PERSONAL EXPOSURE TO NITROGEN DIOXIDE IN LOS ANGELES

EFFETS DE L'EXPOSITION AU BIOXYDE D'AZOTE SUR LES HABITANTS DE LOS ANGELES

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ABSTRACT

A probability sample of 67 people from Los Angeles and Orange Counties was monitored for nitrogen dioxide on eight two-day periods during 1987-1988, with measurements separated by approximately six weeks. Two 24-hour microenvironmental monitors were worn consecutively by each subject, while two separate monitors measured exposures at home and away from home. In addition, one fixed-site monitor was located immediately outside the home and another in the bedroom. Mobility patterns and activities were recorded in diaries. For all cycles, the personal two-day median exposures averaged 28ppb; median bedroom concentrations averaged 19ppb; and median outdoor concentrations averaged 28ppb. Personal away-from-home median exposures averaged 34ppb, while at-home median exposures averaged 21ppb. This study demonstrated the feasibility of precisely measuring personal and microenvironmental exposures to nitrogen dioxide in a random sample.

RESUME

Un échantillon de probabilité de 67 personnes s'est fait surveiller à l'égard de la concentration du bioxyde d'azote pendant huit sessions de deux jours chacune, durant les années de 1987-1988, en mesurant la concentration en question environ toutes les six semaines. Chaque sujet a porté consécutivement deux moniteurs microécologiques à vingt-quatre heures, et deux moniteurs différents ont mesuré les expositions et à l'intérieur de la maison et en dehors. En plus, un moniteur fixe s'est mis juste à l'extérieur de la maison, et un autre appareil s'est trouvé dans la chambre à coucher. Chaque sujet a rapporté dans un journal personnel le schéma habituel de sa mobilité et de ses activités. Pour tous les cycles, les expositions médianes pour deux jours par rapport à chaque personne ont atteint la moyenne de 28 ppm; les concentrations médianes découvertes dans les chambres ont atteint la moyenne de 19ppm; et les concentrations à l'extérieur des maisons ont atteint la moyenne de 28ppm. Les expositions médianes des individus hors de leurs maisons ont atteint la moyenne de 34ppm, tandis que les expositions médianes trouvées dans les maisons ont atteint la moyenne de 21ppm. Ces découvertes démontrent la possibilité de faire des mesures exactes des effets de l'exposition au bioxyde d'azote parmi les individus sur le plan microécologique.

INTRODUCTION

Studies in several countries have reported on indoor residential and outdoor concentrations of nitrogen dioxide (Lebret et al, 1987; Jedrychowski et al, 1987; Matsumura et al, 1987; Hu et al, 1987; Kim et al, 1987). It is clear, from these studies, that nitrogen dioxide concentration varies spatially and temporally across a geographic region. It is also clear that nitrogen dioxide concentration varies from home to home depending upon indoor sources and local ambient concentrations. Concentration of this gas may also vary from room to room within a home. Understanding personal exposure to nitrogen dioxide requires investigating the factors that influence microenvironmental concentrations concurrently with actual exposure measurements.

In order to further understand personal exposure to NO_2, two coordinated studies were conducted by the Gas Research Institute and the Southern California Gas Company. One study, not reported here, involved monitoring over 600 people for one 2-day period during one year from June, 1987 through May, 1988. This paper describes a microenvironmental study that monitored fewer people repeatedly during different times of the year to obtain data on seasonal and microenvironmental differences. The primary purposes

and 2) to provide a measure of variation in personal exposure to NO_2 over approximately a one year period.

The microenvironmental study was designed to monitor personal exposure of a randomly selected population to NO_2 concentrations during each of eight cycles over the period of one year. In each cycle, exposure concentrations were measured during two consecutive 24-hour periods for: total exposure during each 24-hour period; and, exposure concentrations within two designated micro-environments. Also, 48 hour concentrations in the bedroom and outside were monitored Each cycle provided repeated measurements of a representative sample over nearly a one-year period in Southern California allowing comparison of NO_2 exposures by individuals over time and for the sample as a whole. The two basic microenvironments selected for sampling were: 1) inside the subject's home, referred to as "at home" and, 2) any other location, referred to as "away from home".

Subjects were monitored for a maximum of eight 2-day cycles during the field effort. Each cycle lasted approximately six weeks. Cycle one began in June, 1987 and cycle eight ended in May 1987.

METHODOLOGY

Participants were selected to provide a random sample of residents in Los Angeles and Orange counties (California, USA) meeting the following guidelines: participant telephone numbers resided within the Los Angeles and Orange counties, participants had to be eight years of age or older, and speak English.

