Tables and figures

of

Air pollution in Dutch homes

by

Erik Lebret

List of symbols and acronyms.

ACR	air change rate (h^{-1})
CA	coefficient of alienation
CO	carbon monoxide (mg/m^3)
CO_2	carbon dioxide (%, ppm)
D	diffusion coefficient ($cm^2/sec.$)
NO	nitrogen oxide ($\mu g/m^3$)
NO_2	nitrogen dioxide ($\mu g/m^3$)
NO_x	oxides of nitrogen ($NO + NO_2$; $\mu g/m^3$)
p	significance level
PM_{10}	suspended particles < 10 μm ($\mu g/m^3$)
ppm	parts per million (μL/L)
R, R^2	(squared) multiple correlation coefficient
RSP	respirable suspended particles ($\mu g/m^3$)
SF_6	sulphurhexafluoride ($\mu g/m^3$)
SMC	squared multiple correlation
SO_2	sulphur dioxide ($\mu g/m^3$)
TI	tracer gas transfer index (min/m^3)
TSP	total suspended particles ($\mu g/m^3$)
VOC	volatile organic compounds ($\mu g/m^3$)

1 μm = 1 micron = 10^{-6} meter
1 μg = 1 microgram = 10^{-6} gram
1 mg = 1 milligram = 10^{-3} gram

TABLE 1. Average time allocation in different microenvironments in the Netherlands (derived from Knulst and Schoonderwoerd 1983)

microenvironment		% of time
Indoors	at home	70
	other buildings	21
Transit	car, public transportation	3
	walking, bicycle	2
Outdoors		1
Other		3

TABLE 2. Current state of knowledge on air pollution inside homes

<u>Emission sources</u>

Chamber studies done for several sources.
Few measurements under dynamic conditions.
Few studies of emission rates during normal use.
Lack of information about distribution of sources within population.

<u>Dilution</u>

Understanding of basic components affecting air-exchange rates.
Measurement techniques available.
Site-specific models developed, but more general application problematic.
Only limited information available on distribution of air-exchange rates in existing buildings.
Mixing inside buildings without mechanical ventilation systems not well understood.

<u>Indoor concentrations</u>

Survey-type data collected for some pollutants.
Applicability of survey data to entire building stock unknown.
Dilution and mechanical filtration typically assumed to be first-order determinants of concentrations.
Chemical and physical interactions, as well as removal rates, not well defined.
Little known about variations in both removal and penetration rate.

(Adapted from Spengler and Sexton 1983)

TABLE 3. Compilation of typical pollutant levels inside homes and indoor/outdoor concentration ratios, in relation to the presence of indoor pollutant sources

pollutant	type of homes	typical indoor concentration	indoor/outdoor concentration ratio
Carbon monoxide	-homes without sources:	1-5 mg/m^3	1
	-smokers homes:	1-10 mg/m^3	> 1
	-homes with unvented combustion appliances:	10-50 mg/m^3 (peaks >100 mg/m^3)	>> 1
Nitrogen dioxide	-homes without sources:	10-50 $\mu g/m^3$	< 1
	-homes with unvented combustion appliances:	50-500 $\mu g/m^3$ (peaks 500-1000 $\mu g/m^3$)	>> 1
Respirable suspended particles	-non-smokers homes:	10-50 $\mu g/m^3$	1
	-smokers homes:	50-500 $\mu g/m^3$ (peaks 1000 $\mu g/m^3$)	>> 1
Volatile organic compounds	-occupied homes:	*	>> 1

* = limited measurements, variable results

(Adapted from National Academy of Sciences 1981)

TABLE 4. Ventilation requirements according to the Dutch ventilation standard for homes (NEN 1087)

type of room	ventilation (m^3/h)	based on
main living room	75 - 150	CO_2 and odour production by a maximum of 6 occupants
other rooms	> 25	CO_2 and odour production by one occupant
kitchen	75 - 100	food odours and humidity
open kitchen (mechanical ventilation is required)	75 - 150	food odours and humidity production from cooking
bathroom	50	humidity
toilet	25	odours
other locations (cellar, attic)	> 25	presence of one occupant

TABLE 5. Registered fatal CO poisoning in the Netherlands 1961-1980

	1961-1965	1966-1970	1971-1975	1975-1980
coal-related	333	423	17	?
direct poisoning, town gas	80	10	--	--
geiser-related	21	34*	60*	38*
gas heater-related	3	12*	7*	11*

* number of accidents in which one or more people died; number of deaths approximately twice as high

Sources: Douze 1971; VEG Gasinstituut 1976, 1983.

TABLE 6. Real-time measurement program (winter 1982/83, 1983/84); home description and measurement period

home	building type	number of floors	number of rooms	gas appliances	ventilation appliances	kitchen volume (m^3)	number of occupants	measurement period(hours)
1	multi family	1	4	cooker unvented geiser	none	20	2	136
2	multi family	1	5	unvented geiser	range hood	10	3	160
3	single family	2	3	cooker unvented geiser	none	28	2	230
4	single family	2	5	cooker vented geiser space heater	range hood	25	3	164
5	single family	3	6	cooker	range hood mechanical ventilation	103*	4	227
6	single family	2	5	cooker unvented geiser space heater	window fan	15	1	273
7	single family	3	6	cooker vented geiser	range hood	118*	4	179
8	single family	3	5	cooker unvented geiser	range hood	14	1	187
9	single family	2	6	cooker	mechanical ventilation	100*	3	135
10	single family	2	5	cooker unvented geiser	range hood	80*	2	188
11	multi family	1	4	cooker unvented geiser 1 space heater	none	12	2	203
12	multi family	1	5	cooker unvented geiser	window fan	15	2	222

* open kitchen/living room

TABLE 7. Overall mean and range of the 4-hour average air change rate (air changes per hour) and the overall mean transfer index (min/m^3) of 10 homes of the real-time monitoring program (winter 1982/83, 1983/84)

home nr.	4-hour average ventilation rate (h^{-1}) overall mean	range	overal mean transfer index (min/m^3)
3	8	3-14	0.26
4	7	4-19	0.34
5	0.8	0.4-3	0.73
6	2	1-6	2.10
7	0.5	0.4-0.8	0.96
8	4	2-8	1.00
9	0.7	0.4-1	0.80
10	3	2-6	0.22
11	9	4-24	0.55
12	5	2-9	0.89

TABLE 8. Response rates in the 3 age-groups of homes of the week-long measurement program(winter 1981/82,1982/83)

age-groups of homes	number approached	number (and %) participating	number (and %) of non response not contacted	refusals
Ede, post-war homes (winter 1981/82)	326	174 (54%)	62 (19%)	89 (27%)
Rotterdam, pre-war homes (winter 1982/83)	417	102 (25%)	138 (33%)	102 (42%)
Ede, less than 6 years old homes (winter 1982/83)	149	103 (69%)	12 (8%)	34 (23%)

TABLE 9. Distribution of marital status of occupants, home ownership and building type in the study population of post-war homes in Ede (week-long measurement program, n=174; winter 1981/82), in comparison with the official data for the study area obtained from the municipality of Ede

	study population	official data
marital status of occupants:		
- unmarried	8%	17%
- married	80%	73%
- divorced	2%	2%
- widowed	10%	7%
home ownership:		
- private homes	43%	39%
- rented homes	57%	61%
building type:		
- single family homes	72%	68%
- multi family homes	28%	32%

TABLE 10. General characteristics of the occupants and their homes for the 3 age-groups of homes of the week-long measurement program (winter 1981/82, 1982/83)

	Ede post-war homes (n=174)	Rotterdam pre-war homes (n=102)	Ede less than 6 years old homes (n=103)
respondents sex (%): female	84	60	85
male	16	40	15
mean respondents age (years):	49	43	38
marital status (%): single	3	18	1
unmarried couple	5	18	2
married	80	45	94
widowed	10	9	2
divorced	2	10	1
mean family size:	2.98	2.52	3.75
mean socio-economic status (score 1-6/low-high)	3.6	3.4	3.8
families with one or more smokers (%)	60	66	61
home ownership (%): private homes	43	17	39
rented homes	57	83	61
building type (%): single family homes	72	0	90
multi family homes	28	100	10
number of floors per home (%):			
1 floor	27	44	*
>1 floor	73	56	
mean number of rooms	5.1	4.3	4.9
homes with an open kitchen (%)	30	12	84
mean volume of living room (m^3)	79	76	103
mean volume of kitchen (m^3)	17	15	*
cooking fuel (%): gas	95	99	94
electricity	5	1	6
water heater (%): unvented geiser	44	64	2
vented geiser	13	12	2
others	43	24	96
space heating (%): local gas heaters	26	76	0
central heating	74	24	100
kitchen ventilation appliances (%):			
window fan	10	34	0
range hood	48	24	65
mechanical ventilation system	26	0	79

* not determined

TABLE 11. Percentage of homes in which none of the ventilation provisions in kitchen, living room and bedroom were actively used for ventilation, according to the questionnaire answers (week-long measurement program, winter 1981/82, 1982/83)

location	Ede post-war homes (n=174)	Rotterdam pre-war homes (n=102)
kitchen	5%	6%
living room	17%	20%
bedroom	3%	15%

TABLE 12. Geometric mean and range (in parenthesis) of the average daily use of the range hood and kitchen window fan (in minutes) in Ede and Rotterdam, according to the diaries (week-long measurement program, winter 1981/82, 1982/83)

	average daily use	
	Ede post-war homes	Rotterdam pre-war homes
range hood	37 (0-372) n=71	18 (0-144) n=21
window fan	3 (0-635) n=12	2 (0-189) n=26

TABLE 13. Geometric mean of the percentage of time during which interior doors were open in Ede and Rotterdam, according to the diaries (week-long measurement program, winter 1981/82, 1982/83)

location	geometric mean (% of time)	
	Ede (n=128) post-war homes	Rotterdam (n=82) pre-war homes
interior kitchen door	29	29
interior living room door	3	4
interior bedroom door	3	7

TABLE 14. Geometric mean and range (in parenthesis) of the average daily use of gas appliances (in minutes) in Ede and Rotterdam, according to the diaries (week-long measurement program, winter 1981/82, 1982/83)

gas appliance	average daily use Ede post-war homes	 Rotterdam pre-war homes
cooking range	68 (0-448) n=119	55 (0-244) n=81
gas oven	3 (0-54) n=77	2 (0-26) n=41
geiser	16 (0-96) n=67	6 (0-76) n=62

TABLE 15. Geometric mean and range (in parenthesis) of daily tobacco consumption in Ede and Rotterdam, according to the diaries, broken down by the number of smoking occupants (week-long measurement program, winter 1981/82, 1982/83)

number of smoking occupants	daily tobacco consumption in cigarettes/day Ede post-war homes	 Rotterdam pre-war homes
0	1 (0-10) n=48	2 (0-12) n=30
1	7 (0-32) n=53	11 (0-33) n=35
2	21 (4-44) n=23	25 (10-44) n=15
3	19 (15-25) n=3	29 n=1
4	66 n=1	7 n=1
all homes	5 (0-66) n=128	7 (0-44) n=82

TABLE 16. Percentage of homes in which groups of products were used, which may act as indoor sources of VOC, in 3 age groups of homes (week-long measurement program, winter 1981/82, 1982/83)

product group	percentage of homes in which product groups were used		
	Ede post-war homes (n=134)	Rotterdam pre-war homes (n=87)	Ede <6 years old homes (n=97)
solvents	12	10	15
paint	6	2	9
adhesives	19	7	26
furniture polish and -wax	30	13	20
aerosol sprays	43	55	53
spot removers	1	0	0
air refreshener	17	16	23
oil lamp and -burners	7	6	7

TABLE 17. Geometric mean and range (in parenthesis) of the air change rate (ACR) in air changes per hour and transfer index (TI) in min/m^3 in kitchens and living rooms in Ede and Rotterdam (week-long measurement program, winter 1981/82, 1982/83)

location	geometric mean (and range) of TI and ACR in	
	Ede post-war homes	Rotterdam pre-war homes
kitchen TI	0.5 (0.1-2.3) n=72	0.6 (0.1-4.6) n=69
living room TI	0.2 (0.02-1.1) n=73	0.2 (0.1-2.4) n=73
kitchen ACR	4 (0.5-24) n=72	6 (0.9-47) n=69
living room ACR*	2 (0.5-7) n=26	1 (0.3-3) n=6

* only for homes with an open kitchen/living room

TABLE 18. Multiple regression analysis of the logarithm of the transfer index (TI) in the living room (dependent variable) on the logarithm of the TI in the kitchen, number of doors between kitchen and living room and city (Ede=1, Rotterdam=2)(independent variables) (week-long measurement program, winter 1981/82, 1982/83)

independent variables	regression coefficient	standardized regression coefficient	significance level
log. of kitchen TI	0.66	0.48	< 0.01
nr. of doors between kitchen and living room	-0.23	-0.51	< 0.01
city	0.14	0.19	0.02
(constant)	-0.35		< 0.01

$R^2 = 0.38$ d.f. = 3, 116 F-model = 25.48 $p<0.001$

TABLE 19. Range in the maximum 1-minute and 1-hour average CO concentration and in the overall-mean CO concentration (mg/m^3) in 12 homes of the real-time monitoring program (winter 1982/83, 1983/84)

location	maximum concentrations		
	1-minute average	1-hour average	overall mean concentration
kitchen	5-108	3-56	1-4
living room	4-28	2-26	1-4
bedroom	4-48	1-26	<1-4
outdoors			<1-2

TABLE 20. Independent variables used in a multiple regression analysis with the logarithm of weekly average CO levels in the kitchen as dependent variable(week-long measurement program, winter 1981/82, 1982/83)

	independent variables	comment
	presence of unvented geiser	not present=1; present=2
	burner type of geiser	primary aerated=0; secundary aerated=1
set 1	shower connected to geiser	no=0; yes=1
n=114	time since last geiser maintenance	<0.5 year=1; 0.5-1 year=2; >1 year=3
	presence of smokers	no smokers=0; one or more smokers=1
	presence of range hood	not present=1; present=2
	presence of kitchen window fan	not present=1; present=2
	kitchen volume	m^3
	city	Ede=1; Rotterdam=2
	use of gas cooking range*	according to diary information (cf. part 2, section 2.2)
	use of gas oven*	" " " "
	use of unvented geiser*	" " " "
	use of pilot light cooking range*	" " " "
set 2	use of pilot light unvented geiser	" " " "
n=82	tobacco consumption	" " " "
	use of range hood*	" " " "
	use of window fan*	" " " "
	use of ventilation provisions in kitchen*	" " " "
	tracer gas transfer index*	cf. part 2, section 2.2.
	kitchen volume	m^3
	city	Ede=1; Rotterdam=2

* logarithmic transformation

TABLE 21. Regression equations of the logarithm of weekly average CO levels in the kitchen on the independent variables of set 1(cf. table 20)

	selected independent variables	regression coefficient	standardized regression coefficient	significance level
	primary aerated geiser burner	0.22	0.35	<0.01
Equation 1*	city	-0.11	-0.20	0.02
	presence of smokers	0.08	0.16	0.07
	(constant)	0.19		0.01
	R^2=0.15 d.f.=3, 110 F-model=7.72 p<0.001			
	presence of unvented geiser	0.21	0.40	<0.01
	secundary aerated geiser burner	-0.17	-0.32	<0.01
Equation 2*	city	-0.13	-0.25	0.01
	presence of smokers	0.09	0.17	0.05
	(constant)	0.01		0.89
	R^2=0.15 d.f.=4, 109 F-model=6.14 p<0.001			

* Equation 1: burner type of the geiser represented by 2 dummy variables for primary and secundary aerated burners

Equation 2: burner type of the geiser represented by 1 dummy variable for secundary aerated burners

TABLE 22. Regression equation of the logarithm of weekly average CO levels in the kitchen on the independent variables of set 2 (cf. table 20)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
city	-0.19	-0.38	<0.01
use of geiser pilot light	0.04	0.29	0.01
use of gas cooker	0.16	0.21	0.04
(constant)	0.02		0.88

R^2=0.18 d.f.=3, 78 F-model=6.87 p<0.001

TABLE 23. Regression equation of the logarithm of weekly average CO levels in the kitchen on the independent variables of set 2, after adding the independent variables 'presence of unvented geiser' and 'secundary aerated geiser burner' to set 2 (cf. tabel 20)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
city	-0.19	-0.36	<0.01
presence of unvented geiser	0.21	0.40	<0.01
secundary aerated geiser burner	-0.12	-0.23	0.05
use of gas cooker	0.16	0.21	0.03
tobacco consumption	0.13	0.19	0.05
(constant)	-0.32		0.07

R^2=0.22 d.f.=5, 76 F-model=6.25 p<0.001

TABLE 24. Regression equation of the logarithm of the weekly average CO levels in the living room on the independent variables 'logarithm of the weekly average CO levels in the kitchen', 'number of doors between kitchen and living room', 'presence of smokers' and 'city' (week-long measurement program, winter 1981/82, 1982/83)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
log. of CO levels in kitchen	0.54	0.47	<0.001
nr. of doors between kitchen and living room	-0.06	-0.19	0.04
presence of smokers	0.10	0.16	0.08
(constant)	-0.05		0.44

R^2=0.34 d.f.=3, 87 F-model=16.53 p<0.001

TABLE 25. Range in the maximum 1-minute, 1-hour and 24-hour average NO_2 concentration and in the overall mean NO_2 concentration ($\mu g/m^3$) in 12 homes of the real-time monitoring program (winter 1982/83, 1983/84)

location	maximum concentrations 1-minute average	1-hour average	24-hour average	overall mean concentration
kitchen	400-3808	230-2055	53-478	36-227
living room	195-1007	101- 879	49-259	32-142
bedroom	57- 806	48- 718	22-100	16-104
outdoors				25- 70

TABLE 26. Percentage of hours of the measurement period with a 1-hour average NO_2 concentration higher than 300 $\mu g/m^3$ in the 12 homes of the real-time monitoring program (winter 1982/1983, 1983/84)

home	% of hours with a NO_2 concentration > 300 $\mu g/m^3$ kitchen	living room	bedroom
1	3	0	0
2	18	0	0
3	11	3	2
4	1	0	0
5	0	0	0
6	2	1	0
7	6	6	-
8	0	0	0
9	0	0	0
10	11	4	1
11	22	3	3
12	2	1	0

