iii) In comparison with the WHO's upper limit guideline value for SO_2, all the stations except Cankaya exceeded on 85% - 100% of the days of the monitoring. At Cankaya the percentage was 75%, and SO_2 levels were below the guideline value on 21 days out of 85 effective days for monitoring.

iv) As indicated above, SO_2 concentration at Cankaya was lowest for the majority of days of the monitoring. However, the concentration varied from below the 1st to above the 4th emergency levels. This is a characteristic feature of the southern zone of the City including Kavaklidere.

v) As to the concentration of PM, number of days exceeding the 1st level is 3 - 7% of the effective monitoring days, and the 2nd level was never exceeded at all the stations.

2.5.2 High Concentration and Meteorological Condition

All the sixteen days when high concentration was recorded at all the stations were selected, and the meteorological conditions of the days were examined. They are December 20 and 21, 1984, January 16 - 19 and 22 - 27, February 22 and 23, and March 11 and 12 in 1985.

The wind roses at the 3 stations averaged over these periods are shown in Figure 2.5.1.

In comparison with the wind roses averaged over the entire period of observation, they show the following characteristics.

i) At the Meteorological Agency, the wind direction of ENE observed most frequently throughout the whole period is further dominating during the high concentration periods. Western winds seen in the whole period are seldom observed at the times of high concentration.

ii) NNE-NE and W winds at Tandogan, and ENE-E and NW winds at Kavaklidere are high in frequency being similar to the patterns during the whole period. However, frequencies of W-S winds are considerably lower than those in the whole period.

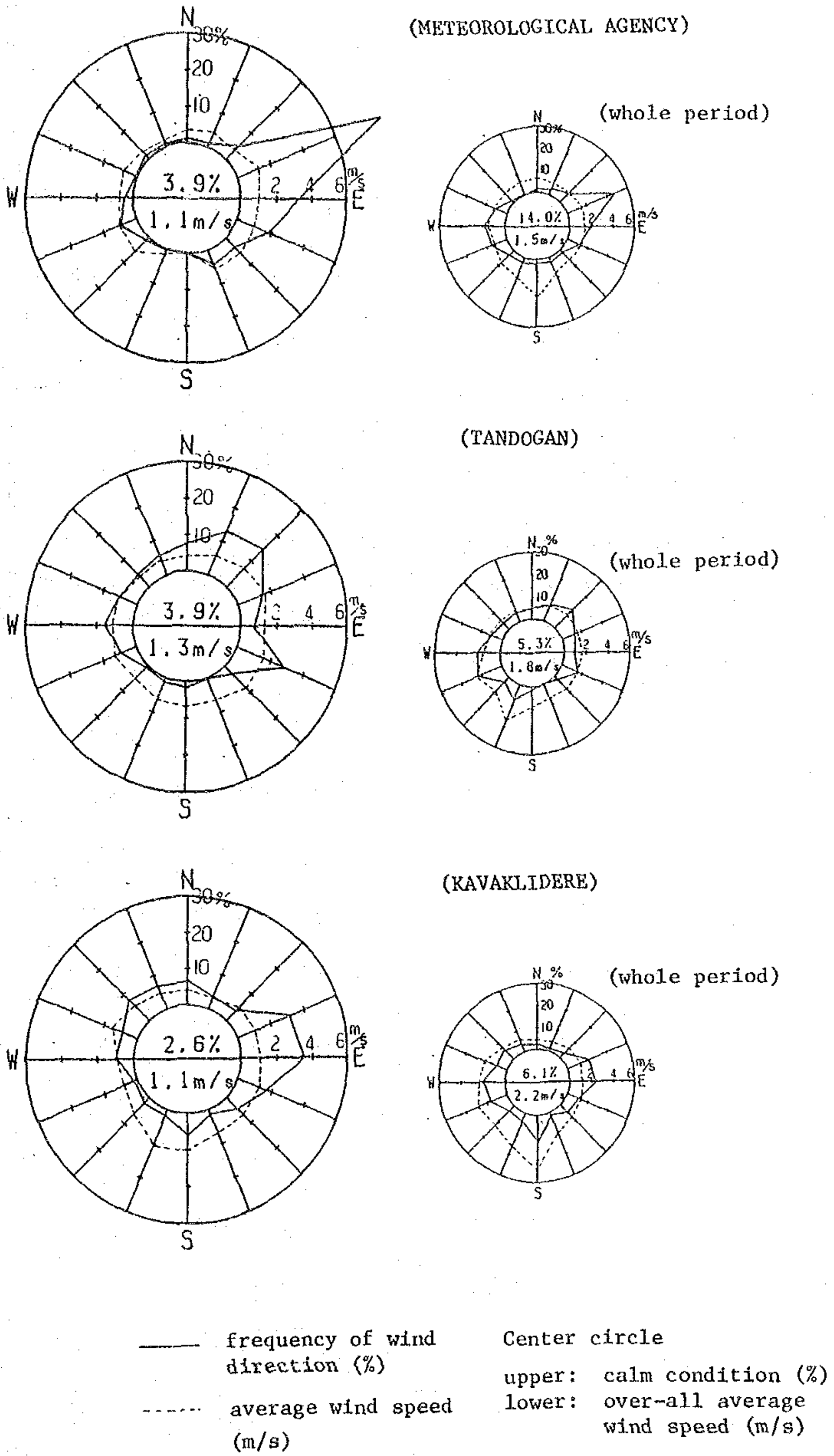


Figure 2.5.1 Wind Rose during the Days of High Concentration

iii) Average wind speeds are lower than those for the whole period.