A 2-stage random sampling design was used. The first stage was random selection of a household, and the second stage was random selection of an individual within the household. The study sample was selected from a set of random telephone numbers for Orange and Los Angeles counties.

Basic information was obtained for both the household and for the targeted individual within the household during the telephone interview. Household data included characteristics of the dwelling and the heating and cooking facilities within the dwelling; personal data included cooking and travel time data for the previous day. In addition, information was obtained for major activities that engaged the subject for at least 20 hours per week outside the home. At the end of the questionnaire, the target was asked to participate in the monitoring portion of the study.

Participant attrition was lower for all stages of this study than originally projected. Of 140 subjects that completed telephone interviews, 85 agreed to participate in personal sampling. The drop-out rate between recruitment and set-up by the field technician was 21%.

The study began with 67 subjects agreeing to participate in Cycle 1. Forty-eight subjects agreed to participate in sampling during the eighth cycle, yielding an overall attrition of 28%.

The microenvironmental study consisted of eight cycles. During each cycle the subject was monitored once for two consecutive 24-hour periods. This schedule allowed monitoring of subjects once every six weeks during the one year field effort thus assuring capture of NO_2 exposure data for representative seasons and weather conditions in the Southern California sampling area.

The primary objective was to measure total personal NO_2 exposure for each of the 24-hour periods as well as exposures in two microenvironments and two ambient concentrations in designated locations using personal sampling badges. The participant recorded times of exposure in a diary. After badge exposure, the participant placed the badges into a package and returned them to the field office by mail.

Measurements were made using the Yanagisawa NO_2 personal sampling badge (Yanagisawa and Nishimura, 1982). The personal sampling badge consists of a plastic badge case, a triethanolamine (TEA)-doped cellulose fiber filter, a single teflon filter sheet and a bound stack of four teflon filter sheets. These badges were manufactured at Harvard, packaged in foil pouches, sealed and shipped to the field office.

The gaseous concentration of NO_2 was calculated from the diffusion characteristics of the sampler, the exposure time, and the nanomoles of nitrite measured. Nitrogen dioxide was reported in nanomoles and ppb.

Badges were assembled and packaged in small corrugated mailers. Each package contained six to eight sampling badges as follows:

two 24-hour personal badges
two microenvironmental badges
    'at home'
    'away-from-home'
one bedroom badge
one outdoor badge
one blank badge assigned to 50% of the packages
one replicate bedroom badge assigned to 50% of the packages

The participant was asked to wear a 24-hour personal badge on each of the two days of monitoring. In addition, the appropriate microenvironmental badge was to be worn on both days. A stationary "badroom" badge was placed in the subject's bedroom. The location was to be as close as possible to the area where the subject slept, preferably on a nightstand. The stationary "outdoor" badge was placed in a location protected from water exposure.

RESULTS

This paper presents a general discussion of the primary results of the microenvironmental study. Tables 1-6 list the NO_2 concentrations summaries for each badge type.

Figure 1 shows the median NO_2 concentrations for each badge type for each test cycle. Median values are presented as the most representative of the central tendency for these data. The "away

from home" and "at home" badges were not worn during the first cycle.

Figure 2 is a box plot of the data from three selected cycles. It is presented to represent the general distributions noticed in the study. A box plot identifies eight distributional parameters that permit a visual comparison of the dispersion from one sample to another. The dots represent the 5th and 95th percentiles. The solid horizontal line represents each quartile, while the striped horizontal line locates the arithmetic average. Single vertical lines connect the 90th percentile to the third quartile and the first quartile to the 10th percentile. The first and third quartile lines mark the lower and upper boundaries of 50 percent interquartile range. The region between the two dots represents 90 percent of the data values.

The personal exposure badges (Day 1 and Day 2) appear to have concentrations greater than that reported in the bedrooms but less than that reported outside. The "at home" portion of the exposure seems to be slightly higher than the bedroom concentrations. However, the most striking finding is that the "away from home" portion of the exposure seems to be much higher than the outside concentrations.

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Table 1. NO_2 (ppb) concentration distributions by cycle for the "Day 1 Personal" sampler. Nominal 24-hour exposure period.

Cycle	Mean	S.D.	Median	Min.	Max.	N
1	25.7	12.2	24.1	6.3	64.4	64
2	27.9	16.1	24.0	5.9	66.7	60
3	29.8	16.6	27.7	7.7	106.7	54
4	27.5	14.8	24.5	4.0	70.9	53
5	30.9	27.6	23.7	1.2	179.6	51
6	30.8	24.5	25.4	4.9	160.5	49
7	34.6	28.5	28.9	4.3	171.2	47
8	21.0	11.7	18.8	4.6	58.0	42

Table 2. NO_2 (ppb) concentration distributions by cycle for the "Day 2 Personal" sampler. Nominal 24-hour exposure period.

