V-2-3-3 Dependence of SPM concentrations during the short term field survey on atmospheric stability

Table V-2-11 and Fig. V-2-15 show the dependence of SPM concentration during the short term field survey on atmospheric stability. The results do not show the clear relationship between SPM concentration and atmospheric stability.

Table V-2-11 Dependence of SPM concentration during short term field survey on atmospheric stability

Monitoring stations	Survey	Item	Calm	Atmospheric stability at windy						Ave
				A	B	C	D	E	F	
(MP1) J.T.C. HALL	1st survey	n	5	-	40	36	53	146	8	288
		AVE	36.8	-	27.1	19.4	15.1	19.5	13.5	19.9
		SIG	30.6	-	22.2	14.6	13.3	18.2	9.7	18.2
	2nd survey	n	-	3	59	33	56	90	12	253
		AVE	-	36.7	27.3	27.6	23.9	23.7	24.7	25.3
		SIG	-	17.5	16.6	20.7	16.3	11.6	13.6	15.6
	3rd survey	n	5	-	44	43	94	90	-	276
		AVE	34.0	-	14.7	11.2	15.0	17.9	-	15.6
		SIG	33.8	-	13.4	11.7	13.9	11.9	-	13.9
	4th survey	n	9	-	68	33	41	136	-	287
		AVE	30.6	-	25.6	17.2	20.4	30.9	-	26.6
		SIG	29.5	-	25.1	20.5	25.1	24.7	-	25.1
	Average	n	19	3	211	145	244	462	20	1104
		AVE	33.1	36.7	24.1	18.3	18.0	23.4	20.2	21.8
		SIG	31.1	17.5	20.9	17.9	17.1	19.1	13.4	19.3
(MP2) N.U.S.	1st survey	n	1	-	36	40	88	116	6	287
		AVE	66.0	-	31.5	24.3	23.5	25.1	30.5	25.6
		SIG	0.0	-	20.7	17.3	16.1	15.9	11.0	17.1
	2nd survey	n	1	3	64	38	86	66	10	268
		AVE	0.0	50.7	38.7	34.2	32.8	37.6	26.1	35.4
		SIG	0.0	15.5	23.3	20.7	17.5	21.0	15.3	20.6
	3rd survey	n	3	2	41	38	106	86	-	276
		AVE	32.7	7.5	27.1	20.5	21.9	21.5	-	22.3
		SIG	26.6	2.5	11.8	14.3	12.7	13.8	-	13.6
	4th survey	n	5	1	56	44	49	133	-	288
		AVE	8.8	0.0	30.9	16.4	24.2	33.3	-	28.2
		SIG	4.7	0.0	25.0	19.4	25.0	28.2	-	26.5
	Average	n	10	6	197	160	329	401	16	1119
		AVE	20.8	27.8	32.8	23.6	25.5	29.1	27.8	27.8
		SIG	24.2	25.5	21.9	19.3	17.7	22.0	14.0	20.6
(MP6) NANYANG.T.I.	1st survey	n	30	5	39	17	37	144	11	283
		AVE	29.1	18.6	14.1	10.1	12.2	20.3	28.7	19.0
		SIG	19.5	9.7	11.8	11.0	11.2	18.4	29.8	17.9
	2nd survey	n	10	8	70	13	30	107	13	251
		AVE	26.3	44.9	37.0	36.2	32.5	39.1	45.6	37.6
		SIG	18.8	19.9	26.1	21.7	23.6	21.3	22.5	23.3
	3rd survey	n	42	3	61	20	62	86	1	275
		AVE	35.6	18.7	22.9	23.4	21.4	33.6	30.0	27.9
		SIG	18.7	16.4	19.6	15.0	16.2	22.6	0.0	20.3
	4th survey	n	42	7	65	20	36	117	-	287
		AVE	36.0	13.4	17.8	19.6	20.3	34.9	-	27.8
		SIG	14.2	17.1	18.3	21.8	20.5	23.6	-	22.3
	Average	n	124	23	235	70	165	454	25	1096
		AVE	33.4	26.2	24.2	21.5	21.1	31.0	37.6	27.8
		SIG	17.9	21.8	22.3	19.8	19.0	22.6	26.9	22.0

n; The numbers of cases

AVE; Average ($\mu g/m^3$)

SIG; Standard deviation ($\mu g/m^3$)

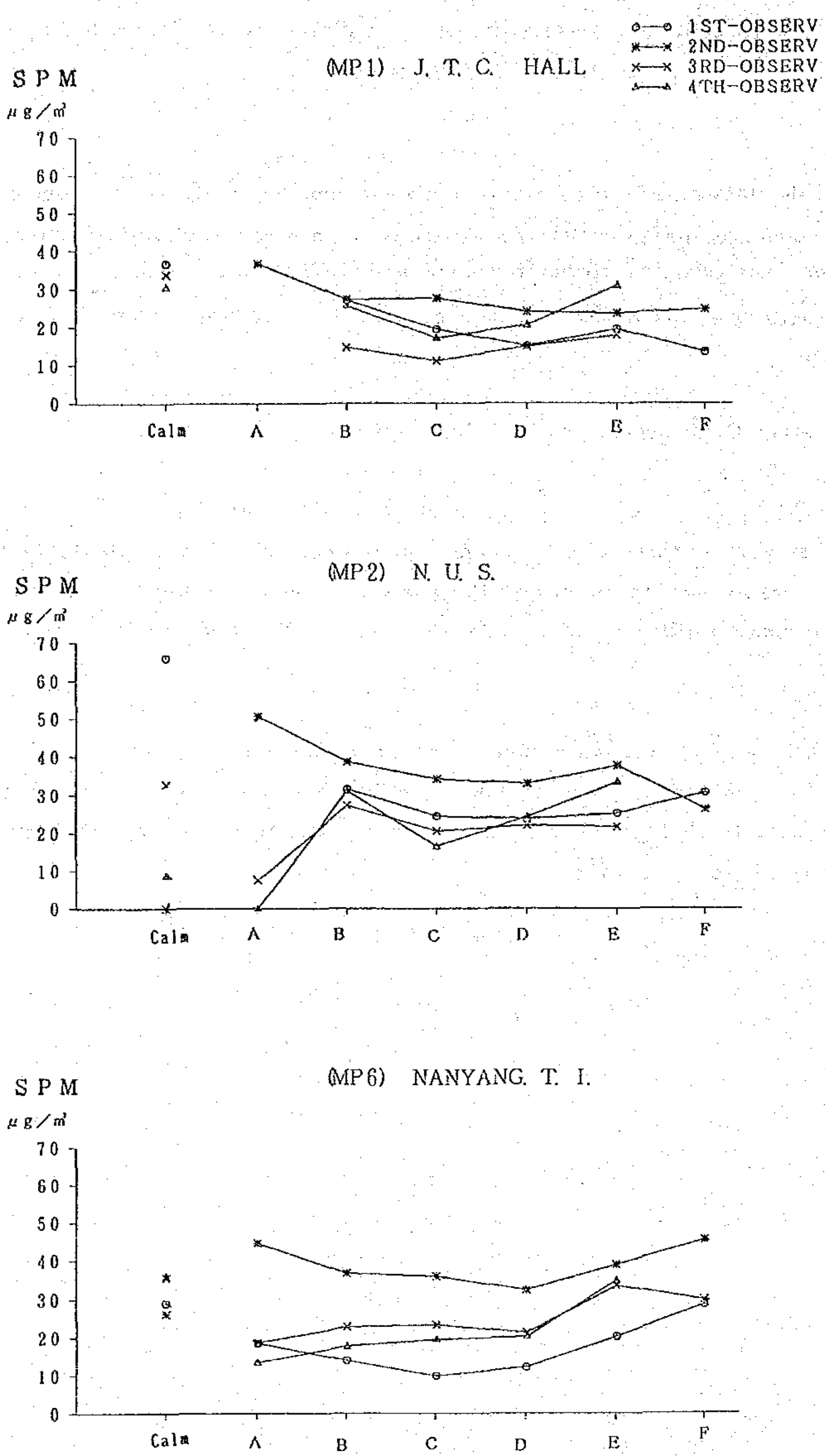


Fig. V-2-15 Dependence of SPM concentration during short term field survey on atmospheric stability

CHAPTER 3 ANALYSIS OF CHEMICAL COMPONENTS IN PARTICULATE MATTERS

Using the data measured by high volume sampler, we analyzed the concentrations of chemical components in TPM by instrument neutron activation analysis, X-ray fluorescence analysis, ion chromatography and differential thermal analysis. If these concentrations are under the confidence, 1/10 of such the values are taken up in calculation.

V-3-1 Average Concentration of Chemical Components

Table V-3-1 shows the average concentration of chemical components in each short term field survey. In this table, '*' means that the numbers of non detectable data is 50% or more. In each short term survey, the analysis of element and the analysis of carbon were performed on different day. So in this table, TPM concentrations of each day are shown.

The ranking of the concentration of chemical components is following C > Si > Cl SO_4^{2-} > Cl^- > Al. The concentrations of soil particle, sea-salt particle and secondary particle are relatively high. About Ag, Ba, Cs, K, La, Lu, Ni and W, the large portion of data are under detectable limits.

Table V-3-1 Average concentrations of chemical components

	Method of analysis	Components	Unit	1st survey		2nd survey		3rd survey		4th survey		Average of four surveys	
				Average	Geometric mean	Average	Geometric mean	Average	Geometric mean	Average	Geometric mean	Average	Geometric mean
Element	Instrument activation analysis	Ag	ng/m³	0.064*	0.063*	0.406*	0.185*	0.143*	0.068*	0.105*	0.071*	0.179*	0.087*
		Al		1665.000	1290.242	2706.000	2113.726	1578.540	841.269	2619.500	1646.097	2142.260	1394.048
		As		6.716	3.318	7.639	4.661	4.263	1.198	6.390	1.362	6.252	2.241
		Ba		15.790*	5.248*	17.200*	7.264*	41.005*	5.197*	27.140*	8.793*	25.284*	6.460*
		Br		85.600	65.144	107.500	93.439	102.050	68.936	99.400	83.389	98.637	76.911
		Ca		1157.000	869.544	2470.500	1871.759	1656.000	844.169	2603.000	1272.344	1971.625	1149.857
		Cd		6.350*	4.327*	5.350*	3.691*	5.050*	3.716*	5.750*	4.295*	5.625*	3.996*
		Ce		1.505	1.069	2.392	2.036	1.607	1.253	1.862	1.368	1.842	1.390
		Cl		4740.000	4643.021	1956.500	1868.831	2995.000	2866.449	3990.000	3828.132	3420.375	3129.179
		Co		0.244	0.130	0.505	0.292	0.316	0.190	1.136	0.283	0.550	0.212
		Cr		4.132	2.382	7.043	5.400	6.159	3.769	7.553	4.155	6.222	3.767
		Cs		0.090*	0.037*	0.097*	0.038*	0.078*	0.029*	0.096*	0.033*	0.090*	0.034*
		Cu		53.750	30.158	109.250	89.671	48.900	29.865	46.150	26.662	64.513	38.307
		Fe		637.500	514.703	1408.000	1087.710	1027.750	639.193	1097.000	749.846	1042.563	719.728
		Hf		0.087	0.038	0.158	0.084	0.083	0.047	0.140	0.054	0.117	0.053
		K		273.500*	130.053*	871.000*	359.946*	475.500	254.822	578.000*	283.667*	549.500*	241.185*
		La		0.325*	0.137*	1.005	0.522	0.568*	0.242*	0.688*	0.247*	0.646*	0.256*
		Lu		0.008*	0.003*	0.011*	0.006*	0.003*	0.002*	0.009*	0.004*	0.008*	0.003*
		Mn		11.805	10.295	34.170	23.730	25.560	13.225	17.705	10.475	22.310	13.564
		Na		1155.000	737.237	1278.500	1104.422	1538.000	1410.670	1999.000	1911.196	1492.625	1217.218
		Ni		9.080*	4.456*	8.890*	5.255*	4.235*	2.007*	9.420*	3.356*	7.906*	3.539*
		Sb		1.803	0.720	3.704	2.151	1.602	0.987	4.291	1.218	2.850	1.168
		Sc		0.182	0.134	0.347	0.264	0.201	0.134	0.318	0.202	0.262	0.176
		Se		0.992	0.525	1.680	1.111	0.436	0.222	1.119	0.951	1.057	0.593
		Sm		0.108	0.067	0.161	0.120	0.088	0.049	0.091	0.041	0.112	0.063
		Th		0.411	0.310	0.612	0.497	0.356	0.259	0.588	0.357	0.492	0.345
		Ti		83.600	42.298	134.500	100.510	97.050	47.248	87.900	33.547	100.763	50.950
		V		20.319	11.018	29.450	27.306	14.405	10.694	12.820	8.519	19.248	12.867
		W		0.589*	0.262*	2.478	1.081	1.307*	0.375*	0.976*	0.279*	1.337*	0.415*
		Zn		57.350	46.025	136.850	98.901	94.625	50.753	78.750	57.032	91.894	60.248
	X-ray flourenscense	Cd	ng/m³	2.455	1.428	3.180	1.785	3.215	1.685	4.430	2.959	3.320	1.888
		Pb		190.350	89.664	297.250	265.000	244.800	164.766	199.600	101.657	233.000	141.313
		S		1101.500	1019.757	1746.500	1509.244	1253.000	1123.554	1690.000	1465.435	1447.750	1261.694
		Si		7045.000	5186.411	9240.000	7652.980	9762.500	7072.121	13755.000	10224.695	9950.625	7319.381
	Ion chromatagraphy	Cl^-	ng/m³	3310.000	3246.189	1313.000	1236.319	1858.000	1740.169	2825.500	2669.715	2326.625	2077.974
		NO_3^-		530.000	508.918	1649.000	1581.170	666.050	641.654	1457.000	1426.940	1075.512	926.474
		SO_4^{--}		2570.000	2329.472	4515.000	4267.527	1965.000	1812.632	3200.000	2907.022	3062.500	2690.283
	TPM	TPM	μg/m³	48.545	44.033	73.210	67.812	54.410	49.930	90.255	82.711	66.605	59.259
Carbon	Differential thermal analysis	Elemental C	μg/m³	12.345	11.440	18.840	17.323	10.615	8.961	16.095	15.605	14.474	12.903
		Organic C		4.020	3.656	4.480	3.800	3.585	2.782	5.325	4.795	4.352	3.690
		Total C		16.365	15.130	23.320	21.274	14.200	11.915	21.420	20.528	18.826	16.751
	TPM	TPM		73.570	70.278	88.745	84.091	70.770	65.735	75.740	72.570	77.206	72.867

Note: (1) 1/10 of value was adopted for averaging with data below detection limit.
(2) * marked when data over 50% are found below detection limit.

V-3-2 Spatial Distribution of Chemical Components

Fig. V-3-1 shows the spatial distribution of the concentration of representative chemical components. These components are considered to be marker elements of the main emission sources. Marker elements are followings.

Sc, Al, Ti	Soil
Na, Cl	Sea-salt particle
Pb, Br	Gasoline automobile
V	Petroleum combustion
Mn	Steel mill
Zn, K	Wastes incineration
Ca	Cement
SO_4^{2-}, NO_3^-	Secondary particle
Organic C	Diesel automobile

The spatial distributions of these components are followings.

(1) Soil

In the north part and north-east part in the object area, the concentrations of Sc, Al and Ti are relatively higher than the concentration in urban area. Except the north part and the north-east part, the concentrations of the each component are almost the same in the objective area. But at (MP7) - Bukit Panjang P.P., the concentrations are extremely high in each short term field survey. It seems to be the influence of upflung dust from the road.

(2) Sea-salt particle

The concentrations of Na and Cl are relatively high near the coast. And in the inland, the concentrations are low.

(3) Gasoline automobile

The concentrations of Pb and Br are relatively high at the monitoring points near the road - for example, (MP7), (MP13) and (MP17). It seems to be the influence of the exhaust fumes from cars.

(4) Petroleum combustion

V (vanadium) is emitted by burning petroleum. The concentrations of V are relatively high at MP1, MP4 and MP5. In the east part, the concentrations are relatively low.

(5) Steel mill

At (MP5) Jurong Hill Top, the concentration of Mn is relatively high. It seems to be the influence of the steel works locating in the south side of MP5. During the 2nd field survey, the extremely high concentrations of Mn are measured at (MP19) JTC Bedok F.F., but the reason is uncertain.

(6) Wastes incineration

Zn and K are emitted by incineration of the wastes. But the spatial distribution of the concentration don't show the clear tendency.

(7) Cement

Ca is emitted from the hardening cement etc. The concentrations at (MP5) - Jurong Hill Top, (MP7) - Bukit Panjang P.P. are relatively high. During the 4th field survey, the extremely high concentrations are measured at (MP20) - Singapore O.P.S. The reason is uncertain.

(8) Secondary particle

SO_4^{2-} and NO_3^- are originated in secondary particles. The concentrations are almost the same in the objective area. Especially, NO_3^- shows such a tendency. One of the reasons may be due to the reaction velocities of $SO_2 \rightarrow SO_4^{2-}$ and $NO \rightarrow NO_3^-$. The velocities aren't so fast, thus the regional difference of the concentration are not so clear.

(9) Diesel automobile

The concentrations of organic carbon are relatively high at (MP7) Bukit Panjang P.P., (MP4) Kranji Sewage T.P., (MP11) Chong Pang P.P. and (MP17) Paya Lebar P.S. Diesel car may affect the concentration at these stations.

