle and engine operating data will be fed into “VETO” vehicle modelling software, which will provide high quality estimates of instantaneous real-world vehicle emissions, which can be integrated over the vehicle journey. The output of this work will be distilled into route-specific Emissions Factors which will then be transferred via an emissions calculation computer program (COPERT III) and subsequently into the GIS-based atmospheric dispersion model. Traffic volume data will be quantified with the aid of the SCATS system. Limited experimental validation work (outdoor & indoor) will also be carried out using low-cost PM monitoring equipment. It is proposed to calibrate low-cost PM measuring instruments by reference to high quality data being continuously recorded by Dublin City Council via the PM10 monitor located at Marino. Outdoor and indoor measurements will be made in the vicinity of this monitoring station

The results of this work can be combined with the SATURN modelling work of sub-project 4 to quantify the overall fuel consumption (and hence CO2 emissions) and pollutant emissions consequences of different urban transport scenarios. Also, this project will link into Subproject 6 on Climate Change through quantification of the effects of ambient conditions on vehicle emissions and fuel economy.

[7] 3.4. Fujita, E., Watson, J.G., and Chow, J.C., Northern Front Range Air Quality Study, volume C: source apportionment and simulation methods and evaluation. 1998, Desert Research Institute: Reno, NV.

[8] 3.5. Ntziachristos, L. and Samaras, Z., COPERT III Computer programme to calculate emissions from road transport. Methodology and emission factors. 2000, European Environment Agency: Copenhagen

[9] 3.6. Venn, A.J. et al.; Living near a main road and the risk of wheezing illness in children; Am J Respir Crit Care Med; 2001 Dec 15; 164(12): 2177-80

5. Project Management

Dr. David Timoney will assume overall responsibility for the management of this work package, interacting with Mr. D. Lennon of Urban Institute Ireland (vehicle instrumentation, PM measurement, Outdoor–Indoor Air Quality measurement).

6. Expected Results

. • A route-specific set of emissions and fuel consumption factors, derived from detailed analysis of series of vehicle speed and emissions profiles, for a range of vehicle types for the Malahide corridor, as a function of time of day and time of year. This data will be cross-correlated with records from the SCATS system to yield overall PM and other emissions source quantities for input to a GIS based atmospheric dispersion model. From this can be derived a predicted map of the PM10 concentration of the Malahide corridor area and initial estimates of the effects on indoor air quality for buildings with differing ventilation characteristics, at different proximities to the route. A predicted map of the daily variation of the noise contours in the reference area

7. Composition and Experience of Team

Dr. David J. Timoney, B.E., M.Eng.Sc., Ph.D., C.Dip.A.F. MSAE, C.Eng., FIEI. Senior Lecturer in Mechanical Engineering and Director, UCD Energy Conversion Research Centre, University College Dublin.

Dr. William J. Smith B.E., Ph.D., Lecturer in Mechanical Engineering and Director, UCD Formula Student Car Programme.
Mr. Donal Lennon, Manager, Built Environment Lab, Urban Institute Ireland. Mr. Lennon has extensive experience of instrumentation and measurement of vehicles, and of building performance, ventilation, indoor environmental quality, daylight and overshadowing and of acoustics.

8. Facilities/Capabilities

Much of the work involved in this sub-project is of a computational nature but, within the limits of the resources available, it is proposed to conduct experiments on vehicle movement and engine operating patterns, on vehicle emissions, ambient and indoor air quality (PM), and on noise surveys. It is planned to use, as far as possible, data acquisition and other equipment already available at the UCD School of Electrical, Electronic & Mechanical Engineering and at Urban Institute Ireland. Small consumable items will be purchased and some equipment may be rented on a short term basis.

8. Declarations on Other Sources of Funding and on Tax Clearance

UCD, TCD and NUIM rely on this funding to cover marginal costs and have not sought additional funding; whereas ERA-Maptec provides 50% funding through their own sources.

University College Dublin will provide a current Tax Clearance Certificate, on request from the Environmental Protection Agency.

9. Compliance with National Policies on the Environment, Gender and Poverty

Urban Institute Ireland (UII), UCD (Project leader) UCD conforms with the university policy with respect to best practice in the areas of ethics, the environment and socio-cultural matters, including poverty. In particular, this project focuses on the development of an in-depth understanding of the environmental issues associated with urban areas. University College Dublin has an Equal Opportunities Committee with the brief to support Gender Mainstreaming within the university.