H-1 INDOOR AIR POLLUTION IN OFFICE BUILDINGS WITH OXIDES OF NITROGEN

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1. INTRODUCTION

To clarify the mechanism and the level of nitrogen oxides of indoor and outdoor origin in air conditioned buildings, field measurements were made in several buildings including one small building, three intermediate, two subway stations.

The spatial distribution of NO, NO_2, CO, CO_2 in rooms were obtained and the cumulative frequency distribution curves were examined. The magnitude of spatial variation were expressed in coefficient of variation and the values were not much different from those of CO_2.

The mass balance of oxides of nitrogen were calculated and compared with those calculated from actual smoking amount.

The relation of the concentration just outside of building and those of air pollution control station, indoor, outdoor concentration were examined by testing the correlations and ratio. also correlation of values at two measurement stations in a same building were examined and NO showed very strong correlations.

The correlation of number of occupants and the concentration of NO, NO_2, CO, CO_2 were calculated and there were little correlation except with CO_2.

2. OUTLINE OF MEASUREMENTS

The method of measurements are shown in Table 1. Samples were taken in Teddler bags or PVC bags and analysed immediately after sampling.

Measuring points were 43 points (Build. A), 17 points (Build. B), 14 points (Build. C), 48 points (Build. D) besides the fixed points provided in the center of the rooms for horizontal distribution and at important points in duct systems for outdoor air intake, return air, supply air and outside air itself.

Table 1. Method of Measurements

Items	Methods
Quantity of Air Distribution	Traverse measurement in air ducts with hot wire anemometer.
Number of Occupants	Visually counted every 5 - 10 minutes.
Smoking	Same to above.
Oxides of Nitrogen	Chemi-luminescence method with Monitor Lab. 8440.
Carbon Dioxide	NDIR, Beckman 315R.
Carbon Mono-oxide	Electro-chemical metho with Ecolizer.
Particulate Matter	Light scattering type density meter and particle counters C1-250 and KC-01.

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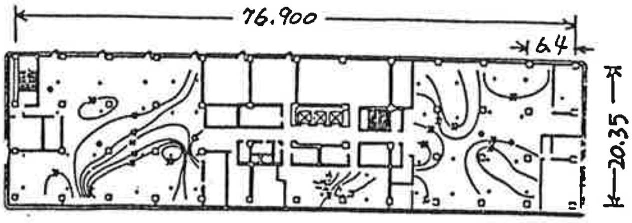
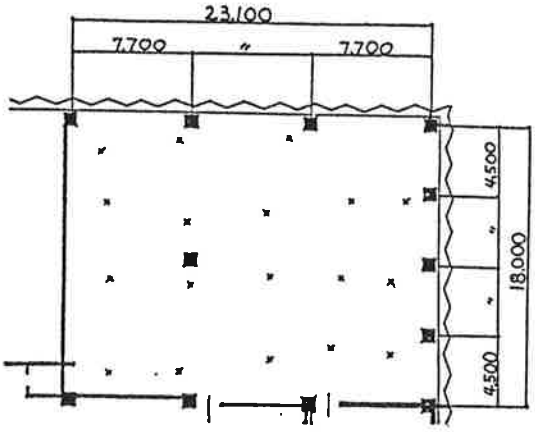
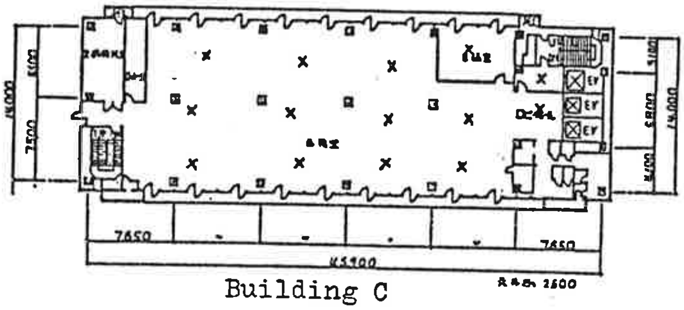


