MEASUREMENT OF NITROGEN DIOXIDE INDOOR AND OUTDOOR CONCENTRATIONS WITH PASSIVE SAMPLING DEVICES

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Summary

In the framework of a study on respiratory symptoms in pre-school children, NO_2 concentrations were measured in a total of 1225 apartments indoor (livingroom or children's room) and outdoor by means of passive samplers. In apartments with gas stove the NO_2 concentrations were on average 20 $\mu g/m^3$ higher than in apartments with electric stove. In apartments with smokers, NO_2 concentrations were on average 5 $\mu g/m^3$ higher than in non- smoker apartments. The ratio between indoor and outdoor NO_2- concentrations was higher in summer than in winter, because of higher ventilation rates. The frequency of respiratory symptoms per child and day was found to increase with increasing level of NO_2 measured outdoors not indoors. It was concluded that NO_2 outdoors represents an other mixture than NO_2 indoors and may have different health effects.

Introduction

In a Swiss of a study on respiratory symptoms in pre-school children, nitrogen dioxide concentrations were measured in a total of 1225 apartments indoor and outdoor by means of passive samplers (1). 32% of the examined apartments were equipped with a gas stove and in 41% of all apartments at least one person smoked. In this paper results of NO_2 measurements in apartments with different NO_2 sources and their relationship to the corresponding outdoor measurements will be presented. A summary of the results of the children health survey will be added.

Methods

Ambient NO_2-levels were measured with passive samplers according to Palmes, with the exception of polypropylene to be used for the tubes instead of polyacryl (3). The size of the tubes was 7.4 cm in length and 1.0 cm in diameter. Three stainless steel meshes were used as support for the adsorbing material at its one end. Triethanolamine was used as adsorbent and the analytical determination was done according to the Saltzmann reaction.

The passive samplers were located outside the apartment and in the room in which the child stayed most frequently (livingroom or children's room). The samplers were changed by the parents weekly for six weeks; they received a new set of samplers every week. For the analysis six week averages of NO_2 concentrations indoor and outdoor

were computed for each family.

Daily respiratory symptoms were recorded by the parents in diary form during a 6 week period evenly distributed over a year, each familiy participating during one period. The symptoms recorded included: cough during the day, cough at night, sore throat, running nose, fever, earache and breathing difficulty (symptoms easily recognised by lay people). The study was performed in the cities of Basel and Zürich, in the suburban community of Wetzikon and in the rural area Rafzerfeld (both in the canton of Zürich).

Results

Table 1 presents the average concentration of NO_2 indoor and outdoor in the 4 survey regions divided into summer and winter.

In apartments with smokers NO_2 concentrations were slightly higher than in non-smoking apartments. The difference in electric stove apartments was about 5 $\mu g/m^3$, in apartments with gas stove 3 $\mu g/m^3$. However, the corresponding outdoor NO_2 levels of smoker apartments were higher than of non-smoking apartments. The indoor/outdoor ratio was higher in apartments with smokers.

NO_2 levels in apartments with gas stove were much higher than in apartments with electric stove. Differences were at 21 $\mu g/m^3$ for non-smokers and at 18 $\mu g/m^3$ for smokers. The indoor/outdoor ratio was always significantly higher in apartments with gas kitchen. All indoor measurements were carried out in the living room or children's room and not in the kitchen. The gas apparently diffused into the whole apartment very efficiently.

Figure 1 shows the weekly averages of indoor and outdoor concentrations of NO_2 over a year in three study regions separately for apartments with gas and electric stove. Houses in Rafzerfeld were not equipped with gas stove. The different pattern of the indoor / outdoor ratio over the year shows the influence of ventilation on indoor NO_2-levels.

In summer, the indoor/outdoor ratio was much higher than in winter because of higher ventilation rates. Windows were mostly opened during summer. Indoor levels in apartments with gas stove were even higher than outdoor levels.

In winter during inversion episodes with low ambient temperatures and high outdoor NO_2 levels, indoor levels did not increase as much because the ventilation rate was lower. Windows remained closed because of the low temperatures.

The childrens frequency of the daily recorded respiratory symptoms during the 6 week periods was found to increase with increasing levels of NO_2 measured outdoors. This relationship remained significant ($p < 0.001$) in a multiple regression model in which the factors smoking, origin, indoor air pollution, age and sex, season and parents'appreciation of air pollution in the living site were taken into account. No significant influence of gas stoves and smoking could be detected.

