NILU: F 11/2005

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REFERENCE: Q-303
DATE: FEBRUARY 2005

Integrated exposure management tool characterizing air pollution-relevant human exposure in urban environment

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Presented at:
5th Urban Air Quality Conference in Valencia
29-31 March 2005

TITLE

Integrated exposure management tool characterizing air pollution-relevant human exposure in urban environment

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ABSTRACT

The main objective of Urban Exposure is to study human exposure from air-pollution compounds that account for up to two important pathways of exposure (inhalation and dermal absorption), and to quantify exposure specifically for particulate matter and chloroform in several European urban areas. The scientific aim is to develop science-based methods for quantification of exposure. The environmental and policy-relevant product is the implementation of these methods in conjunction with a robust multiphase modelling environmental management system.

Up to the Mid Term Assessment Meeting, the project team has performed a literature study and review on particulate matter properties and concentrations in ambient and indoor environment, exposure modelling, inhalation and dermal absorption modelling, and a review of levels of disinfections by-products in European drinking water. Basic stand-alone models for indoor particles mass size distribution, inhalation dosimetry and dermal absorption were established tested and verified. The model performance has been satisfactory compared to available sets of measurements.

The integration of the stand-alone models described above with the air quality management system has been discussed in detail within the scientific group and with the End Users. Based on the functionality of the stand-alone models and the discussions with End Users, a detailed specification has been written describing the functionality of how to use these modules and how to integrate them with an Air Quality management System. The first integration of the modules into AirQUIS has now been programmed and the first results will be presented at the UAQ2005 Conference.

1. INTRUDCTION

Urban Exposure is an EU funded projects from the FP5, KA City of Tomorrow. The partners in the project are :

- Norwegian Institute for Air Research, NILU, Co-ordinator
- Institute for Ecology of Industrial Areas, IETU
- Fraunhofer-Gesellshaft zur Foerderung der Angewandten Forschung, FHG.ITA,
- University of Essex, UESSEX,
- Academy of Sciences of the Czech Republic, AS CR,
- Technion – Israel Institute of Technology, TECHNION,
- Technical Universisty of Crete, TU-Crete,
- National Centre for Scientific Research “Demokritos”, INTRP-Demokritos,
- Municipality of Oslo Department of Public Health, ODPH

2. METHODOLOGY

A state-of-the-art management and decision support system for environmental issues, AirQUIS, is used as the platform for the development of the Management tool to be used to study human exposure in the urban environment.

There are three categories of sources that will affect a person in this system. The first is the outdoor concentrations generated by the different outdoor sources that will be an input for inhalation and lung deposition. The second source is the indoor concentrations, which is the outdoor concentration (through windows and ventilation) together with the various sources inside the homes and working places. Dermal absorption of gaseous compounds through the skin is the third category of source accounted for in this system.

2.1 Development of the Environmental Modules for Total Human Exposure

A stand alone version of the statistical tool (TUC) has been developed and its components have been tested against available data from the literature. The model has been applied in a series of indoor-outdoor experiments performed in Oslo. Human exposure and consequent dose has been calculated for particulate matter exposure. The chemical composition of the particulate matter has also been taken into account. Modules for indoor-outdoor modelling (Fraunhofer Institute), inhalation (Technion) and dermal absorption (Demokritos) have been developed and delivered to NILU for further integration in the AirQUIS system.

Statistical exposure tools

Data have been collected on available measurement and monitoring data for particles and DBPs. Stochastic exposure models were reviewed. Realistic exposure scenarios have been performed for the Oslo Metropolitan area using the statistical exposure tool. Exposure for particulate matter has been studied. The statistical tool has been used to study differences for several outdoor and indoor exposure scenarios.

Integrated micro-environmental model.

The model takes account of arbitrary probability density distributions of the independent variables and was implemented as FORTRAN code. In its latest version, it also includes a revised equilibrium concentration allowing resolution of different sources with contributions in the same particle size range.

Inhalation dosimetry model

Two improved versions of the inhalation dosimetry model were developed: a stand-alone version, used primarily for validation studies, and a core module without graphic user interface, to be implemented within AirQUIS as the inhalation dosimetry toolbox. Modified predefined exposure scenarios were implemented within the stand-alone tool to be able to match conditions in published studies for the validation process.