Building A



Building B



Building C

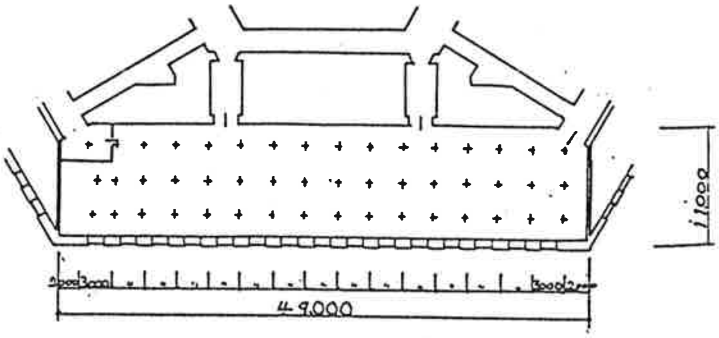
The horizontal distribution were taken several times a day and diurnal changes every 30 minutes at important points. These measurements were repeated 2 - 3 days in each building.

Outline of buildings measured were shown in Table 2.

3. RESULTS AND DISCUSSION

1) Time Variation of Concentration.

The concentration of CO_2 in Build. A and C had a tendency of non-steady state throughout the day. In Build. D it reached the steady state very shortly. From diurnal variation of oxides of nitrogen the influence from the out-



Building C

Fig. 1. Buildings Measured

Table 2. Outline of Buildings Measured

Building	Structure	Rooms Measured	Air Conditioning
A	Reinforced Concrete 6 floors 9600 m floor area Built in 1973	Offices in 4th floor 1600 m	2 systems each floor
B	Reinforced Steel Concrete 6 floors 24759 m floor area Built in 1977	Offices in 5th floor 3183 m	6 systems each floor w/Fan coil units System ceiling
C	Reinforced Steel Concrete 10 floors 8097 m floor area Built in 1974	Offices in 4th floor 729 m	1 system each floor w/Fan coil units Ceiling return
D	Steel Construction 52 floors 176443 m floor area Built in 1979	Office in 12th floor 550 m	1 system each office Fan coil units System ceiling

None of these buildings used any gas-removing devices.

door air looks stronger than the indoor origin.

2) Horizontal Distributions.

From the results of measurements of the horizontal distribution of indoor concentration of NO_x, CO, CO_2, it is very difficult to indicate any definit tendency. This is probably because one of the main origin of these gases are the expired air of occupants and smoking which are distributed rather uniformly throughout the room.

The cumulative distribution curves of these concentration show the sharp change at high percentages (90 - 95%) to right side which indicate the existence of spots of higher concentration within rooms.

The range of horizontal distribution of NO, NO_2 expressed by Coefficient of Variation shows little difference from those of CO_2 except for Build. D which has rather high C.V. values.

3) Mass Balance.

Though mass balance were calculated at air conditioning systems in each building, we were not able to obtain reliable data because of probable air leaks between rooms or through air duct systems.