TABLE 27. Reliability coefficient of 24-hour average NO_2 concentration and of daily maximum of 1-hour average NO_2 concentration in 3 locations, calculated from data of 7 consecutive days in 7 homes (real-time monitoring program, winter 1982/83, 1983/84)

location	average time	reliability coefficient of values from a single day	reliability coefficient of average values over 7 days
kitchen	1-hour av.	0.53	0.92
	24-hour av.	0.66	0.95
living room	1-hour av.	0.33	0.85
	24-hour av.	0.72	0.96
bedroom	1-hour av.	0.46	0.90
	24-hour av.	0.71	0.96

TABLE 28. Squared correlation coefficient (R^2) and coefficient of alienation (CA) of short-term peak concentrations in 3 indoor locations in the 12 homes of the real-time monitoring program (winter 1981/83, 1983/84), using the overall mean NO_2 concentration as predictor variable

	maximum 1-minute average NO_2 concentration		maximum 1-hour average NO_2 concentration	
	R^2	CA	R^2	CA
kitchen	0.56	0.70	0.57	0.70
living room	0.53	0.72	0.78	0.49
bedroom	0.79	0.48	0.90	0.33

TABLE 29. Percentage of homes in which NO_2 levels in indoor locations exceeded the 1-hour average value of the proposed criteria for ambient air of 300 µg/m^3, assuming a ratio of peak to mean concentration of 6 in kitchens and living rooms and 4 in bedrooms (week-long measurement program 1981/82, 1982/83)

location	percentage of homes	
	Ede post-war homes (n=174)	Rotterdam pre-war homes (n=102)
kitchen	58	82
living room	4	38
bedroom	3	14

TABLE 30. Independent variables used in multiple regression analysis with the logarithm of weekly average NO_2 levels in the kitchen as dependent variable(week-long measurement program,winter 1981/82 1982/83)

	independent variable	comment
	outdoor NO_2 level	$\mu g/m^3$
	cooking fuel	electric=0; gas=1
	presence of unvented geiser	not present=1, present=2
	burner type of geiser	primary aerated=0; secundary aerated=1
	shower connected to geiser	no=0; yes=1
set 1	presence of range hood	not present=1; present=2
n=270	presence of kitchen window fan	not present=1; present=2
	type of space heating	central heating=1; local gas heaters=2
	presence of smokers	no smokers=0; 1 or more smokers=1
	kitchen volume	m^3
	city	Ede=1; Rotterdam=2
	outdoor NO_2 level	$\mu g/m^3$
	cooking fuel	cf set 1
	presence of unvented geiser	cf set 1
	burner type of geiser	cf set 1
	use of gas cooking range*	according to diary information (cf part 2, section 2.3)
	use of oven*	
	use of unvented geiser*	
	use of pilot light cooking range*	
set 2 n=205	use of pilot light unvented geiser*	
	use of range hood*	
	use of kitchen window fan*	
	use of ventilation provisions in kitchen*	
	use of interior door in kitchen*	
	tobacco consumption*	
	type of space heating	cf set 1
	kitchen volume	m^3
	city	cf set 1
set 3	set 2 +	cf set 2
n=106	tracer gas transfer index in the kitchen*	cf part 2, section 2.2.6

* logarithmic transformation

TABLE 31. Regression equation of the logarithm of weekly average NO_2 levels in the kitchen on the independent variables of set 1 (cf. table 30)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
presence of unvented geiser	0.28	0.45	<0.01
cooking fuel	0.21	0.16	<0.01
outdoor NO_2 level	0.003	0.11	<0.01
kitchen volume	-0.001	-0.17	<0.01
type of space heating	0.09	0.14	<0.01
shower connected to geiser	0.07	0.11	0.04
(constant)	0.94		<0.01

$R^2=0.55$ d.f.=6, 263 F-model=55.56 $p<0.001$ CA=0.68

TABLE 32. Geometric mean of weekly average NO_2 levels in the kitchen ($\mu g/m^3$) broken down by the presence of gas cooker and unvented geiser (week-long measurement program, winter 1981/82, 1982/83)

	without gas cooker	with gas cooker
without unvented geiser	28	47
with unvented geiser	50	115

TABLE 33. Regression equation of the logarithm of weekly average NO_2 levels in the kitchen on the independent variables of set 2 (cf table 30)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
presence of unvented geiser	0.28	0.45	<0.01
use of gas cooker	0.14	0.23	<0.01
outdoor NO_2 level	0.003	0.12	<0.01
kitchen volume	-0.001	-0.17	<0.01
use of pilot light unvented geiser	0.02	0.13	0.02
use of ventilation provisions in the kitchen	0.04	0.11	0.02
type of space heating	0.07	0.11	0.04
(constant)	0.92		<0.01

$R^2=0.61$ d.f.=7, 197 F-model=47.71 $p<0.001$ CA=0.62

TABLE 34. Independent variables used in multiple regression analysis with the logarithm of weekly average NO_2 levels in the living room as dependent variable (week-long measurement program, winter 1981/82, 1982/83)

	independent variables	comment
	kitchen NO_2 level*	$\mu g/m^3$
	outdoor NO_2 level	$\mu g/m^3$
set 1	number of doors between kitchen	
n=271	and living room	
	presence of smokers	no smokers=0; 1 or more smokers=1
	type of space heating	central heating=1;local gasheaters=2
	living room volume	m^3
	city	Ede=1; Rotterdam=2
	kitchen NO_2 level*	$\mu g/m^3$
	outdoor NO_2 level	$\mu g/m^3$
	number of doors between kitchen and living room	
set 2	use of interior door kitchen*	according to diary information (cf
n=201	use of interior door living room*	part 2, section 2.3)
	use of ventilation provisions living room*	
	tobacco consumption*	
	type of space heating	cf set 1
	living room volume	m^3
	city	Ede=1; Rotterdam=2
set 3	set 2 +	cf set 1
n=117	tracer gas transfer index in the living room*	cf part 2, section 2.3.6

* logarithmic transformation

TABLE 35. Regression equation of the logarithm of weekly average NO_2 levels in the living room on the independent variables of set 1 (cf. table 34)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
kitchen NO_2 level	0.53	0.71	<0.01
number of doors between kitchen and living room	-0.08	-0.31	<0.01
type of space heating	0.11	0.24	<0.01
(constant)	0.54		<0.01

R^2=0.64 d.f.=3, 267 F-model=161.58 $p<0.001$ CA=0.60

TABLE 36. Regression equation of the logarithm of weekly average NO_2 levels in the living room on the independent variables of set 2 (cf. table 34)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
kitchen NO_2 level	0.57	0.73	<0.01
number of doors between kitchen and living room	-0.06	-0.28	<0.01
type of space heating	0.12	0.26	<0.01
(constant)	0.46		<0.01

R^2=0.70 d.f.=3, 197 F-model=158.26 $p<0.001$ CA=0.55

TABLE 37. Regression equation of the logarithm of weekly average NO_2 levels in the living room on the independent variables of set 3 (cf. table 34)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
kitchen NO_2 level	0.63	0.76	<0.01
number of doors between kitchen and living room	-0.07	-0.23	<0.01
type of space heating	0.10	0.20	<0.01
tracer gas transfer index in the living room	0.11	0.18	<0.01
(constant)	0.45		<0.01

R^2=0.73 d.f.=4, 112 F-model=79.61 $p<0.001$ CA=0.52

TABLE 38. Independent variables used in multiple regression analysis with the logarithm of weekly average NO_2 levels in the bedroom as dependent variable (week-long measurement program, winter 1981/82, 1982/83)

	independent variables	comment
set 1 n=274	kitchen NO_2 level*	$\mu g/m^3$
	living room NO_2 level*	$\mu g/m^3$
	outdoor NO_2 level	$\mu g/m^3$
	floor of bedroom relative to kitchen floor	
	number of doors between kitchen and bedroom	
	presence of smokers	no smokers=0; 1 or more smokers=1
	type of space heating	central heating=1;local gasheaters=2
	bedroom volume	m^3
	city	Ede=1; Rotterdam=2
set 2 n=210	kitchen NO_2 level*	cf set 1
	living room NO_2 level*	cf set 1
	outdoor NO_2 level	cf set 1
	floor of bedroom relative to kitchen floor	
	number doors between kitchen and bedroom	
	use of interior kitchen door*	according to diary information cf. part 2, section 2.3)
	use of interior bedroom door*	
	use of ventilation provisions bedroom*	
	tobacco consumption*	
	type of space heating	cf set 1
	bedroom volume	cf set 1
	city	cf set 1

* logarithmic transformation

TABLE 39. Regression equations of the logarithm of weekly average NO_2 levels in the bedroom on the independent variables of set 1 (above: data of 2 towns combined; centre: data of Ede; below: data of Rotterdam) (cf. table 38)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
kitchen NO_2 level	0.26	0.34	<0.01
living room NO_2 level	0.36	0.35	<0.01
outdoor NO_2 level	0.002	0.10	0.02
number of doors between kitchen and bedroom	-0.11	-0.10	0.02
city	0.07	0.14	<0.01
(constant)	0.52		<0.01
R^2=0.52 d.f.=5, 268 F-model=59.82 p<0.001 CA=0.69			
kitchen NO_2 level	0.32	0.50	<0.01
living room NO_2 level	0.16	0.17	0.02
outdoor NO_2 level	0.002	0.14	0.02
number of doors between kitchen and living room	-0.24	-0.12	0.02
(constant)	1.02		<0.01
R^2=0.48 d.f.=4, 167 F-model=42.62 p<0.001 CA=0.71			
living room NO_2 level	0.78	0.71	<0.01
(constant)	0.31		0.02
R^2=0.49 d.f.=1, 100 F-model=97.45 p<0.001 CA=0.71			

TABLE 40. Regression analysis of the logarithm of weekly average NO_2 levels in the bedroom on the independent variables of set 2 (above: data of the 2 towns combined; centre: data of Ede; below: data of Rotterdam)(cf. table 38)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
kitchen NO_2 level	0.31	0.40	<0.01
living room NO_2 level	0.35	0.34	<0.01
city	0.09	0.18	<0.01
(constant)	0.28		<0.01
R^2=0.58 d.f.=3, 206 F-model=96.20 p<0.001 CA=0.64			
kitchen NO_2 level	0.33	0.50	<0.01
living room NO_2 level	0.26	0.27	<0.01
number of doors between kitchen and bedroom	-0.33	-0.13	0.03
(constant)	1.11		<0.01
R^2=0.53 d.f.=3, 124 F-model=51.35 p<0.001 CA=0.68			
living room NO_2 level	0.80	0.78	<0.01
type of space heating	-0.11	-0.19	0.03
use of interior bedroom door	0.02	0.16	0.04
(constant)	0.41		<0.01
R^2=0.53 d.f.=3, 78 F-model=31.05 p<0.001 CA=0.68			

TABLE 41. Geometric mean and range of weekly average NO_2 levels in kitchen, living room and bedroom obtained in this and related studies in Dutch homes between 1980-1984

study/city	location		weekly average NO_2 concentration ($\mu g/m^3$) geometric mean	range
Ede	kitchen	n=173	65	9-539
suburban	living room	n=173	36	8-166
this study	bedroom	n=172	28	7-151
Rotterdam	kitchen	n=102	88	27-525
urban (inner-city)	living room	n=102	47	16-212
this study	bedroom	n=102	41	7-173
Arnhem/Enschede	kitchen	n=294	74	8-352
urban	living room	n-289	37	6-258
Lebret et al.1981				
Vlagtwedde	kitchen	n=164	59	9-292
rural	living room	n=163	29	9-180
Remijn et al.1984	bedroom	n=164	17	8-103
Rotterdam	kitchen	n=223	85	17-589
urban (inner-city)	living room	n=227	51	11-207
Hoek et al.1984	bedroom	n=228	33	9-109
Wageningen	kitchen	n=35	62	13-247
suburban	living room	n=35	39	15-117
Noy et al.1984	bedroom	n=35	29	6-104

TABLE 42. Average NO_2 concentrations ($\mu g/m^3$) in the 15 homes of the repeated measurement program (March 1982-February 1983) by indoor location and season

location	season winter	spring	summer	autumn
kitchen	55	58	42	46
living room	25	28	26	22
bedroom	19	24	22	19

TABLE 43. Reliability coefficient for a single week-long indoor NO_2 measurement by indoor location and season (repeated measurement program, March 1982-February 1983)

location	season			
	winter	spring	summer	autumn
kitchen	0.87	0.84	0.71	0.80
living room	0.87	0.82	0.57	0.81
bedroom	0.93	0.71	0.50	0.72

TABLE 44. Percentage of homes in which weekly average indoor RSP levels exceeded the 24-hour average TSP concentration-limit of 260 $\mu g/m^3$ and 24-hour average PM_{10} concentration-limit of 150 $\mu g/m^3$ of US Primary Standard for outdoor particulate matter, respectively of the proposed revision of the standard (EPA 1984); week-long measurement program (winter 1981/82, 1982/83)

	percentage of homes with indoor RSP levels exceeding	
	260 $\mu g/m^3$ (TSP)	150 $\mu g/m^3$ (PM_{10})
Ede (post-war homes, n=169)	4	15
Rotterdam (pre-war homes, n=91)	1	9

TABLE 45. Independent variables used in multiple regression analysis with the logarithm of weekly average RSP levels in the living room as dependent variables (week-long measurement program, winter 1981/82, 1982/83)

	independent variables	comment
	family size	
set 1	frequency of vacuum cleaning	number of times per week
n=254	number of smoking occupants	
	volume of the living room	m^3
	type of space heating	central heating=1; local gas heaters=2
	city	Ede=1; Rotterdam=2
	family size	
	frequency of vacuum cleaning	number of times per week
	cigarette consumption*	according to questionnaire (cf part 2, section 2.3)
set 2	cigar consumption*	
n=254	pipe consumption*	
	volume of the living room	m^3
	type of space heating	central heating=1; local gas heaters=2
	city	Ede=1; Rotterdam=2
	person-hours	persons x hours spent indoors per day according to diary information (cf part 2, section 2.3)
set 3	frequency of vacuum cleaning	
n=184	cigarette consumption*	
	cigar consumption*	
	pipe consumption*	
	use of ventilation provisions in living room*	
	volume of living room	m^3
	type of space heating	central heating=1; local gas heaters=2
	city	Ede=1; Rotterdam=2

* logarithmic transformation

TABLE 46. Regression equation of the logarithm of weekly average RSP levels in the living room on the independent variables of set 1 (cf. table 45)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
number of smokers	0.25	0.63	<0.01
(constant)	1.54		<0.01

R^2=0.40 d.f.=1, 252 F-model=168.29 p<0.001 CA=0.77

TABLE 47. Regression equation of the logarithm of weekly average RSP levels in the living room on the independent variables of set 2 (cf. table 45)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
cigarette consumption	0.37	0.65	<0.01
cigar consumption	0.53	0.23	0.01
family size	0.03	0.11	0.01
(constant)	1.41		<0.01

R^2=0.49 d.f.=3, 250 F-model=83.70 p<0.001 CA=0.71

TABLE 48. Regression equation of the logarithm of weekly average RSP levels in the living room on the independent variables of set 3 (cf. table 45)

selected independent variables	regression coefficients	standardized regression coefficients	significance level
cigarette consumption	0.24	0.64	<0.01
cigar consumption	0.19	0.16	<0.01
person-hours	0.002	0.14	0.01
use of ventilation provisions	0.05	0.11	0.04
(constant)	1.32		<0.01

R^2=0.49 d.f.=4, 179 F-model=43.20 $p<0.001$ CA=0.75

TABLE 49. Geometric mean and range (in parenthesis) of instantaneous RSP concentrations (μg/m^3) in 3 indoor locations in homes in Ede and Rotterdam (week-long measurement program, winter 1981/82, 1982/83)

	Ede post-war homes	Rotterdam pre-war homes
kitchen	61 (10-769) n=112	78 (10-780) n=95
living room	68 (10-681) n=121	80 (10-1000) n=92
bedroom	47 (10-255) n=105	54 (10-1000) n=94

TABLE 50. Geometric mean of instantaneous RSP concentrations in the living room broken down by prior smoking activities (week-long measurement program, winter 1981/82, 1982/83)

time since smoking		geometric mean RSP concentration (μg/m^3)
no smoking	n=98	41
more then 1 hour ago	n=18	52
between 0.5 to 1 hour ago	n= 7	76
less than 0.5 hour ago	n=27	141
during the measurements	n=54	191

Table 51. Mean and range of weekly average RSP levels from repeated measurements in 4 homes (repeated measurement program, July 1982-February 1983)

home		RSP concentration (μg/m^3)	
		mean	range
A	n=15	45	20- 84
B	n=15	35	16- 61
C*	n=15	105	42-149
D*	n=14	118	56-184

* smokers homes

TABLE 52. Classification of volatile organic compounds in 5 groups

Straight-chain hydrocarbons	Branched-chain hydrocarbons	Alicyclic hydrocarbons	Aromatic hydrocarbons	Chlorinated hydrocarbons
n-hexane	3-methylpentane	cyclohexane	benzene	tetrachloromethane
n-heptane	2-methylhexane	methylcyclohexane	toluene	trichloroethene
n-octane	3-methylhexane	dimethylcyclopentanes	xylenes	tetrachloroethene
n-nonane			ethylbenzene	chlorobenzene
n-decane			n-propylbenzene	m-dichlorobenzene
n-undecane			i-propylbenzene	p-dichlorobenzene
n-dodecane			o-methylethylbenzene	1,2,3-trichlorobenzene
n-tridecane			m-methylethylbenzene	1,2,4-trichlorobenzene
n-tetradecane			p-methylethylbenzene	1,3,5-trichlorobenzene
n-pentadecane			1,2,3-trimethylbenzene	
n-hexadecane			1,2,4-trimethylbenzene	
			1,3,5-trimethylbenzene	
			n-butylbenzene	
			p-methyl-i-propylbenzene	
			naphtalene	
			1-methylnaphtalene	