Discussion and Conclusion

Indoor levels of NO_2 are mainly affected by outdoor levels. The same conclusions were found by other authors (2). Ventilation has an important influence on indoor NO_2 concentrations: in summer, the indoor/outdoor ratio is much higher than in winter. The ventilation rate in winter is much lower than in summer.

Additionally, NO_2 sources indoors like gas stoves and smoking contribute to an increase of indoor NO_2 levels. In general no critical concentrations will be reached. However, inside good insulated and low ventilated rooms indoor NO_2 concentrations can reach considerable levels, which may affect health. For a healthy indoor environment in apartments with gas stove it is, therefore, important to supply the rooms with sufficient fresh air (4).

In this study, there was no effect of indoor NO_2 on the frequency of the childrens respiratory symptoms. The increase of respiratory symptoms with outdoor NO_2 cannot be attributed to NO_2 directly but to an effect of additional pollutants in the mixture of outdoor air. Car-exhaust and fuel-furnaces are the major sources of outdoor NO_2 emission, both carrying an additional mixture of pollutants e.g. respirable particles, nitrogen oxides, sulphur oxides and aldehydes. Indoor sources, however, are gas stoves and to a certain amount smoking. Hence, NO_2 outdoors represents another mixture than indoors. If indoor and outdoor levels are in the same range, effect on health may be different.

References

(1) Braun-Fahrländer Ch., Ackermann-Liebrich U., Wanner H.U., Rutishauser M., Gnehm H.E., Minder Ch.E.: Auswirkungen von Luftschadstoffen auf die Atemwege von Kleinkindern. Schweiz. med. Wschr. 119, 1424-1433 (1989).

(2) COST Project 613: Indoor Air Quality and its Impact on Man. Report No. 3: Indoor Pollution by NO_2 in European Countries. Commission of the European Communities, April 1989.

(3) Hangartner M., Burri P., Monn Ch.: Passive Sampling of Nitrogen dioxide, Sulfur dioxide and Ozone in Ambient Air. Proceedings of the 8th World Clean Air Congress, Vol. 3, 681-686. Den Haag, 11. - 15. Sept. 1989.

(4) International Energy Agency (1987): Annex IX: Minimum ventilation rates. Final report of working phases I and II (Trepte L. ed). Stephanns Druck GmbH. D-7772 Uhldingen-Mühlhofen.

		WINTER (October - March)							SUMMER (April - September)						
		NO_2 indoor			NO_2 outdoor			proportion NO_{2in}/NO_{2out}	NO_2 indoor			NO_2 outdoor			proportion NO_{2in}/NO_{2out}
region	indoor sources	mean value	SE	N	mean value	SE	N	%	mean value	SE	N	mean value	SE	N	%
Basel	electric stove +														
	non smoker	20.9	0.9	74	54.1	1.2	74	39	25.5	0.8	86	43.5	1.3	86	59
	smoker	25.7	1.0	71	56.2	1.2	71	46	33.2	1.0	64	51.1	1.6	64	65
	gas stove	40.2	2.4	48	53.4	1.2	48	75	46.2	2.3	51	51.3	1.3	51	90
	gas stove + smoker	46.8	6.3	59	57.5	1.4	59	81	44.1	1.7	54	51.7	1.6	54	85
Zürich	electric stove +														
	non smoker	19.3	0.8	61	51.6	1.4	61	37	23.0	1.0	50	42.1	2.3	50	55
	smoker	21.8	1.5	30	52.9	2.0	30	41	27.0	1.9	36	44.9	2.5	36	60
	gas stove	37.1	3.3	15	54.3	2.7	15	68	55.2	9.3	20	46.8	2.9	20	118
	gas stove + smoker	39.0	2.3	20	54.1	2.6	20	72	43.4	3.2	13	52.7	4.0	13	82
Wetzikon	electric stove +														
	non smoker	13.2	0.9	44	38.3	1.4	44	34	12.8	1.9	46	25.2	1.2	46	51
	smoker	16.4	2.2	22	38.9	1.5	22	42	18.2	1.1	32	26.2	1.6	32	70
	gas stove	29.1	1.5	24	41.0	2.7	24	71	29.6	2.5	14	27.8	1.7	14	107
	gas stove + smoker	33.3	2.8	14	43.1	1.8	14	77	34.2	5.0	23	28.6	1.8	23	120
Rafzerfeld	electric stove +														
	nonsmoker	10.6	0.5	78	31.1	1.0	78	34	10.0	0.4	87	18.7	2.1	87	53
	smoker	13.3	0.7	53	31.9	1.2	53	42	12.3	0.8	36	18.5	1.0	36	67

