CHAPTER 5

Chapter 5 ANALYSIS OF THE PRESENT AIR QUALITY BY AIR QUALITY SIMULATION MODEL

5.1 Outline of the Air Quality Simulation Model

5.1.1 General Process of Air Quality Simulation

General process of air quality simulation is shown in Figure 5.1.1. The air quality simulation model adopted in this Study is based on the dispersion equations for air pollutants derived from the theories in physics. The model is established to simulate the processes through which pollutants are emitted into the atmosphere from sources and are transported and dispersed. However, it is extremely difficult to incorporate all of factors quantitatively into the mathematical representation of air pollution phenomena. The pollutants are emitted through various processes of various sources, and are transported under various meteorological conditions. Therefore, important factors of meteorology and pollutant sources that are essential to describe particular aspects of air pollution phenomena should be chosen effectively, and should be represented by simplified forms in the mathematical model.

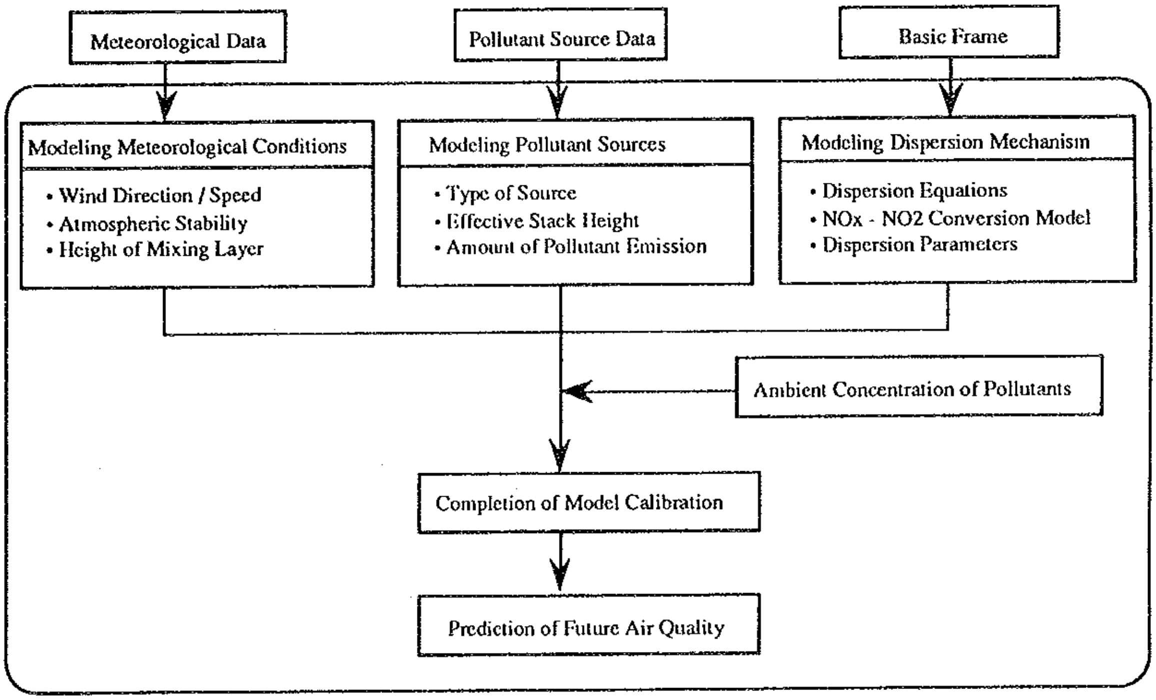


Figure 5.1.1 General Process of Air Quality Simulation

5.1.2 Basic Frame of Simulation Model

The basic frame of the simulation model is as follows:

(1) Averaging Time of Air Pollutant Concentration

1) Period : Non-heating period : from April to September
Heating period : from October to March

2) Time Period :

Morning	6:00 ~ 11:00
Afternoon	11:00 ~ 17:00
Evening	17:00 ~ 23:00
Midnight	23:00 ~ 6:00

(2) Classification of Meteorological Conditions

1) Wind direction : 16 directions (N, NNE, NE, ----------, NNW)

2) Wind speed classes:

Class	Wind Speed (m/s)
Calm	0~0.4
Windy	0.5~0.9 (Breeze) 1.0~1.9 2.0~2.9 3.0~3.9 4.0~5.9 6.0~7.9 8.0~

3) Atmospheric stability : Classifications of Pasquill's atmospheric stability are adopted (see Table 5.1.1).

(3) Computational Grid Size

The grid size for computation is determine to be 2km x 2km.

5.1.3 Meteorological Model

(1) Meteorological Block and Representative Meteorological Condition

Considering the results of meteorological observation, the computational area are horizontally divided into five (5) blocks as shown in Figure 5.1.2, and vertically divided into five (5) layers.

For these layers, the wind speeds and directions were specified at the following hights to be applied to the indicated heights of emission sources:

1) 10m above the ground : for emission sources at 0 - 30m
2) 50m above the ground : for emission sources at 30 - 75m
3) 100m above the ground : for emission sources at 75 - 125m
4) 150m above the ground : for emission sources at 125 - 200m
5) 250m above the ground : for emission sources at 200m or more

Wind roses for whole year at the height of 10m are shown by time zones in Figure 5.1.3.

Wind direction distributions of 5 stations at the height of 10m are shown by seasons and time zones in Figures D5.1.1 through D5.1.5 and Tables D5.1.1 through D5.1.5 in Data Book.

(2) Wind of the Upper Layer

Wind speed varies with the altitude, therefore, the wind speed of the upper layer is estimated by the following equation.

$$U_Z = U_S (Z/Z_S)^P$$

where,

U_Z : wind speed at the height of Z meters
U_S : wind speed observed at the height of Zs meters
P : power

According to the results of the upper-layer meteorological observation, values of "P" in the study area have been estimated as "P=0.3 for the daytime" and "P=0.4 for the nighttime". These estimated values are considered to be reasonable in comparison with those normally employed in Japan.

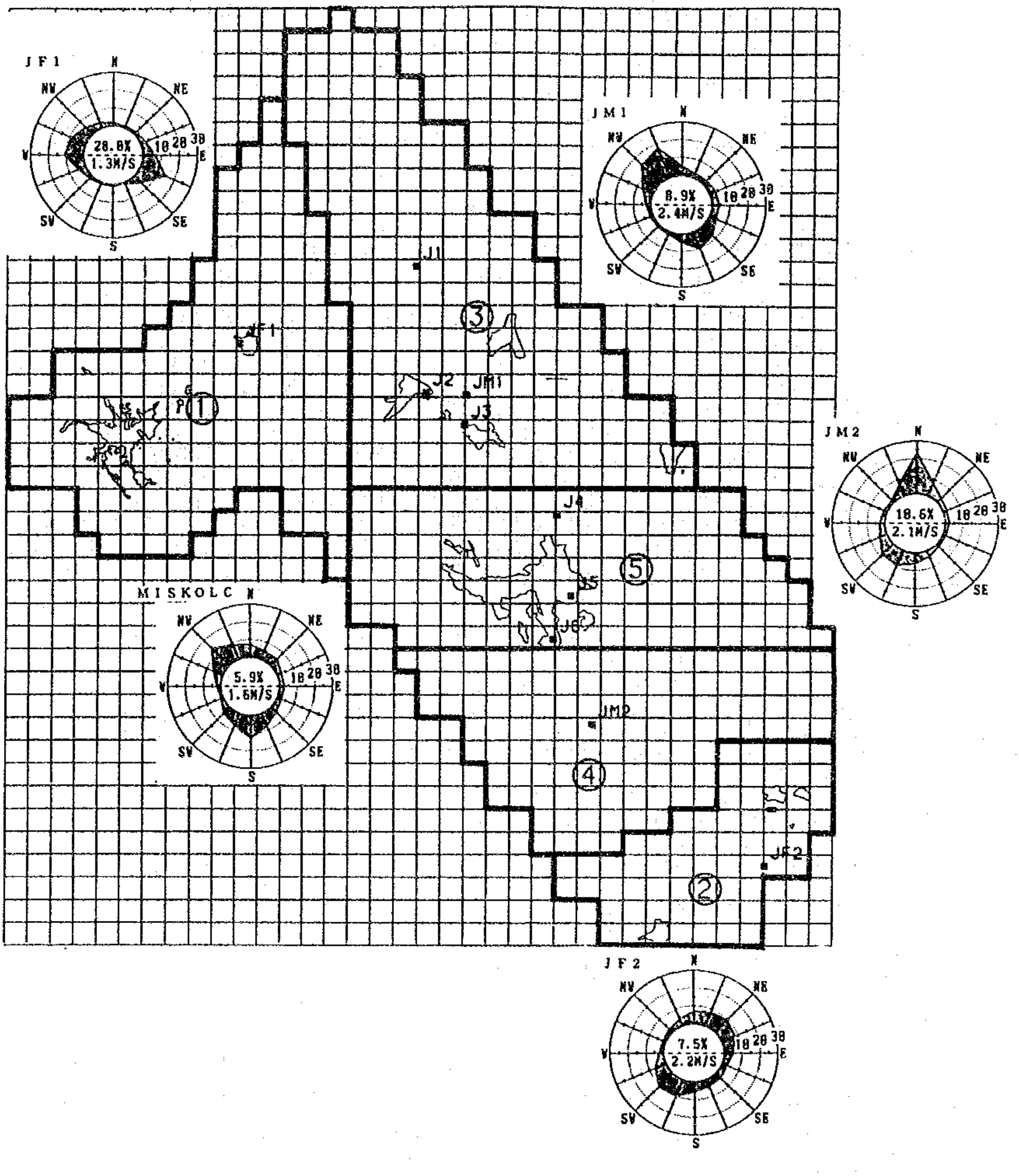
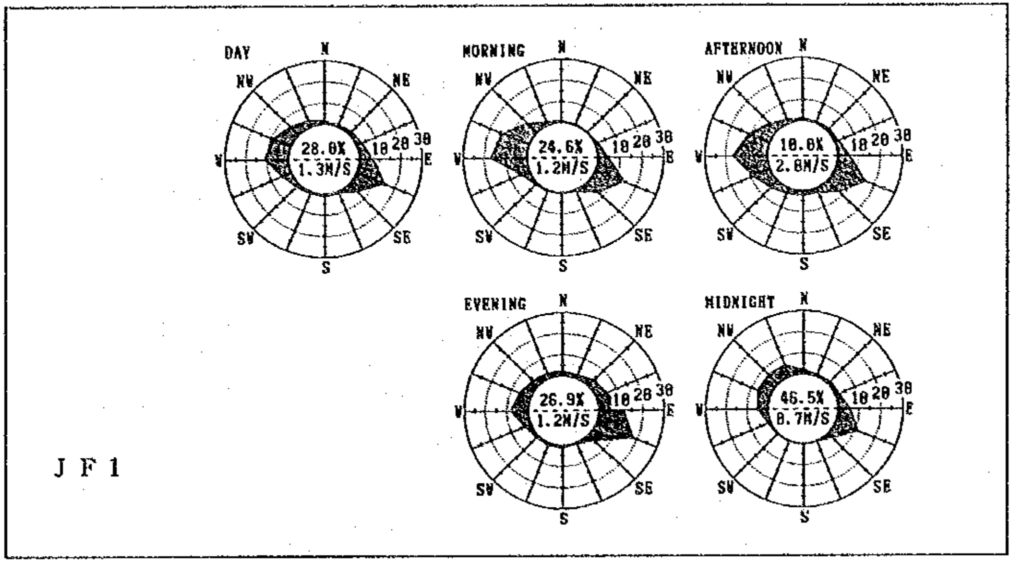
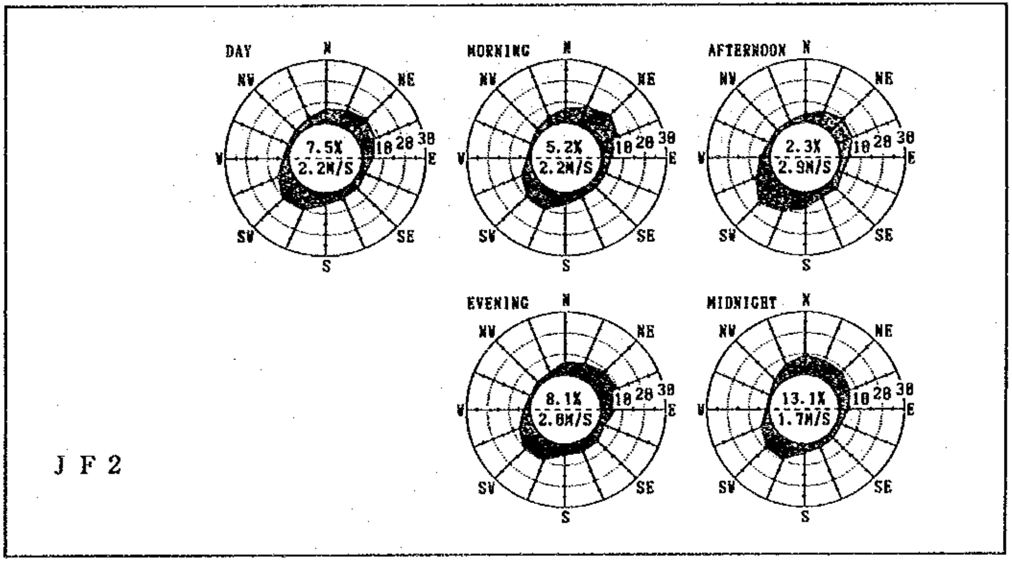


Figure 5.1.2 Meteorological Blocks for the Study Area





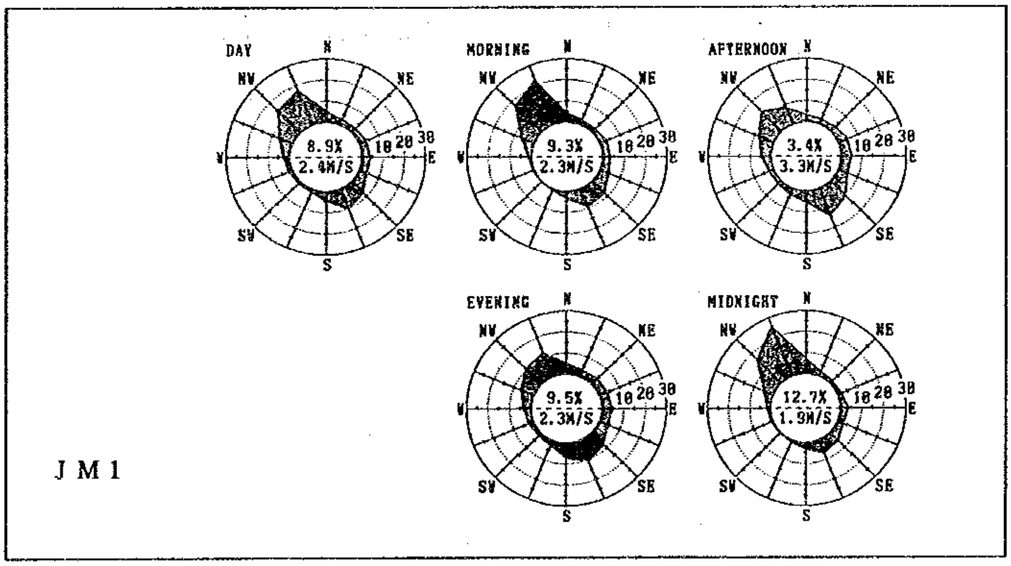


Figure 5.1.3 (1) Wind Roses at 10m Height (Whole Year)

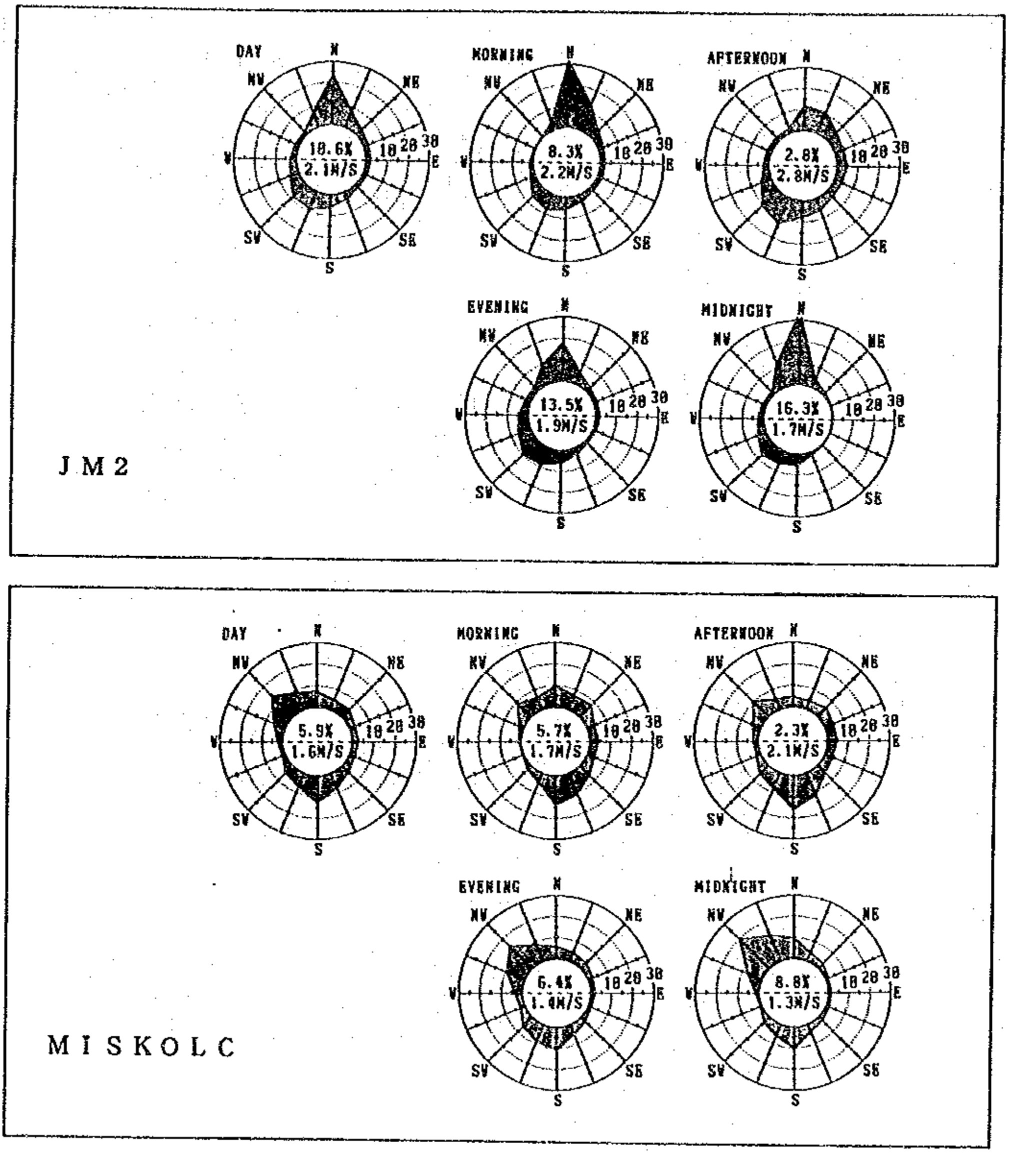


Figure 5.1.3 (2) Wind Roses at 10m Height (Whole Year)

Wind direction does not greatly vary with the altitude when the air is unstable or neutral. When the wind direction on the ground is different from that of the upper layer, air pollutants emitted from high stacks can hardly affect the air quality near the ground level. Therefore the wind direction at the upper layer is assumed to be the same as that of ground level.

(3) Atmospheric Stability

Atmospheric stability was classified according to Pasquill's classification as shown in Table 5.1.1.

Appearance frequency of the stability classes by time zones for whole year is shown in Figure 5.1.4.

Appearance frequency of the stability classes at each station by seasons and time zones is shown in Figures D5.1.6 through D5.1.10 and Tables D5.1.6 through D5.1.10 in Data Book.

Table 5.1.1 Pasquill's Classification of Atmospheric Stability

Wind Speed (U) m/s	Solar Radiation (T) kW/m^2				Net Radiation (Q) kW/m^2		
	$T \geq 0.60$	$0.60>T \geq 0.30$	$0.30>T \geq 0.15$	$0.15 > T$	$Q \geq -0.020$	$-0.020> Q \geq -0.040$	$-0.040>Q$
$U < 2$	A	A-B	B	D	D	G	G
$2 \leq U < 3$	A-B	B	C	D	D	E	F
$3 \leq U < 4$	B	B-C	C	D	D	D	E
$4 \leq U < 6$	C	C-D	D	D	D	D	D
$6 \leq U$	C	D	D	D	D	D	D

(4) Meteorological Conditions for Simulation

Overall meteorological conditions at ground level used for the simulation are shown in Tables D5.1.11 through D5.1.20 in Data Book as appearance frequency and percentage of wind classified by atmospheric stability, wind direction, and wind speed.

(5) Height of the Mixing Layer (Lid)

In accordance with the observed vertical profiles of air temperature, and considering the model performance, the lid was set at the height of 30m - 150m depending on the type of source for mornings and evenings in the heating season.

1) Point source : 150m
2) Stationary area source : 50m
3) Automobiles : 30m

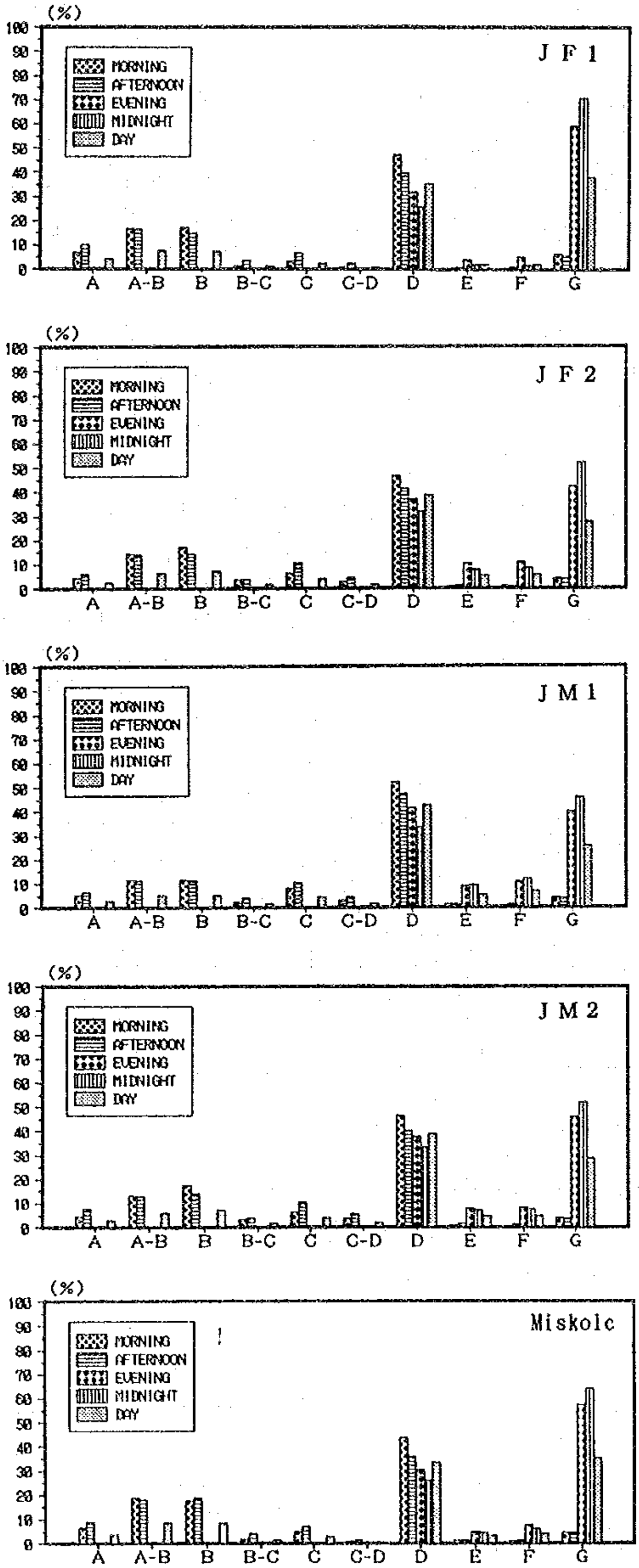


Figure 5.1.4 Appearance Frequency of Atmospheric Stability (All season)

5.1.4 Pollution Source Model

Source modeling is made by taking into account configuration and scale of emission sources. Sources (stack, road, etc.) are classified into three types as shown below.