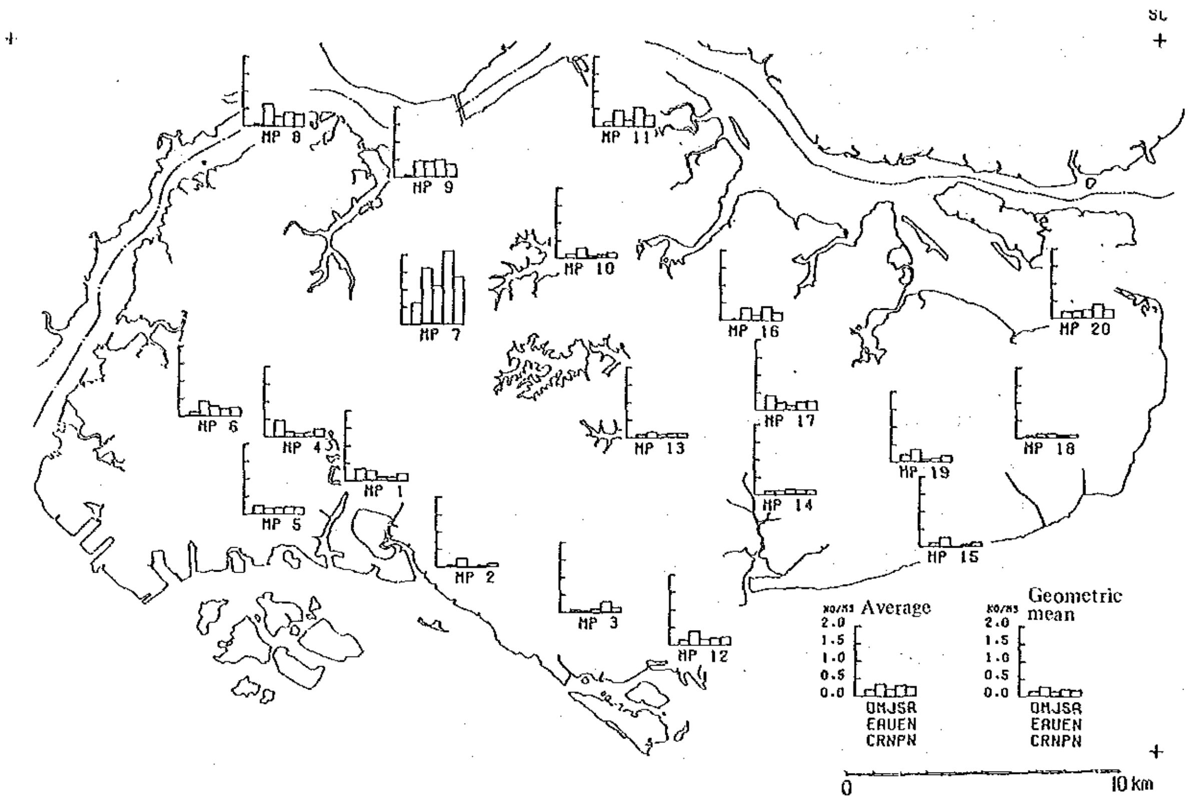


Fig. V-3-1-(1) Concentration distribution of Sc

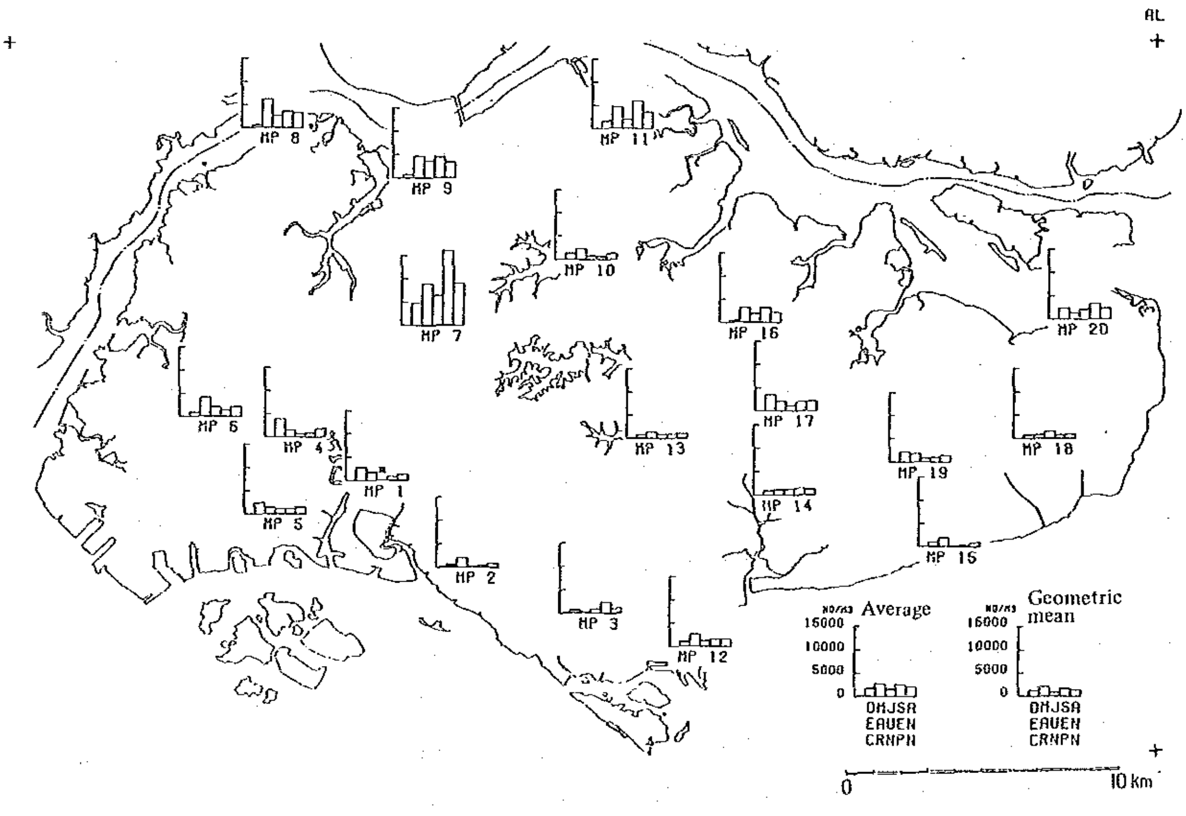


Fig. V-3-1-(2) Concentration distribution of Al

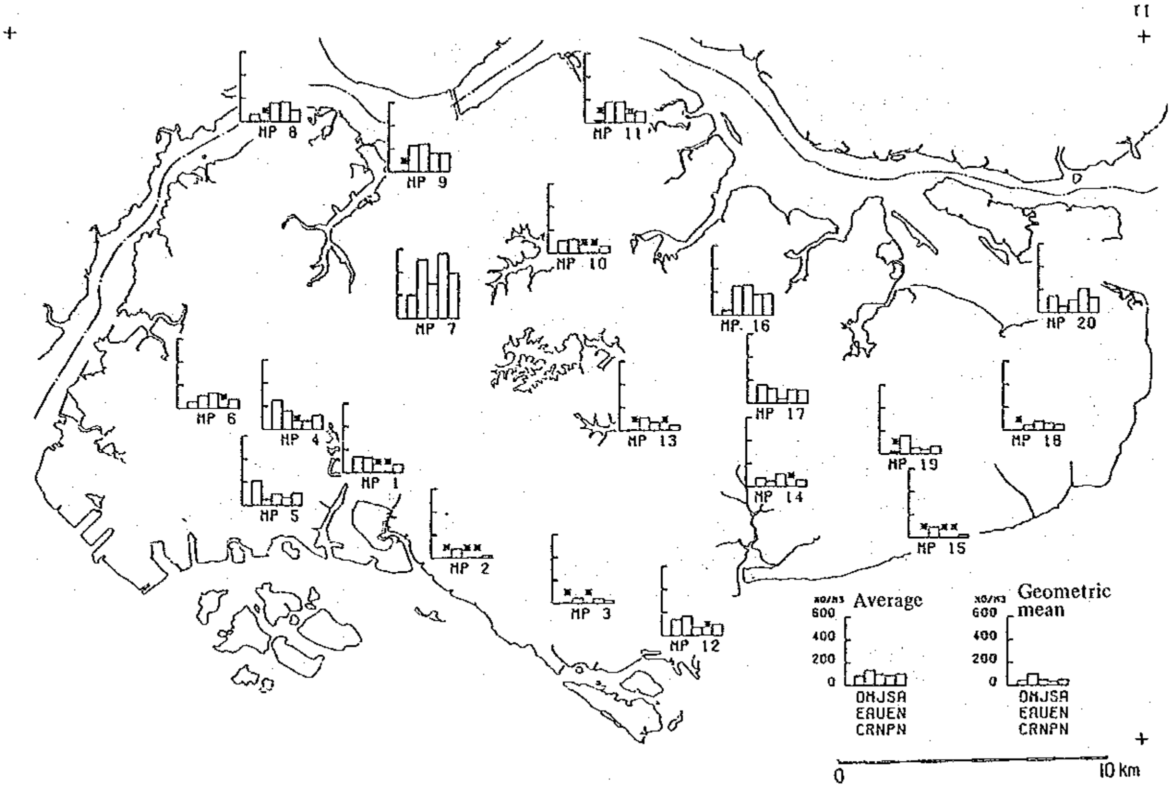


Fig. V-3-1-(3) Concentration distribution of Ti

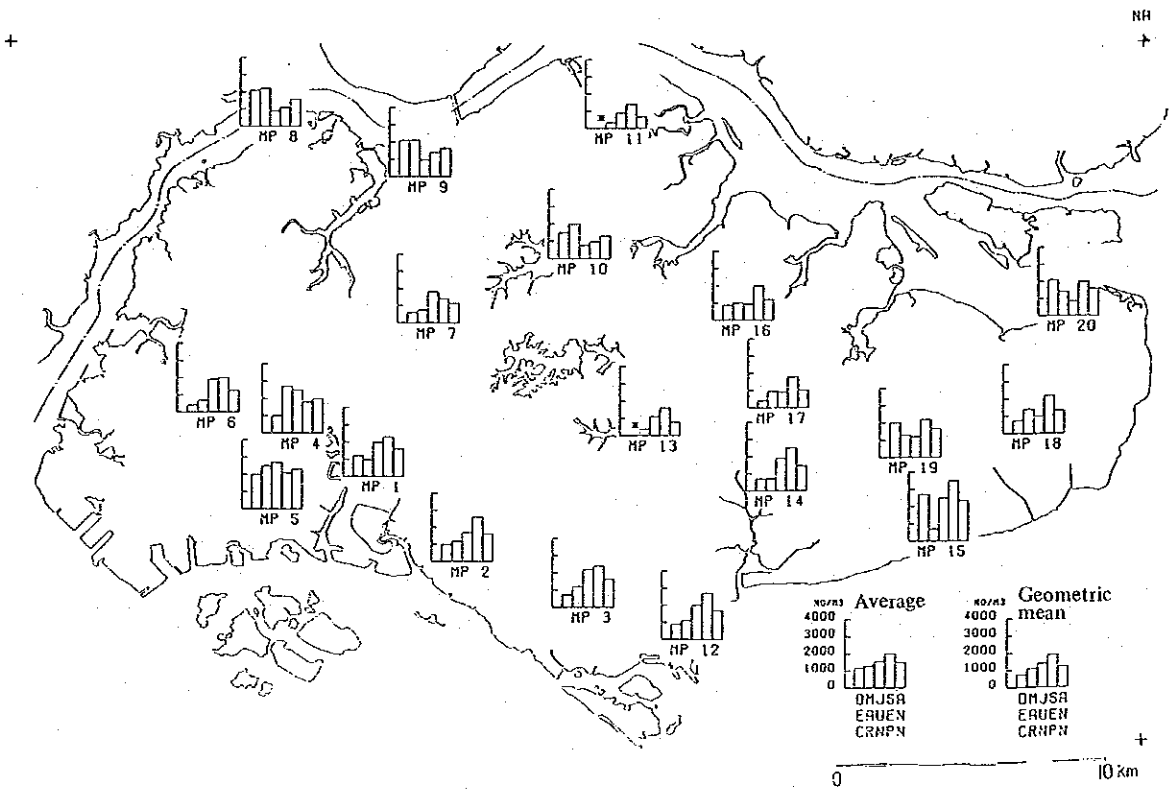


Fig. V-3-1-(4) Concentration distribution of Na

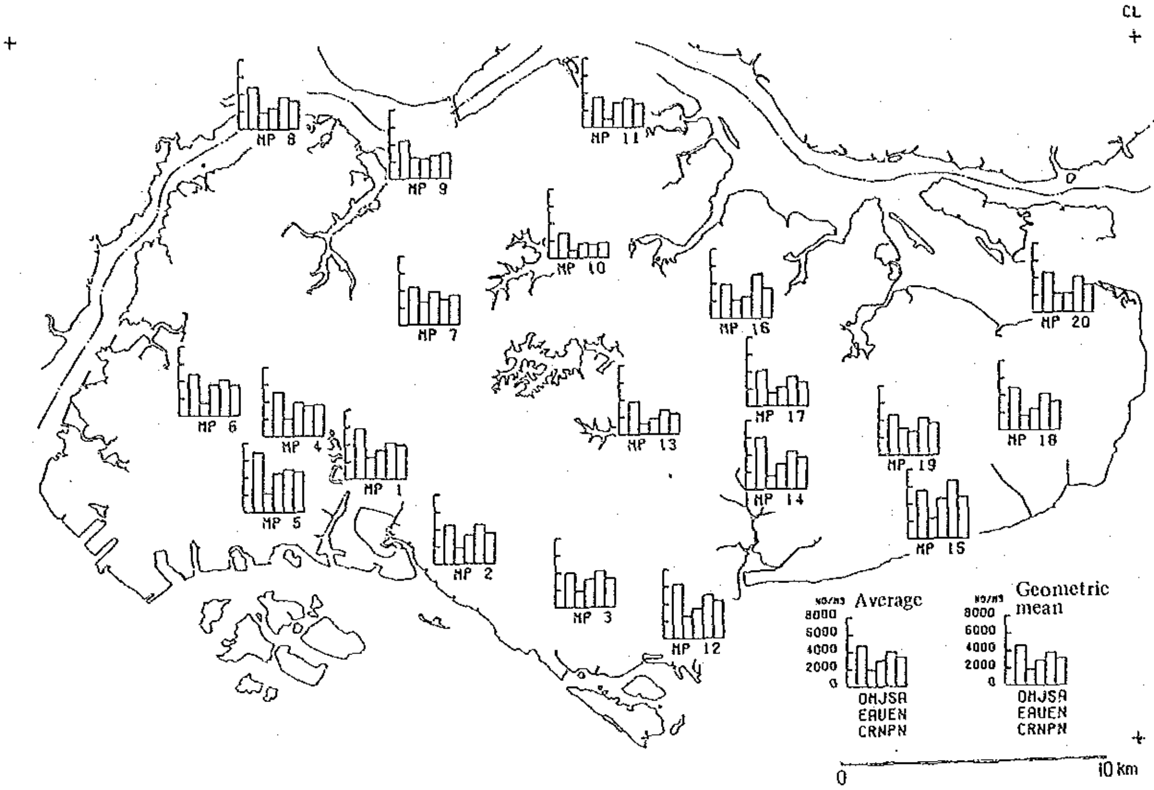


Fig. V-3-1-(5) Concentration distribution of Cl

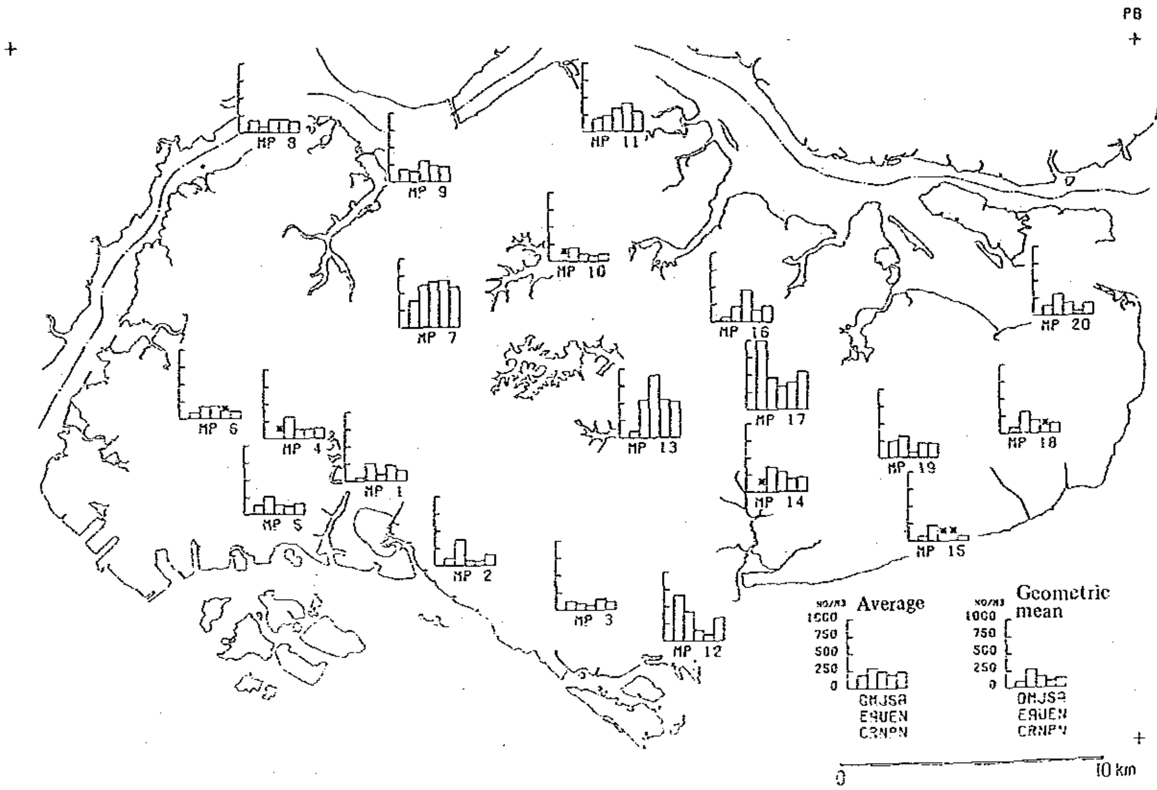


Fig. V-3-1-(6) Concentration distribution of Pb

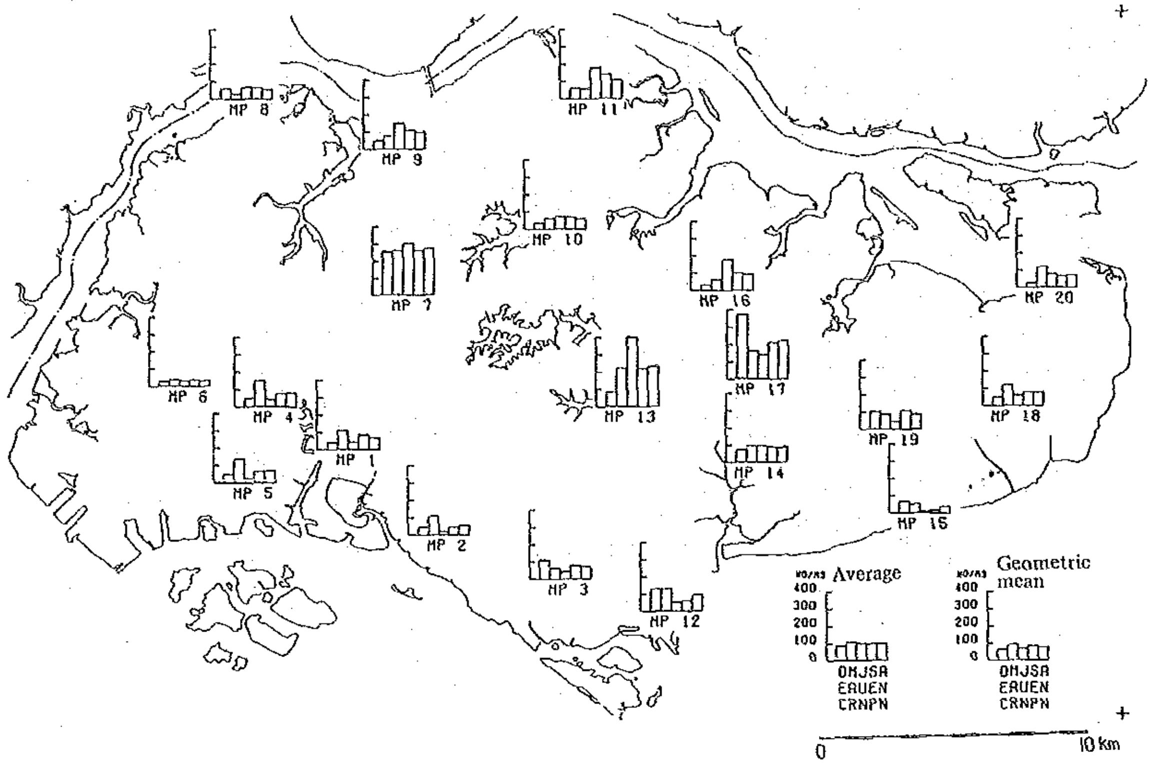


Fig. V-3-1-(7) Concentration distribution of Br

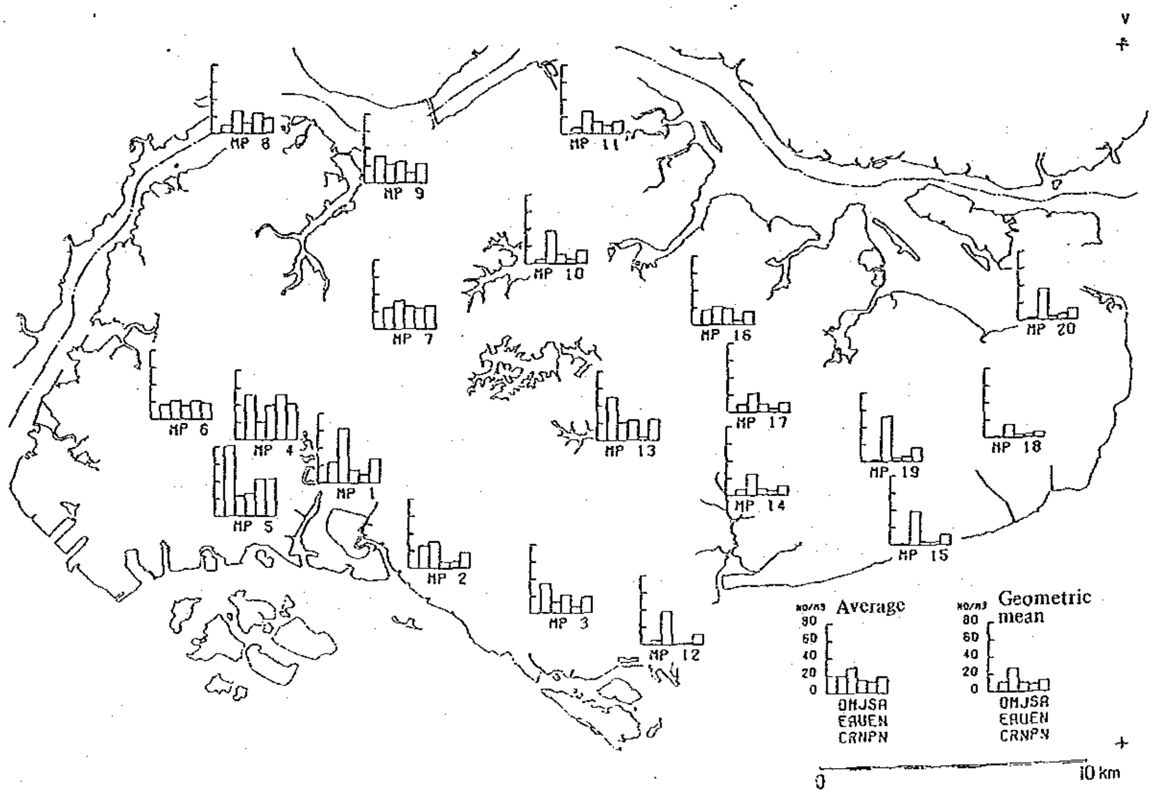


Fig. V-3-1-(8) Concentration distribution of V

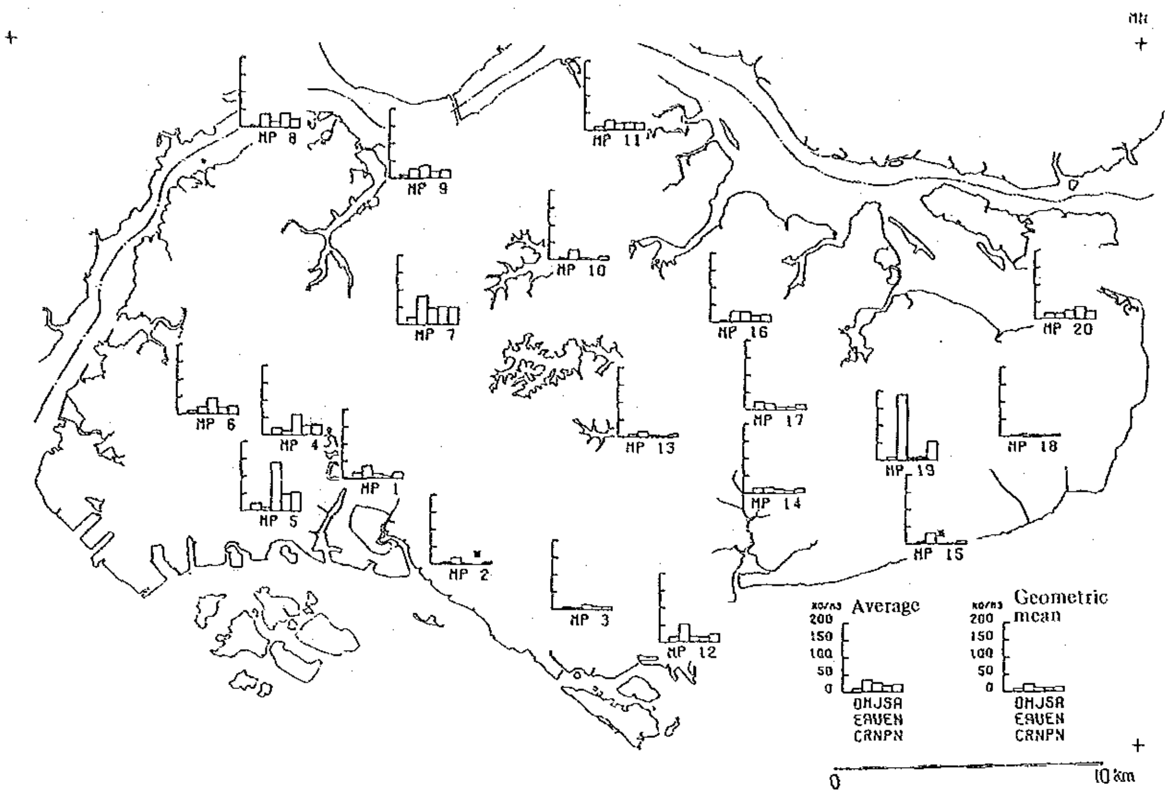


Fig. V-3-1-(9) Concentration distribution of Mn

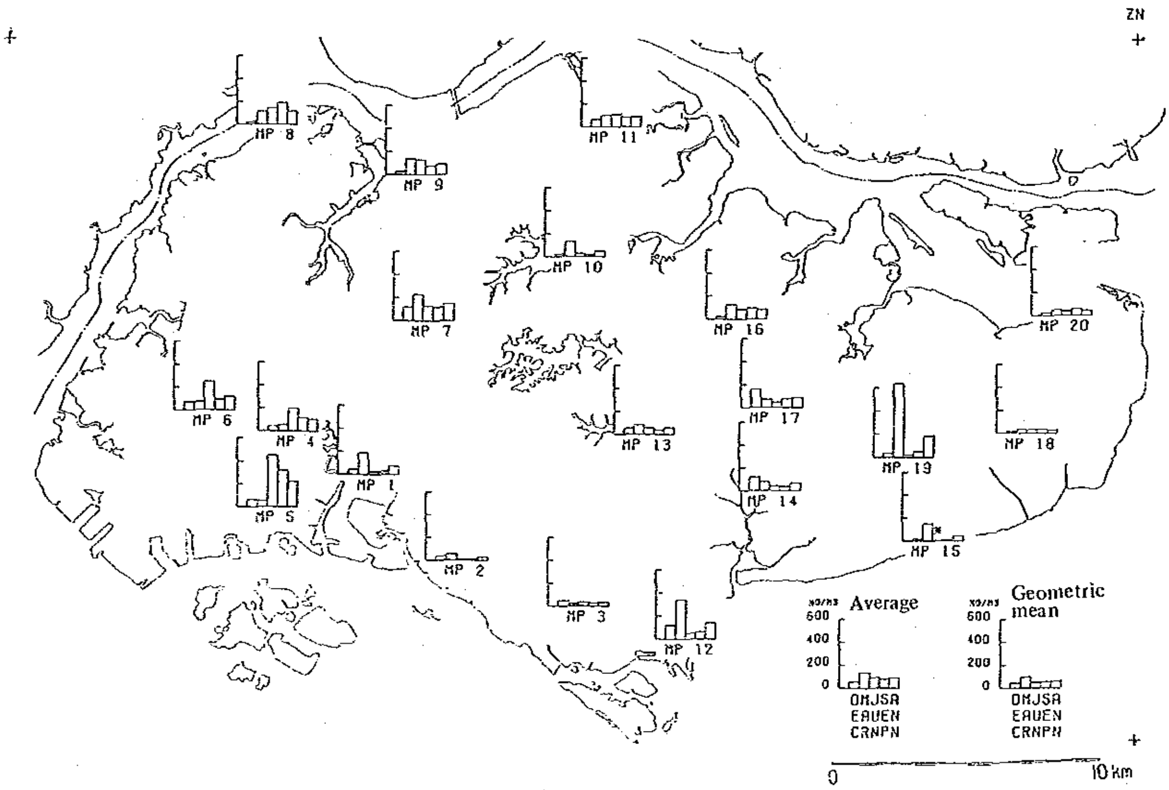


Fig. V-3-1-(10) Concentration distribution of Zn

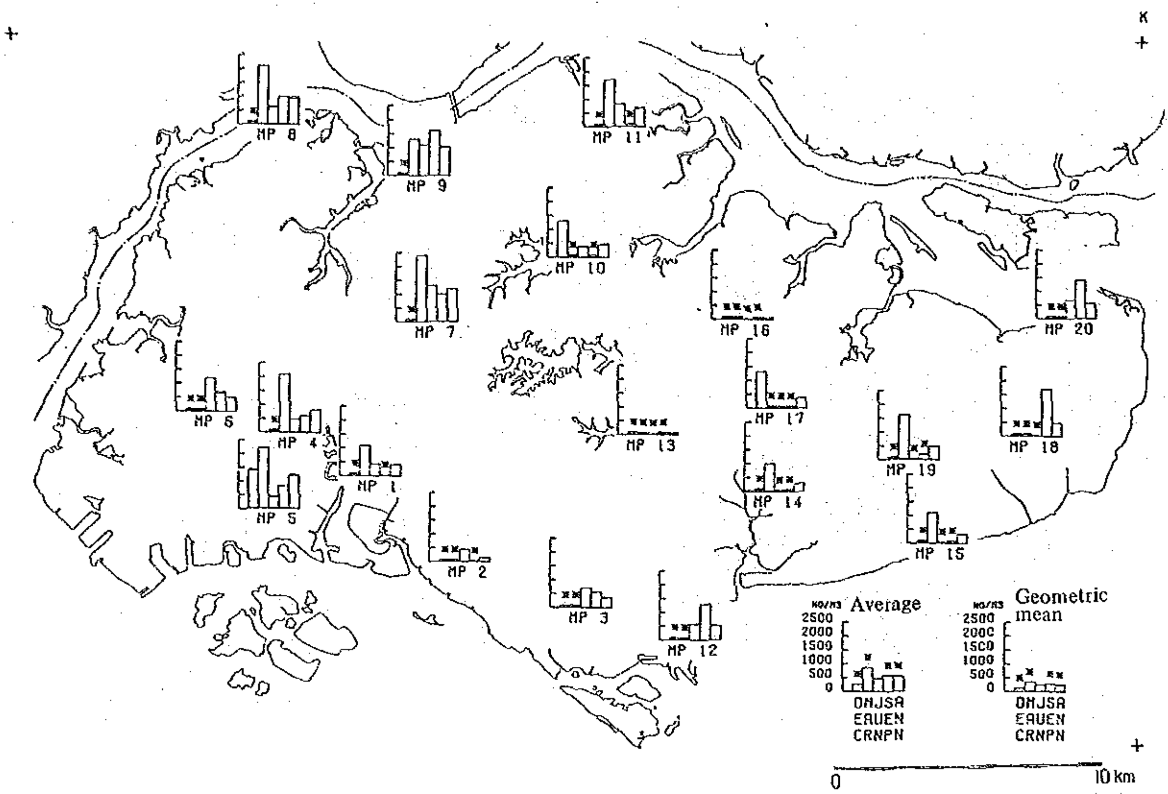


Fig. V-3-1-(11) Concentration distribution of K

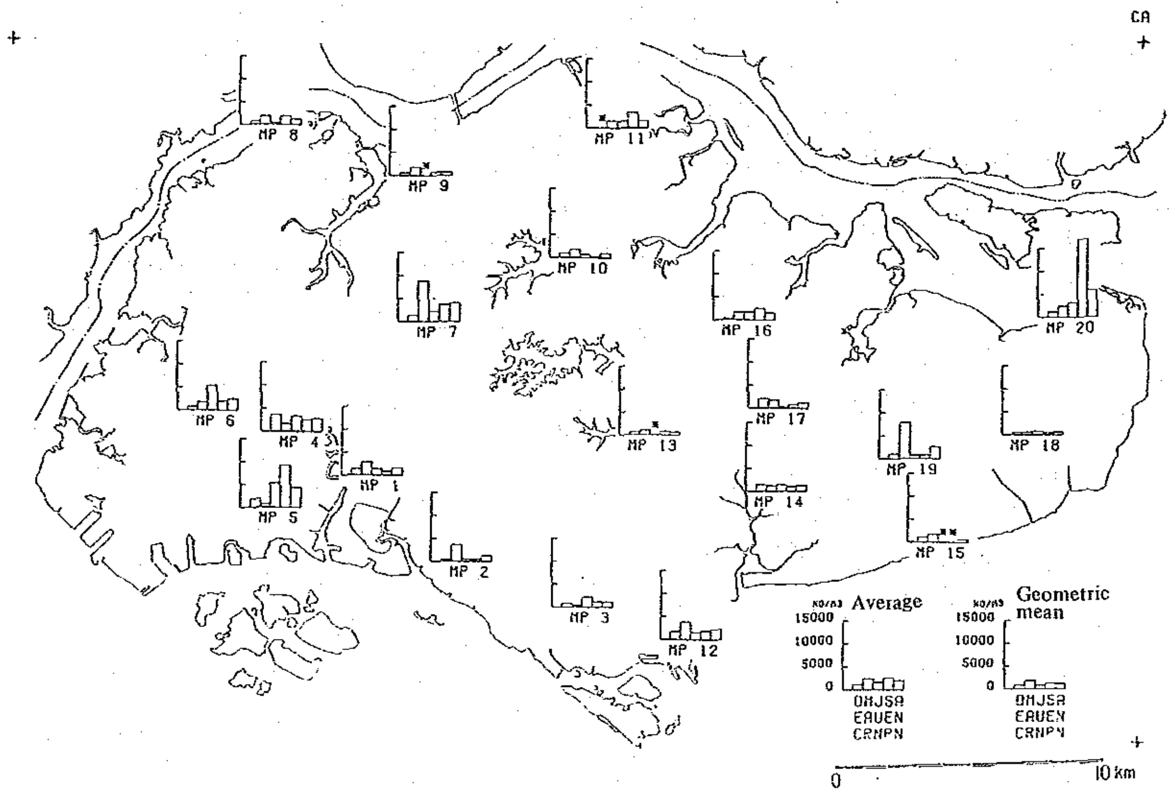


Fig. V-3-1-(12) Concentration distribution of Ca

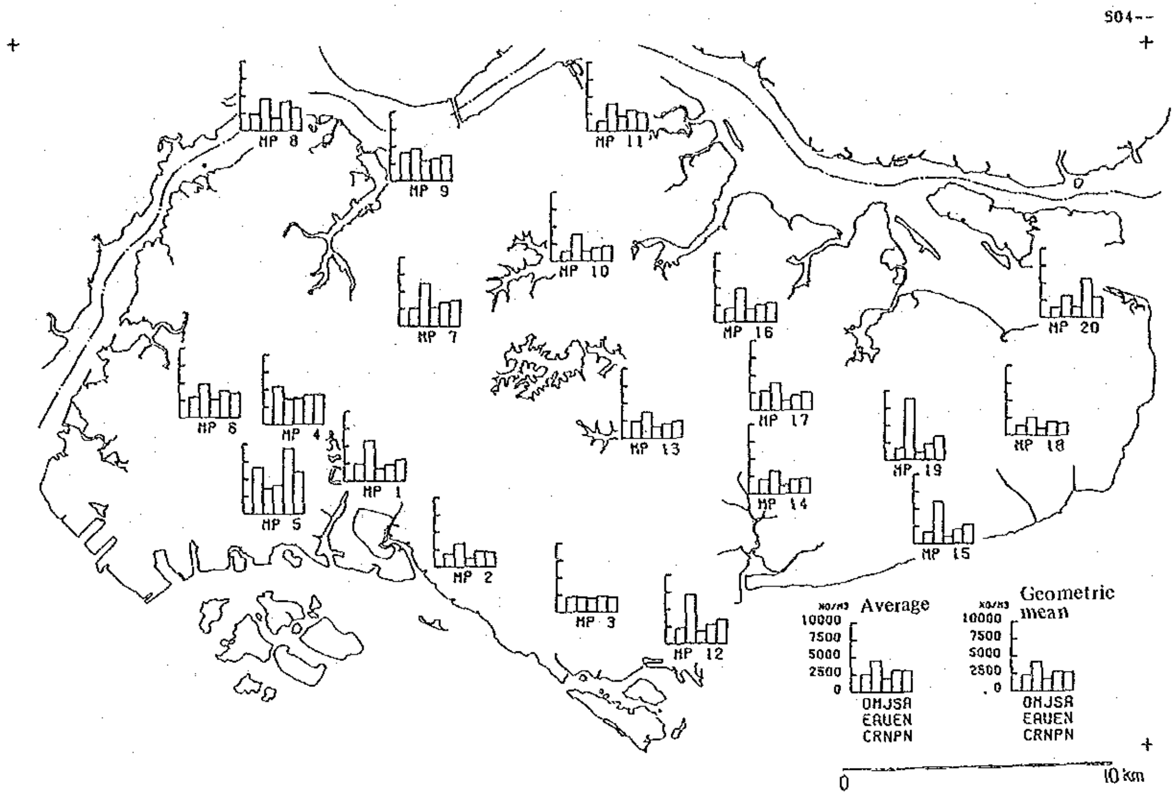


Fig. V-3-1-(13) Concentration distribution of $SO_4{}^{2-}$

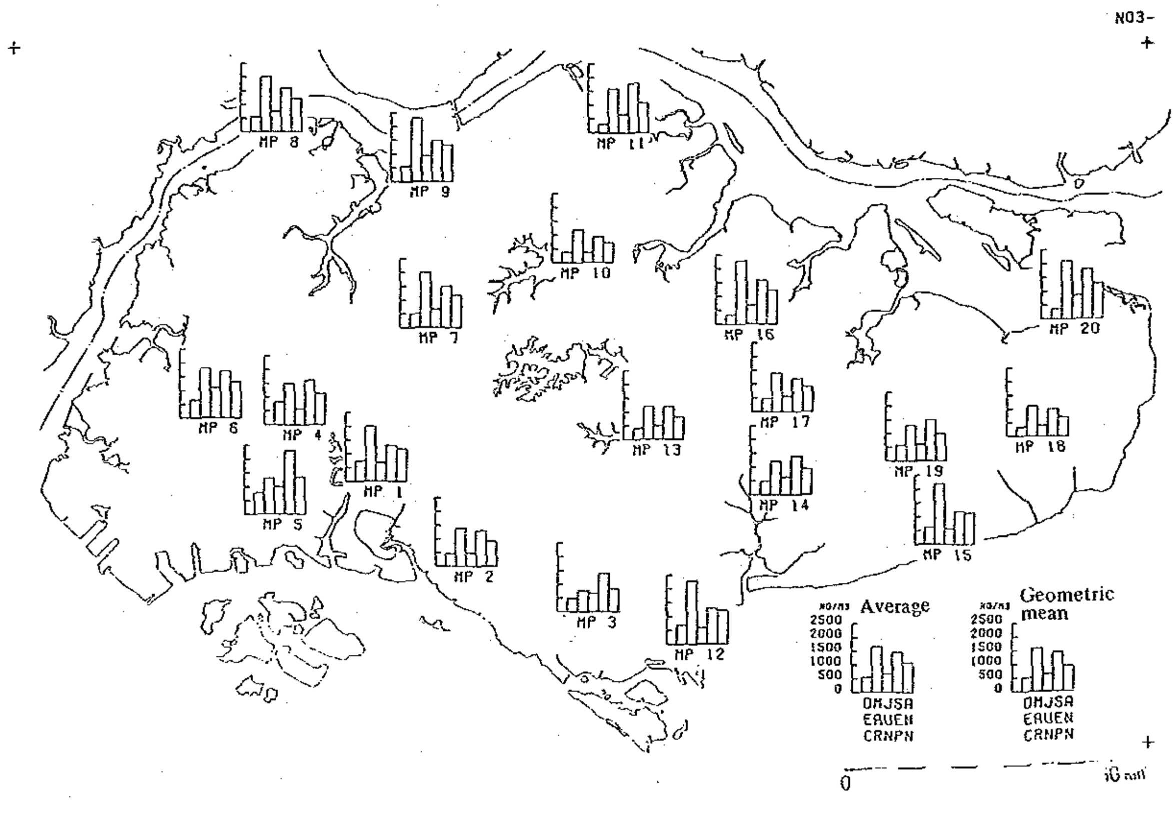


Fig. V-3-1-(14) Concentration distribution of $NO_3{}^{-}$

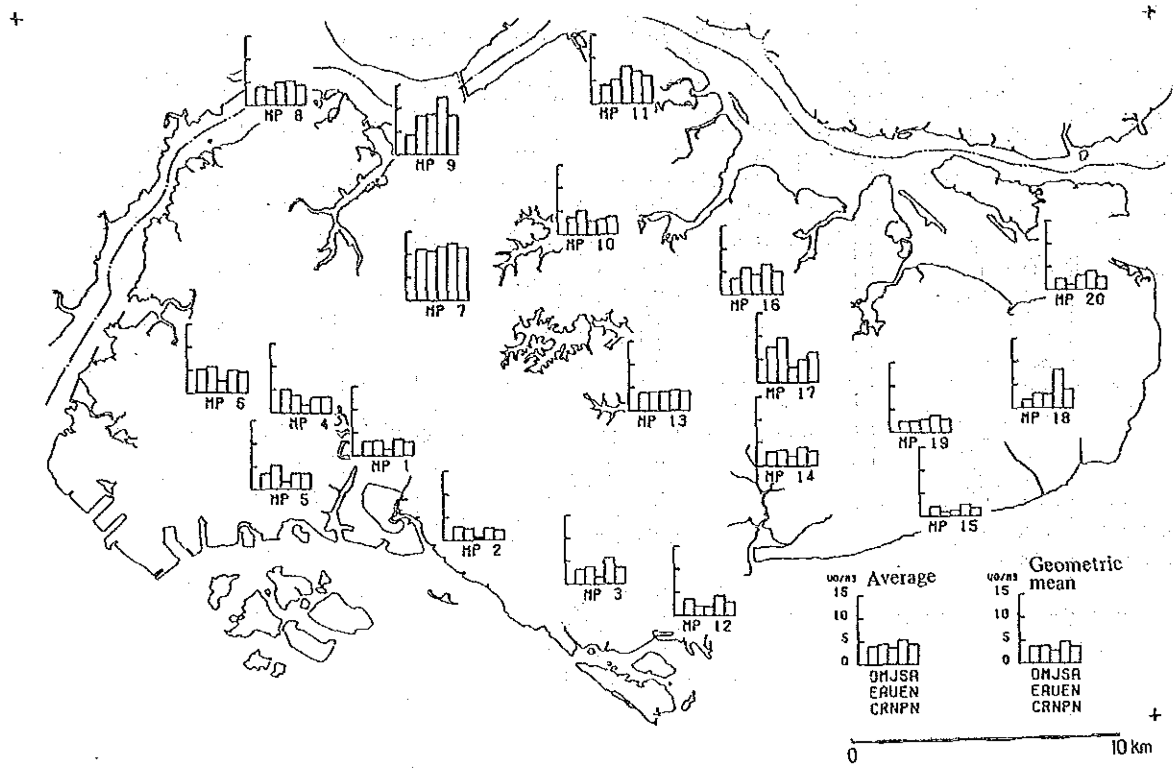


Fig. V-3-1-(15) Concentration distribution of Organic C

V-3-3 The Relationship among Chemical Components

In this section, the relationships among chemical components were analyzed. Fig. V-3-2 shows the scatter grams of the concentration on the chemical components. In this analysis, we consider seven emission sources and select the pair of components in each emission source as shown in Table V-3-2. In these components, carbon components are measured on different day. So the concentrations are corrected.

From the results of these analyses, following pairs show the relatively high correlation (correlation coefficient $\geqq 0.9$), Al - Si, Al - Sc, Si - Sc, Pb - Br, Elem C - Org C, Cl - CL^- and V - SO_2.

Table V-3-2 Pair of chemical component

Emission source	Components
Soil	Al - Si
	Al - Sc
	Al - Ti
	Al - Fe
	Si - Fe
	Si - Ti
	Si- Sc
	Sc - Fe
	Ti - Fe
	Sc - Ti
Sea-salt particle	Na - Cl
	Na - Cl^-
	Cl - Cl^-

Emission source	Components
Gasoline automobile	Pb - Br
	Pb - Elem C
	Pb - Org C
	Br - Elem C
	Br - Org C
	Elem C - Org C
Petroleum combustion	V - S
	V - SO_2
	S - SO_2
	SO_2 - Elem C
	SO_2 - Org C
	V - Elem C
	V - Org C
	S - Elem C
	S - Org C

Emission source	Components
Steel mill	Mn - Cr
	Mn - Fe
	Cr - Fe
Wastes incineration	Zn - K
	Zn - As
	As - K
Secondary particle	Na - NO_3^-
	SO_4^{--} - NO_3^-
	SO_4^{--} - SO_2

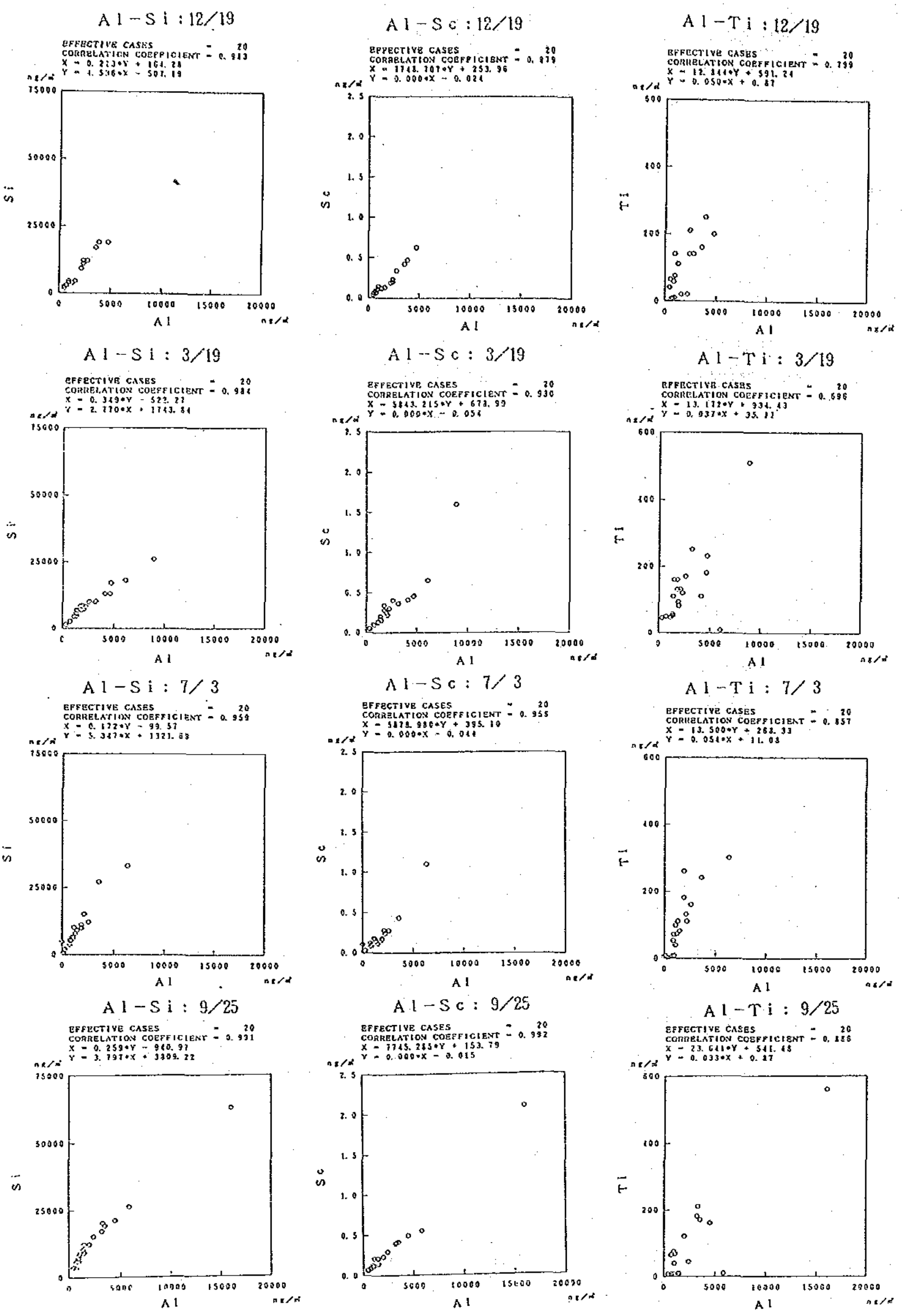


Fig. V-3-2-(1) Scatter grams of chemical components (Soil)

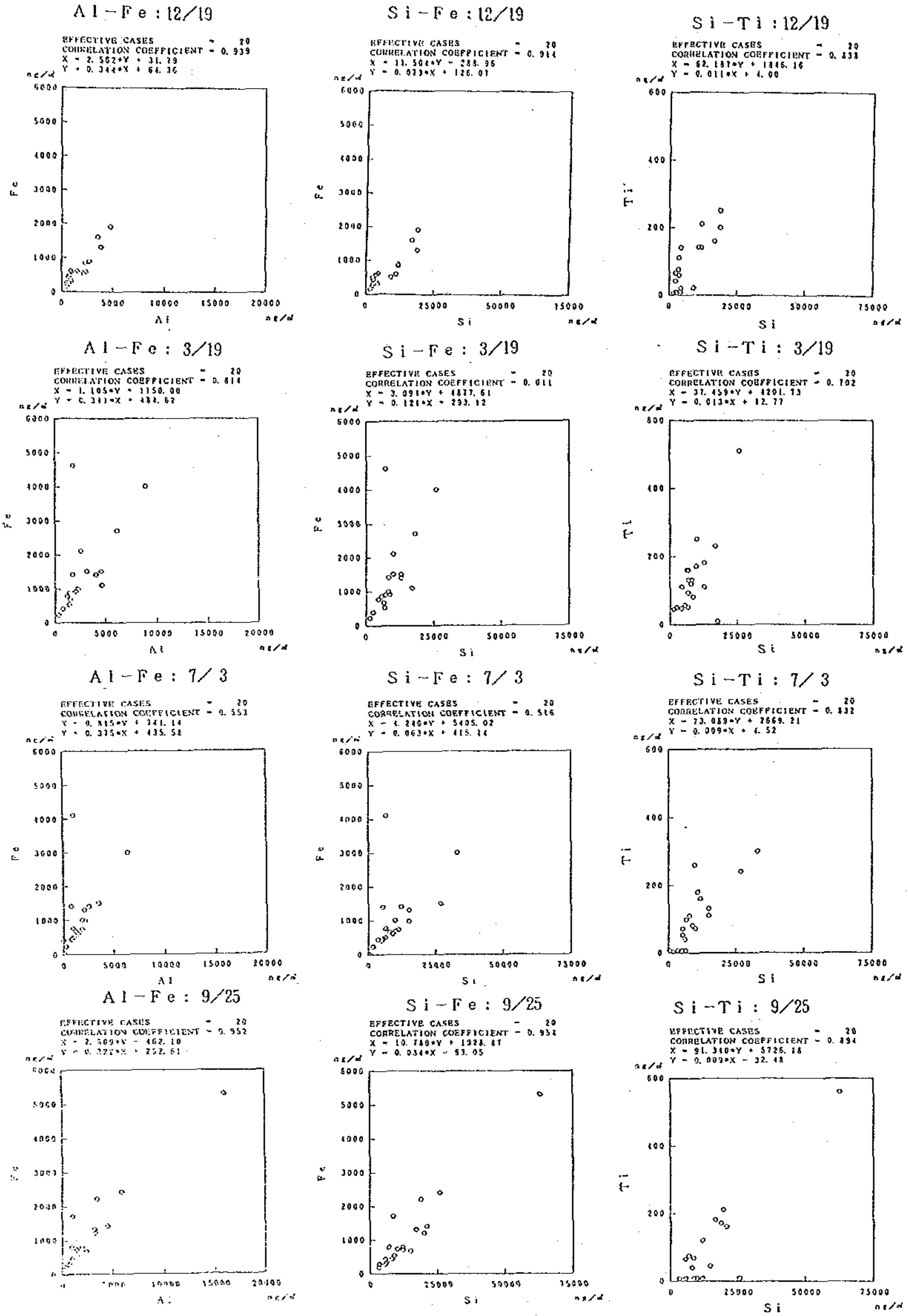


Fig. V-3-2-(2) Scatter grams of chemical components (Soil)

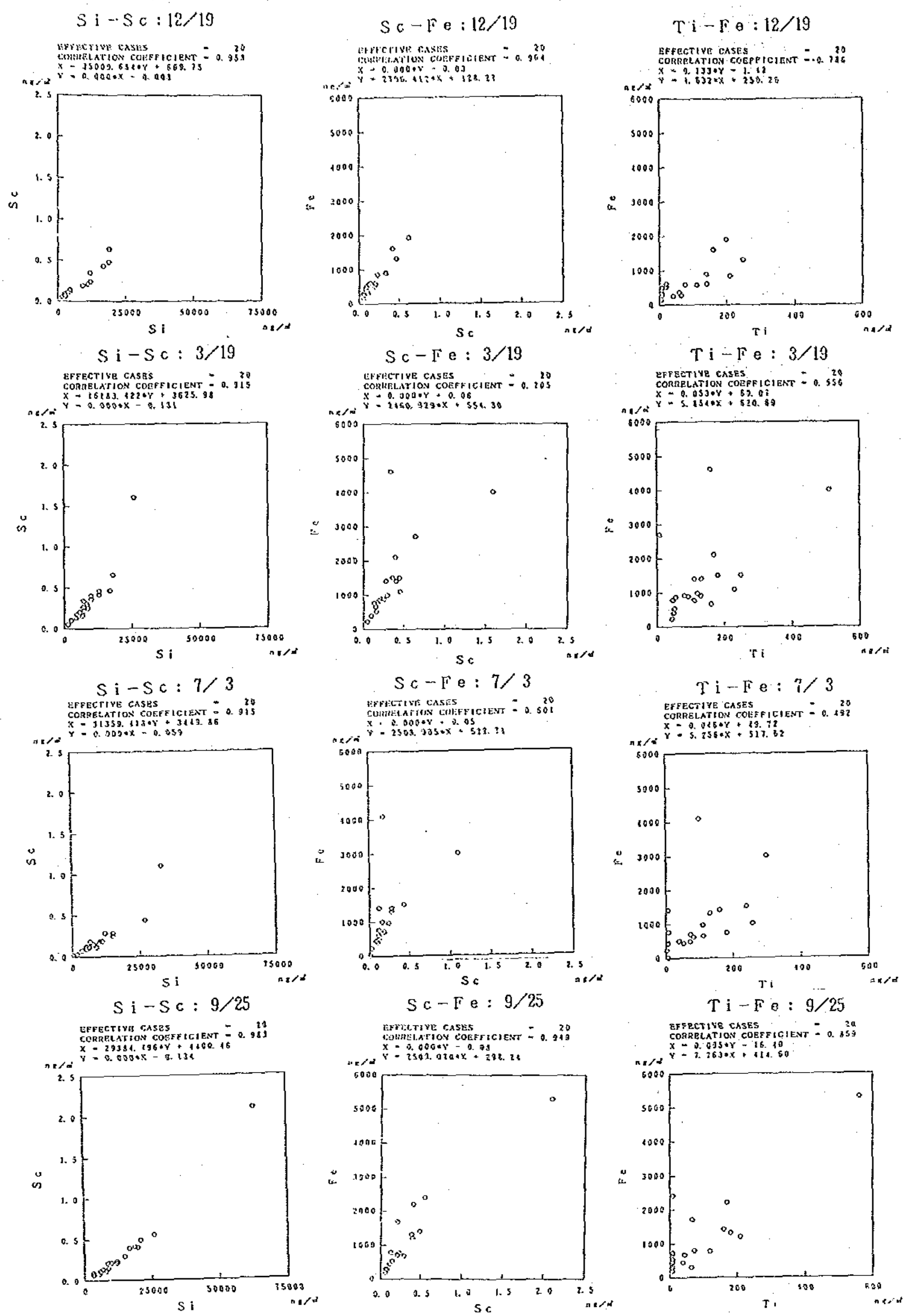


Fig. V-3-2-(3) Scatter grams of chemical components (Soil)

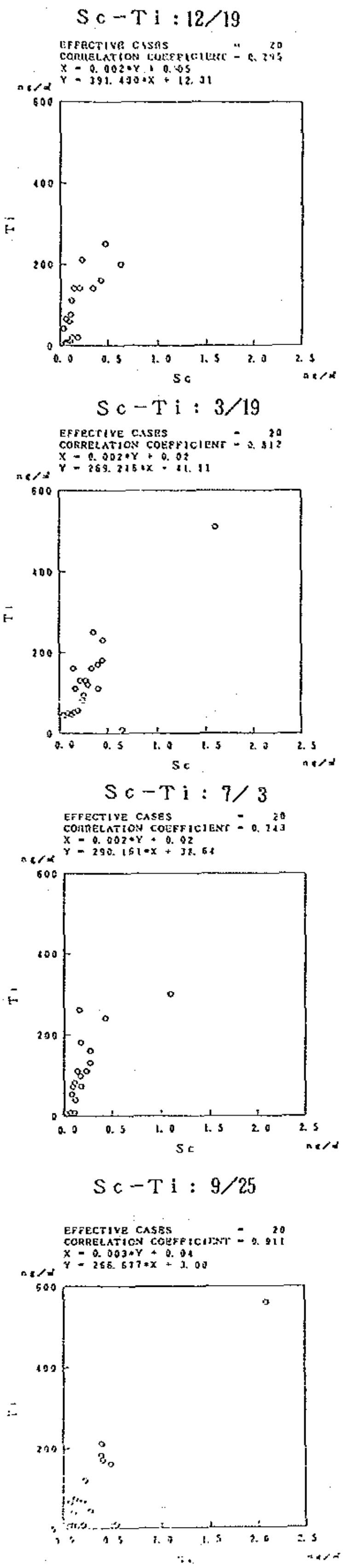


Fig. V-3-2-(4) Scatter grams of chemical components (Soil)

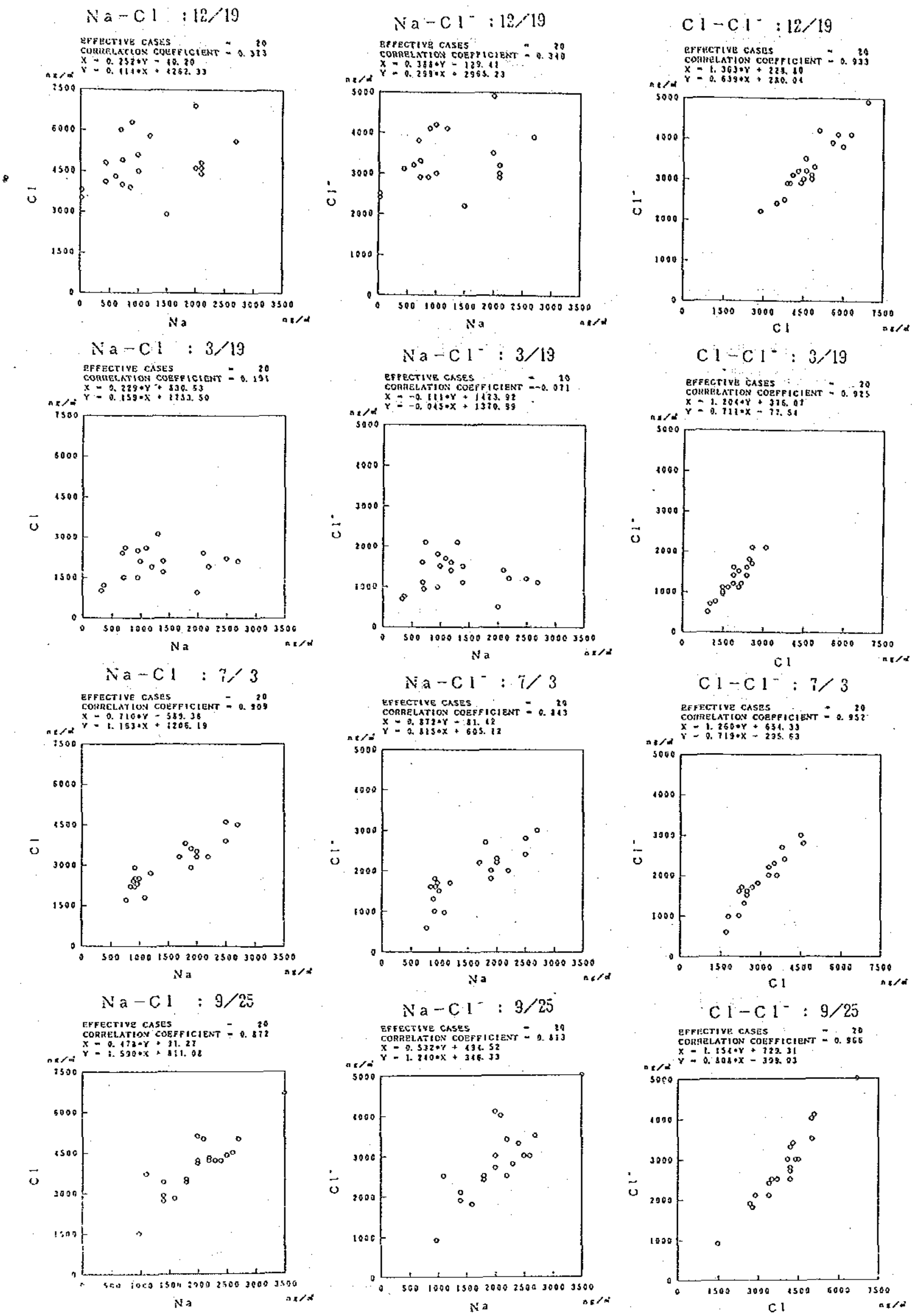


Fig. V-3-2-(5) Scatter grams of chemical components (Sea-salt particle)

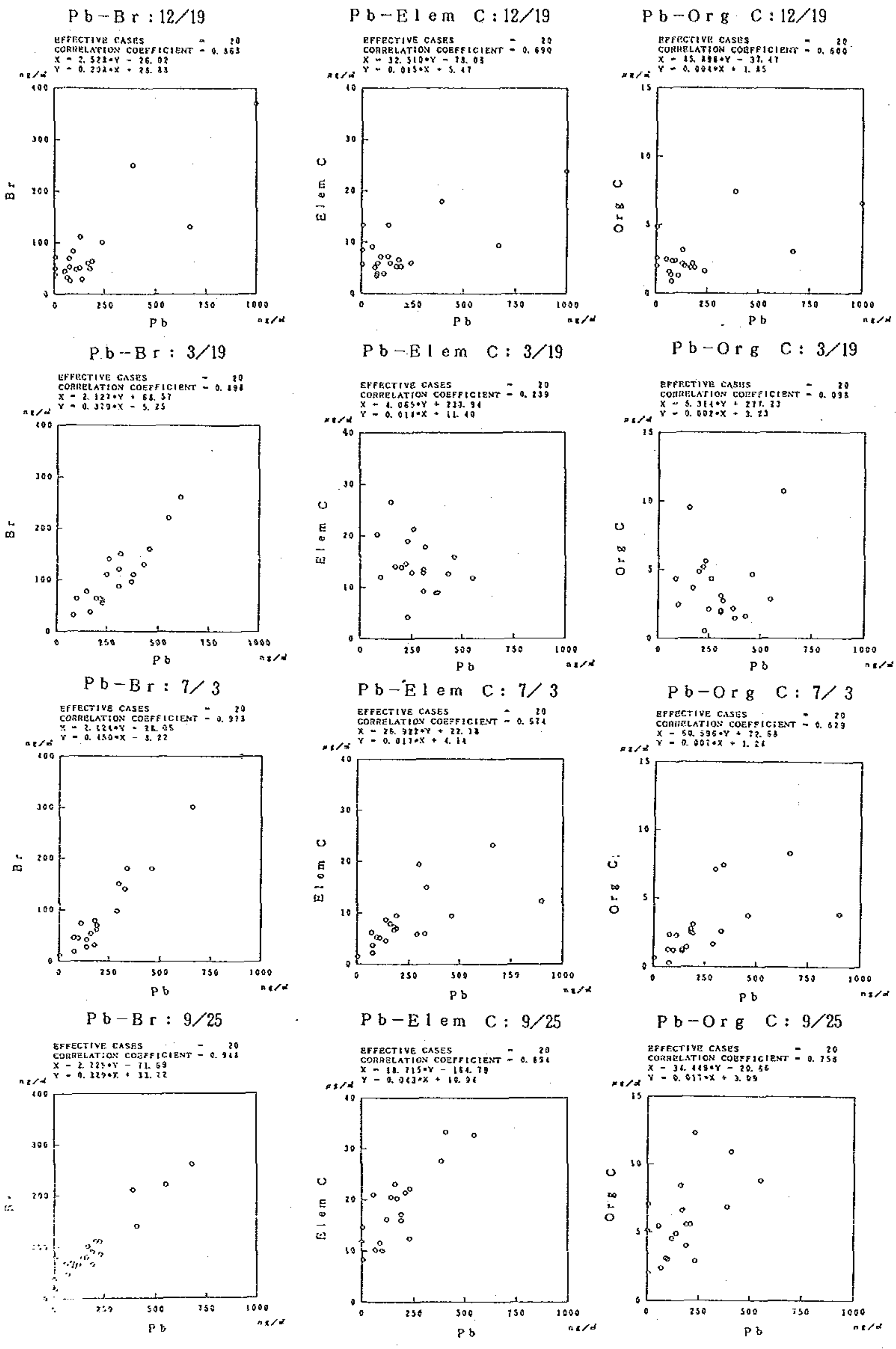


Fig. V-3-2-(6) Scatter grams of chemical components (Gasoline automobile)

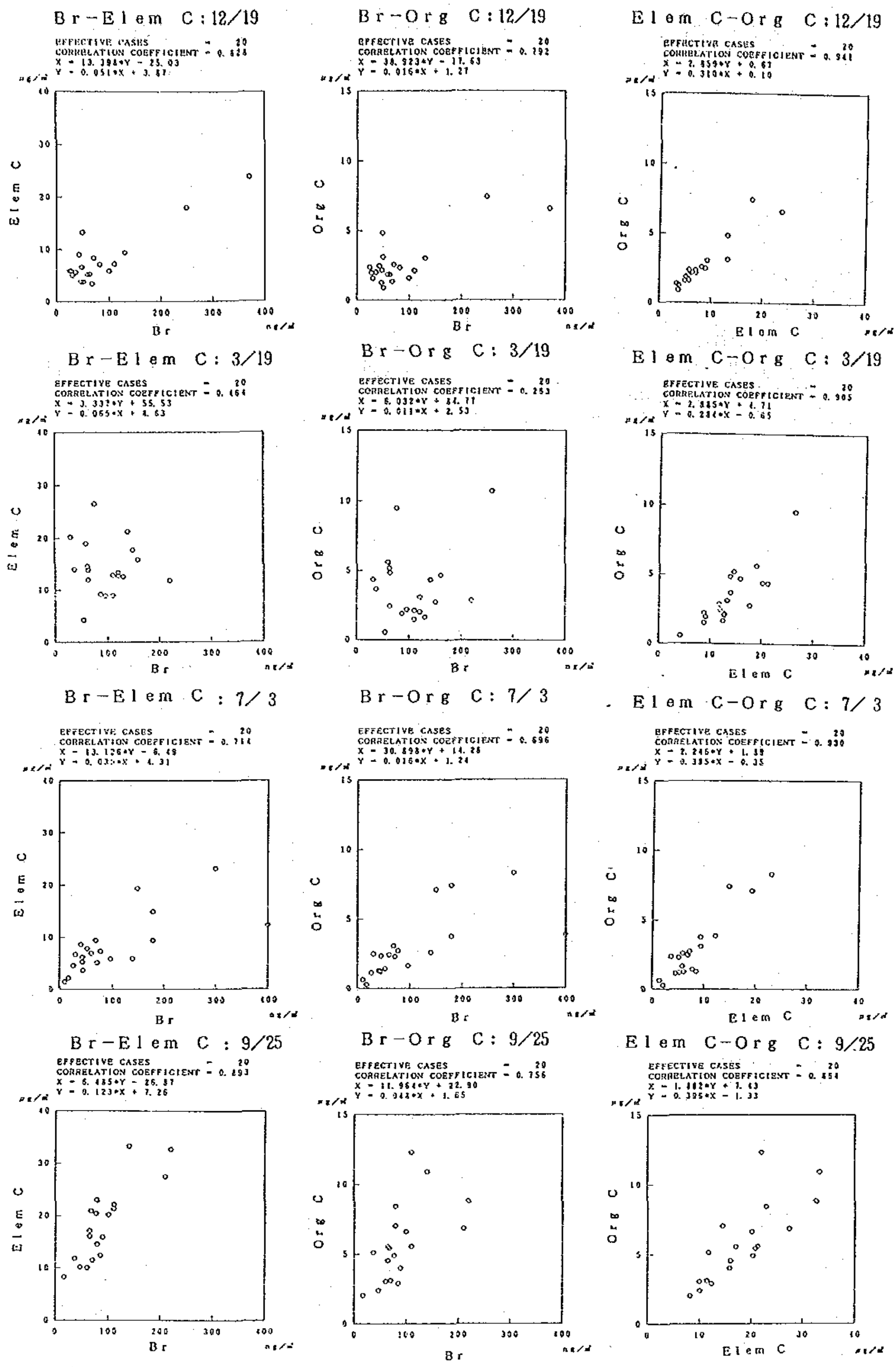


Fig. V-3-2-(7) Scatter grams of chemical components (Gasoline automobile)

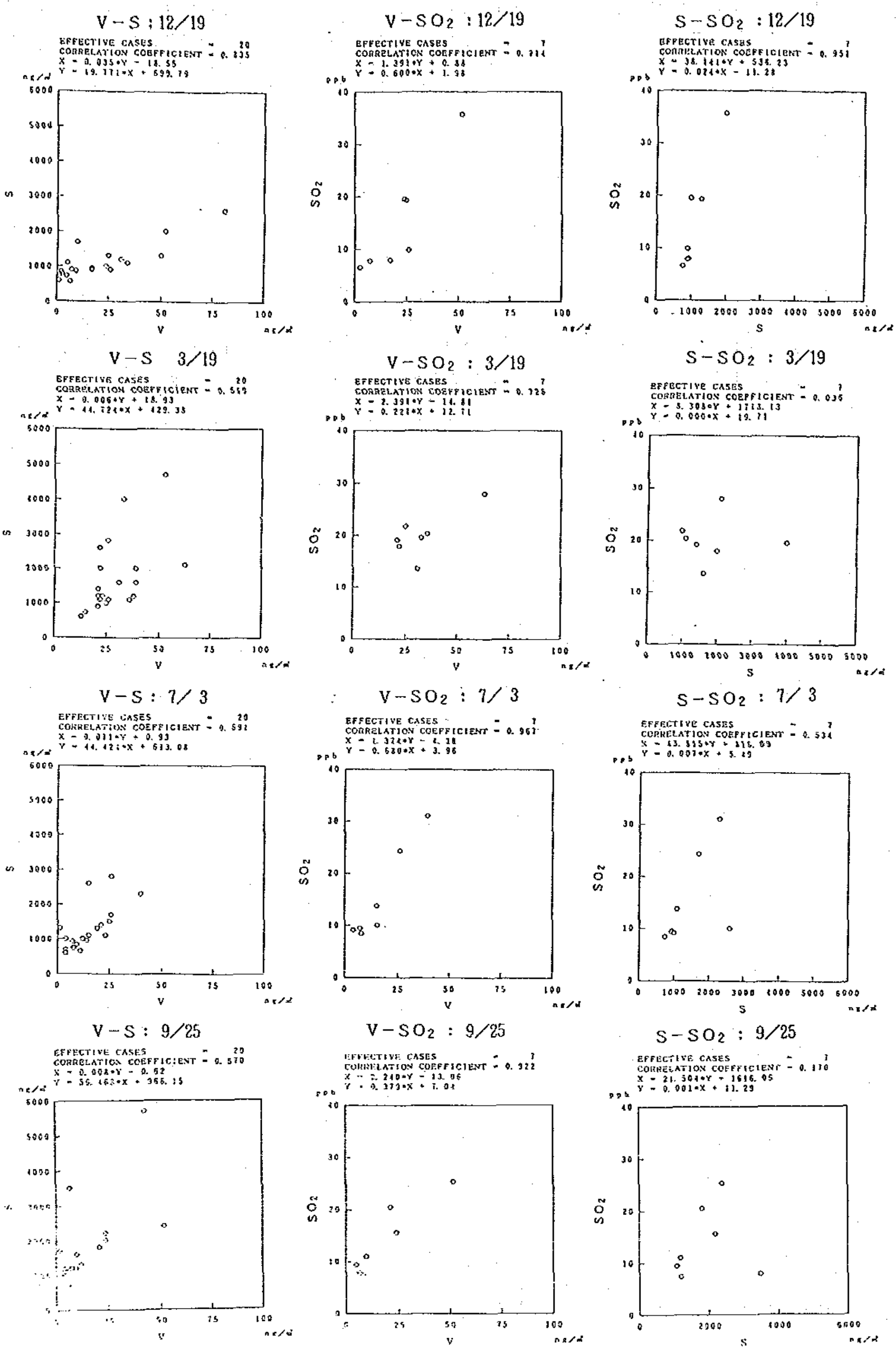


Fig. V-3-2-(8) Scatter grams of chemical components (Petroleum combustion)

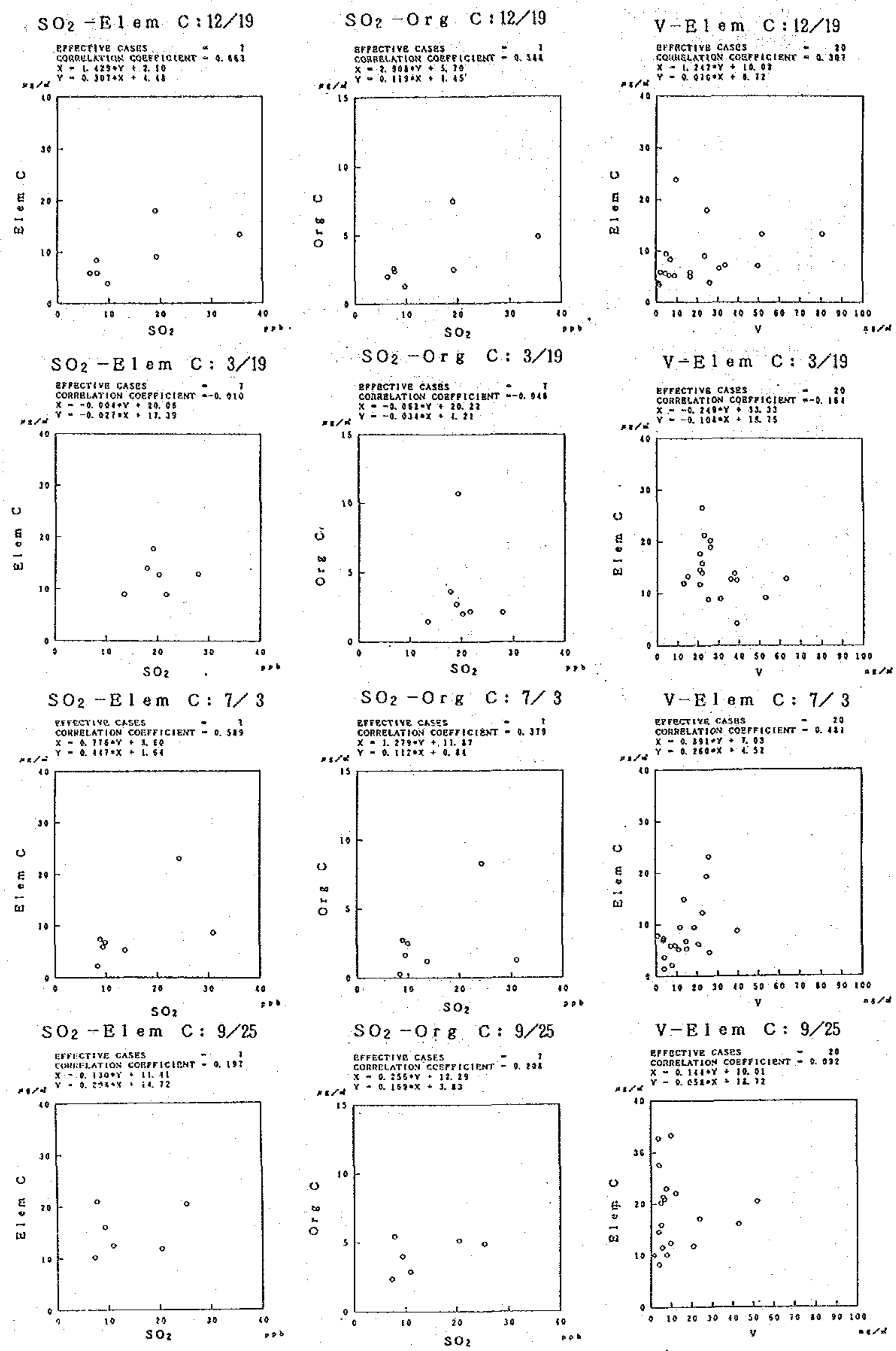


Fig. V-3-2-(9) Scatter grams of chemical components (Petroleum combustion)

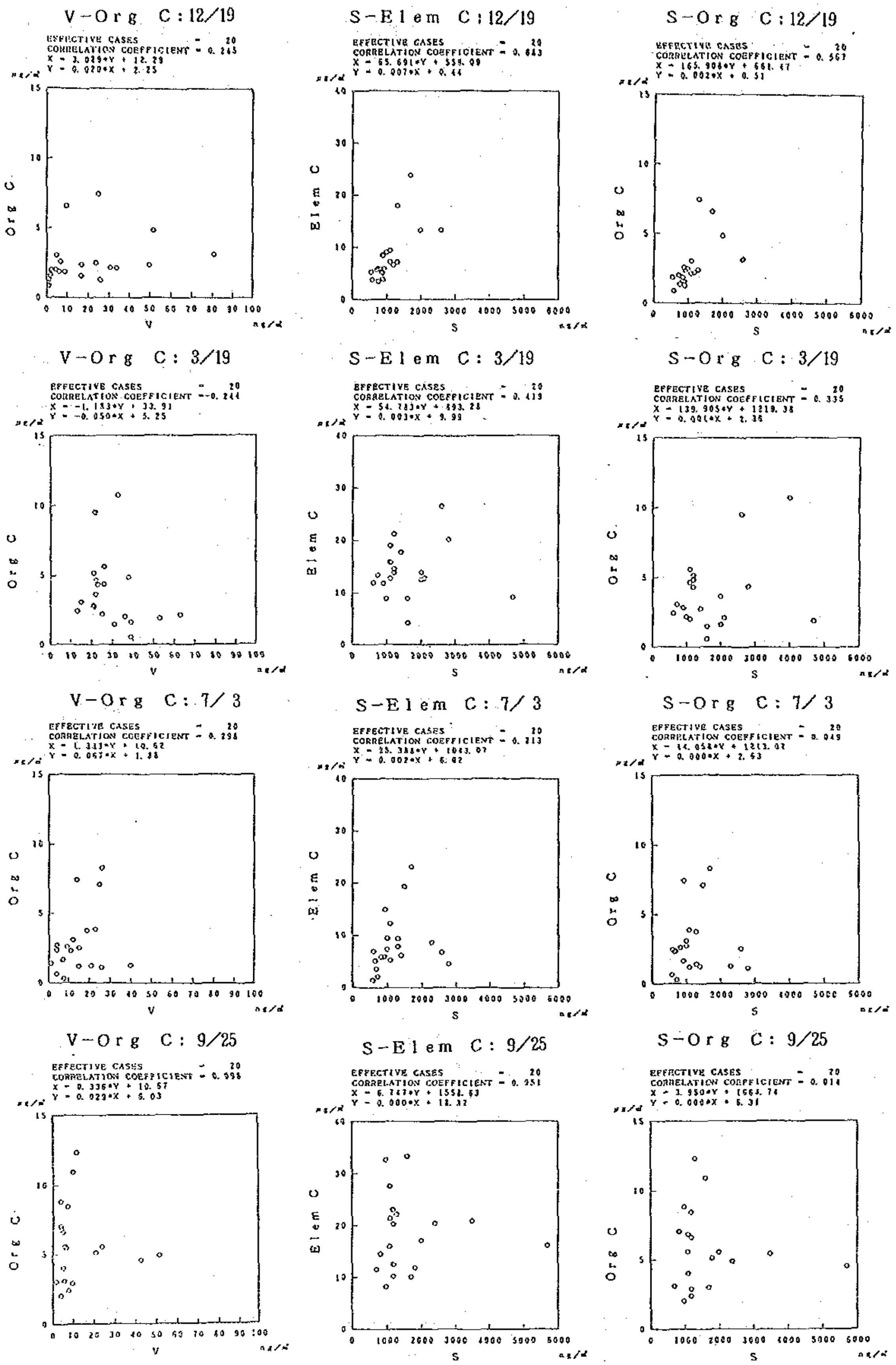


Fig. V-3-2-(10) Scatter grams of chemical components (Petroleum combustion)