Dermal absorption model

A theoretical dermal absorption model was prepared and a first version, parameterised for chloroform and tested against literature data. The model includes an estimation of after-exposure volatilisation effects (this is not routinely included in dermal absorption models). The team has evaluated what additional physiological and other factors to include in the model, based on what additional information they provide to the model, and on results of reported parameter sensitivity studies. The DPM Dermal Absorption Module for the estimation of dermal and systemic rates and doses during and after a given exposure period (including the so called volatilization effect) has now been finalised.

2.2 Development of the Management Tool Interface

The interface between the existing air quality management tool (AirQUIS) and the modules have been specified. Four technical options were available, and have been reviewed. The data flow (input/output) between the management tool and the modules has been agreed upon and a functional and technical specification has been written and reviewed by the partners.

A state-of-the-art management and decision support system for environmental issues is used as the platform to study human exposure in urban environment. The modelling framework has already as components a measurement database, and the graphical user interface including the GIS (geographical information system).

The user interface of the current system is to a large extent a map interface from which spatial distribution of pollution sources, monitoring stations, measurements, model results and other geographically linked objects can be presented. The map interface can be used as an entrance for making queries to the database.

There are three categories of sources that will affect a person in this system. The first is the outdoor concentrations generated by the different outdoor sources that will be an input for inhalation and deposition in the lungs during the hours spent outside. This outdoor concentration will also be one of the indoor sources (through windows and ventilation) together with the various sources inside the homes and working places. The user will specify the number of hours spent in each of the different environments. Dermal absorption of gaseous compounds through the skin is the third category of source accounted for in this system.

The user of the system will have to specify the daily route of a person to calculate the dose the person is exposed to during the course of the selected timeframe.

Person characterization and daily route
The user will choose the tab "Person characterization and daily route" to specify necessary input for the module calculating deposition of particles in the lungs.

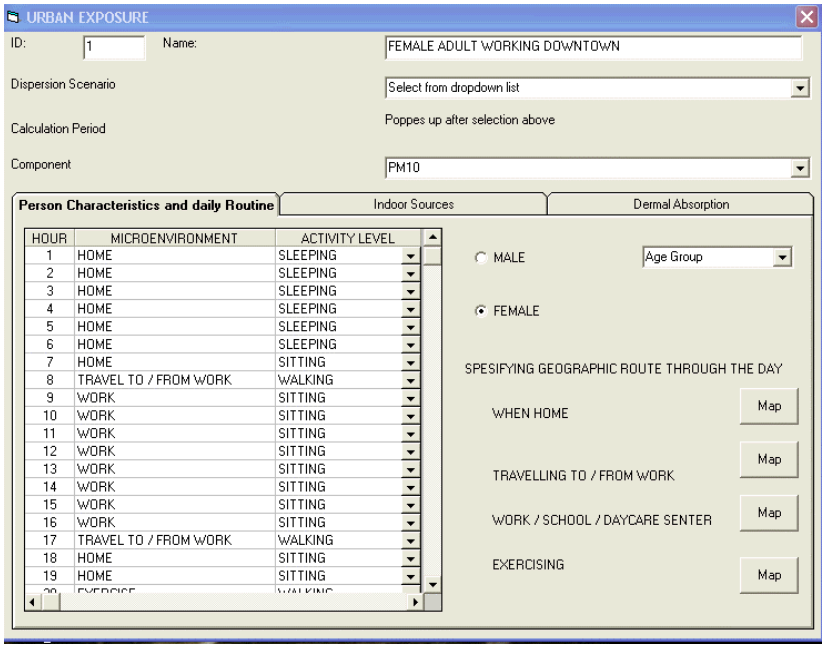

Figure 1: Suggested form for Person Characteristics and daily route specification.

In the form the user will specify age group and male/female and number of hours within each microenvironment and the activity level each hour of the day.

The inhalation module will for each hour *either* receive an outdoor concentration sampled in the predefined diameters directly from AirQUIS, *or* indoor concentrations sampled in the predefined diameters from the indoor module.

Indoor module tab
In the tab 'Indoor sources' in the form in AirQUIS the user must specify (ticking off) the necessary information to the indoor module about indoor activity.