	Type of Pollutant Sources		
	Poing Source	Line Source	Area Source
Industrial and Commercial Establishments	Large scale (about 50 sources)	-	Small scale
Automobiles	-	Major roads	Minor roads
Householeds	-	-	All

(1) Stationary Sources

1) Point Sources

About 50 major plants are treated as point sources. Emission conditions such as effective stack height, emission rate, etc. are determined individually. The ÉKF file was used as the basis and necessary corrections were made based on the results of the questionnaire and visiting survey and the flue gas measurement survey.

2) Area Sources

Medium-to-small industrial and commercial sources and other small-scale sources including households are treated as area sources. Pollutant emission quantity for each grid element was calculated based on the population and per-capita consumption of fuels estimated from the result of the fuel consumption survey. The population by grid elements is shown in Figure D5.1.6 in Data Book.

(2) Automobiles

1) Line Sources

Standardized roads like national highways and major roads where the traffic volume is more than 10,000 vehicles/day are treated as line sources.

2) Area Sources

Roads other than above-mentioned roads are treated as area sources.

(3) Effective Stack Height

The effective stack height is determined as follows:

$$H_e = H_o + H$$

where,

H_e : effective stack height
H_o : actual stack height
H : rise of the plume above the stack

The rise of the plume above the stack (H) is determined by the following equation.

1) Stationary Source in Windy Condition

<u>CONCAWE equation</u>

$$H = 0.175 \cdot Q_H^{1/2} \cdot u^{-3/4}$$

where,

H : rise of the plume above the stack (m)
u : wind speed at the top of stack (m/s)
Q_H : heat emission due to efflux of stack gas (cal/s)

$Q_H = \rho \cdot Cp \cdot Q \cdot T$

ρ : density of stack gas at 0 °C = $1.293 \text{x} 10^3$ (g/m3)
C_p : specific heat at constant pressure = 0.24 (cal/°K·g)
Q : emission rate of stack gas (Nm3/s)
T : difference between the stack gas temperature (T_C) and the ambient temperature = T_C-15 (°C)

2) Stationary Source in Calm Condition

<u>Briggs equation</u>

$$H = 1.4 \cdot Q_H^{1/4} \cdot (d\theta/dz)^{-3/8}$$

where, $d\theta/dz$: vertical potential temperature gradient of atmosphere

3) Line Source

Motor Vehicle : H_e = 1.5 m

4) Area Source

Communal : H_e = 15 m
Motor Vehicle : H_e = 1.5 m

(4) Time Variation Patterns

Time variations of plant operation, traffic volume, and fuel use in households were determined to be as follows.

1) Stationary Sources

i) Point source

Operation hours by seasons indicated in the ÉKF data file were used.

ii) Area source

Referring to the results of the questionnaire survey on home heating, ratios of fuel use in households by seasons and time zones were determined to be as follows.

Seasonal :
Non-heating season : 16.7 %
Heating season : 83.3 %

Time-zonal :
Morning : 25.2 %
Afternoon : 30.8 %
Evening : 30.8 %
Mid-night : 13.2 %

2) Automobiles

Based on the results of the fuel consumption survey and the traffic volume survey of 24 hours, ratios of traffic volume by seasons and time zones were determined to be as follows.

Seasonal :
Non-heating season : 55 %
Heating season : 45 %

Time-zonal :
Morning : 31.2 %
Afternoon : 38.0 %
Evening : 24.0 %
Mid-night : 6.8 %

(5) Amount of Pollutant Emissions at Present

Annual amounts of SO_2 emissions from industries, households and moter vehicles are shown by grid elements in Figures 5.1.5 though 5.1.7, and those of NOx are shown in Figures 5.1.8 through 5.1.10.

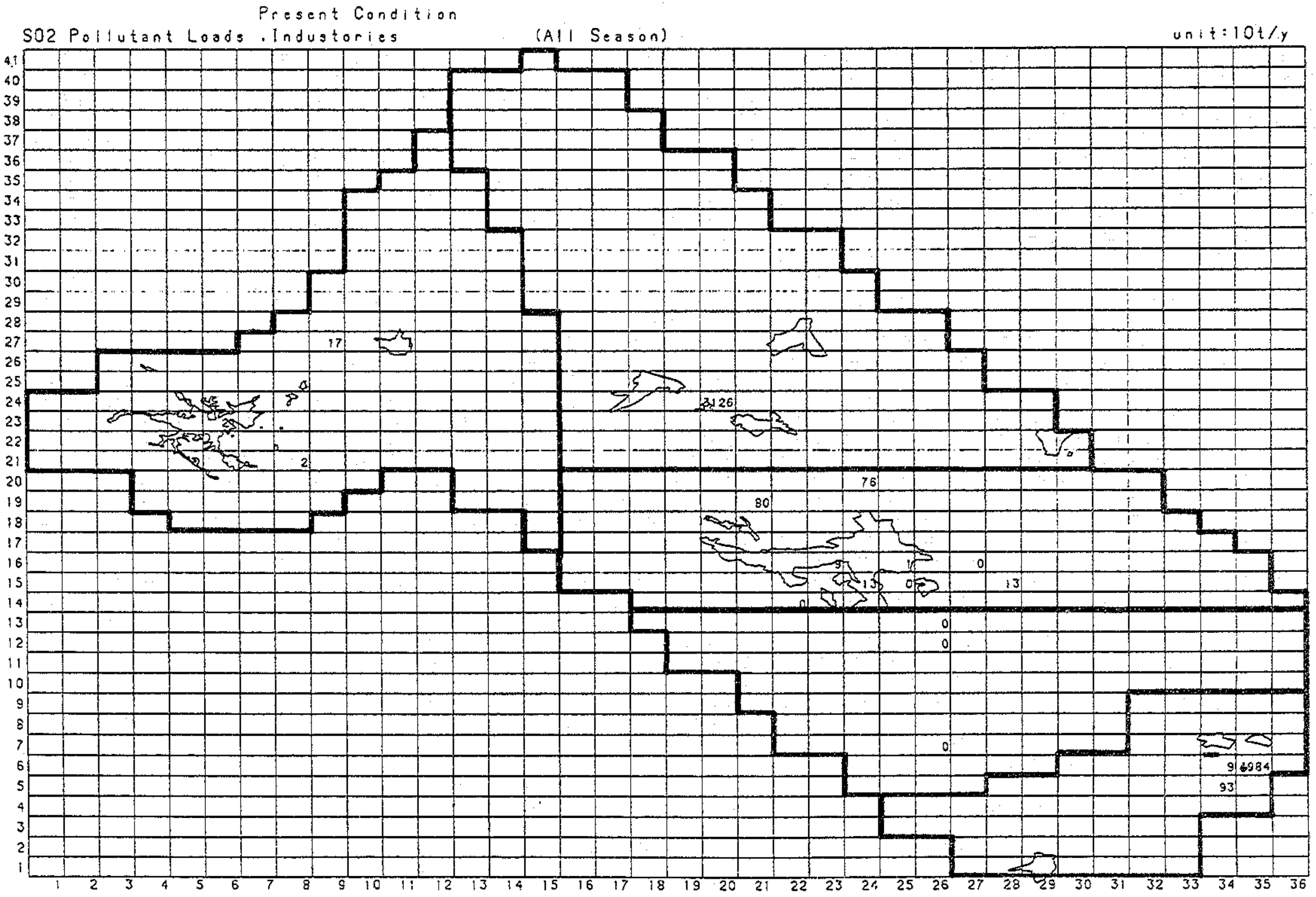


Figure 5.1.5 Annual Amount of SO_2 Emission From Industries (Present)

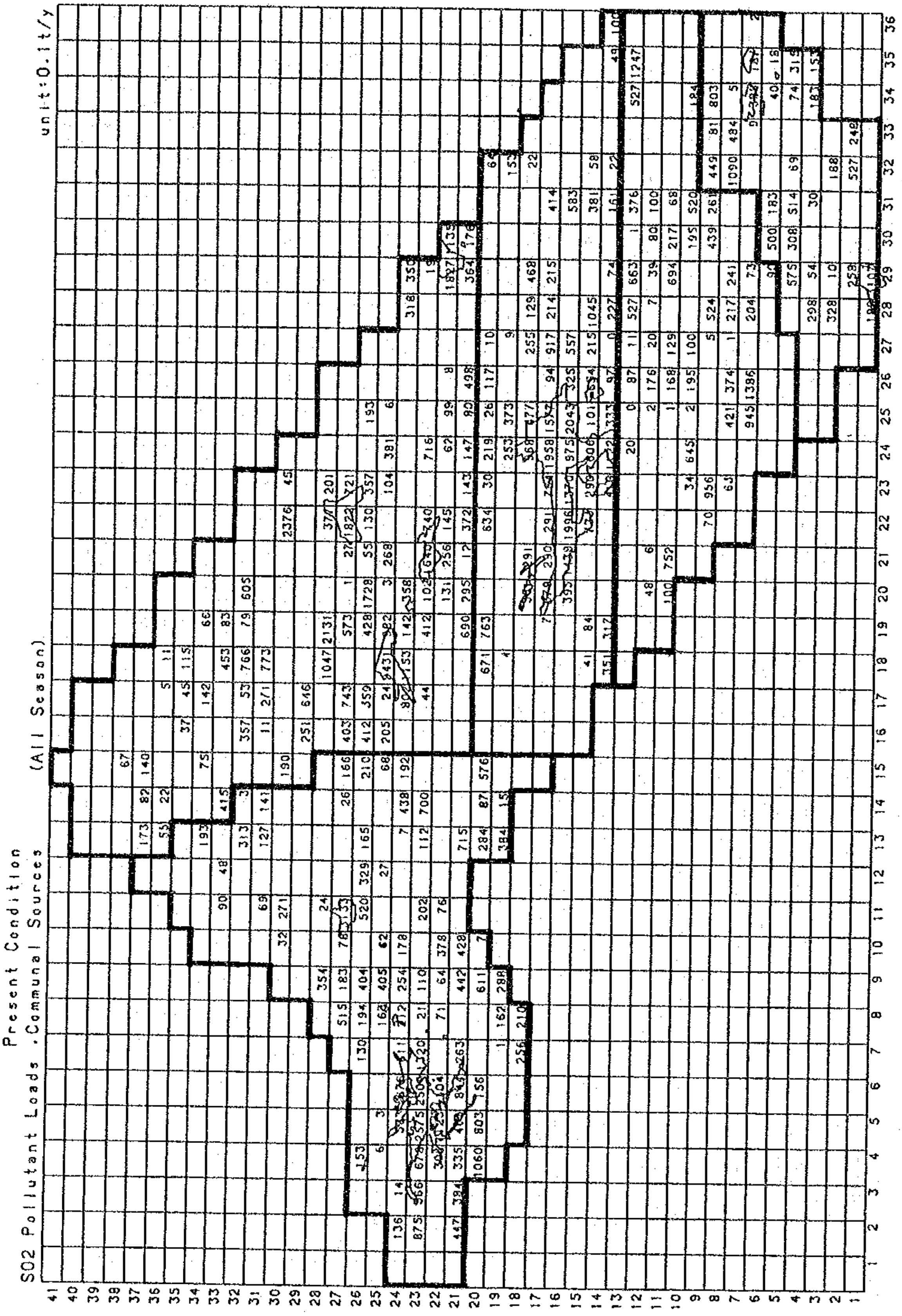


Figure 5.1.6 Annual Amount of SO$_2$ Emission From Communal Facilities (Present)

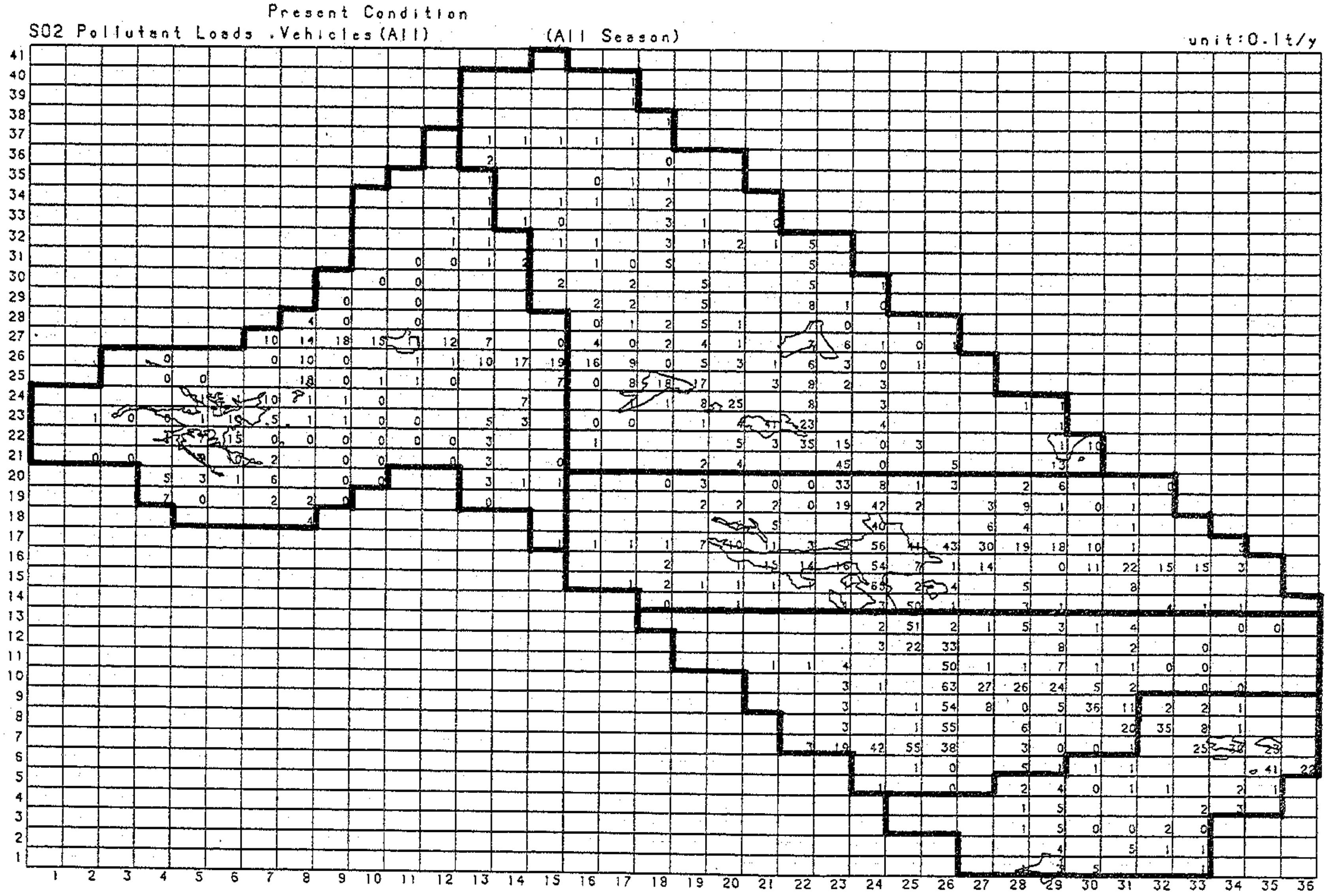


Figure 5.1.7 Annual Amount of SO_2 Emission From Motor Vehicles (Present)

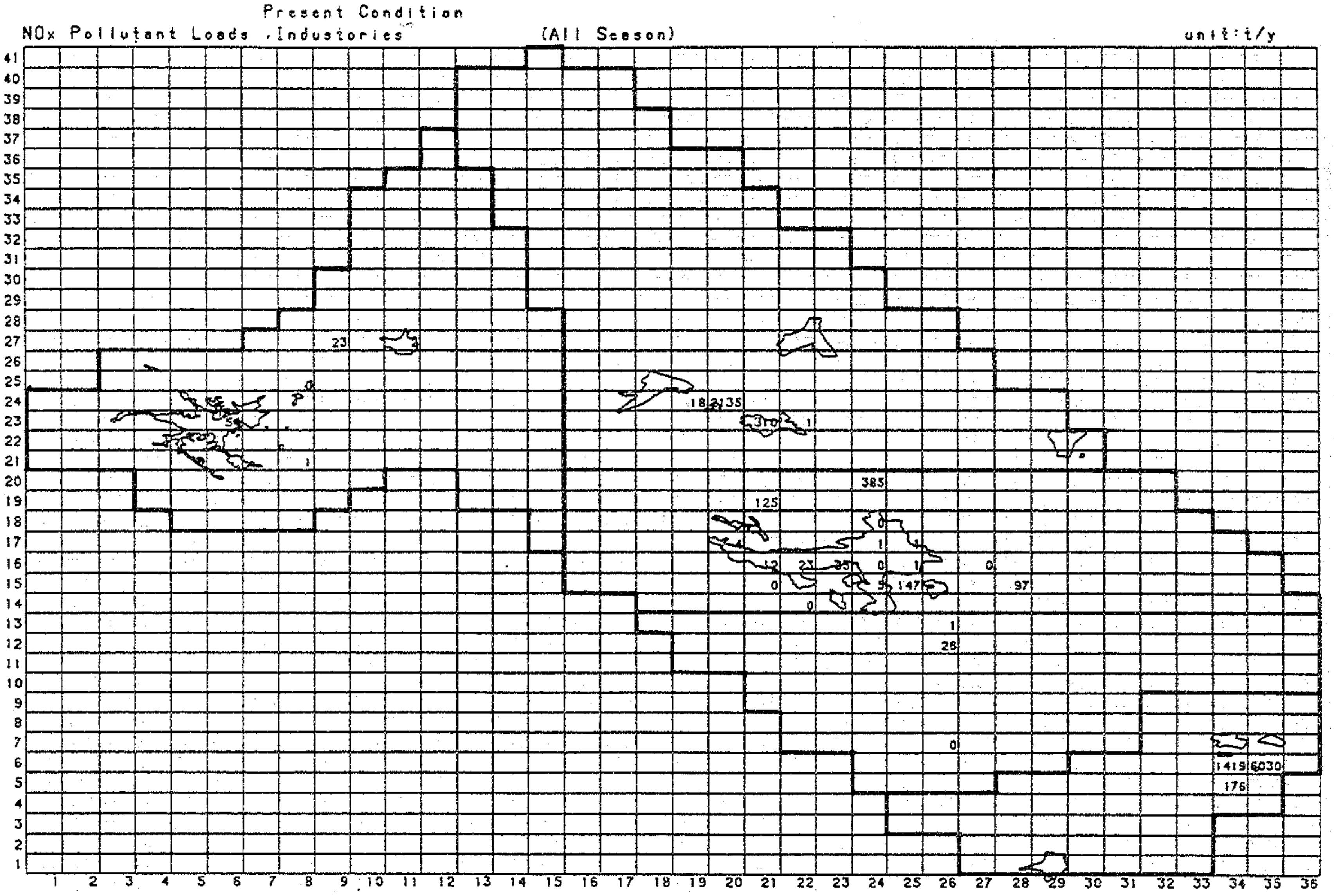


Figure 5.1.8 Annual Amount of NOx Emission From Industries (Present)

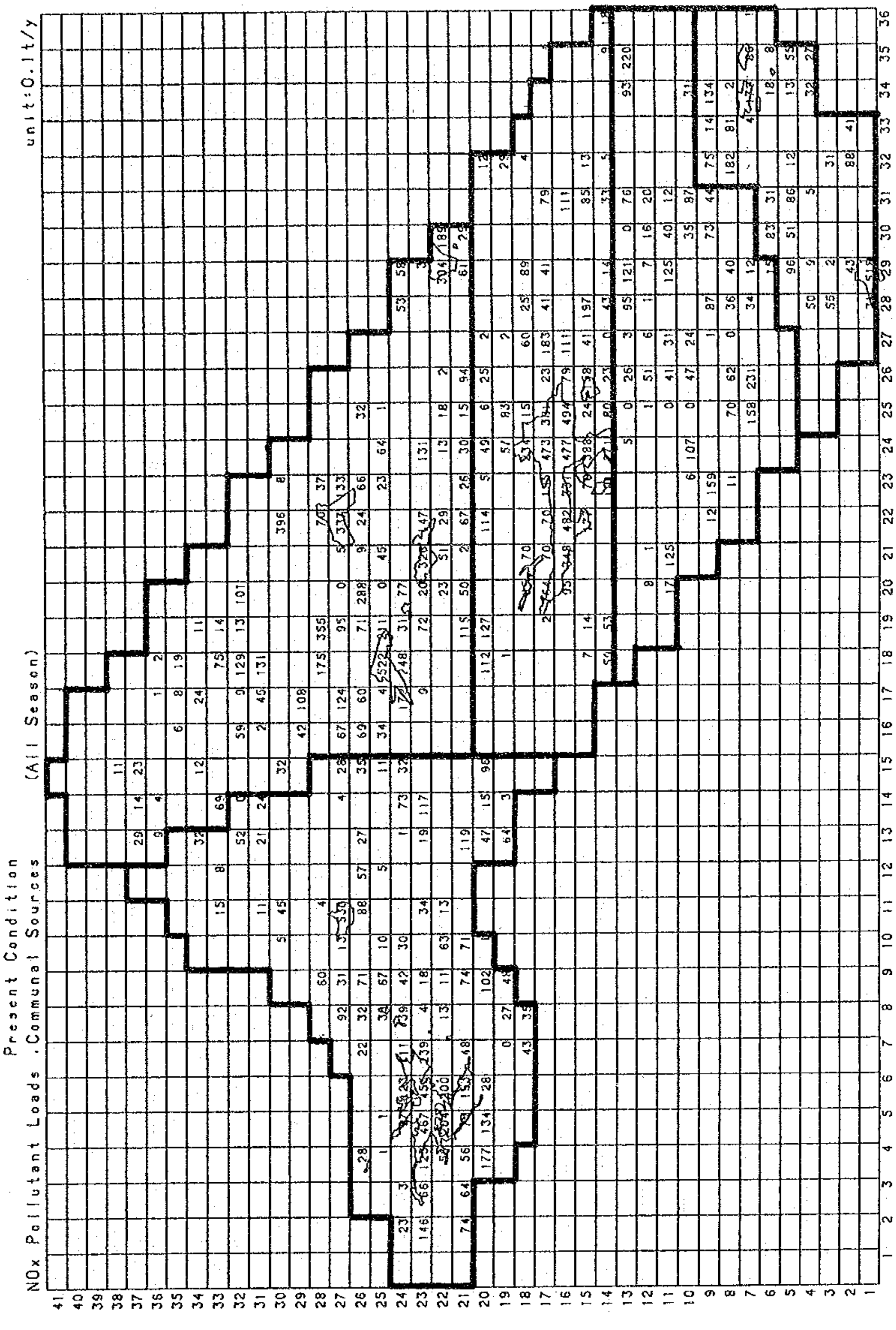


Figure 5.1.9 Annual Amount of NOx Emission From Communal Facilities (Present)