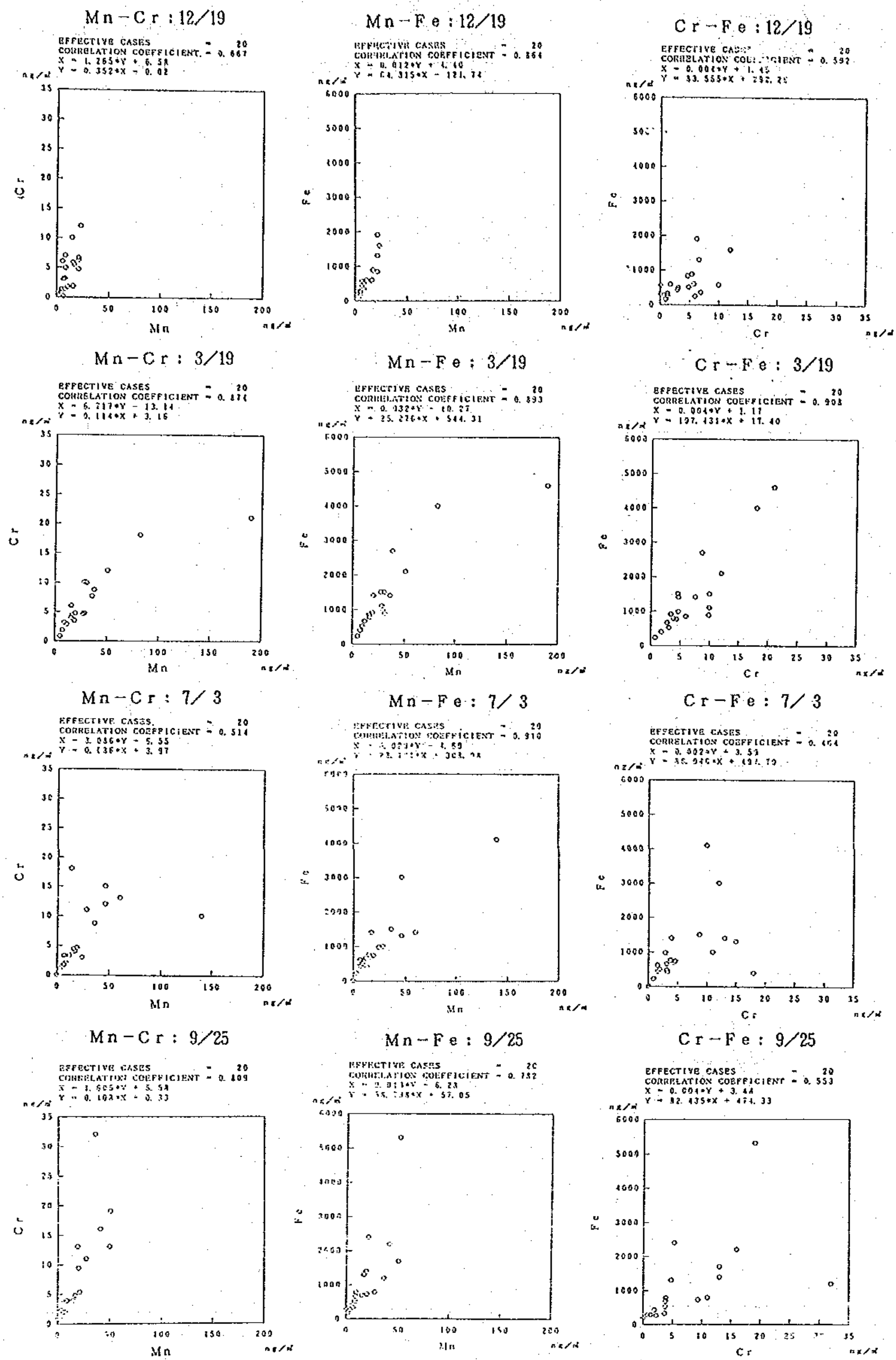


Fig. V-3-2-(11) Scatter grams of chemical components (Steel mill)

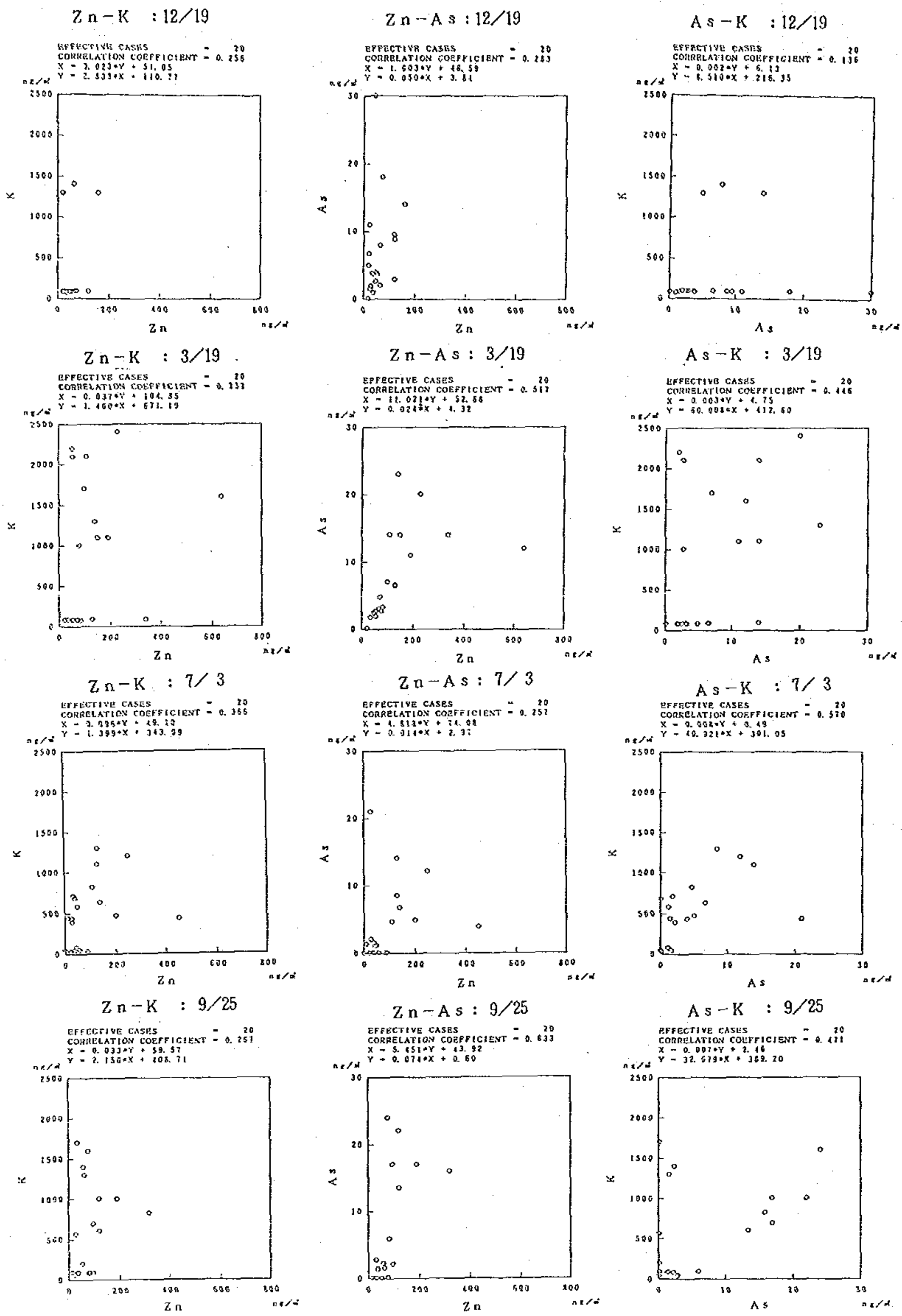


Fig. V-3-2-(12) Scatter grams of chemical components (Wastes incineration)

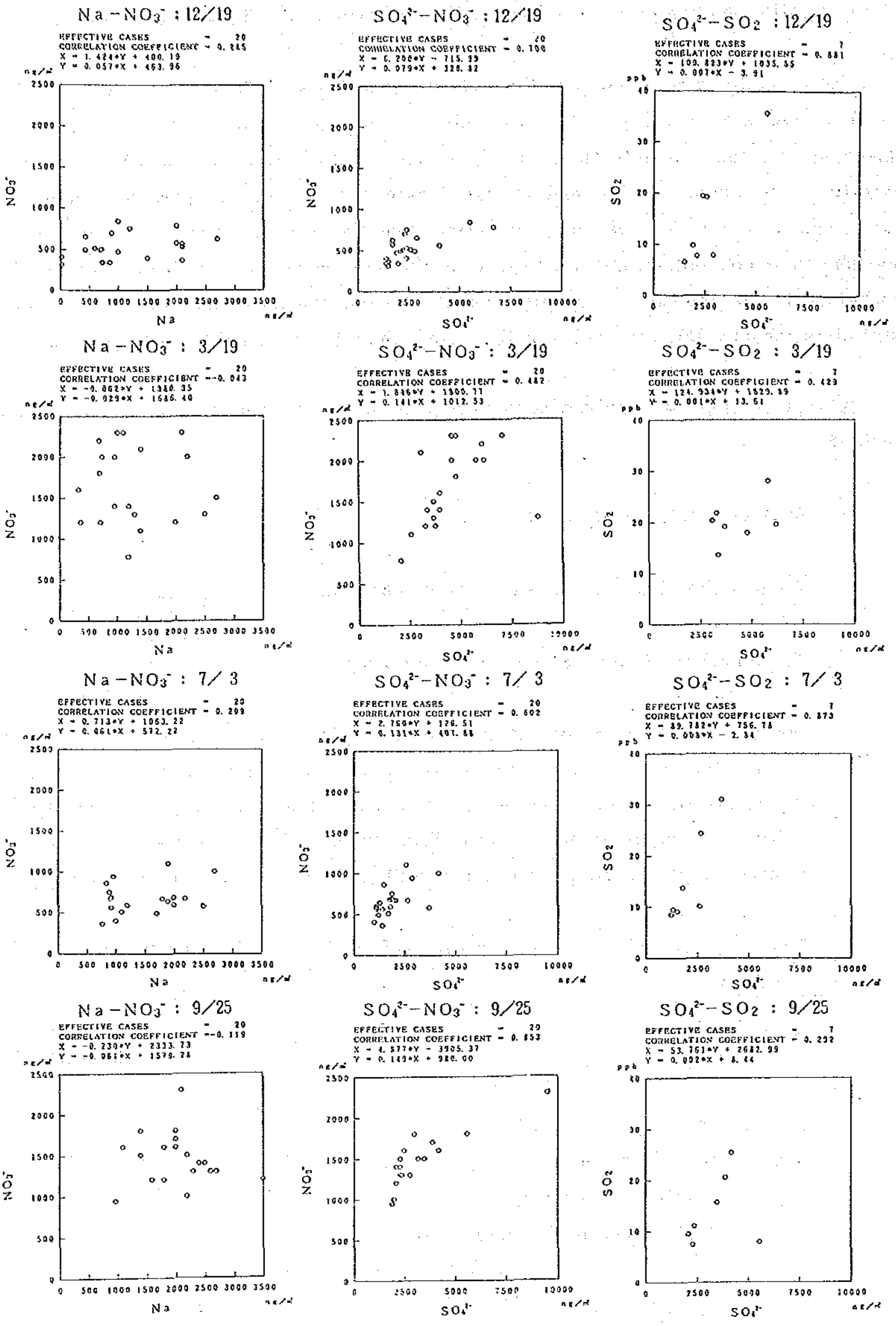


Fig. V-3-2-(13) Scatter grams of chemical components (Secondary particle)

V-3-4 Spatial and Seasonal Variations of Concentrations of Chemical Components

The spatial and seasonal variations of concentrations of chemical components depend on their emission sources. The soil which is the source of Al, Si and Sc is widely spreaded. So the concentrations of Al, Si and Sc don't show the spatial and seasonal variations so much. As Na and Cl are originated in sea-salt particle, their spatial variations of the concentrations are large. And the seasonal variations are also large because their concentrations also depend on the meteorological conditions. Pb and Br are contained in the exhaust gas of automobiles. So the concentrations are apt to show the spatial variations. But the concentrations don't show the seasonal variations so much.

In this section, we analyze such variations using the techniques called analysis of variance.

(1) Abstract on the analysis of variance

We test the difference of significance about the data using the two-way layout.

The algorism of two-way layout is following;

We consider two factors (A and B) to explain one variable. Each factor has several controlling elements, namely A_1, A_2 .... A_h for factor A, and B_1, B_2, ... B_k for factor B. When the pair of controlling elements - (A_i, B_j), we consider the value of variable to be X_{ij} (see Table V-3-3). Two way layout is the method testing whether the pair of two controlling elements have the effects to X_{ij}.

Here, we consider random variable of x_{ij} to be X_{ij}. Following equation is obtained.

$$X_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij} \qquad \text{Equation V-3-1}$$

μ; Average

α_i; Effect of factor A

β_j; Effect of factor B,

ε_{ij}; Difference in X_{ij} distribution - $N(0, \sigma^2)$

Table V-3-3 Variable Xij for a pair of A and B

A \ B	B_1	B_2	······	B_j	······	B_k
A_1	x_{11}	x_{12}	······	x_{1j}	······	x_{1k}
A_2	x_{21}	x_{22}	······	x_{2j}	······	x_{2k}
⋮	······					
A_i	x_{i1}	x_{i2}	······	x_{ij}	······	x_{ik}
⋮	······					
A_h	x_{h1}	x_{h2}	······	x_{hj}	······	x_{hk}

If we assume that $\sum_{i=1}^{h} \alpha_i = 0$, and $\sum_{i=1}^{K} \beta_j = 0$, the generality of Equation V-3-1 is kept. Using this assumption, we calculate F value. Here, we define the following summation.

$$S_T = \sum_{i=1}^{h}\sum_{j=1}^{k}(X_{ij} - \overline{X}_{..})^2$$
$$= \sum_{i=1}^{h}\sum_{j=1}^{k}\left\{(\overline{X}_{i.} - \overline{X}_{..}) + (\overline{X}_{.j} - \overline{X}_{..}) + (X_{ij} - \overline{X}_{i.} - \overline{X}_{.j} + \overline{X}_{..})\right\}^2 \quad \text{Equation V-3-2}$$

This Equation is modified.

$$S_T = k\sum_{i=1}^{h}(\overline{X}_{i.} - \overline{X}_{..})^2 + h\sum_{j=1}^{k}(\overline{X}_{.j} - \overline{X}_{..})^2 + \sum_{i=1}^{h}\sum_{j=1}^{k}(X_{ij} - \overline{X}_{i.} - \overline{X}_{.j} + \overline{X}_{..})^2 \quad \text{Equation V-3-3}$$

Here we define following equations.

$$\left.\begin{aligned} S_A &= k\sum_{i=1}^{h}(\overline{X}_{i.} - \overline{X}_{..})^2 \\ S_B &= h\sum_{j=1}^{k}(\overline{X}_{.j} - \overline{X}_{..})^2 \\ S_E &= \sum_{i=1}^{h}\sum_{j=1}^{k}(X_{ij} - \overline{X}_{i.} - \overline{X}_{.j} + \overline{X}_{..})^2 \end{aligned}\right\} \quad \text{Equation V-3-4}$$

Equation V-3-3 is expressed by Equation V-3-4 as following.

$$S_T = S_A + S_B + S_E \quad \text{Equation V-3-5}$$

In the condition of "$\alpha i=0$, namely factor A doesn't affect X", F value shows F distribution with degree of freedom {(h-1),(h-1)(k-1)}. In the condition of "$\beta j=0$, namely factor B doesn't affect X", F value shows F distribution with degree of freedom {(k-1),(h-1)(k-1)}. Then, we set the critical region on the right-hand side of F distribution and test the effect of factors A and B to X.

F value is calculated by following equation.

hypothesis $\alpha i = 0$; $F = \frac{S_A/(h-1)}{S_E/(h-1)(k-1)}$ Equation V-3-6

hypothesis $\beta j = 0$; $F = \frac{S_B/(k-1)}{S_E/(h-1)(k-1)}$ Equation V-3-7

(2) Analysis of variance on the chemical component concentrations

The variations of chemical component concentrations have two effective factors. One is monitoring station, the other is seasons. We test the significant difference by sum of square, degree of freedom and unbiased variance. Table V-3-4 shows F values of the chemical components. As carbon are measured on the different day with other components, carbon data used in this analysis are corrected. From these results, Al, Sc and Si (originated in soil) show the significant difference. This may be due to the wide distribution of soil. Na and Cl show the significant difference. Pb and Br show the significant difference by stations, but don't show by seasons.

Table V-3-4 F value resulting from analysis of variance

Method of analysis		Chemical component	F value (about station)	F value (about season)
Element	Instrument newtron activation analysis	Ag	1.79	7.40**
		Al	5.80**	3.20 *
		As	2.70**	1.17
		Ba	2.89**	0.76
		Br	6.13**	0.65
		Ca	1.53	1.81
		Cd	0.76	0.08
		Ce	3.19**	2.91 *
		Cl	5.62**	79.08**
		Co	1.03	1.05
		Cr	1.58	1.62
		Cs	3.78**	0.19
		Cu	1.57	8.23**
		Fe	3.49**	3.37 *
		Hf	2.51**	2.54
		K	1.31	3.58 *
		La	3.10**	4.88**
		Lu	1.06	1.83
		Mn	1.30	2.78
		Na	2.07 *	7.67**
		Ni	0.75	0.77
		Sb	0.94	1.35
		Sc	9.34**	4.35**
		Se	1.71	7.58**
		Sm	2.85**	4.38**
		Th	4.55**	2.70
		Ti	4.57**	1.87
		V	2.18 *	6.63**
		W	0.86	3.13 *
		Zn	1.25	2.54
	X-ray flourenscense analysis	Cd	1.31	2.51
		Pb	4.02**	2.12
		S	2.17 *	3.36 *
		Si	5.00**	4.04 *
	Ion chromatography	Cl^-	5.53**	74.39**
		NO_3^-	2.33 *	88.28**
		SO_4^{--}	2.38**	15.31**
	TPM	TPM	7.14**	19.03**
Carbon	Differential thermal analysis	Elemental carbon	6.02**	28.26**
		Organic carbon	7.43**	20.39**
		Total carbon	6.97**	28.28**
	TPM	TPM	8.64**	4.54**
Average for 12 days		TPM	8.32**	11.12**
		SPM	6.73**	13.71**

$F^{19}_{57}(0.01) = 2.25$

$F^{19}_{57}(0.05) = 1.77$

$F^{3}_{57}(0.01) = 4.15$

$F^{3}_{57}(0.05) = 2.77$

** 1 % Significant difference
* 5 % Significant difference

V-3-5 Comparison the Concentrations of Chemical Components among Monitoring Stations

In this section, we performed the comparison of the concentrations of chemical components at (MP10) - Seletar Reservoir with those of chemical components at other stations. The concentrations of particulate matters at MP10 are relatively low. Other stations locate in different environments. (MP3) - Bukit Merah Flatted Factory locates in urban area. (MP5) - Jurong Hill Top locates in industrial area. (MP7) - Bukit Panjang P.P. locates near the road. (MP8) - Lim Chu Kang Marine P.P. locates near the wastes reclamation land. (MP15) - East Coast Swimming Lagoon locates near the coast. (MP20) - Singapore Offshore Petroleum Services locates in reclaimed land. Fig. V-3-3 shows the results of the comparisons. In these figures, X and Y axis are shown by logarithm. When one concentration is above the diagonal line, it means that the concentration is higher than the concentration at MP10. The data under the limit of measurement are excluded. And carbon data are also excluded. '*' after symbol of element means that its data is measured by X ray flourescense analysis.

The samples used in this analysis are obtained from TPM measured by high volume sampler. The TPM data are measured for one day (from 11 A.M. through 24 hours). These data are affected by wind. Fig. V-3-4 and Table V-3-5 show the characteristics of wind on the day when the samples have been obtained. From these figures and tables, the prevailing wind direction in each short term field survey are followings, NE in 1st survey, SW or NE in 2nd survey, SSW SSE in 3rd survey and S SE in 4th survey. But the prevailing wind direction varies in time especially at 2nd and 4th surveys. Thus the analysis were performed for 1st and 3rd surveys except 2nd and 3rd surveys.

(1) MP3

The difference of each chemical component concentration between MP3 and MP10 is small. But in 1st survey, the concentrations of Br and V at MP3 become higher owing to the exhaust gas from automobiles. This is due to that MP3 locates on the leeward of Jalan Bukit Merah road. During 3rd survey - in which the prevailing wind direction is S, following components show relatively high concentrations, V, S, Mn, Cr, Na, Cl, Cl^-, Ca and Si. These tendencies may be due to the effects of petroleum combustion, sea-salt particle and cement.

(2) MP5

This monitoring station locates on the north side of the industrial area. So the concentrations of many chemical components become high. Especially during 3rd survey - the prevailing wind direction is S, these tendencies can be seen. During 1st survey, the concentrations of Ti, Sc, Si, Al, Mn, Zn, V and SO_4^{2-} are found high. The high concentrations of V and SO_4^{2-} are due to the burning of petroleum. The concentrations of Ti, Sc and Si are affected by soil. During the 3rd survey, the concentrations of Cr, Mn, Fe and Zn become high. It may be due to the effect of the steel mill located on the south side of MP5. The concentrations of Na, Cl and Cl^- originated in sea-salt particle are high. And the concentrations of Sc, Si, V, SO_4^{2-} and S are also high. The concentration of V during 3rd survey is lower than the concentration during 1st survey. This may be due to that MP5 is not directly effected by the exhaust fumes from Jurong power plant.

(3) MP7

This monitoring station is surrounded by Woodlands road and Choa Chu Kang road. So the concentrations of chemical components are very high during 1st and 3rd surveys. Especially during 1st survey, the concentrations of Br, V, Sc, Al, Si and Mn are high. During 3rd survey, the concentrations of Pb Br, Cr, Mn, Fe, Al, Si, Ca and Zn are very high. And Mn, Fe, S and Ti show the relatively high concentration during 1st survey. V, Ca, S, Na, Cl and Cl^- show the relatively high concentration during 3rd survey. From these facts, the high concentrations of several components may be due to the effects of exhaust fumes from automobiles and fling up dust of the roads.

(4) MP8

During 1st survey, the concentration of V is relatively high. But the concentrations of other components at MP8 show the same levels with those of the components at MP10. During 3rd survey - prevailing wind direction is S, the concentrations are high. Especially, the concentrations of Cr, Mn, Zn, Sc, Al and Si are high. This may be due to the effects of the land reclaimed with wastes located on south-west part of MP8.

(5) MP15

During 1st survey - the prevailing wind velocity is N, the concentrations of the components show the same levels with those of the components at MP10, except Br. The high concentration of Br may be due to the effects of East Coast Park Way road running north side of MP15. On the other hand, during 3rd survey - the prevailing wind velocity is S, the concentrations of the components at MP15 become lower than those of the components at MP10. Especially the concentrations of Sc, Al and Si originated in soil are low. And Br concentration is also low. But the concentrations of Na, Cl and Cl^- become higher. This is due to the wind from the sea.

(6) MP20

The concentrations of the components at MP20 show the same level with those of the components at MP10. Both in 1st and 3rd surveys, Sc, Al and Si originated in soil show higher concentration. And Mn, Cr and Ca show the higher concentrations, too. In this monitoring station, several components show extremely high concentration, for example Ba.

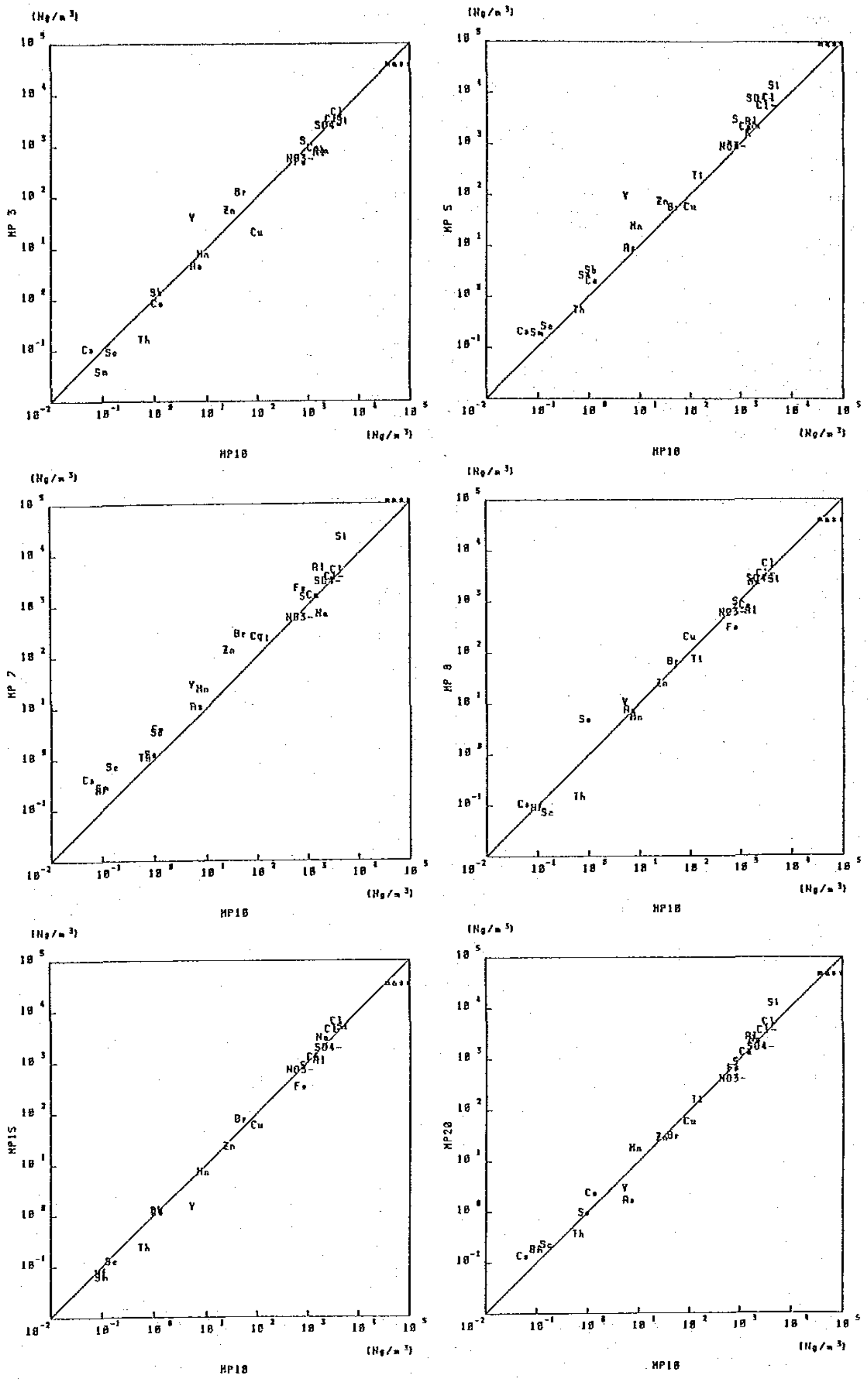


Fig. V-3-3-(1) Chemical components concentration in MP10 and other stations (1st survey)

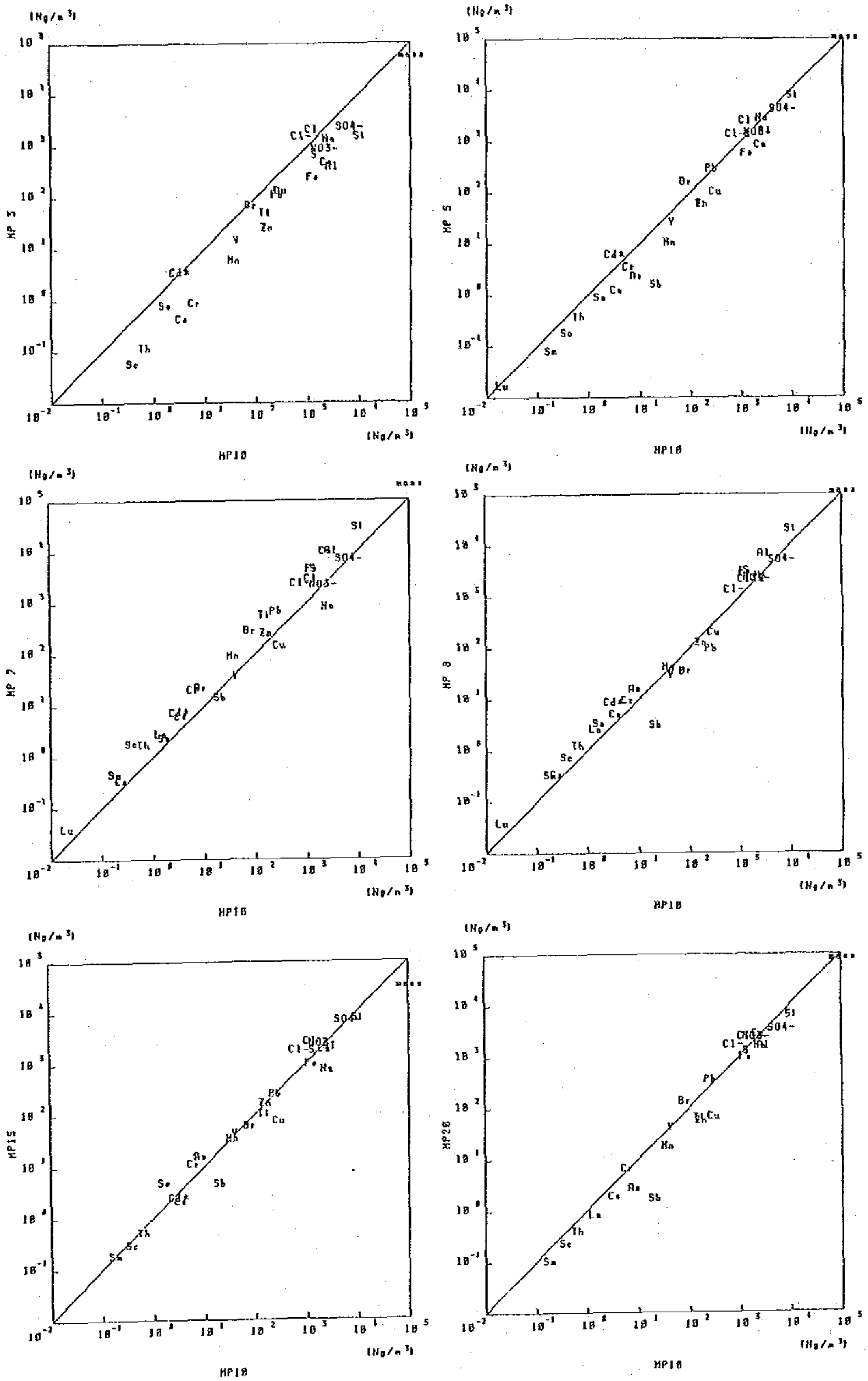


Fig. V-3-3-(2) Chemical components concentration in MP10 and other stations (2nd survey)

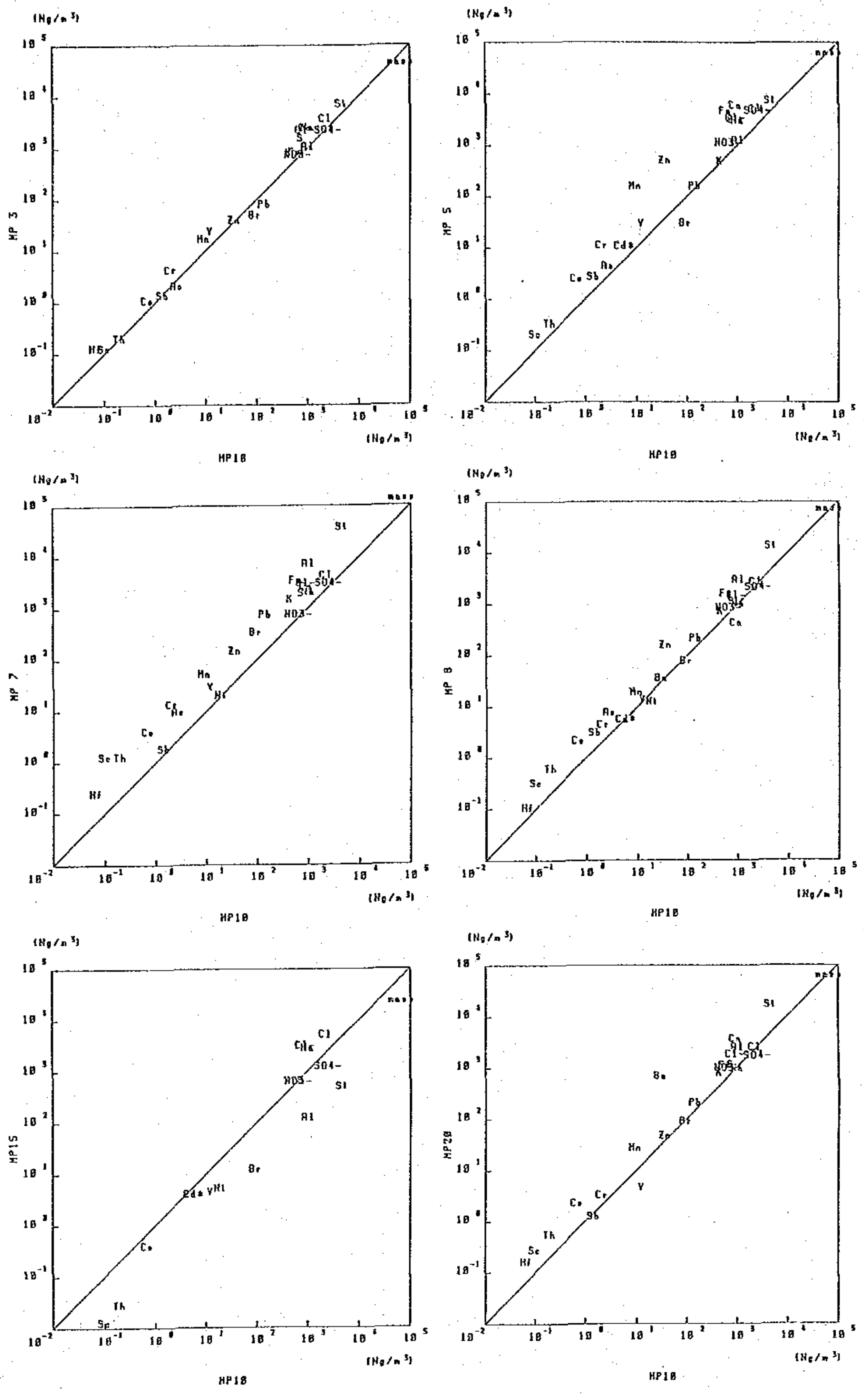


Fig. V-3-3-(3) Chemical components concentration in MP10 and other stations (3rd survey)

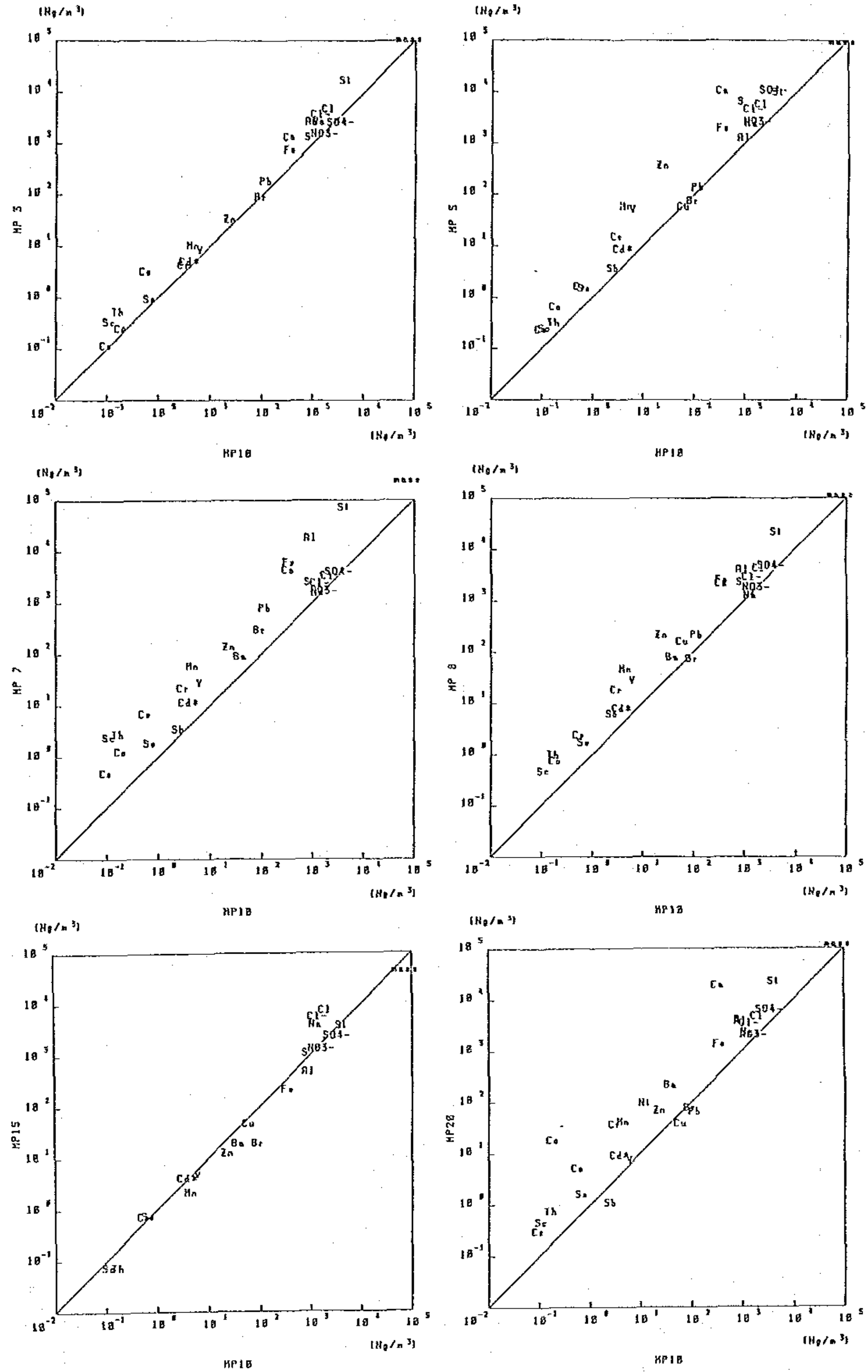


Fig. V-3-3-(4) Chemical components concentration in MP10 and other stations (4th survey)

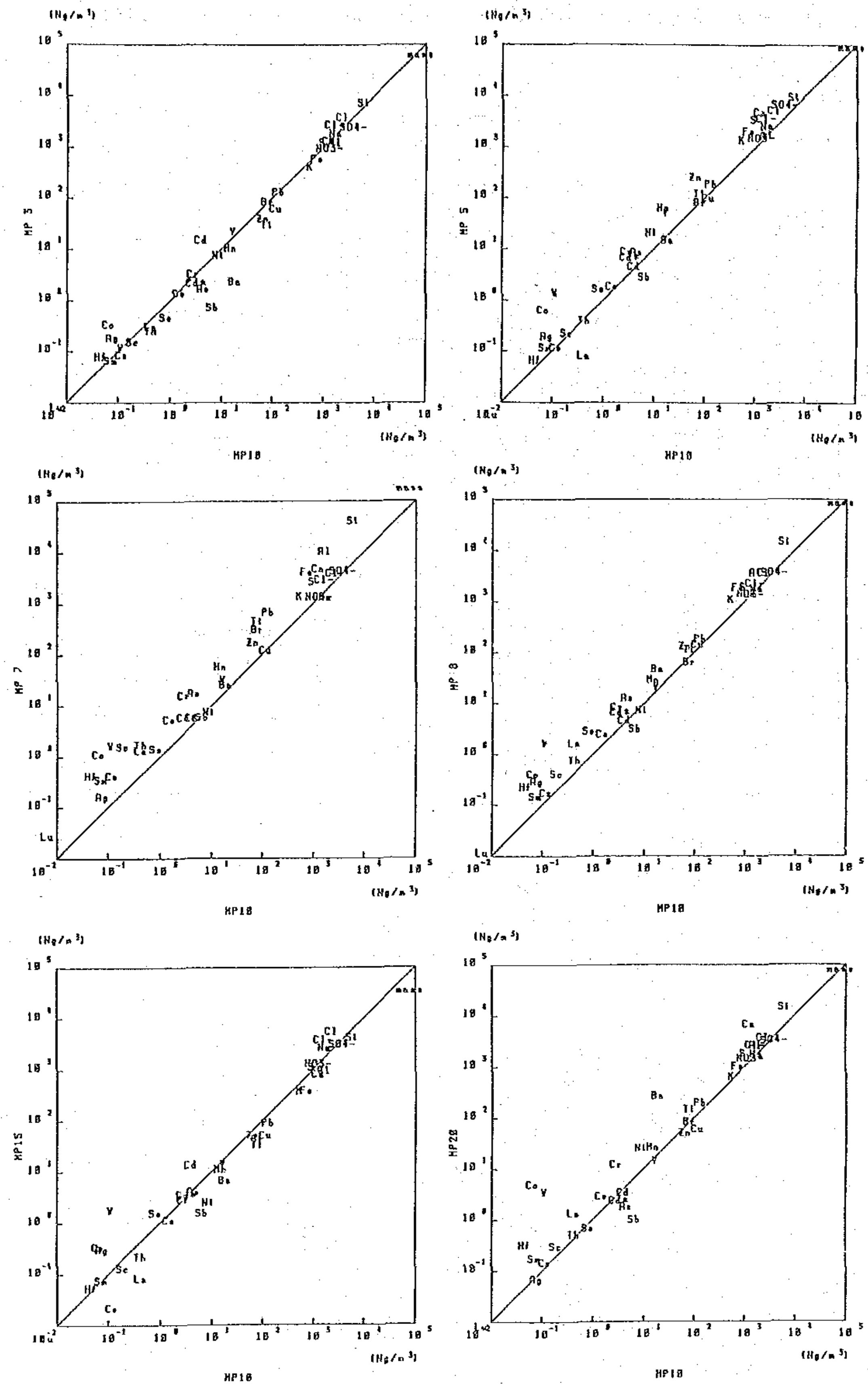


Fig. V-3-3-(5) Chemical components concentration (Average of four surveys)

Table V-3-5-(1) Meteorological data (1st survey, Dec. 19-20, 1983)

Date	Hour	Wind direction, wind velocity (unit: 0.1 m/s)							Dust concentration (μg/m³)		
		MP1	MP2	MP4	MP6	MP7	MP14	MP20	MP1	MP2	MP6
12/19	11	NNE 27	NE 37	NNE 19	NNE 9	NNE 12	NNE 14	NW 34	20	10	18
	12	NE 36	NE 50	NNE 31	NE 13	NE 15	NE 19	NNW 26	12	10	5
	13	NE 49	NE 47	NNE 34	NE 15	NNE 16	NE 16	NNW 30	4	8	0
	14	NNE 40	NNE 52	NNE 22	NE 13	N 14	NNE 17	NW 32	10	8	0
	15	NE 48	NE 53	NNE 22	NNE 12	N 15	NE 20	NW 25	18	0	4
	16	NE 32	NE 53	NNE 23	NNE 14	NNE 12	NNE 18	NW 27	12	10	10
	17	NNE 35	NE 63	NNE 28	NNE 14	NNE 15	NE 14	NNW 23	20	20	10
	18	NE 44	NE 54	NNE 21	NNE 18	NE 15	NE 24	NNW 17	32	15	10
	19	NE 39	NE 57	NE 22	NNE 14	NE 11	NE 17	NNW 28	15	10	10
	20	NNE 33	NE 37	NE 19	NE 7	NE 8	NE 11	NNW 23	0	20	20
	21	NE 34	NE 40	NNE 15	C 4	NNE 12	NE 15	NNW 19	12	20	40
	22	NE 29	NE 28	NE 17	C 4	ENE 5	NE 12	NNE 21	5	12	38
	23	NE 27	NE 32	NE 19	C 4	C 4	ENE 15	NNW 32	16	18	60
	24	NE 34	NE 43	NE 27	NE 8	ENE 11	NE 22	NW 22	10	10	20
12/20	1	NE 35	NE 32	NE 25	NE 9	C 4	NE 14	NNW 21	15	12	30
	2	NE 31	NE 32	NNE 11	NE 11	C 3	NE 14	NNW 13	20	18	8
	3	NE 29	NE 37	NE 18	NE 8	C 3	NE 15	NNW 11	28	20	0
	4	NE 20	NE 30	N 10	NNE 8	C 3	NE 10	NNW 14	18	18	8
	5	NE 19	NE 39	NNE 12	NE 12	E 5	NE 10	NNW 12	19	8	20
	6	NE 22	ENE 21	NE 18	NE 7	SE 5	ENE 7	N 11	23	10	25
	7	NNE 21	NE 27	NE 18	NE 7	C 4	NE 7	N 10	23	30	30
	8	NNE 16	NE 24	NNE 13	C 4	C 2	NE 9	NW 11	26	34	20
	9	NNE 17	NE 33	N 18	N 9	NNW 9	NE 11	NNW 15	56	50	28
	10	NE 36	NE 43	NNE 15	NE 9	NNE 14	NE 17	N 23	48	38	42

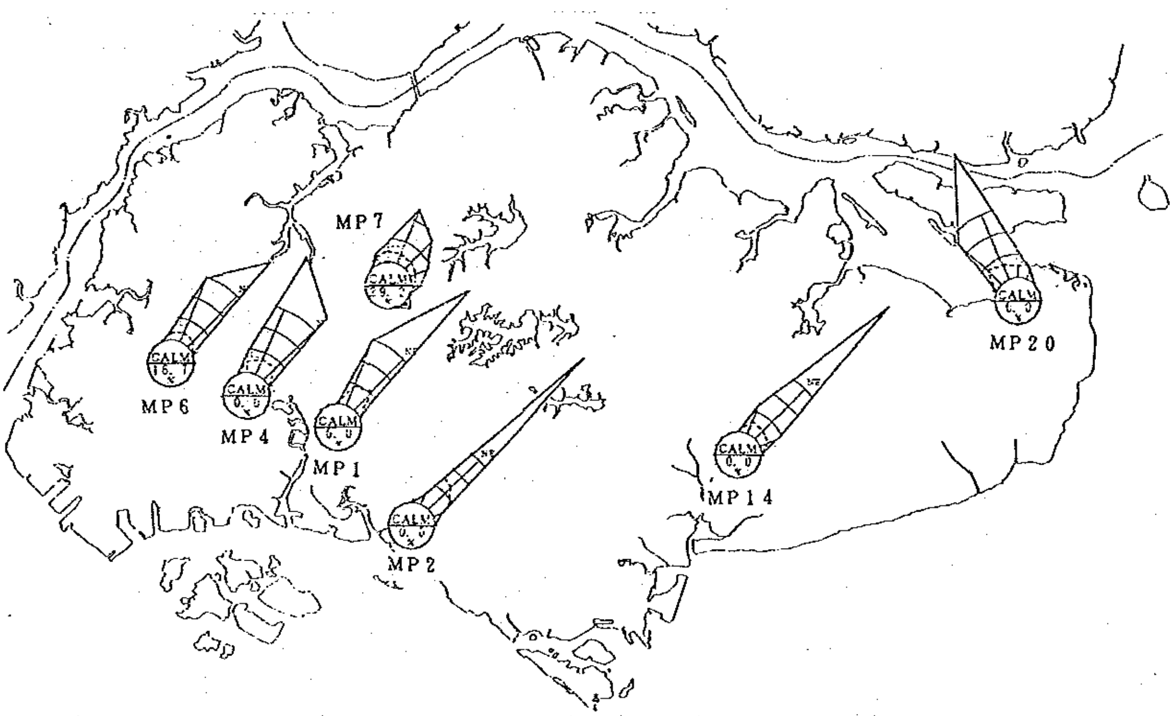


Fig. V-3-4-(1) Wind rose (1st survey, Dec. 19-20, 1983)