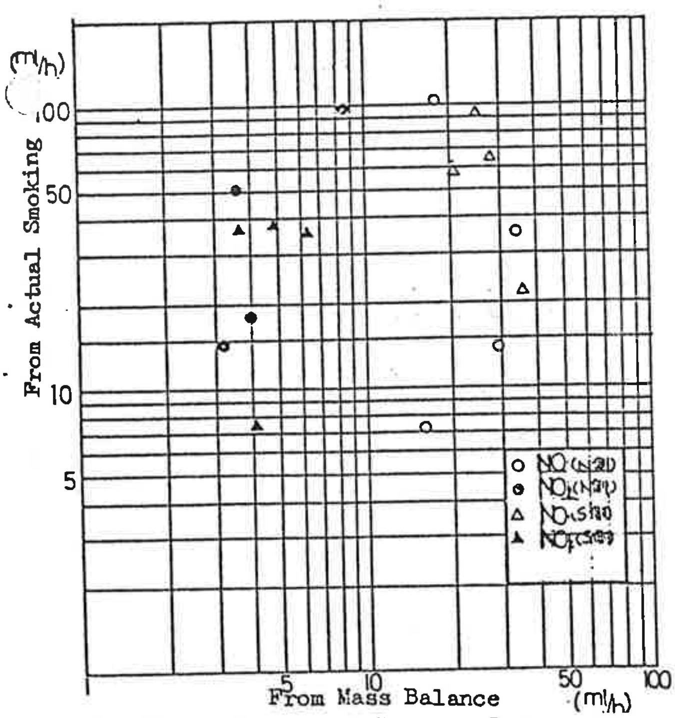


Fig. 2. Comparison of Source Intensities

Comparison between the source intensities which were calculated from the concentration and supply air quantities and those from actual smoking amount (generation from cigarette supposed as 0.5 ml/cig. for NO, 0.1 ml/cig. for NO_2) is shown in Fig. 2.

With the assumption of no-adsorption, nor chemical changes, relatively clother relation is seen for NO than NO_2 though not clear in either case.

4) Relation between Near-by and Station Values.

With Build. A the NO_x values obtained at the National Air Pollution Control Network Station which was located 200 m away and the values near-by the building were compared as Table 3.

The ratio of near-by value to station value and their correlation coefficient were obtained with samples of every hour for three days.

These values had no consistent tendency and this implies many other strong fnfluencing factors for these values to be further studied.

5) Indoor and Near-by Values.

As near-by values we used the concentration of intake air or roof air and indoor values average concentration. Indoor to outdoor ratio of NO, NO_2, CO, CO_2 are shown in Table 4.

With NO_2 and CO_2 each building has relatively similar values by day but with NO values are very diversified for building and day. Except Buil. D, NO has larger values than NO_2 and larger than unity. The structure and climatic conditions seem to have grave effect for this.

Correlation coefficient of NO, NO_2, CO of indoor and outdoor values of every hour are shown in Table 5. With Build. B, NO has strong correlation with CO. With Build. C the relation changes by day.

Table 3. Relation between Near-by and Station Values

Building	Date of Measurement	Correlation Coefficient		Ratio of Near-by Value to Station Value	
		NO	NO_2	NO	NO_2
A	2/28	0.888	0.518	0.86	0.28
	3/1	0.232	0.274	0.36	0.18
	3/2	-0.209	0.331	2.60	0.52

Table 4. Indoor Values to Near-by Values Ratio

Building	Date of Measurements	NO	NO_2	CO	CO_2
A	2/28	2.0	0.73	1.65	2.67
	3/1	1.95	0.92	2.75	3.27
	3/2	1.71	0.65	2.56	4.14
B	12/18	2.0	0.47	1.20	
	12/19	1.3	0.6	1.35	
	12/20	0.8	0.6	1.72	
C	12/9	1.23	0.7	1.71	
D	3/5	0.48	0.84	1.71	2.02
	3/6	0.39	0.79	1.31	2.13
	3/7	0.57	0.82	1.92	2.35

Table 5. Correlation Coefficients of Indoor and Outdoor Values

Building	Date of Measurement	NO	NO_2	CO
B	12/18	0.904	0.664	0.308
	12/19	0.802	-0.064	-0.773
	12/20	0.827	0.615	-0.328
C	12/9	0.248	0.753	
	12/10	0.519	0.248	

Table 6. Correlation Coefficients of Two Fixed Points Values

Building	Date of Measurement	NO	NO_2	CO
B	12/18	0.993	0.759	0.782
	12/19	0.946	0.875	0.574
	12/20	0.961	0.079	0.912

Table 7. Correlation Coefficients with Number of Occupants

Building	Date of Measurement	NO	NO_2	CO	CO_2
B	12/18	0.471	-0.266	0.202	
	12/19	-0.105	0.075	-0.170	
	12/20	0.409	-0.093	0.147	
C	12/9	0.300	0.249		0.687
	12/10	-0.067	-0.154		0.402