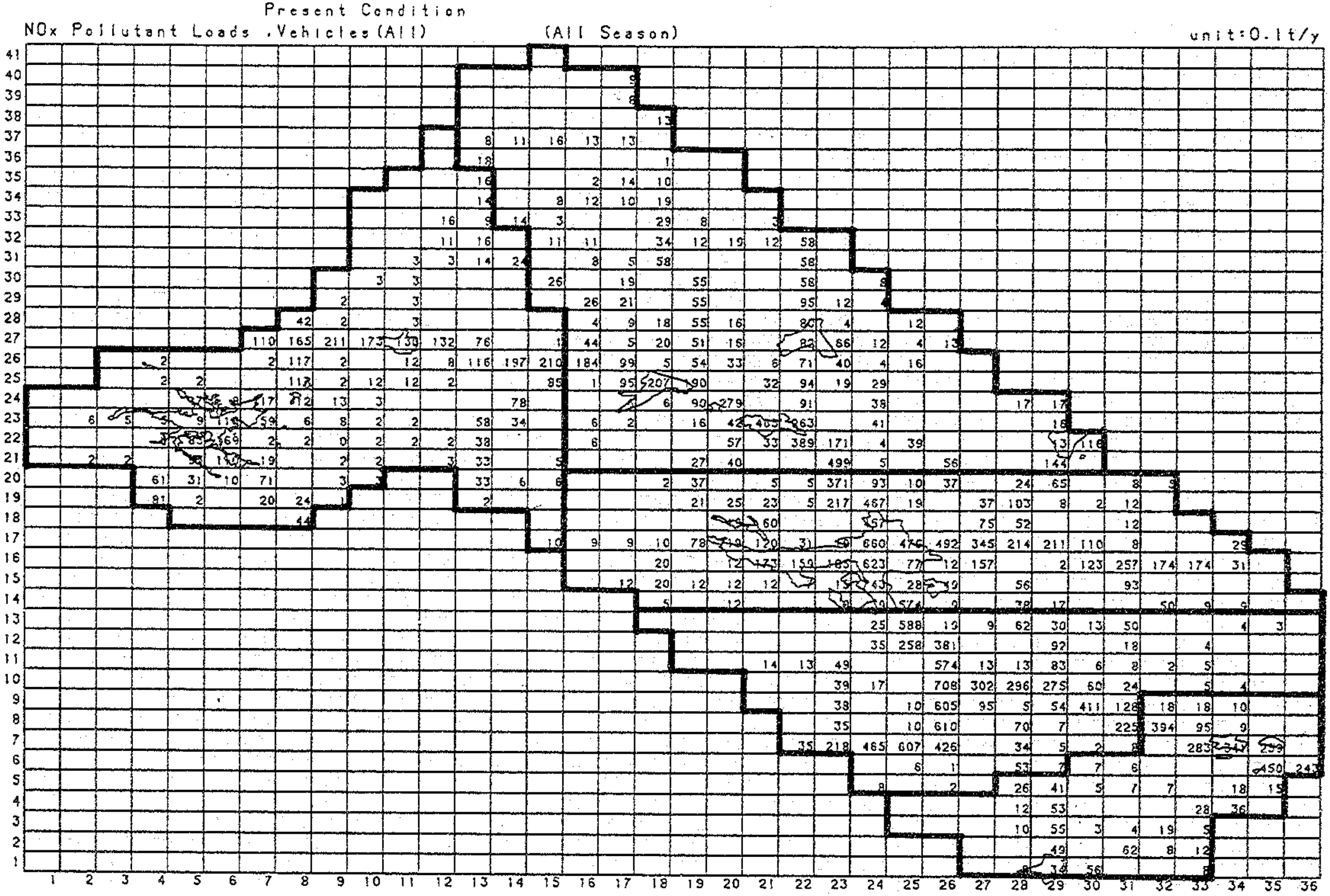


Figure 5.1.10 Annual Amount of NOx Emission From Motor Vehicles (Present)

5.1.5 Dispersion Equations

(1) Point Source Equation

When windy (u > 0.4 m/s), the following plume equation is used.

$$C(R,z)=\frac{Qp}{\sqrt{2\pi}\,\frac{\pi}{8}R\sigma zU}\cdot\left[\exp\left(-\frac{(z-He)^{2}}{2\sigma z^{2}}\right)+\exp\left(-\frac{(z+He)^{2}}{2\sigma z^{2}}\right)\right]$$

C (R, z) : Concentration at the location (R, z)
R : Horizontal distance (m) from a point source to a computation point
z : z coordinates (m) of the computation point (along height)
Qp : Point source intensity (Nm^3/s)
U : Wind speed (m/s)
He : Effective stack height (m)
σz : Vertical dispersion parameter (m) (using the Pasquill-Gifford chart)

When calm (u $\leqq$ 0.4 m/s), the following puff equation is used.

$$C(x,y,T)=\frac{1}{(2\pi)}\int_{0}^{T}\frac{2Qp}{\sigma y^{2}\sigma z}\exp\left(-\frac{(x-Ut)^{2}}{2\sigma y^{2}}-\frac{y^{2}}{2\sigma y^{2}}-\frac{He^{2}}{2\sigma z^{2}}\right)dt$$

A steady-state solution for the calm condition was applied after integrating the above equation up to t = ∞, with U = 0, $\sigma y = \alpha t$, and $\sigma z = \gamma t$.

$$C(R,z)=\frac{Qp}{(2\pi)^{3/2}\gamma}\cdot\left(\frac{1}{R^{2}+\frac{\alpha^{2}}{\gamma^{2}}(z-He)^{2}}+\frac{1}{R^{2}+\frac{\alpha^{2}}{\gamma^{2}}(z+He)^{2}}\right)$$

$R^2 = x^2 + y^2$

α, γ : Coefficients for dispersion parameters for calm
$\sigma x = \sigma y = \alpha \cdot t$
$\sigma z = \gamma \cdot t$
t : Time lapse (s)

(2) Area Source Equation

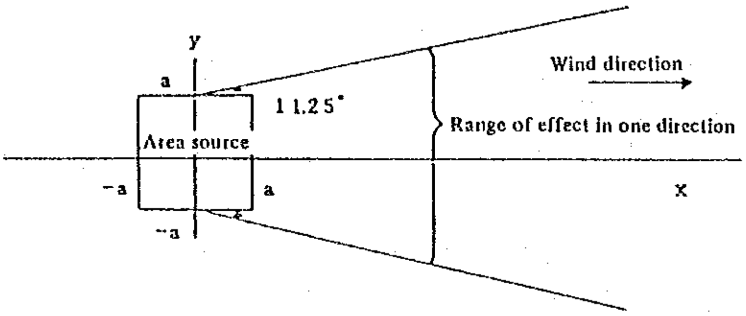
When windy, the plume equation applicable to long-term average concentration is used, assuming that a square area source with a side 2a long is present in isolation.

$$C = \frac{QA}{\sqrt{2\pi u}} \int_{x-a}^{x+a} \frac{2a}{\left(\frac{\pi}{8}\varepsilon + 2a\right)\sigma z(\varepsilon)} \cdot [F] d\varepsilon$$

$$[F] = \exp\left(-\frac{(z - He)^2}{2\sigma z(\varepsilon)^2}\right) + \exp\left(-\frac{(z + He)^2}{2\sigma z(\varepsilon)^2}\right)$$

QA : Area Source intensity (Nm3/s)
u : Wind speed (m/s)
He : Effective stack height (m)
σ z : Vertical diffusion parameter (m)
2a : Length (m) of a side of a square area source

A conceptual diagram of a square area source dispersion model is shown below.



When calm, the following equation is used by applying the simplified puff equation (steady-state solution) to a circular area source that has the same area as a square area source with a side 2a long.

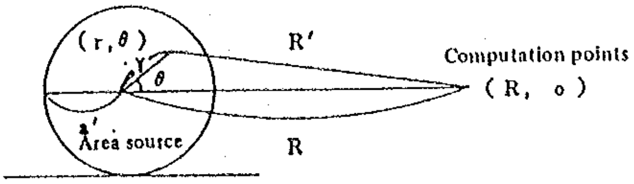
$$C = \frac{QA}{(2p)^{3/2} r} \int_0^{a'} \int_0^{2} \left(\frac{1}{R'^2 + b_1{}^2} + \frac{1}{R'^2 + b_2{}^2} \right) r \cdot d\theta \cdot dr$$

$$a' = \frac{2a}{\sqrt{\pi}}$$

$$R' = \left(r^2 + R^2 - 2\ r\ R\cos\theta\right)^{1/2}$$

$$b_1 = \frac{\alpha}{\gamma}(z - He), \quad b_2 = \frac{\alpha}{\gamma}(z + He),$$

A conceptual diagram of a circular area source dispersion model is shown below.



(3) Line Souse Equation

When windy, the 2π / 16 equation which brings uniform concentration in the direction of y is used.

$$C=\int_{r_1}^{r_2}\frac{QL}{\sqrt{2\pi}\,\frac{\pi}{8}\,r\sigma z(r)u}\cdot\left[\exp\left(-\frac{(z-He)^2}{2\sigma z(r)^2}\right)+\exp\left(-\frac{(z+He)^2}{2\sigma z(r)^2}\right)\right]\cdot dr$$

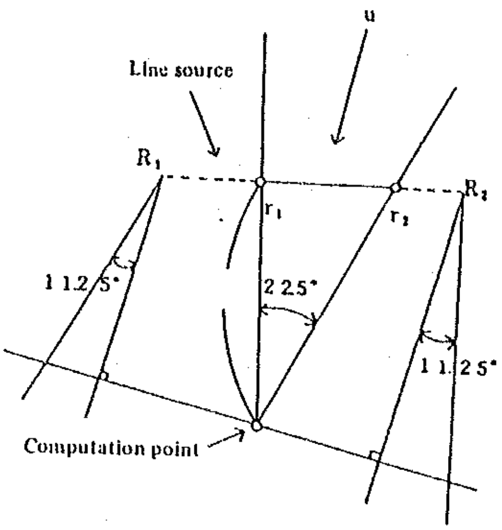
z : z coordinate (m) at the computation point
r : Distance (m) from the computation point to a line source
r_1, r_2 : Integration interval (m) of a line source
QL : Line source intensity (Nm^3 / s.m)
u : Wind speed (m/s)
He : Effective stack height (m)
σz : Vertical diffusion parameter (m)

When calm, the following equation is used.

$$C=\int_{r_1}^{r_2}\frac{QL}{(2\pi)^{3/2}r}\left(\frac{1}{r^2+{b_1}^2}+\frac{2}{r^2+{b_2}^2}\right)\,dr$$

$$b_1=\frac{\alpha}{\gamma}(z-He)\qquad b_2=\frac{\alpha}{\gamma}(z+He)\qquad r^2=x^2+y^2$$

A conceptual diagram of line source dispersion model is shown below.



5.1.6 Dispersion Parameters

Dispersion parameters for windy conditions are as shown in Table 5.1.2 which is the approximation of the Pasquill-Gifford chart, and those for calm and breeze conditions are shown in Table 5.1.3.

Table 5.1.2 Dispersion Parameters for Windy Conditions

$\sigma_y(x) = \gamma y \cdot x^{\alpha y}$

Atmospheric stability	αy	γy	Down-wind distance, x (m)
A	0.901 0.851	0.426 0.602	0 ~ 1,000 1,000 ~
B	0.914 0.865	0.282 0.396	0 ~ 1,000 1,000 ~
C	0.924 0.885	0.1772 0.232	0 ~ 1,000 1,000 ~
D	0.929 0.889	0.1107 0.1467	0 ~ 1,000 1,000 ~
E	0.921 0.897	0.0864 0.1019	0 ~ 1,000 1,000 ~
F	0.929 0.889	0.0554 0.0733	0 ~ 1,000 1,000 ~
G	0.921 0.896	0.0380 0.0452	0 ~ 1,000 1,000 ~

$\sigma_z(x) = \gamma z \cdot x^{\alpha z}$

Atmospheric stability	αz	γz	Down-wind distance, x (m)
A	1.122 1.514 2.109	0.0800 0.00855 0.000212	0 ~ 300 300 ~ 500 500 ~
B	0.964 1.094	0.1272 0.0570	0 ~ 500 500 ~
C	0.918	0.1068	0 ~
D	0.826 0.632 0.555	0.1046 0.400 0.811	0 ~ 1,000 1,000 ~ 10,000 10,000 ~
E	0.788 0.565 0.415	0.0928 0.433 1.732	0 ~ 1,000 1,000 ~ 10,000 10,000 ~
F	0.784 0.526 0.323	0.0621 0.370 2.41	0 ~ 1,000 1,000 ~ 10,000 10,000 ~
G	0.794 0.637 0.431 0.222	0.0373 0.1105 0.529 3.62	0 ~ 1,000 1,000 ~ 2,000 2,000 ~ 10,000 10,000 ~

Table 5.1.3 Dispersion Parameters for Calm and Breeze

(1) Calm (≤ 0.4 m/s)

Atomospheric Sability Classes	α	γ
A	0.948	1.569
A-B	0.859	0.862
B	0.781	0.474
B-C	0.702	0.314
C	0.635	0.208
C-D	0.542	0.153
D	0.470	0.113
E	0.439	0.067
F	0.439	0.048
G	0.439	0.029

(2) Breeze (0.5 ~ 0.9 m/s)

Atomospheric Sability Classes	α	γ
A	0.748	1.569
A-B	0.659	0.862
B	0.581	0.474
B-C	0.502	0.314
C	0.435	0.208
C-D	0.342	0.153
D	0.270	0.113
E	0.239	0.067
F	0.239	0.048
G	0.239	0.029

In computation, dispersion parameter values were determined for the following groups of the stability classes based on the values of above tables and appearance frequency of each stability class:

Unstable : A ~ B-C
Neutral : C ~ D
Stable : E ~ G

5.1.7 NO_2 Conversion Model

In order to separate the concentration of NO_2 from the computed NOx concentration, a statistical NO_2 conversion model is used. This model estimates the relationship between the concentrations of NOx and NO_2 statistically based on the observed concentrations of the both. This relation (equation) is used to estimate the NO_2 concentration from the computed value of the NOx concentration. The following form was assumed as the NO_2 conversion model, and coefficients a and b were evaluated by means of the least square method.

$$[\, NO_2 \,] = a \cdot [\, NOx \,]^{b}$$

The concentration data of NOx and NO_2 at 9 monitoring stations for one year were used, and the following equation was obtained.

$$[NO2] = 1.09 ([NOx]_S + [NOx]_B)^{0.85}$$

where,

$[NOx]_S$: Computed NOx concentration caused by the all man-made pollution sources ($\mu g/m^3$)

$[NOx]_B$: Background NOx concentration ($\mu g/m^3$)

Correlation between the observed concentrations of NOx and NO_2 is shown in Figure 5.1.11.

5.1.8 Method of Model Evaluation

Measured data at the ambient air quality monitoring stations are used for the evaluation of the reproducibility of the simulation model. The computed pollutant concentrations are compared with the measured data, and the accuracy of the computed value is evaluated according to the criteria shown in Table 5.1.4. Adjustment of model parameters is repeated until the conditions needed for Rank B are satisfied.

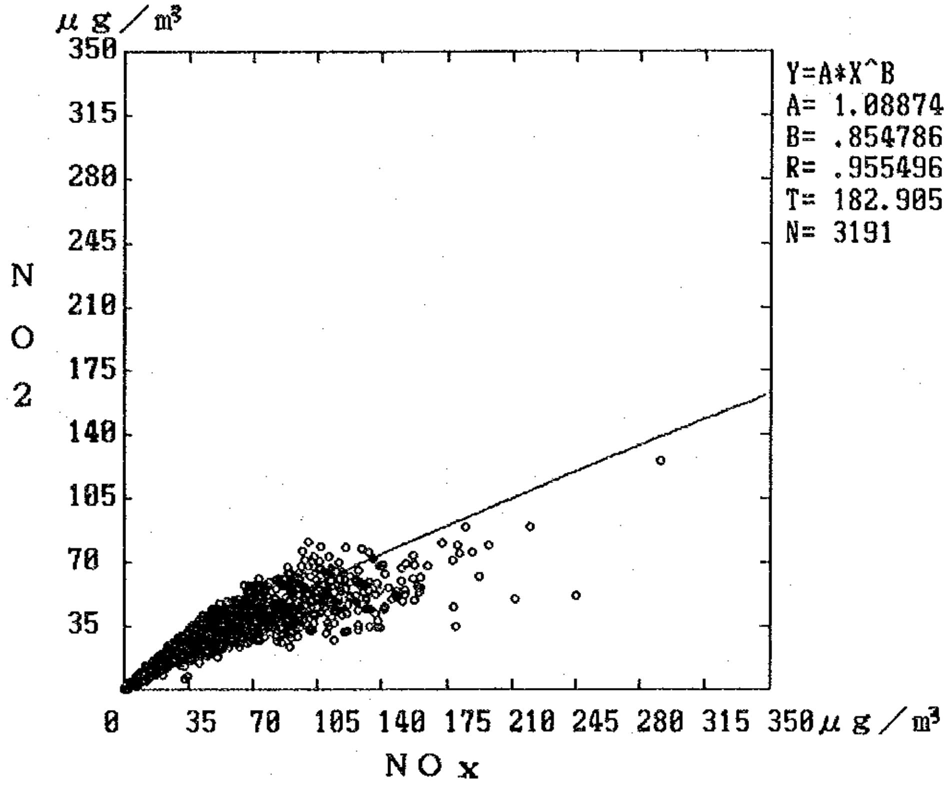


Figure 5.1.11 Correlation Between Observed Concentrations of NOx and NO_2

Table 5.1.4 Conditions for Evaluation of the Accuracy of the Dispersion Model

- Individual conditions pertaining to the conformity between calculated and measured values.

1. $a_0 \le \frac{1}{3}(\overline{Y} - BG) + BG$
2. $a_0 \le \frac{2}{5}(\overline{Y} - BG) + BG$
3. The inclination of a regressing line shall range from 0.8 to 1.2 and be as close to 1 as possible. In addition, the correlation coefficient shall be at least 0.71 and should possibly exceed 0.8.
4. $S'/\overline{Y} \le \frac{1}{5}$
5. $S'/\overline{Y} \le \frac{1}{4}$
6. $S'/\overline{Y} \le \frac{1}{3}$

$\overline{Y}$: Mean measured value available form a measuring station
$\overline{X}$: Mean computed value for the measuring station
a_0 : $\overline{Y} - \overline{X}$
BG : Background values in the nature
$S'/\overline{Y}$: Variation coefficient obtained from $\overline{Y} = \overline{X} + a_0$

- Accuracy ranking pertaining to the conformity between computed and measured values.

(a) Rank A

Either the conditions 1, 3, and 5, or 1 and 4, stated above, be satisfied. Even if the conditions 1 and 4 are satisfied, the inclination of a regressing line should be as close to 1 as possible.

(b) Rank B

The conditions 2 and 5 shall be satisfied.

(c) Rank C

The conditions 2 and 6 shall be satisfied.

Note : It is desired that the inclination of regressing lines should also be as close to 1 as possible in the cases of Ranks B and C.

5.2 Air Quality Simulation Under the Present Conditions

5.2.1 Model Evaluation Against Observed Data

(1) Computation of Pollutant Concentrations at Monitoring Stations

In order to establish the air quality simulation model, computation of pollutant concentrations at the monitoring stations were made based on the present amounts of pollutant emissions. In these comparisons, Station J6 was excluded since the station lacked the data in October and around when high pollutant concentration occurred. For SO_2, JF1 was also excluded since the observed concentrations were considerably higher in comparison to emission loads and were very difficult to reproduce by the model.

1) SO_2

Tables 5.2.1 and 5.2.2, and Figure 5.2.1 show the comparisons of computed SO_2 concentrations with the observed data. As can be seen from Figure 5.2.1, the correlation between the measured values and the computed values is high. However, the computed values are a little lower than the observed values.

2) NOx

Tables 5.2.3 and 5.2.4, and Figure 5.2.2 show the comparisons of computed NOx concentrations with the observed data. Similar to SO_2, the correlation between the observed values and the computed values is high, but the latter is a little lower than the former.

Table 5.2.1 Computed Concentration of SO_2

PERIOD	TIME PERIOD	S02 PPB							AVE.
		JF2	J1	J2	J3	J4	J5	J7	
ALL SEASON JAN.-DEC.	MORN.	12.1	7.4	14.6	19.2	13.7	14.5	9.3	13
	AFTER.	8.3	7.9	12.9	14.5	12.0	10.1	5.1	10
	EVEN.	8.3	9.3	14.4	13.6	15.5	18.2	10.5	13
	NIGHT	7.4	3.4	6.1	7.9	6.5	8.2	5.3	6
	DAY	8.8	6.8	11.7	13.3	11.6	12.5	7.4	10
NON-HEATING SEASON APR.-SEP.	MORN.	14.4	2.9	10.3	16.4	7.5	6.9	4.7	9
	AFTER.	7.3	3.5	6.7	7.6	4.9	3.6	2.2	5
	EVEN.	4.7	3.8	6.3	5.3	6.1	6.7	4.5	5
	NIGHT	5.8	1.3	2.9	3.2	3.2	4.7	3.1	3
	DAY	7.7	2.8	6.2	7.6	5.2	5.4	3.5	5
HEATING SEASON OCT.-MAR.	MORN.	9.7	11.8	18.8	22.0	19.9	22.1	13.9	17
	AFTER.	9.3	12.2	19.2	21.4	19.2	16.6	8.0	15
	EVEN.	12.0	14.8	22.5	21.9	25.0	29.7	16.5	20
	NIGHT	9.0	5.6	9.4	12.7	9.7	11.8	7.6	9
	DAY	10.0	10.8	17.1	19.1	18.0	19.6	11.2	15

Table 5.2.2 Observed Concentration of SO_2

PERIOD	TIME PERIOD	S02 PPB							AVE.
		JF2	J1	J2	J3	J4	J5	J7	
ALL SEASON JAN.-DEC.	MORN.	11.7	6.2	15.5	14.4	8.1	11.7	8.2	11
	AFTER.	11.8	8.7	22.3	20.3	10.7	15.0	11.8	14
	EVEN.	7.9	5.8	17.1	19.4	11.4	19.3	11.4	13
	NIGHT	5.2	3.4	10.8	11.2	7.2	9.8	6.4	8
	DAY	8.9	5.9	16.2	16.2	9.3	13.9	9.4	11
NON-HEATING SEASON APR.-SEP.	MORN.	12.8	2.9	12.4	9.6	3.5	4.8	4.9	7
	AFTER.	10.7	3.8	17.0	11.4	3.9	4.1	5.2	8
	EVEN.	4.7	2.1	5.7	5.0	2.6	3.9	3.7	4
	NIGHT	2.2	1.1	2.9	2.9	1.2	2.6	2.4	2
	DAY	7.2	2.4	9.1	6.9	2.7	3.8	3.9	5
HEATING SEASON OCT.-MAR.	MORN.	10.6	9.5	18.9	19.2	13.3	18.2	11.5	14
	AFTER.	13.0	13.4	27.9	29.2	18.4	25.4	18.5	21
	EVEN.	11.1	9.4	29.3	33.9	21.3	33.9	19.1	23
	NIGHT	8.2	5.6	19.2	19.6	14.1	16.7	10.6	13
	DAY	10.7	9.3	23.8	25.5	16.8	23.5	14.9	18

