

## SUMMARY

This report is the third and final part of the study “The Influence of Contaminants in Ambient Air on the Indoor Air Quality, part 1: Exposure of Children”.

In this report, data of the measuring campaign (workpackage 2) in 50 dwellings is used to develop an exposure assessment of children. In this work package, a stepwise approach was used to convert air concentrations of gases and particulate matter (measured in WP 2) in different micro-environments in which typically Flemish children spend their time into children’s exposure to air pollutants.

Firstly, indoor and outdoor concentrations are evaluated relative to the type of microenvironment type (1.1.1 and 1.1.2). Concentrations in dwellings, schools and other microenvironments are summarized. Differences between micro-environments in dwellings (bedroom versus living room) and differences between front door and backdoor concentrations are assessed. It is also tested whether traffic density near dwellings affects indoor and outdoor concentrations (1.1.3). Finally, correlations between indoor occupant activities or product use indoors and these indoor concentrations are calculated (1.1.4).

To evaluate the contribution of indoor and outdoor sources of air pollution separately, the measured indoor concentrations are broken down into a fraction that is related to outdoor air pollution that has infiltrated indoors, and a fraction that is related to indoor sources (1.1.5). The latter indoor concentrations were then again analysed for relationships with indoor activities, product use, building materials, ... (1.1.6)

In a second part (1.2), children’s exposure to air pollutants is determined for different age categories and for different locations, with traffic density as the important indicator for location specific differences in air pollution. Typical exposure scenarios were set up using the median concentrations in different micro-environments and typical time activity patterns. The children’s exposure to air pollutants was allocated to either the outdoor sources and the indoor sources.

Finally, in addition to the typical (median) exposure, the distribution of exposure was also assessed using the range of concentrations across the examined micro-environments. Such distributions are in particular useful to estimate the exposure of high exposed children.

Exposure data were also converted into pollutant doses to children.

A discussion of the results is given in chapter 2 together with some policy recommendations.

The main conclusions of WP 3 are:

### *High indoor concentrations, large variations and exceedance of limit values*

Among the 14 measured gases the most abundant gases in both indoor and outdoor environment were formaldehyde (up to 124  $\mu\text{g}/\text{m}^3$ ), acetaldehyde (up to 65  $\mu\text{g}/\text{m}^3$ ),  $\text{NO}_2$  (up to 122  $\mu\text{g}/\text{m}^3$ ) and toluene (up to 122  $\mu\text{g}/\text{m}^3$ ). These upper values are all for indoor environments (living rooms and bedrooms). Concentrations of gases show a very high variability between different houses ( $n=50$ ), both indoors and outdoors. Especially for some gases like formaldehyde and toluene (for which the concentrations in bedrooms varied with a 6/69 factor of 50) that can be associated with building materials and product use, there is a need to assess how widespread this problem is. Product standards, ventilation and prevention information are needed and their efficiency tested. In more than 85 % of the investigated indoor environments, the guideline values of the Flemish Indoor Decree for TVOC (200

$\mu\text{g}/\text{m}^3$ ), formaldehyde and benzene were exceeded. In addition, in 3 houses the intervention values for benzene and in 1 house the intervention value for formaldehyde was exceeded. It is recommended to measure selected gases (TVOC, benzene, formaldehyde) in a larger dataset of Flemish houses in order to evaluate the magnitude of the problem in Flanders.

#### *Outdoor pollution contributes to indoor pollution*

On the basis of MTBE as the indicator of infiltration indoors, an assessment was made for the dwellings of the fraction of the indoor concentration attributable to indoor sources. The relative contribution of outdoor generated and indoor sources was dependent on the pollutant type: typically, 85 % of the total indoor formaldehyde concentration was attributed to indoor sources, whereas for benzene, trichloroethene, and tetrachloroethene the infiltration of outdoor generated compounds dominated (by 70 %) the indoor concentration. Variability of the infiltration factor results in a variability of the contribution of indoor sources to the indoor concentrations of about a factor 2.

#### *Measurements of concentrations do not show clear relations with indoor sources and activities.*

In general, only few significant correlations between indoor concentrations and indoor/building properties were present. Indoor concentrations of toluene and PM were affected by presence of smokers. Indoor concentrations of xylenes and TVOC's (combustion products) were associated with stove use. However, for most of the expected source-concentration analyses, no significant relationships between source and concentration were present. This can be explained by the large averaging time (7 days) of the measurements for the 50 dwellings.

#### *Exposure is dominated by time spent indoors*

Exposure of children is dominated by the time spent indoors at home, basically in the living room (on average 4h/day) and bedroom (on average 11h/day) at home and in the school or day care (on average 4h/day). Other micro-environments, namely transport, are less important in an average exposure pattern, although they give rise to high concentrations. If health effects from exposure to air pollution is dominated by the long-term average exposure then our attention should go to the micro-environments where most time is spent. But at the same time acute effects from peak exposure cannot be excluded, keeping other microenvironments like motorised traffic, like leisure indoors in the picture.

The typical exposure of children to the selected pollutants does not vary significantly across ages and across locations. Typical exposures to traffic related pollutants are slightly (but not significantly) higher in hot spot areas compared to urban or background areas. Exposure indoors dominates the total exposure. Using the range of concentrations at home results in a highly exposed group of children whose exposure is 2 times (for benzene) higher than the median or typical exposure.

Exposure to air pollution is widespread and difficult to avoid. Ambient air quality policies will result in lower outdoor concentrations and a lower exposure, but at the same time the 7/69 relative importance of indoor air pollution due to indoor sources will increase. In ambient air quality standard setting the exposure indoors to outdoor pollution that has infiltrated is implicit. This study shows that the contribution of this infiltrated outdoor air pollution is different for the different pollutants studied. This is a point of attention in ambient air quality policies, to include the exposure indoors more explicit.

Exact recommendations for precautionary measures to reduce or avoid exposure to certain gases are difficult to make at the moment because no clear source-concentrations-exposure relationships were found. For this, work on short-term and long-term emission sources and

their relation to concentrations, using various time average measurements should be performed. This is best placed in the context of product policies. Currently, the federal product policy only regulates bulk concentrations of a product, and no emissions, nor does it link to typical and high exposures. There is limited evidence on the health relevance of these exposures. This requires further toxicological and epidemiological evidence of indoor exposure and effects.

Finally a continued effort to inform the public on good product use to the public is welcomed. A good cooperation and communication with industry to appeal for better labelling and to stimulate the development of innovative and safe product, especially to avoid exposure of children, is the best way forward.