Modelling personal exposure to particulate matter in the Haifa Bay Area

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Calculations of individual aggregated respiratory dose of particulate matter related to outdoor sources for a summer and winter period have been made for an adult female in Haifa, Israel. The daily routine and activity level decides the quantitative contribution to the dose in the various microenvironments.

The method

In the Urban Exposure project (EVK4-CT-2002-00090), a routinely used air quality management tool, AirQUIS, has been extended to provide individual exposure estimates, and an estimate of aggregated respiratory dose of particles.

The outdoor concentrations are calculated using a Eulerian dispersion model and the indoor concentrations are calculated on the basis of outdoor concentrations taking into account house age and ambient wind speed. Based on defined daily routes, the hourly concentration of particulate matter is calculated for various microenvironments.

The respiratory deposition for various particle sizes is calculated on the basis of the microenvironmental concentrations, activity level, gender and age. The aggregated daily dose is calculated from the hourly values.

Table 1: Daily routine and activity level.

HOUR	µENVIROMENT	ACTIVITYLEVEL
1	HOME	SLEEPING
2	HOME	SLEEPING
3	HOME	SLEEPING
4	HOME	SLEEPING
5	HOME	SLEEPING
6	HOME	SLEEPING
7	HOME	SLEEPING
8	TRAVEL TO	SITTING
9	WORKING	SITTING
10	WORKING	SITTING
11	WORKING	SITTING
12	WORKING	SITTING
13	WORKING	SITTING
14	WORKING	SITTING
15	WORKING	SITTING
16	WORKING	SITTING
17	WORKING	SITTING
18	TRAVEL FROM	SITTING
19	HOME	SITTING
20	HOME	SITTING
21	HOME	SITTING
22	HOME	SITTING
23	HOME	SLEEPING
24	HOME	SLEEPING

Figure 1: City of Haifa showing home, work and travel route.

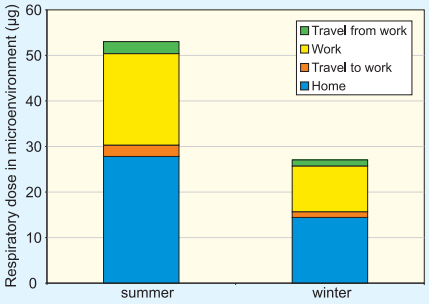

Figure 3: Aggregated respiratory dose (24 hour) of PM_{10} for the summer case (see Figure 2) and the winter case (8 January 2005) in the various microenvironments.

Description of calculations

Calculations of individual exposure to particulate matter have been performed for Haifa, which is a coastal town in the north of Israel (~460,000 inhabitants). It borders an industrial region consisting of some of Israel's major industries, including an oil fired power plant, petroleum refineries, and large petrochemical and agrochemical complexes. Daily traffic in the region is relatively high. The main natural source of airborne particulate matter (PM) is Sahara dust.

Data for calculation of outdoor concentrations were made available through the online air quality modelling project for the Haifa Bay Area. Scenarios that are relevant to daily routines in the Eastern Mediterranean have been defined.

24 August 2004 and 8 January 2005 represent summer and winter periods, respectively. Calculations have been made for a female living in living in the south eastern part of the Carmel, travelling by car to her work further nord west on the Carmel mountain. The placement of the various microenvironments and travel route are shown in Figure 1 and the time activity pattern is shown in Table 1.

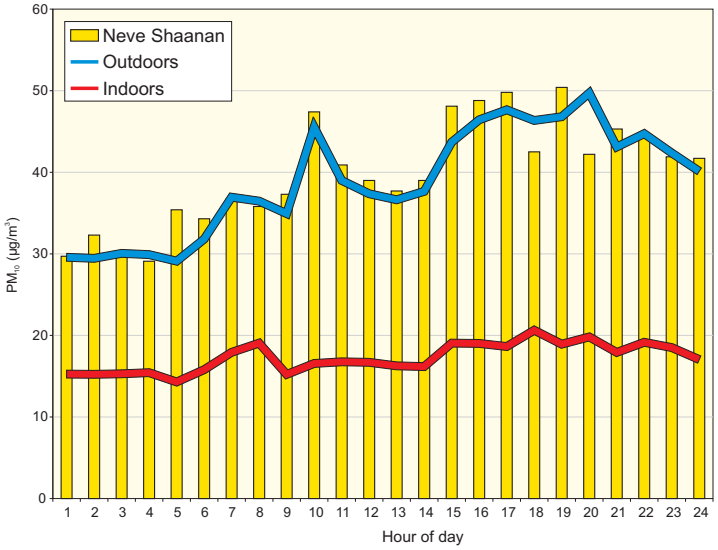

Figure 2: Hourly concentrations of PM_{10} on 24 August 2004. Calculated outdoor and indoor concentrations for the given microenvironments (see Table 1), and the measured concentrations at an urban residential station (Neve Shaanan).

Results and conclusions

The calculated outdoor concentrations for 24 August compare well to the measured values at Neve Shaanan (*see Figure 2*). The calculated PM_{10} concentration for the indoor environments are between 36 and 52% of the outdoor concentration when outdoor air is the only indoor source.

The calculated ratio $PM_{2.5}/PM_{10}$ for outdoor air is on average 68% for all the microenvironments, which is in reasonable agreement with the observations for Neve Shaanan. The calculated $PM_{2.5}/PM_{10}$ ratio for indoor air is almost unity. This is because the coarser particles are efficiently filtered when air passes the building shell.

The concentrations in the various microenvironments do not vary much for this case study due to low spatial and temporal variation for the chosen days (*see Figure 2*). The PM concentrations are generally higher for the summer day compared to the winter day (not shown), which results in a higher respiratory deposition of particles for the summer case (*see Figure 3*). In general the home environment is the highest contributor to the aggregated respiratory dose of particles. This is because a larger part of the day is spent there.

References

Laupsa, H. and Fløisand, I., Calculation of personal exposure. *The Urban Exposure Management Tool.* TR 04/2005

Coulson, G., et al., *Exposure risks from pollutants in domestic environments: The urban exposure project.* Indoor Built Environ., vol. 14, no. 3, 209-213 (2005).

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