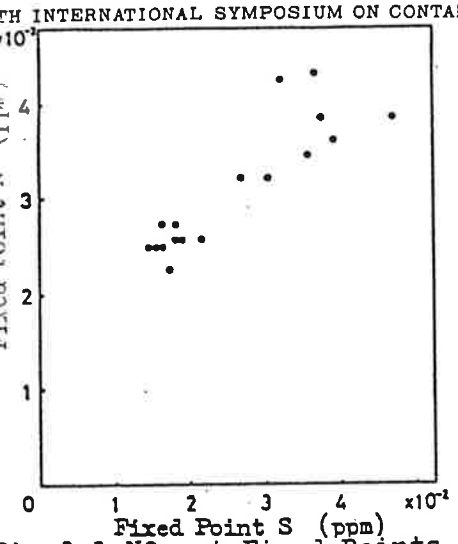


Fig.3-1.NO_2 at Fixed Points

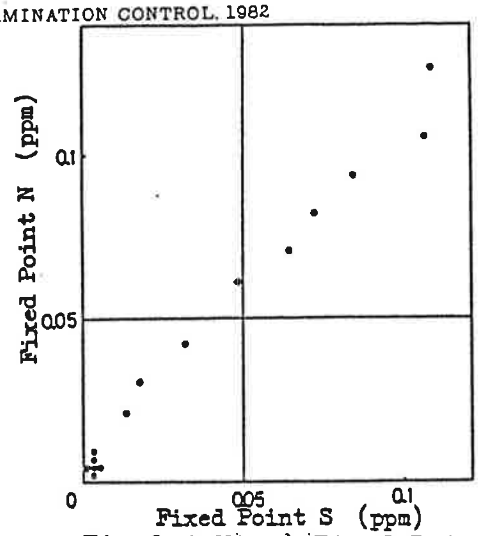


Fig.3-2.NO at Fixed Points

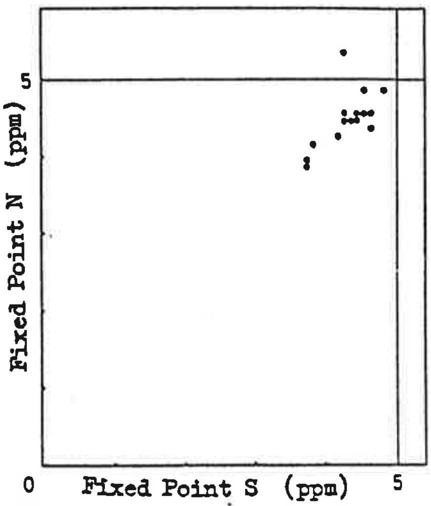


Fig.3-3.CO at Fixed Points

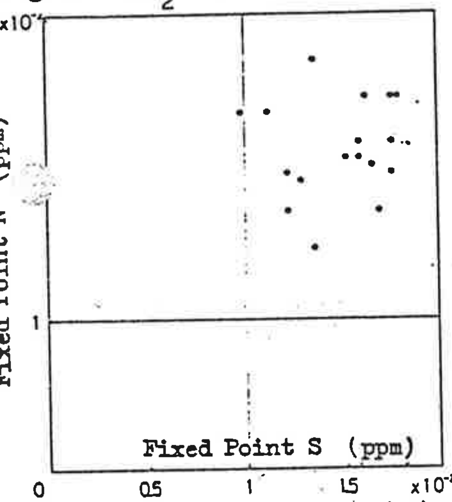


Fig.3-4.NO_2 at Fixed Points

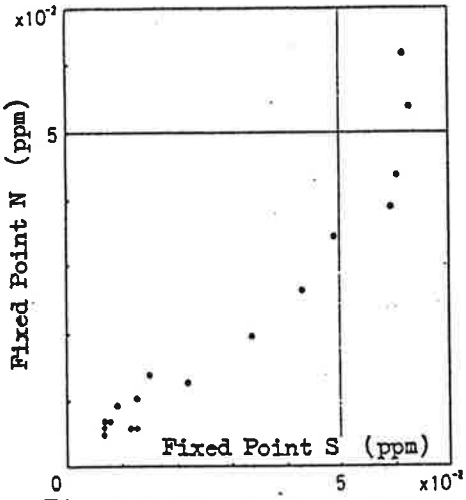


Fig.3-5.NO at Fixed Points

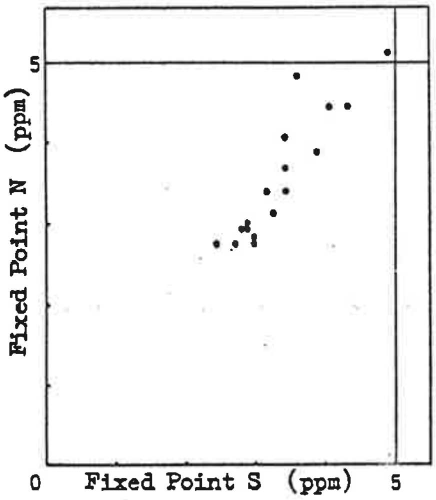


Fig.3-6.CO at Fixed Points

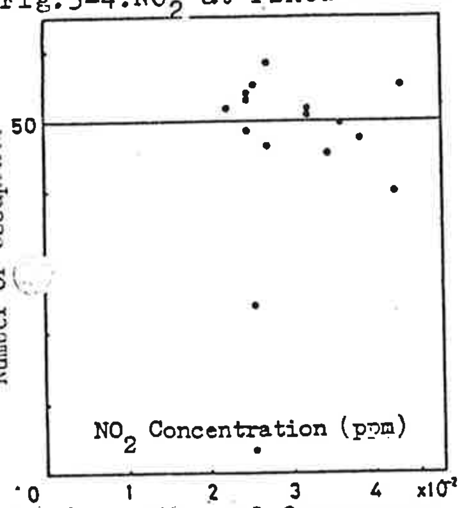


Fig.3-7. NO_2 and Occupancy

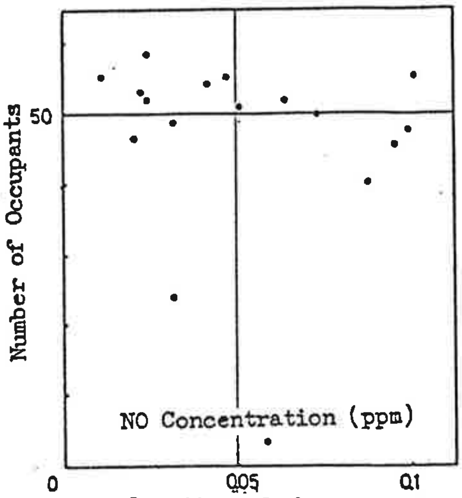