TABLE 53. Percentage of homes with volatile organic compounds (VOC) levels above detection limit, median and maximum concentration of VOC in three age-groups of homes and outdoors, and the ratio of median indoor/median outdoor concentration (week-long measurement program, winter 1981/82, 1982/83)

Compound	% above det.lim.	Ede post-war homes median	Ede post-war homes maximum	Rotterdam pre-war homes median	Rotterdam pre-war homes maximum	Ede < 6 years old homes median	Ede < 6 years old homes maximum	outdoors median	outdoors maximum	overall indoor/outdoor ratio
n-hexane	99	4	107	5	338	3	178	2	4	2
n-heptane	100	3	68	3	30	2	556	1	3	3
n-octane	98	2	60	1	36	1	533	< 0.3	1	> 3
n-nonane	99	4	269	3	278	6	407	< 0.3	8	> 15
n-decane	99	9	433	8	807	14	905	0.6	5	> 15
n-undecane	97	5	191	3	229	9	445	0.4	3	15
n-dodecane	95	2	118	1	40	4	96	< 0.3	1	> 10
n-tridecane	92	1	18	1	13	2	38	< 0.3	< 0.3	> 3
n-tetradecane	97	2	8	1	7	2	46	< 0.3	< 0.3	> 6
n-pentadecane	95	1	4	0.9	3	2	5	< 0.3	0.5	> 3
n-hexadecane	61	< 0.3	3	0.8	2	1	4	< 0.3	< 0.3	3
3-methylpentane	99	3	101	3	82	2	52	1	3	3
2-methylhexane	99	2	54	3	19	2	278	1	4	3
3-methylhexane	99	2	44	2	14	1	233	0.9	3	2
cyclohexane	98	1	22	2	26	1	355	0.4	2	3
methylcyclohexane	100	1	50	2	33	1	504	0.6	2	3
dimethylcyclopentane is.	32	< 0.3	3	< 0.3	2	< 0.3	60	< 0.3	0.4	> 1
dimethylcyclopentane is.	27	< 0.3	2	< 0.3	2	< 0.3	29	< 0.3	0.4	> 1
dimethylcyclopentane is.	85	0.7	8	0.7	5	0.5	59	< 0.3	0.9	> 2
limonene	98	26	216	18	773	45	693	< 0.3	10	> 80
benzene	99	7	148	7	24	5	53	3	7	2
toluene	99	40	697	23	526	43	2252	5	17	8
xylenes	99	12	178	9	159	10	753	3	30	3
ethylbenzene	94	3	45	2	117	2	138	0.4	14	5
n-propylbenzene	65	1	27	< 0.3	18	0.4	15	< 0.3	0.7	> 2
i-propylbenzene	45	0.3	11	< 0.3	5	< 0.3	10	< 0.3	0.3	--
O-methylethylbenzene	80	2	72	1	51	1	156	< 0.3	2	> 3
m-methylethylbenzene	95	3	166	3	82	3	227	0.4	2	8
p-methylethylbenzene	82	2	77	1	54	2	94	< 0.3	1	> 6
1,2,3-trimethylbenzene	57	1	40	< 0.3	24	< 0.3	16	< 0.3	0.9	> 1
1,2,4-trimethylbenzene	98	6	276	4	165	5	400	0.7	4	7
1,3,5-trimethylbenzene	92	2	99	1	37	2	93	< 0.3	1	> 6
n-butylbenzene	72	0.9	40	0.8	30	1	20	< 0.3	0.6	> 3
p-methyl-i-propylbenzene	76	0.7	32	0.6	11	1	10	< 0.3	< 0.3	> 3
naphtalene	25	< 0.3	14	< 0.3	4	< 0.3	7	< 0.3	< 0.3	--
1-methylnaphtalene	11	< 0.3	2	< 0.3	0.5	< 0.3	0.9	< 0.3	< 0.3	--
tetrachloromethane	8	< 4	6	< 4	25	< 4	25	< 4	20	--
trichloroethene	2	< 2	106	< 2	11	< 2	30	< 2	< 2	--
tetrachloroethene	30	< 2	205	< 2	49	< 2	182	< 2	< 2	--
chlorobenzene	10	< 0.4	< 0.4	< 0.4	3	< 0.4	27	< 0.4	< 0.4	--
m-dichlorobenzene	4	< 0.6	9	< 0.6	6	< 0.6	6	< 0.6	< 0.6	--
p-dichlorobenzene	50	2	138	< 0.6	299	< 0.6	240	< 0.6	< 0.6	> 3
1,2,3-trichlorobenzene	2	< 0.8	3	< 0.8	3	< 0.8	28	< 0.8	< 0.8	--
1,2,4-trichlorobenzene	3	< 0.8	15	< 0.8	5	< 0.8	33	< 0.8	< 0.8	--
1,3,5-trichlorobenzene	1	< 0.8	8	< 0.8	< 0.8	< 0.8	5	< 0.8	< 0.8	--

Volatile organic compound concentration ($\mu g/m^3$)

TABLE 54. Patterns of 2 clusters of interrelated volatile organic compounds in 3 age-groups of homes, resulting from maximum likelihood factor analysis with oblique rotation; compounds with factor loadings of 0.5 or higher are indicated with a + (week-long measurement program, winter 1981/82, 1982/83)

Compound	cluster 1			cluster 2		
	post-war homes	pre-war homes	<6 years old homes	post-war homes	pre-war homes	<6 year old homes
n-hexane		+	+			
n-heptane	+	+	+			
n-octane	+					
n-nonane				+	+	+
n-decane				+	+	+
n-undecane				+	+	
n-dodecane					+	
n-tridecane					+	
n-tetradecane						
n-pentadecane						
n-hexadecane						
3-methylpentane		+	+			
2-methylhexane	+	+	+			
3-methylhexane	+	+	+			
cyclohexane						
methylcyclohexane	+	+	+			
dimethylcyclopentane is.	+	+	+			
dimethylcyclopentane is.	+	+	+			
dimethylcyclopentane is.	+	+	+			
limonene						
benzene		+				
toluene						
xylenes					+	+
ethylbenzene					+	+
n-propylbenzene						
i-propylbenzene						
O-methylethylbenzene				+		+
m-methylethylbenzene					+	+
p-methylethylbenzene				+	+	+
1,2,3-trimethylbenzene						
1,2,4-trimethylbenzene					+	+
1,3,5-trimethylbenzene					+	+
n-butylbenzene				+	+	+
p-methyl-i-propylbenzene				+		+
naphtalene						
1-methylnaphtalene						
tetrachloromethane						
trichloroethene						
tetrachloroethene						
chlorobenzene					+	
m-dichlorobenzene						
p-dichlorobenzene						
1,2,3-trichlorobenzene						
1,2,4-trichlorobenzene						
1,3,5-trichlorobenzene						

TABLE 55. Sign of regression coefficients of independent variables selected in multiple regression equations ($p < 0.10$) with the logarithm of volatile organic compound concentrations as dependent variables and the proportion of the variance in the dependent variables explained by the selected independent variables (R^2), for different age-groups of homes (week-long measurement program, winter 1981/82, 1982/83)

dependent variables	age-group of homes	independent variables: use of solvent	use of paint	use of adhesives	use of aerosol sprays	presence of oil lamp -burners	presence of smokers	explained variance R^2
Straight-chain hydrocarbons	post-war	+					+	0.16
	pre-war	+		-			+	0.15
	<6 years old		+			+	+	0.07
	all homes	+	+			+	+	0.13
Branched-chain hydrocarbons	post-war	+					+	0.07
	pre-war							0.00
	<6 years old							0.00
	all homes	+					+	0.01
Alicyclic hydrocarbons	post-war	+						0.07
	pre-war							0.00
	<6 years old							0.00
	all homes	+				+	+	0.04
Aromatic hydrocarbons	post-war	+					+	0.17
	pre-war	+						0.03
	<6 years old		+					0.09
	all homes	+	+				+	0.11
Chlorinated hydrocarbons	post-war							0.00
	pre-war			-				0.02
	<6 years old	+					+	0.10
	all homes	+			+		+	0.03
cluster 1	post-war	+						0.08
	pre-war	+						0.04
	<6 years old					+		0.02
	all homes	+				+	+	0.06
cluster 2	post-war	+					+	0.22
	pre-war	+						0.22
	<6 years old		+					0.10
	all homes	+	+				+	0.18
limonene	post-war	-	+	+			-	0.06
	pre-war			-				0.08
	<6 years old							0.00
	all homes		+					0.01

TABLE 56. Geometric mean of straight-chain and aromatic hydrocarbon levels (µg/m³) broken down by the use of solvents and the presence of smokers in the homes (week-long measurement program, winter 1981/82, 1982/83)

compounds	presence of smokers	solvent use	
		no	yes
straight-chain hydrocarbon concentration	no smokers	39 (n=110)	66 (n=17)
	smokers	54 (n=168)	185 (n=23)
aromatic hydrocarbon concentration	no smokers	67 (n=110)	104 (n=17)
	smokers	87 (n=168)	226 (n=23)

TABLE 57. Median and maximum concentration (µg/m^3) of volatile organic compounds and reliability coefficient of 14 repeated measurements in four homes every second week between August 1982 and February 1983 (repeated measurement program)

Compound	Volatile organic compound concentration (µg/m^3)								
	Home A		Home B		Home C		Home D		Reliability
	median	maximum	median	maximum	median	maximum	median	maximum	coefficient
n-hexane	2	3	3	214	2	12	54	193	0.39
n-heptane	2	2	2	4	3	10	2	139	0.02
n-octane	2	2	0.7	2	1	11	1	12	0.07
n-nonane	14	33	3	17	17	33	5	46	0.21
n-decane	48	106	11	43	29	58	9	72	0.47
n-undecane	115	194	5	16	8	21	3	12	0.85
n-dodecane	98	249	0.8	3	1	4	0.9	2	0.80
n-tridecane	37	223	0.9	2	0.5	2	0.9	1	0.52
n-tetradecane	9	11	2	3	0.6	2	1	2	0.96
n-pentadecane	2	4	1	2	0.5	1	1	2	0.70
n-hexadecane	1	2	< 0.3	2	< 0.3	< 0.3	< 0.3	1	0.37
3-methylpentane	1	2	3	39	1	5	20	46	0.58
-methylhexane	1	2	2	4	0.9	3	2	143	0.04
-methylhexane	1	2	2	3	0.7	2	2	105	0.03
cyclohexane	0.9	2	0.9	72	0.5	1	7	143	0.07
methylcyclohexane	1	2	1	3	0.6	2	0.9	60	0.03
dimethylcyclopentane is.	< 0.3	0.3	< 0.3	0.5	< 0.3	< 0.3	< 0.3	13	0.03
dimethylcyclopentane is.	< 0.3	0.3	< 0.3	0.4	< 0.3	< 0.3	< 0.3	23	0.02
dimethylcyclopentane is.	0.6	0.9	0.6	1	0.3	0.8	0.5	34	0.02
limonene	24	88	5	191	37	77	39	174	0.04
benzene	3	7	5	11	5	11	6	10	0.32
toluene	21	51	27	70	16	68	41	765	0.08
xylenes	7	15	5	14	7	19	7	16	0.03
ethylbenzene	1	3	1	8	2	5	2	10	0.01
n-propylbenzene	< 0.3	2	< 0.3	0.9	2	4	0.5	2	0.31
i-propylbenzene	< 0.3	3	< 0.3	0.5	0.6	1	0.5	1	0.11
o-methylethylbenzene	< 0.3	7	< 0.3	3	4	9	2	12	0.18
m-methylethylbenzene	3	8	2	4	5	16	2	12	0.23
p-methylethylbenzene	3	7	0.8	3	3	6	1	10	0.15
1,2,3-trimethylbenzene	< 0.3	5	< 0.3	3	< 0.3	6	< 0.3	3	0.14
1,2,4-trimethylbenzene	8	17	4	11	9	20	4	20	0.28
1,3,5-trimethylbenzene	2	17	1	10	3	19	1	20	0.20
n-butylbenzene	3	7	< 0.3	3	3	7	0.6	5	0.44
p-methyl-i-propylbenzene	1	6	0.7	63	1	3	0.9	3	0.01
naphtalene	< 0.3	3	< 0.3	1	< 0.3	2	< 0.3	1	0.35
1-methylnaphtalene	0.6	0.9	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.70
tetrachloromethane	< 4	< 4	< 4	489	< 4	< 4	< 4	42	0.01
trichloroethene	3	5	3	5	< 2	4	3	174	0.02
tetrachloroethene	< 2	6	4	6	< 2	5	3	208	0.02
chlorobenzene	< 0.4	0.5	< 0.4	0.5	< 0.4	< 0.4	< 0.4	< 0.4	0.02

FIGURE 1. Sampling and instrument arrangement of the real-time monitoring program

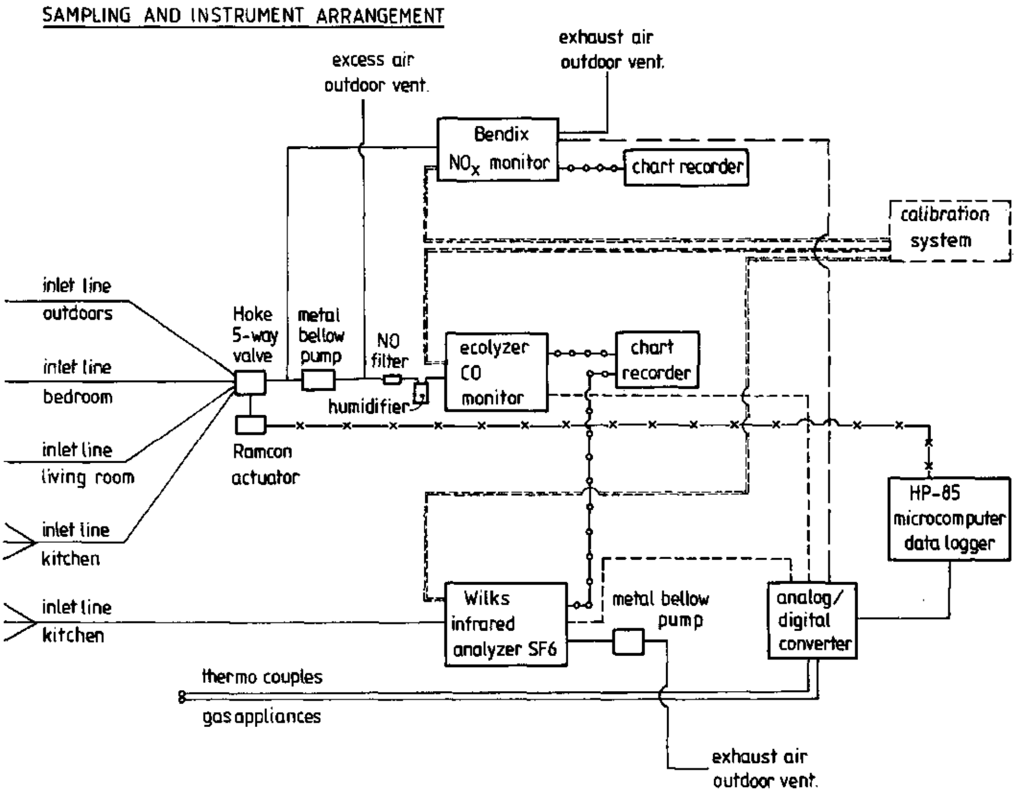
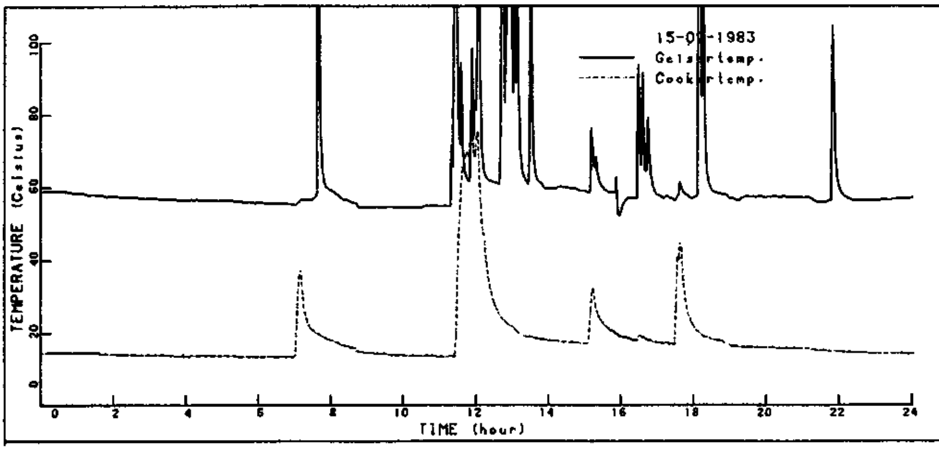


FIGURE 2. Pattern of use of unvented gas appliances, monitored by thermo couples placed above the appliances; examples from home 2 and 3 of the real-time monitoring program (winter 1982/83, 1983/84)(geiser: solid line, cooker: dotted line)

home 2



home 3

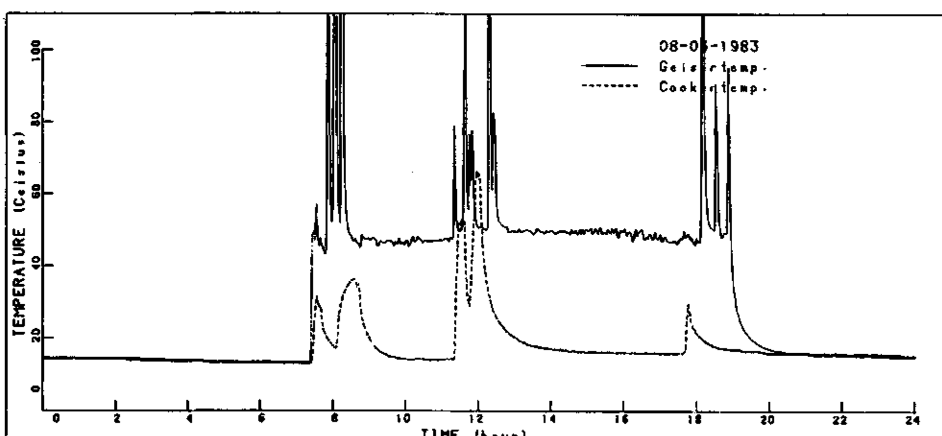


FIGURE 3. Use of the oven for space heating in home 7 of the real-time monitoring program (winter 1982/83, 1983/84)

