Odor intensity of a real room - Field evaluation and laboratory investigations

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ODOR INTENSITY OF A REAL ROOM
FIELD EVALUATION AND LABORATORY INVESTIGATIONS

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ABSTRACT
A simple method was used to assess odor intensity in indoor environments by a trained panel. Reliable results were obtained. Other factors, i.e., interaction with other senses, annoyance and other cognitive processes seemed to influence individual evaluation, especially during adaptation. Therefore, laboratory experiments could be useful to assess immediate odor intensity with minimum context influences. Comparison of odor sampled in Tedlar® bags and in the living room were acceptable in terms of intensity but not in terms of recognition and description, indicating presence of biases. Chemical analysis revealed some differences in VOC composition that could explain the change in the nature of the stimulus.

INDEX TERMS
Indoor air, Odor intensity, Tedlar® bags, Field evaluation, Perceived air quality

INTRODUCTION
Indoor air quality is usually assessed in two different manners, i.e., chemical analysis that provides the composition in volatile organic compounds (VOC) and sensory analysis (odor and common chemical sense) that grants the human reaction to this chemical mixture (Ramalho, 2000). Both are needed if health and annoyance effects are being researched. Annoyance measurements are particularly difficult to achieve due to lack of calibration and influence of subjective factors. On the contrary, odor intensity measurements can be realized objectively since calibration and therefore comparison are achievable.

Measurements of odor intensity in indoor air were first realized by use of linear continuous scales (Yaglou, Riley and Coggins, 1936). This scale is easy to use and often employed in perceived air quality studies (Wargocki, Wyon, Sundell *et al.*, 2000). However, as no reference is used, no comparison between buildings, laboratories and investigations can be achieved with these scales, because of individual differences in their interpretation. Therefore, odor intensity scales should be calibrated by use of an odorous standard (ECA-IAQ, 1999).

Magnitude estimation with several references has been applied to indoor air quality (IAQ) assessments with or without moduli (numbers associated to the references). The latter remains nonetheless in limited use in IAQ investigations (Berglund, Berglund, Lindvall, *et al.*, 1982). The former, based on the theory of olf and decipol, was largely used to quantify perceived air quality (Fanger, 1988; Bluyssen, De Oliveira Fernandes, Groes, *et al.* 1996). However, the use of these units has been widely criticized (Aizlewood, Oseland and Raw, 1996).

Another method was rarely used in indoor air (Dravnieks, 1983) despite being standardized (ASTM, 1993). This method allows the measurement of an unknown odor intensity by matching some position on a reference scale (e.g., concentration steps of n-butanol). It is difficult to use in the field and requires air sampling and transport in order to assess odor intensity in laboratory conditions.

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The purpose of this study is first to provide a simple and practical method to assess the odor intensity of an indoor environment, second to study the influence of space and time in individual evaluation and finally to compare these results with laboratory assessments of the same indoor atmosphere sampled in Tedlar® bags.

METHODS

Field evaluation

A trained panel evaluated the odor intensity both in an uninhabited 35 m^2 living room from an experimental house and in a 27 m^2 meeting room near the test laboratory. Three investigations were made in the first environment just before lunch (07/17/01, 07/20/01 and 12/13/01) and two in the meeting room in late afternoon (12/07/01 and 12/11/01). Seven to nine panel members between 23 and 34 years old participated in each experiment. Furniture in the living room consisted of wood shelves, armchairs, and a small table. New carpet tiles covered the floor and walls were painted. A wood table and chairs were the main furniture in the meeting room with carpet, painted walls and acoustic tiles as decorative materials. Ventilation conditions were always maintained at a minimum before and during the experiment.

The method used to assess odor intensity is a non-structured linear scale (180 mm) with lower and upper limits provided by reference flasks of n-butanol in water solutions at 20 and 5000 ppm vol/vol respectively (c. 1.3 and 313 ppmv in the gas phase at 20 °C). The panel was trained in assessment reliability of unknowns by this method until a relative standard deviation (rsd) under 15% was reached. The reference flasks were presented to the panelists outdoors for living room investigations or in the laboratory for the meeting room evaluation just before entrance. Four to five assessors entered the room with questionnaires ready and had to mark on the scale the odor intensity immediately after opening the door and at two minutes interval afterwards. They remained with the experimenter in the room during 10-15 minutes. The room remained closed before, during and after the panel intervention. In each test, assessors upon entering the indoor environment were free to sit, walk or even speak between evaluations, in order to diminish the stress induced by the test. After intensity evaluation, each subject was asked to determine in some words the nature of the odor. Temperature was also measured during each test.

Laboratory investigation

After the field evaluation took place, the indoor atmosphere was sampled in 10L Tedlar® bags (polyvinyl fluoride polymer) to be assessed by the same panel in the laboratory (a room with cabins kept at 20 °C). Bags were modified in order to include a large diameter valve suitable to olfactory sniffing with small glass cones. A commercial bag sampler was used to fill three bags for each test. No sample was taken in July. The same method of intensity evaluation was used with the same reference flasks. Sampled atmosphere assessments occur in less than 4 hours after bag filling. Each panelist performed a simple odor description task afterwards.