Fig.3-8. NO and Occupancy

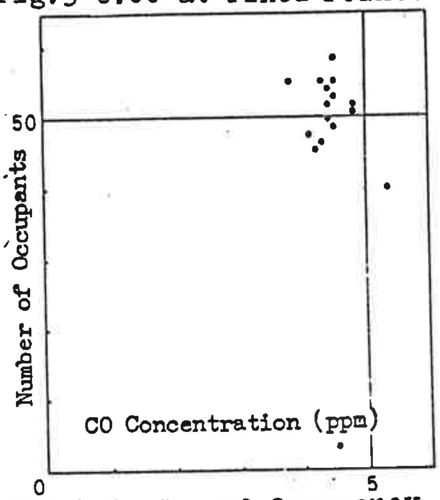


Fig.3-9. CO and Occupancy

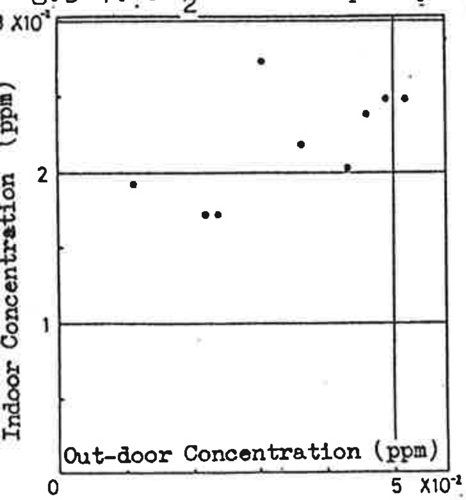


Fig.3-10.NO_2 Indoor-Outdoor

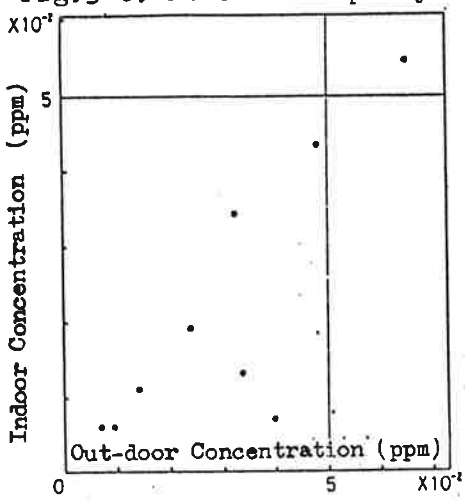


Fig.3-11. NO Indoor-Outdoor

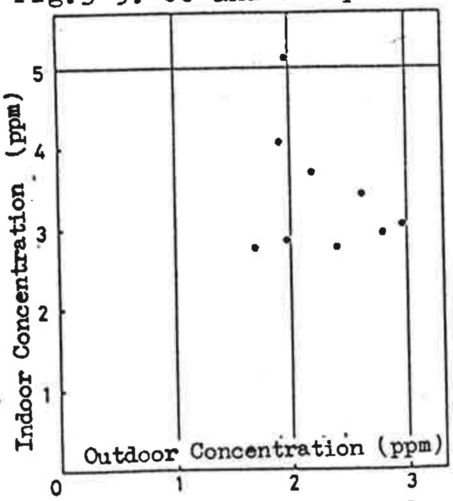


Fig.3-12.CO Indoor-Outdoor

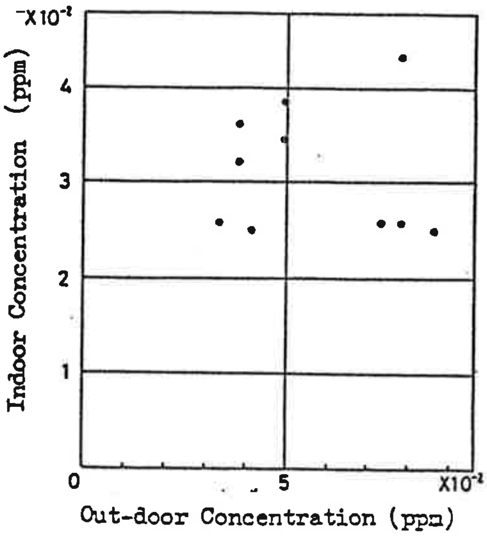


Fig.3-13. NO_2 Indoor-Outdoor

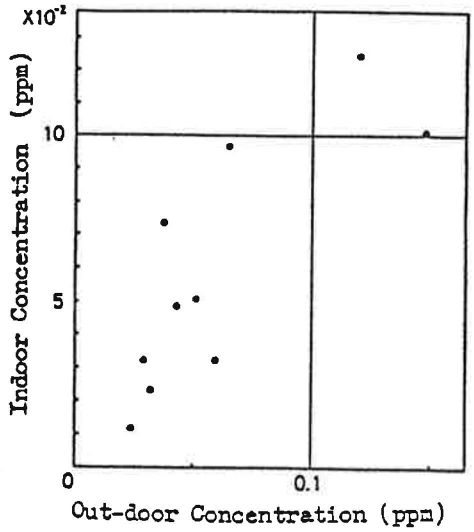


Fig.3-14.NO Indoor-Outdoor

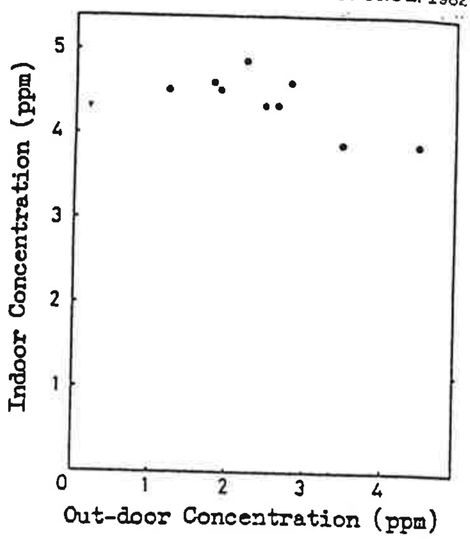


Fig.3-15.CO Indoor-Outdoor