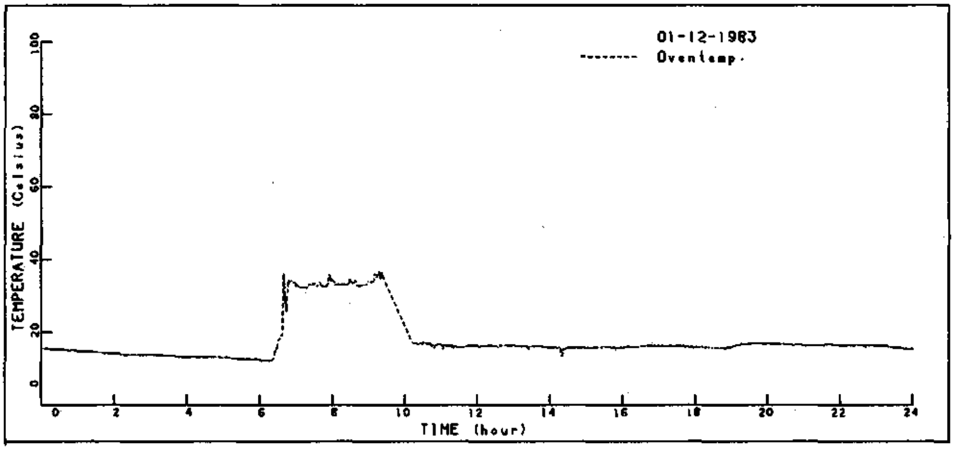


FIGURE 4. Use of gas appliances (above), air-change rate in the kitchen (centre) and SF_6 concentration in the kitchen (below), in home 4 of the real-time monitoring program (winter 1982/83, 1983/84)

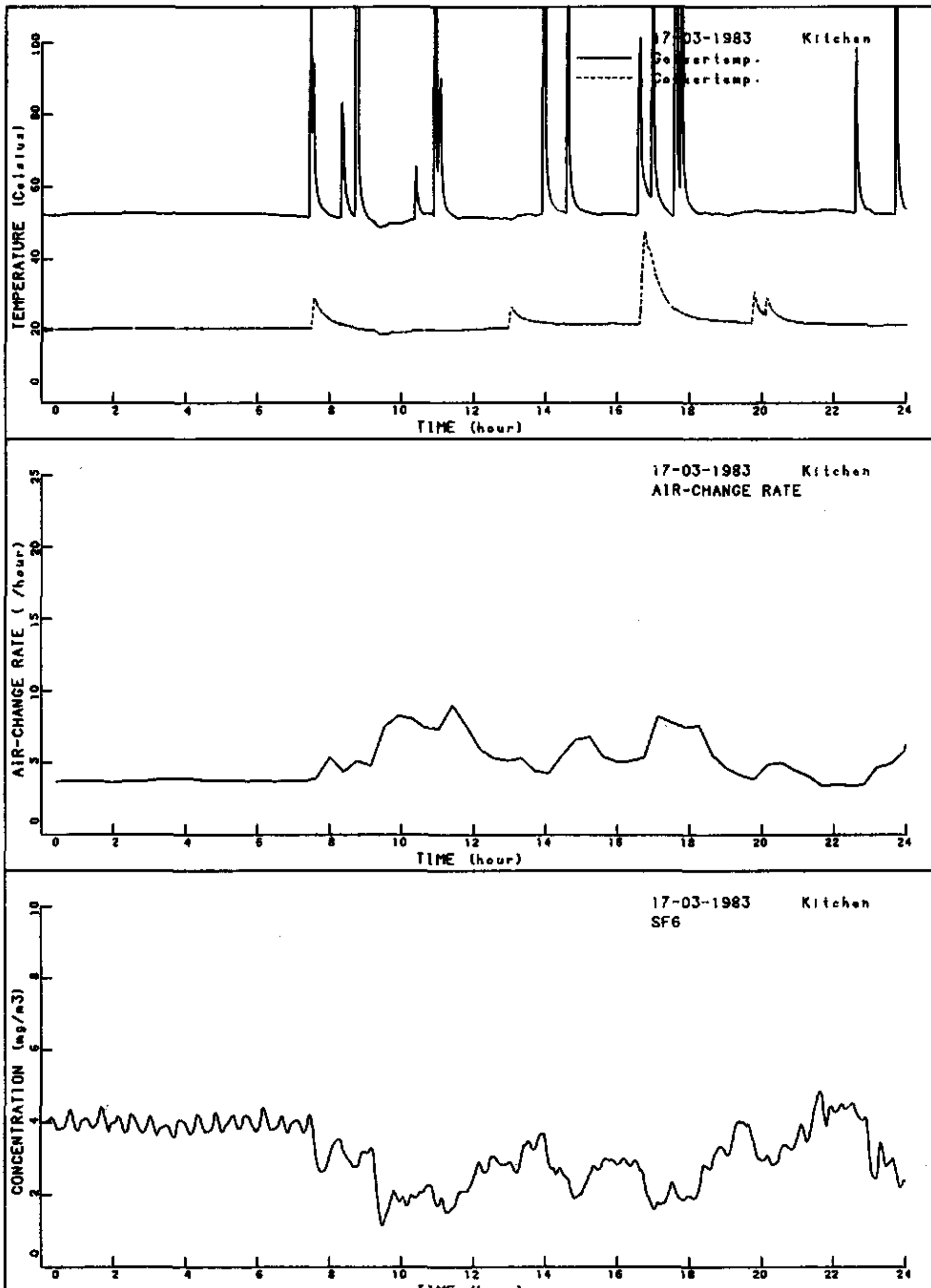


FIGURE 5. Operation of the regrigerator motor, monitored by a thermo couple (above) and SF_6 concentration in the kitchen (below), in home 4 of the real-time monitoring program (winter 1982/83, 1983/84)

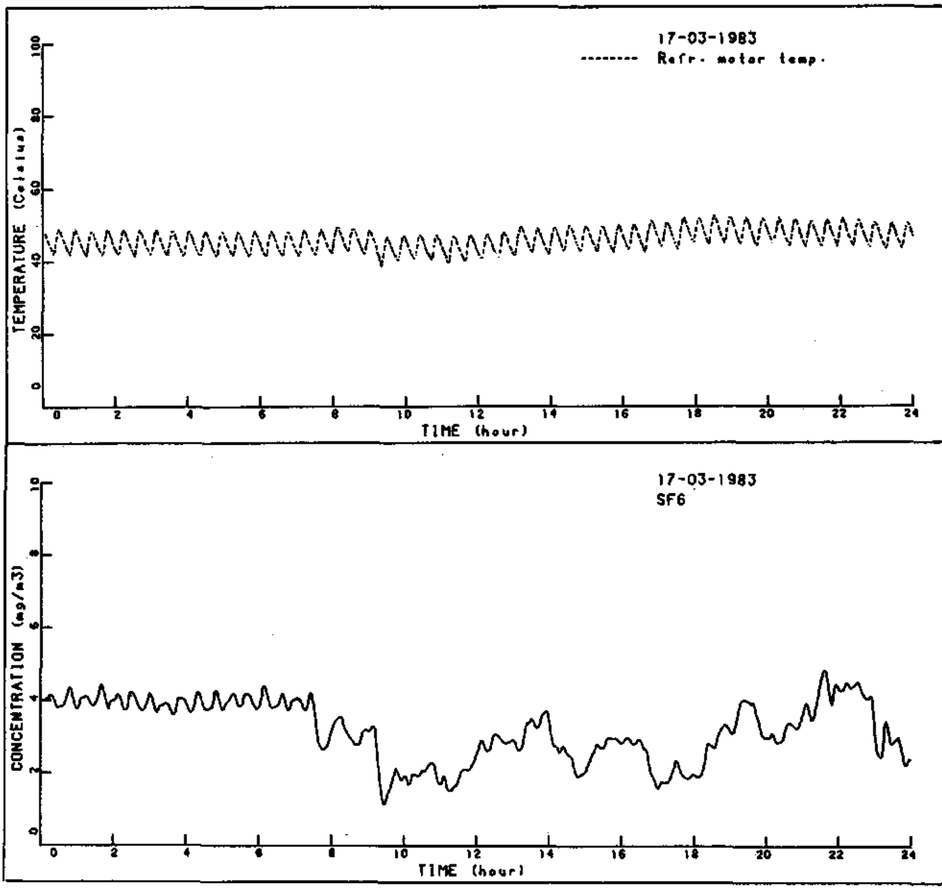
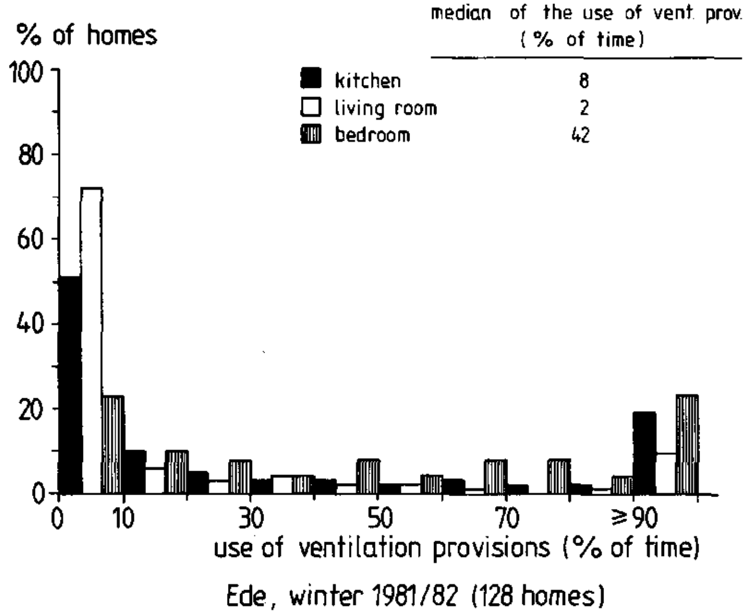


FIGURE 6. Frequency distribution and median of the total use of ventilation provisions, according to the diaries, in 3 rooms in Ede (post-war homes) and Rotterdam (pre-war homes); week-long measurement program (winter 1981/82, 1982/83)



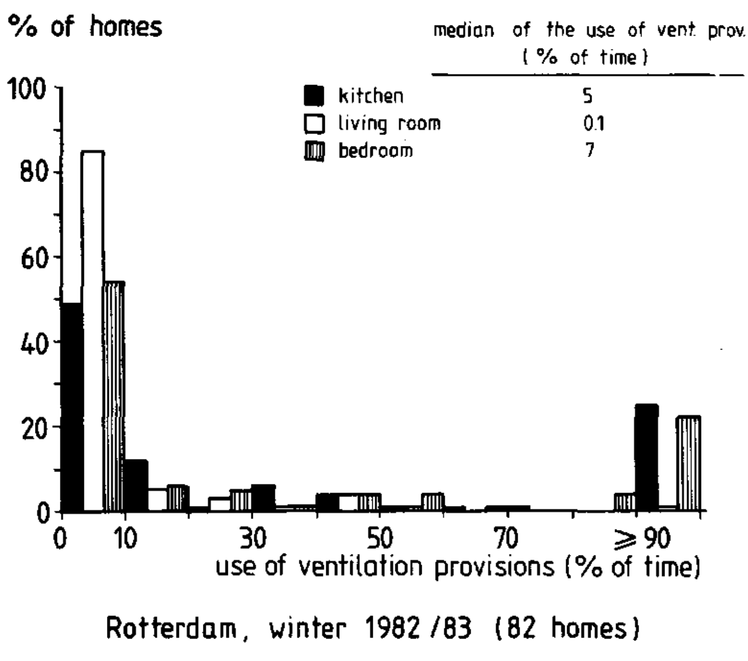


FIGURE 7. CO concentrations (mg/m^3) versus time of day in 3 locations in home 12 of the real-time monitoring program, winter 1982/83, 1983/84

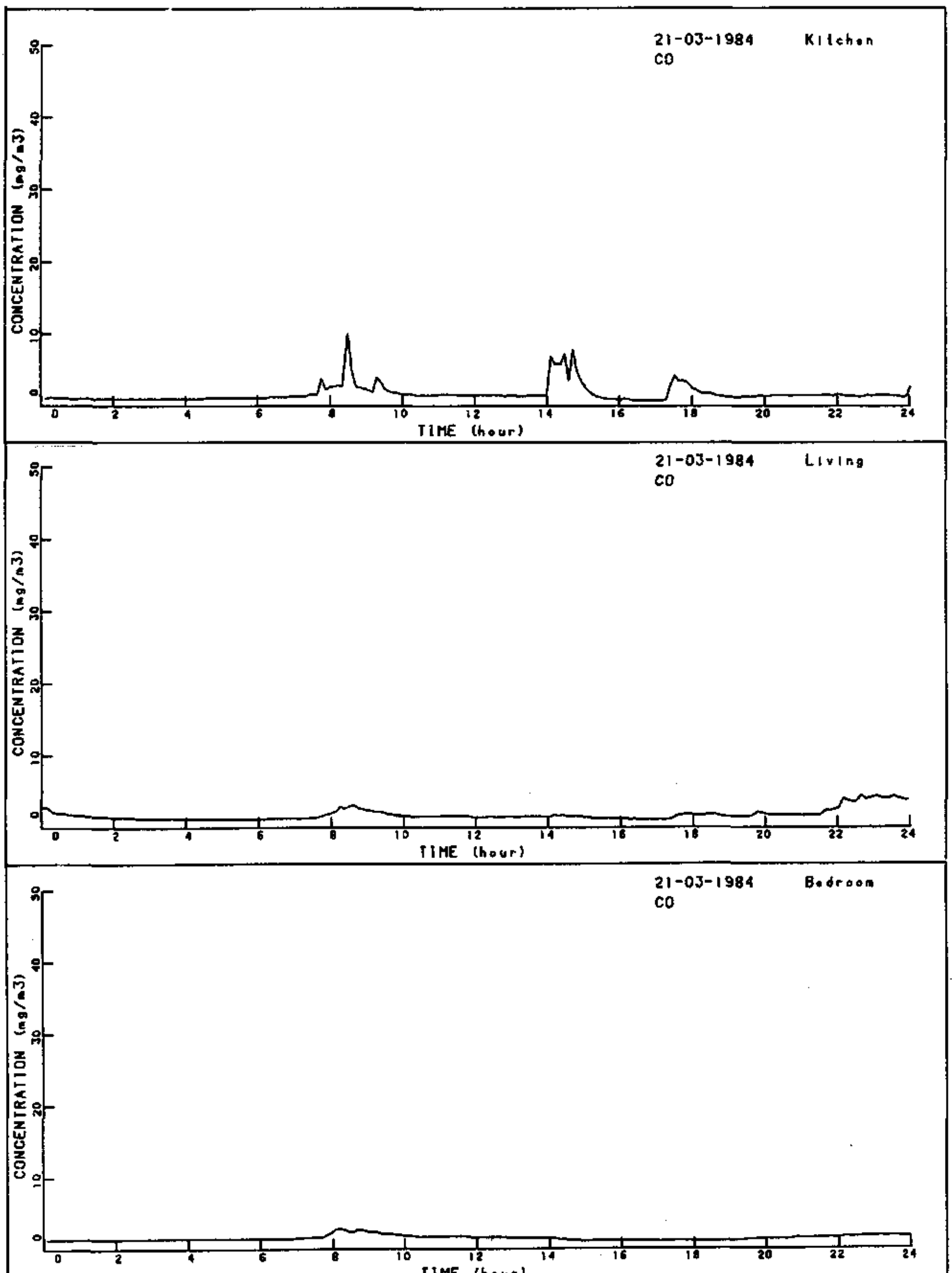
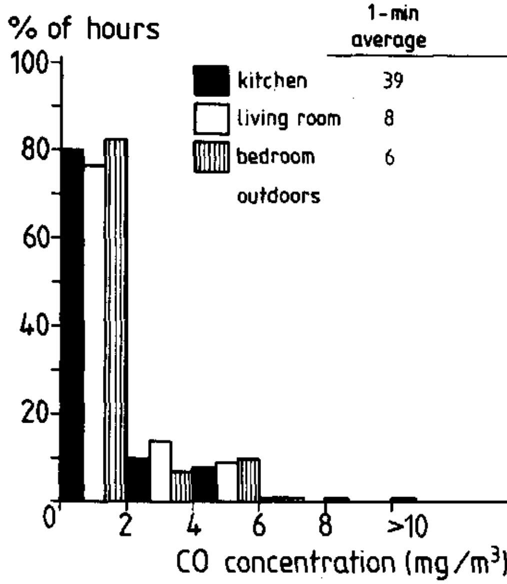
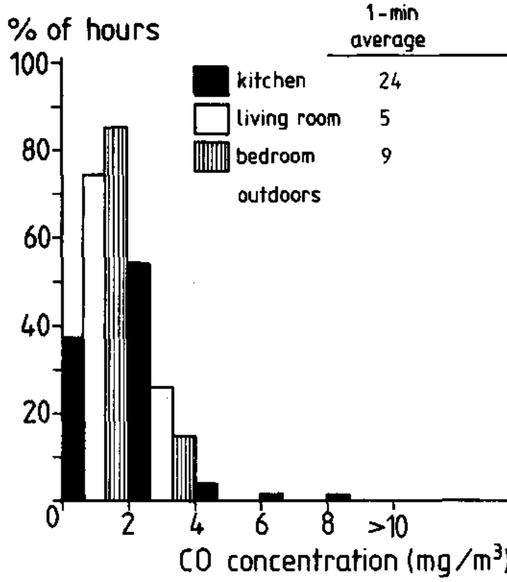


FIGURE 8. Frequency distribution of 1-hour average CO concentrations; maximum 1-minute average and 1-hour average CO concentration and overall mean concentration (mg/m³) in 12 homes of the real-time monitoring program (winter 1982/83, 1983/84)