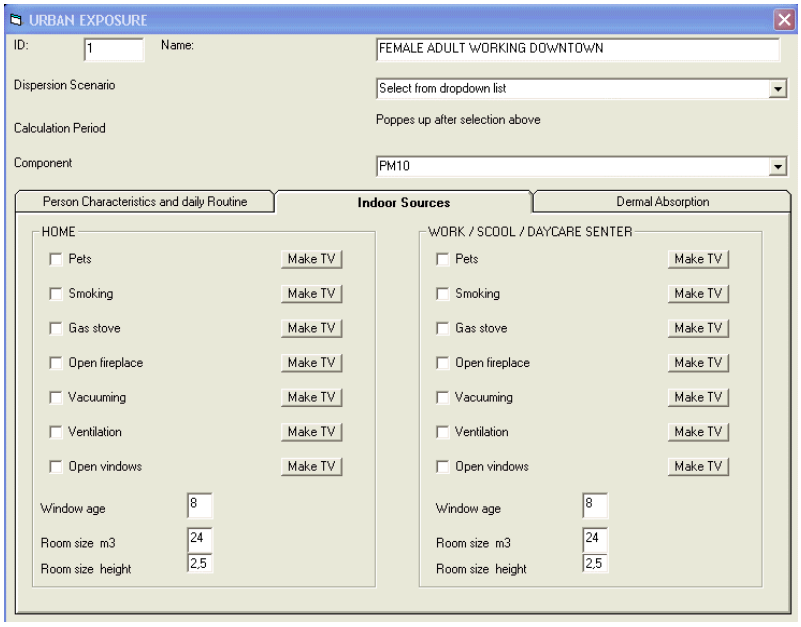

Figure 2: Suggested form for the indoor source specification.

The above informationis transferred from the AirQUIS application to the indoor module for each hour in addition to the outdoor concentration taken from the receptor point(s) specified in the 'Person and daily route tab'. The indoor module has information about the source strength for each source category

The output from the indoor module will be indoor concentrations split up in size bins to the inhalatation module as input for calculation of deposition in the lungs.

Dermal absorption
The third tab in the form where the indoor and outdoor sources are specified is the necessary input for the module that accounts for absorption of gaseous compounds through the human skin.

The user must specify the source type, concentration of gas in the room and body weight and height of the person. The last two points will be needed as input for calculation of skin volume, skin area and blood flow.

Output will be the dermal and/or systemic dose in mg for the gas. This output could then be presented as colours (numbers) on the GIS map in AirQUIS, in the receptor point location where the calculated dose per hour is stored.

Results and presentation
The results from the inhalation module is one time series with dose per hour for the calculation period for the defined person with a user defined route throughout the day.

The results can also be presented on the GIS in colour levels for a specific hour of the day The user will then be able to see the size of the dose for the different persons at that specific time of day.

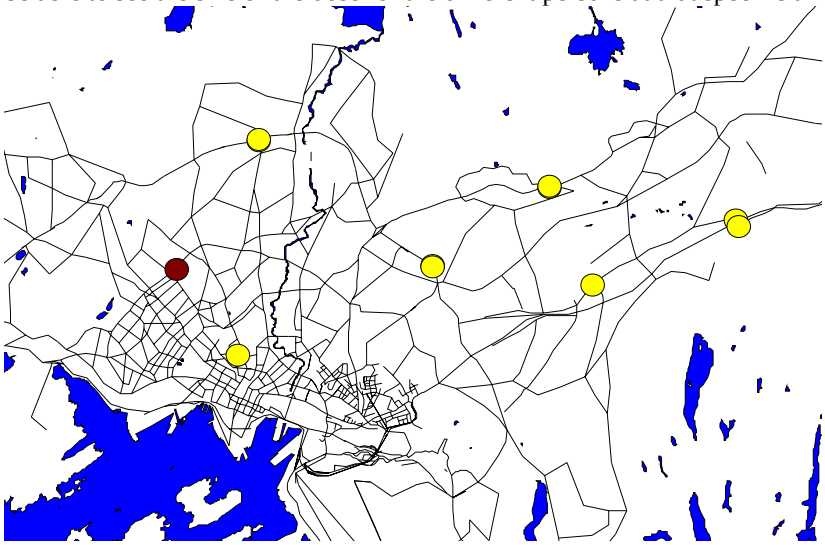

Figure 3 : Example of GIS presentation of personal exposure

3. ACKNOWLEDGEMENTS

Urban Exposure is one of the projects within CLEAR - Cluster of European Air Quality Research (www.nilu.no/clear). The overall aim of CLEAR is to improve our underpinning scientific understanding of urban air pollution and to provide next generation tools for end users and stakeholders to manage the air quality in cities.

4. REFERENCES

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