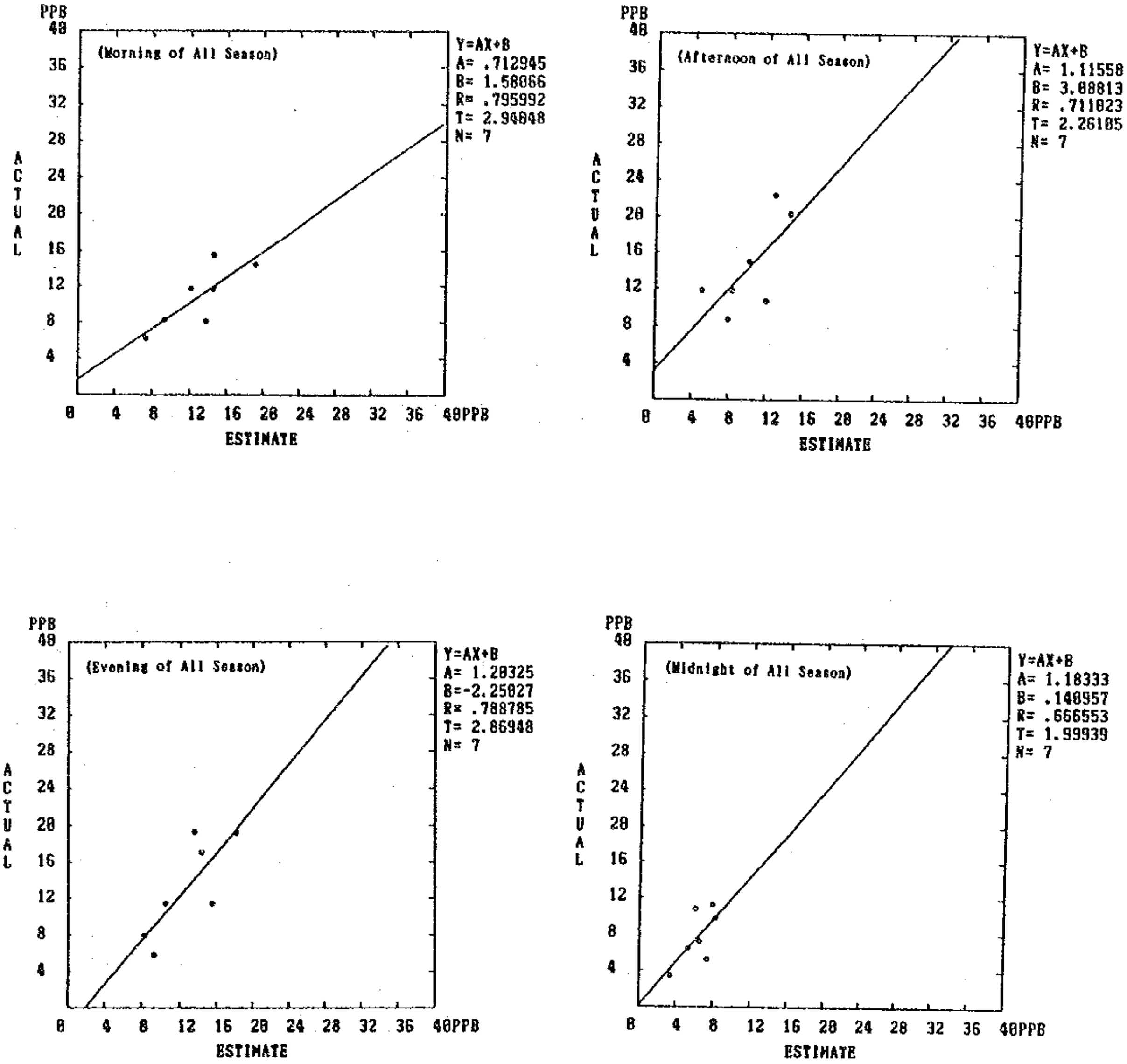


Figure 5.2.1 (1) Comparison of Computed and Observed Concentrations of SO_2

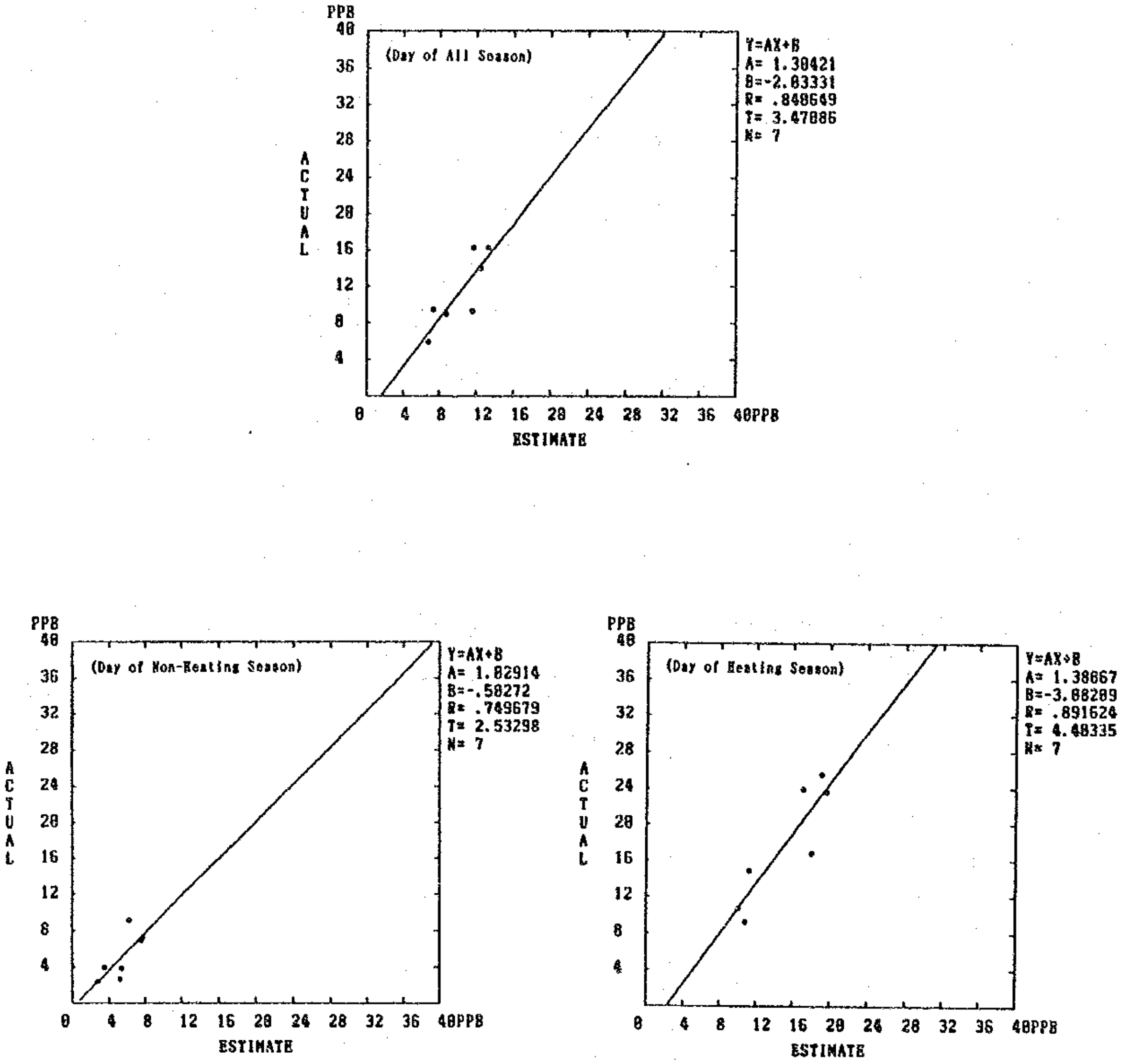


Figure 5.2.1 (2) Comparison of Computed and Observed Concentrations of SO_2

Table 5.2.3 Computed Concentration of NOx

	TIME					NOX			PPB		
PERIOD	PERIOD	JF1	JF2	J1	J2	J3	J4	J5	J6	J7	AVE.
ALL SEASON JAN.-DEC.	MORN.	10.1	9.0	5.7	34.4	22.8	15.6	22.3	27.6	31.9	20
	AFTER.	5.4	5.8	3.4	21.4	12.7	9.0	11.3	18.0	14.0	11
	EVEN.	18.3	11.3	8.3	36.6	25.0	21.0	37.4	34.6	47.9	27
	NIGHT	3.1	4.0	1.7	13.7	7.8	4.5	10.5	9.1	15.8	8
	DAY	8.9	7.3	4.6	25.7	16.4	12.1	19.9	21.5	26.7	16
NON-HEATING SEASON APR.-SEP.	MORN.	2.3	6.5	1.4	29.7	11.8	5.0	8.0	17.4	13.3	11
	AFTER.	2.1	4.4	1.5	13.6	6.8	5.1	6.7	15.9	7.9	7
	EVEN.	9.6	7.7	3.7	27.7	14.7	10.4	23.0	24.9	37.8	18
	NIGHT	2.3	4.0	1.1	16.0	7.0	3.7	11.0	9.0	17.9	8
	DAY	4.1	5.5	1.9	21.2	9.9	6.0	12.3	16.5	19.4	11
HEATING SEASON OCT.-MAR.	MORN.	18.0	11.6	10.0	39.1	33.9	26.4	36.7	37.9	50.7	29
	AFTER.	8.7	7.2	5.3	29.3	18.5	12.9	16.0	20.1	20.0	15
	EVEN.	27.0	14.9	13.0	45.5	35.5	31.6	51.9	44.2	58.0	36
	NIGHT	3.8	4.1	2.2	11.4	8.6	5.2	10.0	9.1	13.8	8
	DAY	13.8	9.1	7.3	30.2	23.1	18.1	27.5	26.6	34.1	21

Table 5.2.4 Observed Concentration of NOx

	TIME					NOX			PPB		
PERIOD	PERIOD	JF1	JF2	J1	J2	J3	J4	J5	J6	J7	AVE.
ALL SEASON JAN.-DEC.	MORN.	12.1	6.9	14.2	43.5	24.1	17.1	32.8	33.8	38.0	25
	AFTER.	8.9	4.6	9.2	28.7	15.7	13.9	23.7	23.4	24.7	17
	EVEN.	13.2	6.0	12.1	36.4	15.0	20.6	35.0	24.8	32.7	22
	NIGHT	9.5	6.3	8.7	24.8	14.1	13.6	20.2	14.7	23.7	15
	DAY	10.8	5.9	10.8	32.6	16.8	16.2	27.4	23.4	29.2	19
NON-HEATING SEASON APR.-SEP.	MORN.	7.5	6.4	10.9	33.5	19.0	10.4	20.3	24.2	30.8	18
	AFTER.	3.1	2.7	6.3	19.7	9.1	6.3	10.3	11.9	15.3	9
	EVEN.	5.9	4.3	8.5	23.7	8.2	9.7	17.0	14.5	22.4	13
	NIGHT	6.6	6.3	8.4	21.2	10.6	8.6	12.8	8.4	21.0	12
	DAY	5.8	4.9	8.4	24.0	11.4	8.7	14.8	14.1	21.9	13
HEATING SEASON OCT.-MAR.	MORN.	16.9	7.5	16.4	53.7	29.3	23.8	45.1	43.3	45.2	31
	AFTER.	14.9	6.6	11.2	37.8	22.3	21.5	36.8	34.9	34.1	24
	EVEN.	20.9	7.7	14.7	49.4	22.0	31.5	52.7	35.0	42.8	31
	NIGHT	12.8	6.3	9.0	28.5	17.7	18.8	27.4	21.1	26.5	19
	DAY	16.2	7.0	12.5	41.3	22.3	23.7	39.7	32.7	36.4	26

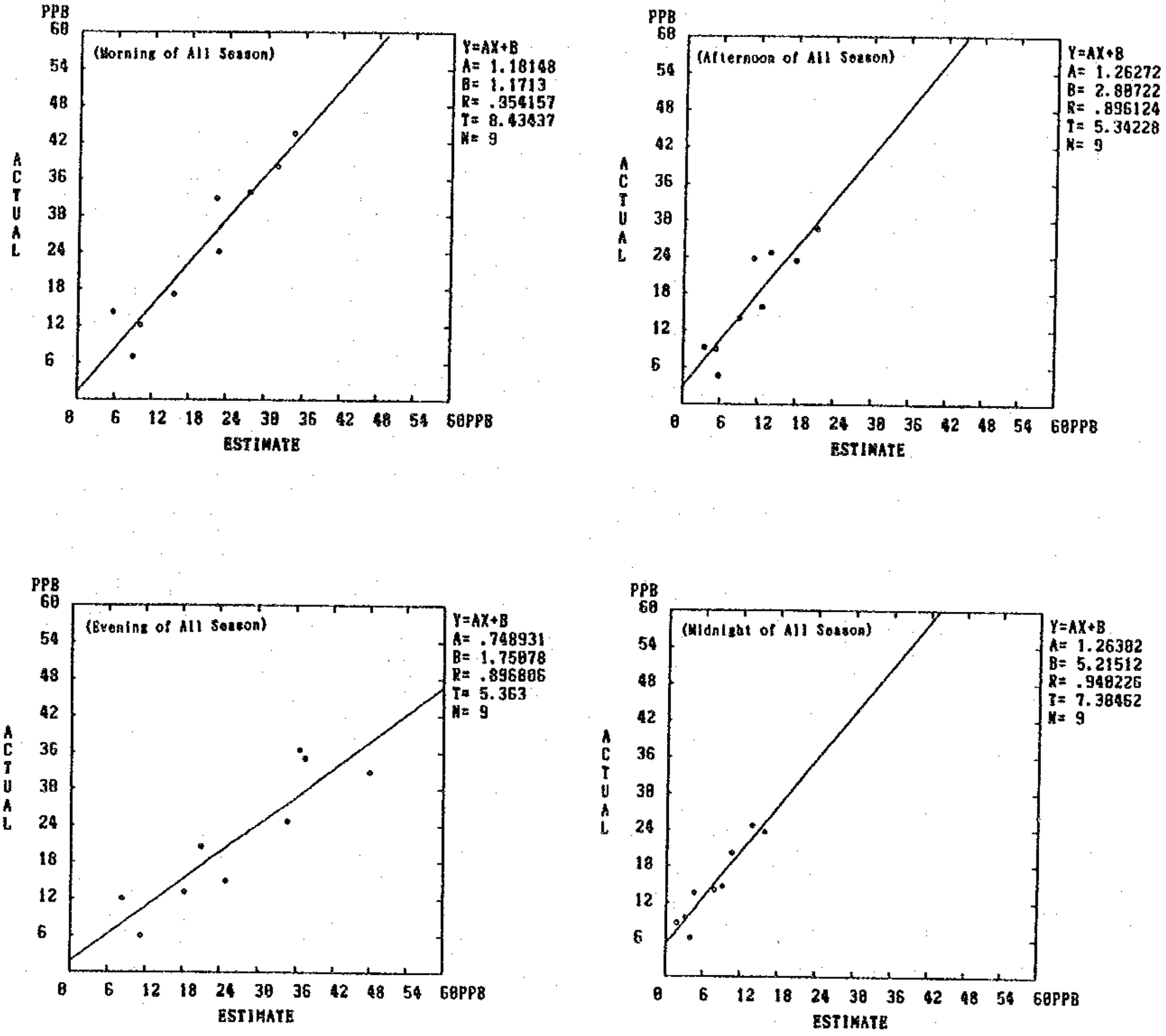


Figure 5.2.2 (1) Comparison of Computed and Observed Concentration of NOx

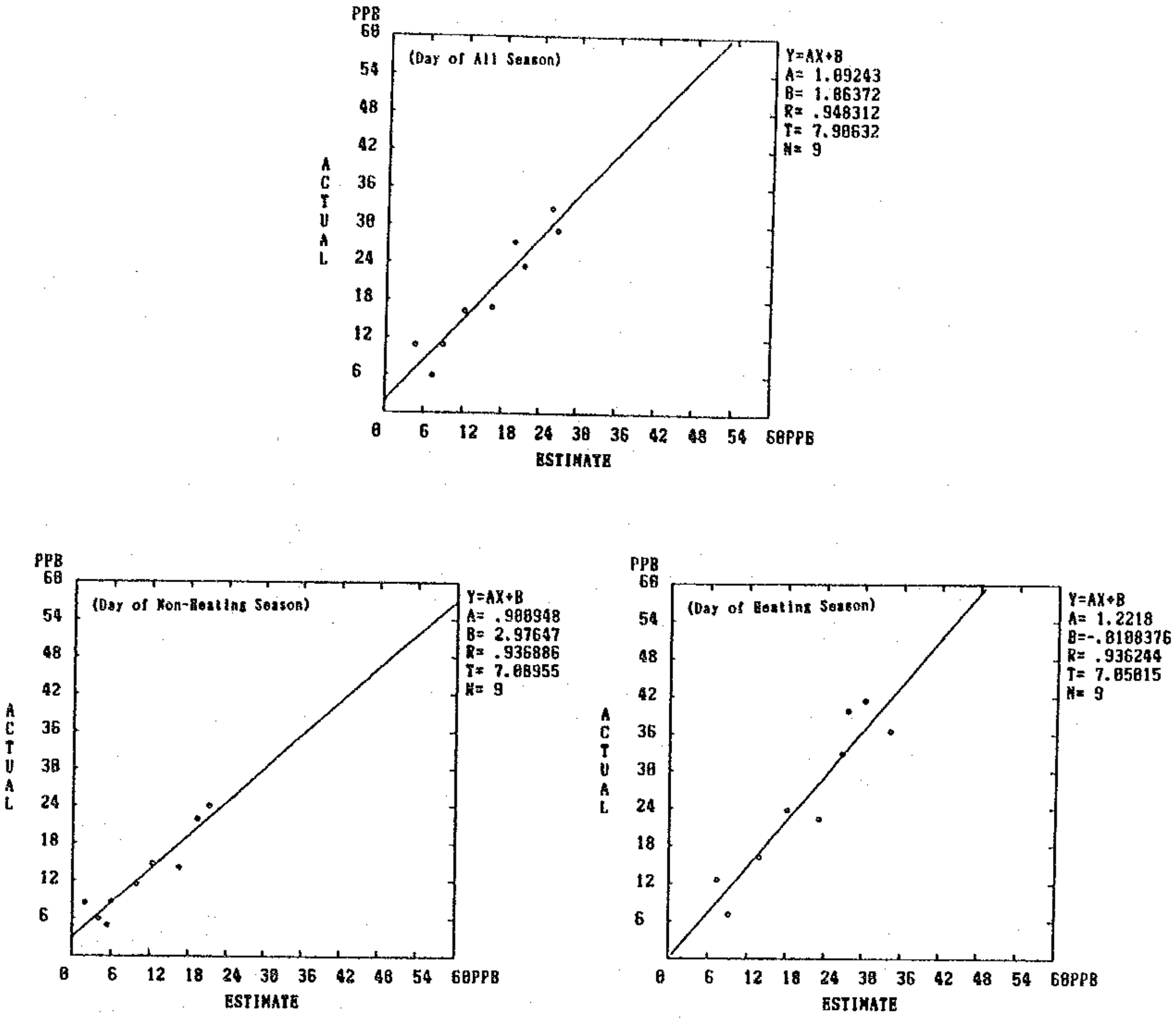


Figure 5.2.2 (2) Comparison of Computed and Observed Concentration of NOx

(2) Degree of Agreement Between Computed and Observed Values

Accuracy of the simulation model was evaluated based on the model evaluation criteria shown in Table 5.1.4.

1) SO_2

The evaluation result for SO_2 is shown in Table 5.2.5. Although the computed and the observed values do not agree well in certain time zones of the non-heating season, the overall performance of the model is judged to be satisfactory.

Table 5.2.5 Result of Model Evaluation for SO_2

Time Zone	Season		
	Non-heating Season	Heating Season	Year
Morning	-	A	A
Afternoon	-	A	A
Evening	C	B	A
Mid-night	-	B	C
Whole day	C	A	A

2) NOx

The evaluation result for NOx is shown in Table 5.2.6. Although the computed and observed values do not agree well in certain time zones, the daily averages of both seasons and whole year are ranked A. The model is sufficiently accurate to be used for long-term simulation. However, since the computed values are a little lower than the observed values, it is considered to be necessary to add a background concentration when computing the area-wide concentration distribution.

Table 5.2.6 Result of Model Evaluation for NOx

Time Zone	Season		
	Non-heating Season	Heating Season	Year
Morning	-	A	A
Afternoon	-	C	B
Evening	-	A	C
Mid-night	A	-	-
Whole day	A	A	A

(3) Background Concentration

Reproductions of the pollutant concentrations at the monitoring stations by the simulation model were generally satisfactory. However, the simulated values were a little lower than the actual values. Among various factors causing these differences, the following are considered to be significant :

1) Return of the pollutant into the computation area by circulating air flows or the change of wind direction
2) Presence of pollution sources in or out of the computation area whose pollutant emissions are not well known
3) Long time detention of the pollutant whose concentration is difficult to compute through the model
4) Errors associated with measured values
5) Absorption into and adsorption on the ground
6) Transformation of the pollutant in the atmosphere by reactions
7) Natural presence of the pollutant as a background

Since the above factors can not be evaluated individually, the difference between the observed values and the computed values are treated as "the background concentration".

In this study, the background concentration was determined for each pollutant in each season as shown in Table 5.2.7. The background concentration is to be added to the computed concentration.

Table 5.2.7 Background Concentration

Unit : μg/m³ (ppb)

Pollutant	Season		
	Non-heating	Heating	Whole year
SO_2	0	8 (3)	3 (1)
NOx	4 (2)	10 (5)	6 (3)

5.2.2 Pollutant Concentration Distribution in the Study Area

(1) SO_2

The computed present concentration distributions of SO2 in the Study Area are shown in Figure 5.2.3 for annual average and in Figure 5.2.4 for heating season average.

More details are displayed by Figures D5.2.1 through D5.2.4 and D5.2.11 through D5.2.22 in Data Book.

The higher concentrations appear sporadically in the densely populated urban areas. The concentration is particularly higher in Miskolc, Ozd and Sajoszentpeter. The areas where the annual average concentration exceeds the ambient air quality standard for living area (70 μg/m^3) are:

- Whole area of Miskolc except part of the western and southern areas
- Central areas of Sajoszentpeter and Ozd

The concentration in the central part of Miskolc is more than 90 μg/m^3, i.e. nearly the level of the quality standard for industrial area (100 μg/m^3).

In the Heating season, the areas exceeding the annual standards spread further. The living area standard is exceeded also in the following areas:

- Wide area along the Route 26 from Miskolc to Kazincbarcika
- Ozd, Putnok, and their outskirts

Areas where the standard for industrial area is exceeded in the heating season are Miskolc, Sajoszentpeter, Kazincbarcika and their outskirts, and Ozd.

(2) NO_x

The present concentration distributions of NOx are shown in Figure 5.2.5 for the annual average and in Figure 5.2.6 for the heating season average.

More details are displayed by Figures D5.2.5 and D5.2.23 through D5.2.28 in Data Book.

The higher concentrations are observed in densely populated urban areas and peripheries of major roads. The distribution is rather continuous geographically.

The annual quality standard for Specially Protected Area (30 μg/m^3) is exceeded in Miskolc, part of Sajoszentpeter, and the area along the Route 26 connecting these towns.

However, the whole area satisfies the quality standard for living area (100 $\mu g/m^3$).

In the heating season, the annual quality standard for specially protected area is exceeded in the area along Routes 3, 26 and 35, and in Ozd. No areas exceed the standard for living area.