	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	39	14	2
living room	8	7	2
bedroom	6	6	1
outdoors			<1

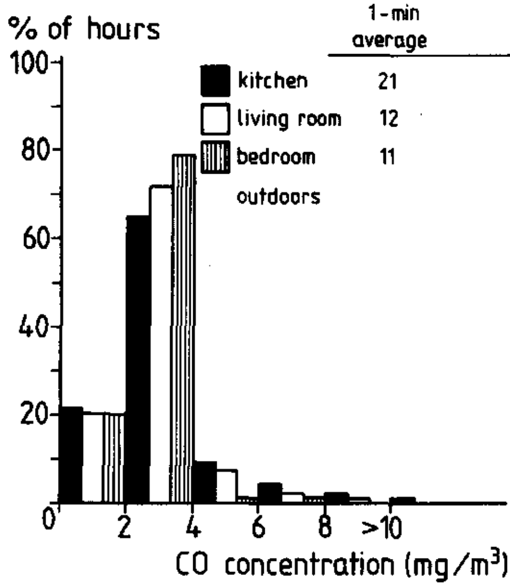
HOME 1 (136 hours)



	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	24	10	3
living room	5	2	2
bedroom	9	3	1
outdoors			1

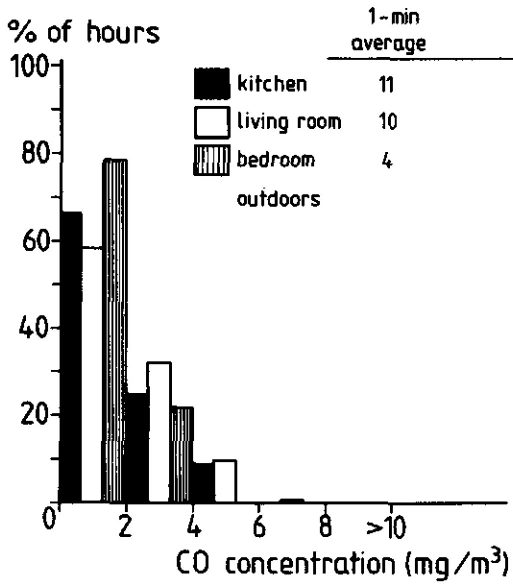
HOME 2 (48 hours)

FIGURE 8 (continued)



	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	21	12	3
living room	12	9	3
bedroom	11	8	2
outdoors			2

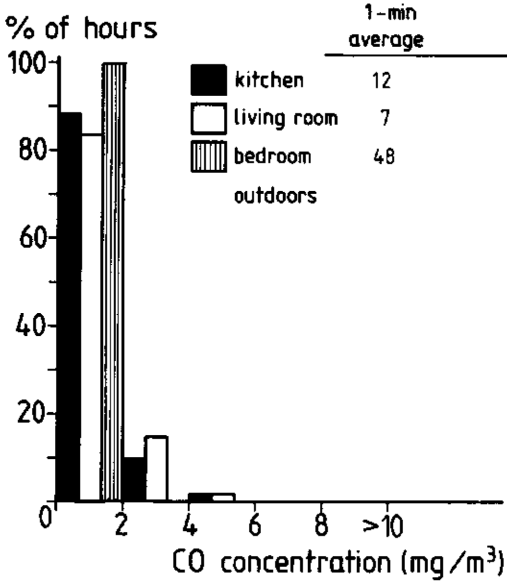
HOME 3 (230 hours)



	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	11	5	2
living room	10	6	2
bedroom	4	3	< 1
outdoors			< 1

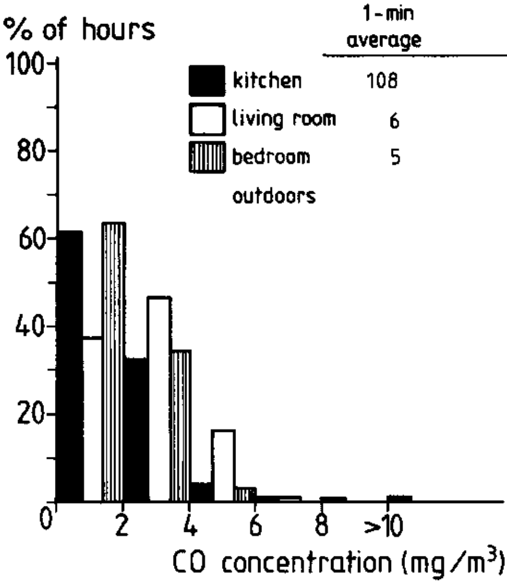
HOME 4 (164 hours)

FIGURE 8 (continued)



	maximum concentration (mg/m³) 1-min average	maximum concentration (mg/m³) 1-hour average	overall mean concentration (mg/m³)
kitchen	12	4	1
living room	7	5	1
bedroom	48	6	< 1
outdoors			< 1

HOME 5 (227 hours)

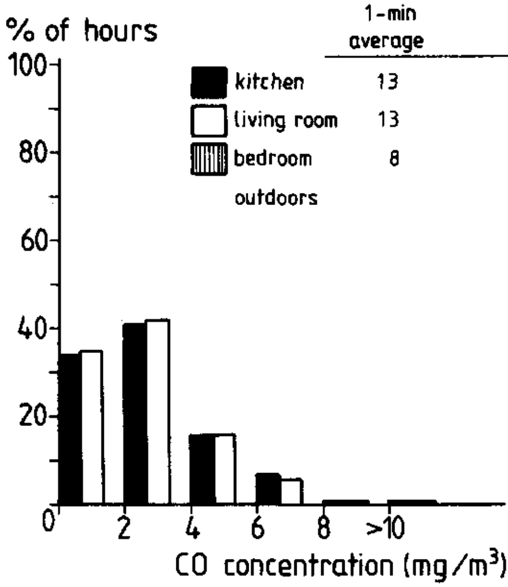


	maximum concentration (mg/m³) 1-min average	maximum concentration (mg/m³) 1-hour average	overall mean concentration (mg/m³)
kitchen	108	56	2
living room	6	6	2
bedroom	5	5	2
outdoors			2

HOME 6 (273 hours)

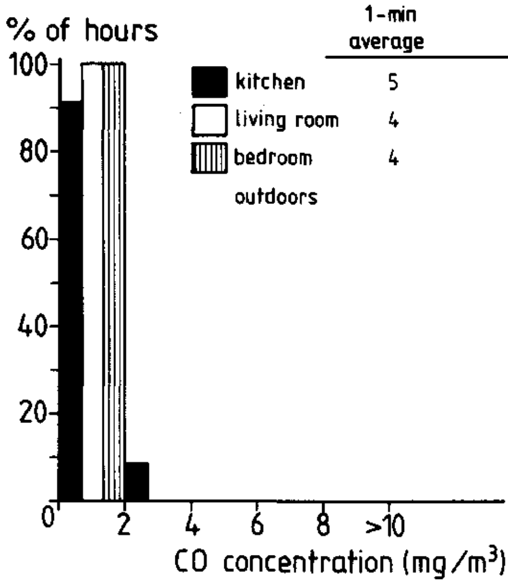
FIGURE 8 (continued)

	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	13	11	3
living room	13	11	3
bedroom	8	–	2
outdoors			2



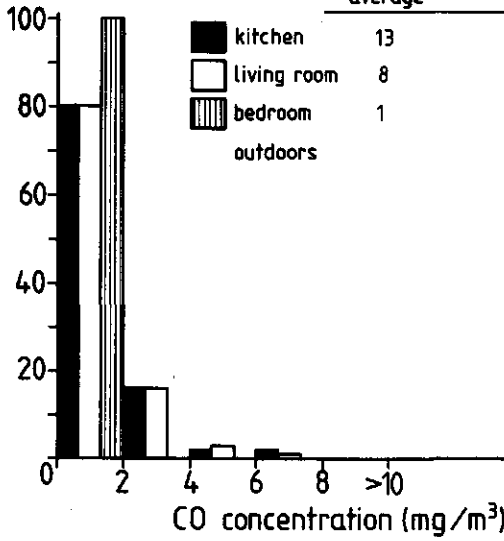
HOME 7 (179 hours)

	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	5	3	1
living room	4	2	1
bedroom	4	2	1
outdoors			1



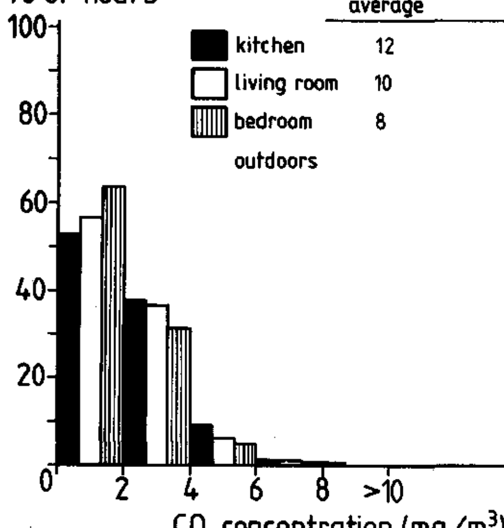
HOME 8 (187 hours)

FIGURE 8 (continued)



	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	13	7	1
living room	8	6	1
bedroom	1	1	<1
outdoors			<1

HOME 9 (136 hours)

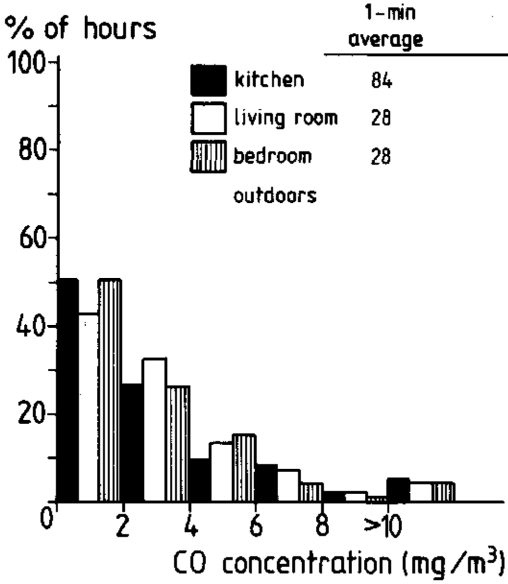


	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	12	8	2
living room	10	6	2
bedroom	8	6	1
outdoors			<1

HOME 10 (188 hours)

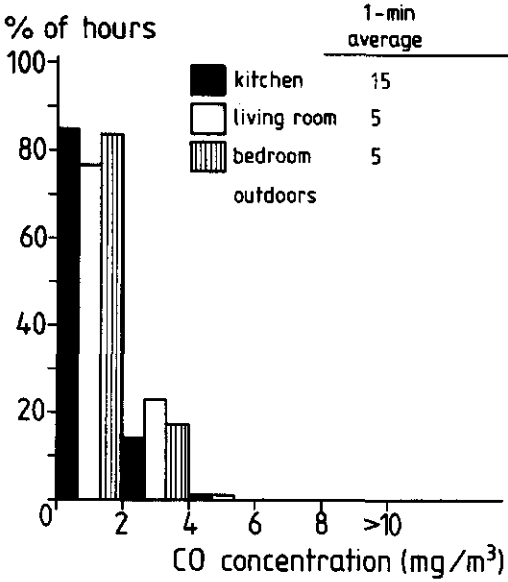
FIGURE 8 (continued)

	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	84	47	4
living room	28	26	4
bedroom	28	26	3
outdoors			1



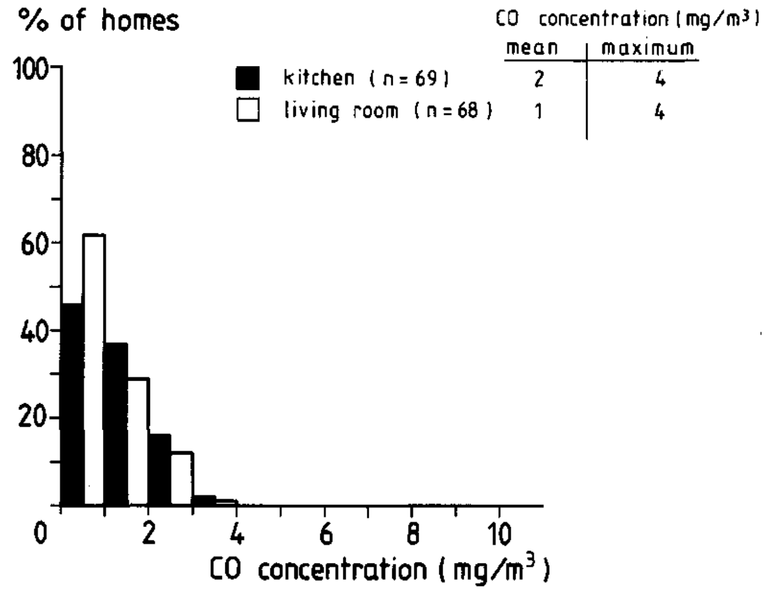
HOME 11 (203 hours)

	maximum concentration (mg/m³) 1-min average	1-hour average	overall mean concentration (mg/m³)
kitchen	15	6	1
living room	5	4	2
bedroom	5	4	1
outdoors			1

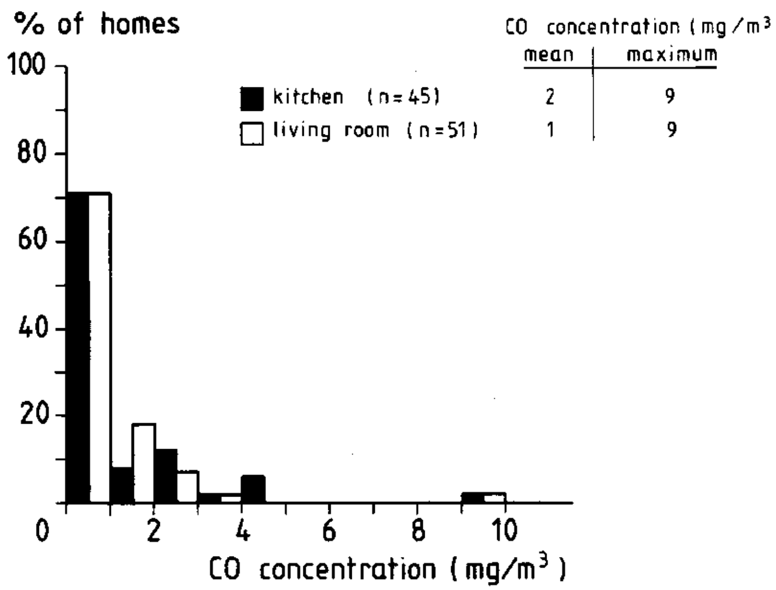


HOME 12 (222 hours)

FIGURE 9. Frequency distribution of weekly average CO concentrations (mg/m^3) in kitchens and living rooms in Ede (post-war homes) and Rotterdam (pre-war homes); week-long measurement program, winter 1981/82, 1982/83



Ede, winter 1981/82



Rotterdam, winter 1982/83

FIGURE 10. Pattern of use of unvented gas appliances (above) and simultaneous NO_x concentrations ($\mu g/m^3$) in the kitchen (below); example from home 2 of the real-time monitoring program (winter 1982/83, 1983/84)

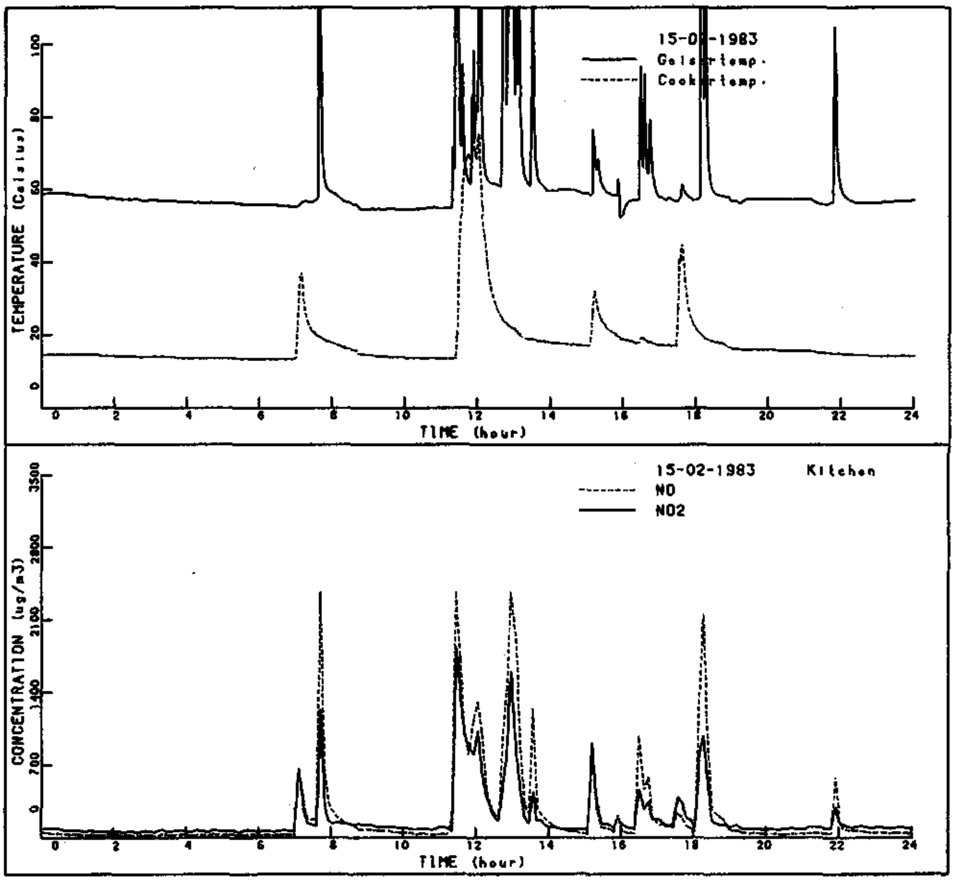


FIGURE 11. NO_x concentration pattern in the kitchen from the use of the gas cooker; example from home 9 of the real-time monitoring program (winter 1982/83, 1983/84)

