INDOOR MEASUREMENTS OF NITROGENDIOXIDE AND SULFURDIOXIDE IN MECHANICALLY AND NATURALLY VENTILATED ROOMS COMPARED WITH OUTDOOR MEASUREMENTS

Christian Monn, Markus Hangartner, Hans-Urs Wanner
Federal Institute of Technology
Department of Hygiene and Applied Physiology
ETH-Zentrum, CH-8092 Zurich

Abstract

Weekly measurements were made to compare the indoor levels of NO_2 and SO_2 with outdoor levels in different rooms in a city and in the countryside. Measurements were effected with passive sampling diffusion tubes. The following NO_2 indoor/outdoor ratios were found: 0.6 - 0.7 in air-conditioned rooms (winter), 0.2 - 0.4 in air-conditioned rooms with special air filters, 0.25 - 0.45 in dwellings with natural ventilation (winter) and about 1.0 in summer . The indoor concentration of pollutants depends on the outdoor concentration of pollutants, the type of ventilation and filtration and the air exchange rate.

Introduction and Methods

It is of interest to compare the indoor concentration of NO_2 and SO_2 with outdoor concentrations of NO_2 and SO_2. Concentration levels vary in rooms with different air ventilation rates (5). Indoor concentrations show the real exposure to pollutants because most of the time is spent indoors (3, 4).

Two office-buildings in a polluted area in Zurich were measured for 11 weeks in the winter 1985. All rooms were air-conditioned; in some rooms the air passed through special air-filters. Also included in the study were about 20 dwellings in and around Zurich with lower outdoor concentrations of pollutants (Wetzikon, small town 25 km from Zurich; Rafz, small village 35 km from Zürich). Measurements were made for 5 weeks in the winter 1985/86 and 5 weeks in the summer 1986. Dwellings with gas-cookers were excluded in the study, since gas-cookers are responsible for high NO_2 emissions. Passive sampling is a method to measure average concentrations of NO_2 and SO_2 (2, 1). The sampling tubes are placed indoors and outside the window for one week. NO_2 is determined according to the Saltzmann-method, SO_2 is determined according to the Pararosaniline-method (Detection limits for weekly exposure: NO_2: 4 $\mu g/m^3$, SO_2: 30 $\mu g/m^3$).

Results

Figure 1 shows the indoor pollutant level following the fluctuation of the outdoor concentration. The average indoor/outdoor ratio for NO_2 in unfiltered rooms is 67%. In specially filtered rooms this rate can be as low as 40%.

Table 1 shows the SO_2 concentration never exceeding the detection limit of 30 $\mu g/m^3$.

Table 1: SO_2 outdoor concentration in office building A

week number 85/86	47	48	49	50	2	3	4	5
Outdoor SO_2 $\mu g/m^3$	76	65	47	53	23	22	30	31

Table 2 indicates that the indoor concentration of NO_2 can be significantly decreased with an air-filter.

Table 2: NO_2 indoor/outdoor concentration in office buildings

	Indoor		Outdoor		I/O Ratio
	$\bar{x}$	s	$\bar{x}$	s	
Building A	43	9	65	10	66 %
A*	27	7	65	10	40 %
Building B	13	4	68	14	20 %

Building A air-conditioned
A* and B additionally equipped with air-filters
$\bar{x}$: NO_2 concentration ($\mu g/m^3$) average over 11 weeks
s: standard deviation

Table 3: NO_2 indoor/outdoor concentrations in dwellings (winter)

week numbers 1986		4		5		6		7		8		Average	I/O Ratio
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	
Zürich n=17	I	15	7	15	5	17	6	21	5	19	6	17	32 %
	O	43	14	56	7	44	8	58	7	66	9	53	
Wetzikon n=16	I	10	4	13	7	11	4	17	7	13	5	13	29 %
	O	32	11	53	15	33	8	50	9	57	7	45	
Rafz n=18	I	8	3	10	4	10	4	12	4	10	4	10	29 %
	O	26	7	37	7	29	4	37	5	42	5	34	

$\bar{x}$: NO_2 concentration (average) in $\mu g/m^3$.
I/O: indoor/outdoor concentrations
n: number of dwellings
s: standard deviation

Table 4: SO_2 outdoor concentration (winter)

week number (1986)	4 $\bar{x}$	s	5 $\bar{x}$	s	6 $\bar{x}$	s	7 $\bar{x}$	s	8 $\bar{x}$	s
Zürich	41	7	49	10	76	11	89	15	92	15
Wetzikon	<30		<30		50	12	61	11	70	18
Rafz	<30		<30		<30		37	12	45	13

$\bar{x}$: SO_2 concentration (average) in µg/m³. s: standard deviation
measurements have been made in front of the windows.
Average SO_2 indoor concentrations never exceeded 30 µg/m³.

