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INDEX OF INDOOR AIR CHEMICAL POLLUTION IN BRUSSELS HABITAT

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Abstract

An index of indoor chemical pollution has been developed on the basis of more than 1200 surveys in dwellings conducted by the Regional Unit for Indoor Pollution Intervention (French acronym CRIPI) in the Brussels-Capital Region. This tool is intended for giving assistance in medical diagnosis. It provides a rapid evaluation of the contamination level by volatile organic compounds of a dwelling. It is also useful in cases where one of the most frequently found compound shows a particularly high concentration. The index has been developed for benzene, toluene, pinene, limonene, triclorethylene, tetrachlorethylene and formaldehyde. It allows for facing the lack of reference standard in Belgium.

Keywords: *indoor pollution, VOC, chemical index*

Rezumat

*Indicele poluării chimice a aerului din interior în habitatul din Bruxelles***.** S-a dezvoltat un indice al poluării chimice interioare pe baza a peste 1,200 de analize efectuate în locuinţe de Unitatea Regională pentru Intervenţia în caz de poluare în interior (CRIPI prescurtarea din franceză) din Bruxelles – capitala regiunii. Acest instrument poate oferi asistenţă în diagnosticarea medicală. Acesta oferă o evaluare rapidă a nivelului de contaminare a unei locuinţe cu compuşi organici volatili. De asemenea, acesta este util şi în cazurile în care unul dintre cei mai frecvenţi compuşi găsiţi indică o concentraţie relativ mare. Indicele a fost dezvoltat pentru benzen, toluen, pinen, tricloretilenă şi formaldehidă. Acesta permite înfruntarea cu lipsa de standarde de referinţă din Belgia.

Cuvinte-cheie: *poluare din interior, COV, indice chimic*

INTRODUCTION

For nine years, a service of analysis of indoor air pollution has been established in Brussels-Capital Region. This service meets the increasing demand for a monitoring of environment-related diseases.

Much of our time is spent indoor, whether at home, at work, or during leisure activities. The prevalence of allergic diseases has been increasing over recent decades in the Western world. Young children are of special concern since most of them spend the first years of their lives in kindergartens or schools. An early exposure to indoor air pollution enhances the risk of acute lower respiratory system infections in children under 5 years old.

Indoor pollution is a major problem among environmental pollution nuisances to health. Pollutants from either chemical or biological origins may have multiple and varied sources. They range from building materials to furniture through tiled floors, paints, combustion and heating devices, cleaning products, pets and more.

To address this issue, the Regional Unit for Indoor Pollution Intervention (French acronym CRIPI) provides assistance to medical diagnosis when a physician suspects that a health problem may be related to the patient's habitat. A set of chemical and biological samples is collected from the patient's home. These samples are then analyzed, identified and quantified, as well as their potential sources. This environmental diagnosis is completed by recommendations and advises to residents in order to reduce or even eliminate the nuisances [1].

Between September 2000 and December 2009, some 1,200 dwelling's surveys were conducted on medical demand. The physicians requesting the intervention of the CRIPI Unit were mostly general practitioners (64%), however, pediatricians (15%) and lung specialists (10%) also made use of this service. The health problems mentioned were

mainly airway respiratory diseases (rhinitis, pharyngitis, and sinusitis) and lower airway respiratory diseases (chronic cough, asthma, bronchitis). Respiratory problems are common amongst children: indeed 30% of the enquiries made by CRIPI were for patients between the ages of 0 to 6, half of these were aged under 2 years old. In recent years, skin diseases, general symptoms such as headaches and atypical discomfort as health problems related to indoor environment have been mentioned in an increasing number of enquiries made by CRIPI. That phenomenon was recalled mainly for adults.

The objective of this work is to set up a tool to support the physician to easily understand the general information on the chemical pollution status of the dwelling. This tool is first based on analytical results of volatile organic compounds concentrations in the air. Further studies are required for analyzing the chemical composition of fine particles in suspension, as well as their micromorphology.

METHODS AND INSTRUMENTATION

The enquiries were conducted in the 19 administrative districts of the Brussels-Capital Region, both in poor and wealthy neighborhoods. The distribution of the number of investigations is shown in Figure 1. Patients were either owners or tenants of the investigated dwellings. Twenty percent of requests came from social housing.