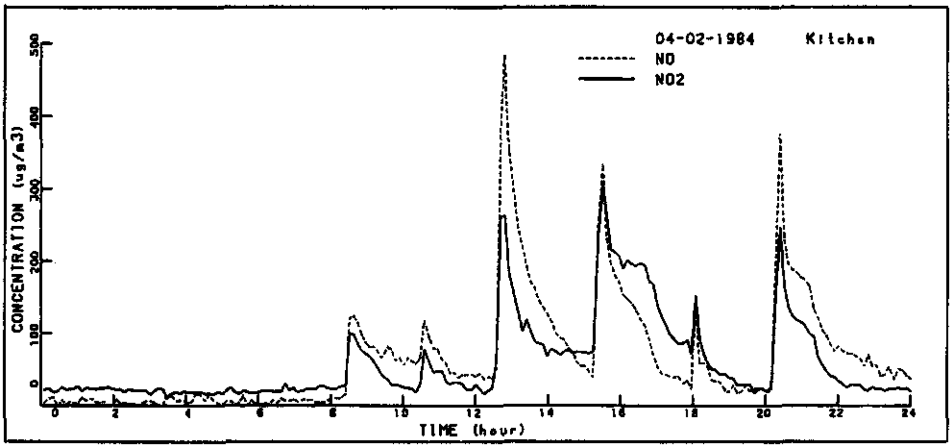
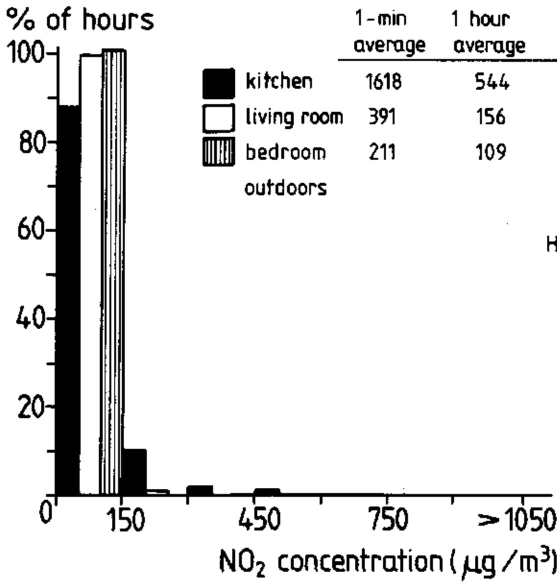
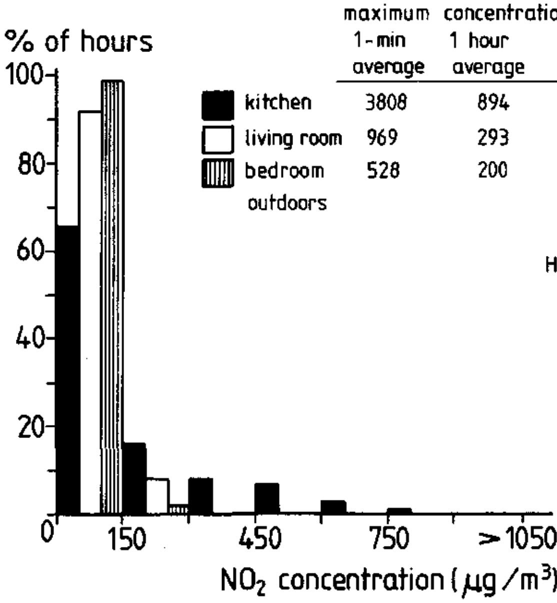


FIGURE 12. Frequency distribution of 1-hour average NO_2 concentration; maximum 1-minute, 1-hour and 24-hour average NO_2 concentration and overall mean NO_2 concentration (µg/m^3) in 12 homes of the real-time monitoring program (winter 1982/83, 1983/84)



	maximum concentration ($\mu g/m^3$) 1-min average	1 hour average	24-hour average	overall mean concentration ($\mu g/m^3$)
kitchen	1618	544	182	72
living room	391	156	88	33
bedroom	211	109	51	27
outdoors				25

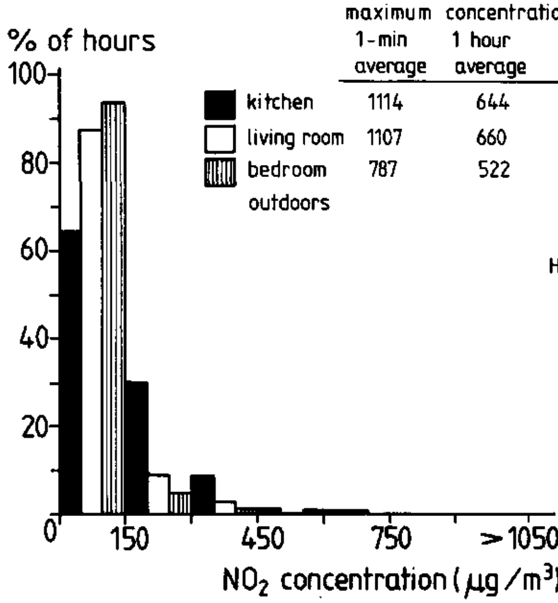
HOME 1 (136 hours)



	maximum concentration ($\mu g/m^3$) 1-min average	1 hour average	24-hour average	overall mean concentration ($\mu g/m^3$)
kitchen	3808	894	216	188
living room	969	293	89	74
bedroom	528	200	57	54
outdoors				42

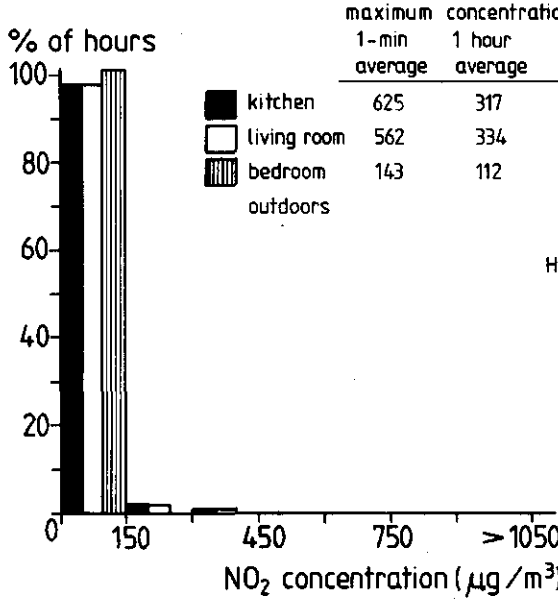
HOME 2 (160 hours)

FIGURE 12 (continued)



	maximum concentration (μg/m³) 1-min average	1 hour average	24-hour average	overall mean concentration (μg/m³)
kitchen	1114	644	218	147
living room	1107	660	177	93
bedroom	787	522	93	69
outdoors				57

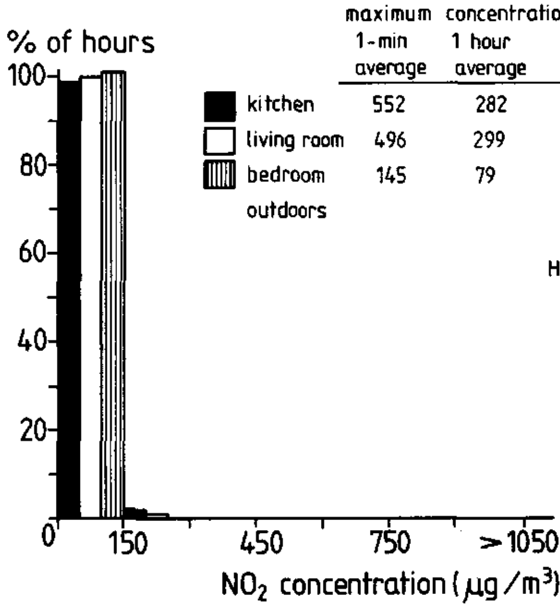
HOME 3 (230 hours)



	maximum concentration (μg/m³) 1-min average	1 hour average	24-hour average	overall mean concentration (μg/m³)
kitchen	625	317	67	54
living room	562	334	60	43
bedroom	143	112	44	30
outdoors				37

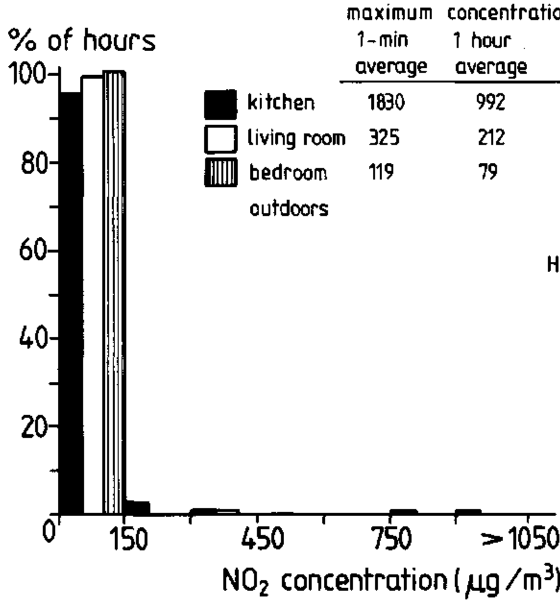
HOME 4 (164 hours)

FIGURE 12 (continued)



	maximum concentration (µg/m³) 1-min average	1 hour average	24-hour average	overall mean concentration (µg/m³)
kitchen	552	282	58	36
living room	496	299	49	32
bedroom	145	79	31	22
outdoors				26

HOME 5 (227 hours)



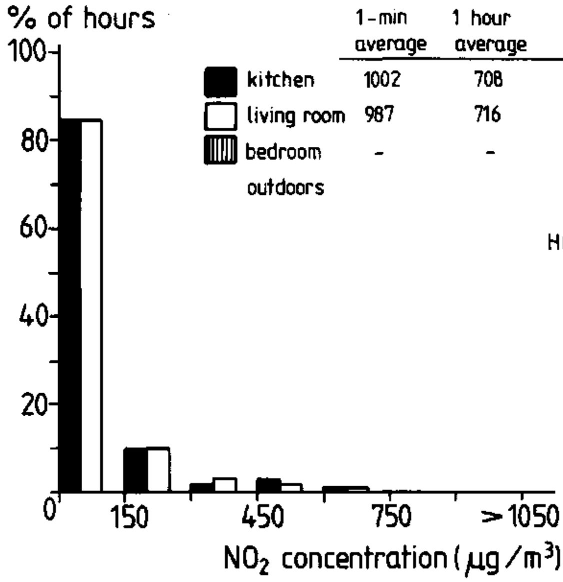
	maximum concentration (µg/m³) 1-min average	1 hour average	24-hour average	overall mean concentration (µg/m³)
kitchen	1830	992	140	50
living room	325	212	68	40
bedroom	119	79	22	16
outdoors				41

HOME 6 (273 hours)

FIGURE 12 (continued)

	maximum concentration ($\mu g/m^3$) 1-min average	1 hour average	24-hour average	overall mean concentration ($\mu g/m^3$)
kitchen	1002	708	147	92
living room	987	716	151	91
bedroom	-	-	-	-
outdoors				70

HOME 7 (179 hours)



	maximum concentration ($\mu g/m^3$) 1-min average	1 hour average	24-hour average	overall mean concentration ($\mu g/m^3$)
kitchen	569	230	105	84
living room	195	101	51	40
bedroom	186	115	51	40
outdoors				41

HOME 8 (187 hours)

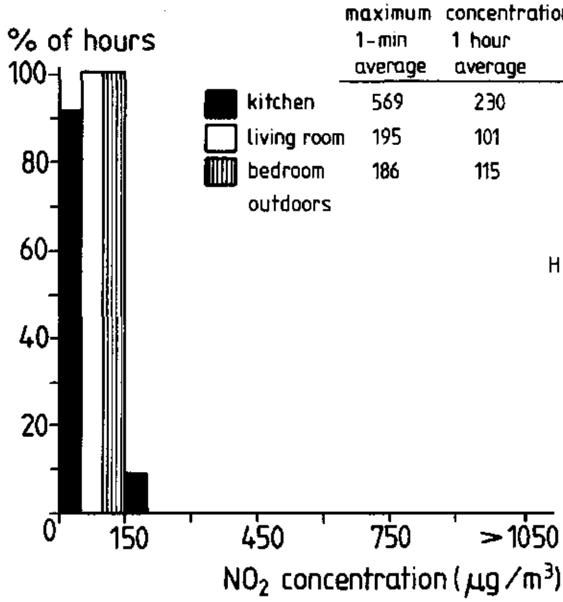
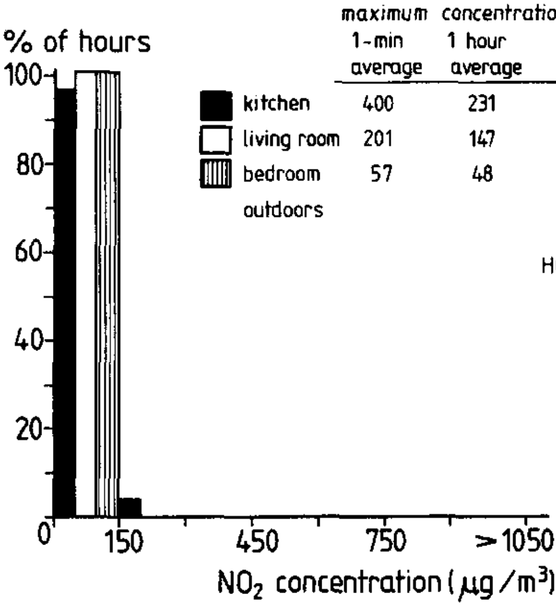
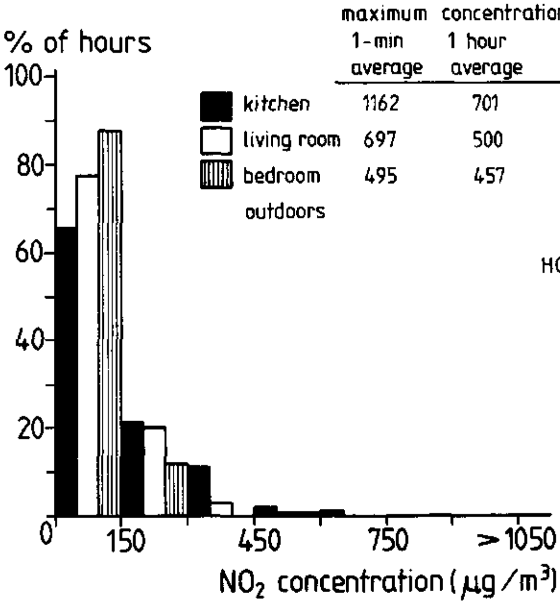


FIGURE 12 (continued)



	maximum 1-min average	concentration (μg/m³) 1 hour average	24-hour average	overall mean concentration (μg/m³)
kitchen	400	231	53	39
living room	201	147	40	33
bedroom	57	48	28	24
outdoors				25

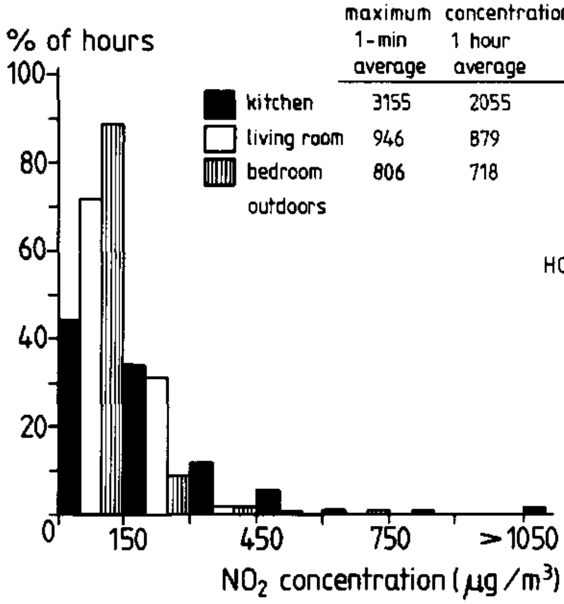
HOME 9 (136 hours)



	maximum 1-min average	concentration (μg/m³) 1 hour average	24-hour average	overall mean concentration (μg/m³)
kitchen	1162	701	190	156
living room	697	500	138	116
bedroom	495	457	100	91
outdoors				52

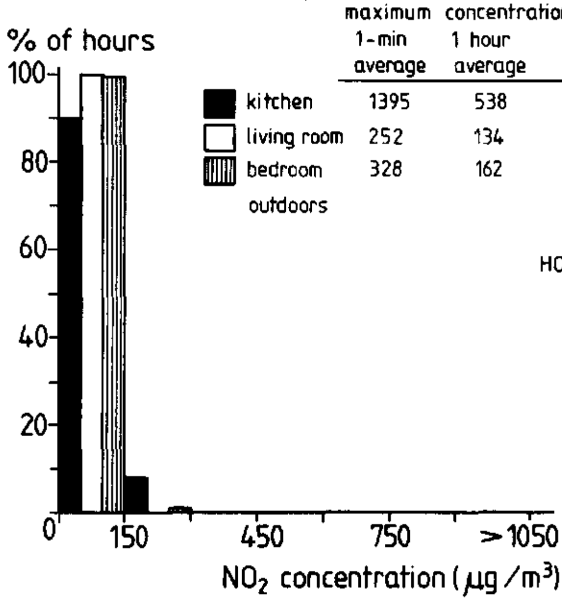
HOME 10 (188 hours)

FIGURE 12 (continued)



	maximum concentration ($\mu g/m^3$) 1-min average	1 hour average	24-hour average	overall mean concentration ($\mu g/m^3$)
kitchen	3155	2055	478	227
living room	946	879	259	142
bedroom	806	718	200	104
outdoors				58

HOME 11 (203 hours)



	maximum concentration ($\mu g/m^3$) 1-min average	1 hour average	24-hour average	overall mean concentration ($\mu g/m^3$)
kitchen	1395	538	137	81
living room	252	134	77	52
bedroom	328	162	55	40
outdoors				62

HOME 12 (222 hours)

FIGURE 13. NO_x concentrations ($\mu g/m^3$) versus time of day in 3 locations in home 3 of the real-time monitoring program (winter 1982/83, 1983/84)

