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SAMPLING OF INDOOR AIR FOR SENSORY ANALYSIS IN SITU

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Abstract

In indoor air quality studies the choice of sampling points as to site and time is important because a building is a dynamic system. Furthermore, stimulus appraisals in most sensory analyses in the field are dependent on proper dilution procedures. The sample representativity in an olfactometer for field use was found to be good for dimethyl monosulfide, hydrogen sulfide, and formaldehyde, the ratio between theoretical and analysed values being 0.94-1.11. The rise and fall times in the olfactometer as well as in a mobile environmental chamber for sensory field studies have been demonstrated to be satisfactorily short and to permit the use of efficient and time saving experimental designs for human whole body exposures. The performance of the sampling procedure during sensory field studies has been examined for samples of volatile organic compounds taken simultaneously on site in the building and in the exposure hood of the olfactometer. The losses in the sampling, dosing and exposure system of the equipment are small.

Introduction

Indoor air contains hundreds of chemical components (5, 6, 8, 9, 10). A majority of the indoor air contaminants in public buildings are odorous (4). Usually no single compound is responsible for the sensory effects of indoor air, the effects being the result of complex interactions between compounds and host related factors (3). Since the odor of indoor air cannot be predicted easily from the chemical composition of the air, sensory analysis is a necessary tool in studies of indoor air quality.

When sampling air for sensory analysis, some problems need special attention. The choice of sampling points as to site and time is important because a building is a dynamic system. Furthermore, the sample-equipment interaction is of utmost importance, since even minute quantities of chemical pollutants may be decisive for the resultant odor of the sample. Many sensory pollutants are reactive and may be lost in the sampling system more easily than other compounds. Moreover, the sampling of air may in itself affect the object being studied since, the balanced ventilation systems of modern buildings are rather sensitive.

Sampling problems

Indoor air quality is to a large extent related to human activities. In a study of an office building in the city of Stockholm, the hourly variation of the CO and CO_2 concentration was examined by infrared analysis (UNOR and URAS, respectively). Fig. 1 shows the concentration of CO and CO_2, respectively, over the time of day. Each data point is the mean value of 5-10 observations over a 5 week period. The CO_2 level close to the street varies considerably with time as a result of the traffic flow but within the building there is less variation. On the other hand the outdoor/indoor relationship for CO_2 is the inverse since it is mainly related to the current number of occupants. Apparently choice of time points for sampling during the day will largely influence the time-course functions especially for pollutants related to (irregular) human activities.

The recirculation of return air affects the concentrations of indoor air pollutants differently for different compounds (3). Sometimes twice the outdoor input air rate is required to evacuate strong odor components compared to what is required for, e.g., CO_2. The condition of the filter equipment in the ventilation unit may itself be a decisive factor for the indoor air quality. Table 1 shows ranges of the concentrations of volatile organic compounds between different sampling sites in a "sick" building. The building is a preschool that had been closed for 4 years prior to this experiment because the occupants had had adverse sensory symptoms due to the indoor air. "Outdoor compounds" (benzene, toluene, m- and p-xylene, and o-xylene) and "indoor compounds" (n-hexanal, styrene, α-pinene, and 4 as yet unidentified compounds) are shown for 4 sampling sites (outdoors, air inlet, middle of a room, air outlet) and for 2 air filter conditions. Both groups of compounds were selected on the basis of the indoor/outdoor concentration relationship for the constituent compounds.

For both of the filter conditions the inlet air showed low concentrations whereas when the one year old dust filter was used the concentrations of organic compounds in the room were generally much higher than with the new filter. In both cases there was little or no difference in the concentrations found between samples taken in the room and samples taken from the outlet air.

Sample-equipment interaction

Stimulus appraisals in olfactometry are dependent on proper dilution procedures. The concentrations to which observers are exposed are

Table 1. Range in concentrations (n=1-4), ug/m^3, of volatile organic compounds between sampling sites in a "sick" preschool closed for the last 4 years due to its causing adverse sensory symptoms among the occupants. (2 filter conditions, heat recovery by a rotary heat exchanger of regenerative type).