Table V-3-5-(2) Meteorological data (2nd survey, Mar. 19-20, 1984)

Date	Hour	Wind direction, wind velocity (unit: 0.1 m/s)							Dust concentration ($\mu g/m^3$)		
		MP1	MP2	MP4	MP6	MP7	MP14	MP20	MP1	MP2	MP6
	11	SW 26	SW 31	WSW 30	WSW 16	WSW 17	W 17	WNW 11	10	15	20
	12	SW 33	SW 28	WSW 30	SW 12	SW 18	W 16	ESE 5	18	15	0
	13	SW 38	SW 33	WSW 38	SW 14	SW 18	WNW 31	E 10	18	5	10
	14	WSW 40	SW 41	SW 42	SW 17	WSW 19	W 38	NE 8	12	8	10
	15	SW 44	SW 42	SSW 51	SW 19	WSW 24	WSW 40	W 5	0	5	0
	16	SW 43	SW 35	SW 51	SW 18	SW 22	WSW 32	SSE 30	15	0	10
3 / 19	17	SW 33	WSW 32	SW 41	SW 16	WSW 20	WSW 33	SE 25	8	10	0
	18	WSW 33	SW 30	SW 41	SW 10	WSW 17	SW 22	SE 21	20	10	0
	19	SW 20	SSW 22	SW 23	SW 7	SSW 10	S 22	E 17	20	5	10
	20	SE 18	SE 21	SE 15	C 3	ESE 8	SE 20	ENE 8	18	5	20
	21	ESE 18	ESE 15	E 21	C 4	ESE 5	SE 18	NE 5	35	15	30
	22	E 17	E 15	E 20	C 3	ESE 6	E 12	C 2	40	12	49
	23	NE 18	ENE 15	NE 13	NNE 11	C 4	ENE 12	C 1	50	20	72
	24	NE 16	ENE 16	NE 17	NE 6	ESE 5	E 11	C 2	40	40	80
	1	ENE 17	E 15	ENE 18	C 4	C 4	SE 13	C 3	58	45	72
	2	NE 9	ENE 15	NE 8	NNE 7	C 3	ESE 9	C 1	38	50	72
	3	NE 6	ENE 7	ENE 8	NE 6	C 3	C 3	C 2	20	54	62
	4	ENE 12	E 12	NE 12	NNE 8	E 5	ESE 12	C 3	30	60	62
3 / 20	5	NNE 10	NE 9	NNE 10	NNE 9	E 5	E 8	C 2	40	58	49
	6	NNW 12	NNE 11	NNW 12	N 9	C 4	NNE 5	C 2	68	40	80
	7	NE 8	E 10	NNE 7	NE 5	ESE 5	C 3	C 2	80	54	70
	8	C 4	C 1	NNW 5	C 4	NW 7	C 4	C 3	80	60	65
	9	C 3	SSE 7	C 4	C 4	C 2	SSW 9	C 4	120	52	75
	10	C 2	S 11	NNE 8	N 7	NE 8	SSE 16	ESE 6	40	28	125

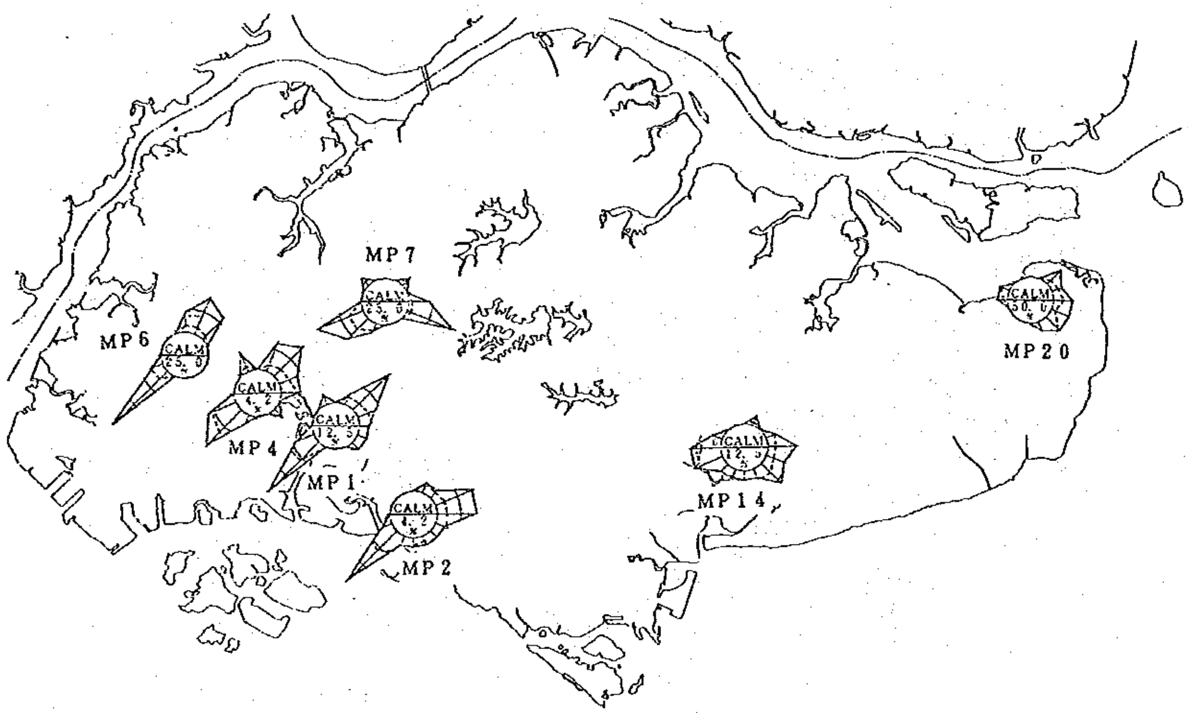


Fig. V-3-4-(2) Wind rose (2nd survey, Mar. 19-20, 1984)

Table V-3-5-(3) Meteorological data (3rd survey, July 3-4, 1984)

Date	Hour	Wind direction, wind velocity (unit: 0.1 m/s)							Dust concentration (μg/m³)		
		MP1	MP2	MP4	MP6	MP7	MP14	MP20	MP1	MP2	MP6
7 / 3	11	SW 27	SW 32	SSW 39	SW 11	SSW 15	SSW 21	C 4	34	8	0
	12	WSW 37	SW 36	SW 38	WSW 12	WSW 19	WSW 31	SSW 6	22	8	15
	13	SW 27	SW 47	SSW 35	SW 20	SW 15	SW 29	C 2	30	10	20
	14	SW 21	SW 15	SSW 38	SW 16	S 18	WNW 21	C 4	10	35	0
	15	SSW 26	SW 19	S 33	SW 12	SSW 16	W 13	C 1	8	20	0
	16	S 35	SSW 25	S 38	SSW 14	S 22	SSW 26	SE 7	10	20	10
	17	S 31	SSW 28	S 36	SSW 12	S 20	SSW 22	SE 6	4	15	10
	18	S 26	SSW 23	S 27	SSW 11	S 19	SSW 21	SE 7	10	24	10
	19	S 20	SSW 18	SSW 27	SSW 10	S 15	SW 17	SE 6	2	35	10
	20	SSW 17	SSW 15	S 16	SSW 9	SSE 8	SSW 15	ESE 5	10	35	15
	21	SSE 21	SSE 21	SSE 21	S 7	E 9	S 23	ESE 6	4	32	24
	22	SSE 19	SE 18	SE 21	S 6	E 5	S 17	ESE 7	5	30	20
	23	SSE 21	SSE 18	SSE 21	S 5	E 6	SSW 12	SE 5	0	30	10
	24	SSE 17	SSE 20	SSE 16	C 4	C 4	SSW 13	ESE 6	0	30	20
7 / 4	1	S 14	SSE 21	SSE 15	S 9	E 6	SSW 12	C 3	6	22	18
	2	SSE 23	SSE 25	SSE 28	S 7	E 7	S 20	C 4	0	15	20
	3	SSE 20	SSE 25	SSE 22	SSW 6	C 4	S 13	C 4	10	20	30
	4	SSE 17	S 23	SSE 15	SSW 12	C 2	SSW 9	C 3	0	10	18
	5	SSE 10	SSE 18	SE 11	S 7	C 3	S 9	C 2	0	5	28
	6	ESE 19	ESE 16	ENE 6	C 2	E 6	SSE 11	C 3	0	0	30
	7	SSE 11	SSE 20	SW 9	SW 5	SE 9	SSW 26	ESE 6	4	0	30
	8	SSW 35	SSW 44	S 36	SSW 22	S 14	WSW 24	SSE 6	0	10	20
	9	SW 32	SW 44	SW 41	WSW 9	SW 12	WSW 39	S 8	0	0	22
	10	SSW 45	SSW 53	S 55	SSW 15	SSW 19	SW 36	SSE 8	0	0	20

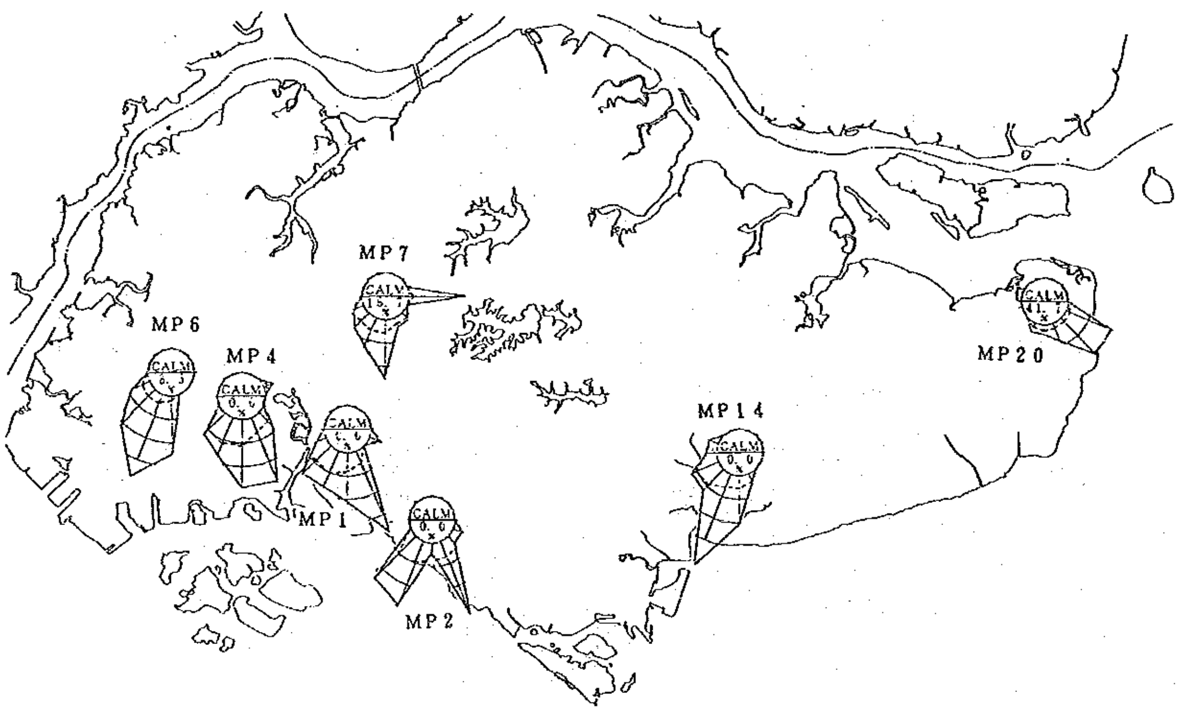


Fig. V-3-4-(3) Wind rose (3rd survey, July 3-4, 1984)

Table V-3-5-(4) Meteorological data (4th survey, Sept. 25-26, 1984)

Date	Hour	Wind direction, wind velocity (unit: 0.1 m/s)							Dust concentration (μg/m³)		
		MP1	MP2	MP4	MP6	MP7	MP14	MP20	MP1	MP2	MP6
9 / 25	11	S 32	S 31	SSE 40	S 17	S 19	S 21	ESE 21	8	6	25
	12	S 32	S 36	SSE 40	S 22	S 25	SSW 25	ESE 23	10	4	10
	13	S 33	S 40	SSE 43	S 21	S 24	S 30	ESE 27	13	18	10
	14	S 35	S 43	S 46	S 24	S 22	S 29	SE 18	10	30	22
	15	S 36	SSW 41	S 48	SSW 27	SSE 25	S 32	ESE 30	5	25	12
	16	S 44	S 45	SSE 54	S 29	S 25	SSW 27	E 32	10	16	30
	17	S 44	S 38	S 52	SSW 27	SSE 30	S 25	ESE 34	15	35	28
	18	S 33	S 33	S 38	SSW 18	S 21	SSE 24	E 25	15	18	20
	19	SSE 28	SSE 21	SSE 31	S 11	SSE 14	S 19	ESE 15	19	20	45
	20	SE 18	SSE 18	SE 23	SSE 10	ESE 7	SSE 23	ESE 16	17	22	12
	21	SE 19	SE 18	SE 26	SSE 10	ENE 5	SSE 19	ESE 10	17	22	20
	22	ESE 25	ESE 19	ESE 30	SSE 11	C 4	SSE 19	E 17	8	18	28
	23	SE 24	SE 22	ESE 26	SE 9	E 5	SSE 23	E 16	18	8	30
	24	ESE 20	ESE 19	ESE 22	ESE 6	C 4	SSE 13	ESE 7	15	8	15
9 / 26	1	SE 20	SE 19	ESE 19	C 3	C 4	SSE 12	E 17	18	2	10
	2	SE 20	SE 19	SE 24	SE 6	C 4	SSE 11	ESE 11	22	0	0
	3	SE 21	SE 18	ESE 28	SE 6	C 3	SSE 11	C 4	15	2	15
	4	SE 22	SE 19	SE 22	ESE 5	C 3	S 14	ESE 9	10	5	20
	5	E 8	ESE 8	E 12	NNE 5	C 4	S 6	C 2	10	0	10
	6	NNE 9	ENE 13	N 13	N 11	C 3	C 4	C 4	10	8	12
	7	NNE 8	NE 8	NNE 6	NNE 8	E 6	C 3	C 3	40	8	35
	8	ENE 10	E 14	NE 8	NNE 9	ENE 6	C 4	C 3	46	12	65
	9	C 2	ENE 7	N 7	N 8	NNW 5	SE 10	C 4	44	50	80
	10	C 2	SSW 11	NNW 9	NW 6	WNW 6	S 11	ESE 12	54	44	80

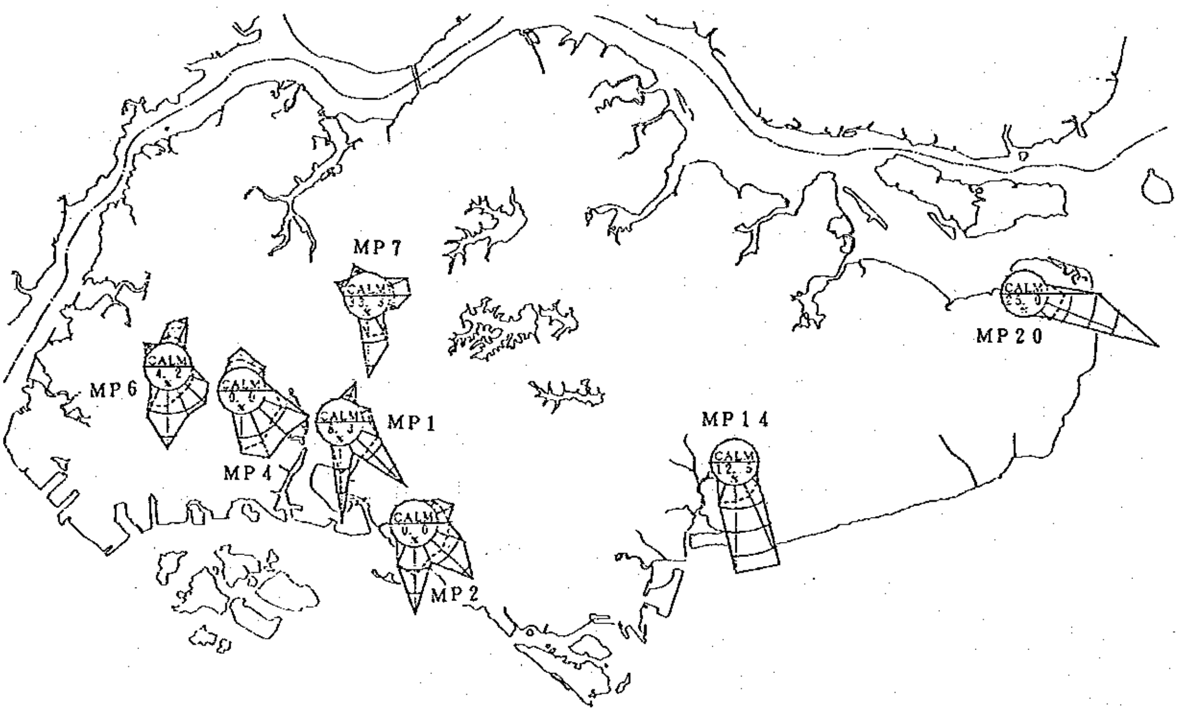


Fig. V-3-4-(4) Wind rose (4th survey, Sept. 25-26, 1984)

PART VI
SIMULATION

PART VI SIMULATION

The procedure of the simulation about SO_2 concentration in the previous study is following. First, emission sources of SO_2 in the objective area are investigated. Using these data, environmental concentrations of SO_2 are calculated by the diffusion model. And then, the comparison between the observed data and the calculated value are performed. After necessary adjustment of the diffusion model, the prediction of SO_2 concentrations in the future are performed.

But, as mentioned in PART II, the species of emission source on particulate matters are numerous. So it is difficult to grasp the emission volume for all emission sources. And it is impossible to estimate the contribution from each emission source by diffusion model.

In this study, we consider the following hypotheses and predict the concentrations of particulate matters in the future. The concentrations of particulate matters measured in this field survey are affected by all emission sources. And the concentrations don't vary in the future. Then, in order to estimate the effect of the coal power plant and the integrated steel mill to be established, the concentrations of particulate matters from these new factories are added to the observed data of the present level. The concentration estimations are performed at all mesh-points of square mesh of 1 kilometer. In this diffusion model about particulate matters, falling by gravity is considered.

CHAPTER 1 ESTIMATING THE CONCENTRATIONS OF TPM AND SPM BY THE INTERPOLATION METHOD

TPM and SPM concentrations were measured at twenty monitoring stations in Singapore. Then the concentrations at mesh-points covering whole area were calculated by the interpolation methods. Fig. VI-1-1 and VI-1-2 show the spatial distribution of TPM and SPM concentrations. At (MP7) - BUKIT PANJANG P.P. and (MP17) - PAYA LEBAR P.S., the concentrations are high. This is due to the effect of the road having heavy traffic and the effect is confined in the local area. Thus, when we correct the concentrations on the mesh-points, the data at MP7 and MP17 were excluded. Fig. VI-1-3 shows the mesh-points. We calculated the concentrations at the center of all meshes.

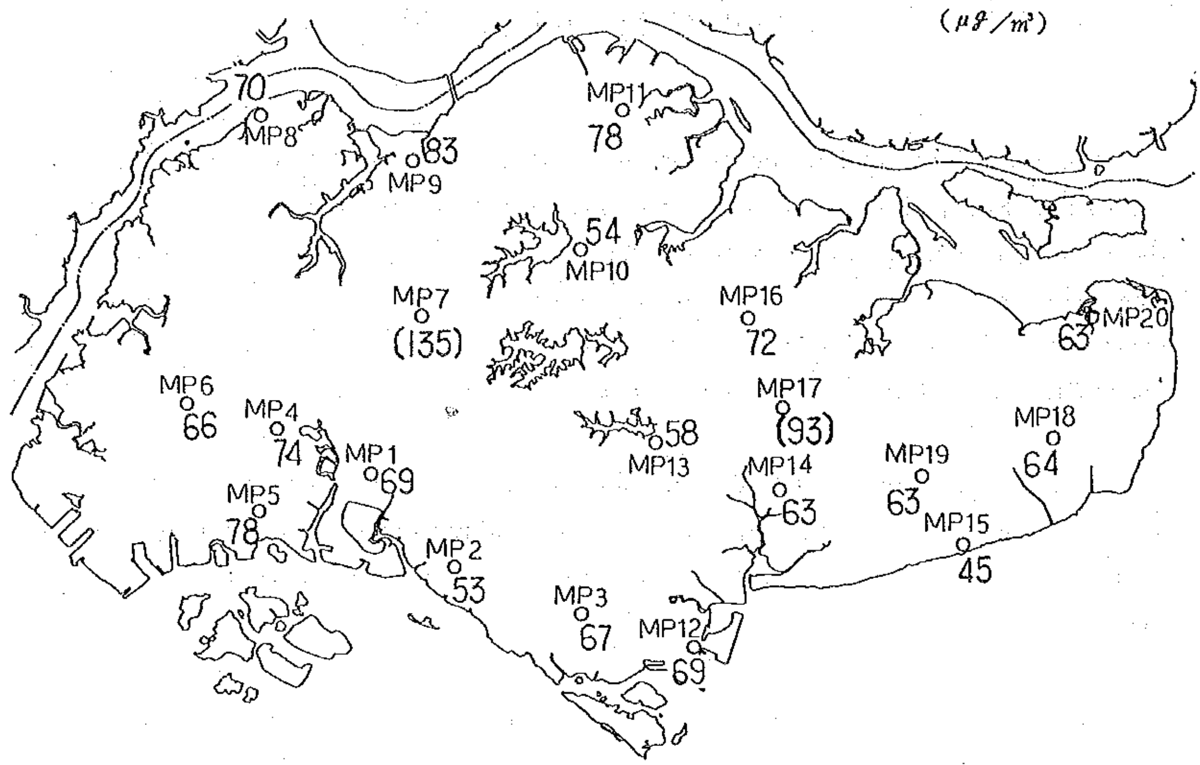


Fig. VI-1-1 Distribution of TPM concentrations measured by high volume sampler (through the year)

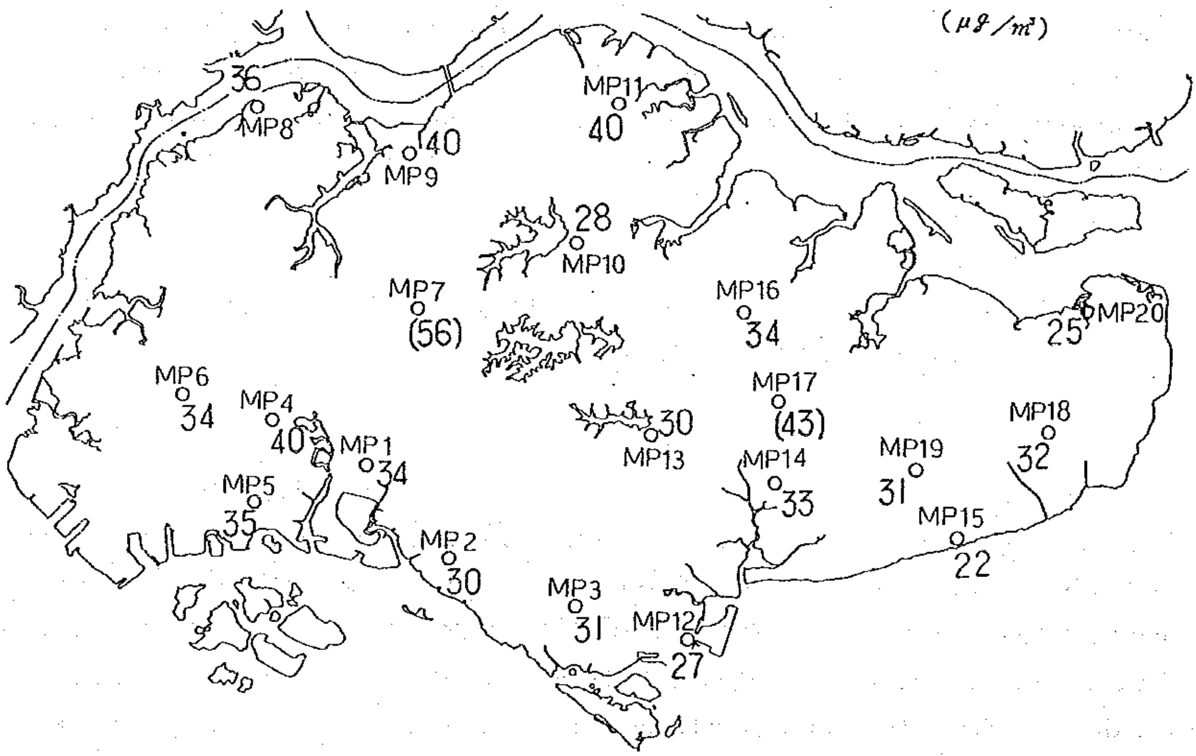


Fig. VI-1-2 Distribution of SPM concentrations measured by high volume sampler (through the year)

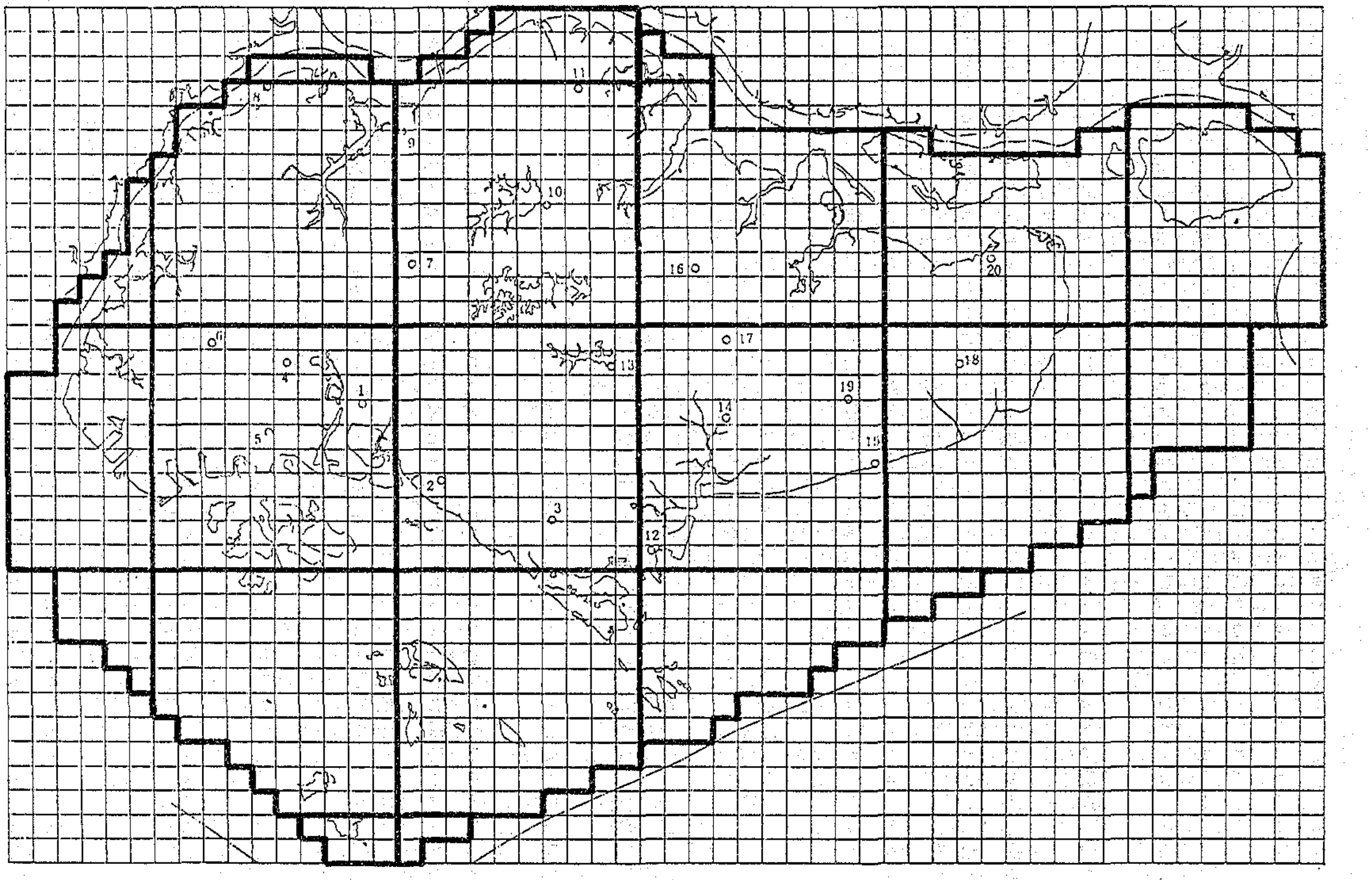


Fig. VI-1-3 Objective area and mesh points

VI-1-1 Estimation of Spatial Distributions of Concentrations by Interpolation Methods

Several interpolation methods are generally adopted in estimating spatial distributions of the concentrations. Each method shows different results. So it is not good to estimate the distributions of the concentrations by only one method. Thus, we used two interpolation methods. One is the weighted average method and the other is two-dimensional spline method. We describe these two methods in following sections.

VI-1-1-1 Weighted average method

When we estimate the unknown concentration at an objective point by the concentrations around the point, we weigh the known values and average these data. The weight is decided by the distance between the objective point and the surrounding points. The closer the distance is, the bigger the weight is. In our case, an inverse of r^2 was adopted as a weight. (r; distance between points) The concentration at point (xi, Yi) is defined as follow;

$$C(Xi, Yi) = \sum_{j=1}^{n}\left(\frac{Cj}{rij^2}\right) / \sum_{j=1}^{n}\left(\frac{1}{rij^2}\right) \qquad \text{Equation VI-1-1}$$

where Cj is the concentration at (Xj, Yj) and known value rij is the distance between point (Xi, Yi) and point (Xj, Yj)

VI-1-1-2 Two-dimensional spline interpolation method

We set coordinate system (X, Y, Z) as following. We set a location of any data on two-dimensional horizontal plane (X, Y). And we let the data value correspond to the height Z. Then we try to get the plane which satisfy above condition, i.e. Z = Zi (i=1, 2 ... N) at (X, Y) = (Xi, Yi), (i = 1, 2 ... N). From the theory of infinitesimal change, we consider E defined as Equation VI-1-2

$$E = \int\int_{A'} \left\{ (\Delta Z)^2 + \sigma(\nabla Z)^2 \right\} dx\,dy \qquad \text{Equation VI-1-2}$$

$$\Delta = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}, \quad \nabla = \frac{\partial}{\partial x} i + \frac{\partial}{\partial y} j)$$

where

expresses the ratio between the energy of strain and the energy of expansion. The integrated area A' must be wider than the objective area-A. If the boundary of area A' – i.e. A' is enough far from the boundary of A, the boundary condition is defined as follows:

$$\frac{\partial Z}{\partial n} = \Delta Z = 0 \quad \text{on } \partial A' \qquad \text{Equation VI-1-3}$$

(where $\frac{\partial}{\partial n}$ means differential in the direction of outward normal)

When we set the variation of Equation VI-1-2 zero, then

$$\Delta^2 Z - \sigma \Delta Z = 0 \qquad \text{Equation VI-1-4}$$

is obtained.

Thus, Z expresses the data value at (X, Y) and satisfies Equation VI-1-4 and also satisfies the boundary condition - Equation VI-1-3.

In this case, A' is taken to be the wider area than the objective area. And this area is divided with square meshes. Then Equation VI-1-4 is converted difference equation and the concentrations at all mesh-points of square mesh are calculated.

VI-1-2 The Results from Estimating TPM and SPM Concentrations in the Meshes

Figs. VI-1-4 to VI-1-7 show the contour of TPM and SPM concentrations estimated by two methods. The concentrations in the meshes are shown in the reference material part.

The results by two interpolation methods show the similar pattern in the main land where relatively many monitoring stations are established. But in the south part of the main land and above the sea in the south-east of the main land, the concentration distributions are different. This may be due to the difference of the boundary conditions. In the case of weighted average method, the estimated concentrations near the boundary closes to the averaged value of the concentrations at surrounding monitoring stations. Using the two-dimensional sprine interpolation method, the gradient of the concentration near the boundary close to zero. But as the relatively good agreement can be seen in the main land, both methods are considered to be the appropriate methods.

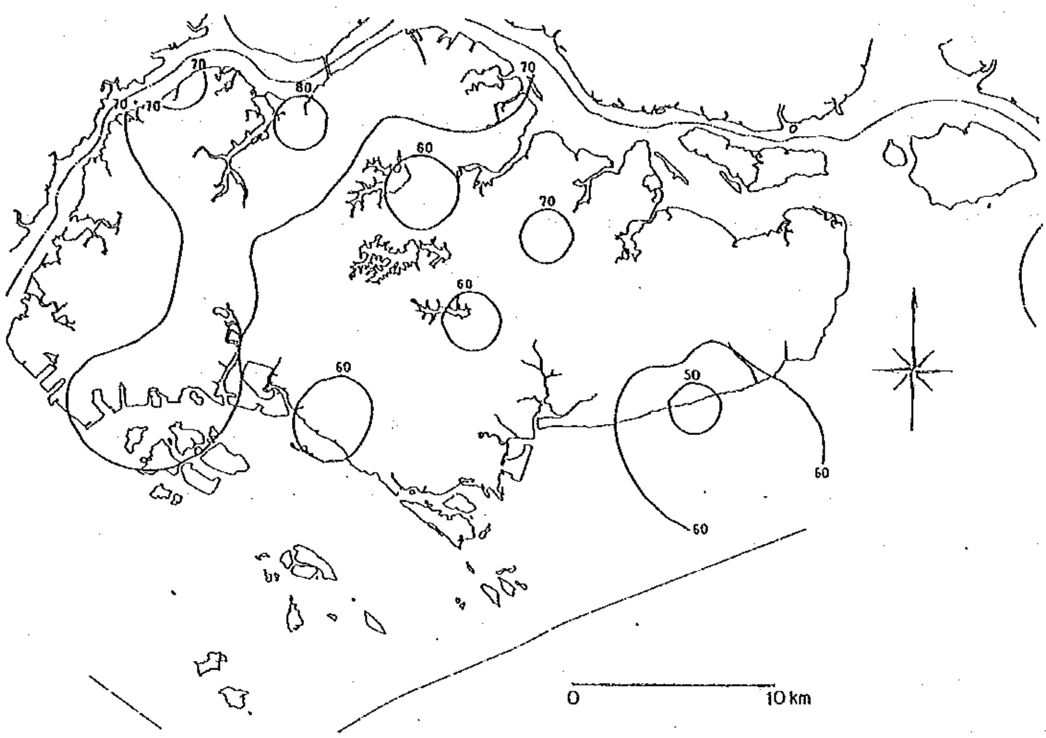


Fig. VI-1-4 Contour of TPM concentrations at present (by weighted average method) (unit; μg/m³)

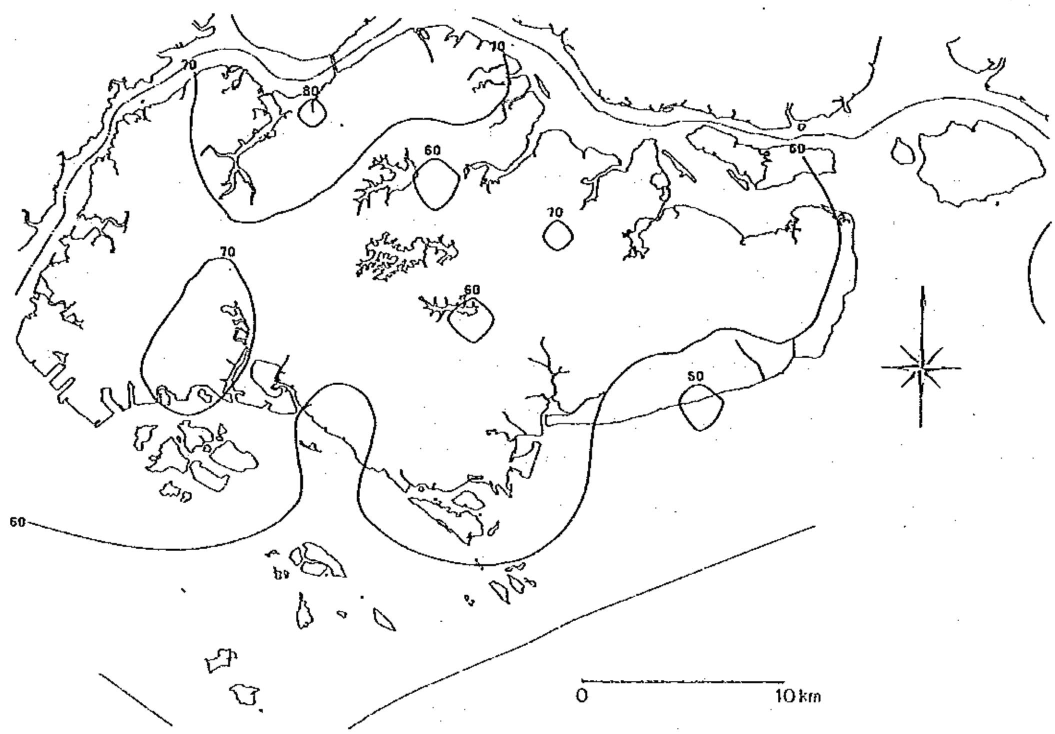


Fig. VI-1-5 Contour of TPM concentrations at present (by two-dimensional spline method) (unit; μg/m³)

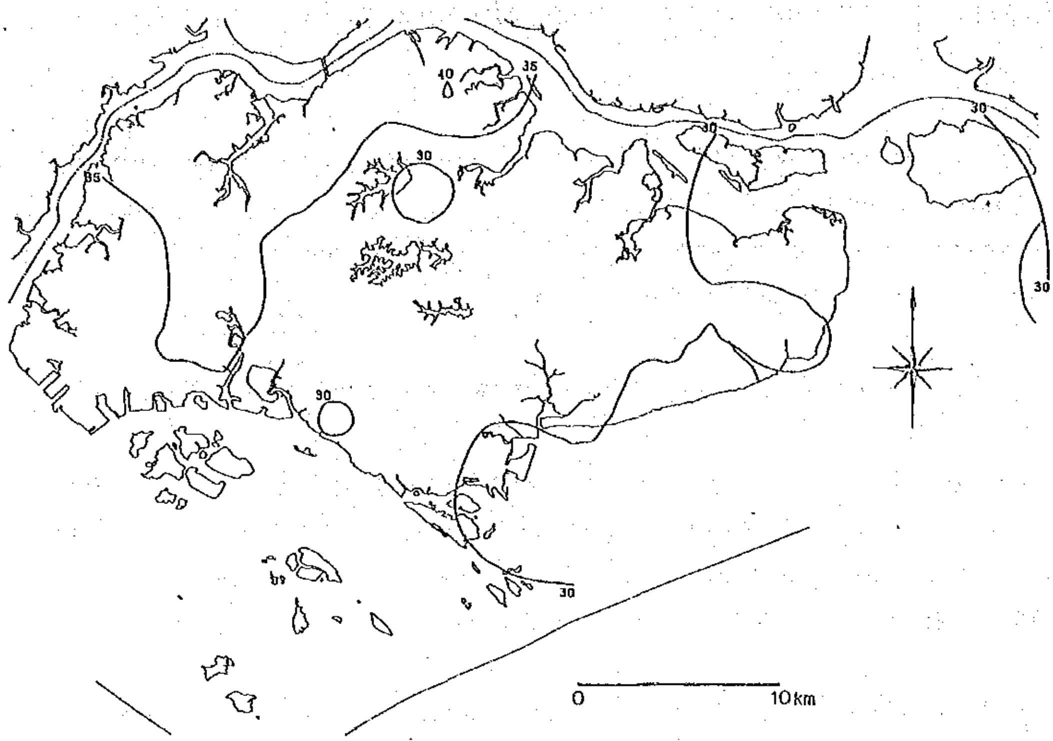


Fig. VI-1-6 Contour of SPM concentrations at present (by weighted average method) (unit; μg/m^3)

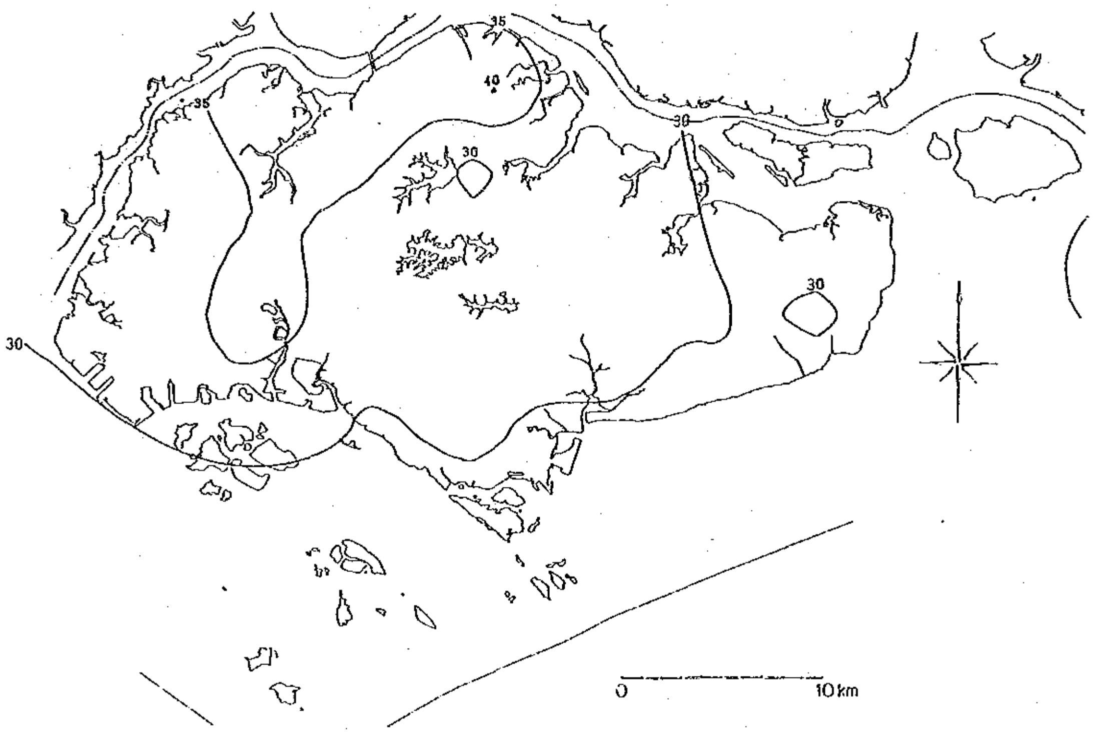


Fig. VI-1-7 Contour of SPM concentrations at present (by two-dimensional spline method) (unit; μg/m^3)

CHAPTER 2 PREDICTION OF TPM AND SPM CONCENTRATIONS IN FUTURE

The coal firing power stations and integrated steel mill are proposed to be sited. In this chapter, we predicted the variations of TPM and SPM concentrations by the effects of above facilities. The used model is Plume-Puff model, and falling of particulate matters by gravity is considered into this model.

VI-2-1 Informations of Emission Sources at the Newly-established Facilities

We took five emission sources of the new facilities into this model. They are the coal firing boilers at Seraya Power Station and Tekong Power Station, and three stacks at Tekong Integrated Steel Mill. Table VI-2-1 shows the informations of emission sources. Fig. VI-2-1 shows the locations of new facilities.

In Table VI-2-1, the effective stack height, the diameter of stack, the emission velocity of exhaust gas, the temperature of exhaust gas, the emission volume of exhaust gas and the emission volume of dust are based on the designed value. Falling velocities of particulate matters depend on their size. Thus, as mentioned in PART IV, we categorized the size distribution of dust emitted from each source.

Table VI-2-1 Informations of emission sources at newly-established factories

Factories		Plant No.	Stack No.	Height (m)	Diameter (m)	Velocity (m/s)	Temperature (°C)	Gas volume (Nm^3/H)	Particulate volume (kg/H)	Rate by size (%)			
										2 μm <	2-10	10-20	20 μm ≥
Seraya Power Station		63	2	183	7.62	25	150	2,650,000	130	34.3	54.6	10.0	1.1
Tekong Power Station		64	1	183	7.36	25	150	2,470,000	120	34.3	54.6	10.0	1.1
Tekong Integrated Steel Mill	Grate Kiln	65	1	170	8.97	30	100	5,000,000	900	48.9	32.1	10.4	8.6
	Reheating Furnance	65	2	70	1.45	30	500	63,000	6	73.7	22.4	3.1	0.8
	Electric Arc Furnance	65	3	120	6.0	25	120	1,800,000	324	43.2	52.5	4.2	0.1

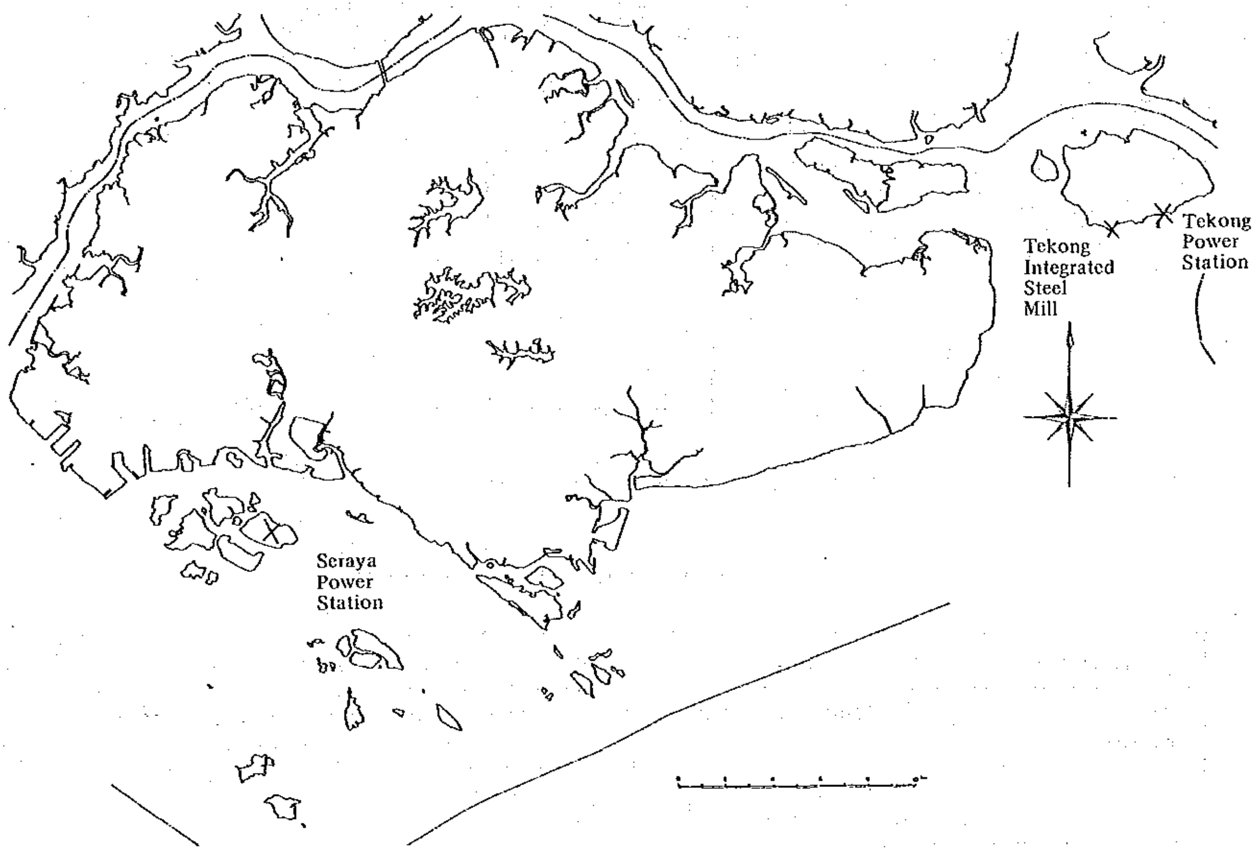


Fig. VI-2-1 Locations of newly-established factories

VI-2-2 Simulation Model

As stated in the previous section, many models have been proposed as the diffusion prediction model. In this study, Gaussian plume and puff model was adopted as used in previous study. The time scale of averaging is one year. As shown in Fig. VI-2-2, this model consists of four sub-models.

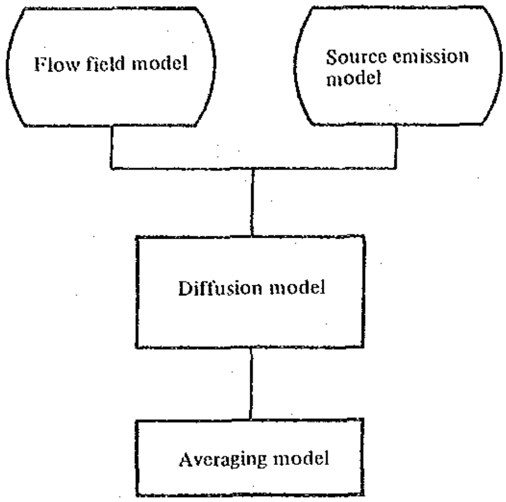


Fig. VI-2-2 Construction of prediction model

Table VI-2-2 Items in construction of prediction model

Element	Items	Description
Flow field model	Frequency occurrence	Joint probability frequency of wind direction, velocity and stability
	Wind velocity of upper layer	Power law index
Source emission model	Source data	Source location, height, emission data etc.
	Plume rise calculation	Moses & Carson and Brigg's equation with falling by gravity
Diffusion model	Diffusion equation	Gaussian plume and puff equation
	Plume and puff widths	Pasquill-Gifford, Turner's chart
Averaging model	Calculation of annual average	Weighed average by joint frequency occurrence of meteorological conditions

VI-2-2-1 Flow field model

As mentioned before, meteorological condition was classified by wind direction, wind velocity and etc. The results were not much different from the previous one. Then, in this simulation, the flow field model used in the previous simulation was adopted.