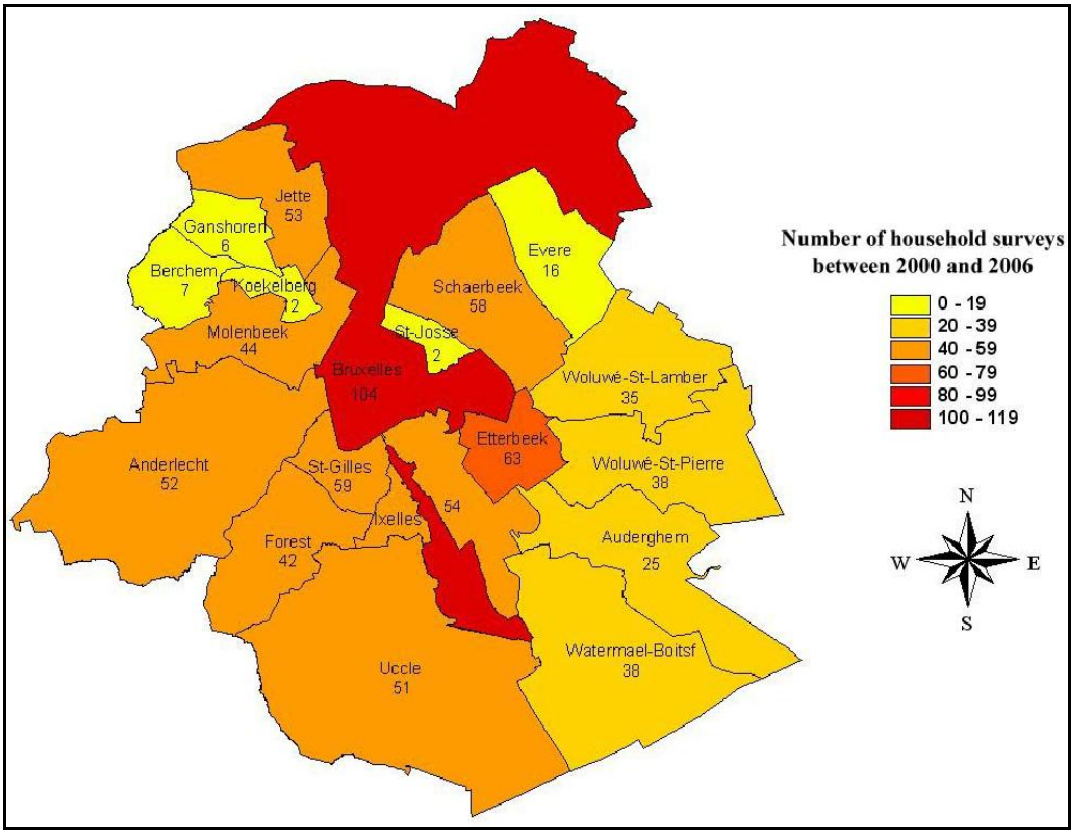

Fig. 1 Map of Brussels-Capital Region districts giving the number of surveys per district

The investigation at each home included three parts: the completion of a questionnaire by the inhabitant, if possible the patient; chemical and biological sampling of the habitat. The questionnaires are dealing with health problems, maintenance and ventilation of the home and were designed in order to obtain the best possible inventory of potential sources of indoor pollution.

Biological samples were collected following a decision-tree based on a preliminary visual examination at the air, surfaces and dust on walls, furniture and mattresses (for the determination of mite allergens and possible mold). Samples were taken from the main living rooms and from outside [2, 3].

At the chemical level, samples of air were taken using a passive radial diffusion device (Radiello's) filled with TENAX for adsorption of volatile organic compounds such as benzene, toluene, xylene, chlorinated terpenes etc. The complete sampling procedure took in average one hour. The compounds retained on the cartridges were subsequently thermally desorbed. For the

determination of pesticides, dust from carpets was collected by sucking up a surface of 1m ² for 1 minute using a vacuum cleaner with a special tip (1200W). Pesticides were then extracted using a mixture of ether / hexane (5: 95).

The analysis of VOCs (Volatile Organic Compounds) and pesticides was carried out by gas chromatography coupled with mass spectrometry (GC-MS). The results were expressed in µg/m³ of air for VOCs and mg / kg of dust for pesticides.

Among the measured VOCs, limonene and α-pinene compounds were generally present at the highest concentration. These substances, considered as irritants, are mostly generated by air fresheners, household cleaners and waxes for furniture. In Austria, the guideline value for the sum of terpenes is 150 µg/m³ [4]. The concentrations of limonene and α-pinene generally were quite low (percentile 50 <10 µg/m³), however, the long-term effects of low dose are not yet known.

Note that the highest values in limonene were measured in the living room and bathroom. The highest concentrations of α-pinene were recorded in bathrooms.

Formaldehyde was directly measured via a portable analyzer INTERSCAN with electrochemical cell. The detection limit of this analyzer can be lower than 10 ppb. The results are expressed in µg/m³ (1 ppb = 1.2 µg/m³).

RESULTS

Volatile Organic Compounds

11% of investigated homes were beyond the comfort range of 200 µg/m^3 applied in the United States [5] for the total concentration of volatile organic compounds. The value of the percentile 50, corresponding to 50% of surveys, reached 83 µg/m³. One can notice on the graph showing the distribution of VOCs in the different rooms investigated, that the highest values were reached in the kitchen and the child's bedroom. The values obtained for outdoor air amply confirmed that indoor air is more polluted than outdoor air.