Filter condition	Outdoors	Air inlet	Room	Air outlet
Old filter				
"Indoor Organics"	1- 3	4	18-33	22-35
"Outdoor Organics"	5-38	14	32-53	30-69
New filter				
"Indoor Organics"	1- 3	1- 4	3- 6	1- 6
"Outdoor Organics"	8-27	4-28	4-12	3-20

usually expressed solely as dilution factors when no chemical analyses are performed, or as predicted concentration levels when chemical analyses actually have taken place at a preceeding step in the dosage system. Since losses due to wall adsorption or chemical alteration occur, the validity of dilution calculations in olfactometry must be studied. The net yield in the exposure hood of the sampling equipment for two sulfides (dimethyl monosulfide and hydrogen sulfide, S35) and formaldehyde was studied by means of a flame ionization detector, a scintillation counter and wet chemical methods (chromotropic acid and sodium bisulfite). As shown in Table 2, a high degree of correspondence was found, the ratio between theoretical values and the analysed being 0.94-1.11.

Table 2. Ratio between theoretical values and analysed values of concentration in exposure hood (estimated/empiric). (Means and standard errors based on 8-23 observations.)

Compound	Hood concentration ug/m^3	Ratio: estimated/empiric
Hydrogen sulfide	1.85	0.94+-0.04
Dimethyl sulfide	7430	1.11+-0.12
Formaldehyde*	573	0.94+-0.03
Formaldehyde*	691	0.94+-0.13

*Different studies.

Analyses were also performed on samples from 4 different points in the exposure hood to check whether the mixing of the sample gas and the dilutant cleaned air was sufficiently well done. No statistical differ-

ence was found between sampling points with dimethyl monosulfide as the test gas (one way analysis of variance, F=0.97, df=4,19). The small dispersion of the analysis results shows that the stability in the exposure hoods is good during constant exposure. Another problem is the temporal course and stability of concentration in the exposure equipment when the concentration is changed stepwise. Knowledge about this is essential if reliable psychophysical experiments on air pollutants are to be carried out (2).

A mobile three unit laboratory with a sampling system to an environmental chamber, was attached to the "sick" preschool. The air in a room was led through large tubings (200 mm diameter) and fans, at a flow rate of 15-80 l/s to the environmental chamber, and then back again in order not to disturb the performance of the ventilation system of the building. Since the volume of the environmental chamber, including the tubings, was about the same as the volume of the room in the building (20 and 25 m^3, respectively) the start of sampling would diminish the ventilation air rate of the room by a factor of two.

Fig. 2 shows the rise and fall times in the environmental chamber of an indicator pollutant (CO_2) which had been fed for 1 hour into the study room until an approximate steady-state had been attained, determined by an infra-red analyzer (BINOS). Then the dosage to the chamber was started. The curves in the figure refer to 5 experiments with 2 different air sampling rates. Rise as well as fall times are satisfactorily short (100 $\pm$10% of steady-state concentration within 20-30 min) and should permit the use of efficient and time saving experimental designs for human whole body exposures.

The spacial distribution in the environmental chamber of the pollutants continously sampled from the room was investigated by analysing the CO_2 content. Samples were taken at 3 sites in the chamber in immediate time succession every 5 min during sampling. No differences were found between the sampling sites. The dispersion of data values between successive observations was small, the ratio between the extreme values and the mean values being at the most 0.97-1.03.

The performance of the sampling procedure during sensory field studies was examined. Samples of volatile organic compounds were taken simultaneous on site in the building and in the exposure hood of the mobile laboratory. The procedure of sampling and analysis was the same as described in (9). Fig. 3 shows the results for 4 selected compounds (toluene, n-butanol, C_{10}+C_{11}-alkane, or C_9-alkane, and α-pienen) obtained in two separate studies of indoor air quality: a detached preschool, and a multi-storey office building. Since the concentration distribution is positively skewed, the values are plotted in logarithmic coordinates. The diagonal represents identity between concentrations from the two sampling sites: in the room and in the exposure hood. The losses in the sampling, dosing and exposure system of the mobile laboratories are small, which strengthens our confidence in the methods developed.