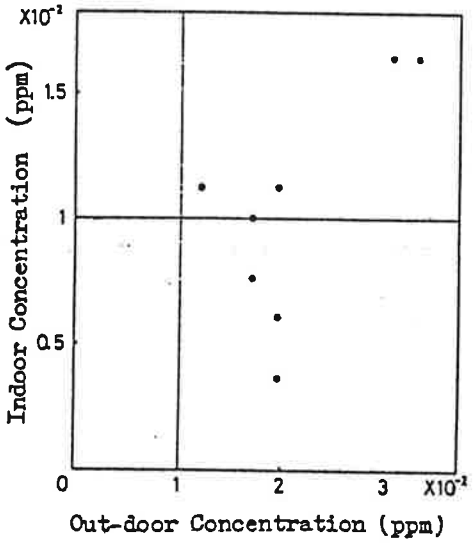


Fig.3-16. NO_2 Indoor-Outdoor

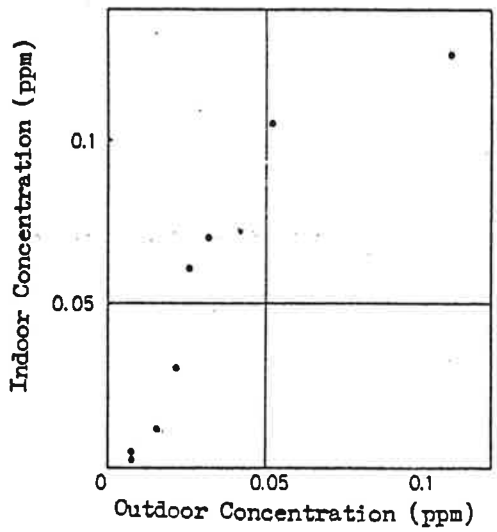


Fig.3-17.NO Indoor-Outdoor

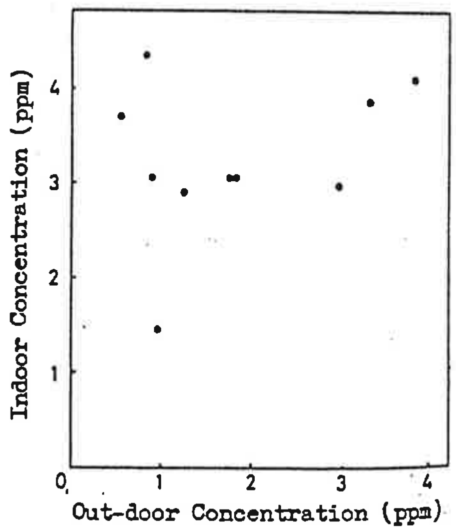


Fig.3-18.CO Indoor-Outdoo:

6) Correlation Coefficients of Two Points.

With Build. B two sets of values obtained in the center of rooms supplied by two different air conditioning systems were compared with correlation coefficient(Fig. 6). NO has very strong correlation.

7) Correlation with Number of Occupants.

Smoking being major source of NO, NO_2, CO, the concentration of these pollutants should be related with the number of occupants, and the correlation coefficients are shown in Table 7. Though with CO_2 we have correlation, we cannot see any definit correlation with NO, NO_2, CO to number of occupants.

REFERENCES

1) Yoshizawa,S. et al;Indoor Air Pollutio: in Office Buildings(Case of Oxides of Nitrogen), Sum. of Tech. Pap. of Ann. Meet. of AIJ:335-336,1980

2) Yoshizawa,S. et al; ibid:343-345, 1981

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