(3) NO_2

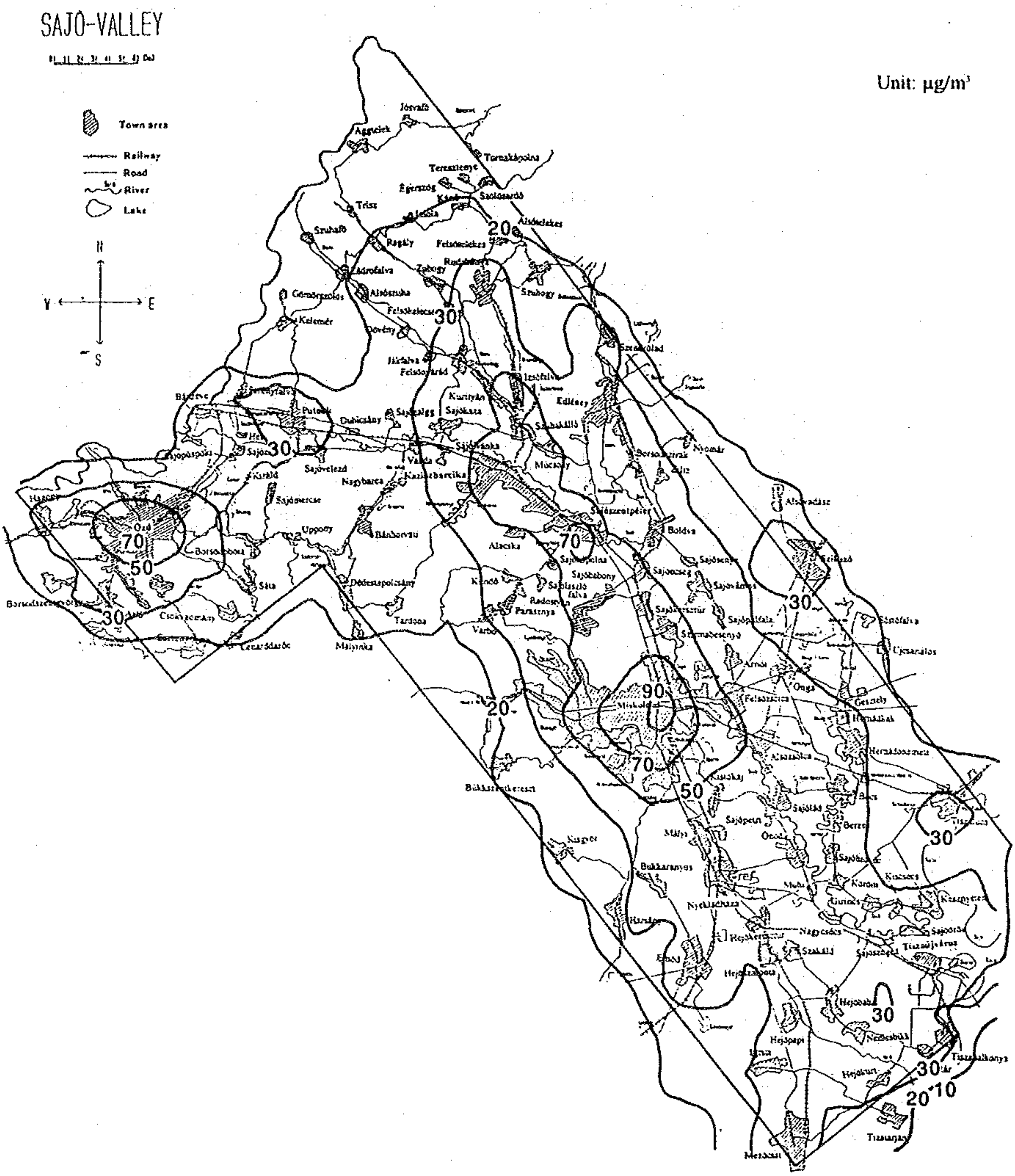
Using the NO_2 conversion model described in Section 5.1.7, the concentration distributions of NO_2 were obtained from the computed concentration distributions of NOx as shown in Figures 5.2.7 (annual) and 5.2.8 (heating season).

More details are displayed by Figures D5.2.6 through D5.2.10 and D5.2.29 through D5.2.38 Data Book.

The concentration distribution pattern is very similar to that of NOx. The concentration is higher in urban areas and peripheral areas of the major roads.

In the annual average, the quality standard for specially protected area (30 $\mu g/m^3$) is exceeded in the central zone and a part of southern zone of Miskolc. The whole area satisfies the living area standard (70 $\mu g/m^3$).

In the heating season, the annual standard for specially protected area is exceeded in Miskolc except the western zone, and in a part of the area along the Route 26.



Unit: μg/m³

Figure 5.2.3 Annual Average Concentration Isopleth for SO_2 (All Sources)

Unit: μg/m³

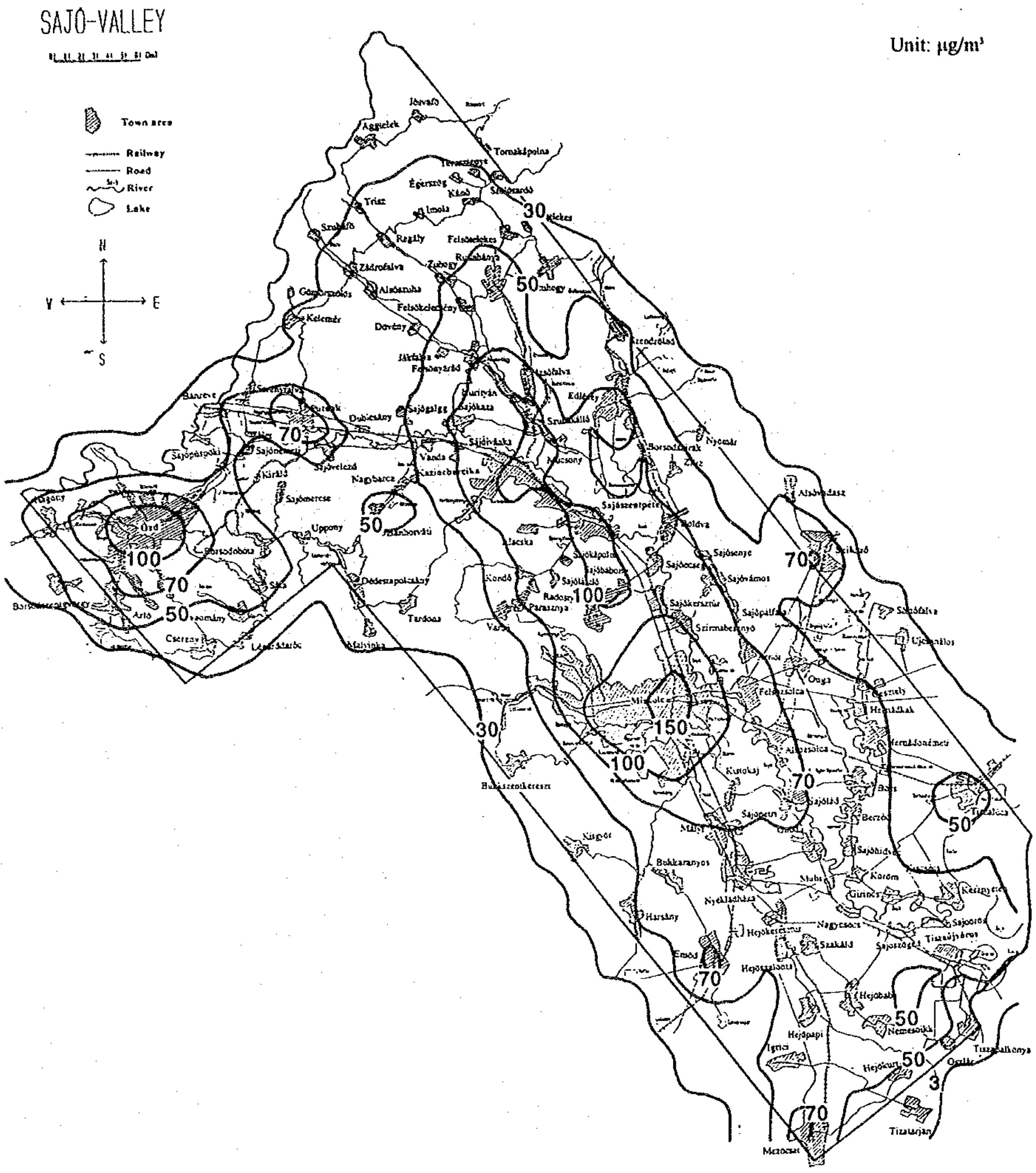


Figure 5.2.4 Concentration Isopleth for SO_2 in Heating Season (All Sources)

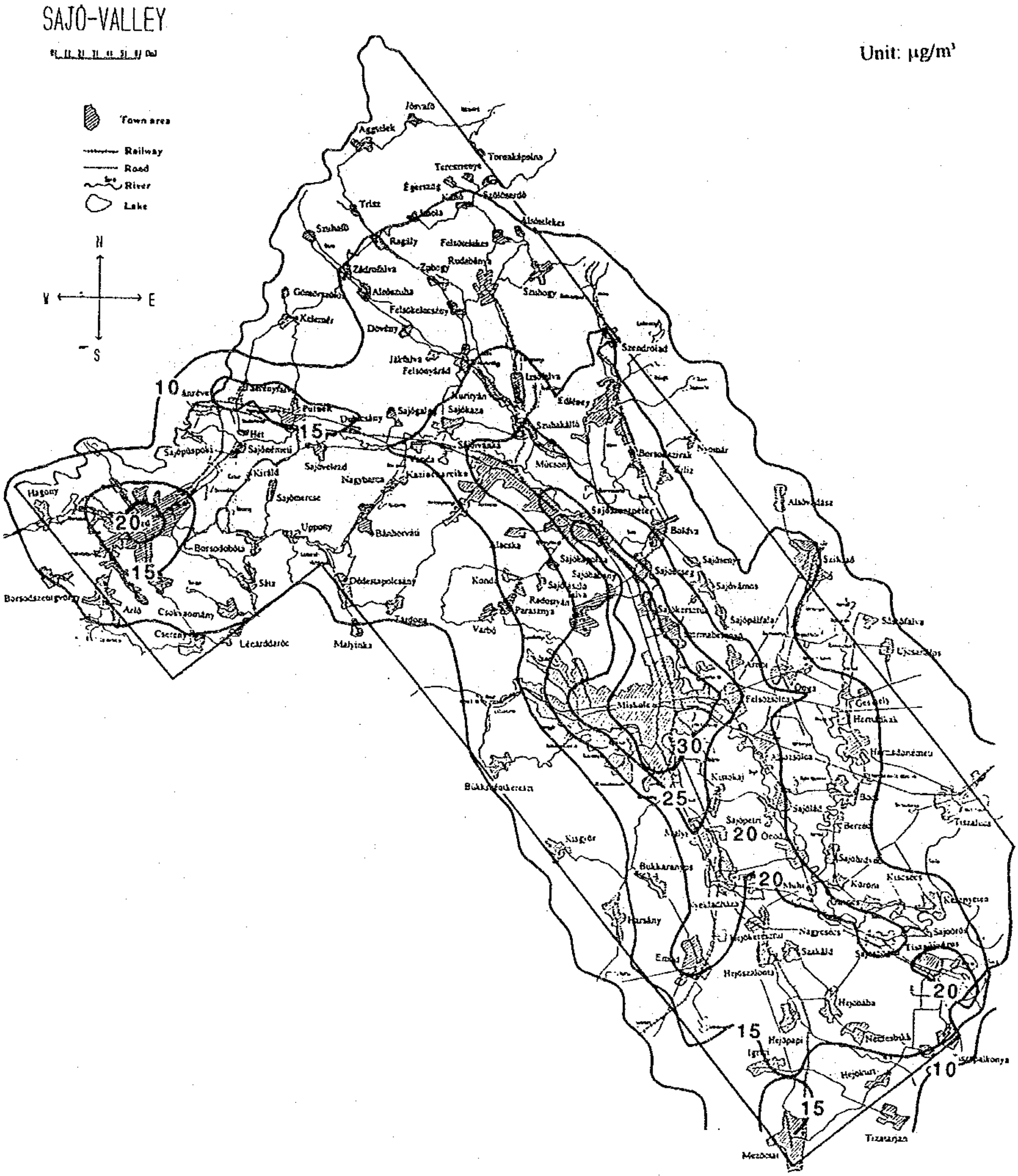


Figure 5.2.5 Annual Average Concentration Isopleth for NO_x (All Sources)

Unit: μg/m³

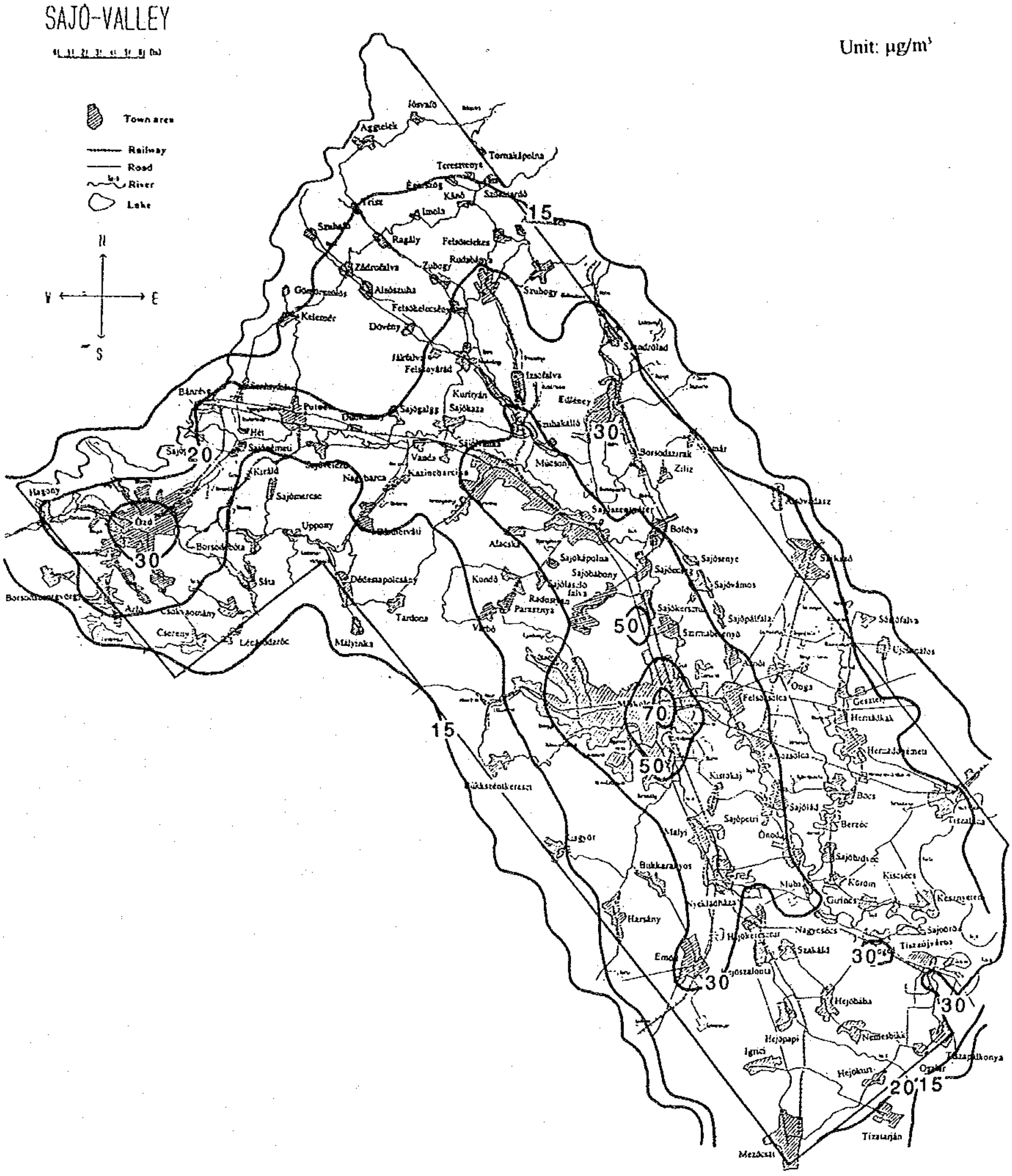
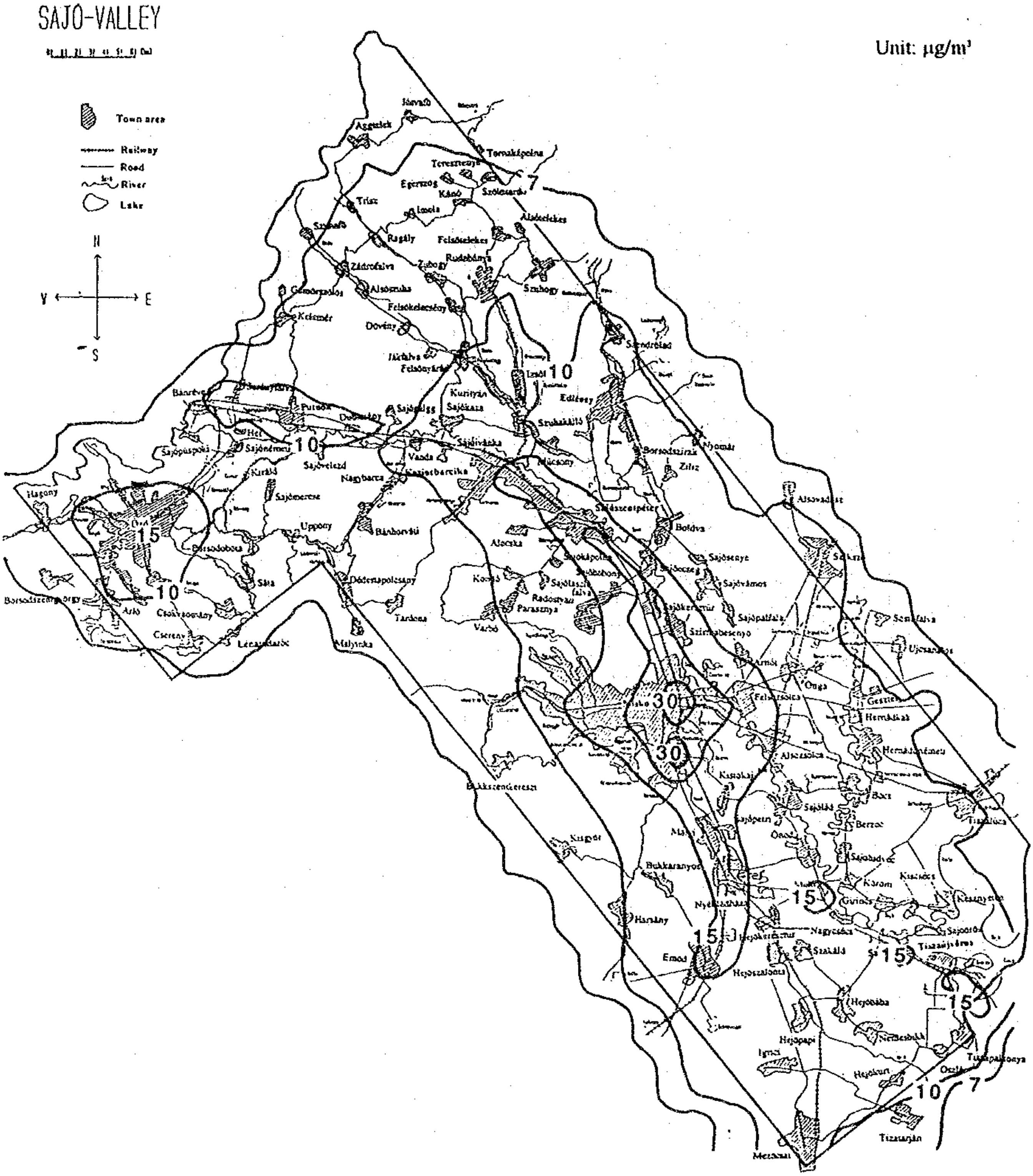


Figure 5.2.6 Concentration Isopleth for NO_x in Heating Season (All Sources)



Unit: μg/m³

Figure 5.2.7 Annual Average Concentration Isopleth for NO_2 (All Sources)

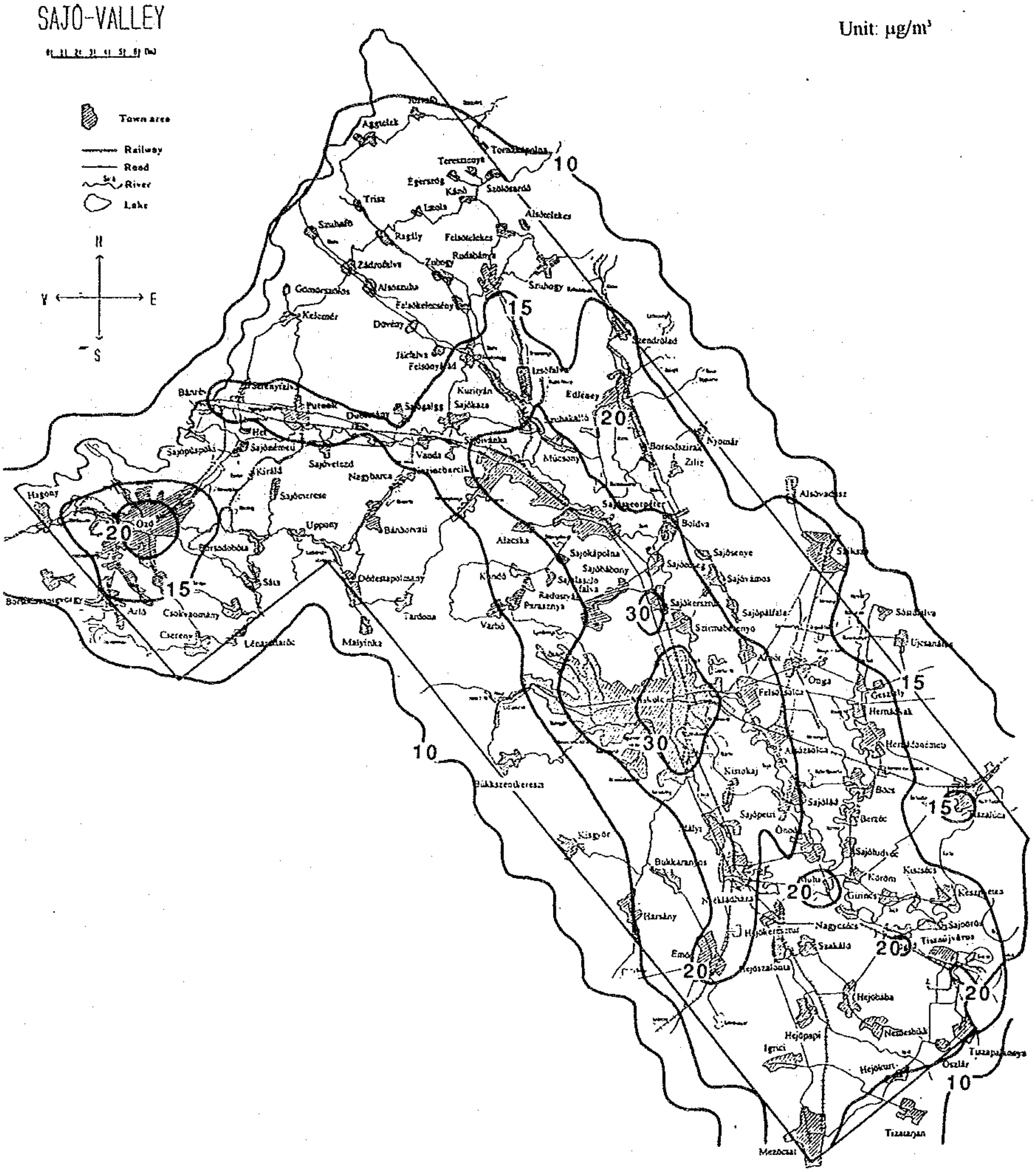


Figure 5.2.8 Concentration Isopleth for NO_2 in Heating Season (All Sources)

5.2.3 Analysis of Source Contribution to Ambient Concentration

(1) SO_2

Contribution ratios of pollution sources in the SO_2 concentration at the monitoring stations are shown in Table 5.2.8. "Communal" occupies the greatest contribution followed by "Industry", while the contribution of automobiles is small except some stations. In the seasonal tendency, the contribution of "Industry" is large in the summer and "Communal" is large in the winter. The greatest contribution of "Communal" is at JF1, that of "Industry" is at JF2, and "Automobiles" at J2 and J6.

(2) NOx

Contribution ratios of pollution sources in the NOx concentration at the monitoring stations are shown in Table 5.2.9. As a whole, "Automobiles" occupies the greatest contribution followed by "Communal", while the contribution of "Industry" is considerably smaller than the other two except at some stations. In the seasonal tendency, the contribution of "Automobiles" is large in the summer. In the winter, the contributions of "Automobiles" and "Communal" are about the same level and these two together occupy more than 90% of the total.

In terms of location, Stations J2, J6 and J7 are largely affected by automobiles, and JF1 and J1 are affected by communal sources with relatively high ratios.