(1) Classification by season and time

As already stated in Section V-1-1-1 of PART V, meteorological flow field was classified by season and time as in Table VI-2-3.

Table VI-2-3 Classification by season and time

Season / Time	SW Monsoon April to October	NE Monsoon November to March
Day	7:00 - 17:59	7:00 - 17:59
Night	18:00 - 6:59	18:00 - 6:59

(2) Classification of meteorological condition

Meteorological condition was classified by wind direction, wind velocity and atmospheric stability. The classification of each term is as follows;

① Wind direction; 16 different wind vectors

② Wind velocity; 7 ranks as shown in Table VI-2-4

③ Atmospheric stability; The atmospheric stability is categorized by MITI method which is modified Pasquill's and uses net radiation flux instead of cloud coverage (Table V-1-6). The stability is categorized into 6 classes of windy and 4 classes for calm.

Table VI-2-4 Representative wind velocity of wind velocity classes

Velocity interval		Representative velocity
Calm	0 - 0.4 m/s	0.0 m/s
Windy	0.5 - 0.9	0.7
	1.0 - 1.9	1.5
	2.0 - 2.9	2.5
	3.0 - 3.9	3.5
	4.0 - 5.9	5.0
	6.0 -	7.0

(3) Regional block separation

In the previous study (July 15, 1981 - July 14, 1982), the cluster analysis and principal component analysis suggested that monitoring stations were divided into two groups, i.e., eastern group - CHANGI AIRPORT and western group - J.T.C. HALL. In this study, the similar results were obtained. So in this study, using the previous data at CHANGI AIRPORT and J.T.C. HALL, we performed the diffusion calculation of particulate matters. Fig. VI-2-3 shows regional block separation and representative stations.

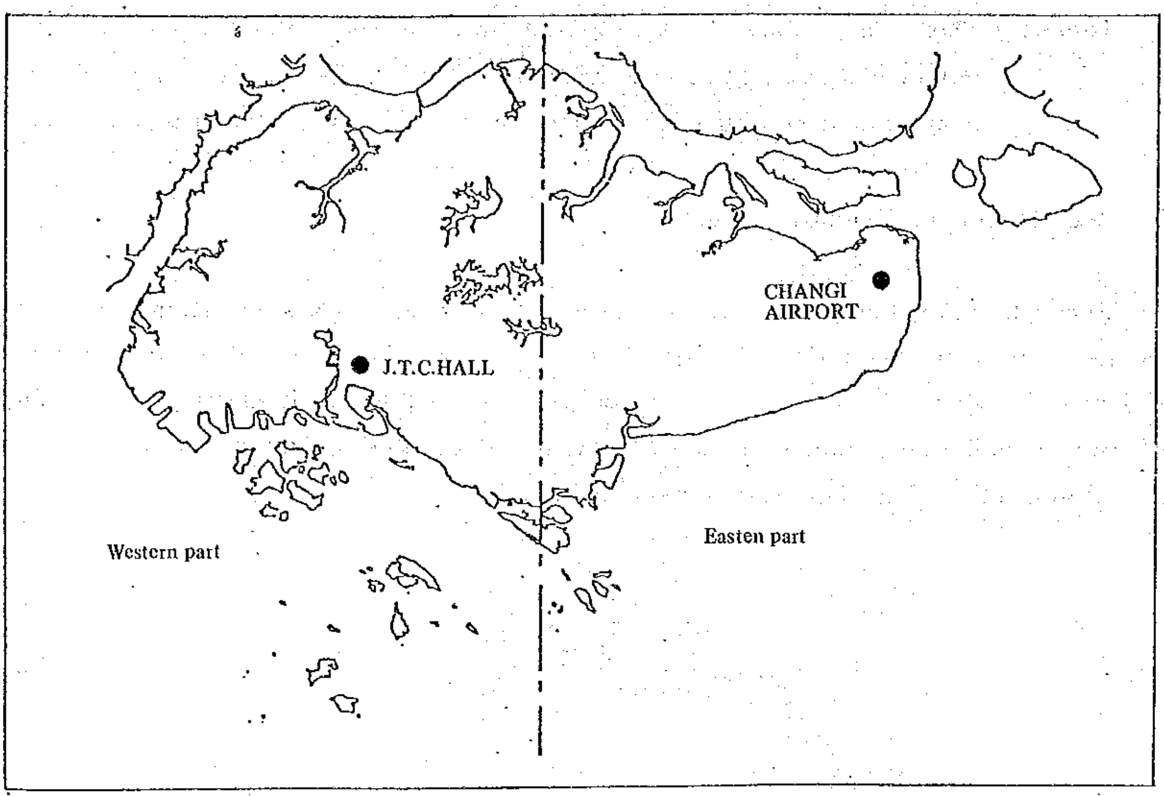


Fig. VI-2-3 Regional block and representative stations

(4) Vertical profile of wind

Wind velocity and turbulence are influenced by ground surface and changes with height. The transport and dispersion of matters are also influenced and changed with height. To reproduce the difference of diffusion by height, the flow field was separated into two layers. As wind data were measured near the ground, wind velocities at upper level were calculated by applying power law (see Equation VI-2-1). These data were used in this diffusion model. Here, exponent P in Equation VI-2-1 are adopted by EPA of U.S.A in their CDM manual.

$$U \text{ (at height } Z_2) = U \text{ (at height } Z_1) (Z_2/Z_1)^P \qquad \text{Equation VI-2-1}$$

Table VI-2-5 Values of P by CDM manual of EPA

Pasquill's stability category	A	B	C	D	E	F
P	0.1	0.15	0.20	0.25	0.25	0.30

Remarks: These values have been proposed by Demarrais (1959) based on the wind velocity data at 145 m and ground level of Brook Haven Tower. The tower is sited near coast and surrounded by gently rolling hills with pine trees

VI-2-2-2 Modeling of emission sources

Generally stack gas plume ascends in the air because of its momentum and buoyancy and reach to some level (Fig. VI-2-4). The final height is called effective stack height (He) and diffusion calculation is performed as if the plume gas is emitted at He. In this diffusion model, the plume rise Δh was calculated by Moses-Carson Equation for windy condition and by Brigg's Equation in calm condition.

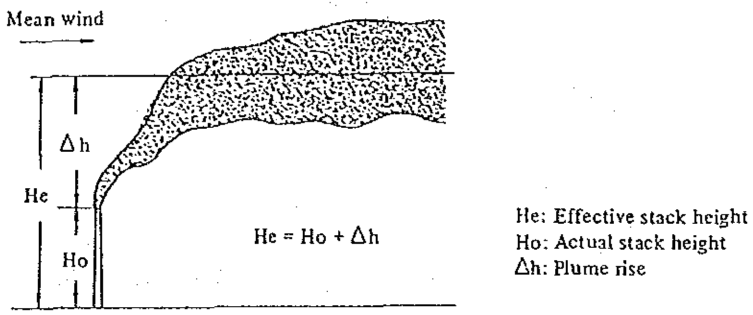


Fig. VI-2-4 Effective stack height

The plume rise formulate are given as follows:

(1) Moses and Carson Equation

$$\Delta h = (C_1 \cdot V_s \cdot D + C_2\, Q_H^{1/2}) \cdot U^{-1} \qquad \text{Equation VI-2-2}$$

where;

- Q_H : Emission rate of heat = $\rho \cdot Q \cdot C_p \cdot \Delta T$ (cal/s)
- C_p : Specific heat of effluent gas at constant pressure, usually the gas is assumed to be the air = 0.24 (cal/g.k)
- ρ : Density of effluent gas if it is assumed to be the air = 1293 (g/m^3)
- Q : Rate of the mass effluent gas (Nm^3/s)
- ΔT : Temperature difference between the effluent gas and ambient air, usually assumed to be equal to $(T_G - 27)$ (^oC)

T_G : Temperature of the effluent gas (°C)
U : Wind velocity at the stack height (m/s)
V_s : Speed of effluent gas at the exit of stack (m/s)
D : Diameter of exit of the stack (m)

For the constants C_1 and C_2, proposed values by Moses and Carson are used.

	dθ/dz	C_1	C_2
Unstable	dθ/dz < 0	3.47	0.33
Neutral	dθ/dz = 0	0.35	0.171
Stable	dθ/dz > 0	-1.04	0.145

Here dθ/dz is the potential temperature gradient and given by

$$\frac{d\theta}{dz} = \frac{dT}{dz} + \Gamma d \quad (^{\circ}C/m)$$

where; Γd is the dry adiabatic lapse rate and equal to 0.0098 (°C/m).

(2) Brigg's equation

Brigg's equation is written as follows:

$$\Delta h = 1.4 \cdot Q_H^{1/4} \cdot (d\theta/dz)^{-3/8}$$ Equation VI-2-3

where dθ/dz = 0.005°C/m

VI-2-2-3 Diffusion calculation

In this research project, Gaussian plume and puff equations are adopted for diffusion model as used in the previous study. And then falling of particulate matters by gravity is considered in the model. The final velocity of particulate matter depends on its size. In this model, particle size is classified into 4 ranks, under 2 μm, 2-10 μm, 10-20 μm and over 20 μm, and concentrations of particulate matters in each rank are calculated.

(1) Diffusion equation

We show the diffusion equation of particulate matters.

① Plume equation considering of falling by gravity.
Concentration of matters at a point (x, y, z) is given by

$$C(x,y,z) = \frac{Op}{2\pi\sigma_y\sigma_z U} \cdot (\exp(-\frac{y^2}{2\sigma_y^2}))\left\{\exp\left\{-\frac{(He-Z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(He+Z)^2}{2\sigma_z^2}\right\}\right\} \quad \text{Equation VI-2-4}$$

where the notations are as follows:

C(x, y, z): Concentration of pollutants at a point (x, y, z)

x, y, z : Longitudinal, lateral and vertical coordinate of the point. x and y are measured from source point and lateral distance from the axis which passes through source point, respectively. z is the vertical height of the point above the ground.

Q_p : Emission rate of the pollutant (Nm^3/s)

U : Wind velocity (m/s)

He : Effective height of the plume axis (m)

σ_y : Plume width in lateral direction (m)

σ_z : Vertical plume width (m)

In the equation, the ground point where source stack stands is the origin (0,0,0), x axis is down wind and y axis is taken normal to the x axis. The z axis is taken vertically upwards. Therefore, the coordinate of the source point is (0,0,He), where He is the effective plume height, i.e., sum of stack height and plume rise.

In the estimation of pollutant concentration, diffusion calculation is performed for each wind direction of 16 sectors. The frequency distribution of wind direction inside of each sector is assumed to be equally flat, and the lateral distribution of concentration inside of each sector is also assumed constant. Then a modified plume equation (Holland (1953)) which gives the laterally averaged concentration in one sector is more suitable for long term average concentration Equation VI-2-5.

$$C(x,z) = \sqrt{\frac{1}{2\pi}}\ \frac{Qp}{\frac{\pi}{8}\ x\sigma_z U} \cdot \left[\exp\left\{-\frac{(He-Z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(He+Z)^2}{2\sigma_z^2}\right\}\right] \quad \text{Equation VI-2-5}$$

For particulate matters, falling by gravity must be considered. Thus we think that effective stack height (He) varies in time and modify Equation VI-2-5. Then

$$C(x, z) = \sqrt{\frac{1}{2\pi}} \frac{Q_p}{\frac{\pi}{8} x \sigma_z U} \cdot \left[\exp\left\{-\frac{(He - V_s x/U - Z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(He - V_s x/U + Z)^2}{2\sigma_z^2}\right\}\right] \quad \text{Equation VI-2-6}$$

Vs; falling velocity

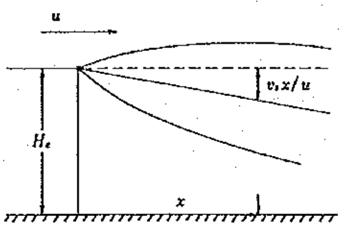


Fig. VI-2-5 Scheme on fall down of particles by gravity

② Puff equation considering fall by gravity (applied for in calm)

The concern at a point (x, y, z) by a puff element is expressed by the following equation:

$$C(x, y, z) = \int_0^t \frac{Q_p}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \cdot \exp\left(-\frac{x^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2}\right) \cdot \left[\exp\left\{-\frac{(He - Z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(He + Z)^2}{2\sigma_z^2}\right\}\right] dt \quad \text{Equation VI-2-7}$$

σx, σy and σz are the function of time-t.

When we consider fall by gravity, He (effective stack height) is expressed as the function of time He = He - Vs·t. Then, using this equation, Equation VI-2-7 is modified as follow:

$$C(y, y, z) = \int_0^t \frac{Q_p}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \cdot \exp\left(-\frac{x^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2}\right) \cdot \left[\exp\left\{-\frac{(He - V_s t - Z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(He - V_s t + Z)^2}{2\sigma_z^2}\right\}\right] dt \quad \text{Equation VI-2-8}$$

(2) Falling of particulate matters by gravity

Particulate matters fall by gravity. The falling velocity is decided by gravity and resistance. We decided the velocity by Stokes's law. (Equation VI-2-9)

$$V_s = \frac{2r^2 \rho_s g}{9 \nu \rho_a}$$ Equation VI-2-9

Here

r; Radius of particulate matter (m)

g; Gravity acceleration (m/s^2)

ν; Kinematic viscosity of air (m^2/s)

ρa; Density of air (g/m^3)

ρs; Density of particulate matter (g/m^3)

We set these constances as follows: $g = 9.78$, $\nu = 15.66 \times 10^{-6}$ (at 27°C), $\rho a = 1176$ (at 27°C), $\rho s = 1.72 \times 10^6$ (diameter < 2 μm) and $\rho s = 2.30 \times 10^6$ (diameter ≥ 2 μm).

In Equation VI-2-9, the final velocity is proportional to r^2. The bigger a particle is, the faster the velocity is. In the diffusion model about particulate matters, falling velocity for each size rank must be calculated. But it is difficult to calculate the falling velocity at each emission source. So we consider that the falling velocity of particle emitted from any source is as same as that of particle in the air, and we performed the diffusion calculation.

① Size distribution in the ambient air

We assume that size distribution in the ambient air is according to Rosin-Rammlar's distribution (Equation IV-2-2). The size distribution was obtained by the data, which were measured by Andersen sampler in the short term field surveys. Table VI-2-6 shows the calculated size distribution.

Table VI-2-6 Size distribution of particulate matters in ambient air

Percentage (%)	2 μm below	63.95
	2 - 10	26.46
	10 - 20	6.10
	20 μm over	3.49
	n	0.517
	p	0.7130
Median diameter	(μm)	0.95

Note: These values were calculated by the data of Andersen sampler.

② Average diameter for each rank of particle size

Average diameters (d) were calculated by following equation.

$$d = \frac{\int_{x_1}^{x_2} x\left(-\frac{dR}{dx}\right) dx}{\int_{x_1}^{x_2} \left(-\frac{dR}{dx}\right) dx}$$ Equation VI-2-10

Note:

x_1; Minimum size for one rank (μm)

x_2; Maximum size for one rank (μm)

Table VI-2-7 shows the calculated values.

③ Falling velocity for particle size rank

Using Equation VI-2-9, the falling velocity was calculated for each rank of particle size. The result is shown in Table VI-2-7.

Table VI-2-7 Average size and falling velocity for each rank

Rank (diameter)	Average size d (μm)	Falling velocity Vs (m/s)
2 μm <	0.569	1.64×10^{-5}
2-10 μm	4.664	1.48×10^{-3}
10-20 μm	13.901	1.31×10^{-2}
20 μm ≥	30	6.11×10^{-2}

(3) Diffusion parameters

In this model, the diffusion parameters are used as the same parameters of the previous study. In windy, these parameters are decided with Pasquill's chart (Fig. VI-2-6). In calm, these are decided with MITI's chart which are modification of Turner's charts. But the adopted stability is changed as to reproduce the actual condition as well as possible. (See Tables VI-2-8, VI-2-9).

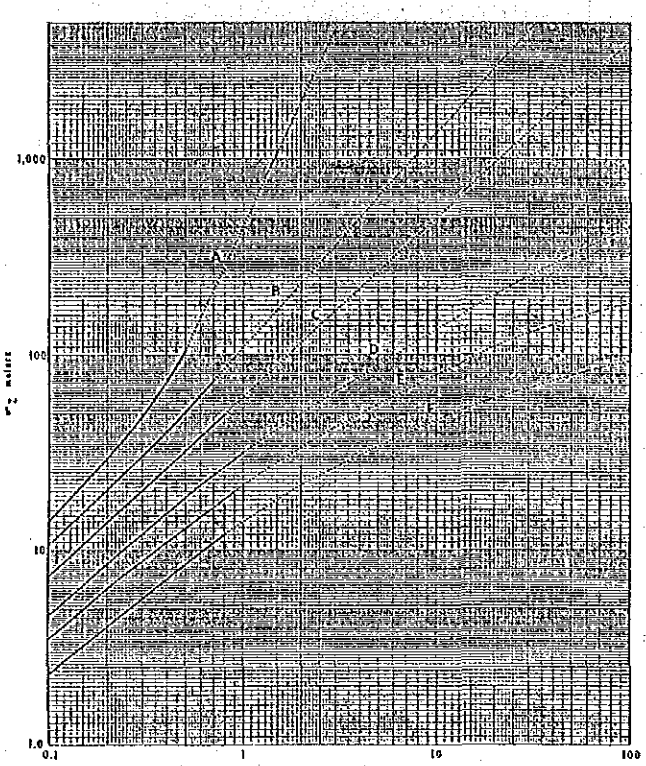
Table VI-2-8 Diffusion parameters for plume equation (windy condition)

Atmospheric stability	A	B	C	D	E	F
Adopted diffusion widths in Pasquill's chart	C			D	D-E	E

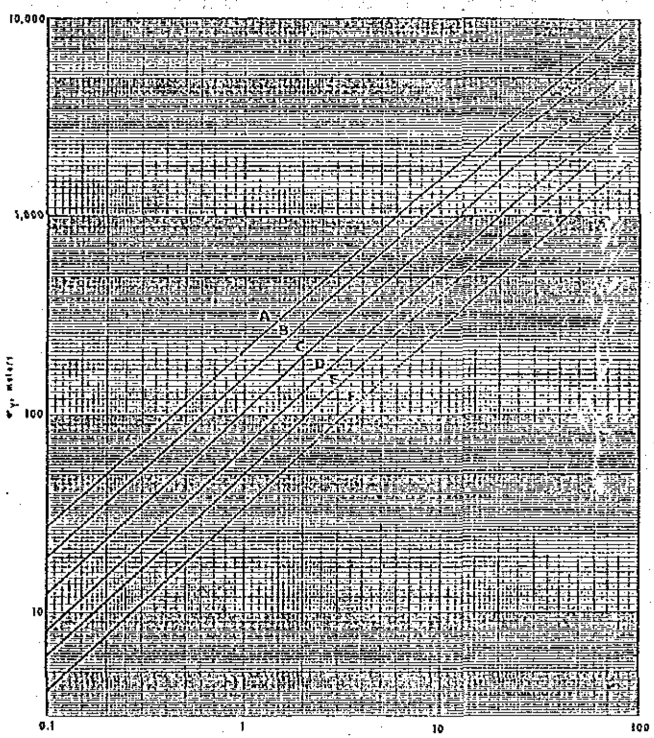
Note; Symbols are equal to Pasquill's chart

Table VI-2-9 Diffusion parameters for puff equation (calm condition)

Atmospheric stability	CA	CB	CC	CD
Adopted diffusion widths in MITI's chart	CA	CB	CC	CD



Distance downwind (km)



Distance downwind (km)

Fig. VI-2-6 Pasquill-Gifford charts

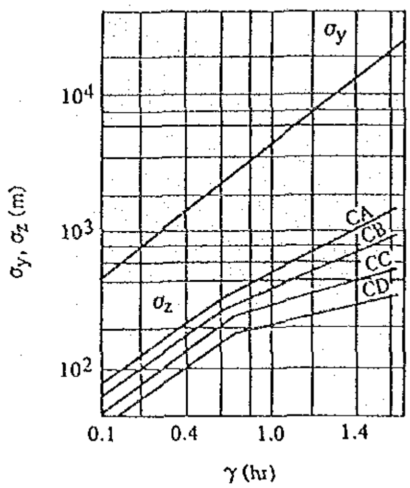


Fig. VI-2-7 Puff diffusion parameters by MITI

VI-2-2-4 Calculation of long term average concentration

Diffusion calculations are performed for each class of wind direction, wind velocity and stability category, and long term average concentration is obtained by taking weighed average by joint frequency of each meteorological class.

The weighed average concentration for windy condition is given by

$$\overline{C} = \sum_i \sum_j \sum_k C(D_i, V_j, st_k) \cdot f(D_i, V_j, st_k) \qquad \text{Equation VI-2-11}$$

where, $C(D_i, V_j, st_k)$ is the hourly concentration under the meteorological category of wind direction D_i, wind velocity rank V_j and stability category st_k, and $f(D_i, V_j, st_k)$ is the joint frequency of D_i, V_j, st_k.

The weighed average concentration for calm condition is similarly given by

$$\overline{C} = \sum_k C(st_k) \cdot f(st_k) \qquad \text{Equation VI-2-12}$$

where, $C(st_k)$ is the hourly concentration under stability category st_k. $f(st_k)$ is the frequency of stability category st_k.

The weighed average concentrations for windy and calm conditions are calculated for each season and time of day.

VI-2-3 Predicted Concentration of TPM and SPM

Table VI-2-10 shows the contributed concentrations at each monitoring station. The station which is the most effected by newly-established factories is (MP11) - CHONG PANG P.P. located in the north part of the objective area (TPM concentration - 0.40 $\mu g/m^3$, SPM concentration - 0.30 $\mu g/m^3$). This may be due to the effect of the newly-established factories in Tekong Island. The emission volume of these factories occupy 90% of total emission volume. And the prevailing wind direction in the east part of the object area is ESE. Thus MP11 locates on the leeward of the main emission sources.

In order to clarify the effects of falling by gravity, we calculated the concentrations in the case of neglecting falling by gravity. This result is shown in Table VI-2-11. From Tables VI-2-10 and VI-2-11, the effects of gravity can be seen. The larger the size of particle is, the bigger the difference of concentrations is.

Figs. VI-2-8 and VI-2-9 show the contour on the contributed concentrations of TPM and SPM. The maximum concentration of TPM is 1.27 $\mu g/m^3$ and that of SPM is 1.04 $\mu g/m^3$. These values can be seen in the south of Tekong Island. As the stacks at newly-established factories are high, the concentrations near the factories become low.

Table VI-2-10 Contribution to TPM and SPM concentrations from newly-established factories (in the case of considering gravity)

(Unit; $\mu g/m^3$)

Monitoring stations	TPM All size	SPM Under 10 μm diameter	Concentration for size rank (Unit; $\mu g/m^3$)			
			2 μm <	2 ~ 10 μm	10 ~ 20 μm	20 μm ≧
(MP1) J. T. C. HALL	0.14	0.10	0.05	0.05	0.02	0.02
(MP2) N. U. S.	0.12	0.08	0.04	0.04	0.02	0.02
(MP3) BUKIT MERAH F. F.	0.14	0.10	0.05	0.05	0.02	0.03
(MP4) BOON LAY APART	0.19	0.15	0.07	0.08	0.02	0.02
(MP5) JURONG HILL TOP	0.13	0.09	0.04	0.05	0.02	0.02
(MP6) NANYANG. T. I.	0.16	0.12	0.06	0.07	0.02	0.02
(MP7) BUKIT PANJANG P. P.	0.18	0.14	0.07	0.07	0.02	0.02
(MP8) LIM CHU KANG M. P. P.	0.17	0.13	0.06	0.07	0.02	0.02
(MP9) KRANJI SEWAGE T. P.	0.19	0.15	0.07	0.08	0.02	0.02
(MP10) SELETAR R. W. P. S.	0.20	0.15	0.07	0.08	0.02	0.03
(MP11) CHONG PANG P. P.	0.40	0.30	0.15	0.15	0.04	0.06
(MP12) NATIONAL. I. C.	0.15	0.11	0.05	0.05	0.02	0.03
(MP13) MACRITCHIE R. W. P. S.	0.15	0.11	0.05	0.05	0.02	0.03
(MP14) KALLANG F. F.	0.17	0.11	0.06	0.06	0.02	0.04
(MP15) EAST COAST S. LAGOON	0.22	0.13	0.07	0.07	0.02	0.06
(MP16) ANG MO KIO F. F.	0.23	0.16	0.08	0.08	0.02	0.04
(MP17) PAYA LEBAR P. S.	0.18	0.12	0.06	0.06	0.02	0.04
(MP18) CHANGI. C. CENTER	0.19	0.13	0.07	0.07	0.02	0.04
(MP19) JTC BEDOK F. F.	0.19	0.13	0.06	0.06	0.02	0.05
(MP20) SINGAPORE O. P. S.	0.26	0.21	0.11	0.10	0.02	0.03

Table VI-2-11 Contribution to TPM and SPM concentrations from newly-established factories (in the case of neglecting gravity)

(Unit; $\mu g/m^3$)

Monitoring stations	TPM All size	SPM Under 10 μm diameter	Concentration for size rank			
			2 μm <	2 ~ 10 μm	10 ~ 20 μm	20 μm ≧
(MP1) J. T. C. HALL	0.11	0.10	0.05	0.05	0.01	0.00
(MP2) N. U. S.	0.09	0.08	0.04	0.04	0.01	0.00
(MP3) BUKIT MERAH F. F.	0.11	0.09	0.05	0.05	0.01	0.00
(MP4) BOON LAY APART	0.16	0.14	0.07	0.08	0.01	0.01
(MP5) JURONG HILL TOP	0.10	0.09	0.04	0.05	0.01	0.00
(MP6) NANYANG. T. I.	0.14	0.12	0.06	0.06	0.01	0.01
(MP7) BUKIT PANJANG P. P.	0.16	0.14	0.07	0.07	0.01	0.01
(MP8) LIM CHU KANG M. P. P.	0.14	0.13	0.06	0.07	0.01	0.01
(MP9) KRANJI SEWAGE T. P.	0.16	0.14	0.07	0.07	0.01	0.01
(MP10) SELETAR R. W. P. S.	0.17	0.15	0.07	0.07	0.01	0.01
(MP11) CHONG PANG P. P.	0.34	0.29	0.15	0.14	0.03	0.02
(MP12) NATIONAL. I. C.	0.12	0.10	0.05	0.05	0.01	0.01
(MP13) MACRITCHIE R. W. P. S.	0.12	0.10	0.05	0.05	0.01	0.01
(MP14) KALLANG F. F.	0.13	0.11	0.06	0.05	0.01	0.01
(MP15) EAST COAST S. LAGOON	0.15	0.13	0.07	0.06	0.01	0.01
(MP16) ANG MO KIO F. F.	0.18	0.16	0.08	0.08	0.02	0.01
(MP17) PAYA LEBAR P. S.	0.13	0.11	0.06	0.06	0.01	0.01
(MP18) CHANGI. C. CENTER	0.15	0.13	0.07	0.06	0.01	0.01
(MP19) JTC BEDOK F. F.	0.14	0.12	0.06	0.06	0.01	0.01
(MP20) SINGAPORE O. P. S.	0.24	0.21	0.11	0.10	0.02	0.01

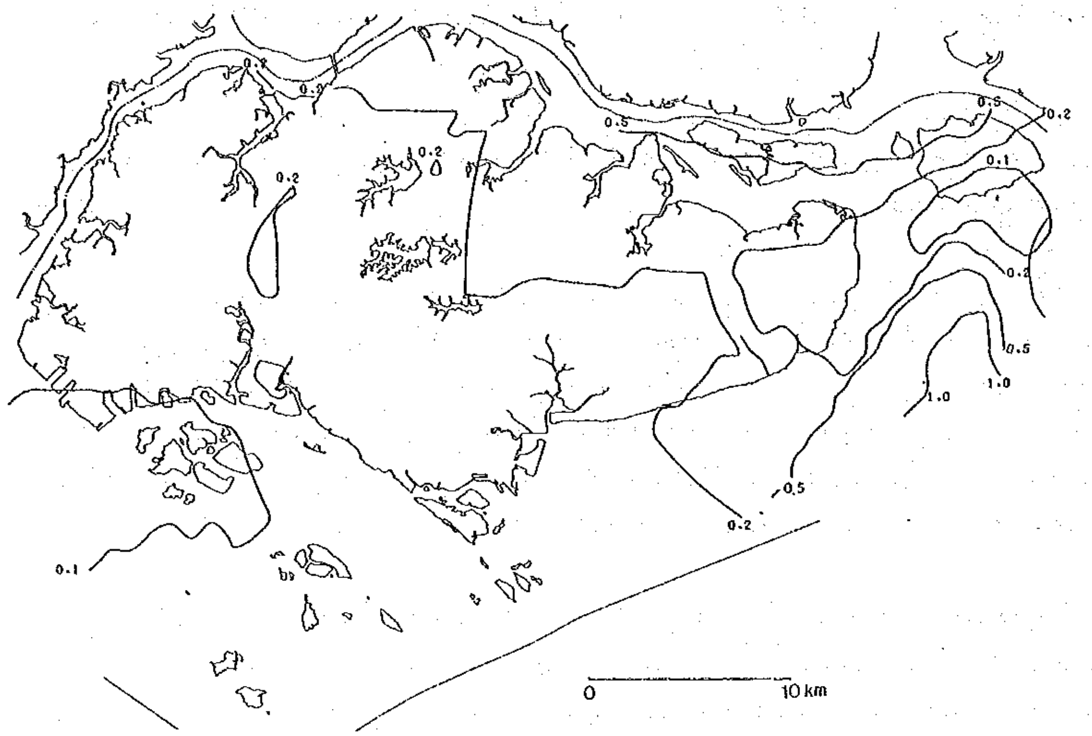


Fig. VI-2-8 Contour of TPM concentration effected by newly-established factories (unit μg/m³)

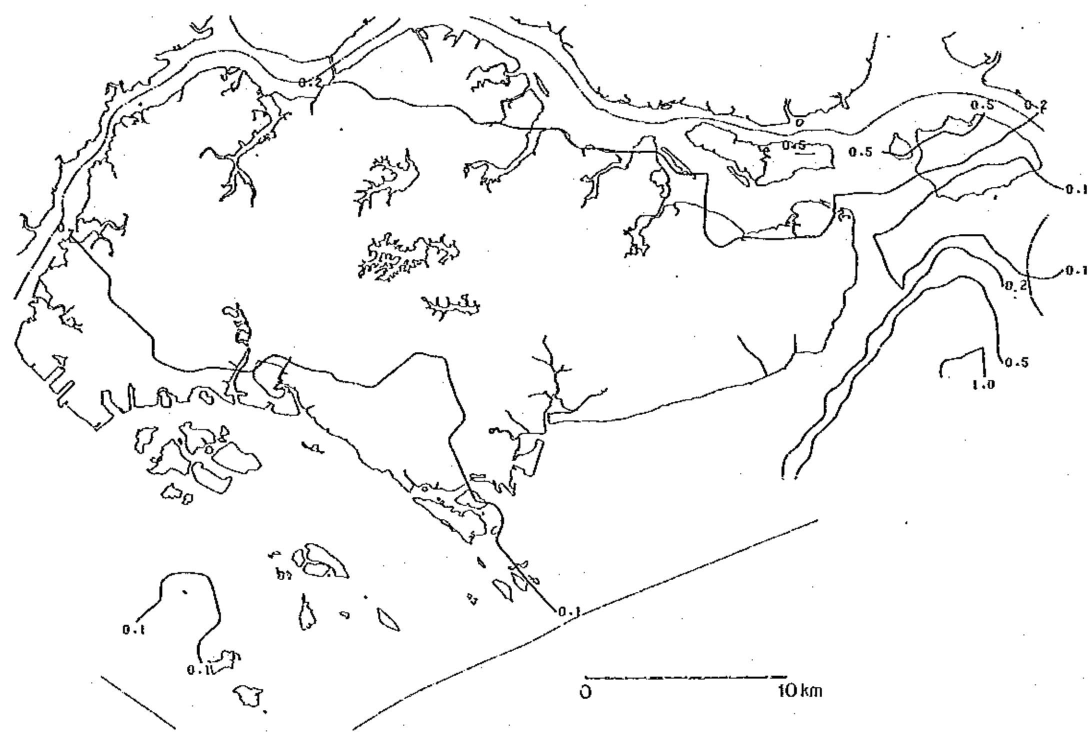


Fig. VI-2-9 Contour of SPM concentration effected by newly-established factories (unit μg/m³)

CHAPTER 3 PREDICTED CONCENTRATIONS OF TPM AND SPM IN FUTURE

We estimated the concentrations of TPM and SPM in future, using the measured data and calculated data.

At twenty monitoring stations, TPM and SPM concentrations were measured. Using these data, we calculated the concentrations at all mesh-points of square mesh. These values were regarded as the present concentrations. Then, using the diffusion model, we calculated the contributed concentrations by newly-established factories. We estimated the future concentrations of TPM and SPM with these two data. Here, we assumed that the present concentration will not change in future.

Table VI-3-1 shows the results at twenty stations. The contributions on the future concentration from newly-established factories are considered to be small. Similarly, the contour of the future concentrations are shown in Fig. VI-3-1 to VI-3-4. As the contributions by newly-established factories are small, the contours of the future concentrations do not differ from those of the present concentrations. The concentrations in all mesh are shown in the reference materials part.

Table VI-3-1 Predicted concentrations of TPM and SPM in future

(Unit; $\mu g/m^3$)

Monitoring stations	TPM			SPM		
	T1 Monitored concentration by high volume sampler	T2 Contributing concentration by new factories	T1 + T2 Future predicted concentration	S1 Monitored concentration by high volume sampler	S2 Contributing concentration by new factories	S1 + S2 Future predicted concentration
(MP1) J. T. C. HALL	68. 6	0. 14	68. 7	33. 9	0. 10	34. 0
(MP2) N. U. S.	53. 2	0. 12	53. 3	29. 5	0. 08	29. 6
(MP3) BUKIT MERAH F. F.	66. 7	0. 14	66. 8	31. 3	0. 10	31. 4
(MP4) BOON LAY APART	74. 2	0. 19	74. 4	39. 5	0. 15	39. 7
(MP5) JURONG HILL TOP	78. 2	0. 13	78. 3	34. 5	0. 09	34. 6
(MP6) NANYANG. T. I.	66. 4	0. 16	66. 6	33. 5	0. 12	33. 6
(MP7) BUKIT PANJANG P. P.	134. 6	0. 18	134. 8	55. 5	0. 14	55. 6
(MP8) LIM CHU KANG M. P. P.	69. 7	0. 17	69. 9	36. 4	0. 13	36. 5
(MP9) KRANJI SEWAGE T. P.	83. 3	0. 19	83. 5	39. 9	0. 15	40. 1
(MP10) SELETAR R. W. P. S.	54. 0	0. 20	54. 2	28. 0	0. 15	28. 2
(MP11) CHONG PANG P. P.	77. 9	0. 40	78. 3	40. 3	0. 30	40. 6
(MP12) NATIONAL. I. C.	69. 0	0. 15	69. 2	27. 4	0. 11	27. 5
(MP13) MACRITCHIE R. W. P. S.	57. 5	0. 15	57. 7	30. 2	0. 11	30. 3
(MP14) KALLANG F. F.	63. 3	0. 17	63. 5	33. 3	0. 11	33. 4
(MP15) EAST COAST S. LAGOON	44. 7	0. 22	44. 9	22. 2	0. 13	22. 3
(MP16) ANG MO KIO F. F.	72. 3	0. 23	72. 5	34. 0	0. 16	34. 2
(MP17) PAYA LEBAR P. S.	93. 1	0. 18	93. 3	42. 8	0. 12	42. 9
(MP18) CHANGI. C. CENTER	63. 5	0. 19	63. 7	32. 4	0. 13	32. 5
(MP19) JTC BEDOK F. F.	62. 6	0. 19	62. 8	30. 8	0. 13	30. 9
(MP20) SINGAPORE O. P. S.	63. 4	0. 26	63. 7	24. 5	0. 21	24. 7

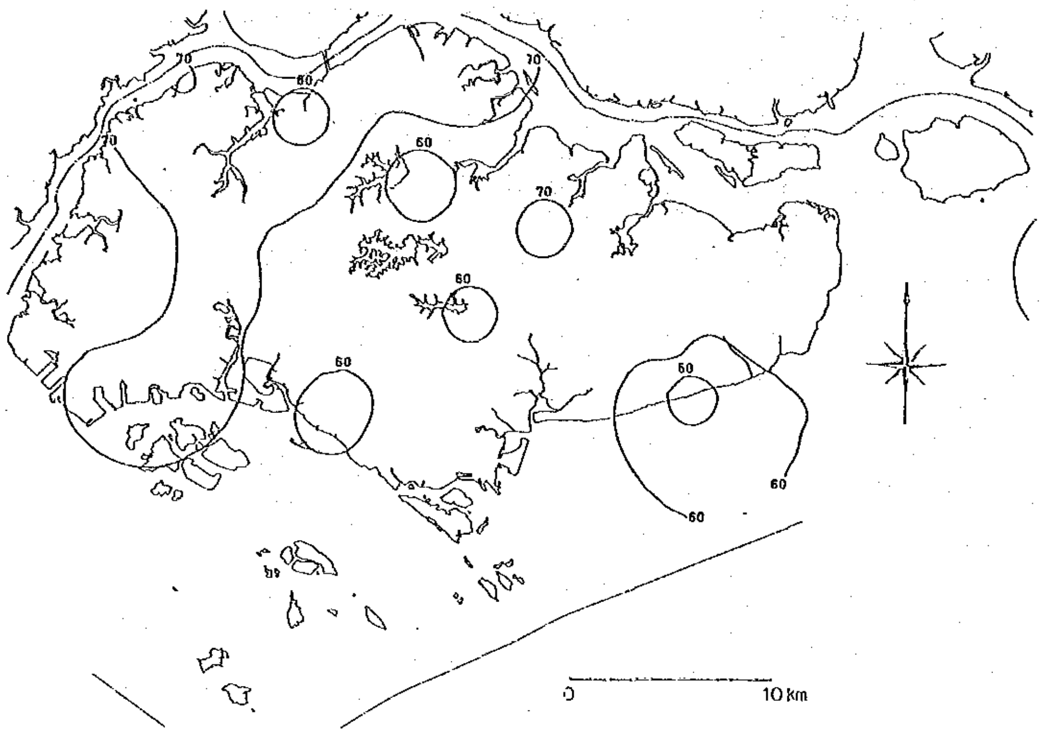


Fig. VI-3-1 TPM concentration in future (estimated by weighted average method)(unit; μg/m^3)

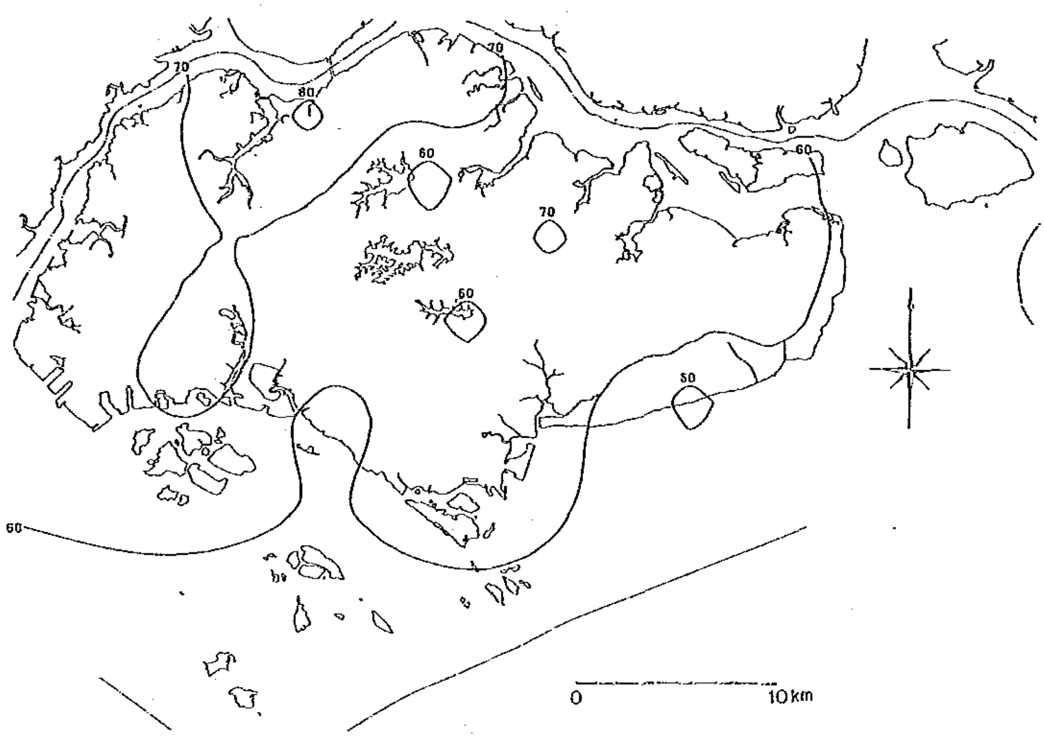


Fig. VI-3-2 TPM concentration in future (estimated by two-dimensional spline method) (unit; μg/m^3)

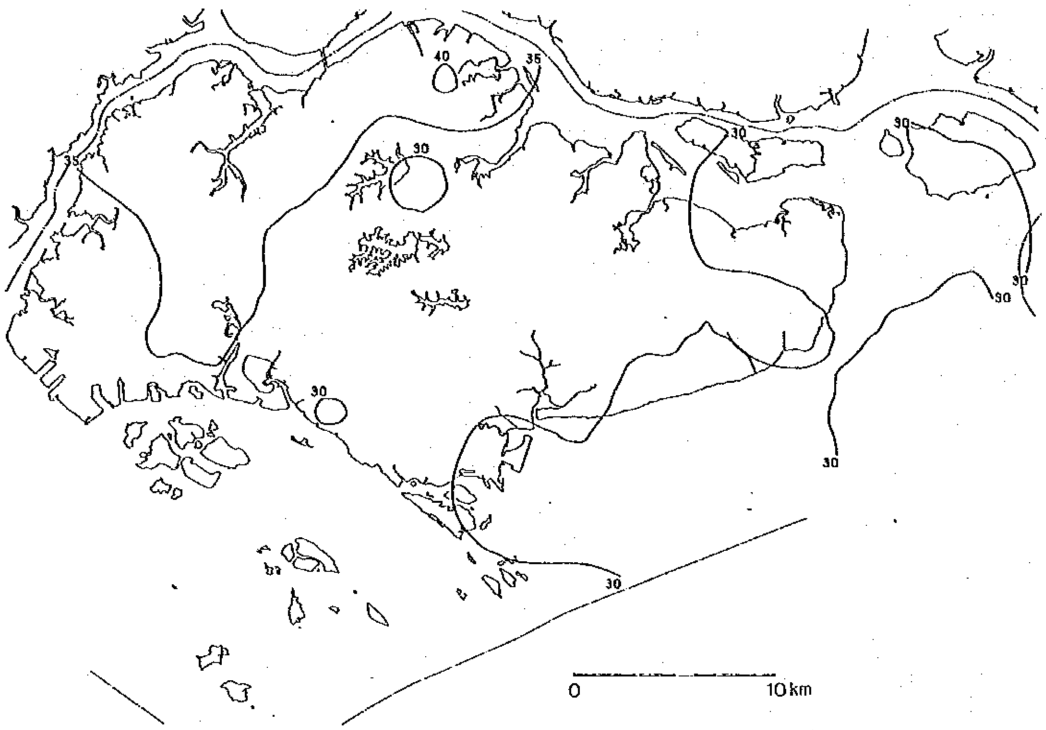


Fig. VI-3-3 SPM concentration in future (estimated by weighted average method)(unit; μg/m^3)

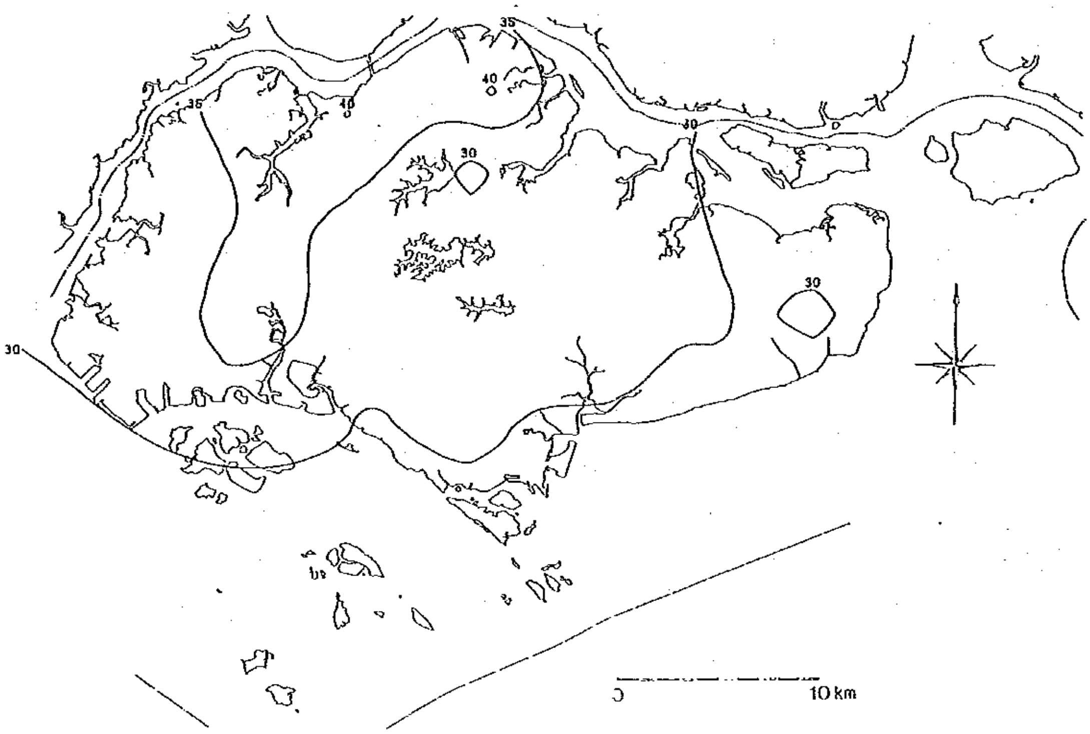


Fig. VI-3-4 SPM concentration in future (estimated by two-dimensional spline method) (unit; μg/m^3)

PART VII

ESTIMATION OF EMISSION SOURCES OF PARTICULATE MATTERS AND CONTRIBUTION RATES ON PARTICLE CONCENTRATIONS FROM EACH EMISSION SOURCE

PART VII ESTIMATION OF EMISSION SOURCES OF PARTICULATE MATTERS AND CONTRIBUTION RATES ON PARTICLE CONCENTRATIONS FROM EACH EMISSION SOURCE

As mentioned in PART VI, the effects of particulate matters emitted from the newly-established facilities (coal firing power stations and integrated steel mill) to the concentrations in the air are less than 1% of the total concentration. In this part, we analyzed how the emission sources except the newly-established facilities give effects to the concentrations of particulate matters in the air. In this analysis, we estimated the emission sources by principal component analysis and estimated the contribution rates of each emission source (for example, soil, sea-salt particle, gasoline automobile, petroleum combustion, steel mill, wastes incineration, cement) by CMB method (chemical mass balance method). And in this analysis, we used the receptor model, which is described at II-4-2.

CHAPTER 1 IDENTIFICATION OF EMISSION SOURCES ON PARTICULATE MATTERS BY PRINCIPAL COMPONENT ANALYSIS

We performed four short term field surveys in the year, and measured thirty-seven chemical components concentrations in particulate matters and total particulate matters (TPM) in twenty monitoring stations. So using these data, we identified the emission sources of each particulate matter in each short term survey.

At first, we analyzed the relationships among the concentrations in different stations by principal component analysis. Here the input data were correlation matrix, which were calculated among twenty stations. Hereinafter we referred this method as to method I. Secondary, using the correlation matrix which were calculated among chemical components concentrations, we performed principal component analysis. Hereinafter, we referred this method as to method II. Table VII-1-1 shows the variables for each method.

The concentrations of Cd (Cadmium) are measured by two different technique - i.e. instrument neutron activate analysis (INAA) and X-ray flourescence analysis (XRF). As the accuracy of the former method is not good, we adopted the concentrations measured by XRF. When a concentration is under a measurable limit, 10% of such data is adopted.

Table VII-1-1 The variables and data in method I and II

Method	Variable	Variable number	Data	Data number	Duration
I	Station	20	Chemical component	37	Each short term survey
II	Chemical component	37	Station	20	Each short term survey

VII-1-1 Summary of Principal Component Analysis

Principal component analysis is a multivariate technique for examining relationships among several quantitative variables (X_1, X_2, --- X_p). It is used for summerizing data and detecting linear relationships (as already mentioned at V-1-1-7).