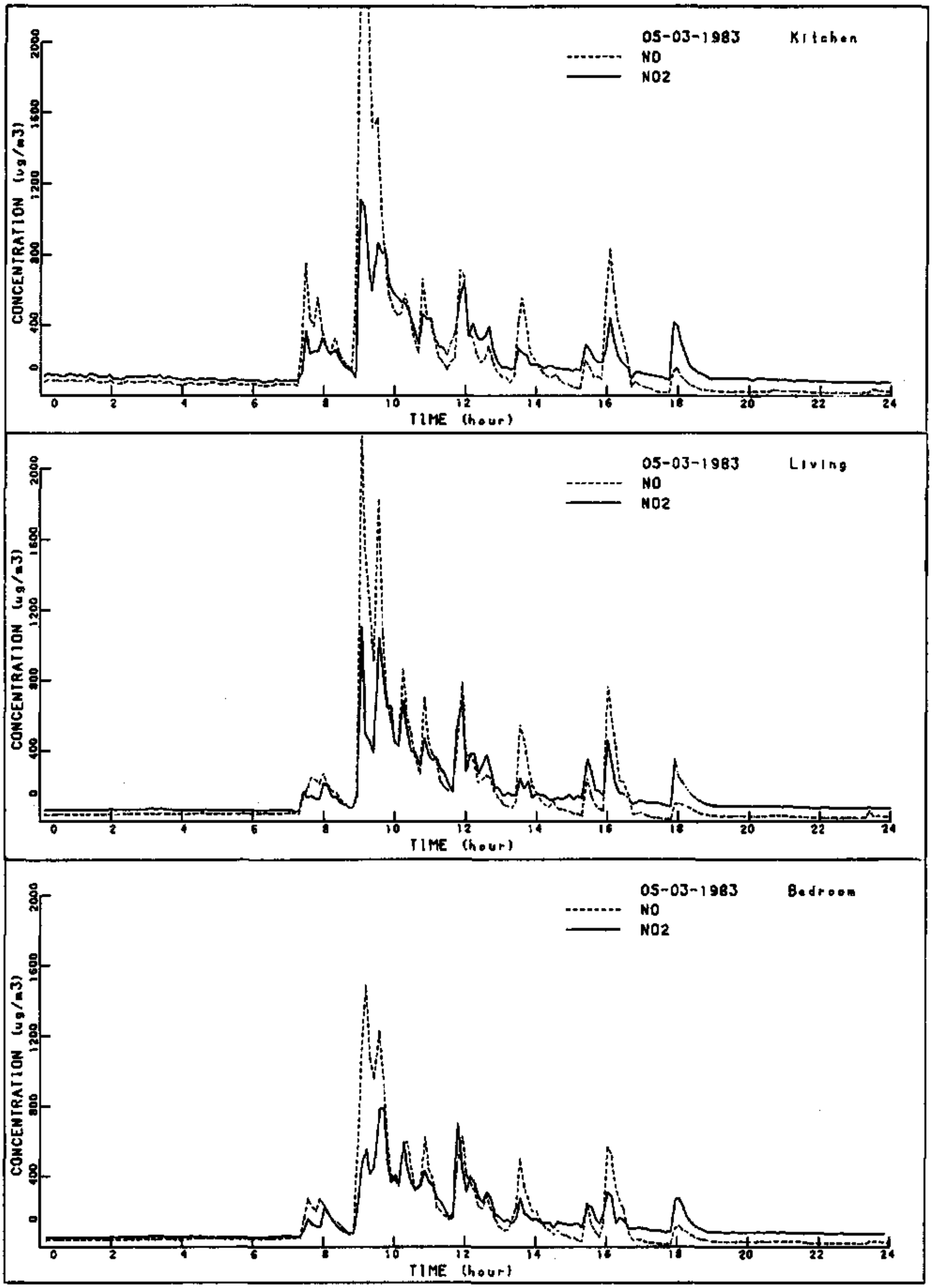


FIGURE 14. Use of gas applianes (above), CO concentration (centre) and NO_x concentration (below), versus time of day in home 4 of the real-time monitoring program (winter 1982/83, 1983/84)

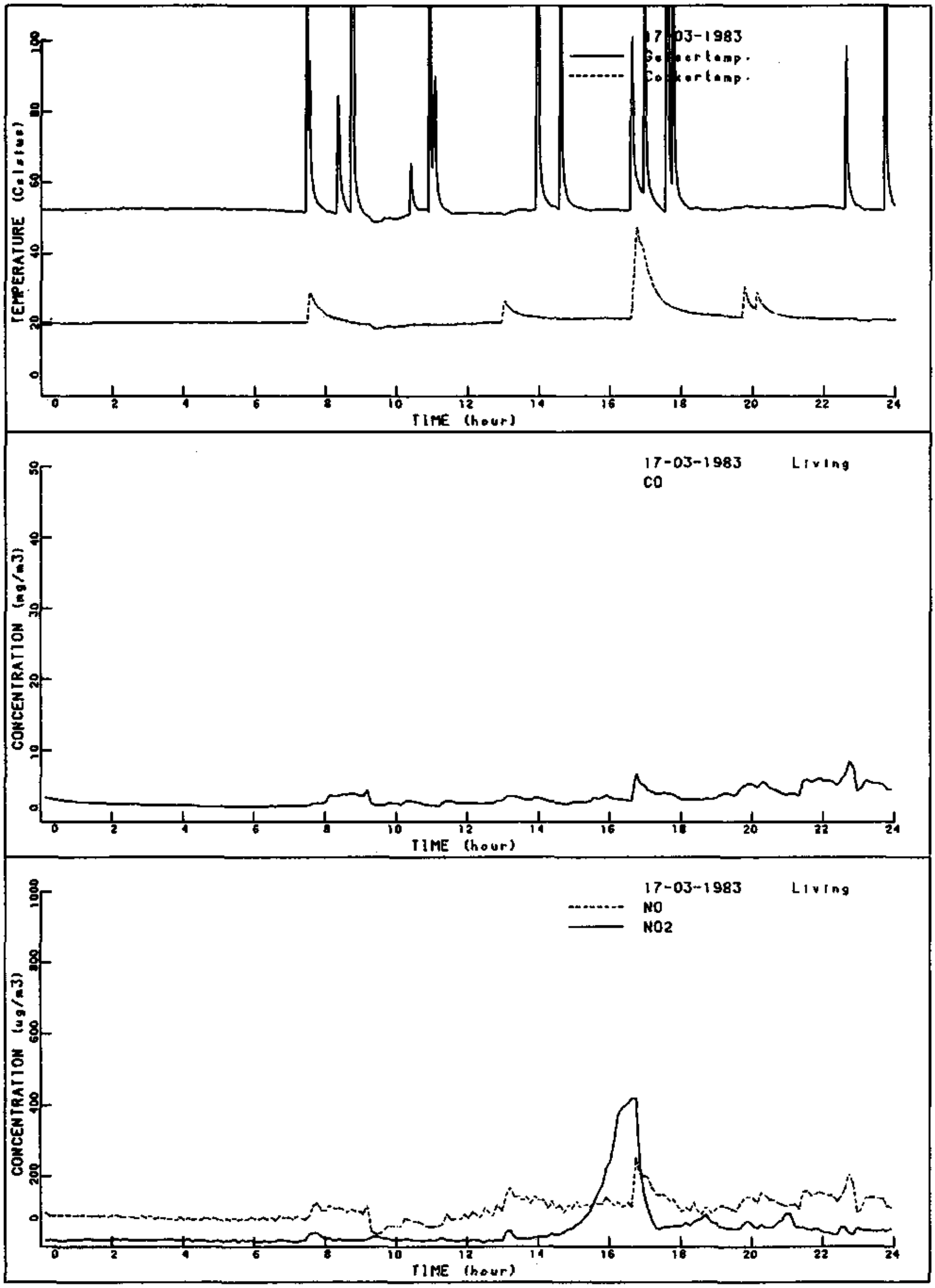
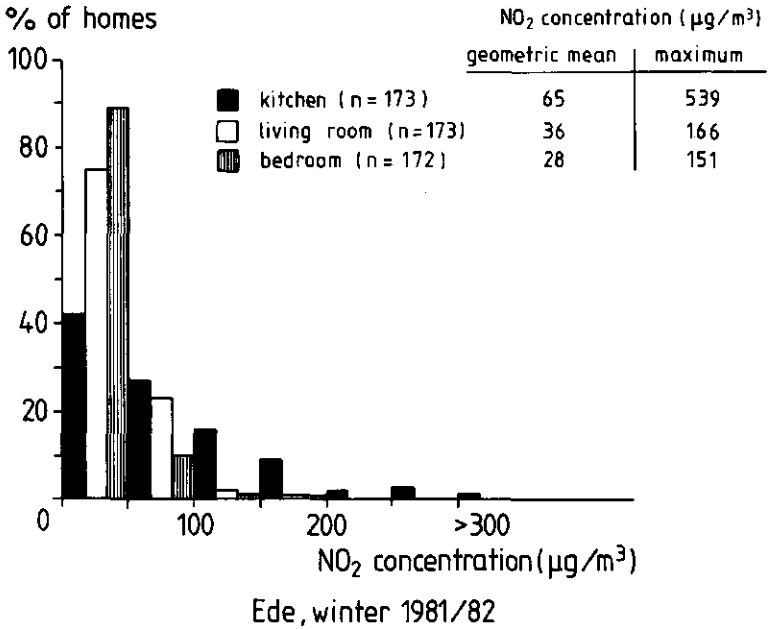


FIGURE 15. Frequency distribution, geometric mean and maximum of weekly average NO_2 concentrations in ($\mu g/m^3$) in 3 indoor locations in homes in Ede (post-war homes) and Rotterdam (pre-war homes), week-long measurement program (winter 1981/82, 1982/83)



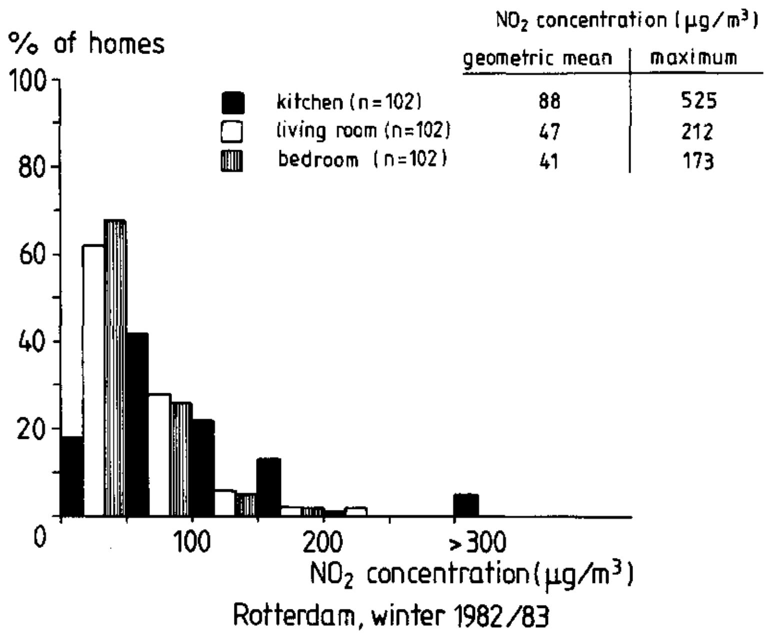


FIGURE 16. Frequency distribution, geometric mean and maximum of weekly average RSP concentrations (µg/m³) in living rooms of homes in Ede (post-war homes) and Rotterdam (pre-war homes); week-long measurement program (winter 1981/82, 1982/83)

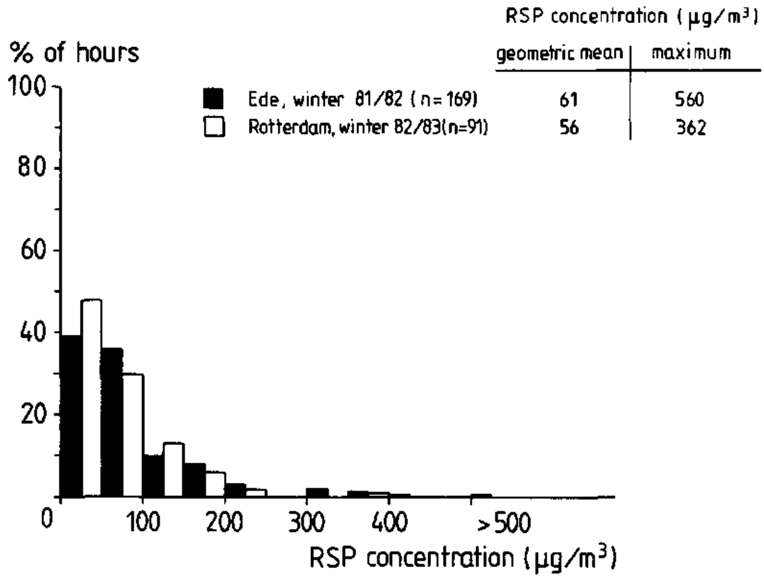


FIGURE 17. Weekly average RSP levels in 4 homes (A,B non-smokers homes; C,D smokers homes) versus time; repeated measurement program (July 1982-March 1983)

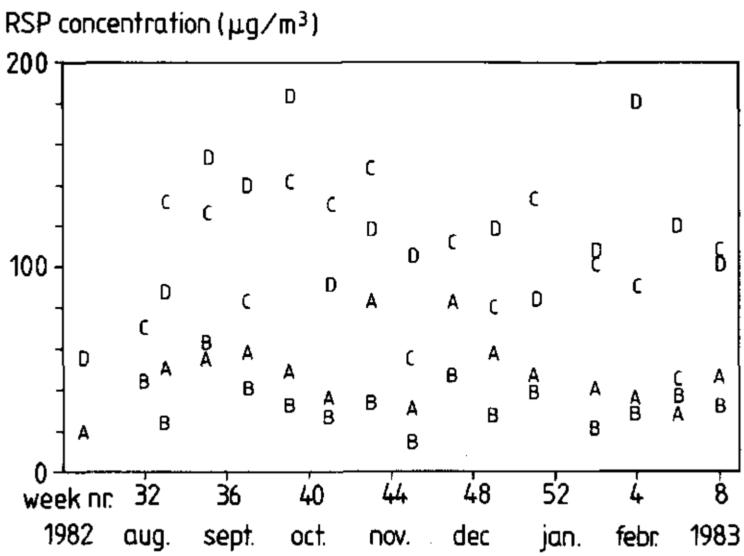
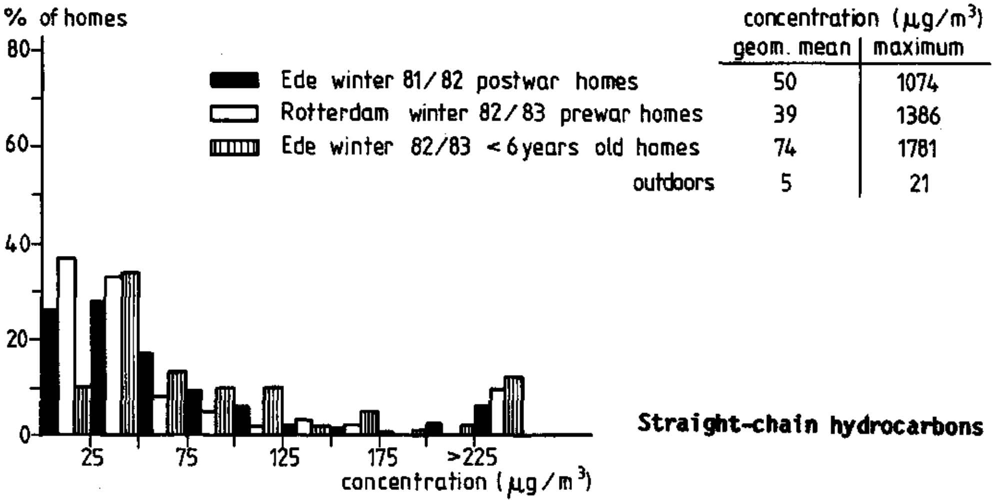
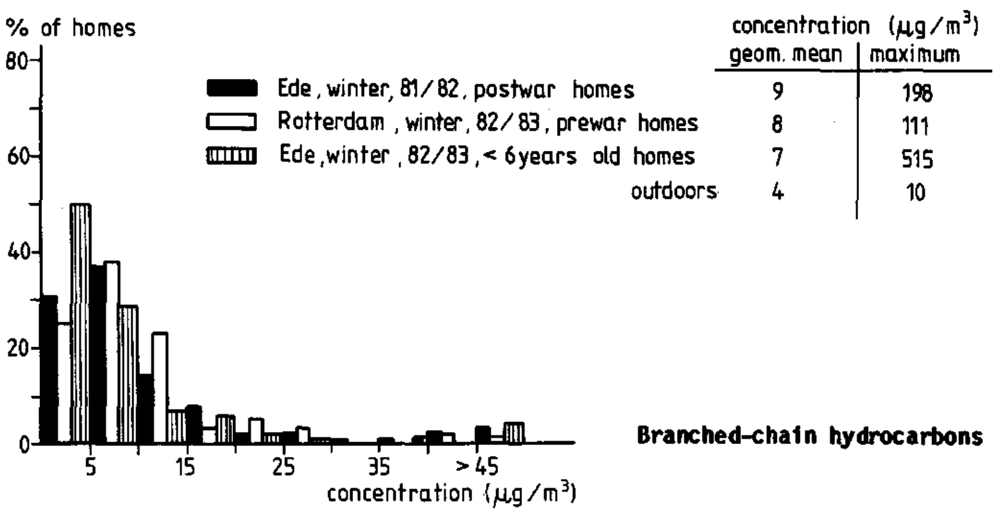


FIGURE 18. Frequency distribution, geometric mean and maximum concentration ($\mu g/m^3$) of 5 groups of volatile organic compounds in 3 age-groups of homes; week-long measurement program (winter 1981/82, 1982/83)