Table 5.2.8 Source Contribution to SO_2 Concentration at Each Monitoring Station (%)

		JF1	JF2	J1	J2	J3	J4	J5	J6	J7
Non-heating Season	Industry	40.7	90.9	70.4	58.1	76.3	67.3	50.9	45.1	48.6
	Communal	55.6	6.5	29.6	24.2	18.4	28.8	41.5	39.2	25.7
	Automobiles	3.7	2.6	0.0	17.7	5.3	3.8	7.5	15.7	25.7
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Heating Season	Industry	11.2	62.0	34.3	22.8	34.0	29.3	23.9	25.0	26.5
	Communal	86.7	35.0	64.8	70.2	62.3	68.0	72.1	70.7	59.3
	Automobiles	2.1	3.0	0.9	7.0	3.7	2.8	4.1	4.3	14.2
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All Seasons	Industry	16.5	74.2	41.2	32.2	46.3	37.6	29.4	29.7	31.5
	Communal	81.2	22.5	57.4	57.6	49.3	59.0	65.1	63.6	52.1
	Automobiles	2.4	3.4	1.5	10.2	4.5	3.4	5.6	6.8	16.4
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 5.2.9 Source Contribution to NO_x Concentration at Each Monitoring Station (%)

		JF1	JF2	J1	J2	J3	J4	J5	J6	J7
Non-heating Season	Industry	7.3	32.7	21.1	3.8	15.2	18.3	6.5	4.8	3.1
	Communal	19.5	5.5	21.1	4.7	11.1	18.3	17.1	11.5	3.1
	Automobiles	73.2	61.8	57.9	91.5	73.7	63.3	76.4	83.6	93.8
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Heating Season	Industry	2.9	19.8	12.3	4.6	9.6	7.7	4.7	4.9	2.9
	Communal	56.9	28.6	56.2	27.2	37.4	48.9	46.2	41.0	14.4
	Automobiles	40.1	51.6	31.5	68.2	53.0	43.4	49.1	54.1	82.7
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All Seasons	Industry	4.4	24.3	15.2	4.3	11.5	10.0	5.5	5.1	3.0
	Communal	47.8	20.3	50.0	18.0	29.1	41.7	37.2	29.6	10.1
	Automobiles	47.8	55.4	34.8	77.7	59.4	48.3	57.3	65.3	86.9
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

CHAPTER 6

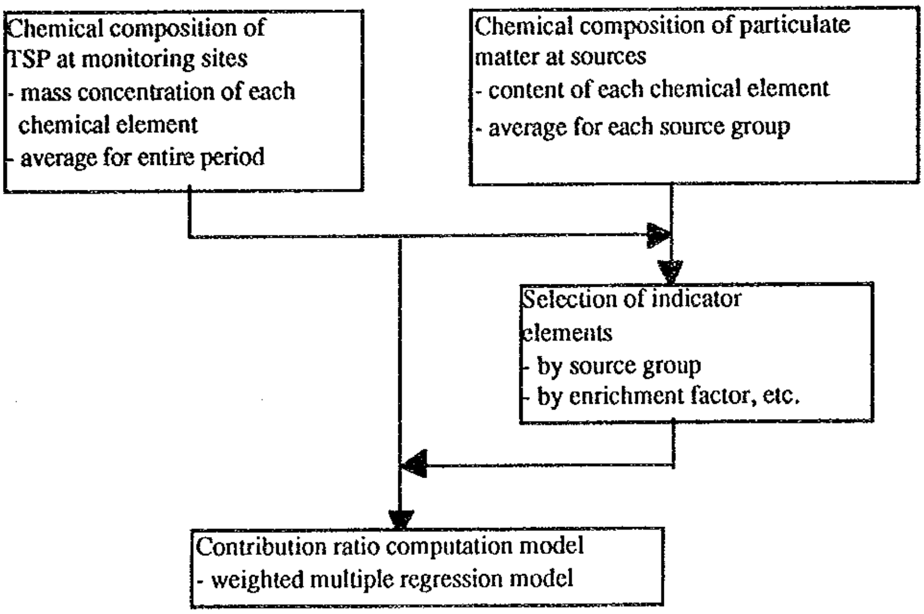
CHAPTER 6 ANALYSIS OF SOURCE CONTRIBUTION OF TSP BY CMB METHOD

6.1 Outline of the CMB Method

The CMB method (Chemical Mass Balance method) is one of receptor models for analyzing ratios of contribution of source groups to the ambient concentration of particulate matter. The method employs multi-variable regression analysis based on the mass conservation law on the data for chemical composition of particulate matter samples taken from the ambiant, where the concentration is known, and the chemical compositions of samples taken at emission source groups.

(1) Computational Flow for Contribution Ratio

General flow for computation of contributions by source groups to the ambient concentration of total suspended particulates (TSP) is as shown below.



(2) Data for Chemical Composition of TSP at Monitoring Sites

- Samples taken as TSP at ambient air quality monitoring sites are analyzed for the contents of chemical elements such as various metals, ions and carbons. For each site, the average content of each element for entire period and deviations are calculated.

(3) Data for Chemical Composition of Particulate Matter at Sources

Samples taken at sources of TSP are also analyzed for their chemical composition in the same manner. Contents of the elements are averaged by groups of sources such as soil, steel production, coal burning, and automobile exhaust gas. Enrichment factor (EF) of each element for each source group is calculated for each monitoring site as follows:

$$EF = \frac{Xi,\text{source}}{Xi,\text{atm.}}$$

where,

Xi, source: content of element i in particulate matter from a source group
Xi, atm.: content of element i in TSP at a monitoring site

(4) Selection of Indicator Elements

Among the elements analyzed, those with large values of enrichment factor (e.g., greater than 2) are extracted for each source group. From these, elements whose content values are not considered to be sufficiently accurate or those that tend to be fractionated under atmospheric transport processes are further excluded. An example for the selected elements for a source group may be as follows:

Na, Al, K, Ti, V, Cr, Mn, Fe, Zn, C-ele

(5) Computation Model for Contribution Ratio

The mathematical formulation of CMB method is explained as follows. The receptor model for estimating the contributions by pollution sources is based on the law of conservation of mass. For example, assuming that (p) numbers of emission sources exist and supposing no mass changing interactions occur, SPM concentration (C) measured at the receptor is obtained by taking the sum of contributions (Sj) of each emission source as in Equation (1).

$$C = \sum_{j=1}^{p} Sj \qquad (1)$$

Similarly, concentration (Ci) of component (i) in the SPM is expressed by Equation (2). Here (aij) is the mass fraction of source contribution (j) possessing component (i) at the receptor.

$$Ci = \sum_{j=1}^{p} aij\ Sj \qquad (2)$$

Assuming that (n) numbers of components are analyzed at the sources and receptors, then an equation is set up for each component. If the number (n) is greater than or equal to the number (p), the answer can be obtained by solving the set of p linear equations.

When the number (n) is greater than (p), a set of maximum accurate values is obtained by minimizing the value (χ^2) expressed in Equation (3).

$$\chi^2 = \sum_{i=1}^{n} \frac{(Ci - \sum_{j=1}^{p} aij \cdot Sj)^2}{Wi^{-2}} \qquad (3)$$

where,

n: Number of indicator elements
p: Number of source groups
Ci: Mass concentration of element i in TSP at a monitoring site (μg/m3)
aij: Content of element i in particulate matter of source group j
Sj: Contribution of source group j to the concentration of TSP (μg/m3)
Wi: Weighting factor of element i determined by Ci and error in measured values of Ci

Case 1: $Wi^2 = Ci^{-2}$
Case 2: $Wi^2 = ci^{-2}$, where ci is error of Ci

Equation (4) is the matrix form expression of Equation (2).

$$¢ = A\$ \qquad (4)$$

Here (¢) is n-dimensional vector of component concentration, and (A) is n by p matrix of mass fraction of sources, and ($) is n-dimensional vector of contributions by sources.

Generally, the solution by the least square method is as follows.

$$\$ = ({}^{t}AWA)^{-1}\,{}^{t}AW¢ \qquad (5)$$

Here, (W) is a diagonal matrix with diagonal components of wi^2. Errors of estimations for the source contributions depend on the way the weights (wi) are chosen.

6.2 Composition Analysis of Particulate Matter

Analyses of chemical elements in the ambient total suspended particulates (TSP) and in the particulates from pollution sources were made.

6.2.1 Composition of TSP in the Ambient

TSP is sampled by high volume air samplers and its concentration and composition were analyzed.

(1) Measuring Points

Measuring points were selected from the automatic monitoring stations as follows:

Kazincbarcika	(J2)
Nyekladhaza	(J7)
ÁNTSZ-BAZ	(H1)

Locations are shown in Figure 3.1.1.

(2) Measuring Time

Sampling and measurements were made once per month at a sampling time of 24 hours. Sampling was performed over a one-year period from June of 1993 to May of 1994. In July, measurements were made twice at J2 and at J7.

(3) Elements Analyzed

Pb, Cd, Cr, Ni, Fe, Cu, Zn, Mn, Hg, Na, K, Ca, Mg, V, Ti, Al, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, C-ele, C-org

(4) Method of Analysis

Atomic absorption spectro-photometry, spectro-photometry and the non-dispersive infra-red method (NDIR method) were used. Metallic ingredients were measured by resolving the sample with acid. Ions were extracted with water, and the carbon ingredients were brought back to Japan and directly classified into C-ele and C-org with the thermal carbon analyzer (NDIR). The C-org of carbon was separated by volatilizing the sample at 450 °C.

(5) Results

The results of analysis of the elements in TSP are presented in Table D6.2.1 in Data Book. The monthly variations in TSP and carbon concentrations are shown in Figure 6.2.1.

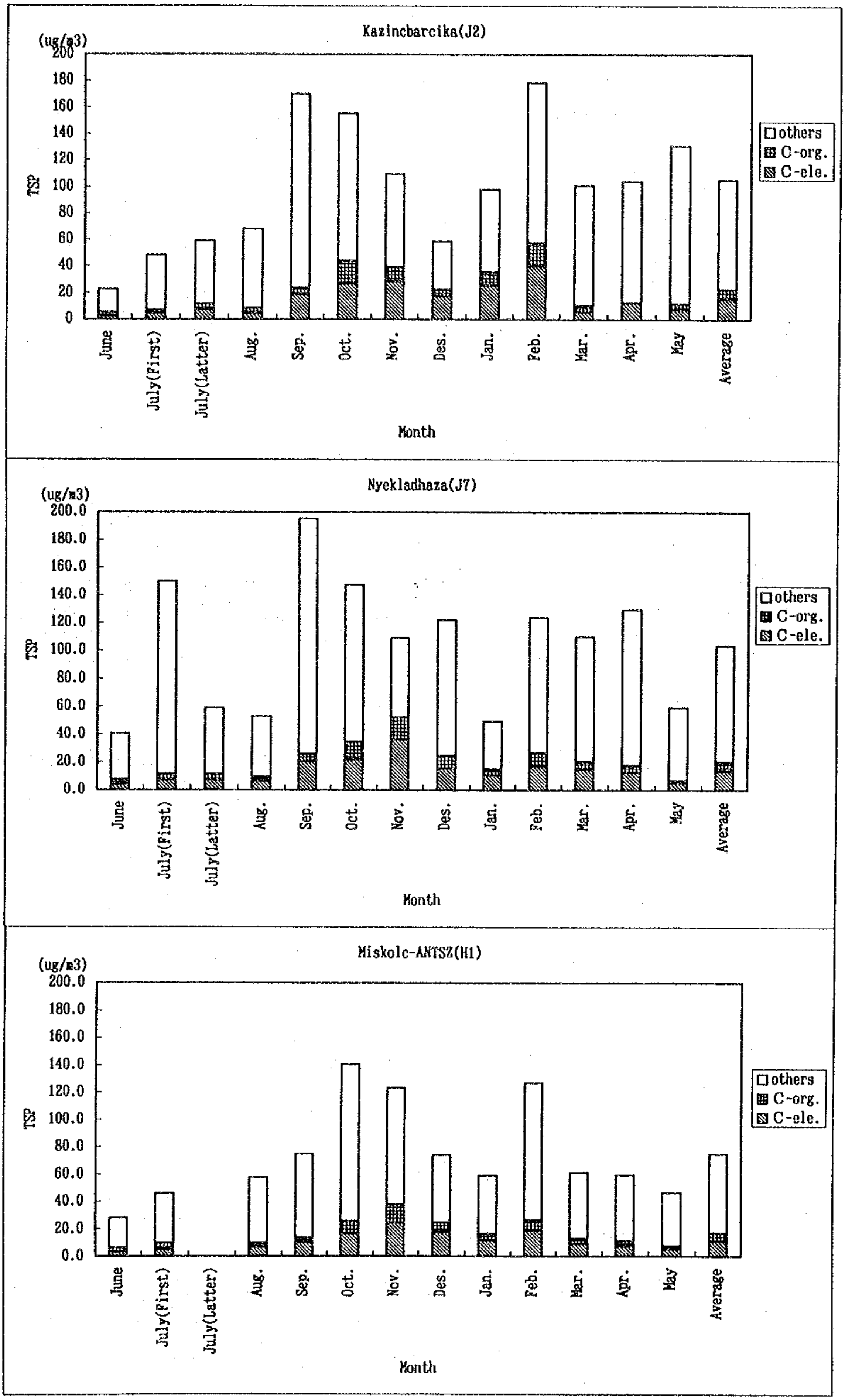


Figure 6.2.1 Monthly Variation of TSP and Carbon Concentration

In the initial periods of sampling TSP, filter papers supplied by the Hungarian side was used. The blank value of alkali metal in this filter paper was found to be high, therefore, some elements were not possible to be quantified. Thereafter, filter papers of a low blank value prepared by the Japanese side were used.

The percentage of total carbon in TSP falls in the range of about 10 to 40 percent. The percentage of carbon became higher in winter.

The annual average value of each carbon concentration was highest at J2, followed by J7 and H1.

Of the metal ingredients, Fe, Al and Ca, which are frequently founded in the soil, have relatively high content values, followed by Ti, Mg, Na and K.

The percentage contents of Fe, Pb, Zn, Mn, K and Ca were clearly higher at H1 than at J2 and J7. On the other hand, the percentage contents of Cu, Na and Ti at the J7 point were higher than at other points. For many elements, the percentage contents at J2 were lower than at H1 and J7, but the concentrations and percentage contents of SO_4^{2-}, NO_3^- and NH_4^-were higher at J2.

6.2.2 Composition of Particulate Matter at Emission Sources

Samples were taken from soil, stationary pollution sources, and automobiles. Elements analyzed were the same as those for TSP.

(1) Sampling for Analysis

1) Soil Samples

Soil samples were taken at 4 points shown in Figure 3.1.1. They are:

Kazincbarcika	(J2)
Nyekladhaza	(J7)
Miskolc	(EC1)
Mucsony (ash disposal site)	(JM1)

The soil samples were taken during May 26 - June 1, 1993.

2) Sample From Stationary Sources

Considering the industrial types whose emitting dusts contain rather large amount of polluting substances, 11 samples from 9 factories were seleded for composition analysis. The factories and combustion facilities selected are shown in Table 6.2.1.

Table 6.2.1 Stationary Sources for Dust Sample Taking

No.	Name of Enterprise	Facility
05/0	TISZAI EROMU RT. BORSODI HOEROMU	water tube boiler 100 t/h
07/0	PANNONGLAS IPARI RT. SAJOSZENTPETERI UVEGGYAR	glass melting tank oven
08/0	BORSODI ERCELOKESZITO MUZSGORITO KFT.	sintering furnace
09/2	SAGROCHEM KFT.	incinerator: solvent 100 kg/h, solid 60 kg/h
17/1	HEJOCSABAI CEMENT-ES MESZIPARI RT.	shaft kiln for limestone 19 t/h
17/1	HEJOCSABAI CEMENT-ES MESZIPARI RT.	cement kiln 83 t/h
18/0	STRABAG HUNGARIA EPITO KFT.	dryer for aggregate 60 t/h
25/1	TISZAI EROMU RT. I. HOEROMU	water tube boiler 125 t/h
25/2	TISZAI II HOEROMU	water tube boiler 670 t/h
26/3	KOROSI CS, S.U. KAZANHAZ	section boiler 0.232 MW
15/4	DNM DIOSGYORY NEMESACEL MUVEK FA.	blast furnace E.P. dust, cyclone dust E.P. dross

3) Automobiles

Sampling of dust from automobiles has been entrusted to the Institute for Transport Sciences. Number of samples and types of automobiles are as follows:

Passenger car :	4 samples (2-stroke engine, diesel and gasoline engine)
Light truck :	1 sample (diesel engine)
Heavy vehicle :	1 sample (diesel engine)

The dilution tunnel and low volume air sampler were used for the sampling of particulate matter in vehicle exhaust emissions.

The sampling was carried out in the following test modes:

1. ECE 15.04 : United Nations/Economic Commission
for EUROPE : Urban Driving Cycle

2.1. 90 EUDC : Extra Urban Driving Cycle,
max. speed of the cycle : 90 km/h
130 km/h or 40 kW/1,000 kg power
for low powerd cars
2.2. 120 EUDC : Extra Urban Driving Cycle;
max. speed of the cycle : 120 km/h
3. Miskolc Mode 1
4. Miskolc Mode 2
5. 40 km/h constant speed
6. 60 km/h constant speed
7. 80 km/h constant speed
8. 100 km/h constant speed

(2) Method of Analysis

The method of analysis of the samples from each source is the same as that for TSP, but the soil samples were prepared for analysis by drying at 105°C in a dryer.

(3) Results

All Tables presenting the results cited below are included in Data Book.

1) Soil Sample

Table D6.2.2 shows the results of soil ingredients analysis. At stations except the ash disposal site, metallic ingredients at high concentrations (1000 mg/kg or above) were Fe, Al and Ca, followed by Mg, Ti and K. The Ca level at Buzater (ECI) was much lower comparing with other 3 sites. While the Zn concentration was slightly higher at EC1, the levels at other 3 sites were about the same.

In comparing the data at the ash disposal site with others, the concentration levels of Al, Ca, Na and C-ele were higher, but the levels of Pb and Hg were lower.

2) Samples From Stationary Sources

The stack gas emissions and concentrations of each ingredient at stationary sources are shown in Table D6.2.3. Table D6.2.4 shows the percentage of carbon contained in the dust and the concentration of carbon in the discharged gas. Samples in DNM (No. 15/4) are from E.P. dust, cyclone dust and E.P. dross that were directly collected.

Among the facilities where the dust emission factor was large, the highest value, 209 kg/hr, was observed at the Tiszai II thermal power station, where the stack gas flux is large. This was followed by about 120 kg/hr at the Tiszai I thermal power station and at the B.E.M. sintering furnace, and by 36 kg/hr at the Borsod thermal power station. The emission factors of heavy metals, etc., at these facilities are also high. Among other facilities, the emission factor of cement dust at Hejocsabai Cement-ES is about 10 kg/hr; elsewhere it is lower than this by one or two orders of magnitude.

The emission rates of metals were high at B.E.M. The Pb emission is especially high at 404 g/hr. Elements such as Cd, Cr, Ni, and Cu are about the same as that at power stations, and the levels are quite high in comparison to other facilities. The Fe emission rate was 4.4 kg/hr, same as the level at Tiszai II. Na, K and Ca are also emitted on the order of kg/hr.

As for emission rates of heavy metals at other facilities, emissions of 558 g/hr of Ni and 2,200 g/hr of V at Tiszai II are exceptionally high. Another noteworthy feature is that a large volume of Ti is emitted from the aggregate dryer at Strabag Hungaria.

Among ions, Cl^- is emitted at high rates at the coal thermal power stations of Borsod and Tisa I, and Na^+, K^+ and $Ca^{2+}$are emitted at high rates at B.E.M.

With respect to carbon ingredients, emission rates are very high at the Tisa II thermal power station and B.E.M. The C-ele emission from the cement kiln is high, and this may be due to combined carbon such as CaCO3.

3) Automobiles

Concentrations and emission factors of dust and the elements in exhaust gas from automobiles are shown in Table D6.2.5. Table D6.2.6 shows the analysis results and emission factors of carbon elements in the exhaust gas from passenger cars and small trucks. Table D6.2.7shows the analysis results of carbon elements in the exhaust gas from large-size vehicle engines.

In the analysis of heavy metals, the volumes of dust collected from passenger cars and light trucks were extremely low, and the filter paper had high blank values for some elements. Quantitative analysis of these ingredients was difficult. Consequently, for Trabant 601, Mazda E2200, and Skoda 105, data on two mode types were shown by simply averaging.

The mean values in the table were determined by averaging each test vehicle and each mode. Mean Pb values are shown for gasoline classified as either leaded or unleaded.

The results of analysis of metals and ions are summarized below.

There are large volumes of Pb emissions from the Trabant, Skoda and Dacia, in which leaded gasoline is used.

The concentrations of dust and heavy metals, except Pb, from large-size engines were higher by one order or more of magnitude than those from small trucks. The dust concentration of the former is also higher in general.

The filter paper blank values for Na, K, Ca, Mg and the ions were rather high.

The carbon analysis results of passenger cars and small trucks are summarized below.

a. The emission factors of carbon elements are lower in Miskolc mode-1 and 2 and ECE15.4 than in 90EUDC and 120EUDC.

b. According to Skoda 105, the emission factor increases rapidly in proportion to the vehicle speed (the emission factor at 100km/h is 0.1477g/km for C-total, which is about seven times larger than that at 60 km/h).

c. Most of carbon discharged from diesel automobiles are C-ele. But Skoda 105 and Trabant 601, which have a 2-Stroke engine, discharge C-org.

d. Most C-total percentages in the dust are within the 50-90% range.

As for large-size engines, the concentration of carbon has a tendency to increase with the load.

6.3 Source Contribution Analysis by the CMB Method

(1) Ambient TSP Concentration Used in the Analysis

In the analyses of the CMB method, the averages of the values measured eleven times at Stations J2, J7, and H1 during the period from July 1993 through May 1994 were used as the ambient TSP concentration.

The average concentrations of elements in TSP at each stations are shown in Table 6.3.1.

Table 6.3.1 The Average Concentrations of Elements in TSP

(Unit: μ g/m3)

	Kazincbarcika(J2)			Nyekladhaza(J7)			Miskolc-ANTSZ(H1)		
Component	Average	Cont.(%)	σ	Average	Cont.(%)	σ	Average	Cont.(%)	σ
TSP	110.1	100.0	46.1	105.28	100.0	46.2	80.21	100.0	33.3
Pb	0.072	0.0656	0.038	0.072	0.0683	0.055	0.086	0.1074	0.052
Cd	0.0017	0.0015	0.0013	0.0009	0.0008	0.0005	0.0016	0.0020	0.0009
Cr	0.0062	0.0056	0.0037	0.0096	0.0091	0.0096	0.0096	0.0120	0.0093
Ni	0.0035	0.0032	0.0015	0.0040	0.0038	0.0023	0.0039	0.0049	0.0032
Fe	2.185	1.9845	1.150	3.447	3.2745	3.197	3.748	4.6731	3.061
Cu	0.051	0.0467	0.103	0.116	0.1099	0.163	0.024	0.0295	0.009
Zn	0.062	0.0564	0.030	0.094	0.0894	0.066	0.088	0.1093	0.056
Mn	0.038	0.0347	0.021	0.063	0.0599	0.074	0.059	0.0731	0.050
Hg	0.0014	0.0013	0.0020	0.0012	0.0011	0.0014	0.0006	0.0008	0.0006
Na	0.384	0.3492	0.175	0.539	0.5124	0.508	0.357	0.4445	0.107
K	0.575	0.5221	0.258	0.554	0.5264	0.274	0.736	0.9182	0.525
Ca	1.957	1.7778	0.884	2.584	2.4539	1.766	2.028	2.5284	0.930
Mg	0.422	0.3835	0.271	0.361	0.3430	0.208	0.266	0.3317	0.134
V	0.0057	0.0052	0.0022	0.0075	0.0071	0.0041	0.0080	0.0100	0.0078
Ti	0.199	0.1804	0.236	0.209	0.1986	0.179	0.136	0.1696	0.213
Al	1.320	1.1988	1.113	1.434	1.3624	1.011	0.767	0.9558	0.334
SO4--	16.50	14.9856	10.76	10.92	10.3722	7.40	11.03	13.7572	6.04
NO3-	5.70	5.1763	4.90	3.81	3.6232	3.54	3.46	4.3103	2.81
Cl-	4.26	3.8652	8.05	3.86	3.6629	8.14	0.65	0.8149	0.54
NH4+	4.35	3.9534	3.41	2.32	2.2053	1.92	2.32	2.8924	1.98
Na+	0.25	0.2279	0.17	0.41	0.3851	0.43	0.29	0.3566	0.07
K+	0.54	0.4896	0.27	0.45	0.4231	0.22	0.62	0.7696	0.35
Ca++	1.25	1.1337	0.80	1.59	1.5149	1.17	1.37	1.7069	0.80
Mg++	0.133	0.1209	0.120	0.109	0.1040	0.080	0.102	0.1272	0.061
C-ele.	17.1	15.5231	12.1	15.3	14.5324	8.8	12.5	15.5616	6.0
C-org.	7.8	7.0514	5.4	6.9	6.5279	4.5	5.4	6.7891	3.3
C-total	24.9	22.5745	16.4	22.2	21.0604	13.0	17.9	22.3507	9.2

(2) Selection of Major Sources of TSP

Soil, major stationary sources, and automobiles were selected as major sources of TSP.