Chemical analysis

Volatile organic compounds (VOC) in the living room air was sampled twice in Tenax TA cartridges just after the bag filling operation. Sampling occur also for Tedlar® bags after being assessed by the panel. Analysis of VOC was conducted by thermo-desorption coupled to a gas chromatograph with both flame ionization detector and mass spectrometer.

Interpretation of the linear scale

The lower and upper limits of the linear scale (weak and strong references) were transformed in the decimal logarithm of the gaseous concentration of n-butanol expressed in ppmv (i.e., 0.1 and 2.5 log units at 20 °C). Depending on the temperature during references evaluation, values were corrected but the span of the scale remains the same. Odor intensity was expressed in log units. Student t-tests were used to find significant differences in the means.

RESULTS

Field investigations results

No significant differences were initially found in living room evaluations or in meeting room assessments. However, odor intensity was found to be significantly greater in the living room than in the meeting room ($p < 0.04$). Panel as a whole remains consistent with odor intensity assessments (see Figure 1).

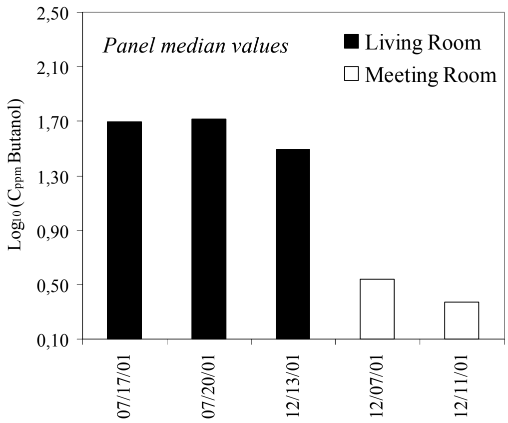

Figure 1. Odor intensity ratings in the living room and in the meeting room upon entering. The Y-scale covers the whole linear scale from the weak (0.1) to the strong reference (2.5).

Inter-individual differences were the lowest upon entering (rsd = 23%). But, odor intensity remained systematically higher in the living room than in the meeting room. No spatial variation was observed in all the tests. Perceived intensity was found to decrease over time for all subjects though an increase was noted for a few panelists (Figure 2).

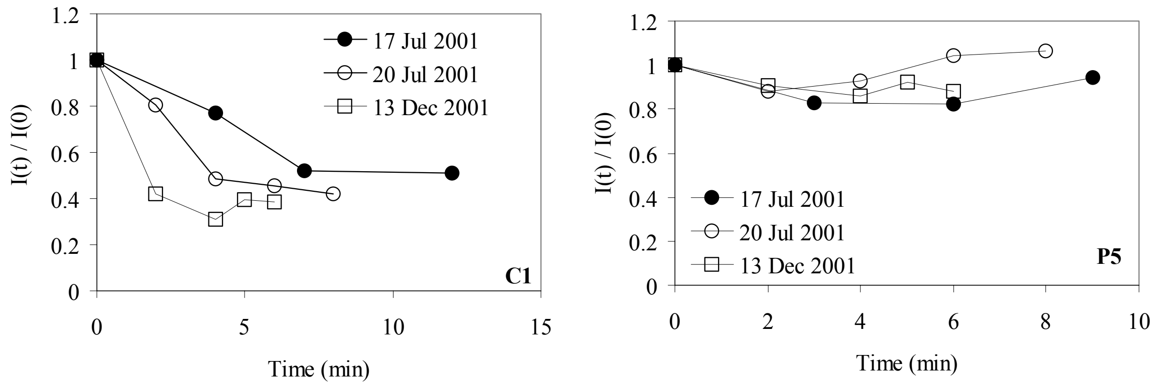

Figure 2. Evolution of the perceived odor intensity in the living room for 2 panelists. Data are normalized by the initial perceived intensity I(0).

Comparison of field and laboratory assessments

Tedlar® bag triplicates have been assessed by the panel. Results were repeatable for each panelist (rsd < 10%). Odor intensity in the meeting room and in sampled air did not match. Perceived intensity in the meeting room was quite low and the background odor of Tedlar®

bags seemed to cover it. Description of the perceived odor confirmed this assumption, i.e., the meeting room was characterized by stuffy, new and wood fire notes whereas sample bag odor was mainly described as bag, plastic and solvent.

Perceived odor intensity in the living room and in the sampled air did quite match in one experiment (see Figure 3). Only one panelist out of eight (M8) showed great differences in intensity evaluation between field and laboratory experiments despite recognizing a very diluted living room odor in the sample bag. Significant correlation between intensity ratings was found when subject M8 is removed (r = 0.97). Previous results showed that interpretation of this correlation is unequivocal.