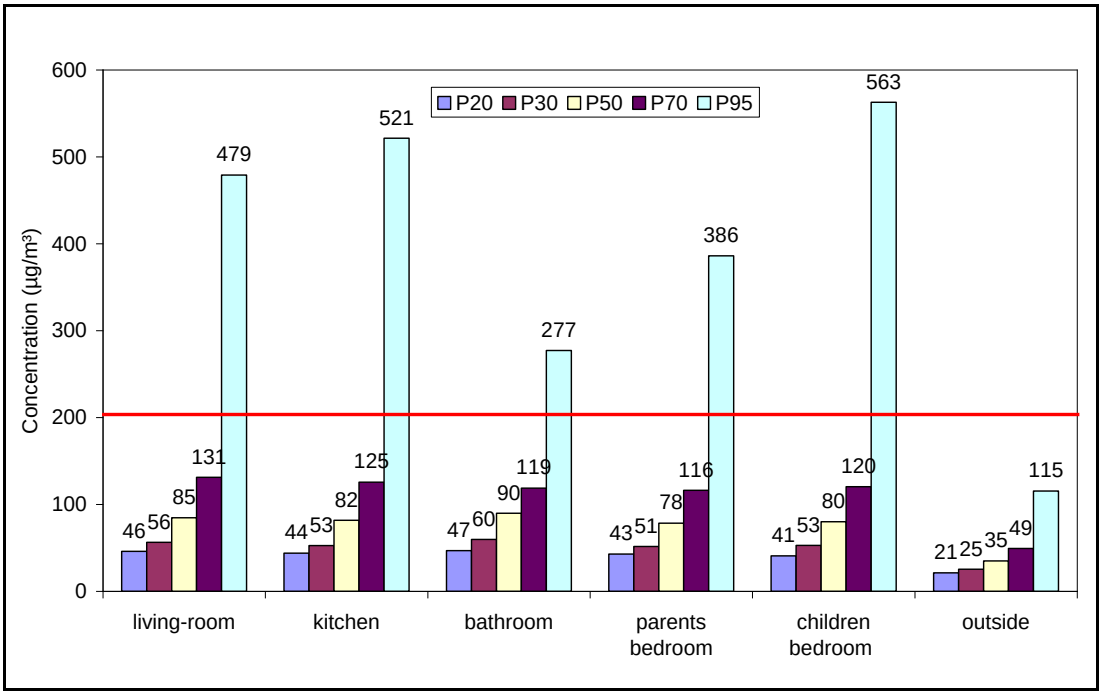

Fig. 2 Distribution of VOCs concentration in the different rooms investigated

Formaldehyde

According to the guideline values proposed by WHO for exposure to formaldehyde [6], four among the visited dwellings exceeded the value of 100 µg/m³ recommended for "normal people". In contrast, the value of 10 µg/m³ defined for "sensitive people" was exceeded in 71% of the dwellings. The maximum values obtained were in the kitchen and the children's room. The later, generally renovated and equipped with new pieces of furniture before the arrival of the new-born.

Measurements with the probe made inside the furniture, for example, showed that the furniture of bathrooms contained the highest concentrations of formaldehyde, mainly a consequence of cosmetics storage in cabinets. Some recent wardrobes and kitchen cupboards also showed high rates of formaldehyde.

DISCUSSION AND CONCLUSIONS

The lack of reference standards used in Belgium led us to use standards or guideline values established in other European countries or in the United States. The exposure standards in the workplaces are listed for information for some compounds such as toluene, trichlorethylene and tetrachlorethylene. For formaldehyde, guideline values exist for the indoor environment [6]. Similarly, recommendations are proposed for benzene in France [7]. For the other compounds, there is no standard available. It was therefore necessary to develop a tool that can assist the physician in the interpretation of the results of indoor compounds chemical analysis. Each result, either biological or chemical, is stored in a database together with information from the questionnaire.

Based on the chemical data obtained, an overall index of chemical indoor air pollution was established. It is based on the percentiles values (P20, P50, P70 and P95) calculated on the data of enquiries from the years 2000 to 2006. Those percentile values represent an average concentration of all the rooms of the dwelling (living room, kitchen, bedroom, children's room and bathroom).

The index varies from "excellent" to "execrable" through 5 categories. These values take into account the concentrations of the 7 pollutants most frequently encountered in the habitat (benzene, toluene, trichlorethylene, tetrachlorethylene, limonene, pinene and formaldehyde) and also the total amount of measured volatile organic compounds. Figure 3 illustrates an example of indoor air pollution index for total VOCs. This case corresponds to a so-called normal habitat.

The chemical pollution index per room was calculated using the same principle.

	0-44	44-83	83-122	122-239	239-445	> 445
TCOV	Excellent	Good	Normal	Bad	Very Bad	Execrable

Fig. 3. Example of global indoor pollution index of habitat

It provides a finer description of pollution than the global index. Indeed, averaging over all rooms decreases the importance of a specific contamination and dilutes the information. Moreover, the origin of the pollutant in the most contaminated room is not apparent, thereby masking the chemical pollution and leading to a possible neglect of certain situations.

This tool allows visualizing the chemical quality of both the whole housing (overall index) and each room (index per room) for different pollutants under investigation. This presentation provides a direct reading of the habitat's situation.

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