Table 1: NO_2-indoor- and outdoor-concentrations with different indoor sources in summer and winter. Average of 6 weekly measurements at all apartments. A total of 1225 apartments in the city of Basel, Zürich, the suburban community of Wetzikon and the rural area of Rafzerfeld.

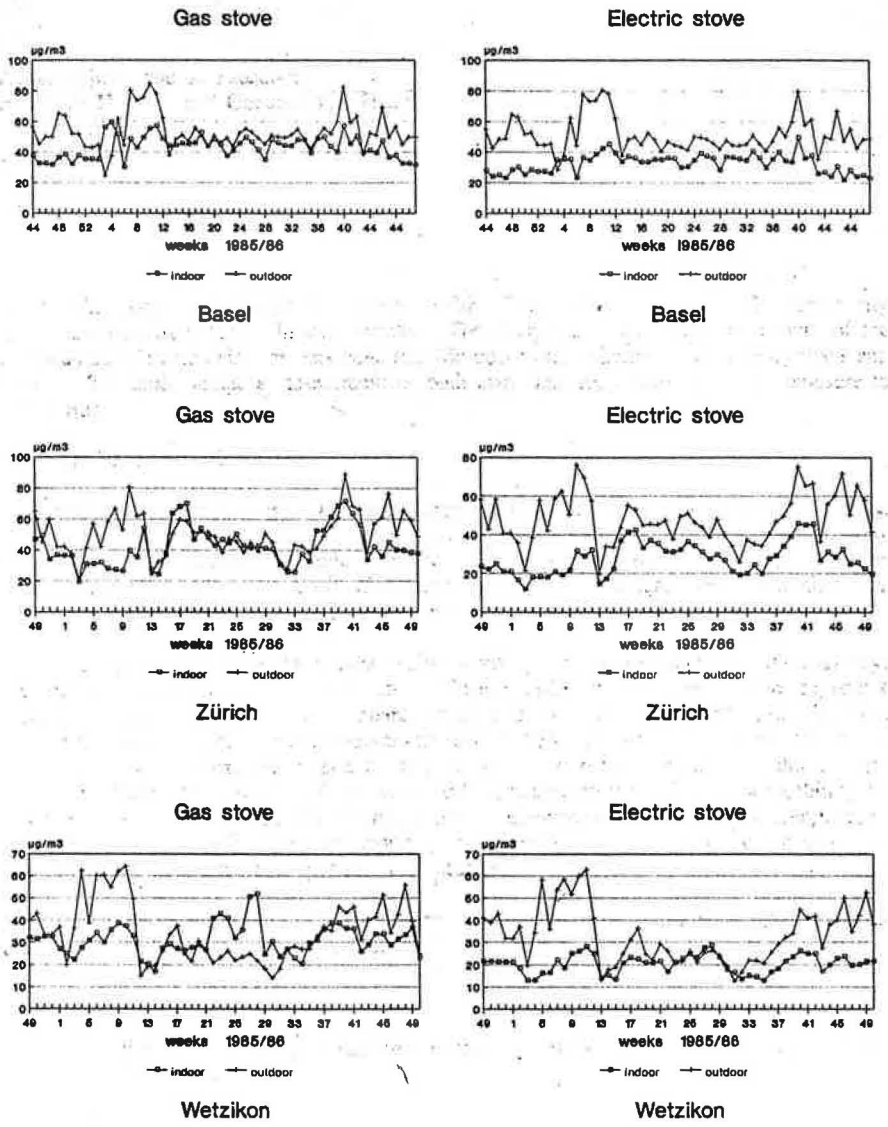

Figure 1: NO_2-concentration in apartments with electric stove and with gas stove. Weekly averages of all dwellings in the cities of Basel und Zürich, and in the suburban community of Wetzikon. Number of dwellings see table 1.