Cycle	Mean	S.D.	Median	Min.	Max.	N
1	23.9	11.9	22.6	3.7	54.6	65
2	24.7	13.6	24.1	-1.0	74.3	62
3	30.6	20.7	26.4	1.0	118.2	51
4	25.6	15.4	22.5	-0.1	74.7	50
5	28.9	23.2	22.8	0.5	132.3	49
6	28.1	22.7	24.1	-0.2	159.7	52
7	32.1	27.4	26.4	4.3	157.7	47
8	20.7	14.6	17.3	1.6	73.4	40

Table 3. NO_2 (ppb) concentration distributions by cycle for the "at home" sampler. Variable exposure time period.

Cycle	Mean	S.D.	Median	Min.	Max.	N
1	NA	NA	NA	NA	NA	NA
2	22.3	13.2	21.0	3.0	70.8	60
3	27.9	17.1	24.1	0.7	68.1	51
4	21.8	13.1	19.5	2.5	57.8	52
5	30.2	27.7	21.8	1.5	121.8	49
6	30.0	35.5	25.1	1.9	244.4	51
7	31.8	30.8	23.9	4.4	185.0	44
8	18.6	11.9	15.0	0.0	46.5	41

Table 4. NO_2 (ppb) concentration distributions by cycle for the "away from home" sampler. Variable exposure time period.

Cycle	Mean	S.D.	Median	Min.	Max.	N
1	NA	NA	NA	NA	NA	NA
2	41.6	36.1	33.1	-3.2	223.5	57
3	48.2	50.9	37.7	0.0	355.8	52
4	40.2	21.7	35.9	0.0	116.5	51
5	45.8	47.0	36.3	0.0	285.6	48
6	39.4	22.1	35.0	0.0	115.6	52
7	53.8	60.6	38.6	0.0	348.8	45
8	24.2	17.8	20.7	0.0	78.5	40

Table 5. NO_2 (ppb) concentration distributions by cycle for the "bedroom" sampler. Nominal 48-hour exposure period.

Cycle	Mean	S.D.	Median	Min.	Max.	N
1	17.5	9.6	18.0	0.2	48.5	65
2	19.7	9.9	19.8	2.3	42.7	62
3	24.5	13.4	21.3	3.8	67.3	54
4	20.7	12.3	19.4	3.6	62.2	53
5	24.0	18.9	18.4	-0.1	81.6	51
6	28.0	36.3	20.2	3.8	198.4	53
7	25.0	15.8	22.1	4.7	70.7	46
8	16.4	12.5	14.4	2.8	75.4	42

Table 6. NO_2 (ppb) concentration distributions by cycle for the "outdoor" sampler. Nominal 48-hour exposure period.

Cycle	Mean	S.D.	Median	Min.	Max.	N
1	23.2	11.4	22.7	4.8	50.1	64
2	26.7	13.1	24.7	3.7	60.3	61
3	33.9	17.5	33.6	5.5	112.7	51
4	32.6	17.9	30.3	3.9	110.1	51
5	31.7	19.8	25.3	6.5	115.5	51
6	33.7	16.5	31.9	6.9	86.3	53
7	35.3	19.3	31.8	3.4	99.2	47
8	21.2	15.1	17.1	1.9	92.2	41