The values of chemical components concentrations spread in wide range. For example, the order of Al concentrations is 10^2 - 10^3, on the other hand, the order of Ag is 10^{-3} - 10^{-4}. Thus using these data, the correlation coefficients are decided only by the components whose order are big. So we standardized these data as follows:

$$Z\alpha i = \frac{X\alpha i - \overline{X\alpha}}{S\alpha} \qquad \text{Equation VII-1-1}$$

where;

$Z\alpha i$: Standardized concentration of component α at station i

$X\alpha i$: Concentration of component α at station i

$\overline{X\alpha}$: Average concentration of twenty stations

$S\alpha$: Standard deviation of twenty stations

VII-1-2 Results of the Analysis

VII-1-2-1 Results of method I

Table VII-1-2 shows the correlation coefficients matrix among the concentrations of different stations in the 1st survey. And Table VII-1-3 and VII-1-4 show the results of principal components analysis using the matrix. Table VII-1-3 shows the eigen values and loading factor of each principal component. And Table VII-1-4 shows the scores of each principal component. Fig. VII-1-1 is scatter of loading factors about 1st and 2nd principal components. Fig. VII-1-2 is scatter of scores about 1st and 2nd principal components. For the remaining survey, the results are shown in Table VII-1-5 to VII-1-13 and Fig. VII-1-3 to VII-1-8.

Table VII-1-2 Correlation coefficient matrix by method I (1st survey)

	MP01	MP02	MP03	MP04	MP05	MP06	MP07	MP08	MP09
MP01	1.000000								
MP02	-0.273694	1.000000							
MP03	-0.383574	0.276226	1.000000						
MP04	0.320910	-0.387026	-0.223139	1.000000					
MP05	-0.034900	0.281547	0.371565	0.039562	1.000000				
MP06	0.100834	0.080858	0.097354	0.112408	0.083295	1.000000			
MP07	0.021918	-0.487152	-0.157383	0.174422	-0.395410	-0.371318	1.000000		
MP08	-0.288099	0.531508	-0.152357	-0.321550	0.066719	0.028119	-0.254556	1.000000	
MP09	-0.298247	0.560039	0.395604	-0.306515	0.446783	-0.014343	-0.422952	0.444591	1.000000
MP10	-0.305067	-0.185106	-0.040572	-0.112646	-0.091348	-0.324094	0.125094	0.114240	0.068519
MP11	-0.134373	-0.200997	-0.265373	-0.156387	-0.560110	-0.203279	0.241538	-0.009737	-0.275397
MP12	-0.018332	0.006070	0.006937	-0.295468	0.002569	0.113233	-0.104492	-0.136910	-0.210842
MP13	-0.120450	0.315952	0.499055	-0.043182	0.213109	0.226730	-0.015963	-0.214118	-0.027807
MP14	0.072957	-0.049379	0.085503	-0.211247	-0.076187	0.102051	-0.201690	-0.038605	-0.095399
MP15	0.280509	0.263232	-0.171310	-0.207060	-0.053677	-0.098984	-0.197314	0.170856	0.179984
MP16	-0.283252	0.331283	-0.034433	-0.023490	-0.061714	0.364587	-0.188855	0.361910	-0.023086
MP17	-0.142503	-0.437070	-0.094131	-0.022618	-0.458020	-0.116592	0.421317	-0.471559	-0.435214
MP18	-0.175615	0.297784	0.125648	-0.360865	0.144244	-0.244457	-0.242567	0.169055	0.192526
MP19	0.025905	-0.075272	-0.074576	0.030723	-0.174726	-0.086892	-0.224106	-0.158081	-0.048242
MP20	0.027342	-0.175375	-0.277293	0.026116	-0.257518	-0.292743	-0.003927	-0.008904	0.000858

	MP10	MP11	MP12	MP13	MP14	MP15	MP16	MP17	MP18
MP10	1.000000								
MP11	0.232541	1.000000							
MP12	-0.315081	-0.169004	1.000000						
MP13	-0.230651	0.035278	-0.077640	1.000000					
MP14	-0.158150	-0.081662	0.386043	-0.101162	1.000000				
MP15	-0.073224	-0.326218	0.172207	-0.301603	-0.077018	1.000000			
MP16	-0.120735	-0.039284	-0.230918	0.362230	0.003880	-0.131961	1.000000		
MP17	0.128079	0.406323	0.134173	0.050893	-0.143314	-0.377611	-0.061645	1.000000	
MP18	-0.087312	-0.188411	-0.067515	-0.210755	0.142072	0.215792	-0.034788	-0.323299	1.000000
MP19	-0.079125	0.206153	-0.074638	-0.234107	-0.285893	0.183303	-0.176880	0.084107	0.135588
MP20	0.145263	0.131275	-0.314990	-0.382828	-0.224300	0.107781	-0.182105	-0.128953	0.411136

	MP19	MP20
MP19	1.000000	
MP20	0.250302	1.000000

Table VII-1-3 Factor loading by method I (1st survey)

Principal component	1	2	3	4	5	6	7	8
MP01	-0.266650	0.021652	-0.739495	-0.227094	0.103948	-0.043737	-0.062629	0.169064
MP02	0.808049	0.024045	0.189772	0.043907	0.182129	0.151638	-0.175526	0.250209
MP03	0.457233	-0.385668	0.243256	0.085689	-0.583199	0.194616	0.079046	-0.004894
MP04	-0.377249	-0.191580	-0.322130	-0.687348	-0.017326	-0.092644	0.116816	-0.100982
MP05	0.605612	-0.193170	-0.177114	-0.289688	-0.463231	-0.150764	-0.009687	-0.124685
MP06	0.236549	-0.517024	-0.247539	-0.145365	0.414226	0.177778	0.047194	-0.357278
MP07	-0.661603	-0.068254	0.207191	-0.002733	-0.156292	-0.316020	-0.077125	0.470511
MP08	0.541323	0.328429	0.286630	-0.013171	0.502716	-0.319915	-0.127595	-0.037996
MP09	0.728494	0.224881	0.205394	-0.126752	-0.226744	-0.075103	-0.194038	-0.167625
MP10	-0.181972	0.322256	0.517953	-0.055106	-0.180286	-0.400520	-0.133497	-0.340124
MP11	-0.509741	0.109142	0.516801	0.174807	0.258744	0.214595	-0.023735	-0.078723
MP12	0.034323	-0.234582	-0.404504	0.734182	-0.021571	0.014049	-0.221330	-0.062186
MP13	0.207025	-0.705731	0.280506	-0.145060	-0.084034	0.268961	0.009447	0.367206
MP14	0.122447	-0.193682	-0.283744	0.602397	0.102965	-0.266251	0.471244	-0.180355
MP15	0.273828	0.484887	-0.445926	0.108294	0.118068	0.040194	-0.435620	0.276114
MP16	0.289629	-0.319221	0.323828	-0.190737	0.646476	0.057346	0.201298	0.120986
MP17	-0.673377	-0.265507	0.312638	0.268059	-0.074466	0.199566	-0.153639	-0.050218
MP18	0.394443	0.516208	-0.012696	0.213936	-0.161213	0.189260	0.518616	0.238383
MP19	-0.149494	0.389642	-0.083467	-0.072115	-0.037842	0.756460	-0.164169	-0.262820
MP20	-0.182268	0.709908	0.030493	-0.186790	-0.031306	0.175145	0.399805	0.057972
VP	3.935037	2.690345	2.273416	1.816952	1.682525	1.366907	1.116008	1.011301
PERCENT	19.7%	13.5%	11.4%	9.1%	8.4%	6.8%	5.6%	5.1%
CUM PCT	19.7%	33.1%	44.5%	53.6%	62.0%	68.8%	74.4%	79.5%

Table VII-1-4 Score of principal component by method I (1st survey)

Principal component	1	2	3	4	5	6	7	8
AG	-1.3953	-0.1986	-0.3649	1.3479	-0.5132	-0.8176	-1.3047	-0.1521
AL	-1.1914	0.5778	-0.0520	-0.6912	-0.4335	0.0687	-0.0425	0.2501
AS	0.1117	-1.5143	0.3839	-1.3162	1.8102	-0.1524	1.0839	-1.8526
BA	0.8115	1.8682	0.5690	-0.3870	0.1534	1.4750	2.6467	0.1273
BR	-0.0619	-0.3103	1.3011	1.5764	-0.8751	1.0681	-0.6290	1.1930
CA	-0.2597	-0.0202	-1.0773	-0.2181	-0.8041	-0.4953	0.0752	-0.7152
CE	-1.1846	0.2402	-0.8551	-0.7492	-0.3399	0.4320	-0.1463	0.2893
CL	1.4879	0.7118	-2.3249	1.2779	0.3190	0.2443	0.5396	0.7399
CO	0.2420	-0.5630	0.0618	0.1640	-0.4688	-0.5238	1.3861	3.4229
CR	-0.2754	-1.7494	-0.2770	0.6622	1.2594	0.8573	1.5040	-1.1214
CS	-0.3557	0.2475	1.0390	-0.9493	-0.7199	-0.0043	0.4335	0.0479
CU	0.9472	1.4271	2.0578	0.4078	0.8421	-2.0038	-0.4361	0.8626
FE	-1.1470	-0.2710	0.3667	-0.0507	-0.7141	-0.5325	-0.0191	0.3836
HF	-1.1718	0.6279	0.5109	-0.0236	1.0006	-1.0833	0.3324	0.4627
K	0.4856	0.3699	1.6684	0.1950	-0.8201	-0.7983	-0.4250	-1.4176
LA	-0.7883	1.2652	1.2532	-0.0413	0.6122	3.2557	0.1313	-1.3888
LU	-0.7134	0.4208	-1.0733	-0.7911	0.6728	0.0416	-0.1760	1.0596
MN	-0.9885	-0.3010	-0.5774	0.1124	-0.4757	-0.5675	0.2445	-0.3546
NA	1.8214	2.9184	-0.1676	-0.3380	0.1380	0.0705	-1.9830	-0.4793
NI	1.7613	-0.5233	-0.0302	-0.3331	-1.4341	0.8966	0.7670	-0.7001
SB	0.1394	-0.6871	-0.2493	2.7019	-0.4233	-0.2454	-0.1082	-0.7963
SC	-1.0137	0.1872	-0.1627	-0.4973	-0.3775	-0.2601	-0.2525	0.7552
SE	1.1348	0.6059	0.7750	0.4092	2.2019	-1.9833	0.4987	-0.4660
SM	-1.0775	0.7195	-0.6351	-0.8233	-0.6272	0.7489	0.2658	0.0954
TH	-1.2387	0.3625	0.6318	-0.2178	-0.1723	-0.0006	-0.2605	-0.4916
TI	-0.7888	0.0175	-0.4309	-0.5301	0.0737	-1.7661	0.3463	-0.7530
V	1.9840	-1.9015	1.1212	-1.5262	-1.1417	0.4221	-0.2003	1.3690
W	0.4499	-0.0894	-0.8290	0.7640	0.6579	-0.6669	1.9600	-0.2969
ZN	-0.2150	-1.4169	0.3580	2.1075	0.0733	0.2008	-0.0604	-0.3097
CDK	-0.0937	-1.3428	-0.1194	-0.8943	3.5684	1.3349	-2.1090	1.6135
PBK	0.1752	-0.0257	1.0383	1.9893	-0.0624	1.3356	-1.1361	0.2797
SK	0.9304	-1.2922	0.3728	-0.9405	-1.1088	-0.1270	-0.5180	0.0551
SIK	-1.0071	0.5132	-0.3306	-0.8041	-0.4192	0.1481	0.1342	0.2238
CLI	0.9500	0.7358	-2.3041	0.5239	-0.0564	0.4133	0.3931	0.5646
NO3I	0.9080	-0.4162	-2.0097	-0.5039	-0.1687	-0.0215	-2.2436	-1.2829
SO4I	1.3098	-0.8462	0.0965	-1.2878	-0.5616	-0.4975	-0.3474	-0.9037
TPM	-0.6822	-0.3475	0.0649	-0.3253	-0.6655	-0.4659	-0.3444	-0.3135
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

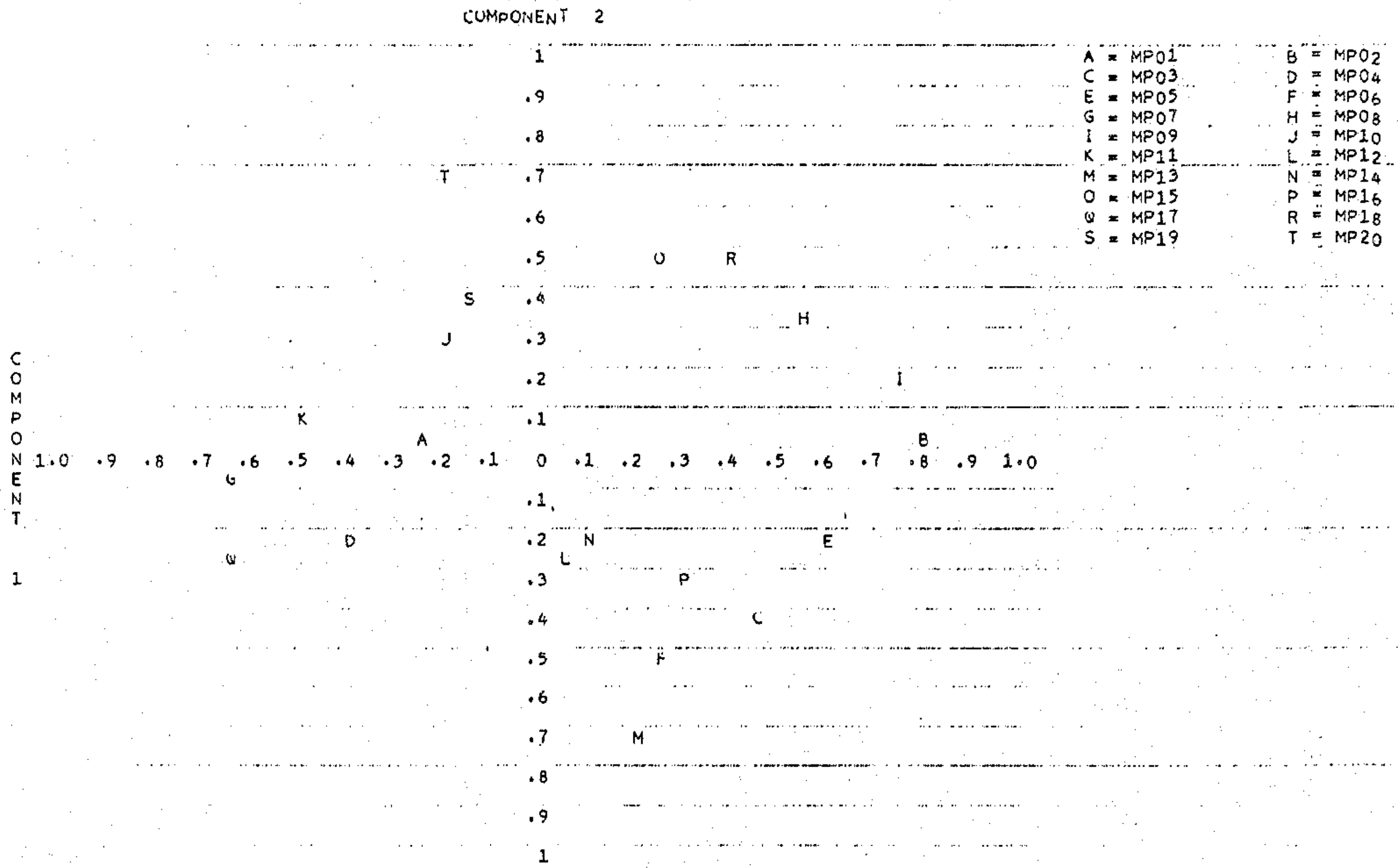


Fig. VII-1-1 Distribution of factor loading by method I (1st survey)

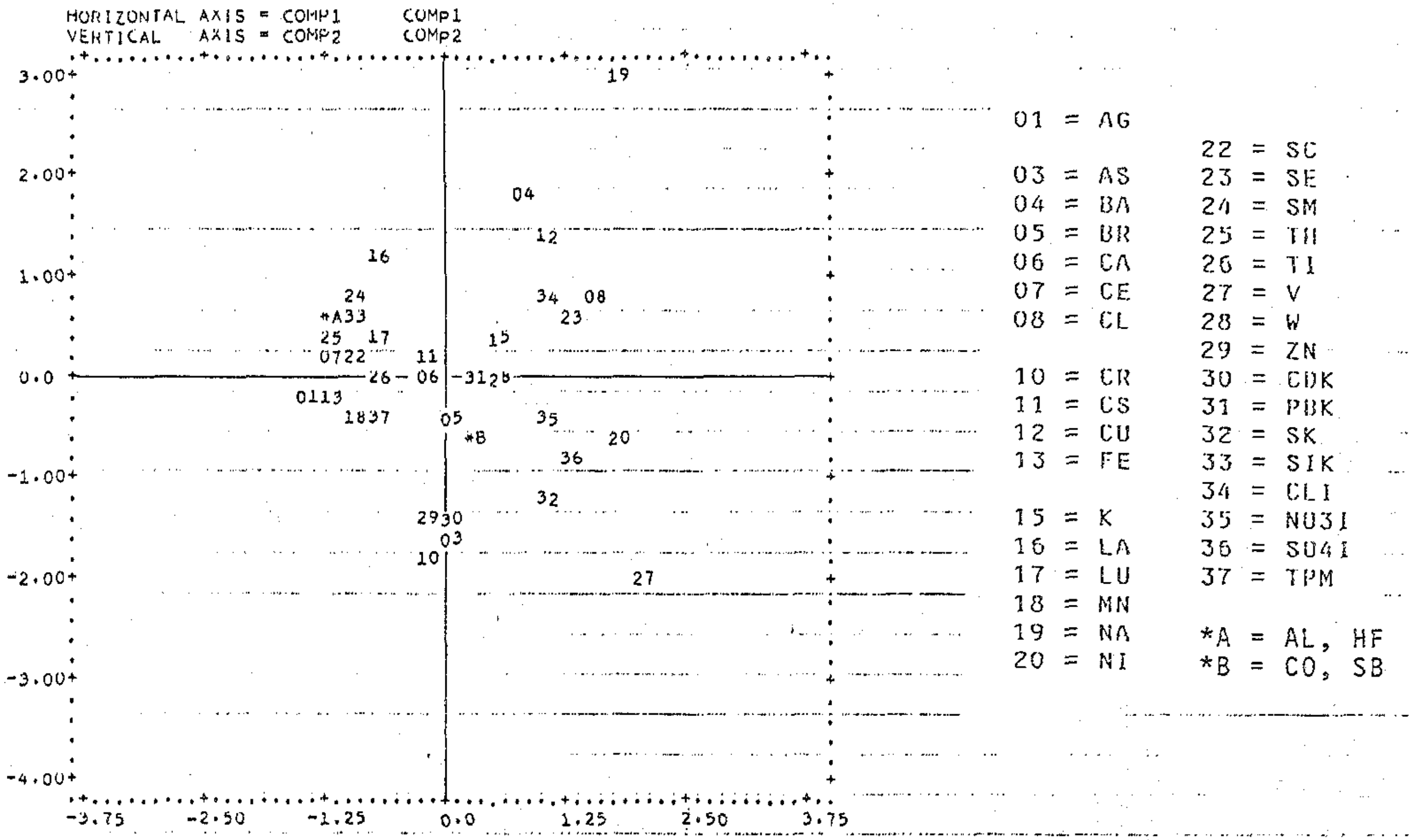


Fig. VII-1-2 Distribution of scores by method I (1st survey)

Table VII-1-5 Correlation coefficient matrix by method I (2nd survey)

	MP01	MP02	MP03	MP04	MP05	MP06	MP07	MP08	MP09
MP01	1.000000								
MP02	0.256897	1.000000							
MP03	0.111669	0.230823	1.000000						
MP04	0.002830	0.110813	0.422167	1.000000					
MP05	0.012918	0.035770	0.552125	0.818649	1.000000				
MP06	0.031062	-0.077378	-0.294649	-0.348216	-0.295544	1.000000			
MP07	-0.419988	0.030449	-0.370488	-0.336003	-0.370665	0.074212	1.000000		
MP08	-0.302455	-0.359300	-0.109936	-0.035062	0.062360	0.372647	0.013611	1.000000	
MP09	0.044030	-0.271875	-0.158280	0.087805	-0.032972	0.118535	0.134646	0.344818	1.000000
MP10	-0.236669	-0.253487	0.003420	-0.134306	-0.084976	-0.086179	-0.040170	0.213513	-0.041222
MP11	-0.252099	-0.276526	-0.477060	-0.223746	-0.399589	0.306036	0.446690	0.393740	0.329783
MP12	0.067962	-0.196746	-0.222949	-0.328135	-0.351793	-0.030503	-0.272035	-0.212741	-0.321259
MP13	-0.309302	-0.002222	-0.207262	0.039593	0.022620	-0.292961	0.193459	-0.385015	-0.296856
MP14	-0.178755	0.024711	0.044446	0.141175	0.212002	-0.373391	-0.285011	-0.216920	-0.462851
MP15	0.295169	-0.242194	-0.157090	-0.186831	-0.270910	-0.122846	-0.293486	-0.198575	-0.075916
MP16	-0.178625	-0.250349	-0.281293	-0.208070	-0.332452	-0.042562	0.106595	-0.099419	-0.030678
MP17	-0.380692	0.141569	0.091652	-0.178698	0.025039	-0.047299	0.161669	-0.098310	-0.389618
MP18	-0.006204	0.217006	0.574444	0.457407	0.553515	-0.429901	-0.291981	-0.446342	-0.116765
MP19	0.426936	0.236103	0.196740	-0.211675	-0.177444	-0.038190	-0.255488	-0.308452	-0.277689
MP20	0.263886	0.387542	-0.074459	-0.025274	0.003109	-0.133870	0.020736	-0.426753	-0.079033

	MP10	MP11	MP12	MP13	MP14	MP15	MP16	MP17	MP18
MP10	1.000000								
MP11	0.158472	1.000000							
MP12	-0.219861	-0.288454	1.000000						
MP13	0.025820	-0.026323	0.087826	1.000000					
MP14	-0.015714	-0.194188	0.212993	0.503815	1.000000				
MP15	-0.280292	-0.207803	0.611962	-0.184116	0.048220	1.000000			
MP16	-0.255589	-0.053145	0.585859	-0.137925	0.085746	0.445017	1.000000		
MP17	0.360088	-0.051294	-0.115522	0.505063	0.172443	-0.421369	-0.348541	1.000000	
MP18	0.059766	-0.515422	-0.214258	0.371929	0.328927	-0.318649	-0.292645	0.321788	1.000000
MP19	-0.157853	-0.313748	0.107809	-0.300048	-0.086564	0.253177	-0.146081	-0.230706	-0.044406
MP20	-0.257710	-0.336967	0.110392	-0.000068	-0.104161	0.087091	0.243749	-0.019940	0.153844

	MP19	MP20
MP19	1.000000	
MP20	-0.055998	1.000000

Table VII-1-6 Factor loading by method I (2nd survey)

Principal component	1	2	3	4	5	6	7
MP01	0.159569	0.531948	-0.475679	-0.309454	-0.077861	-0.264153	-0.057032
MP02	0.408889	0.118775	-0.031709	-0.683158	0.162794	0.076468	0.275289
MP03	0.686943	-0.062598	-0.358269	0.020640	-0.207060	0.228112	-0.093257
MP04	0.616993	-0.227310	-0.372817	0.371582	0.321818	-0.096814	0.162255
MP05	0.715946	-0.284210	-0.348219	0.337394	0.145529	0.106067	0.163038
MP06	-0.544648	-0.092072	-0.217279	-0.240039	-0.172901	0.318724	0.419326
MP07	-0.448168	-0.348439	0.327815	-0.362987	0.414633	-0.071427	-0.039387
MP08	-0.470162	-0.467394	-0.364314	0.334309	-0.197905	0.275046	0.192179
MP09	-0.363537	-0.256321	-0.514639	0.136720	0.402220	-0.193403	-0.314304
MP10	-0.050653	-0.470265	0.140967	0.055616	-0.492048	0.078174	-0.562792
MP11	-0.674370	-0.457537	0.018204	-0.017598	0.067234	-0.335304	0.111347
MP12	-0.157490	0.710770	0.390815	0.314815	-0.137650	0.190696	0.031570
MP13	0.290957	-0.219473	0.763803	0.033000	0.132183	-0.319179	0.093699
MP14	0.427681	0.069784	0.520658	0.385852	-0.134539	-0.206164	0.320571
MP15	-0.192778	0.775657	0.001357	0.325868	-0.073014	-0.133867	-0.108605
MP16	-0.347733	0.519636	0.265193	0.379130	0.349227	0.299575	-0.072199
MP17	0.255608	-0.457589	0.579399	-0.278782	-0.259106	0.266816	-0.060240
MP18	0.847932	-0.172676	0.090349	0.007807	0.084147	0.004087	-0.206084
MP19	0.125500	0.514597	-0.239805	-0.375103	-0.479619	-0.247680	0.016708
MP20	0.197801	0.387496	0.093180	-0.356613	0.558281	0.329943	-0.203321
VP	4.155502	3.362039	2.675936	1.982700	1.647318	1.016388	1.000148
PERCENT	20.8%	16.8%	13.4%	9.9%	8.2%	5.1%	5.0%
CUM PCT	20.8%	37.6%	51.0%	60.9%	69.1%	74.2%	79.2%

Table VII-1-7 Score of principal component by method I (2nd survey)

Principal component	1	2	3	4	5	6	7
AG	0.7941	0.9177	1.5804	3.4661	-0.1746	0.1800	1.9090
AL	-1.1108	-1.0324	0.0015	-0.0783	0.5709	0.4022	0.3233
AS	-0.9336	0.2255	-0.5151	0.6899	0.1196	-1.1200	-1.5466
BA	0.0414	0.1005	-1.3895	0.2264	-1.1258	1.2082	1.9030
BR	2.0881	-0.7534	1.8914	-0.7468	1.4652	-0.5592	-0.0394
CA	0.2082	0.3750	0.3408	-1.6599	0.1540	-0.0469	0.1426
CE	-1.2968	-0.4078	-0.0462	-0.2510	-0.0124	0.6558	0.5855
CL	1.0683	1.5031	-1.1841	-0.0456	0.9533	0.7713	-0.5558
CO	-0.4762	1.2494	0.1069	-0.8279	0.2326	1.2273	1.2127
CR	-0.5307	0.8886	0.2247	0.0506	0.0257	-0.3434	-0.7151
CS	-0.5483	-1.6373	-0.6140	0.5827	0.4556	-1.7713	-1.1829
CU	0.8737	-1.7021	0.4642	-0.9072	-3.2279	1.7448	-1.0821
FE	-0.4444	0.0791	0.1853	-0.4731	-0.5919	-0.0559	0.3521
HF	-0.7291	-0.7835	0.4284	-1.0732	0.0948	-0.4935	1.5979
K	0.4931	-0.9841	-1.2203	1.5371	0.4117	-1.9636	1.2662
LA	-0.9546	-0.0692	0.2422	-0.9061	-0.5719	0.7601	0.6901
LU	0.2100	-0.9302	1.6575	1.3382	-0.6005	1.9030	0.1849
MN	0.2381	0.4175	0.0938	-0.5283	-0.9913	-0.5908	-0.2664
NA	2.0411	-1.1045	-1.7692	1.1816	0.7432	1.9719	-1.3920
NI	2.5408	0.1194	-1.4443	-0.4654	-0.3140	-1.7838	0.5177
SB	-0.0374	-0.5262	1.0671	0.3661	-1.0583	-0.1709	-2.6542
SC	-0.5878	-0.6500	0.2906	-0.4336	0.5929	0.2826	-0.0818
SE	-0.4151	1.2046	0.0333	1.6450	-1.6747	-0.5596	-0.5176
SM	-1.4397	-0.5066	-0.2825	-0.4223	0.0286	-0.1882	0.6848
TH	-1.3245	-0.9711	-0.0317	0.3698	0.5421	-0.8012	0.0636
TI	-0.3259	-0.3206	0.5984	-0.1751	1.1098	-0.4987	-0.9448
V	0.2814	1.5448	-0.3088	-1.3371	-0.6539	-1.0331	-0.8137
W	-0.2254	1.9019	0.6098	1.0860	0.3879	0.1160	-0.3889
ZN	0.1482	0.8536	0.1926	-0.0193	-1.2217	-0.7953	-0.4703
CDx	0.7647	-0.8435	-1.9179	0.0042	-0.4583	-0.0110	1.3662
PBx	1.6864	-0.2581	2.9226	-1.0179	0.8730	-0.7535	0.9265
SK	-0.2791	0.0879	-0.6639	-0.7019	-0.3403	-0.4225	0.2688
SIx	-1.1348	-0.8634	-0.3056	-0.2520	0.7337	0.3133	0.3386
CLI	0.9334	1.6454	-0.8569	-1.2798	0.9747	1.2200	-0.2034
NO3I	-1.1006	1.3520	-0.1337	0.3960	1.9537	1.2977	-0.8302
SO4I	-0.6066	1.1311	0.1120	0.2007	-0.9887	-0.8016	0.1073
TPM	0.0905	-1.2534	-0.3599	0.4619	1.5833	0.7097	-0.7556
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

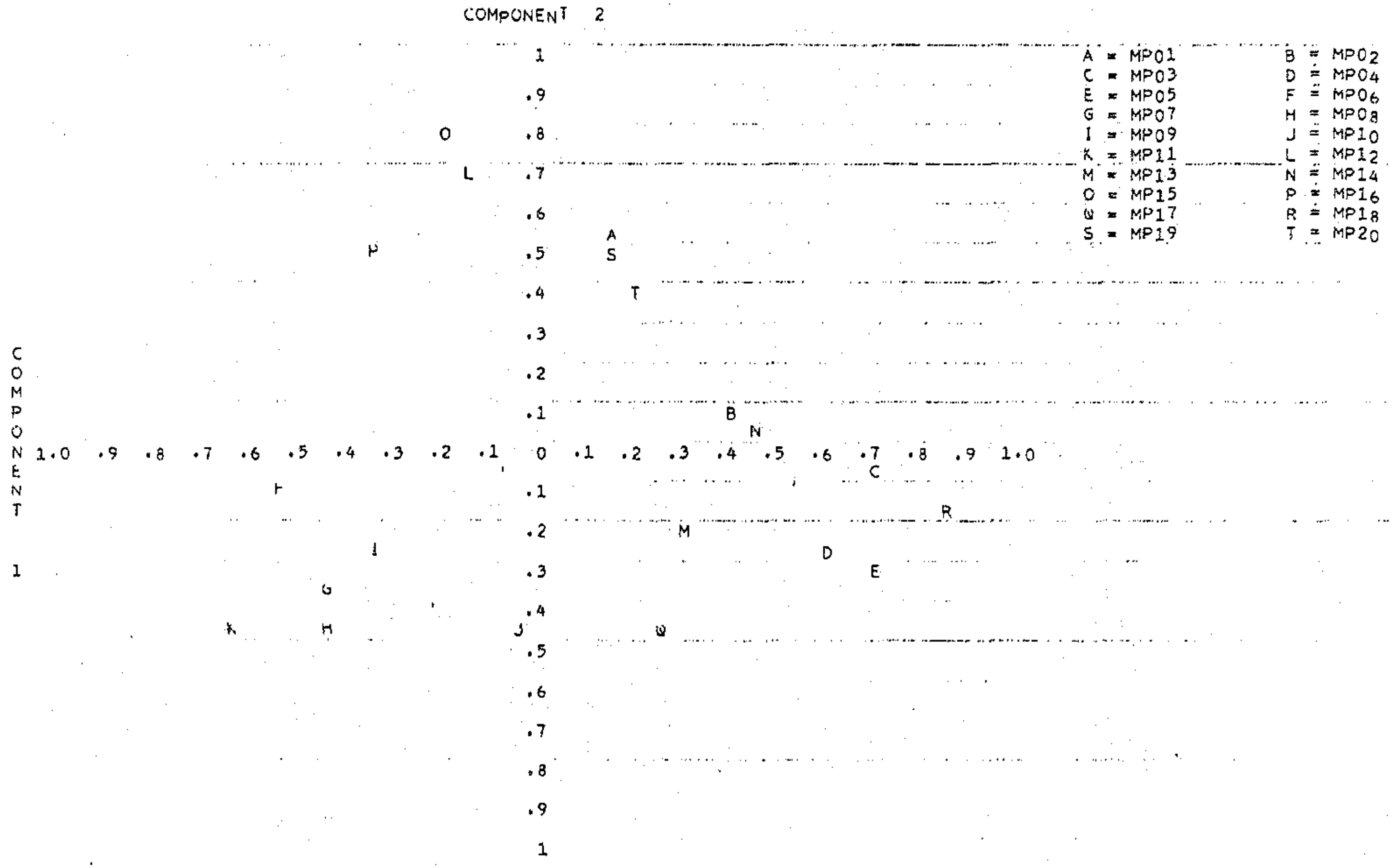
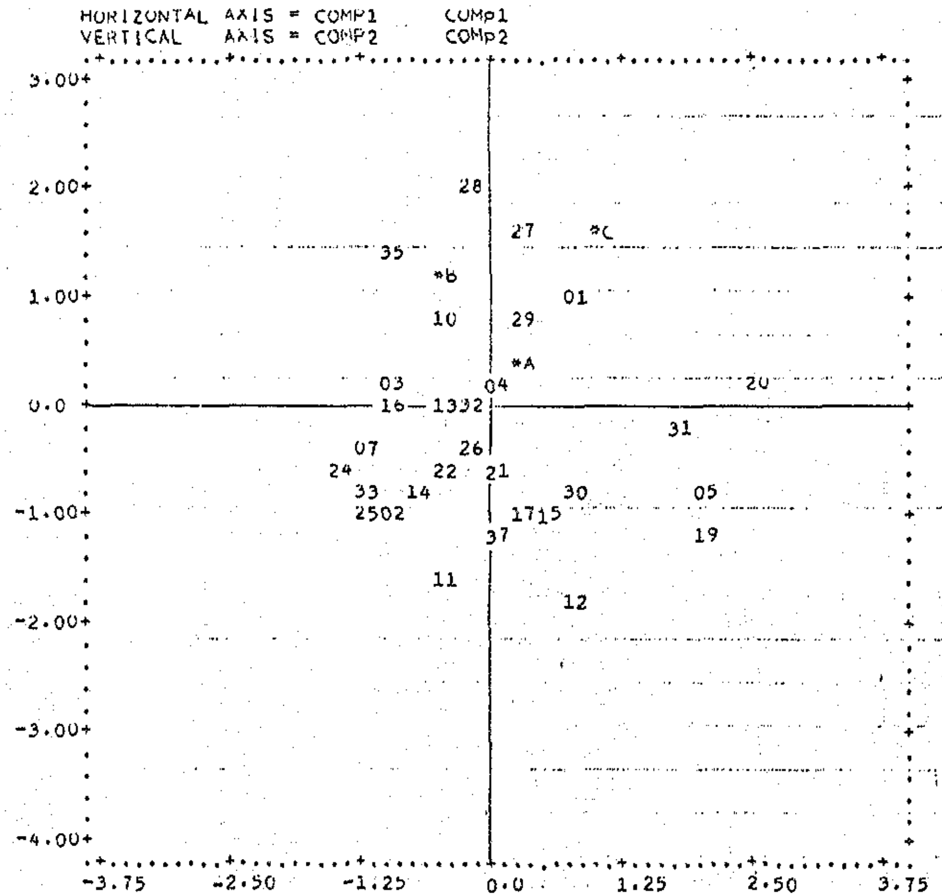


Fig. VII-1-3 Distribution of factor loading by method I (2nd survey)



01 = AG	21 = SB	11 = CS	31 = PBK
02 = AL	22 = SC	12 = CU	32 = SK
03 = AS		13 = FE	33 = SIK
04 = BA	24 = SM	14 = HF	
05 = BR	25 = TH	15 = K	35 = NO3I
	26 = TI	16 = LA	
07 = CE	27 = V	17 = LU	37 = TPM
	28 = W		
	29 = ZN	19 = NA	*A = CA, MN
10 = CR	30 = CDK	20 = NI	*B = CO, SE, SO4I
			*C = CL, CLI

Fig. VII-1-4 Distribution of scores by method I (2nd survey)

Table VII-1-8 Correlation coefficient matrix by method I (3rd survey)

	MP01	MP02	MP03	MP04	MP05	MP06	MP07	MP08	MP09
MP01	1.000000								
MP02	0.247910	1.000000							
MP03	0.250944	0.388963	1.000000						
MP04	0.261803	0.094783	0.439818	1.000000					
MP05	-0.013579	0.155831	0.253581	0.373842	1.000000				
MP06	0.215633	-0.067343	0.164106	0.077485	0.253734	1.000000			
MP07	-0.179869	-0.144615	0.044777	-0.291076	-0.407619	-0.447796	1.000000		
MP08	-0.190565	-0.374636	-0.575292	-0.464681	-0.334242	-0.051848	0.092125	1.000000	
MP09	-0.095936	-0.369561	-0.229371	-0.325346	-0.342488	-0.071268	0.473645	0.505579	1.000000
MP10	-0.193244	-0.008867	-0.320313	-0.080522	-0.306858	-0.182029	0.082952	0.364011	-0.129164
MP11	-0.266132	-0.367274	-0.334879	-0.410072	-0.253832	-0.277811	0.178216	0.261879	0.416566
MP12	-0.046157	0.510734	-0.075650	-0.094178	0.049246	0.177876	-0.083408	-0.010237	-0.340381
MP13	-0.304152	-0.291421	-0.315171	-0.124495	-0.157480	-0.241962	-0.029459	-0.031094	-0.064346
MP14	-0.014426	0.071773	-0.174497	0.141083	-0.227370	-0.225701	-0.331558	0.005855	-0.233949
MP15	0.188027	0.788107	0.238041	0.113427	0.195207	-0.082153	-0.243231	-0.316980	-0.563251
MP16	-0.150206	-0.392021	-0.196006	0.008750	-0.142455	-0.085119	0.109122	-0.101947	0.151219
MP17	-0.290896	-0.227703	-0.309307	-0.431703	-0.119115	-0.009579	-0.089809	0.083274	-0.000055
MP18	-0.342163	-0.155984	-0.327766	-0.308017	-0.212105	-0.256536	0.207396	0.060961	0.003307
MP19	-0.010347	-0.141979	-0.379814	-0.279892	-0.113419	0.003504	-0.409972	0.446071	-0.147389
MP20	-0.161703	-0.141686	-0.000990	-0.351356	-0.341138	-0.056549	0.076466	0.104512	0.143808

	MP10	MP11	MP12	MP13	MP14	MP15	MP16	MP17	MP18
MP10	1.000000								
MP11	-0.116387	1.000000							
MP12	0.201510	-0.189535	1.000000						
MP13	0.273970	0.168636	-0.267083	1.000000					
MP14	-0.112434	0.055483	-0.019677	-0.059662	1.000000				
MP15	-0.190392	-0.332078	0.499578	-0.253149	0.150141	1.000000			
MP16	-0.164684	0.156923	-0.493217	0.270947	0.101577	-0.460579	1.000000		
MP17	0.258197	-0.074498	-0.238278	0.597942	0.017181	-0.218160	0.115240	1.000000	
MP18	0.228302	-0.076329	0.025413	0.096987	0.058493	0.074644	-0.033560	0.417013	1.000000
MP19	-0.120249	0.245509	0.024114	-0.025817	0.450326	0.146257	-0.061284	0.042333	0.068758
MP20	0.004568	0.189576	-0.236045	-0.167861	0.037437	-0.236582	0.090838	0.038015	0.110708

	MP19	MP20
MP19	1.000000	
MP20	0.153399	1.000000

Table VII-1-9 Factor loading by method I (3rd survey)

Principal component	1	2	3	4	5	6	7
MP01	-0.446453	-0.207023	0.278727	0.103557	-0.048368	-0.135510	0.446742
MP02	-0.726595	0.361799	0.032076	-0.296541	0.219757	0.043448	-0.000841
MP03	-0.628418	-0.458272	-0.011628	-0.204094	0.174332	0.247671	0.096724
MP04	-0.586367	-0.382635	-0.220601	0.209896	0.088414	-0.417836	0.184297
MP05	-0.531627	-0.185655	-0.211518	0.237081	-0.304849	0.085172	-0.500260
MP06	-0.292583	-0.168613	0.113700	0.287997	-0.690270	0.339614	0.128969
MP07	0.387475	-0.266491	0.071663	-0.752746	0.254887	-0.062757	-0.062956
MP08	0.598699	0.303238	0.429602	0.013731	-0.382802	-0.233015	0.094664
MP09	0.638887	-0.418843	0.377807	-0.214016	-0.152917	-0.046599	-0.063589
MP10	0.261887	0.408221	-0.314246	-0.334907	-0.276069	-0.344572	0.425712
MP11	0.563430	-0.066181	0.350670	0.104741	0.202419	-0.123809	-0.455787
MP12	-0.409592	0.569320	0.178972	-0.334044	-0.256449	-0.113633	-0.166454
MP13	0.420368	0.081536	-0.691975	0.159257	0.016617	-0.180500	-0.117048
MP14	-0.018740	0.360152	0.117471	0.523835	0.531531	-0.177308	0.197762
MP15	-0.689939	0.509159	0.070949	-0.119452	0.246181	0.069533	-0.183372
MP16	0.389785	-0.425615	-0.250518	0.330939	0.292331	-0.020706	0.029344
MP17	0.436931	0.278612	-0.612720	0.124813	-0.148298	0.346299	0.077486
MP18	0.330071	0.434874	-0.294871	-0.235241	0.153006	0.315980	0.019148
MP19	0.177082	0.522753	0.397712	0.602318	0.053894	0.046723	-0.048526
MP20	0.331240	-0.015810	0.295502	-0.012515	0.242746	0.598113	0.327027
VP	4.550728	2.543638	2.039662	2.028274	1.612186	1.235118	1.146409
PERCENT	22.8%	12.7%	10.2%	10.1%	8.1%	6.2%	5.7%
CUM PCT	22.8%	35.5%	45.7%	55.8%	63.9%	70.0%	75.8%

Table VII-1-10 Score of principal component by method I (3rd survey)

Principal component	1	2	3	4	5	6	7
AG	-0.5383	1.2074	-0.5666	1.4301	2.2988	-1.5602	1.5859
AL	1.1246	0.1146	0.1922	-1.0390	0.3729	0.3294	-0.0876
AS	-0.2840	-0.4627	0.9170	-0.3369	-1.0107	-0.9245	1.7551
BA	0.1681	0.9731	0.1939	-0.0386	1.0436	2.2606	1.9621
BR	1.2736	0.3436	-1.9701	-0.1223	1.2048	-0.5200	-0.3872
CA	-0.9764	-0.4723	-0.2681	0.5193	-0.2371	1.2038	0.4651
CE	1.2090	-0.0057	1.2070	0.4069	0.9382	-0.3338	-1.8058
CL	-2.2042	0.7400	0.4889	-0.3691	1.1379	0.1853	-1.2640
CO	-0.7801	-1.1975	0.4853	0.2145	0.3068	-0.4104	-0.3502
CR	-0.4816	-1.2991	0.1176	0.6500	-0.4503	-0.8147	1.2807
CS	0.6504	0.0498	0.3023	-1.4808	-0.4116	1.1732	0.6335
CU	-0.2327	-0.5392	-2.0124	0.5029	0.3217	2.9248	-0.6377
FE	0.0317	-0.3226	-0.3695	-0.3592	-0.2640	-0.0776	-0.6960
HF	0.3823	-0.7285	-0.3868	0.1721	0.5797	1.1596	2.9928
K	-0.3279	-0.7301	1.1450	-1.8732	-0.9023	0.0476	0.2938
LA	1.1506	1.1943	2.4144	2.5776	0.9823	-0.4140	0.5078
LU	-0.6899	1.2215	-0.0912	0.0052	-1.8205	0.9701	0.3078
MN	-0.4649	-0.4198	-0.6040	0.2761	-0.3488	-0.0490	-0.7041
NA	-2.5710	0.5144	-0.0907	-0.2691	1.1396	-0.2357	-0.1764
NI	-0.2555	2.4461	-0.2372	-2.5686	-0.7648	-2.1185	1.0763
SB	0.8243	-0.3216	-0.1125	1.8835	-1.4737	-1.1275	-0.1997
SC	0.5950	0.0884	0.1613	-1.2225	0.3532	0.0206	0.1269
SE	-0.4602	1.7822	0.7345	1.1193	-1.8847	0.1625	-0.0814
SM	0.6896	-0.3547	1.5180	-0.4458	0.0346	0.1469	-0.7634
TH	1.3260	-0.2324	0.5947	-0.9091	0.2504	0.1233	-0.5106
TI	1.4338	-0.1763	0.3771	0.0681	0.7855	-0.1035	-0.9121
V	-0.3558	-1.7978	-1.3639	-0.2302	0.3497	-1.5226	0.4101
W	-0.3045	-0.4923	-0.5399	1.2503	-0.3731	-0.8353	0.4733
ZN	-0.1939	-0.2830	-0.5156	0.4678	-1.1059	-0.2564	-0.8991
CDK	0.5101	2.6258	-1.6508	0.6124	-1.6295	0.3445	-1.1171
PBK	1.1974	0.3036	-2.2072	0.0324	1.0928	-0.3525	-0.3821
SK	-0.8623	-1.1459	-0.5526	0.2142	-0.9325	-0.0463	-0.1720
SIK	0.9804	-0.1930	0.5001	-1.0394	0.1422	0.5684	0.0395
CLI	-2.0760	0.4521	1.0597	-0.4554	1.6887	0.2706	-1.4968
NO3I	-0.1795	-0.8569	1.2217	1.0281	-0.8185	1.2496	-0.2513
SO4I	-0.4925	-1.3077	-0.4277	-0.1777	-0.6563	-1.0257	-0.5457
TPM	1.1842	-0.7177	0.3360	-0.4940	0.0607	-0.4123	-0.4705
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

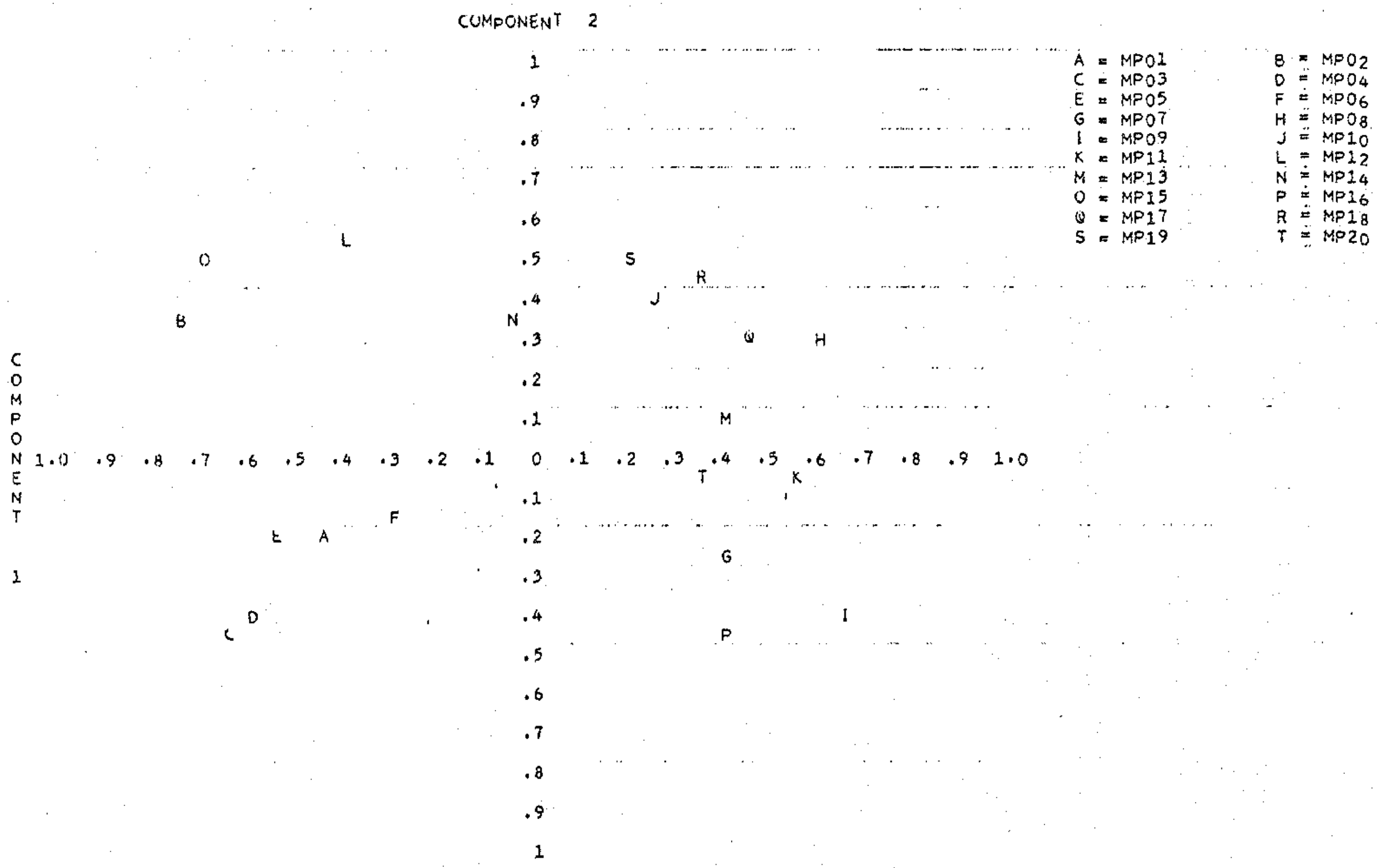
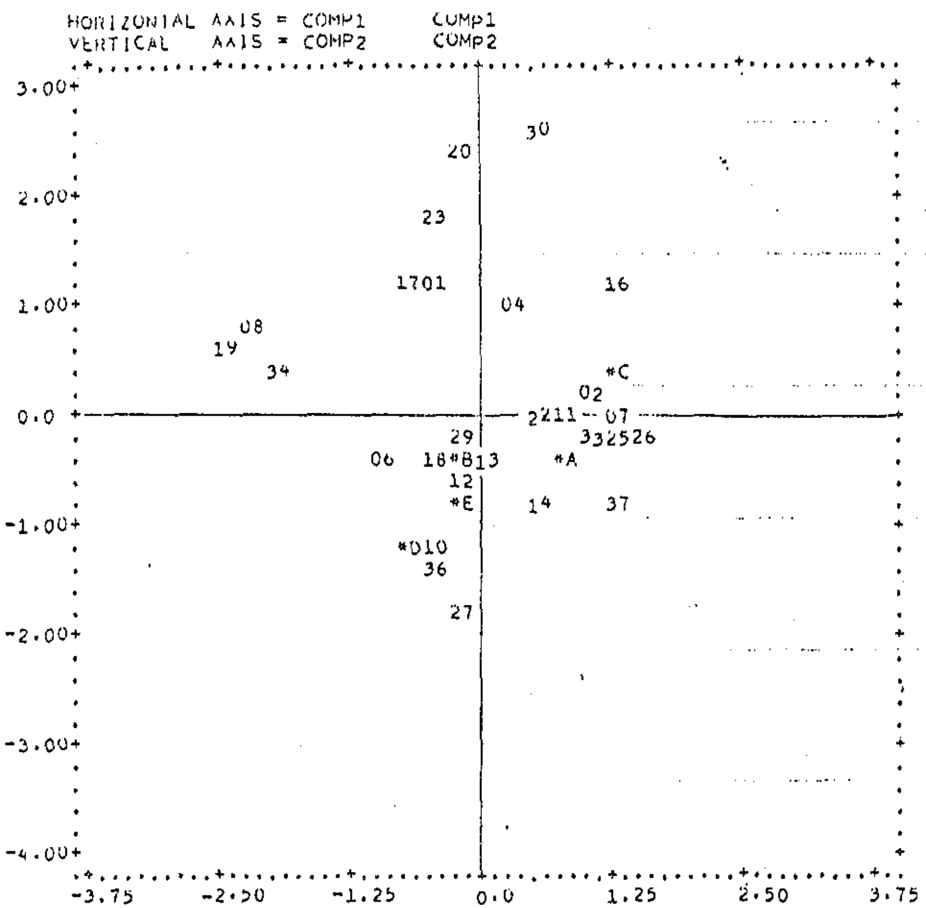