For soil, the soil composition near each monitoring station was decided based on the observation results shown in Table D6.2.2 in Data Book.

For the stationary sources, the the larger emission sources of particulate matter indicated in the observation results (see Table D6.2.3 in Data Book) were selected for each fuel type as shown in Table 6.3.2.

Table 6.3.2 Selected Stationary Sources by Fuel Type

Major Fuel	Observed Stationary Sources
Brown Coal	TISAI HOEROMU
Heavy Oil	TISAI HOEROMU
Sinter (Coal and Cokes)	BORSODI ERCELOKESZJTO MUZSGORITO
Cement Factory(Natural Gas)	HEJOCSABAI CEMENT

As for the chemical elements of particulater matter emitted by automobiles, the average values of those from diesel engine vehicles were adopted for the analyses because of their large amount of emission of particulate matter.

Contents of elements of particulate matter at each pollution source are shown in Table 6.3.3.

Table 6.3.3 The Contents of Elements by Pollution Sources

(Unit: %)

Component	Soil			Stationary Source				Automobiles
	(J2)	(J7)	(EC1)	Brown-coal	Heavy Oil	Sintering (coal&coke)	Cement (natural gas)	Diesel
Pb	0.0015	0.0021	0.0022	0.0034	0.0079	0.3149	ND	0.0879
Cd	0.0012	0.0020	0.0015	ND	ND	0.0032	0.0014	0.0014
Cr	0.0012	0.0020	0.0015	0.0064	0.0083	0.0032	ND	0.0016
Ni	0.0015	0.0013	0.0017	0.0039	0.2662	0.0047	0.0215	0.0051
Fe	1.2549	1.6902	1.9811	1.9390	2.2121	3.4402	3.2812	0.1403
Cu	0.0012	0.0014	0.0019	0.0024	0.0021	0.0327	0.0124	0.0213
Zn	0.0047	0.0051	0.0126	0.0104	0.0061	0.0120	0.0272	1.0387
Mn	0.0436	0.0400	0.0608	0.0201	0.0033	0.0260	0.0107	0.0077
Hg	0.0000	0.0000	0.0000	0.0001	0.0000	0.0005	0.0002	0.0000
Na	0.0113	0.0208	0.0145	0.2280	0.1827	1.0175	ND	0.0000
K	0.1471	0.1523	0.2006	0.3366	0.0101	5.0729	ND	0.0000
Ca	1.1177	0.9380	0.3700	3.9146	0.2909	0.9825	8.1089	1.0359
Mg	0.4300	0.3506	0.3005	0.6354	0.0138	0.0362	ND	0.1613
V	0.0019	0.0014	0.0020	0.0106	1.0519	0.0030	ND	0.0009
Ti	0.2300	0.1845	0.2377	0.0702	ND	0.0036	ND	0.0049
Al	0.9447	1.3009	1.1264	3.2561	0.5108	0.1388	0.3126	1.4173
SO4--	—	—	—	1.2061	47.5758	1.5246	0.0000	0.0366
NO3-	—	—	—	0.0239	0.0358	0.1302	0.2885	0.0125
Cl-	—	—	—	3.7439	*	*	5.7693	0.4771
NH4+	—	—	—	0.0172	0.0393	0.2216	0.6154	0.0006
Na+	0.0011	0.0028	0.0044	0.0345	0.4061	2.5449	0.6250	0.6309
K+	0.0070	0.0023	0.0112	0.0176	0.5115	12.4077	0.3510	0.7384
Ca++	0.0225	0.0074	0.0098	0.0573	0.1122	2.0031	4.8366	0.0000
Mg++	0.0041	0.0014	0.0016	0.0093	0.0351	0.0426	0.0615	0.2451
C-elc.	0.9700	0.5000	0.4100	0.3195	5.3203	3.2945	32.6212	66.8226
C-org.	0.4800	0.7400	0.5100	0.0537	2.0390	1.2711	ND	9.5834
C-total	1.4500	1.2400	0.9200	0.3732	7.3593	4.5773	32.6212	76.4059

(3) Selection of Characteristic Elements

By comparing the element contents of the ambient TSP with that of the particulate matter at the source, the elements having the enrichment factor (EF) of more than 1 were selected. As a result, the following 17 elements were selected as being characteristic:

Pb, Cd, Cr, Ni, Fe, Cu, Zn, Mn, Na, K, Ca, Mg, V, Ti, C-ele, C-org.

(4) Result of Source Contribution Analysis

Based on the above-mentioned data, the contribution of TSP sources to the ambient concentration of TSP at monitoring stations J2, J7, and H1 was estimated and the result is shown in Table 6.3.4.

- At Station J2, the contribution of soil is the largest, having a ratio of 57.3%. Among the stationary sources, the contribution of brown coal fuel, such as that used at thermal power generation plants, is the largest at 25.1%. Automobiles' contribution is estimated at 5.3%.
- At Station J7, the burning of brown coal is the largest contributing emission source (45.2%). Its contribution is greater than the soil's 26.5%. As this station is located alongside a trunk road, the contribution of 12.3% by automobiles is greater than at other stations.
- At Station H1, the contribution of soil is the largest at 45.7%. Of the stationary sources, coal sintering and cement production contribute by greater ratios than those at other stations. The burning of brown coal contributes by relatively small ratio. Automobiles contribute about 9.1%.
- At all stations, the contribution of pollutant sources burning heavy oil is very small.

Table 6.3.4 Source Contribution to Ambient TSP

	Kazincbarcika(J2)		Nyekladhaza(J7)		Miskolc(H1)	
Source	Conc.	%	Conc.	%	Conc.	%
Soil	64.5	57.3	23.8	26.5	45.5	45.7
Brown Coal	28.3	25.1	40.7	45.2	6.8	6.8
Heavy Oil	0.1	0.1	0.2	0.2	0.2	0.2
Sinter (Coal and Cokes)	11.5	10.2	8.8	9.7	25.0	25.1
Cement Factory(Natural Gas)	2.1	1.9	5.4	6.0	13.0	13.1
Automobiles (Diesel)	6.0	5.3	11.1	12.3	9.0	9.1
SUM	112.5	100.0	89.9	100.0	99.6	100.0
(Observed)	(110.1)	—	(105.3)	—	(80.2)	—

CHAPTER 7

Chapter 7 STUDY ON AIR POLLUTION CONTROL MEASURES

7.1 Institutional Framework

7.1.1 Legal Framework

(1) Present Laws and Regulations

The first coherent legislation on air pollution abatement in Hungary was issued in 1973. This is Order No.1/1973. (I.9); MT. Order on the Protection of Clean Air.

Act on environmental protection (IInd Act of 1976) has introduced zoning of the country's territory and determined which activities might be performed in the different categories of protection. On the basis of the authorization of the Act, Order No.21/1986 (VI.2); MT. Order on the Protection of Clean Air, takes measures on the implementation of zoning. The country's total territory belongs to "protected area I" with the exception of areas of nature conservation ("specially protected area") and regions having industrial character ("protected area II"). The order determines the emission limit values, fining, and liability on data submission of the polluters, and also determines the authorities and their tasks in the field of air pollution abatement. The original order has been modified by the Orders No.49/1989 (VI.5) and No.9/1990 (VI.30)

Regulation No.4/1986 (VI.2); OKTH Regulation on the Protection of Clean Air, determines the emission limit values for point, building and area sources of air pollution, furthermore the fines to be imposed on the polluter in the case of harmful (above the limit) emission. Detailed prescriptions are comprised in the regulation as:

- the procedure to determine the (harmful) emissions, formal requirements of the process and the elements of content;
- the method of data submission;
- the method to determine emission limit values;
- the load index values for all settlements of the country which play an important role in the computation of the emission limit values; and
- the method to determine the sum of fines.

The original regulation has been modified by the Regulation No.8/1989 (VIII.24).

Under the Regulation No.5/1990 (XII.6) ; NM Regulation on the Air Polluting Substances, Ambient Air Quality Criteria and on the Monitoring of Ambient Air Quality, the ambient air quality criteria (limit values) are given in the Standard No. MSZ-21854-1990; Hungarian Standard on the Quality Requirements of the Ambient Air. The standard specifies ambient air quality requirements for 34 polluting substances in detail according to zoning and exposure time (yearly, 24 hours and 30 minutes limit values are specified). It determines the category of toxicity for the air polluting substances. The period and rate of permissible exceeding for the substances of different toxicity is specified, too. Some modifications on the abient air quality standards were made in October 1993 (Standard No. MSZ-21854-1M).

Regulation No.10/1986 (IX.24); OKTH Regulation on the Establishment and Appropriation of the Central and Local Environmental Fund, specifies that the fines collected from the polluters for causing harmful emissions are allocated partly to the Central Environmental Fund, and partly to the competent self government of the community where the source of pollution is sited. Implementation of pollution control at existing sources may be supported by appropriation of the Central Environmental Fund. The original regulation has been modified by the regulation No.1/1991 (I.18).

Regulation No.9/1986 (XI.16) is the KM Regulation on the technical requirements of setting into and keeping in operation of road vehicles modifying the Regulation No.23/1975 (XII.31). The regulation specifies emission limit values for the concentrations of CO, NOx and total unburnt hydrocarbons in the exhaust gases of petrol and diesel engines, and for diesel smoke.

Decision No.1041/1990 (X.17); Korm. Decision on the Measures for Reducing Air Pollution Generated by Vehicles, orders to establish a program for the reduction of air pollution by automobiles taking into account the critical air pollution situation in large cities. The program comprises the yearly inspection of automobiles with respect to environmental requirements and the screening out of automobiles with serious pollution problems. It envisages measures to phase out step by step two-stroke engine powered automobiles used in public services. It envisages preferences for the import of automobiles outfitted with a catalytic converter. It orders the wide circulation of lead-free petrol to reduce lead emissions and to accommodate to catalytic converters. Furthermore, the program envisages measures to be taken in town-planning and traffic organization.

(2) Present Ambient Air Quality Standards

The ambient air quality standards in Hungary are in some cases stricter than the guidelines of the WHO, but generally the standards conform to those of the western European countries. For the most common air pollutants, the limit values are shown in Table 7.1.1.

Table 7.1.1 Ambient Air Quality Standards in Hungary

Air Pollutant	Concentration (mg/m3) [(ppm 20°C)]		
	Specially Protected Area	Protected Area I	Protected Area II
SO_2			
- Annual average	0.030 [0.011]	0.070 [0.026]	0.100 [0.038]
- 24-hours average	0.100 [0.038]	0.150 [0.056]	0.300 [0.113]
- 30-minutes value	0.150 [0.056]	0.250 [0.094]	0.400 [0.150]
NO_2			
- Annual average	0.030 [0.016]	0.070 [0.037]	0.120 [0.063]
- 24-hours average	0.070 [0.037]	0.085 [0.044]	0.150 [0.078]
- 30-minutes value	0.085 [0.044]	0.100 [0.052]	0.200 [0.105]
NOx			
- Annual average	0.030 [0.016]	0.100 [0.052]	0.150 [0.078]
- 24-hours average	0.070 [0.037]	0.150 [0.078]	0.200 [0.105]
- 30-minutes value	0.085 [0.044]	0.200 [0.105]	0.400 [0.209]
CO			
- Annual average	1.0 [0.86]	2.0 [1.72]	5.0 [4.29]
- 24-hours average	2.0 [1.72]	5.0 [4.29]	10.0 [8.59]
- 30-minutes value	5.0 [4.29]	10.0 [8.59]	20.0 [17.17]
SPM			
- Annual average	0.030	0.050	0.100
- 24-hours average	0.060	0.100	0.200
- 30-minutes value	0.100	0.200	0.300
O_3			
- 24-hours average	0.100 [0.050]	0.100 [0.050]	0.100 [0.050]
- 30-minutes value	0.110 [0.055]	0.110 [0.055]	0.110 [0.055]
Dust			
- Monthly total (g/m2/30days)	12	16	21
- Annual total (g/m2/year)	100	120	150
Lead			
- 24-hours average	0.0003	0.0003	0.0007
- 30-minutes value	0.0003	0.0003	0.0007

Notes :

1. Specially Protected Area : Nature conservation area
2. Protected Area I : Country's total territory except for "Specially Protected Area" and "Protected Area II".
3. Protected Area II : Regions which have industrial character

(3) Present Emission Standards of Stationary Sources

There are three types of emission standards specified in the regulation as described below.

1) Regional Emission Standards

Regional emission standards are based on the ambient air quality standards.

<u>Point sources</u>

The limit values (E_n) of regional emission are to be determined as follows:

$$E_n = E_f \cdot K_1 \cdot K_2 \qquad \text{(kg/h)}$$

where,

E_f : emission factor to the level categories of emission height, which should be determined by the following table.

Emission Height : H (m)	$E_{f,i}$ (kg/h · m3/mg)
$0 < H \leq 10$	2
$10 < H \leq 20$	6
$20 < H \leq 35$	90
$35 < H \leq 50$	700
$50 < H \leq 80$	2000
$80 < H \leq 100$	4000
$100 < H \leq 120$	6000
$120 < H$	30000

Value of E_f for the particular emission height categories:

$E_f = E_{f,i} / n$ (kg/h · m3/mg)

In which, n is the total number of building sources regarded as points and point sources emitting the same air-polluting material on the same site, on the same emission level

K_1 : permitted limit level of ambient air quality standard for 24 hours at the regional protection category on the site of the pollution source (mg/m^3)

K_2 : calculated value according to the following formula

$$K_2 = (100 - \text{Loading Index})/100$$

The loading index is a regulating value fixed by the authorities in connection with the degree of air-pollution in the region. The value of the loading index for major cities/towns in Sajó valley are shown in the following table.

Area Name	Dust	Gas (SO_2, NOx, CO, etc.)	Others
Alsózsolca	60	50	30
Felsözsolca	60	50	50
Kazincbarcika	60	40	70
Tiszaújváros	70	50	50
Mályi	60	50	50
Miskolc	70	60	50
Nyékládháza	40	30	30
Özd	80	70	50
Sajóbábony	60	50	50
Sajókersztúr	60	50	50
Sajószentpéter	70	50	50
Serényfalva	60	50	50

The value of E_n is calculated down to the second decimal place.

The regional emission standards are to be determined for all pollutants.

<u>Building sources</u>

If the emitting surface of the building source is within 20 meters from the next existing dwelling house or institution and from its border, and from the planned dwelling houses or institutions, then the emission criterion is:

$$E_n = k \cdot V \cdot N \cdot 10^{-6} \qquad (kg/h)$$

where,

k : prescribed C_{max} value in the concerning standard for the given pollutant (mg/m^3)

V : volume of that air space of the building the pollutant is coming from (m^3)

N : frequency of the ventilation; number of the air-change per hour (h^{-1})
(If this value is unknown, in case of natural ventilation, value "N=5" should be taken into consideration.)

If the emitting surface of the building source is in a greater distance than 20 meters from the existing/planned dwelling houses and institutions and from their border, the building source is to be regarded as point source and the criteria should be determined according to the regulations on point sources.

2) Technological Emission Standards

The standards may be specified for newly established or reconstructed technological process as concentration of pollutants (in mg/m3) or as specific emission standards related to the amount of production (in kg-pollutant / t-production). Presently, the government is preparing technological emission standards for the technologies of great importance such as power plants, cement industry, aluminum industry, etc. Technological emission limits will be stricter than the regional emission limits.

3) Emission Standards by Transmission Models

The standards specifically prescribed for stationary sources may be determined by transmission models in cases where there are justification for them. The emission standards are stricter than the regional emission standards.

(4) Present Basic Fines System for Air-pollution Sources

1) Point Source

The basic fine to be paid for the given emission of air pollutant of a point source, broken down according to quarters of a year, is calculated as follows:

$$B = (E - E_n) \cdot t \cdot b_1 \qquad \text{(Forints/quarter of a year)}$$

where,

B: fine to be paid for a quarter due to exceeding of the emission criterion of the given pollutant (Forints/quarter of a year)

E: average value of effective emission for a quarter of a year (kg/h)

E_n: limit value of emission determined for the air pollutant at the given source (kg/h)

t: number of operating hours during a quarter of a year (hr./quarter)

b_1: key of fine (Forint/kg)

The value of b_1 can be determined from the following table. The degree of exceeding the limit value of emission (Z) should be determined as $Z = E/E_n$.

Degree of exceeding the limit value of emission (Z)	Key of fine b_1 (Ft./kg) Danger category of the pollutant 1	2	3	4
1.00 - 2.00	1.0	0.5	0.3	0.2
2.01 - 4.00	2.0	1.0	0.6	0.4
4.01 - 8.00	4.0	2.0	1.2	0.8
8.01 - 12.00	6.0	3.0	1.8	1.2
12.01 - 20.00	8.0	4.0	2.4	1.6
20.01 - 50.00	10.0	5.0	3.0	2.0
50.01 - 100.00	12.0	6.0	3.6	2.4
100.01 -	14.0	7.0	4.2	2.8

2) Building Source

The basic fine to be paid for the given emission of air pollutant of a building source is calculated as follows:

$$B_e = (E-E_n) \cdot t \cdot b_2 \qquad \text{(Forints/year)}$$

where,

B_e: fine to be paid for the exceeding of the limit values of emission criterion of the given pollutant (Forints/year)

E: average value of the effective emission (kg/h)

E_n: limit value of emission determined for the air pollutant at the given source (kg/h)

t: number of operating hours per year (hr./year)

b_2: key of fine (Forint/kg)

The key of fine (b_2) is determined by the following table.

Danger Category of the air pollutant	b_2 (Forint/kg)
4	0.6
3	1.2
2	2.0
1	4.0

If the emitting surface of the building source is in a greater distance than 20 meters from the existing or planned dwelling houses and institution buildings and from their border, the value of b_2 is determined according to the rules stated for point sources.

(5) Present Emission Standards of Mobile Sources

1) Standards on the environmental protection inspection and control of motor cars

Motor vehicles registered in the country, except vehicles of the diplomatic corps and optional for military vehicles, undergo verification concerning their exhaust emissions, whose periodicity is as follows:

- motor vehicles equipped with a positive ignition engine and a three-way catalytic converter, and having controlled mixture preparation --------- 3 years
- other motor vehicles -- 1 year

The verification is performed by the technical inspection stations of the competent authorities or by authorized workshops. The eventual spot-checks of the emissions are made by the crews of the competent authorities.

According to the regulation of KHVM No.18/1991 (XII. 18), permissible level of the exhaust gas pollutant emissions from motor vehicles, agricultural tractors, and slow-moving vehicles are as follows.

Motor vehicles, agricultural tractors, and slow-moving vehicles (with an authorized gross weight of 3500 kg or less), equipped with a positive ignition engine (but without an exhaust gas catalytic converter)

[CO, HC]

Type/model of Vehicle	CO content at the idling (vol. %)	HC content at the idling, and at 60% of the rated speed (unloaded) (ppm)
VAZ Lada, manufactured before January 1, 1987	4.5	1000
SKODA S105, S120, FIAT 126P	3.0	1000
FIAT 125P	4.5	1000
Wartburg 353, BARKAS B1000 (with two-stroke engine)	2.5	-
TRABANT 601 (with two-stroke engine)	3.0	-
DACIA, UAZ	4.0	1000
ZUK	4.0	1000
NYSA	4.0	1000
Others, manufactured between January 1, 1982 and January 1, 1988	3.5	1000
Others, manufactured before January 1, 1982	4.5	1000
Others, manufactured after January 1988	3.0	1000

Notes: 1. The permitted hydrocarbon limit values shall be effective only after May 1, 1993 for motor vehicles equipped with a four-stroke engine.

2. The hydrocarbon content shall be measured by a gas-analyzer calibrated to n-hexane equivalence.

Motor vehicles (with an authorized gross weight of 3500 kg or less), equipped with a positive ignition engine (and with an exhaust gas catalytic converter)

[CO, HC]

Mode of treatment of the exhaust gases	CO content at the idling (vol. %)	CO content at 60% of the rated speed (vol. %)	HC content with free running engines (ppm)
Three-way catalytic converter with controlled preparation of mixture	0.4	0.4	250
Other type of catalytic converters used in :			
four-stroke engines	1.0	1.0	400
two -stroke engines	2.5	2.5	2000

Motor vehicles equipped with a compression ignition diesel engine

- at free-acceleration from idle speed : K1 (m^{-1})
- at free-acceleration from a "raised" idle speed, or measured on a vehicle test bench with engine loaded : K2 (m^{-1})

K1 and **K2** are the light absorption coefficients as given below.

Category of vehicle	Engine type/model	K1	K2
Motor vehicles with an authorized gross weight of than 3500 kg or less		2.5	1.5
Motor vehicles with an authorized gross weight greater than 3500 kg	Naturally aspirated	3.5	1.5
	Supercharged	3.5	2.5

Motor vehicles not listed under the previous paragraphs

- equipped with a compression ignition (diesel) engine : $K1 = 3.5(m^{-1})$
  $K2 = 1.5(m^{-1})$
- equipped with another type as a compression ignition (diesel) engine:

CO : 3.5 vol. %

HC : 1000 ppm (with free running engine)

2) Standards on permitting motor cars into traffic and maintaining the operation of them

According to the regulation of KHVM No.6/1990 (IV. 12), CO content of the exhaust fume of motor vehicles, agricultural tractors and slow-moving vehicles shall not exceed the limit defined as follows :

Motor vehicles equipped with a positive ignition (Otto) engine

Type/Model of Vehicle	CO Content of the Exhaust Fume (Vol. %)	
	basic run	at 60% of nominal rate of revolution
LADA made before January 1, 1980	4.5	5.0
LADA made after January 1, 1980	4.5	4.0
SKODA S105, S120	3.0	2.5
FIAT 126 P, ZIL 130	3.0	2.5
FIAT 125 P	4.5	2.5
WARTBURG, BARKAS B1000	2.5	2.5
TRABANT	3.0	3.5
DACIA, UAZ	4.0	4.0
ZUK	4.0	3.0
NYSA	4.0	4.5
ROBUR	4.0	2.5
Others	4.5	4.5

Motor vehicles equipped with a compression ignition (diesel) engine

for free acceleration from basic run $K \leq 3.5\ m^{-1}$
- for free acceleration from heightened basic run ($n = 1000 \pm 100 min^{-1}$) in case of suction engine $K \leq 1.5\ m^{-1}$
- turbo engine without smoke delimiter $K \leq 2.5\ m^{-1}$

K : light absorption coefficient

Moreover, the contamination content of the exhaust fume of motor vehicles, agricultural tractors, slow-moving vehicles and motorcycles shall not exceed the limit values defined in the regulation.

The limit values are as follows.