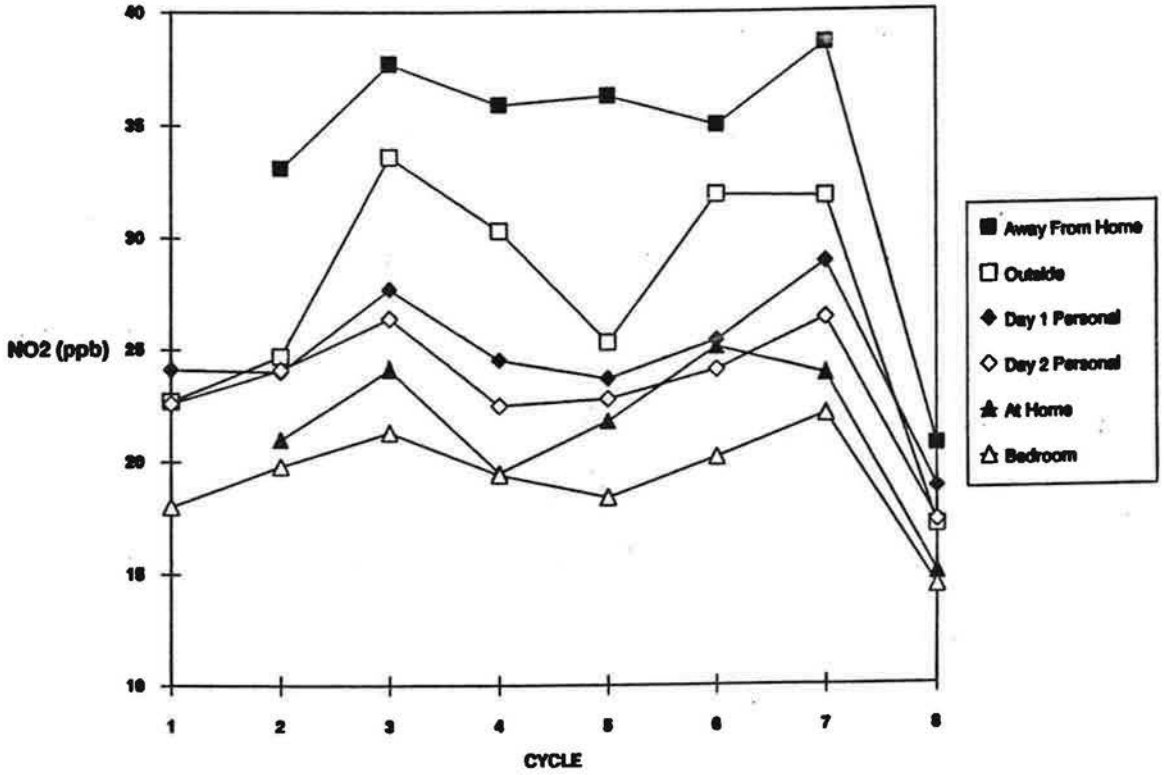

Figure 1. Median NO_2 concentrations for all badge types and all cycles.

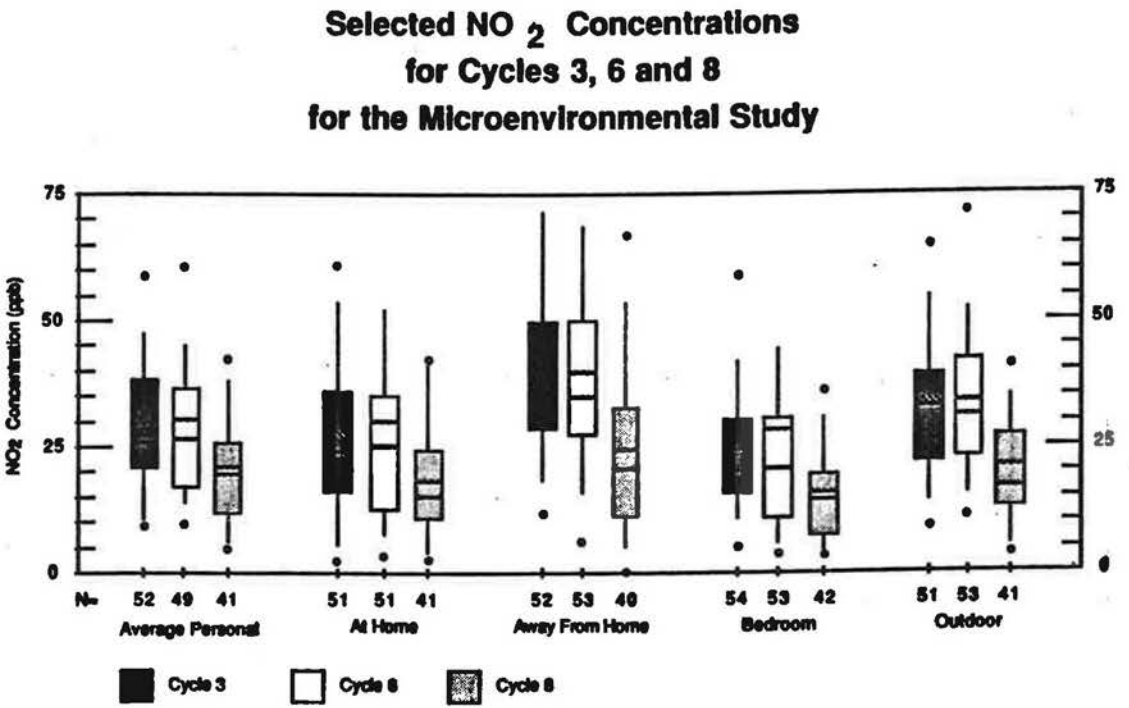

Figure 2. NO_2 concentration distributions for all participants for Average Personal, At Home, Away from Home, Bedroom and Outdoor samplers for selected cycles.