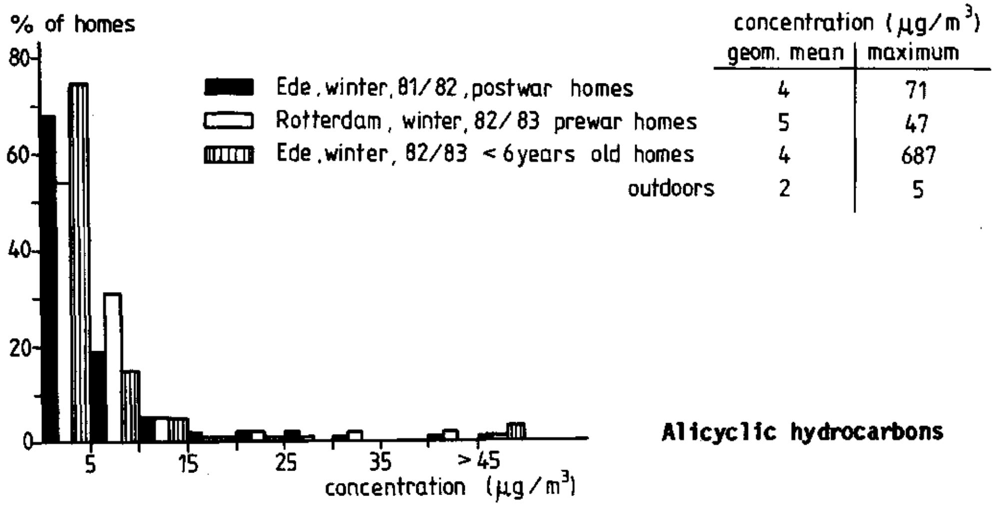


Straight-chain hydrocarbons

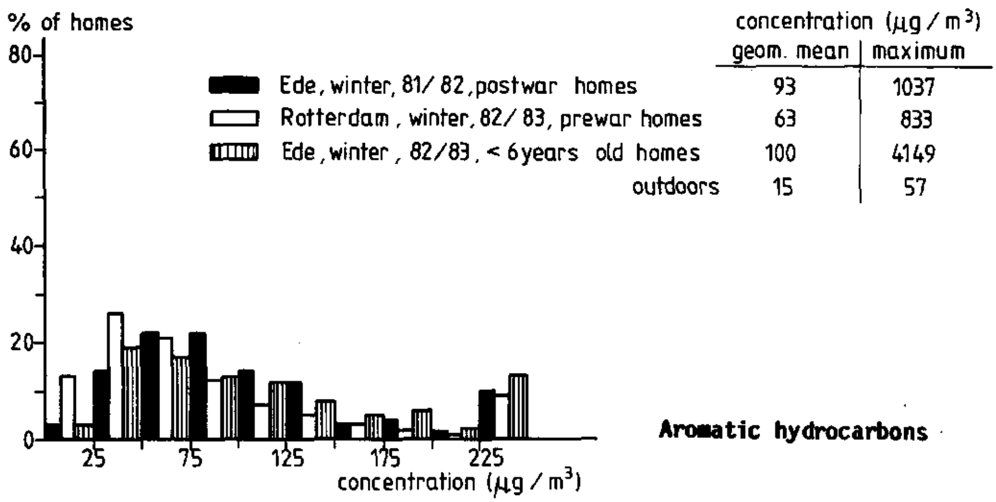


Branched-chain hydrocarbons

FIGURE 18. (continued)

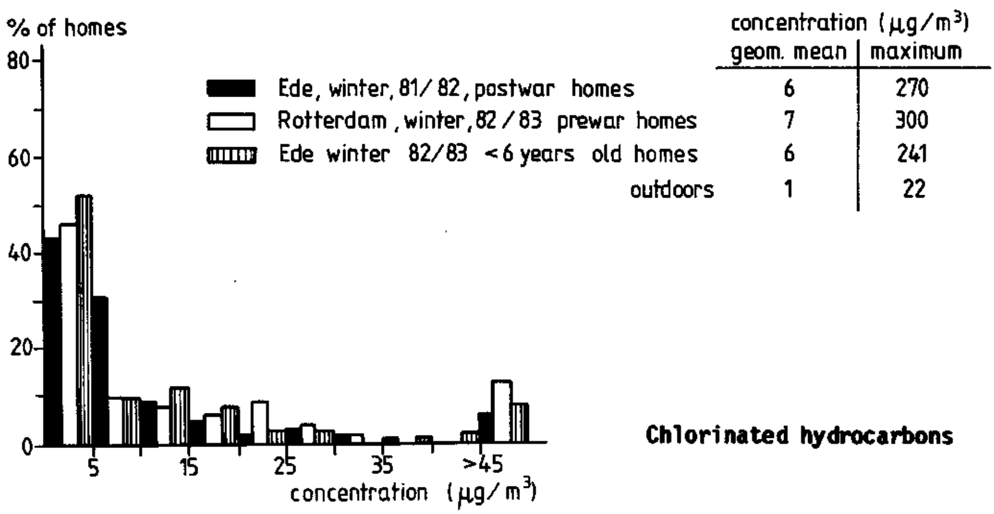


Alicyclic hydrocarbons



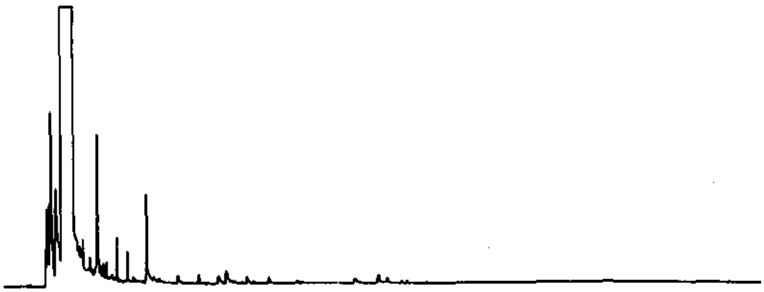
Aromatic hydrocarbons

FIGURE 18. (continued)

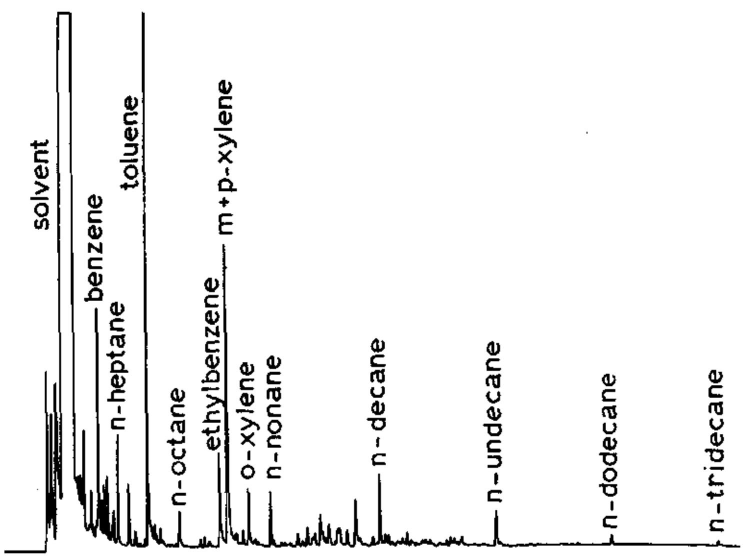


Chlorinated hydrocarbons

FIGURE 19. Examples of gas chromatographic patterns of an outdoor and indoor sample (week-long measurement program, winter 1981/82, 1982/83)



Outdoor sample



Indoor sample

FIGURE 20. Concentrations ($\mu g/m^3$) of volatile organic compounds versus time in 4 homes (A, B, C, D); repeated measurement program (July 1982-March 1983)

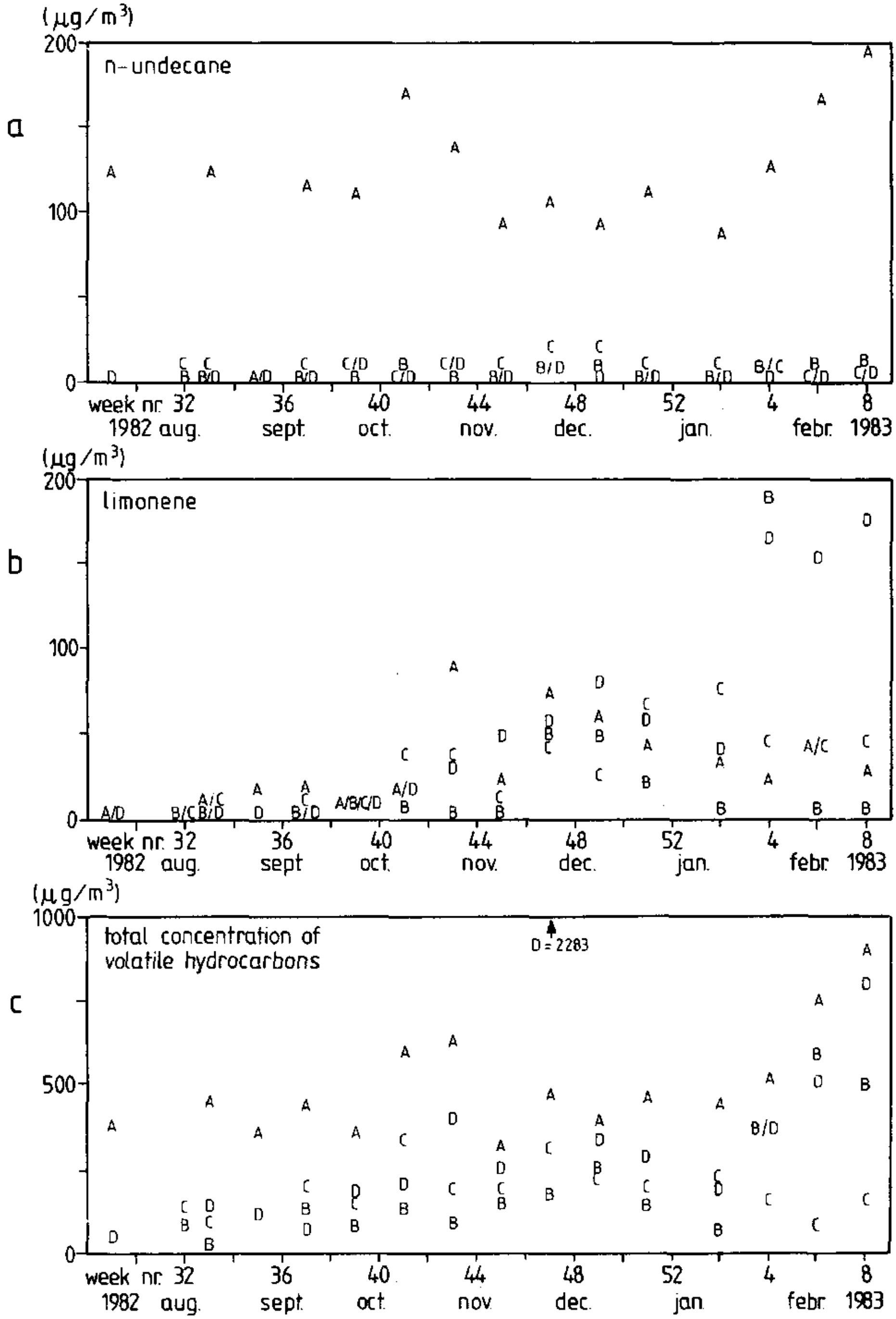
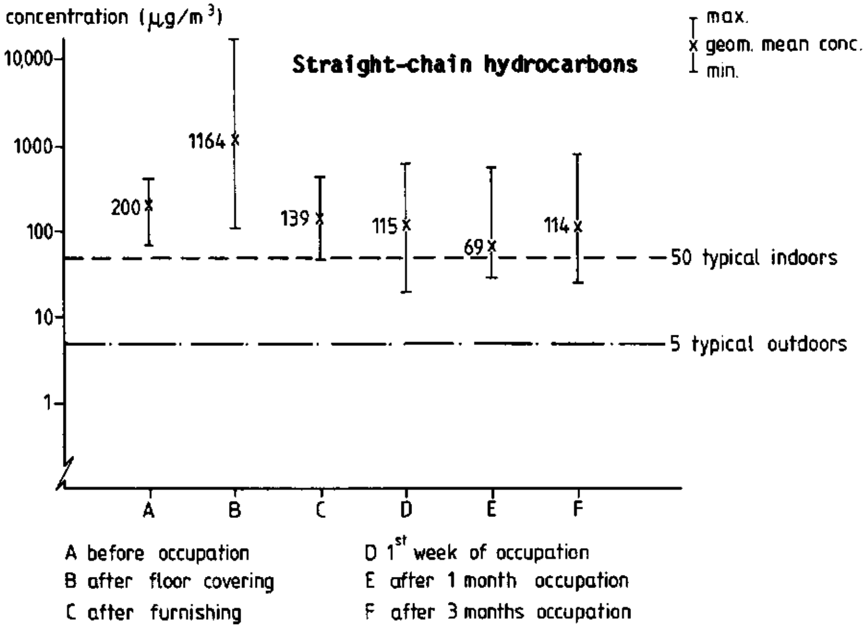


FIGURE 21. Minimum, geometric mean and maximum concentration of 5 groups of volatile organic compounds at different points in time, in 11 newly built homes in Ede (July-November 1983)



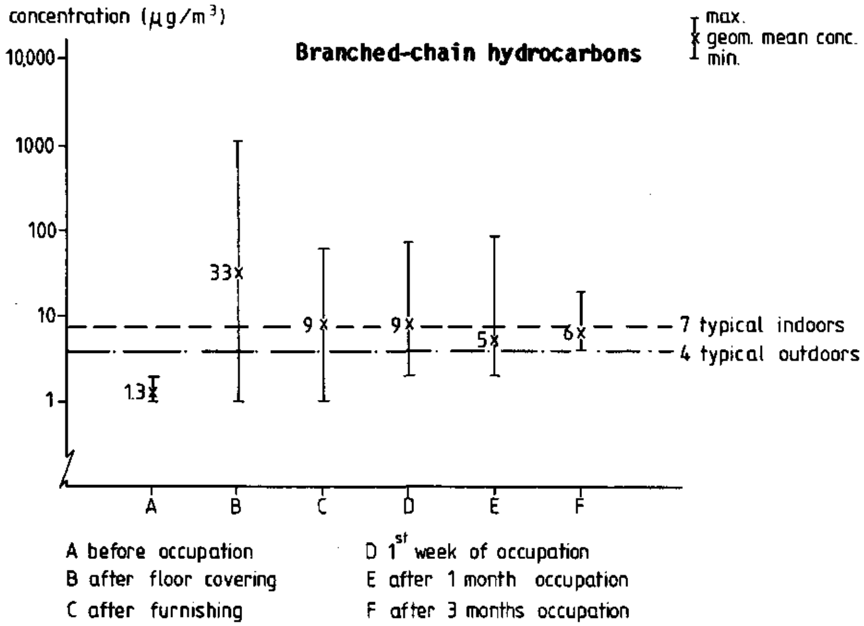
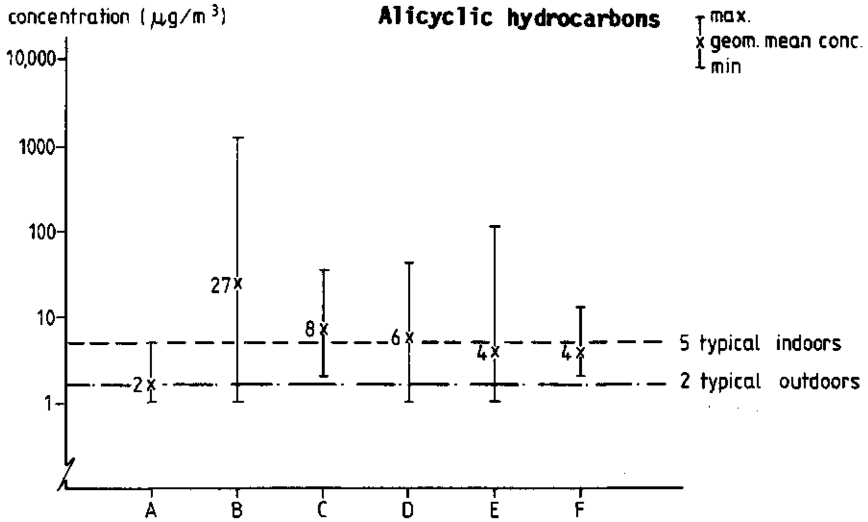
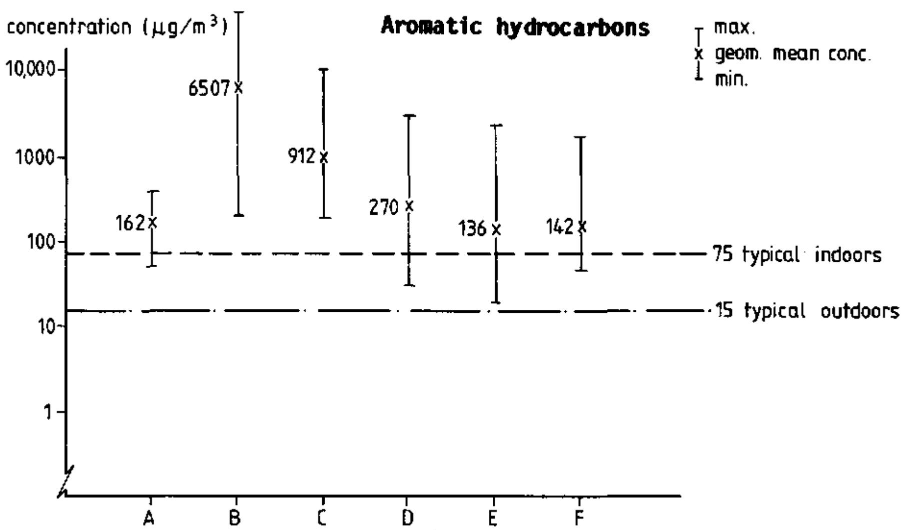


FIGURE 21. (continued)



A before occupation
B after floor covering
C after furnishing
D 1st week of occupation
E after 1 month occupation
F after 3 months occupation



A before occupation
B after floor covering
C after furnishing
D 1st week of occupation
E after 1 month occupation
F after 3 months occupation

FIGURE 21. (continued)