Fig. VII-1-5 Distribution of factor loading by method I (3rd survey)



01 = AG
02 = AL
04 = BA
06 = CA
07 = CE
08 = CL
10 = CR
11 = CS
12 = CU
13 = FE
14 = HF
16 = LA
17 = LU
18 = MN
19 = NA
20 = NI
22 = SC
23 = SE
25 = TH
26 = TI
27 = V
29 = ZN
30 = CDK
33 = SIK
34 = CLI
36 = SO4I
37 = IPM
*A = SB, SM
*B = AS, W
*C = BR, PBK
*D = CO, SK
*E = K, NO3I

Fig. VII-1-6 Distribution of scores by method I (3rd survey)

Table VII-1-11 Correlation coefficient matrix by method I (4th survey)

	MP01	MP02	MP03	MP04	MP05	MP06	MP07	MP08	MP09
MP01	1.000000								
MP02	0.473493	1.000000							
MP03	0.045042	0.226152	1.000000						
MP04	0.034357	0.002578	-0.350607	1.000000					
MP05	-0.029474	0.070569	-0.300086	0.639402	1.000000				
MP06	0.083185	-0.112731	-0.309220	0.463508	0.457985	1.000000			
MP07	-0.439139	-0.453622	0.035347	-0.243856	-0.352695	-0.426202	1.000000		
MP08	-0.544768	-0.523962	-0.508611	0.363468	0.250028	0.327562	0.075019	1.000000	
MP09	-0.471673	-0.521715	-0.089545	-0.051889	-0.226760	-0.063566	0.471138	0.252645	1.000000
MP10	-0.228225	-0.303152	-0.190533	0.029980	-0.301025	-0.242192	0.226406	0.238035	0.353876
MP11	-0.410774	-0.388780	0.046599	-0.323505	-0.317500	-0.371484	0.433586	0.144238	0.481626
MP12	0.274980	0.503376	0.203750	-0.239539	0.026585	0.096222	-0.398819	-0.406416	-0.209878
MP13	0.147819	-0.219971	-0.074622	-0.142493	-0.305517	-0.392686	0.314170	-0.227659	-0.022159
MP14	0.277965	0.320301	0.739470	-0.229234	-0.240413	-0.136360	-0.306801	-0.289173	-0.400044
MP15	0.529692	0.749628	0.227331	-0.145442	0.027618	0.073211	-0.550161	-0.403618	-0.550275
MP16	0.104765	-0.037583	-0.079818	-0.145182	-0.081473	0.198305	-0.154168	-0.112960	-0.257332
MP17	0.207907	-0.253497	-0.059006	-0.269497	-0.347565	-0.548917	0.155240	-0.004732	0.060038
MP18	-0.082097	0.271430	0.110464	-0.100494	-0.211695	-0.036387	-0.198044	-0.154932	-0.012752
MP19	0.678508	0.197733	0.131024	-0.118395	0.026304	0.161493	-0.264858	-0.511835	-0.476396
MP20	-0.051909	0.125523	-0.182513	-0.111619	-0.026729	0.053726	-0.226156	0.026397	-0.162168

	MP10	MP11	MP12	MP13	MP14	MP15	MP16	MP17	MP18
MP10	1.000000								
MP11	0.190546	1.000000							
MP12	-0.453442	-0.378334	1.000000						
MP13	0.226263	0.126774	-0.349263	1.000000					
MP14	-0.126910	-0.123348	0.077585	-0.018093	1.000000				
MP15	-0.610583	-0.391146	0.663820	-0.372829	0.402801	1.000000			
MP16	-0.249043	-0.004012	0.033054	-0.016240	0.023552	0.217666	1.000000		
MP17	0.253426	0.279752	-0.333997	0.517357	0.112533	-0.125728	-0.036244	1.000000	
MP18	-0.071169	-0.420055	0.639031	-0.106007	0.039690	0.306790	-0.054716	-0.228619	1.000000
MP19	-0.581697	-0.322493	0.256109	0.270593	0.214875	0.437629	0.323577	0.102552	-0.033459
MP20	0.276450	-0.264499	0.057514	-0.170913	-0.167501	-0.091358	-0.305897	-0.250329	0.124503

	MP19	MP20
MP19	1.000000	
MP20	-0.218590	1.000000

Table VII-1-12 Factor loading by method I (4th survey)

Principal component	1	2	3	4	5	6
MP01	0.652372	0.202044	0.437233	0.340621	-0.049511	0.048756
MP02	0.754524	0.060807	-0.226054	0.213435	0.139272	0.130473
MP03	0.307307	0.551272	-0.309606	-0.289890	0.496474	0.143199
MP04	-0.033207	-0.710412	0.297353	0.149128	0.246613	0.353189
MP05	0.158651	-0.738436	0.271774	-0.044618	0.204304	0.309652
MP06	0.211217	-0.752823	0.196164	-0.203448	-0.044756	-0.178356
MP07	-0.658915	0.351939	-0.057993	-0.201820	-0.162759	0.312756
MP08	-0.554307	-0.569059	0.031628	-0.083189	0.130152	-0.253187
MP09	-0.682878	0.011389	-0.282428	-0.254582	-0.178468	0.219871
MP10	-0.619129	0.077802	-0.184051	0.530982	0.113654	-0.206904
MP11	-0.607953	0.364389	0.006909	-0.386460	0.097399	-0.099251
MP12	0.697705	-0.024859	-0.451672	-0.135638	-0.361695	0.117873
MP13	-0.257263	0.517789	0.447864	0.360555	-0.236351	0.205263
MP14	0.447200	0.443334	-0.042188	-0.061267	0.647051	-0.181492
MP15	0.883664	0.070147	-0.081975	-0.130236	-0.004384	-0.084382
MP16	0.224556	0.049088	0.376722	-0.436818	-0.300848	-0.539119
MP17	-0.270986	0.580808	0.397708	0.267789	-0.012028	-0.080230
MP18	0.342670	-0.011930	-0.609756	0.080601	-0.410527	0.095351
MP19	0.616207	0.235392	0.559443	-0.061198	-0.252281	0.086208
MP20	0.020092	-0.242388	-0.420795	0.612848	-0.050882	-0.334661
VP	5.276116	3.476027	2.231969	1.672448	1.401380	1.076962
PERCENT	26.4%	17.4%	11.2%	8.4%	7.0%	5.4%
CUM PCT	26.4%	43.8%	54.9%	63.3%	70.3%	75.7%

Table VII-1-13 Score of principal component by method I (4th survey)

Principal component	1	2	3	4	5	6
AG	0.7824	1.7227	-0.7199	-0.5037	4.0679	-0.2080
AL	-0.5156	0.6596	-0.1100	-0.4209	-0.2885	0.1931
AS	-0.7588	-1.4816	0.4296	-0.6181	0.0264	0.9606
BA	0.0553	-0.1338	-1.0434	1.7369	-0.3453	-1.4133
BR	-0.5645	2.0836	1.8175	1.4192	-1.0975	1.0758
CA	0.2445	-0.4361	-0.0499	1.1772	0.0673	-0.4565
CE	-0.6108	0.5595	-0.5202	-0.8808	0.2826	-0.4842
CL	2.8746	0.0847	0.1433	-0.9722	-0.4802	-0.1949
CO	0.4469	0.0708	-0.3942	1.8922	-0.1175	-0.9791
CR	-0.5206	-0.9451	-0.0842	0.7189	0.2437	-0.3477
CS	-0.6228	0.4365	-1.1487	-0.0537	-0.1778	1.0544
CU	-1.1271	-0.2958	0.4137	-0.0551	0.9887	-2.1382
FE	-0.6771	0.0717	0.1293	-0.5928	-0.1166	0.1316
HF	-0.3120	0.1437	-0.8325	0.5755	0.2252	-0.5793
K	0.1366	-0.9369	-2.7036	-0.2383	-2.3442	1.3660
LA	-0.9362	0.8165	-0.5234	-0.4394	1.1564	-0.7475
LU	-0.3682	1.1245	-1.1131	-1.3131	-0.2421	1.0573
MN	-0.5911	-1.2183	0.4100	-0.3019	0.2362	0.1810
NA	3.2858	0.9254	-0.2809	0.1921	-0.0558	0.9078
NI	0.6184	-0.0523	-0.6568	2.5854	-0.3622	-0.1504
SB	0.2204	0.2299	1.1504	-0.6629	-1.0610	-2.7243
SC	-0.4001	0.5314	-0.0720	-0.2974	-0.3670	0.3254
SE	0.1844	-1.3219	0.7685	-1.8522	-1.4658	-1.2991
SM	-0.7578	0.8010	-0.8388	-0.9867	-0.4761	-0.6013
TH	-0.7348	0.7392	-0.0791	-0.8218	0.0055	-0.2480
TI	-0.4759	0.2413	0.0463	0.1539	-0.7665	-0.0020
V	-0.0595	-1.8198	1.7822	0.6454	1.4059	1.8497
W	0.2920	-0.6468	-0.1809	1.5112	-0.0982	-1.4946
ZN	-0.2598	-1.3371	1.0416	-0.2823	0.1986	0.3578
CDK	-0.4037	-0.6648	-2.2200	-0.1543	0.9355	0.8963
PBK	-0.5090	1.9844	2.1253	1.1412	-0.3962	1.1558
SK	0.3088	-1.1769	0.4297	0.5643	0.5271	0.9311
SIK	-0.4850	0.5610	-0.1507	-0.7064	-0.3509	0.0916
CLI	2.6366	0.1932	0.5921	-1.1580	-0.2885	-0.1880
NO3I	0.3206	-1.0879	1.4434	-1.1197	0.9045	0.0922
SO4I	0.1319	-1.4252	0.4925	0.4598	0.4643	0.7251
TPM	-0.8489	0.9998	1.0067	-0.3415	-0.8382	0.9038
	0.0	0.0	0.0	0.0	0.0	0.0
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

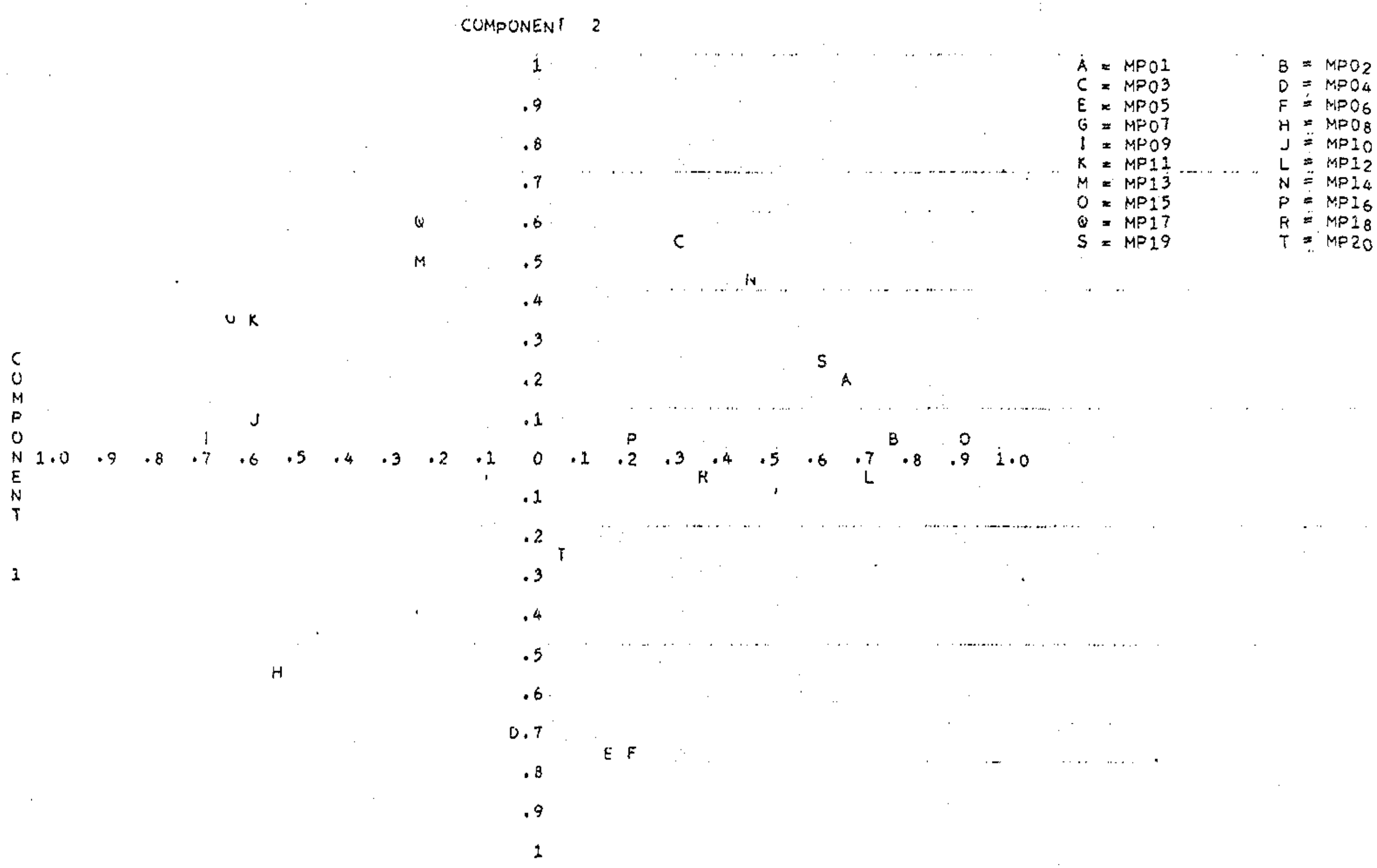


Fig. VII-1-7 Distribution of factor loading by method I (4th survey)

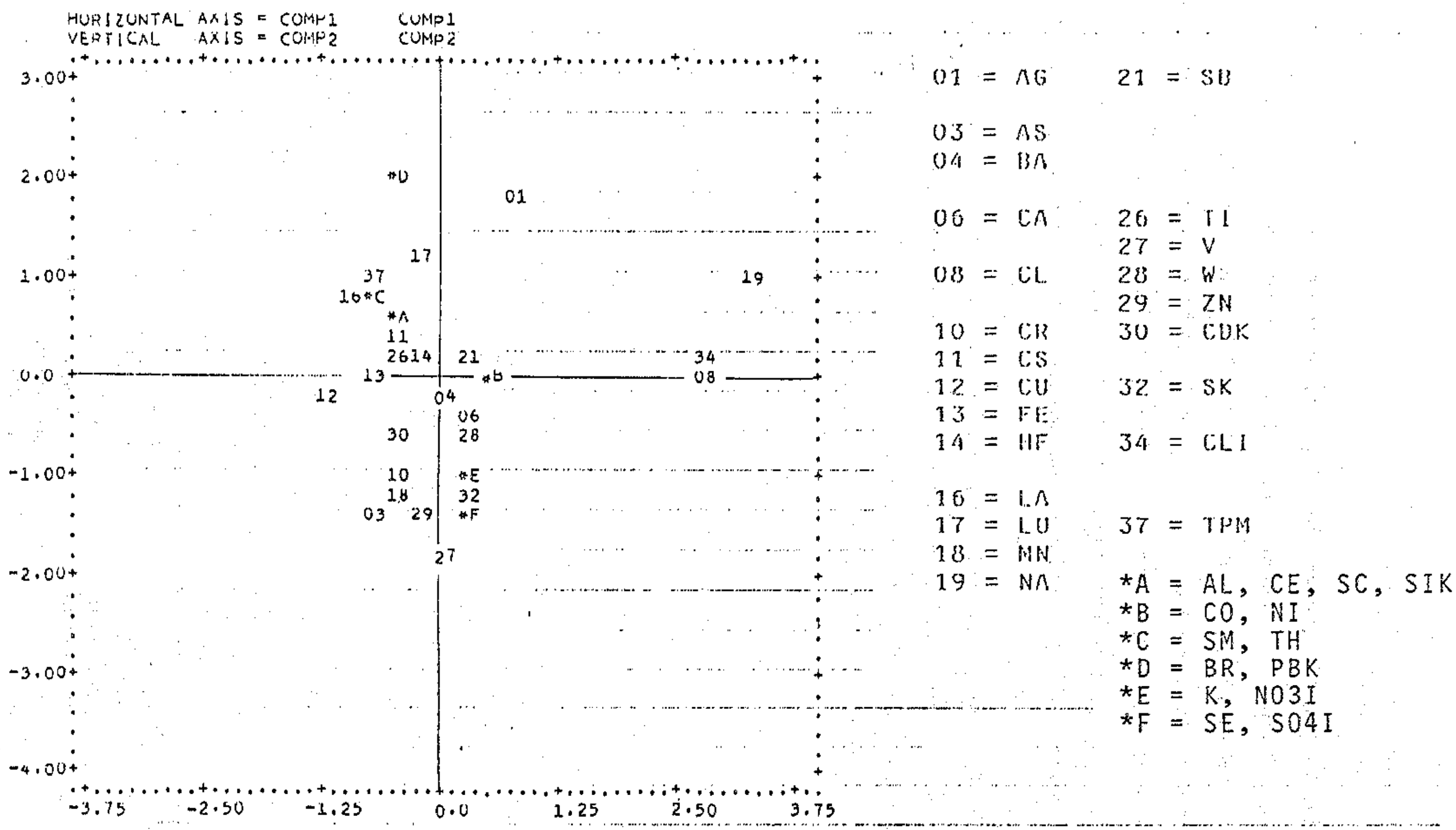


Fig. VII-1-8 Distribution of scores by method I (4th survey)

From these results, we estimated the contributions of emission source on the particle concentrations.

(1) 1st short term field survey

Table VII-1-14 shows the results of principal component analysis in 1st survey. The 1st principal component shows the ratio between the components from sea-salt particles or petroleum combustion and those from soil. At MP2, 5 and 9, the components originated from sea-salt particles and petroleum combustion have higher concentrations. On the other hand, at MP7 and MP17, the components from soil have higher concentrations. The 2nd principal component show the effects from local emission sources-metal processing factories. MP20 accepts large effects from the factories. MP13 doesn't accept so much effects from the factories. The 3rd component show the ratio between the components from gasoline automobiles and those from sea-salt particles. At MP10 and 11, the contributions of gasoline automobiles are relatively higher than that of sea-salt particle. At MP1, 12 and 15, the reverse tendency can be seen.

Table VII-1-14 Results of method I (1st survey)

Principal component	1	2	3
Eigen value	3.94	2.69	2.27
Contribution rate	19.7%	13.5%	11.4%
Factor loading	⊕ MP2, MP5, MP9 ⊖ MP7, MP17	⊕ MP20 ⊖ MP13	⊕ MP10, MP11 ⊖ MP1, MP12, MP15
Score	⊕ Cl, Na, Ni, V, SO_4^{2-} ⊖ Ag, Al, Ce, Fe, Hf, Sc, Sm, Th, Si	⊕ Ba, Cu, Na ⊖ As, Cr, V, Zn, Cd	⊕ Br, Cu, K ⊖ Cl, Cl^- NO_3^-
Explanation of the component	⊕ Sea-salt particle and petroleum combustion ⊖ Soil	⊕ Strongly affected by local emission source (metal processing factories)	

Note:

In loading factor and score, several components are shown, which have large absolute values.

(2) 2nd short term field survey

Table VII-1-15 shows the results of principal component analysis in 2nd survey. The first principal component shows the ratio between the contributions of sea-salt particle or exhaust gas from car and the contributions of soil. At MP3, 4, 5 and 18, the contributions of soil and exhaust gas are relatively high. At MP11, the reverse tendency can be seen. The 2nd and 3rd components do not show clear characteristics.

Table VII-1-15 Results of method I (2nd survey)

Principal component	1	2	3
Eigen value	4.16	3.36	2.68
Contribution rate	20.8%	16.8%	13.4%
Factor loading	⊕ MP3, MP4, MP5 MP18 ⊖ MP11	⊕ MP12, MP15	⊕ MP13
Score	⊕ Br, Cl, Na, Ni, Pb ⊖ Sm, Al, Th, Ce, Si, NO_3^-	⊕ Cl, V, W, Cl^-, NO_3^- ⊖ Cs, Cu	⊕ Ag, Br, Lu, Pb ⊖ Ba, Na, Ni, Cd
Explanation of the component	⊕ Side the stations where the contributions of sea-salt particle and car are greater than that of soil		

Note:

In factor loading and score, several components are shown, which have large absolute values.

(3) 3rd short term field survey

Table VII-1-16 shows the results of principal component analysis in 3rd survey. The 1st principal component shows the ratio between the contribution of soil or exhaust gas and that of sea-salt particle. At MP8, 9 and 11, the contributions of soil and exhaust gas are relatively higher than that of sea-salt particle. On the other hand at MP2, 3 and 15, the reverse tendency can be seen. The 2nd to 4th principal components do not show clear tendency.

Table VII-1-16 Results of method I (3rd survey)

Principal component	1	2	3	4
Eigen value	4.55	2.54	2.04	2.03
Contribution rate	22.8%	12.7%	10.2%	10.1%
Factor loading	⊕ MP8, MP9, MP11 ⊖ MP2, MP3, MP15	⊕ MP12, MP19	⊖ MP13, MP17	⊕ MP19 ⊖ MP7
Score	⊕ Th, Ti, Al, Br, La, Pb, TPM ⊖ Cl, Na, Cl^-	⊕ Ni, Se, Cd ⊖ V, SO_4^{2-}	⊕ La, Sm ⊖ Br, Cu, V, Cd, Pb	⊕ Ag, La, Sb ⊖ Cs, K, Ni
Explanation of the component	⊕ Side the stations where the contributions of soil particle and car are greater than that of sea-salt particle			

Note:
In factor loading and score, several components are shown, which have large absolute values.

(4) 4th short term field survey

Table VII-1-17 shows the results of principal component analysis in 4th survey. The 1st principal component shows the ratio between the contribution of sea-salt particle and soil. At MP1, 2, 12, 15 and 19, the contributions of sea-salt particle are higher. At MP7, 9, 10, and 11, the contributions of soil are higher. The 2nd and 3rd principal components show the ratio between the contribution of refuse combustion and that of exhaust gas from car. As the loading factors of these components are small, a clear tendency cannot be seen.

Table VII-1-17 Results of method I (4th survey)

Principal component	1	2	3
Eigen value	5.28	3.48	2.23
Contribution rate	26.4%	17.4%	11.2%
Factor loading	⊕ MP1, MP2, MP12, MP15, MP19 ⊖ MP7, MP9, MP10, MP11	⊕ MP3, MP13, MP17 ⊖ MP4, MP5, MP6	⊕ MP19 ⊖ MP18
Score	⊕ Cl, Na, Cl^- ⊖ Al, Sc, Si	⊕ Ag, Br, Pb ⊖ As, Se, V, Zn, SO_4^{2-}	⊕ Br, Pb, NO_3^- ⊖ K, Cd
Explanation of the component	⊕ Side the stations where the contributions of sea-salt particle is greater than that of soil		

Note:
In factor loading and score, several components are shown, which have large absolute values.

VII-1-2-2 Results of method II

Table VII-1-18 shows the correlation coefficients matrix of chemical components concentrations in 1st survey. Table VII-1-19 shows the eigen values and loading factors of each principal components. Table VII-1-20 shows the scores of each principal component. Fig. VII-1-9 is the scatter about loading factors. Fig. VII-1-10 is the scatter about scores. For the remaining surveys, the results are shown in Table VII-1-21 to VII-1-29 and Fig. VII-1-11 to VII-1-16.

Table VII-1-18 Correlation coefficient matrix by method II (1st survey)

	AG	AL
AG	1.000000	
AL	0.637117	1.000000

	AG	AL	AS	BA	BR	CA	CE	CL	CO
AS	0.193315	0.461702	1.000000						
BA	-0.166673	0.167640	-0.049935	1.000000					
BR	0.505155	0.551181	0.158163	-0.233416	1.000000				
CA	0.470676	0.665629	0.677161	0.112679	0.299104	1.000000			
CE	0.646212	0.938807	0.459151	0.151733	0.436222	0.721062	1.000000		
CL	0.137740	0.080599	0.042077	0.059131	-0.119360	0.455595	0.190704	1.000000	
CO	0.573699	0.661996	0.354403	0.006217	0.419254	0.567444	0.598491	0.311953	1.000000
CR	0.392563	0.467472	0.599048	-0.163968	0.567428	0.535129	0.489625	0.260443	0.415342
CS	0.428663	0.838890	0.610172	0.149934	0.470510	0.670644	0.694164	-0.027103	0.673875
CU	0.193091	0.262881	-0.007409	-0.014964	0.241591	-0.110920	0.009237	-0.161003	0.269070
FE	0.728307	0.939066	0.489340	-0.031950	0.725901	0.651790	0.859361	0.037274	0.727715
HF	0.526111	0.751754	0.370362	0.114121	0.568059	0.459153	0.700923	-0.096314	0.411173
K	0.123155	0.261407	0.135580	-0.087312	0.329835	0.281137	0.142054	-0.018366	0.071413
LA	0.150356	0.473136	0.224178	0.343321	0.288445	0.266503	0.440649	-0.227409	-0.100193
LU	0.517166	0.778285	0.408376	0.280265	0.398400	0.564989	0.839794	0.123605	0.490360
MN	0.639814	0.846140	0.460363	0.171966	0.524292	0.768759	0.842717	0.395228	0.677061
NA	-0.234263	-0.068777	-0.262623	0.362347	-0.305859	0.072737	-0.100436	0.322927	-0.169932
NI	-0.188423	0.009109	-0.020403	-0.020985	-0.183944	0.123504	0.003179	0.545215	0.102474
SB	0.577451	0.290373	0.156405	-0.246891	0.571807	0.461581	0.237404	0.445762	0.366345
SC	0.695024	0.978750	0.491220	0.042963	0.599585	0.677394	0.930359	0.100568	0.730094
SE	-0.068379	-0.014150	0.175573	0.048533	-0.194584	0.137806	-0.106821	0.360211	0.048971
SM	0.565097	0.946944	0.474490	0.209690	0.373681	0.752644	0.954449	0.203272	0.588425
TH	0.591369	0.881904	0.556658	-0.041585	0.663930	0.650637	0.802982	-0.111134	0.477089
TI	0.569524	0.798885	0.581925	0.221476	0.310400	0.825683	0.784371	0.355778	0.653351
V	-0.082649	0.217402	0.339256	-0.105929	-0.093392	0.351174	0.223037	0.255282	0.428259
W	0.254837	0.154219	0.304751	-0.085137	-0.117272	0.419426	0.235140	0.402715	0.221430
ZN	0.637260	0.440555	0.283310	-0.252865	0.771571	0.381033	0.399564	0.205217	0.444936
CDK	0.272365	0.406032	0.458767	-0.307836	0.355853	0.314222	0.480729	0.076025	0.272488
PBK	0.377363	0.360700	0.045939	-0.107552	0.867842	0.246155	0.318234	0.009405	0.170142
SK	0.152214	0.500604	0.526765	-0.046711	0.263305	0.687802	0.470630	0.403542	0.559471
SIK	0.566296	0.982966	0.525666	0.212803	0.532361	0.754669	0.941299	0.176694	0.671057
CLI	0.230367	0.326894	0.225411	0.077143	-0.032950	0.660142	0.433335	0.933393	0.452420
NO3I	0.271607	0.346482	0.441790	-0.128147	-0.020262	0.701108	0.492816	0.703188	0.276873
SO4I	0.003878	0.362638	0.549073	-0.022357	-0.007584	0.608999	0.356156	0.467271	0.399089
TPM	0.569404	0.693790	0.584569	-0.005203	0.677546	0.758919	0.809895	0.223722	0.696374

	CR	CS	CU	FE	HF	K	LA	LU	MN
CR	1.000000								
CS	0.347074	1.000000							
CU	-0.167261	0.386149	1.000000						
FE	0.592306	0.805806	0.315495	1.000000					
HF	0.500849	0.506943	0.301320	0.772890	1.000000				
K	0.190694	0.265304	0.023677	0.333785	0.195039	1.000000			
LA	0.229279	0.362373	-0.180269	0.334727	0.438178	0.073255	1.000000		
LU	0.599653	0.509029	0.083508	0.703289	0.773679	0.029061	0.304690	1.000000	
MN	0.667256	0.639720	0.065655	0.864118	0.685039	0.360644	0.353272	0.657657	1.000000
NA	-0.441698	0.017941	0.167269	-0.261079	-0.161784	0.095535	-0.047310	0.000487	-0.136982
NI	0.089417	0.008157	-0.110338	-0.023014	-0.298736	0.370948	-0.231831	-0.182093	0.218125
SB	0.707897	0.123417	-0.042264	0.439510	0.292817	0.270002	0.026802	0.090373	0.583653
SC	0.500810	0.831929	0.306980	0.963609	0.748307	0.200349	0.340633	0.791670	0.830527
SE	-0.030136	0.137657	0.509623	-0.002169	0.063643	0.026815	-0.168198	-0.146543	0.114936
SM	0.450735	0.764783	0.025034	0.829478	0.644612	0.203046	0.529556	0.737965	0.824407
TH	0.525793	0.759171	0.174709	0.900710	0.793243	0.434150	0.595235	0.637160	0.771649
TI	0.475202	0.743985	0.187011	0.785963	0.560059	0.426008	0.184735	0.613783	0.876629
V	0.093021	0.331669	-0.072307	0.229710	-0.127545	0.262835	-0.200929	0.006094	0.337250

	CR	CS	CU	FE	HF	K	LA	LU	MN
W	0.474900	0.003524	-0.117057	0.170922	0.355220	-0.151271	-0.031550	0.199383	0.336288
ZN	0.798825	0.268658	0.087190	0.656339	0.482742	0.255742	0.141968	0.300166	0.674810
CDK	0.413693	0.298642	-0.036896	0.422197	0.361856	-0.028803	0.218006	0.479685	0.326980
PBK	0.488392	0.250443	0.073244	0.513464	0.398992	0.320731	0.332785	0.257213	0.472810
SK	0.420593	0.581468	-0.023761	0.539828	0.176264	0.517801	0.044004	0.245388	0.674713
SIK	0.510450	0.649487	0.160051	0.913863	0.728968	0.288735	0.472329	0.795642	0.874417
CLI	0.336033	0.244911	-0.204624	0.240757	0.046879	0.084173	-0.047889	0.295825	0.549023
NO3I	0.292368	0.296250	-0.150356	0.289165	0.036380	0.085101	-0.074320	0.360795	0.473443
SO4I	0.268731	0.463372	0.020977	0.349362	0.044858	0.362981	-0.034080	0.145479	0.532560
TPM	0.638884	0.825353	0.252062	0.937839	0.663296	0.450673	0.325366	0.635120	0.901245

	NA	NI	SB	SC	SE	SM	TH	TI	V
NA	1.000000								
NI	0.224391	1.000000							
SB	-0.235612	0.084415	1.000000						
SC	-0.137755	-0.037057	0.292850	1.000000					
SE	0.222779	0.258548	0.083041	0.000770	1.000000				
SM	-0.027067	0.090311	0.211635	0.905609	-0.047828	1.000000			
TH	-0.235740	-0.142223	0.331067	0.859845	-0.057780	0.814866	1.000000		
TI	0.020149	0.180264	0.380578	0.795027	0.322691	0.778834	0.699993	1.000000	
V	-0.060466	0.060259	-0.050969	0.228027	0.138884	0.268275	0.129865	0.365673	1.000000
W	-0.126939	0.094986	0.438979	0.182307	0.232925	0.287783	0.121864	0.254460	0.032710
ZN	-0.506543	-0.004459	0.874361	0.502210	-0.002807	0.327961	0.532314	0.426679	0.000330
CDK	-0.217601	-0.092861	0.060605	0.466972	0.092858	0.379618	0.430162	0.311226	0.153752
PBK	-0.204581	-0.185368	0.601172	0.383535	-0.108256	0.215411	0.508870	0.275919	-0.191186
SK	0.023763	0.603931	0.308316	0.498482	0.181736	0.513732	0.483529	0.669860	0.835206
SIK	-0.011289	0.065935	0.256655	0.958315	0.007056	0.952478	0.669143	0.838227	0.273497
CLI	0.340345	0.524650	0.393600	0.328829	0.257745	0.464235	0.137802	0.538296	0.360970
NO3I	0.285361	0.455979	0.265697	0.389242	0.229302	0.465097	0.220484	0.540440	0.476472
SO4I	0.145454	0.652739	0.144241	0.353415	0.309350	0.407072	0.325944	0.582769	0.842748
TPM	-0.110681	0.195465	0.472441	0.901439	0.102117	0.812357	0.867865	0.836480	0.395778

	W	ZN	CDK	PBK	SK	SIK	CLI	NO3I	SO4I
W	1.000000								
ZN	0.266035	1.000000							
CDK	-0.044464	0.276415	1.000000						
PBK	-0.274615	0.730075	0.337657	1.000000					
SK	0.070331	0.334907	0.295601	0.232166	1.000000				
SIK	0.166427	0.424506	0.429568	0.373093	0.590414	1.000000			
CLI	0.388019	0.164842	0.190710	0.029056	0.563182	0.433020	1.000000		
NO3I	0.286108	0.157644	0.382060	0.037070	0.618636	0.432669	0.796323	1.000000	
SO4I	0.124986	0.129094	0.192788	-0.006925	0.920153	0.453597	0.589431	0.700120	1.000000
TPM	0.146979	0.634744	0.434762	0.529101	0.755110	0.918835	0.428657	0.472706	0.598251

	TPM
TPM	1.000600

Table VII-1-19 Factor loading by method II (1st survey)

Principal component	1	2	3	4	5	6	7	8
AG	0.660592	-0.293333	0.200126	0.225914	0.222370	-0.089837	-0.240456	-0.181617
AL	0.924200	-0.167828	-0.283814	-0.001550	0.042460	0.015213	-0.062770	-0.083880
AS	0.605896	0.130657	-0.052841	-0.052955	-0.351201	-0.407135	0.342941	0.254392
BA	0.038001	0.037681	-0.584040	0.263028	0.120449	0.424883	0.292744	-0.159439
BR	0.607809	-0.523431	0.361845	-0.274567	0.109782	0.177276	-0.147323	0.077324
CA	0.829303	0.289717	-0.022563	0.189439	-0.108086	0.044416	0.120272	0.075508
CE	0.897583	-0.090084	-0.241241	0.193744	-0.139076	0.025119	-0.168371	-0.062994
CL	0.283794	0.705759	0.290468	0.427720	0.206664	0.181402	-0.156175	0.082979
CO	0.721111	0.098684	0.025040	-0.025361	0.204846	-0.273223	-0.247325	-0.351323
CR	0.669646	-0.086232	0.518924	0.142449	-0.234206	-0.061421	0.235019	0.051079
CS	0.797118	-0.040830	-0.352607	-0.252796	0.094956	-0.115674	0.056792	-0.000268
CU	0.147733	-0.182021	-0.214320	-0.304861	0.794215	-0.327425	0.022384	0.113964
FE	0.943182	-0.246716	-0.014615	-0.121431	0.093290	-0.079815	-0.050410	-0.107397
HF	0.716307	-0.445273	-0.125176	0.163083	0.129989	-0.076788	0.208322	0.055729
K	0.346382	0.104149	0.129333	-0.544408	0.053639	0.407532	0.248052	-0.065075
LA	0.361629	-0.394849	-0.301007	0.100421	-0.339204	0.395057	0.310559	0.200263
LU	0.727755	-0.210167	-0.312672	0.315821	-0.058234	-0.012137	-0.198236	0.041295
MN	0.943120	0.066289	0.083533	0.079242	0.052706	0.141121	0.091069	-0.123079
NA	-0.135901	0.416901	-0.443517	0.122156	0.403997	0.429730	-0.103750	0.253236
NI	0.118847	0.780301	0.135071	-0.261334	0.007215	0.191519	0.008940	-0.174799
SB	0.492817	-0.030005	0.771568	0.176877	0.202878	0.173996	0.133738	-0.058564
SC	0.934901	-0.175957	-0.189969	0.003216	0.074383	-0.113509	-0.153646	-0.063938
SE	0.082475	0.399965	-0.012772	-0.019721	0.562922	-0.280318	0.369376	0.428288
SM	0.885617	-0.011455	-0.313142	0.159479	-0.127256	0.063661	-0.027761	-0.108181
TH	0.870994	-0.325985	-0.107354	-0.153412	-0.104703	0.033115	0.131998	0.057309
TI	0.880998	0.200915	-0.131411	0.012776	0.158814	-0.002305	0.133457	-0.011636
V	0.334751	0.664097	-0.047586	-0.462674	-0.238781	-0.199651	-0.070868	-0.232887
W	0.279839	0.214496	0.248996	0.618017	0.010409	-0.335278	0.401870	-0.188552
ZN	0.627825	-0.272739	0.680503	-0.010128	0.097404	0.037714	0.065618	-0.044340
CDK	0.476877	-0.097177	0.048712	-0.025023	-0.305705	-0.269834	-0.339871	0.579686
PBK	0.467890	-0.435735	0.432310	-0.212595	0.087871	0.430573	-0.119408	0.290762
SK	0.687642	0.545646	0.077262	-0.412097	-0.135647	0.063585	0.028096	-0.026516
SIK	0.949667	-0.062739	-0.275710	0.014380	-0.009642	0.070317	-0.039106	-0.027719
CLI	0.498106	0.684001	0.119192	0.372954	0.065313	0.191067	-0.174273	0.065850
NO3I	0.522845	0.649431	0.058824	0.199058	-0.104877	-0.002189	-0.250984	0.283717
SO4I	0.534396	0.714945	-0.035321	-0.327996	-0.114655	-0.042453	0.092409	0.050556
TPM	0.970633	0.010314	0.021150	-0.207379	0.053101	0.037327	0.013078	0.020561
VP	15.930824	5.107796	3.197919	2.391700	1.957932	1.783848	1.355384	1.269917
PERCENT	43.1%	13.8%	8.6%	6.5%	5.3%	4.8%	3.7%	3.4%
CUM PCT	43.1%	56.9%	65.5%	72.0%	77.3%	82.1%	85.7%	89.2%

Table VII-1-20 Score of principal component by method II (1st survey)

Principal component	1	2	3	4	5	6	7	8
MP01	0.6768	0.4851	-0.3132	1.7546	-0.4570	-0.3550	-1.2117	-0.0346
MP02	-1.0043	0.0235	0.0616	-0.3002	-0.2707	-0.2408	-0.4715	0.0484
MP03	-0.6784	0.0475	0.3715	-0.6600	-0.5436	-0.0640	-0.2989	-1.1736
MP04	2.0168	0.9582	-1.5015	0.6288	-1.5400	-1.4052	0.8869	0.5853
MP05	1.0326	3.0235	0.2233	-1.7059	0.4679	1.1889	0.1484	-0.6655
MP06	-0.3797	0.2778	0.4395	0.1815	-1.2532	-0.6863	0.0739	0.7579
MP07	1.9055	-1.2906	-0.4184	-0.7190	1.9606	-1.5562	-1.5387	-1.0538
MP08	-0.7915	0.4319	-0.5218	-0.5705	2.0345	-0.9005	0.8156	2.7295
MP09	-0.7813	0.5363	-0.2555	-0.7613	0.3744	0.3898	0.0473	-0.0354
MP10	-0.6158	-0.7108	-0.6098	-0.9580	0.5243	0.1247	0.9395	-0.7877
MP11	-0.4919	-1.4273	-0.1443	-0.1971	-0.3872	-0.2055	0.7142	0.0782
MP12	0.2327	0.1728	2.0590	0.9434	0.5777	0.9535	-0.9850	0.7286
MP13	-0.5879	-0.0787	0.4630	-0.9606	-1.3285	-0.8449	-0.7321	-1.0165
MP14	0.0605	0.3755	2.0454	1.8939	0.9395	-0.8638	2.1346	-1.1827
MP15	-0.5544	0.1839	-0.3213	1.0567	0.5400	0.5017	-2.0488	0.6270
MP16	-0.8332	-0.2219	0.0490	-0.4205	-0.7342	-1.0795	0.2797	0.5323
MP17	1.9528	-1.8221	1.2767	-1.0983	-0.6568	1.5383	0.6751	1.0226
MP18	-1.0364	-0.1817	-0.1809	0.1868	-0.0030	0.2642	-0.1903	-0.9116
MP19	-0.1170	-0.2855	-0.5720	0.4723	-0.9709	1.4825	-0.2741	0.7487
MP20	-0.0061	-0.4975	-2.1505	1.2334	0.7242	1.7580	1.0358	-0.9971
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

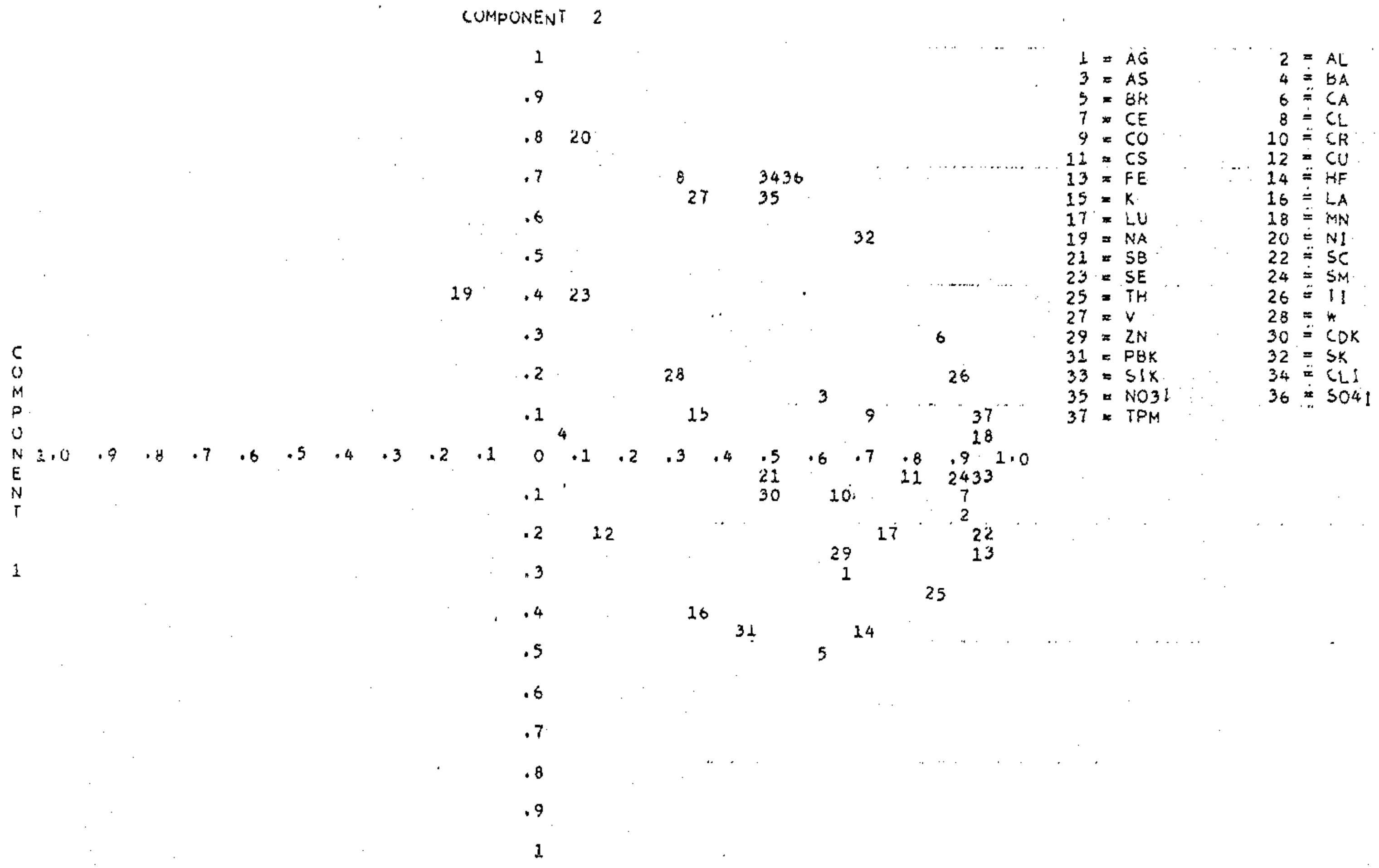
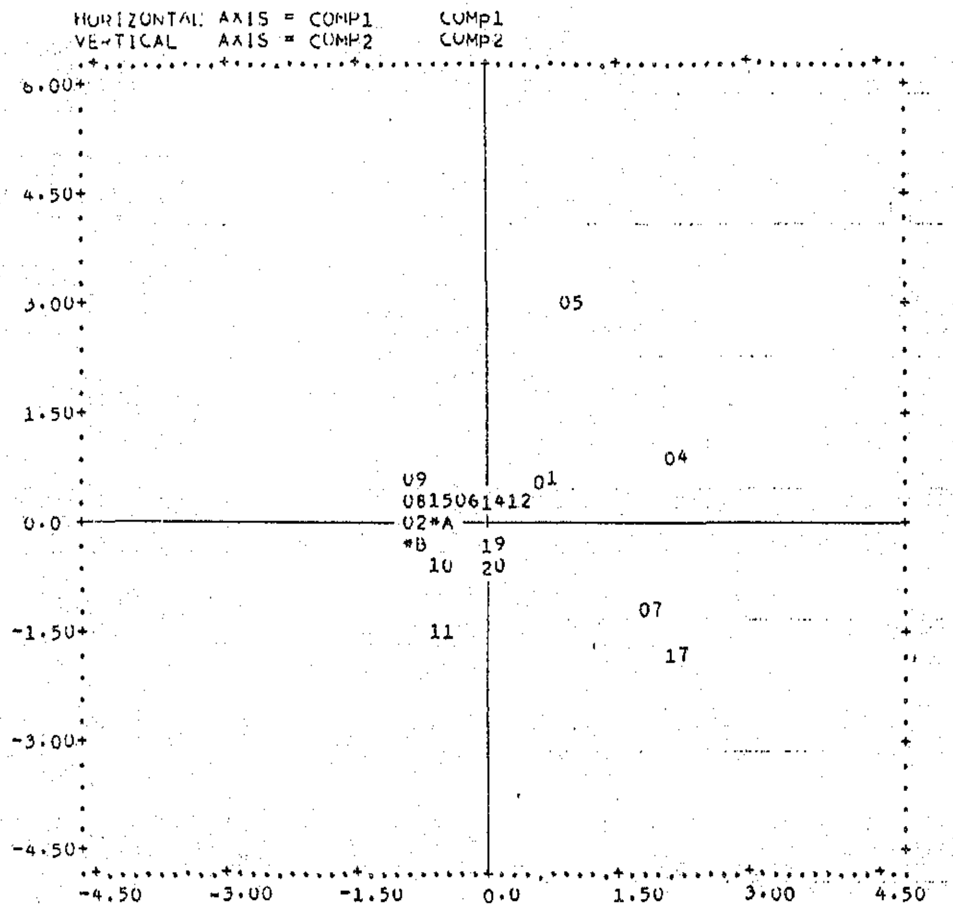


Fig. VII-1-9 Distribution of factor loading by method II (1st survey)



01 = MP01
02 = MP02

04 = MP04
05 = MP05
06 = MP06
07 = MP07
08 = MP08
09 = MP09
10 = MP10
11 = MP11
12 = MP12

14 = MP14
15 = MP15

17 = MP17

19 = MP19
20 = MP20

*A = MP03, MP13
*B = MP16, MP18

Fig. VII-1-10 Distribution of scores by method II (1st survey)