Table 5: NO_2 indoor/outdoor concentration in dwellings (summer)

week numbers 1986		27 $\bar{x}$	s	28 $\bar{x}$	s	29 $\bar{x}$	s	30 $\bar{x}$	s	31 $\bar{x}$	s	Average $\bar{x}$	I/O
Zürich n=19	I	32	8	33	6	34	7	33	7	26	12	32	110 %
	O	31	10	28	14	29	14	27	14	30	16	29	
Wetzi-kon n=20	I	21	6	24	6	20	6	19	6	13	4	19	100 %
	O	26	17	21	11	18	9	18	8	12	5	19	
Rafz n=22	I	14	5	14	5	13	5	14	7	11	5	11	157 %
	O	19	6	10	4	10	4	10	5	10	4	7	

Table 3 shows that the average indoor NO_2 concentration was dependent on the outdoor NO_2 level in the 5 week period covered. We have not found that a weekly outdoor peak automatically leads to a higher indoor level. However, people living in dwellings built in higher polluted areas are also exposed to higher indoor NO_2 levels. In the winter the indoor NO_2 concentration is only 30% ± 10% of the outdoor concentration (average over 5 weeks). The air exchange rate is then very low because of lower temperatures. These rooms are not air-conditioned, they get lower indoor pollutant concentrations than air-conditioned rooms. Even in highly polluted areas, the SO_2 indoor concentration never exceeded 30 µg/m³.

In summer, however, the ventilation rate in the dwellings is higher, because windows remain open night and day. This leads to higher indoor concentrations. Table 5 shows that indoor and outdoor concentrations of NO_2 are similar. On the other hand the ambient NO_2 concentration is lower in the summer. No measurements have been made in air-conditioned rooms in summer yet, but the same results could be expected as in the winter.

Conclusions

In the winter NO_2 and SO_2 indoor concentrations are significantly lower than the outdoor concentrations. It is therefore advisable to stay in rooms when high ambient air pollution is recorded.

Air-conditioning leads to higher indoor concentration of NO_2 (compared with non air-conditioned rooms). The air has to be filtered with additional air filters. Dwellings without indoor NO_2 sources have the lowest I/O ratios in winter, because windows are only opened for minutes.

In summer the NO_2 and SO_2 outdoor concentrations are lower. Indoor NO_2 concentration is in the same range as the outdoor concentration, hence NO_2 indoor exposure could be higher than in winter in highly polluted areas.

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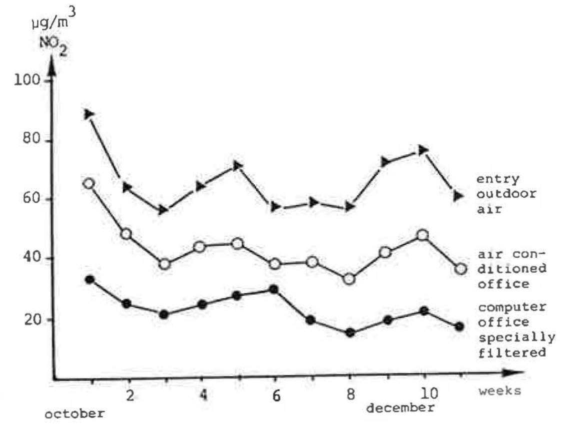

Fig. 1: Relation outdoor - indoor air in an air conditioned building in the town center.

VENTILATION REQUIREMENTS IN BUILDING FOR CONTROL OF BODY ODOR

Masaya Narasaki
Osaka Uniersity, Osaka, Japan

Abstract

We investigate the relationship between the indoor CO_2 level caused by sedentary occupants' expiration and subjective evaluation of body odor by visitors by means of the same method as Yaglou's, and try to estimate the ventilation criteria for sedentary persons. Subjective evaluations of body odor are carried out in an environmental chamber as model tests and in classrooms as field tests. The experiments are carried out with various combinations of temperature, humidity, occupancy density and occupants' sweating condition. From the results, we may conclude that the CO_2 level is a potential index of body odor and 80 % of visitors may be satisfied with indoor air quality, if CO_2 level be kept less than 0.1 % which is adopted as Japanese ventilation standards.

Introduction

In Japanese Building Code, the minimum ventilation rate is 20 m^3/h per occupant in residential and office environments and 30 m^3/h per occupant in buildings with a floor space of over 3,000 m^2. These values corespond with about 0.13 % CO_2 and 0.10 % respectively as the accepted limit. The codes seem to be principally based on Yaglou's result on body odor and ventilation. Since oil shock in 1973, the interest in control of building ventilation has increased as a consequence of the new demands for energy saving. But we have not yet found the criteria for ventilation requirements in buildings.

The body odor is one of main contamination in the occupant space. The fresh air should be fully supplied to maintain body odor at a satisfactory level. Recentry the studies on body odor is investigated to decide the minimum entilation requirement.[2),3),5)] In Japan, those studies were conducted by Asano[1)], Minamino[4)] and et.al.. Also we have made the same studies on body odor in these recent years. the experiments will be only briefly described here.

Method

Facilities

A series of experiments are conducted in a 20 m^3 environmental chamber. The walls of chamber are finished with aluminium foil. The ventilation air is directed into the chamber both from the plenum chamber and from outdoor by the exhaust fan. The chamber process temperature and humidity control. The room air is mixed fully by fan in the chamber. Also, to compare with the model tests in an environmental chamber, a series of the field tests