Motor vehicles with an authorized gross weight of 3500kg or less and buses equipped with a positive ignition (Otto) engine

Gross weight of the vehicle m (kg)	Mass of Contamination Material emitted during Test (g/km)			
	Type approval of the vehicle (Type inspection)		Quality control of serial production	
	Carbon monoxide	Hydrocarbons and Nitrogen Oxides	Carbon monoxide	Hydrocarbons and Nitrogen Oxides
m ≤ 1020	14.3	4.69	17.3	5.87
1020 < m ≤ 1250	16.5	5.06	19.7	6.32
1250 < m ≤ 1470	18.80	5.43	22.5	6.79
1470 < m ≤ 1700	20.7	5.80	24.90	7.26
1700 < m ≤ 1930	23.0	6.17	27.6	7.72
1930 < m < 2150	24.9	6.54	29.9	8.17
2150 < m	27.2	6.91	32.8	8.64

Notes:
1. The inspection procedure and calculation method is according to MSZ 21870/1-4 standard. (For comparison of the values calculated according to the standard to the above limit values, divide by 4.052).
2. The limit values for hydrocarbons and nitrogen oxides together should only be applied to from 1 st January, 1991 onward for the contingent of cars driven by two stroke engine ordered by commercial contract before 1 st January 1987 for the year 1986-90

Trucks with an authorized gross weight greater than 3500 kg, buses, agricultural tractors and slow vehicles equipped with a positive ignition (Otto) engine

- Specific carbon monoxide emission	22.77 g/MJ
- Specific hydrocarbon + Nitrogen oxides	6.95 g/MJ

The inspection procedure and calculation method are according to MSZ 21874 standard. (For conversion of the values calculated according to the standard in kWh emission to g/MJ : 1 g/MJ = 3.6 g/kWh).

Motorcycles and motorbikes

Gross weight of the vehicle m (kg)	Mass of Contamination Material emitted by Motorcycle (g/km)			
	Type approval of the vehicle (Type inspection)		Quality control of serial production	
	CO	HC + NOx	CO	HC + NOx
[Motorcycle equipped with 2-stroke engine]				
m ≤ 100	16	10	20	13
100 < m ≤ 300	16 + 24. A	10 + 5. A	20 + 30.A	10 + 8. A
m > 300	40	15	50	21
[Motorcycle equipped with 4-stroke engine]				
m ≤ 100	25	7	30	10
100 < m ≤ 300	25 + 25. A	7 + 3. A	30 + 30. A	10 + 4. A
m > 300	50	10	60	14
[Motorbikes]				
Two wheel	8	5	9.6	6.5
Three wheel	15	10	18	13

Notes :
1. The inspection procedure and calculation method are according to MSZ 21868 standard in case of motorcycle; MSZ 21867 in case of motorbike.
2. The A in the table is defined by the following relationship: $\frac{m-100}{200}$

Motor vehicles, agricultural tractors and slow vehicles equipped with a compression ignition (diesel) engine

- Smoke

Light Absorption Coefficient ("K") as a Function of Specific Gas Flow

Specific gas flow ($dm^3 . s^{-1}$)	Light absorption coefficient (m^{-1})
42	2.26
45	2.19
50	2.08
55	1.985
60	1.9
65	1.84
70	1.775
75	1.72
80	1.665
85	1.62
90	1.575
95	1.535
100	1.495
105	1.425
115	1.395
125	1.345
130	1.32
135	1.30
140	1.27
145	1.25
150	1.225
155	1.205
160	1.19
165	1.17
170	1.155
175	1.14
180	1.125
185	1.11
190	1.095
195	1.08
200	1.065

The inspection procedure and calculation method are according to MSZ 21865 standard.

- Specific carbon monoxide emission 3.9 g/MJ
- Specific hydrocarbon emission 0.98 g/MJ
- Specific nitrogen oxides emission 5.0 g/MJ

The inspection procedure and calculation method are according to MSZ 21866/1-4 standard. (for conversion of the values calculated according to the standard in kWh emission to g/MJ: 1 g/MJ = 3.6 g/kWh)

(6) Present Standards for Fuels of Power Driven Vehicles

The main characteristics are as follows:

Leaded gasoline

Sulfur content (max.) : 0.05 %
Lead content (max.) : 0.15 g/l

Unleaded gasoline

Sulfur content (max.) : 0.05 %
Lead content (max.) : 0.005 g/l

Diesel fuel

Octane number (min.) 48
Sulfur content (max.) : 0.2 %

(7) Present Restriction for Two-stroke Engines

From January 1, 1992, cars and trucks with two-stroke engines can be used for public and commercial transport purpose (e.g. taxis, vans and light trucks) only if equipped with catalytic converters. The use of these types of cars for private (non-commercial) purpose is not restricted.

(8) Present Incentive Systems for Executing Control Measures

1) Central Environmental Protection Fund

The Central Environmental Protection Fund (hereinafter "CEPF") was regulated by the LXXXIIIrd Act of 1992 (Ref.B-15) as a separated state fund earmarked for the environmental protection. CEPF is administrated by KTM and the decision making right on the utilization of the source belongs to KTM according to the Act. The rule of the operation and the utilization of CEPF in details, the procedural order and the main processes are contained in the Ministerial Ordinance No.20/1993(IV.23) of KTM.

CEPF provides a support for the followings:

- investments and technical measures directly promoting environmental protection;
- commercial solutions concerning the marketing of environmentally friendly products; and
- measures and actions aimed at strengthening the environmental awareness.

Main revenue sources of CEPF are the followings:

- the share of legally imposed environmental protection fines (air pollution fine, sewage fine, etc.);
- environmental product charge of fuels (fuel product charge);
- voluntary payment to and support for the Fund (PHARE program); and
- budgetary award.

According to the Act, the conditions and the types of financial support for projects are as follows. The total support cannot exceed 60% of the estimated total cost of the project.

Grant (non-refundable support)

- The total amount of the grant cannot exceed 30% of the estimated project cost; and
- Grant can be provided only for non-profit oriented activities.

Loan (Refundable support)

- Interest-free loan can be provided with a grace period of 1~2 years and the refund period generally within 1~5 years after the completion of the project; and
- Soft loan, where the interest of the loan ranges between 60~120 % of the basic interest rate set up by the National Bank, with grace period of 1~2 years and the refund period generally within 1~5 years after the completion of the project.

Pay off the interest of bank loan

Support can be provided to pay off the interest of bank loan drawn for the project, but not more in amount than 100 % of the amount calculated with the National Bank's basic interest rate.

Loan guarantee

Loan guarantee can be offered for at most 70 % of the amount of bank loan obtained for the purpose that directly promote environmental protection. In case of the bank loan for a very important environmental protection project, CEPF will assume responsibility for the bank guarantee required by the financial institution.

In the annual program for support in 1993, total amount of funds are estimated as follows:

<u>Domestic sources</u>

- General	600 ~ 1,000 million Forints
- Environmental product charge of fuels	1,500 ~ 1,700 million Forints
Total	2,300 ~ 2,700 million Forints

<u>PHARE source</u> : 6.3 million ECU (≈ 7.8 million US$ in the value of 1994)

The projects concerning air pollution control which are selected as high-priority tasks and can be funded from CEPF sources are as follows:

- Reduction of vehicle emissions (945 ~ 1,135 million Forints)
- Reduction of industrial emissions (30 ~ 50 million Forints)
- Reduction of domestic emissions (60 ~ 100 million Forints)
- Reduction of volatile hydrocarbon emissions and the use of CFCs (2.4 million US$)
- Introduction of energy saving methods satisfying the energy demands of households (0.6 million US$)

2) Others

Commercial customs tariffs are established and put down in legal rules in the case of goods imported to Hungary. Products can be granted various preferences with consideration to environmental protection. For instance, the customs tariff of cars with catalytic converter is 13 %, while that of the others is 18 %, and the customs tariff for the import of used cars is higher by 20 to 30 % than that of new ones. Moreover, preferential customs tariff of 0 % can be applied in case of the use of fluid absorbing materials for pollution controlling purposes, as well as catalytic converter, lead filter, gas analyzer and smoke measurement instrument for motor cars.

Hungary has incentive taxation (tax reduction) systems for purposes of environmental protection; production of some products and installation serving air pollution protection (fluidized bed coal dust fueled equipment, catalytic converter, exhaust-gas filter), professional services on air pollution protection planning and consultation, etc..

(9) The Draft Ambient Air Quality Standards proposed for the Future

The draft governmental decree on an air pollution abatement prepared in 1994 (Ref.B-20) includes a revision of ambient air quality standards. The draft ambient air quality standards consists of Health Standards, Ecological Standards and Smog-alarm Limits, and the air pollutants are classified into classes of hazard level considering their damaging or endangering impact on the air quality. These ambient air quality standards are shown as follows:

1) Health Air Quality Standards

The health air quality standards are applied to urban settlement areas which are classified as inhabited, recreational, institutionalized and green belt areas.

Main parts of the standards are shown in Table 7.1.2, 7.1.3, and 7.1.4. The rest are "Standards of metals from TSP", "Standards of fluorides", "Planning guide values of carcinogenic materials" and "Standards of materials regulated by olfactory threshold limit values".

2) Ecological Air Quality Standards

The ecological air quality standards are valid for the rural settlement areas and areas that are:

- particularly sensitive (sensitivity category "A"); and
- less sensitive (sensitivity category "B")

to air pollution.

The ecological standards are shown in Table 7.1.5 and 7.1.6.

3) Smog-alarm Limit

The standards are limit values to impose smog-alarm measures as shown in Table 7.1.7.

(10) The Draft Emission Standards of Stationary Sources proposed for the Future

According to the draft governmental decree on an air pollution abatement, the Ministry for Environment and Regional Policy (KTM) ordains general and technological emission limit values concerning stationary air polluting point sources. In the license which is necessary for the operator (owner) of the air polluting source to use the environment, KTM can ordain special emission limit values which are stricter than the above-mentioned general and technological emission limit values, if the ambient air quality limit values at the affected area by the air polluting source cannot be ensured even in the case of maintaining the emission limit values. The special emission limit values are imposed on the basis of air quality control and assessment of spread which are carried out at the scene of the establishment for at least a year. KTM also ordains national total mass on emission limit values concerning certain branches of industry.

Table 7.1.2 Proposed Future Health Ambient Air Quality Standards of Air Pollutants regulated by Limit Values

unit: concentration (mg/m^3)

Air Pollutant	Hazardous Level	Short Time Limit Values		Long Time Limit Values
		30 minutes	24 hours	
SO_2	3	0.300	0.150	0.050
NO_2	2	0.150	0.100	0.070
O_3	1	0.150	0.100	-
TSP	3	0.300	0.200	0.100
CO	2	10.0	5.0	3.0
Hydrochloric	2	0.200	0.050	0.030
Benz(o)pyrene	1	-	0.000001	0.000001

Source: Ref.B-20

Notes:

1. Short time limit values: the limit values for 30 minutes and 24 hours which are to be applied according to the following:
   - to prevent the development of acute health problems;
   - to evaluate the polluting effect to the largest extent; and
   - to impose the permissible specific emission limit values of industrial air polluting sources within the frame of transmission calculations.
2. Long time limit values: the limit values referring to a period of half a year (heating, non-heating half year) and one year which are to be applied according to the following:
   - to prevent the development of chronic health problems and environmental damage;
   - to characterize the air quality of certain regions;
   - to evaluate the results of air pollution abatement; and
   - to conduct trend assessment.

Table 7.1.3 Proposed Future Combined Health Ambient Air Quality Standards in the Case of Continuous and Parallel Measurements of SO_2 and Total Suspended Particulate Matter (TSP)

unit: concentration (mg/m^3)

Air Pollutant	Limit Values			
	Heating half-year		Year	
	TSP	SO_2	TSP	SO_2
If there is more TSP than S_2	0.200	0.130	0.150	0.080
If there is less TSP than SO_2	-	-	0.120	0.150

Source: Ref.B-20

Note: The median of the daily mean values measured in the heating half-year and the whole year.

Table 7.1.4 Proposed Future Health Ambient Air Quality Standards of TSP and Its Certain Components

Air Pollutant	Hazardous Level	Long Time Limit Values	
		30 days	Half-year, Year
TSP	3	20 g/m^2/30days	150 t/km^2/year
[from TSP] Lead	1	12 mg/m^2/30days	-
Cadmium	1	0.15 mg/m^2/30days	-
Water-soluble Fluorides, as F	2	50 mg/m^2/30days	-
Benz(o)pyrene	1	0.017 mg/m^2/30days	-

Source: Ref.B-20

Table 7.1.5 Proposed Future Ecological Ambient Air Quality Standards (Concentration)

unit: concentration (mg/m^3)

Air Pollutant	Sensitivity Category	Limit Values		Remarks
		24 hours	Long term,Year	
SO_2	A	0.070	0.020	-
	B	-	0.030	
NO_2	A	0.060	0.030	Growing half-year (Apr.- Oct.)
		0.040	-	Non-growing half-year (Nov.-Mar.)
	B	-	0.040	
NH_3	A and B	0.600	0.008	Monthly ave.: 100
O_3	A and B	-	0.050	Average between 9-16h
		-	0.150	1 hour max. ave.

Source: Ref.B-20

Table 7.1.6 Proposed Future Ecological Ambient Air Quality Standards of Sedimentation

Air Pollutant	Sensitivity Category	Limit Values	Unit of Measurement
NO_X (as N)	A	15	kg/ha/year
	B	25	kg/ha/year
SO_X (as S)	A	24	kg/ha/year
	B	40	kg/ha/year
Aerosols	A and B		kg/ha/year
Ca		140	
Mg		175	
Pb		2.5	
Cu		2.5	
Zn		10	
Cd		0.05	
All Acids	A	2800	mol/ha/year
	B	4000	mol/ha/year

Source: Ref.B-20

Table 7.1.7 Proposed Future Limit Values Imposing Smog-alarm Measures

unit: concentration (mg/m^3)

Air Pollutant	Preparing Period	Classes	
		I	II
SO_2	0.400	0.600	0.800
NO_2	0.350	0.600	0.800
CO	20.0	30.0	40.0
TSP	0.600	0.800	1.000
SO_2 + TSP(Note 1)	0.600	0.800	1.000
O_3	0.200	0.300	0.400

Source: Ref.B-20

Notes:

1. If TSP is greater than 200.
2. The period exceeding the limit values given hereinabove which is necessary to order a smog-alarm:

Preparing period:	3 hour-long period exceeding the limit values
Class I:	3 hour-long period exceeding the limit values
Class II:	3 hour-long period exceeding the limit values

3. Classes I and II come into force if the standards defined referring to the preparing period and Class I exists for 24 hours.
4. The measurement data derived from automatic registering instruments consist of values of 30 minute periods out of which a concentration average for a 3 hour period shall be calculated (e.g. the average for 3 hour is the average of 6 consecutive values of 30 minute periods).
5. Periods exceeding the limit values, which are listed in Note 2, shall occur in at least two stations. In case there is only one measuring station at a given settlement, the smog-alarm can be ordained on the basis of its measurement data.

New emission standards have been proposed in the draft regulation of KTM (Ref.B-32). The emission limit values refer to a mean of 24 hours.

1) General Emission Standards

General emission limit values are valid in every case when there are no technological emission limit values imposed for the given technology. The limit values are classified into four categories concerning "solid materials and inorganic dust materials", "inorganic materials in vapor or gaseous state", "organic materials" and "carcinogenic materials".

The parts of the standards concerning "solid materials and inorganic dust materials" and "inorganic materials in vapor or gaseous state" are shown in Table 7.1.8. and 7.1.9.

2) Technological Emission Standards separately imposed on Certain Technology

These standards are to be imposed separately on 14 main industrial technics as follows:

- glass industry;
- cement industry;
- cupola furnace;
- stationary gas engine;
- paint-job of machines, equipment, components and products;
- firing equipment of dryers
- briquetting of coal
- coking
- baking of ceramic products
- mixing and producing asphalt
- aluminum smelting equipment
- metallurgical equipment including refining equipment for non-ferrous metals and their alloys except for aluminum;
- formation of iron alloys with electronic or metallothermic processes and
- storage and filling of oil or liquid oil-product.

Among them, the standards on glass industry, cement industry and cupola furnace are shown in Table 7.1.10, 7.1.11 and 7.1.12. Some other standards concerning the above-mentioned industries are as follows.

Baking of ceramic products (mass flow is 10 kg/h or higher)

Limit value: SO_2 concentration of smoke-gases--- 1500 mg/m^3 (in relation to 18% O_2 content)

Table 7.1.8 Proposed Future General Emission Limit Values of Stationary Sources concerning Solid Materials and Inorganic Dust Materials

Air Pollutant	Air Pollutant Mass Flow (kg/h)	Limit Values (Permissible Max. Concentration) (mg/m^3)
Class 0	no greater than 0.5	150
(Solid Materials)	greater than 0.5	50
Class I (Cd, Hg, Tl)	0.001 or above	0.2
Class II (As,Pb, etc.)	0.005 or above	1.0
Class III (Cr, Cu, etc.)	0.025 or above	5.0

Source: Ref.B-32

Notes: 1. Materials which are not listed in Classes I to III shall be considered as solid materials.

2. In case several materials belonging to different classes are present simultaneously, the emission limit values are:

Classes I and II together: 1 mg/m^3;

Classes I and III or Classes II and III together: 5 mg/m^3;

however, the limit value referring to the material's own class cannot be exceeded.

Table 7.1.9 Proposed Future General Emission Limit Values of Stationary Sources concerning Inorganic Materials in Vapor or Gaseous State

Air Pollutant	Air Pollutant Mass Flow (kg/h)	Limit Values (Permissible Max. Concentration) (mg/m^3)
Class I (Arsenic hydrogen, etc.)	0.01 or above	1
Class II (HCN, H_2S, etc.)	0.05 or above	5
Class III (Inorganic chlorine)	0.3 or above	30
Class IV (SO_X, NO_X)	5.0 or above	500

Source: Ref.B-32

Table 7.1.10 Proposed Future Technological Emission Limit Values concerning Glass Industry

Technological Process	Emission Limit Values (mg/m^3)					
	Solid Material	SO_2	NO_X	HCl	HF	Pb
Storage, drying raw material, mobilization and grinding	150	500	500	-	-	-
Glass melting						
- pot furnace	-	1100	1200	30	5	0.2
- daily furnace	-	1100	1600	30	5	0.2
- tank furnace	50	1800		30	5	0.2
= with recuperative heat recovery			1400			
= with u-bulb regenerative recovery			2200			
= with cross-bulb regenerative recovery			3500			

Source: Ref.B-32

Notes:
1. In case of tank furnaces, the emission limit values refer to an 8% O_2 content of the exhaust-gas.
2. In case of pot and daily furnaces, the emission limit values refer to a 13% O_2 content of the exhaust-gas.

Table 7.1.11 Proposed Future Technological Emission Limit Values concerning Cement Industry

Technological Process	Emission Limit Values (mg/m^3)		
	Solid Material	SO_2	NO_X
New equipment	50	400	1300
Existing equipment		750	1800
- furnaces with raw material grinding	100		
- clinker ventilation	100		
- cement grinding	80		
- other	50		

Source: Ref.B-32

Notes:
1. In case of existing equipment, the emission limit values shall be enforced from January 1, 1996. That equipment is considered "existing equipment" which operates or has a valid establishment license at the time the regulation comes into force.
2. The emission limit values refer to a 6% O_2 content of the smoke-gas.

Table 7.1.12 Proposed Future Technological Emission Limit Values concerning Cupola Furnace

Air Pollutant	Solid Material	CO	SO_2	NO_X
Emission Limit Value (mg/m^3)	150	1100	500	500

Source: Ref.B-32

Note: In case of existing equipment, the emission limit values shall be enforced from January 1, 1996. That equipment is considered "existing equipment" which operates or has a valid establishment license at the time the regulation comes into force.

Mixing and producing asphalt

Limit values:Solid material concentration of smoke gases --- 20 mg/m^3 (in relation to 17% O_2 content)

Sulfur content of fuels (gas/oil/coal) -------------------------- 1 %

Formation of iron alloys with electronic or metallothermic processes

Limit value: Solid material concentration of smoke gases --- 20 mg/m^3

3) Technological Emission Standards of Firing Equipment with a Thermal Capacity of 15 MW and above

Standards concerning new firing equipment

In case of firing equipment established or reconstructed and operated after the regulation's entry into force with a rated (licensing) thermal capacity input of 15 MW or above, the technological limit values shown in Table 7.1.13, 7.1.14, 7.1.15 and 7.1.16 are to be imposed.

Standards concerning existing firing equipment

- In case of firing equipment which exists when the regulation comes into force or which was established and licensed before the regulation comes into force, the same standards as those concerning new firing equipment are to be enforced from January 1, 1999. Until the day of the enforcement, the above-mentioned equipment can exceed the limit values under certain conditions, however, the environmental fee shall be paid in a higher amount (as an air pollution fee) for the air pollution which exceeds the limit values.

- For solid fuel combustion furnaces altered into Hybrid Fluidized Bed Coal Dust Combustion Furnaces, the desulphurization rate shall be at least 60% and the emission concentration of NO_X cannot exceed 800 mg/m^3.

- For oil combustion furnaces, the emission concentration of SO_2 cannot exceed 2,100 mg/m^3 and the smoke-gas (above 500 MW) concentration of heavy metal and arsenic cannot exceed 2 mg/m^3.

- Concerning all the existing firing equipment belonging within the above-mentioned definition and operated by the Hungarian Electric Company, the following limit values (in annual periods) shall be maintained.

Table 7.1.13 Proposed Future Technological Emission Limit Values concerning New Firing Equipment operated with Solid Fuels

Air Pollutant	Emission Limit Value (mg/m^3)		
	15 - 100 MW	100 - 500 MW	> 500 MW
Solid Material	100	50	50
CO	250	250	250
NO_X (given in NO_2) (Note 1)	650	600	600
SO_2 and SO_3 (given in SO_2)	(see Note 2)	(see Note 3)	400
Chlorides (given in HCl)	200	100	100
Fluorides	30	15	15

Source: Ref.B-32

Notes:

1. In case of domestic lignite maximum 300 mg/m^3 (calorific value: < 7,000 kJ/kg)
2. 2,000 mg/m^3 or at least 60% desulphurating efficiency
3. Limit value except for the following conditions is obtained by interpolating the interval between the value for [15-100MW] and that for [>500MW]
   - In case of firing domestic brown coal and lignite, at least 90% desulphurating efficiency
   - In case of firing imported coal maximum 400 mg/m^3
   - In case of Fluidized Bed Combustion Boiler using domestic coal, at least 75% desulphurating efficiency
4. Concentration given in mg/m^3 refer to dry smoke-gas with 6% O_2 content at a normal state (273°K, 101.3kPa).

Table 7.1.14 Proposed Future Technological Emission Limit Values concerning New Firing Equipment operated with Liquid Fuels

Air Pollutant	Emission Limit Value (mg/m^3)		
	15 - 300 MW	300 - 500 MW	> 500 MW
Solid Material	50	50	50
CO	175	175	175
NO_X (given in NO_2)	350	350	350
SO_2 and SO_3 (given in SO_2)	1700	(see Note 2)	400
Chlorides (given in HCl)	30	30	30
Fluorides (given in HF)	5	5	5
Heavy Metals (Note 1) and Arsenic	2	2	2

Source: Ref.B-32

Notes:

1. The following elements are to be taken into consideration:
   Arsenic, Cadmium, Cobalt, Nickel, Chromium, Lead and Vanadium
2. Limit value is obtained by interpolating the interval between the value for [15-300MW] and that for [>500MW]
3. Concentration given in mg/m^3 refer to dry smoke-gas with 3% O_2 content at a normal state (273°K, 101.3kPa).

Table 7.1.15 Proposed Future Technological Emission Limit Values concerning New Firing Equipment operated with Gaseous Fuels

Air Pollutant	Emission Limit Value (mg/m^3)		
	15 - 100 MW	100 - 500 MW	> 500 MW
Solid Material	5	5	5
CO	100	100	100
NO_X (given in NO_2)	200	200	200
SO_2 and SO_3 (given in SO_2)	35	35	35

Source: Ref.B-32

Note: Concentration given in mg/m^3 refer to dry smoke-gas with 3% O_2 content at a normal state (273°K, 101.3kPa).

Table 7.1.16 Proposed Future Technological Emission Limit Values concerning New Firing Equipment (Gas Turbines)

Air Pollutant	Emission Limit Value (mg/m^3)	
	< 300 MW	> 300 MW
Solid Material (Soot) (Note 1)	4	2
CO	100	100
NO_X (given in NO_2)		
- fuel oils	200	170
- gases	150	90
SO_2 and SO_3 (given in SO_2) fuel oils	115	115

Source: Ref.B-32

Notes:

1. The number of blackening is according to the Bacharach scale.
2. Concentration given in mg/m^3 refer to dry smoke-gas with 15% O_2 content at a normal state (273°K, 101.3kPa).