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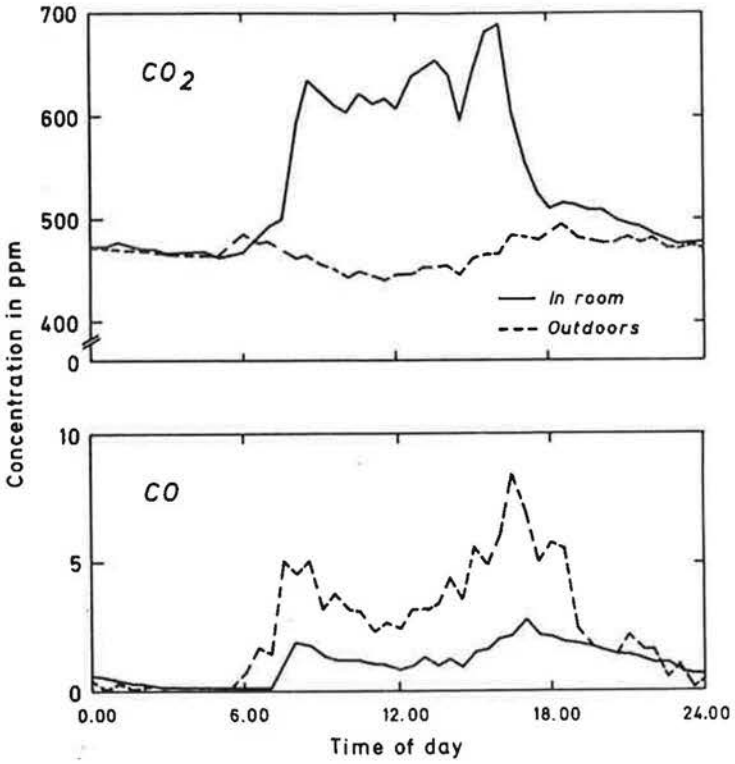

Fig. 1. Variation in concentrations of carbon dioxide (CO_2) and carbon monoxide (CO) over the time of day inside and outside an office building at 1:st floor level. Means of 5-10 3 min observations.

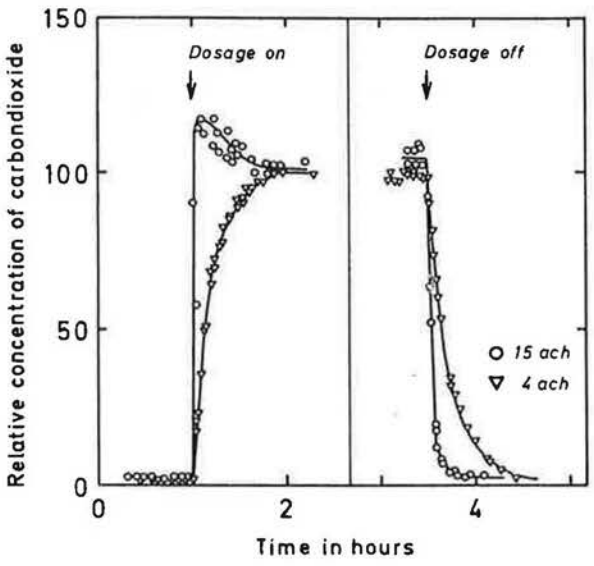

Fig. 2. Rise and fall times in the environmental chamber using CO_2 as an indicator substance. Data collected from 2-3 different experiments each under 2 conditions of 4 and 14 ach respectively. Curves are fitted by eye. CO_2 values are relative concentrations re "steady state" in chamber (950 and 1000 ppm resp).

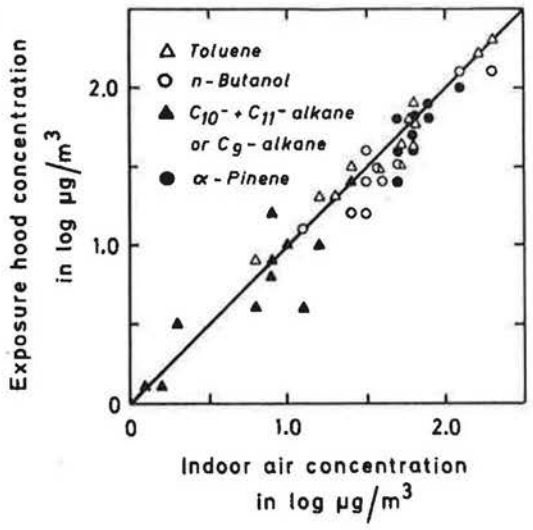

Fig. 3. Comparison of concentrations for toluene, C_9-C_{11}-alkanes, n-butanol, and α-pinene in air samples taken simultaneously in the building and the exposure hood.