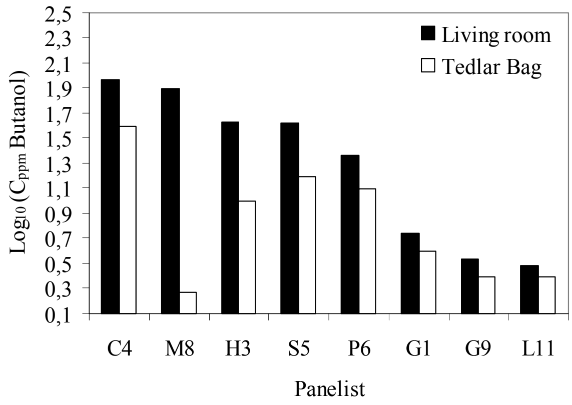

Figure 3. Comparison of the initial odor intensity ratings in the living room with assessments of sampled air in Tedlar® bags (12/13/01 evaluation).

Despite some similitudes in intensity ratings, odor descriptions of the living room and of bag samples were not in agreement. The living room odor was characterized by carpet, wood furniture and woodwork notes and on the other hand, sample bag odor was described as plastic bag, yellowed paper, newspaper, and plastic packaging. Only two subjects (M8 and L11) did recognize a diluted note of the living room odor in the bag samples.

Chemical analysis showed some differences in VOC concentrations between air in the living room and bag samples (see Table 1). The major VOC found in the living room was Toluene, likely due to outside truck traffic. The majority of compounds was found in the sample bags as well, although a few differences in concentration were observed. Two major VOC were found to be emitted by the Tedlar® bags: Phenol and N,N-Dimethyl acetamide.

Table 1. Main VOC detected in the living room air and in the sampled bags after assessments.

	Concentration range min-max (µg.m^{-3})	
Compound	*Living Room (n = 2)*	*Tedlar® Bag (n = 3)*
Toluene	373-395	363-381
Phenylmethanol	42-58	8-9
2-Butanone	12-13	16
tert-Butanol	16-18	24-35
Hexanal	7	9-11
Nonanal	3-5	4
Phenol	1-9	269-331
N,N-Dimethyl acetamide	-	205-465

DISCUSSION

Field results showed that panel values could be used to compare different samples. However, it must first be demonstrated that individual assessments are in accordance with each other. Variations among assessors began to rise after a few minutes due to individual adaptation rates to perceived odor intensity as mentioned in previous studies (Gunnarsen and Fanger, 1988). But the behavior of some individuals suggests that nasal and eye irritation may have arisen (Cain and Cometto-Muñiz, 1995). Factors like annoyance, influence of the other senses (especially vision) or other cognitive processes could also explain this increase in apparent perceived magnitude (Dalton, 2000).

Odor description task could have been influenced by visual recognition of potential sources (carpet and wood furnitures). It is not known how vision has affected immediate and adapted perception. A previous study on environmental tobacco smoke showed an increase in odor intensity with visual recognition of the source (Moschandreas and Relwani, 1992). Thermal variations upon entering could also affect overall perception.

A previous study (Dravnieks, 1983) has compared direct odor assessments in indoor air and through Tedlar® bag samples in a mobile laboratory. No significant correlation was found between the two evaluations ($r = 0.14$, $n = 83$). In the present study, apparent agreement in odor intensity evaluation was achieved between bag samples and the living room but descriptors were not in concordance. Both field description task and laboratory intensity ratings are probably biased. The first could be influenced by context factors and the second by bag background odor. This assumption rises two main questions : How to faithfully describe an odor without being disturbed by context and how to faithfully rate the intensity of odors ? Laboratory experiments can be done in controlled conditions and are therefore useful in order to compare environments with different contexts. An improvement of odor transport from the field to the laboratory is thus needed. In this study, Tedlar® bags were first conditioned at 50°C during 96 hours. Instead of cleansing the bags, the conditioning seemed to have increased the release of some VOC previously trapped inside the polymer film, like phenol and N,N-dimethyl acetamide. These compounds along with the observed differences in concentration (e.g., phenylmethanol) could explain odor description variations in field and laboratory tests. Recognition of diluted living room air suggests that some losses or masking of odorous compounds of interest have occurred in the bags. These observations tend to favor description results over the apparent match in intensity rating.

CONCLUSION

The method presented in this study allowed to achieve reliable results in odor intensity assessments of indoor environments, when ventilation and temperature are controlled. Inter-individual variations in adaptation rates have been observed. Numerous factors seemed to affect the overall perceived intensity whether linked to the context, the individual or both. Laboratory experiments could minimize context influences. The key point remains how to transport an odorous atmosphere from the field to the laboratory. Reliable sampling of odorous atmosphere in bags implies minimal precautions, i.e., diminution or elimination of odorous VOC emitted by the polymer film and sample loss avoidance by increasing film thickness or by further reducing film permeability to gases. Further research is also needed in order to explain to what extent odor description is related to odor intensity.

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