Table VII-1-21 Correlation coefficient matrix by method II (2nd survey)

	AG	AL
AG	1.000000	
AL	-0.032516	1.000000

	AG	AL	AS	BA	BR	CA	CE	CL	CO
AS	0.117753	0.695963	1.000000						
BA	0.066019	0.205869	0.262269	1.000000					
BR	0.005971	0.126922	0.011769	-0.298160	1.000000				
CA	-0.116674	0.507291	0.533271	0.127487	0.391157	1.000000			
CE	0.024424	0.913638	0.705491	0.350939	-0.043837	0.633553	1.000000		
CL	0.166278	0.120852	0.533167	0.285329	0.134053	0.603478	0.244392	1.000000	
CO	0.075031	0.446025	0.379716	0.281582	0.004225	0.747432	0.604237	0.550317	1.000000
CR	0.135442	0.517806	0.759546	0.223057	0.126709	0.855993	0.674001	0.710411	0.757285
CS	-0.137555	0.748684	0.646181	0.039921	0.057559	0.201709	0.613059	-0.083723	-0.061923
CU	-0.337876	0.175118	0.087521	0.166846	-0.068739	0.221061	0.268831	-0.195820	-0.048160
FE	0.012660	0.614066	0.615424	0.313698	0.137381	0.888672	0.765180	0.532974	0.749894
HF	-0.120941	0.833159	0.654694	0.320154	0.286780	0.649562	0.762753	0.238696	0.493953
K	0.094260	0.490166	0.446360	0.153939	0.145685	0.352788	0.439260	0.365513	0.237505
LA	0.020836	0.736124	0.602770	0.351764	-0.041660	0.713537	0.875185	0.284564	0.611857
LU	0.407355	0.590694	0.322440	-0.009000	0.325477	0.288585	0.553900	0.022569	0.153177
MN	-0.067881	0.246873	0.470224	0.234226	0.057515	0.829208	0.464757	0.592095	0.669765
NA	0.023580	-0.077459	0.021601	0.154110	-0.120771	-0.159070	-0.037130	0.190648	-0.380477
NI	-0.233417	-0.331727	0.019379	0.201819	-0.005088	0.273984	-0.168550	0.517588	0.043880
SB	-0.008935	0.444395	0.459378	-0.158749	0.206307	0.505491	0.509291	-0.004284	0.220803
SC	-0.041168	0.930330	0.679221	0.096325	0.358232	0.710569	0.858234	0.279090	0.557913
SE	0.450301	0.248025	0.654354	0.363739	-0.211861	0.449068	0.420920	0.570171	0.566555
SM	-0.038092	0.913583	0.740336	0.466503	0.041395	0.588433	0.912724	0.214540	0.579996
TH	0.007933	0.867793	0.667420	0.152077	0.044197	0.409724	0.787805	0.054670	0.371438
TI	-0.043401	0.695538	0.592090	-0.082438	0.487433	0.675460	0.624171	0.324972	0.529608
V	-0.051046	0.017135	0.390772	0.273800	-0.012551	0.550866	0.267699	0.489162	0.450716
W	0.565299	0.255150	0.583001	0.137173	0.048727	0.483887	0.376044	0.634170	0.604120
ZN	0.095581	0.152340	0.516763	0.308723	0.027127	0.754581	0.386356	0.633281	0.615274
CDK	0.001547	0.402569	0.361512	0.359771	0.099633	0.476800	0.444467	0.466298	0.276521
PBK	0.130501	0.098548	-0.004468	-0.312335	0.898275	0.469923	0.022512	0.068913	0.162280
SK	-0.085262	0.568837	0.725823	0.421791	0.107176	0.866416	0.735307	0.667912	0.660978
SIK	-0.036786	0.963801	0.752782	0.271913	0.129409	0.533580	0.917921	0.211402	0.635088
CLI	0.026992	0.223514	0.489449	0.205161	0.171751	0.721476	0.339154	0.924926	0.697986
NO3I	0.332712	0.514103	0.679541	0.306827	-0.108724	0.232500	0.561056	0.450402	0.445701
SO4I	0.225090	0.336836	0.671800	0.448085	0.038724	0.731729	0.539724	0.671005	0.726386
TPM	-0.063027	0.608021	0.527669	0.121355	0.421218	0.423035	0.650047	0.231240	0.231423

	CR	CS	CU	FE	HF	K	LA	LU	MN
CR	1.000000								
CS	0.256377	1.000000							
CU	0.096174	0.160252	1.000000						
FE	0.907597	0.333974	0.307563	1.000000					
HF	0.591396	0.556506	0.253674	0.700535	1.000000				
K	0.381304	0.554285	0.004440	0.452366	0.449825	1.000000			
LA	0.707769	0.465646	0.363062	0.846329	0.716397	0.296242	1.000000		
LU	0.322848	0.333694	0.326063	0.423504	0.417506	0.235409	0.508394	1.000000	
MN	0.673870	0.082144	0.290175	0.893163	0.438026	0.325825	0.616647	0.107491	1.000000
NA	-0.124851	0.174317	0.100291	-0.116107	-0.280582	0.359782	-0.141820	0.052097	-0.087187
NI	0.218916	-0.137656	-0.048857	0.205412	-0.111227	0.323369	-0.044082	-0.446871	0.472517
SB	0.485203	0.420254	0.440902	0.462013	0.269317	0.129316	0.465694	0.494818	0.378838
SC	0.637378	0.621577	0.173423	0.705119	0.622157	0.462000	0.720172	0.618296	0.378930
SE	0.751927	0.088565	0.128026	0.635710	0.292830	0.263588	0.485629	0.236360	0.650925
SM	0.613522	0.658921	0.216424	0.702872	0.857443	0.457788	0.789252	0.403292	0.404203
TH	0.471732	0.804893	0.108688	0.549867	0.745185	0.533038	0.719930	0.410262	0.251564
TI	0.617044	0.465907	-0.058337	0.556269	0.569775	0.374066	0.498130	0.380696	0.378369
V	0.567196	0.025209	0.178804	0.488827	0.186445	0.151570	0.429988	-0.075709	0.583152

	CR	CS	CU	FE	HF	K	LA	LU	MN
W	0.690121	0.006760	-0.268012	0.483117	0.245779	0.100854	0.482139	0.252976	0.432071
ZN	0.665717	0.023949	0.235112	0.820654	0.353721	0.231620	0.590022	0.087817	0.953068
CDK	0.370104	0.412941	0.259427	0.529777	0.366206	0.776116	0.420404	0.244511	0.418736
PBK	0.218568	-0.091180	-0.021454	0.224004	0.324095	-0.024844	0.095746	0.316868	0.172161
SK	0.894831	0.378515	0.271918	0.925925	0.715443	0.527105	0.736741	0.263354	0.861233
SIK	0.546966	0.752106	0.157162	0.611426	0.834475	0.513105	0.741369	0.551021	0.262742
CLI	0.724175	-0.105829	-0.170767	0.594633	0.352553	0.226604	0.407227	0.052792	0.595561
NO3I	0.496494	0.295561	-0.298853	0.294756	0.368795	0.149719	0.433486	0.236111	0.094089
SO4I	0.894026	0.098844	0.157207	0.806205	0.491250	0.307443	0.621048	0.192984	0.832621
TPM	0.368011	0.666159	0.036408	0.436370	0.619371	0.584861	0.481107	0.575892	0.105251

	NA	NI	SB	SC	SE	SM	TH	TI	V
NA	1.000000								
NI	0.306646	1.000000							
SB	-0.006969	-0.213398	1.000000						
SC	-0.143524	-0.233929	0.575501	1.000000					
SE	-0.129632	0.092399	0.316736	0.287103	1.000000				
SM	-0.150761	-0.205426	0.419601	0.847995	0.442205	1.000000			
TH	-0.118608	-0.260998	0.387724	0.772765	0.304410	0.860036	1.000000		
TI	-0.205776	-0.093011	0.557630	0.811710	0.211919	0.634018	0.646531	1.000000	
V	-0.122041	0.395760	0.358238	0.156122	0.539788	0.270524	0.081399	0.133448	1.000000
W	-0.226907	-0.015790	0.274882	0.352477	0.743446	0.359938	0.349459	0.484085	0.470456
ZN	-0.096971	0.454474	0.378680	0.280497	0.762584	0.361126	0.221539	0.340113	0.656778
CDK	0.506160	0.395161	0.125254	0.423011	0.298946	0.447534	0.372738	0.231769	0.256512
PBK	-0.379390	-0.065399	0.250102	0.324171	-0.067613	0.076843	0.047627	0.457223	0.088981
SK	0.058117	0.381104	0.377868	0.665212	0.603498	0.703427	0.485269	0.525814	0.519051
SIK	0.005964	-0.243449	0.438478	0.915067	0.261992	0.921244	0.873819	0.702487	0.096990
CLI	-0.070879	0.349872	0.043883	0.415965	0.496374	0.297976	0.099036	0.418792	0.519149
NO3I	-0.042507	-0.275186	0.114971	0.432642	0.471028	0.575861	0.515327	0.404410	0.322005
SO4I	-0.168365	0.267665	0.373704	0.428058	0.869351	0.573972	0.365694	0.448426	0.693027
TPM	0.202883	-0.149557	0.374620	0.827766	-0.003819	0.650424	0.703527	0.711123	-0.065583

	W	ZN	CDK	PBK	SK	SIK	CLI	NO3I	SO4I
W	1.000000								
ZN	0.597970	1.000000							
CDK	0.107636	0.345687	1.000000						
PBK	0.200966	0.167726	-0.065761	1.000000					
SK	0.410229	0.791470	0.624681	0.125362	1.000000				
SIK	0.294713	0.190211	0.456159	0.085976	0.636060	1.000000			
CLI	0.631777	0.593764	0.377715	0.165409	0.676117	0.288789	1.000000		
NO3I	0.680590	0.192624	0.064478	-0.065933	0.340308	0.575517	0.436118	1.000000	
SO4I	0.723840	0.905758	0.381096	0.181296	0.807369	0.367742	0.639024	0.481697	1.000000
TPM	0.162892	0.026001	0.444004	0.200063	0.440447	0.815252	0.238279	0.378426	0.143466

	TPM
TPM	1.000000

Table VII-1-22 Factor loading by method II (2nd survey)

Principal component	1	2	3	4	5	6	7
AG	0.073149	0.127257	-0.279629	-0.555812	0.275267	0.586227	0.269292
AL	0.792856	-0.580092	0.044763	-0.086120	-0.009731	-0.105712	0.049018
AS	0.825243	-0.063312	0.101343	-0.244661	0.091267	0.043520	-0.319168
BA	0.335499	0.189729	0.494550	-0.279251	-0.096747	-0.140977	0.469482
BR	0.176629	-0.166794	-0.575192	0.581465	0.384894	0.098601	0.108831
CA	0.848778	0.239541	-0.186303	0.378280	-0.029147	-0.081891	0.015392
CE	0.873964	-0.312910	0.121785	-0.130138	-0.157041	-0.040286	0.068103
CL	0.572344	0.592660	0.048995	-0.028591	0.485063	-0.034687	0.002514
CO	0.723970	0.320129	-0.210443	-0.117122	-0.080177	-0.291144	0.202257
CR	0.902442	0.335208	-0.109717	-0.004874	-0.018192	0.043847	-0.107296
CS	0.515987	-0.623802	0.315233	0.017881	0.049916	0.051151	-0.359484
CU	0.198554	-0.114142	0.285333	0.385153	-0.659837	0.316493	0.118953
FE	0.913906	0.188612	0.024264	0.173969	-0.165118	0.034949	0.122986
HF	0.796790	-0.311659	-0.022034	0.117427	-0.084886	-0.258394	0.227221
K	0.533704	-0.144394	0.421447	0.183906	0.449313	0.145778	0.010888
LA	0.651065	-0.086710	0.062210	-0.052041	-0.304410	-0.000001	0.117249
LU	0.474958	-0.434537	-0.230598	-0.016793	-0.026526	0.565295	0.309231
MN	0.719674	0.529614	0.054018	0.279462	-0.211390	0.036758	-0.031392
NA	-0.085555	-0.042082	0.649072	0.121516	0.419311	0.436144	-0.069647
NI	0.067926	0.637417	0.416305	0.431567	0.276035	-0.114207	-0.117203
SB	0.524607	-0.198074	-0.202175	0.190380	-0.340854	0.432254	-0.420205
SC	0.854831	-0.428199	-0.150170	0.108183	0.052741	-0.061059	0.023353
SE	0.641590	0.466642	0.019536	-0.391415	-0.145318	0.293780	-0.023570
SM	0.861489	-0.340362	0.112782	-0.149438	-0.133426	-0.183479	0.085145
TH	0.733350	-0.517321	0.077022	-0.170127	-0.029069	-0.092753	-0.122104
TI	0.725396	-0.258025	-0.374527	0.147252	0.190234	-0.119599	-0.231790
V	0.484183	0.549398	0.034454	0.031104	-0.183211	0.008663	-0.249980
W	0.603765	0.370037	-0.376068	-0.471210	0.172465	0.151849	-0.109032
ZN	0.689532	0.622117	-0.000444	0.114937	-0.197920	0.133358	-0.069479
CDK	0.548100	0.025642	0.541414	0.279909	0.311839	0.202466	0.200007
PBK	0.216655	-0.040002	-0.753447	0.462336	0.127239	0.087240	0.169391
SK	0.903659	0.237184	0.208600	0.197226	-0.014491	-0.054861	0.044189
SIK	0.820519	-0.523265	0.098507	-0.091376	0.056328	-0.109170	0.015023
CLI	0.621665	0.523298	-0.117539	0.019168	0.336301	-0.232653	0.041451
NO3I	0.556433	-0.051994	-0.096735	-0.672345	0.225935	-0.118280	-0.111909
SO4I	0.804560	0.499090	-0.048063	-0.116455	-0.116001	0.085684	0.011496
TPM	0.628268	-0.575137	0.034165	0.144162	0.372002	0.000730	0.013369
VP	16.023026	5.487446	3.094229	2.811961	2.303757	1.712104	1.223734
PERCENT	43.3%	14.8%	8.4%	7.6%	6.2%	4.6%	3.3%
CUM PCT	43.3%	58.1%	66.5%	74.1%	80.3%	85.0%	88.3%

Table VII-1-23 Score of principal component by method II (2nd survey)

Principal component	1	2	3	4	5	6	7
MP01	0.3337	1.0485	0.6049	-0.0557	0.3234	-0.8443	-0.7337
MP02	-0.4752	0.2793	-0.2018	0.7146	0.0624	-1.0994	0.4040
MP03	-1.3712	0.2845	0.4323	0.4193	0.0077	-0.3713	0.0146
MP04	-0.5115	-0.0337	0.8897	0.5281	2.1199	0.7699	0.1889
MP05	-0.6694	-0.0044	0.9278	0.6863	1.5976	0.9001	0.9081
MP06	0.0411	-0.4193	0.7368	-0.9151	-1.3652	-2.0107	1.9853
MP07	2.7655	-1.5633	-1.4917	1.5310	0.8329	-0.2959	0.0157
MP08	0.9597	-1.1601	2.0643	-0.9691	-0.3294	1.3345	1.4556
MP09	0.5715	-0.7484	1.2341	-0.6345	1.0689	-0.8082	-2.0036
MP10	-0.4063	-0.7683	0.5098	0.6008	-2.1727	1.9091	-1.9740
MP11	0.1708	-1.3078	0.2632	-0.4131	-0.9368	-1.1406	-0.8268
MP12	0.9086	0.9350	-1.2258	-1.5760	-0.0173	1.4896	0.7901
MP13	-0.8580	-0.4576	-1.6083	0.6804	-0.1274	0.2431	0.2908
MP14	-0.7968	0.1159	-0.6379	-0.0467	-0.1129	0.6004	0.4391
MP15	0.0294	1.0358	-0.5570	-1.6923	0.1026	0.1800	-0.9250
MP16	0.0864	0.1256	-1.2123	-1.7691	0.4621	0.0922	-0.2694
MP17	-0.5479	-0.5163	-0.7235	0.9851	-1.0440	0.4211	0.8694
MP18	-1.2353	0.0700	-0.1791	0.5691	0.1635	-0.2578	-0.2674
MP19	1.6082	2.9025	0.8032	1.4995	-0.9760	-0.0628	-0.0075
MP20	-0.6031	0.1820	-0.6287	-0.1424	0.3406	-1.0491	-0.3544
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

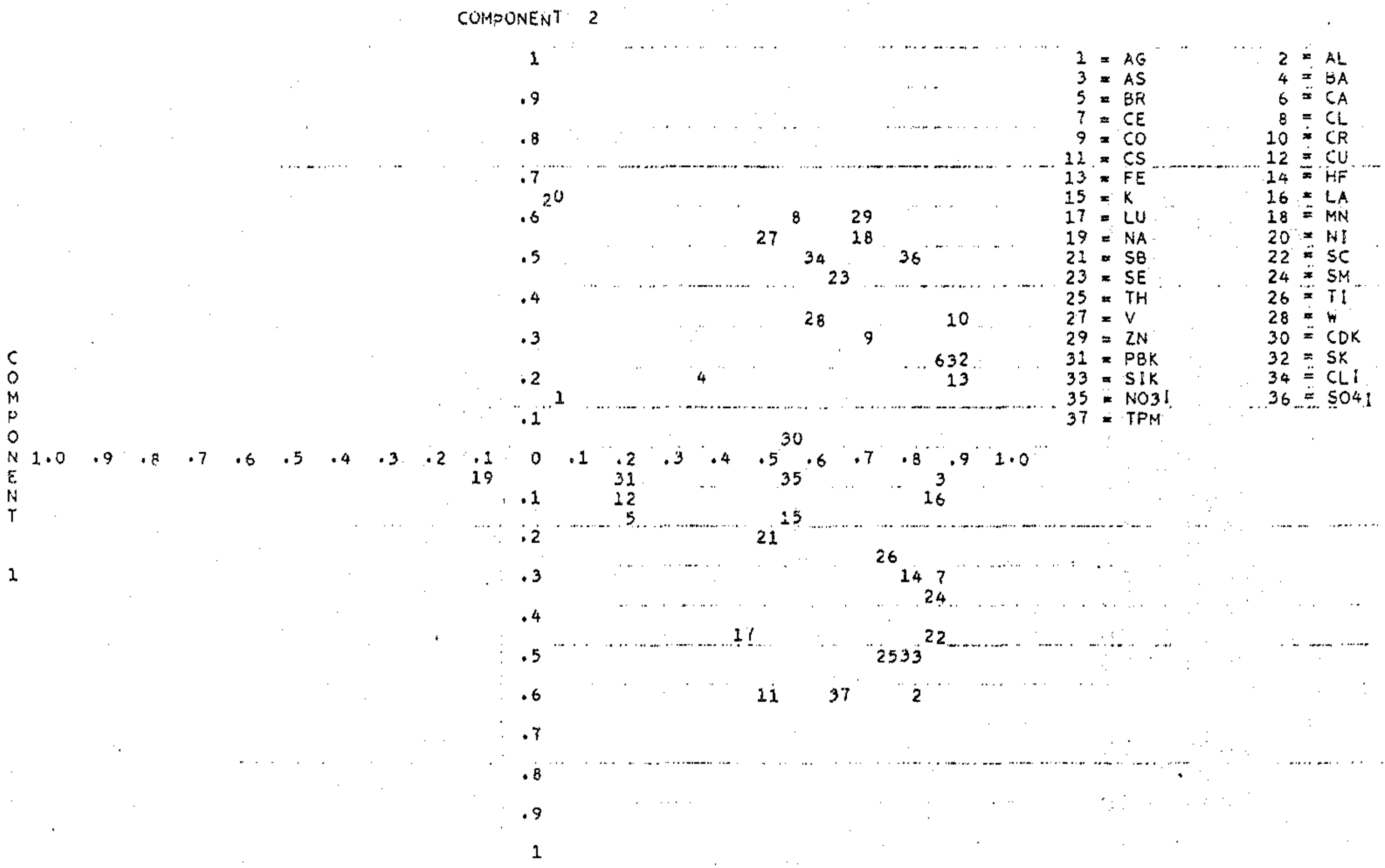


Fig. VII-1-11 Distribution of factor loading by method II (2nd survey)

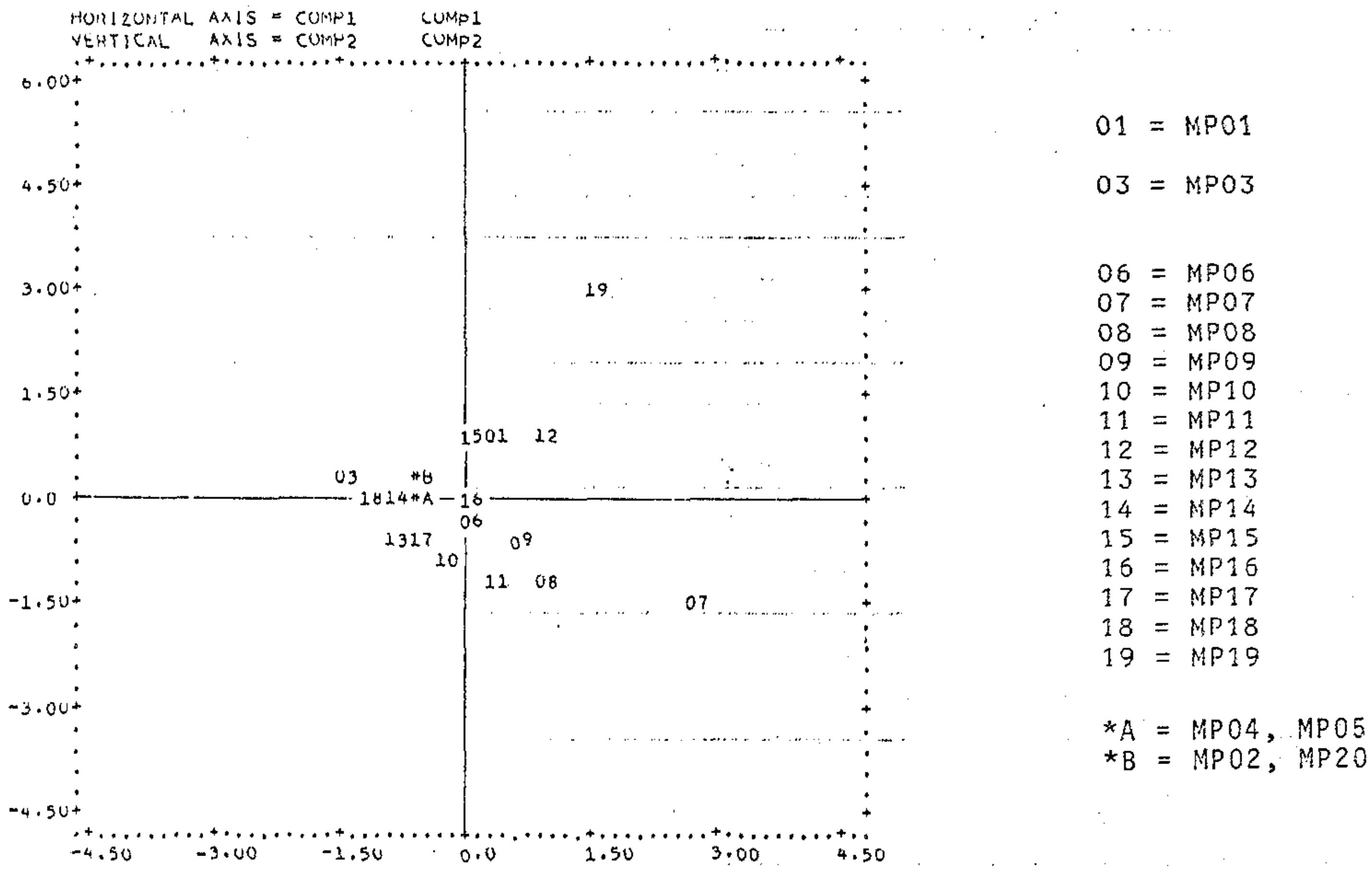


Fig. VII-1-12 Distribution of scores by method II (2nd survey)

Table VII-1-24 Correlation coefficient matrix by method II (3rd survey)

	AG	AL
AG	1.000000	
AL	-0.086695	1.000000

	AG	AL	AS	BA	BR	CA	CE	CL	CO
AS	-0.065366	0.251791	1.000000						
BA	-0.038747	0.125296	-0.123814	1.000000					
BR	-0.080230	0.493342	-0.042695	-0.079375	1.000000				
CA	0.142859	0.127055	0.180003	0.270342	-0.259602	1.000000			
CE	0.010497	0.683801	0.226514	0.088050	0.397457	0.172437	1.000000		
CL	0.138283	-0.047520	0.160730	-0.230393	-0.402939	0.496640	-0.017310	1.000000	
CO	0.212758	0.355991	0.350070	-0.062914	-0.113880	0.711790	0.363325	0.535047	1.000000
CR	0.090648	0.263020	0.768202	-0.102436	0.034895	0.563658	0.194157	0.348811	0.653719
CS	-0.194928	0.871726	0.434170	0.138563	0.264303	0.082729	0.459370	0.002317	0.300307
CU	-0.232131	0.167456	0.016794	0.075232	0.138185	0.611707	0.233809	0.209827	0.465018
FE	0.005281	0.552861	0.227794	0.001671	0.118361	0.631352	0.462039	0.406008	0.843811
HF	0.207626	0.585722	0.454480	0.265450	0.104160	0.330736	0.172215	-0.036729	0.374179
K	-0.179379	0.675074	0.569967	0.174248	0.076776	0.411007	0.561792	0.197886	0.470826
LA	0.187289	0.197045	0.183073	0.319673	0.001319	0.011222	0.546553	-0.299000	-0.008605
LU	-0.065117	0.090265	0.226941	0.012262	-0.166153	0.516667	0.023305	0.215189	0.142017
MN	0.090496	0.219975	0.201783	0.011070	-0.091117	0.764156	0.301296	0.500764	0.868842
NA	0.322054	-0.230436	0.151609	-0.249473	-0.394775	0.485445	-0.234375	0.908927	0.528539
NI	-0.152936	0.413016	0.004730	-0.132806	0.090273	-0.102194	0.036532	0.086948	-0.015891
SB	0.048462	0.268043	0.286922	-0.046796	0.419421	0.364874	0.369131	-0.133317	0.378891
SC	-0.062026	0.956208	0.347220	0.054397	0.462660	0.188675	0.591325	0.127216	0.412647
SE	-0.019872	-0.030426	0.393040	-0.162010	-0.374536	0.371899	0.063149	0.333619	0.383577
SM	0.036125	0.789752	0.463353	0.180658	0.198337	0.289865	0.835337	0.111715	0.552791
TH	-0.121811	0.937072	0.387098	0.129300	0.447620	0.092481	0.807836	-0.091996	0.388971
TI	-0.086603	0.857452	0.206858	0.050444	0.524248	0.107063	0.779781	-0.111921	0.352909
V	0.237642	0.283791	0.349089	-0.206805	0.326791	0.352980	0.219234	0.217155	0.688709
W	0.403645	0.104111	0.230737	-0.086181	-0.137464	0.551726	0.113551	0.247522	0.611235
ZN	0.064915	0.230007	0.256561	-0.072831	-0.067926	0.751469	0.339321	0.438816	0.805727
CDK	-0.083396	-0.148432	-0.111848	-0.251901	-0.045202	0.218418	-0.015803	0.086925	0.128257
PBK	-0.011022	0.491641	-0.050169	-0.085096	0.978133	-0.150392	0.360346	-0.353687	-0.043119
SK	0.151126	0.250038	0.365119	-0.035761	-0.049908	0.843425	0.221932	0.516195	0.860891
SIK	-0.098035	0.958732	0.403116	0.185647	0.427205	0.161955	0.691688	-0.050246	0.391003
CLI	0.111884	0.091450	0.213902	-0.112992	-0.310496	0.474243	0.119221	0.951776	0.609139
NO3I	-0.073802	0.345907	0.474893	0.296687	-0.115057	0.660700	0.455976	0.290968	0.627620
SO4I	0.158622	0.310672	0.391782	-0.081882	0.035138	0.662462	0.370419	0.457470	0.896359
TPM	-0.072156	0.930243	0.405196	0.054440	0.550394	0.193295	0.770289	-0.050011	0.496387

	CR	CS	CU	FE	HF	K	LA	LU	MN
CR	1.000000								
CS	0.258303	1.000000							
CU	0.284024	0.146842	1.000000						
FE	0.463673	0.441884	0.589269	1.000000					
HF	0.598159	0.614956	0.087398	0.263302	1.000000				
K	0.450243	0.744820	0.176870	0.458476	0.459675	1.000000			
LA	0.070858	0.109978	-0.090563	-0.080490	0.182610	0.139256	1.000000		
LU	0.323879	0.179642	0.210652	0.065977	0.135838	0.443166	0.042331	1.000000	
MN	0.514038	0.151461	0.644149	0.909723	0.118189	0.309383	-0.119600	0.139090	1.000000
NA	0.344330	-0.135459	0.165292	0.323756	-0.042894	0.075796	-0.412517	0.199884	0.469389
NI	-0.068519	0.306179	-0.338641	0.200547	0.017374	0.344358	-0.258949	0.139562	-0.041908
SB	0.426775	0.248462	0.328967	0.392982	0.163662	0.338571	0.292578	0.334556	0.415363
SC	0.376024	0.835953	0.162627	0.601402	0.597670	0.692617	0.041639	0.100097	0.274258
SE	0.295433	0.135032	0.340288	0.410984	-0.108201	0.191339	0.172996	0.489353	0.485171
SM	0.379385	0.731605	0.160607	0.562104	0.446830	0.790459	0.387296	0.216680	0.380956
TH	0.325643	0.631329	0.142954	0.521335	0.518157	0.712126	0.314857	0.055723	0.252018
TI	0.311441	0.646607	0.279846	0.492019	0.426370	0.475852	0.441253	0.078701	0.247881
V	0.605199	0.251113	0.285395	0.563500	0.375667	0.347652	-0.205987	-0.096797	0.592216
W	0.578757	0.100749	0.302469	0.387764	0.334497	0.195493	0.168158	0.449655	0.555947
ZN	0.516228	0.197641	0.631930	0.660092	0.093332	0.366003	-0.009013	0.298547	0.949257
CDK	-0.089154	-0.095923	0.288019	0.345541	-0.418658	-0.153804	-0.165132	0.269163	0.452622
PBK	0.099889	0.254728	0.223212	0.184738	0.140942	0.055955	-0.000869	-0.066377	-0.007052
SK	0.705746	0.260463	0.589972	0.759046	0.328139	0.502371	-0.123734	0.486079	0.864478
SIK	0.359366	0.896369	0.174077	0.515807	0.613360	0.753311	0.224975	0.186998	0.232567
CLI	0.393352	0.099700	0.219922	0.476478	0.029774	0.274647	-0.217053	0.126546	0.526219
NO3I	0.539163	0.461216	0.611221	0.577288	0.330572	0.582526	0.405239	0.471542	0.621816
SO4I	0.649324	0.281195	0.461844	0.822632	0.252830	0.503734	-0.113785	0.182681	0.897384
TPM	0.457208	0.797903	0.242045	0.611135	0.552894	0.703266	0.252685	0.106124	0.363391

	NA	NI	SB	SC	SE	SM	TH	TI	V
NA	1.000000								
NI	0.015483	1.000000							
SB	-0.089512	-0.157887	1.000000						
SC	-0.024822	0.499641	0.212871	1.000000					
SE	0.325978	0.001208	0.305896	0.003432	1.000000				
SM	-0.038777	0.160546	0.332509	0.744063	0.241071	1.000000			
TH	-0.298949	0.250789	0.315938	0.857201	0.007230	0.891993	1.000000		
TI	-0.332737	0.168221	0.346216	0.743063	0.044873	0.716855	0.880806	1.000000	
V	0.302976	-0.079727	0.584027	0.337980	-0.051590	0.299634	0.326343	0.240619	1.000000
W	0.271450	-0.194880	0.501384	0.051036	0.405662	0.242005	0.163495	0.306522	0.511946
ZN	0.384946	-0.046841	0.587637	0.247808	0.591188	0.390772	0.272686	0.287680	0.576263
CDK	0.090967	-0.006302	0.405409	-0.189262	0.535959	-0.059102	-0.113369	-0.091559	0.046296
PBK	-0.334506	0.063243	0.464600	0.460743	-0.275873	0.163678	0.423906	0.548277	0.345569
SK	0.540690	-0.045912	0.589629	0.318167	0.479025	0.414215	0.257421	0.235361	0.691235
SIK	-0.205294	0.303478	0.283672	0.914499	0.052234	0.875067	0.960139	0.832307	0.286302
CLI	0.842624	0.067751	-0.158460	0.255048	0.269400	0.270202	0.075899	0.043565	0.236375
NO3I	0.208335	-0.239184	0.529674	-0.312108	0.641938	0.611948	0.429859	0.443572	0.277137
SO4I	0.456145	0.001010	0.569477	0.365176	0.367391	0.515736	0.388829	0.294933	0.824290
TPM	-0.205703	0.243135	0.486787	0.878539	0.033829	0.846391	0.961704	0.890938	0.500109

	W	ZN	CDK	PBK	SK	SIK	CLI	NO3I	SO4I
W	1.000000								
ZN	0.633643	1.000000							
CDK	0.227741	0.586840	1.000000						
PBK	-0.005867	0.031700	0.028360	1.000000					
SK	0.732427	0.887242	0.334391	0.056775	1.000000				
SIK	0.171818	0.235050	-0.161792	0.422823	0.306933	1.000000			
CLI	0.218004	0.416364	-0.038684	-0.269387	0.502622	0.118169	1.000000		
NO3I	0.559322	0.660975	0.181467	-0.045987	0.704213	0.466934	0.355867	1.000000	
SO4I	0.639414	0.885759	0.310358	0.090149	0.912420	0.356054	0.483090	0.602222	1.000000
TPM	0.288945	0.387322	-0.072047	0.546279	0.415685	0.941670	0.102367	0.478128	0.518682

	TPM
TPM	1.000000

Table VII-1-25 Factor loading by method II (3rd survey)

Principal component	1	2	3	4	5	6	7	8	9
AG	0.039968	0.208133	0.001440	-0.056857	0.588847	-0.173610	0.433463	0.503550	0.043613
AL	0.725025	-0.619066	-0.143574	-0.113641	-0.119150	-0.050029	-0.019381	0.138246	0.005065
AS	0.513140	-0.000620	-0.255973	0.231558	0.252109	0.488156	0.087970	-0.466220	-0.093611
BA	0.052164	-0.189392	-0.060985	0.474468	0.074426	-0.498740	-0.481868	0.184961	-0.141954
BR	0.216209	-0.619903	0.472798	-0.451469	0.056419	0.070451	-0.065577	-0.035065	0.287810
CA	0.627141	0.548283	0.001165	0.188166	0.033819	-0.174073	-0.323374	0.212875	0.079504
CE	0.641696	-0.431836	0.109390	0.117971	-0.123631	-0.303231	0.364920	-0.101560	0.123139
CL	0.327966	0.646200	-0.500289	-0.225473	-0.105949	-0.098873	0.131169	-0.044323	0.292022
CO	0.819818	0.406859	-0.068498	-0.125914	0.130786	-0.175846	0.073965	-0.023506	-0.137415
CR	0.686764	0.234771	-0.088318	0.036155	0.434731	0.307634	-0.090640	-0.224606	0.083254
CS	0.670424	-0.497014	-0.264867	0.052538	-0.141219	0.143825	-0.124095	-0.006807	-0.106315
CU	0.499471	0.293773	0.377232	0.014647	-0.231084	-0.255847	-0.409115	-0.218931	0.257000
FE	0.840385	0.208996	0.066973	-0.245331	-0.236077	-0.218175	-0.011674	0.014276	-0.187372
HF	0.533455	-0.282593	-0.254831	0.127236	0.539174	0.069492	-0.317505	0.119978	-0.084914
K	0.750030	-0.221131	-0.341650	0.170150	-0.098454	0.181724	-0.127337	-0.014229	-0.061474
LA	0.161028	-0.323354	0.165042	0.703508	0.194403	-0.222037	0.404121	-0.017866	0.084718
LU	0.330868	0.235079	-0.042426	0.426543	-0.202528	0.496650	-0.186920	0.382332	0.364959
MN	0.737659	0.530942	0.171551	-0.142148	-0.130210	-0.230954	-0.022778	-0.014145	-0.180463
NA	0.219216	0.761531	-0.411250	-0.282593	0.067345	-0.004712	0.075523	0.028419	0.233753
NI	0.117891	-0.264949	-0.430474	-0.327729	-0.393909	0.302863	0.042234	0.401167	-0.197069
SB	0.572514	0.018599	0.631138	0.100815	0.113614	0.293739	0.038750	0.038084	-0.007907
SC	0.738741	-0.500820	-0.283333	-0.242314	-0.098164	0.019431	-0.057083	0.095805	0.050446
SE	0.381204	0.478426	0.047623	0.410002	-0.384655	0.272071	0.257020	-0.053649	-0.000633
SM	0.809052	-0.346918	-0.185647	0.187638	-0.073895	-0.113185	0.222707	-0.015035	-0.039232
TH	0.754760	-0.608007	-0.079875	0.009311	-0.073716	-0.063136	0.106788	-0.043217	-0.068653
TI	0.689517	-0.557287	0.120902	0.028111	-0.063352	-0.133878	0.157426	0.021745	0.181342
V	0.628059	0.170785	0.223490	-0.462513	0.442120	0.087661	-0.029521	-0.111548	-0.197711
W	0.559052	0.403490	0.238898	0.184852	0.340399	0.137464	0.123172	0.299205	0.032748
ZN	0.760693	0.508197	0.288512	-0.025631	-0.180125	-0.053660	0.047252	0.026455	-0.147614
CDK	0.131063	0.409666	0.528403	-0.016166	-0.532570	0.187722	0.166067	0.127429	-0.159359
PBK	0.274306	-0.529627	0.520635	-0.427965	0.065424	0.087093	-0.084437	0.052085	0.345265
SK	0.811852	0.520560	0.115458	-0.046782	0.072217	0.092096	-0.144062	0.105771	0.013244
SIK	0.768920	-0.579675	-0.175508	0.023680	-0.068277	0.007469	-0.035230	0.053805	0.011237
CLI	0.421985	0.511128	-0.541051	-0.217521	-0.075854	-0.224741	0.136408	-0.124085	0.299265
NO3I	0.765160	0.218636	0.075026	0.508326	-0.075862	-0.074934	-0.078845	-0.141927	0.113941
SO4I	0.825508	0.404968	0.127752	-0.202137	0.089917	-0.014311	0.046652	-0.032814	-0.209808
TPM	0.840719	-0.518079	0.037769	-0.096445	0.007667	0.012170	0.057700	-0.013618	-0.009736
VP	13.388947	7.097326	3.036736	2.672517	2.198548	1.727579	1.469236	1.193865	1.031374
PERCENT	36.2%	19.2%	8.2%	7.4%	5.9%	4.7%	4.0%	3.2%	2.8%
CUM PCT	36.2%	55.4%	63.6%	70.8%	76.7%	81.4%	85.4%	88.6%	91.4%

Table VII-1-26 Score of principal component by method II (3rd survey)

Principal component	1	2	3	4	5	6	7	8	9
MP01	-0.3000	0.5445	-1.1342	0.5025	1.4869	1.2676	-0.1095	-2.5125	0.0272
MP02	-1.1686	0.3956	-0.9481	-0.3672	-0.3882	-0.1613	-0.2601	-0.4599	0.2256
MP03	-0.2423	0.4643	-0.7584	-0.3856	0.5235	-0.4150	-1.1084	-0.6277	-0.0307
MP04	0.5748	1.4720	-0.1126	-1.1124	2.5332	0.0487	0.3502	1.2968	-1.2255
MP05	1.6075	2.5848	1.0573	-0.6876	-1.6975	-1.3671	0.1322	-0.7233	-0.7401
MP06	1.4757	0.9905	0.2418	2.0338	-0.1790	1.9187	-1.2429	0.8667	1.3573
MP07	2.1232	-1.8338	-1.6154	-2.1240	-0.3622	-0.0500	-0.5048	0.3948	0.5913
MP08	0.2702	-0.6911	0.2257	0.9465	-0.6929	0.7534	1.2967	0.3348	-1.5711
MP09	1.4518	-1.2186	0.0862	0.6467	0.1477	0.4950	0.9677	-1.1887	-1.0445
MP10	-1.1559	-0.4225	0.1530	-0.3946	-0.3464	0.9518	-0.5226	0.9546	-2.2013
MP11	0.2331	-0.8573	0.6704	0.4278	-0.3246	-0.9498	1.5720	-0.9945	0.7926
MP12	-0.2800	0.3691	-1.0488	0.0413	-1.4305	0.9671	0.5477	1.5183	0.7667
MP13	-0.6385	-0.6290	2.6427	-1.4756	0.0716	0.9776	-0.6771	-0.1068	1.0486
MP14	-0.3761	0.0452	0.0842	0.5487	1.2052	-0.9409	1.9517	1.5848	1.1184
MP15	-1.2649	0.7764	-1.3403	-0.5017	-0.8004	-0.3006	0.4781	-0.3682	1.0833
MP16	0.1631	-0.4039	1.0549	-0.1682	1.2138	-0.6272	-0.3906	-0.1193	0.9999
MP17	-0.7595	-0.2984	0.8883	-0.0716	-0.4520	0.2944	-0.7530	-0.3015	-0.0697
MP18	-0.8956	-0.3711	-0.0205	-0.2796	-0.5380	-0.2497	-0.3060	0.1760	-0.5644
MP19	-0.8253	-0.0605	0.1731	0.6272	-0.1631	-0.2741	0.6625	-0.3133	-0.0830
MP20	0.0070	-0.8563	-0.2993	1.7935	0.1928	-2.3486	-2.0837	0.5888	-0.4805
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

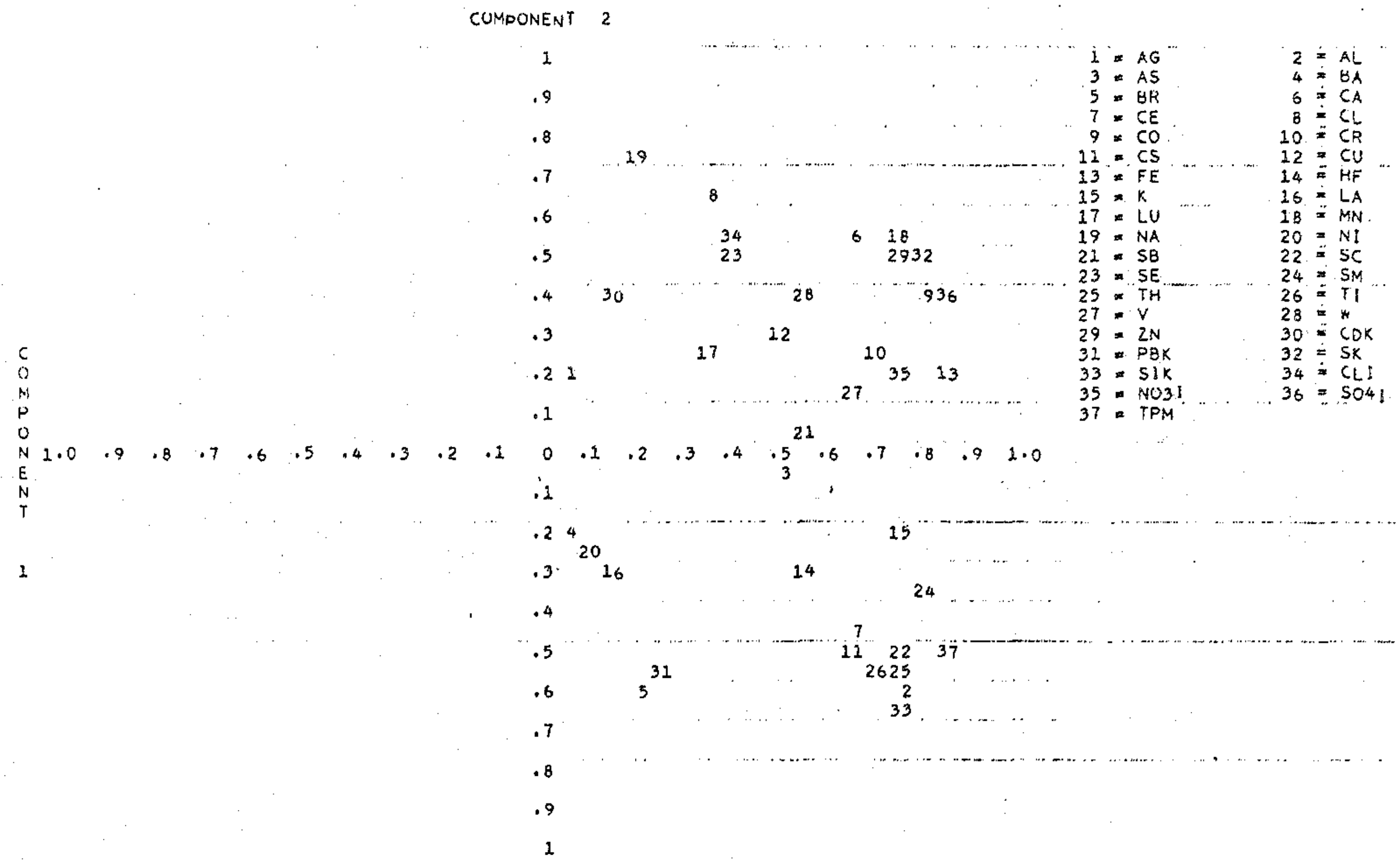


Fig. VII-1-13 Distribution of factor loading by method II (3rd survey)

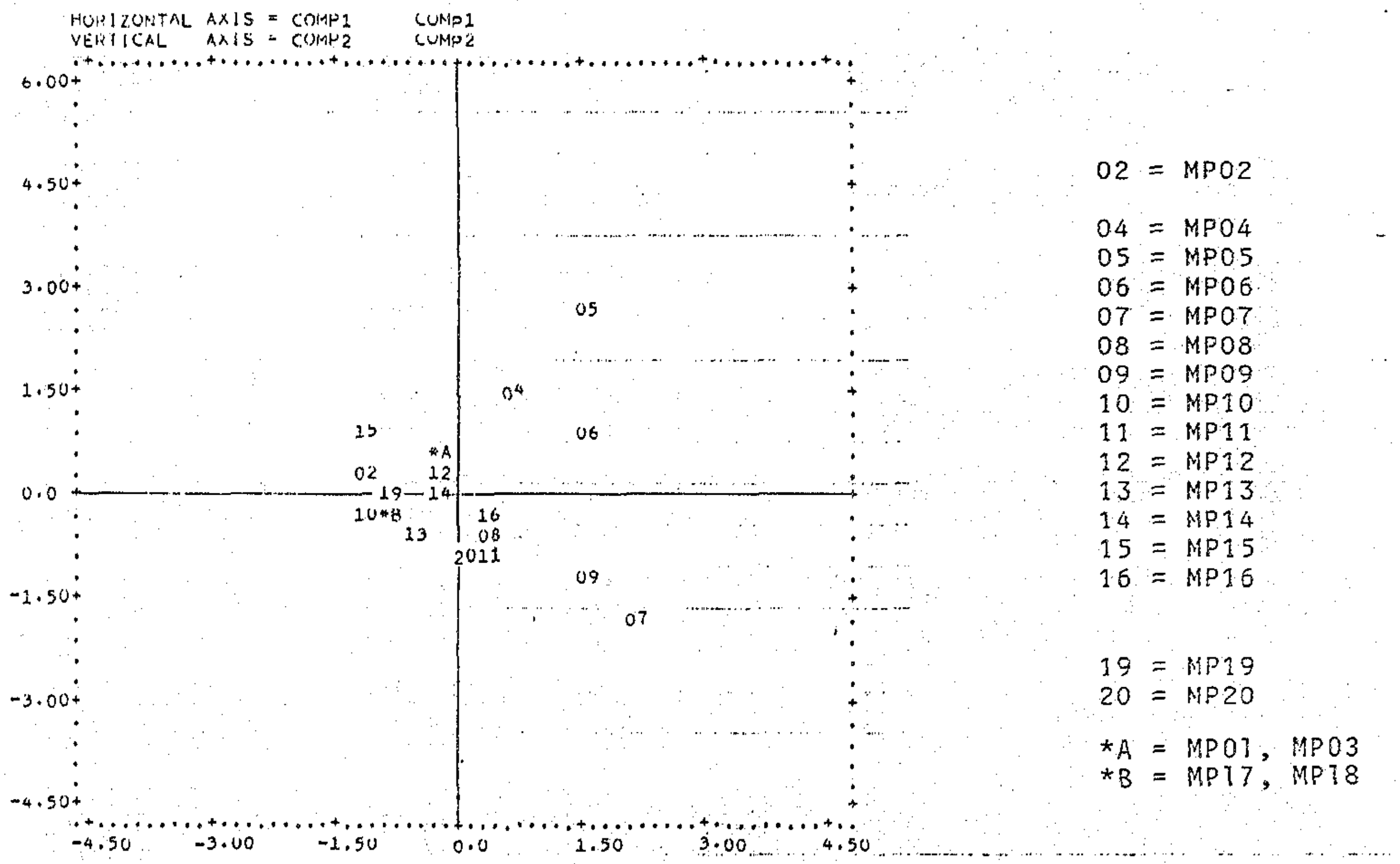


Fig. VII-1-14 Distribution of scores by method II (3rd survey)