iv) In general, high concentration occurs at the times of eastern winds.

Table 2.5.4 shows the hourly frequency of wind direction at Kavaklidere during the 16 days of high pollutant concentration. Eastern winds dominate until noon, and then western winds appear in the afternoon blowing pollutants back, and the eastern winds appear again and dominate over the night. Since the Ankara basin is higher to the east and lower to the west, those winds with periodic change in direction as mentioned above are considered to be valley breeze and mountain breeze that blow along the surface topography with generally low speed (see Figure 2.5.2).

It is considered that high concentration occurrences in Ankara are due, partly at least, to such low-speed mountain breeze that is peculiar to the basined topography, drifting pollutants toward the bottom part of the basin, that is the central part of the City.

Table 2.5.4 Hourly Frequency of Wind Direction at Kavaklidere During the Periods of Hight Pollutant Concentration

	Time	Wind Direction (%)																Mean wind speed (m/s)	Calm (W<0.1m/s) (%)
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW		
Time of Day	1	7.1	7.1	14.3	14.3	14.3	7.1	7.1	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	14.3	1.0	7.1
	2	0.0	0.0	0.0	7.1	28.6	14.3	7.1	0.0	14.3	0.0	7.1	0.0	0.0	0.0	7.1	14.3	1.0	0.0
	3	7.1	7.1	7.1	14.3	28.6	0.0	14.3	0.0	7.1	0.0	0.0	0.0	0.0	0.0	7.1	7.1	0.8	0.0
	4	0.0	0.0	0.0	21.4	7.1	21.4	14.3	0.0	21.4	0.0	0.0	0.0	0.0	0.0	7.1	0.0	1.0	7.1
	5	0.0	0.0	7.1	28.6	21.4	7.1	0.0	7.1	7.1	0.0	0.0	0.0	7.1	0.0	0.0	7.1	0.9	7.1
	6	0.0	0.0	0.0	14.3	21.4	14.3	0.0	0.0	7.1	0.0	0.0	7.1	7.1	14.3	7.1	0.0	1.0	7.1
	7	7.1	0.0	14.3	7.1	14.3	7.1	7.1	0.0	7.1	0.0	0.0	0.0	0.0	0.0	7.1	21.4	0.9	7.1
	8	7.1	0.0	7.1	35.7	28.6	7.1	0.0	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	7.1	1.1	0.0
	9	0.0	0.0	0.0	21.4	42.9	0.0	0.0	0.0	7.1	0.0	7.1	0.0	0.0	0.0	14.3	0.0	1.2	7.1
	10	7.1	0.0	7.1	35.7	35.7	0.0	0.0	0.0	7.1	0.0	0.0	7.1	0.0	0.0	0.0	0.0	1.2	0.0
	11	0.0	0.0	7.1	35.7	7.1	7.1	0.0	0.0	21.4	7.1	7.1	0.0	0.0	0.0	0.0	7.1	1.3	0.0
	12	7.1	21.4	7.1	7.1	7.1	7.1	0.0	0.0	7.1	0.0	0.0	0.0	7.1	14.3	14.3	0.0	1.4	0.0
	13	7.1	7.1	0.0	7.1	14.3	7.1	0.0	0.0	0.0	0.0	7.1	0.0	7.1	14.3	14.3	14.3	1.3	0.0
	14	7.1	0.0	0.0	14.3	7.1	7.1	0.0	0.0	0.0	7.1	0.0	0.0	14.3	14.3	7.1	21.4	1.2	0.0
	15	0.0	7.1	0.0	14.3	14.3	0.0	0.0	0.0	7.1	7.1	0.0	7.1	0.0	21.4	14.3	0.0	1.7	7.1
	16	14.3	0.0	0.0	0.0	14.3	0.0	0.0	7.1	7.1	0.0	7.1	0.0	14.3	7.1	28.6	0.0	1.3	0.0
	17	6.7	6.7	0.0	6.7	6.7	13.3	0.0	0.0	0.0	0.0	6.7	0.0	20.0	13.3	0.0	20.0	1.2	0.0
	18	6.7	6.7	0.0	6.7	6.7	0.0	26.7	0.0	6.7	0.0	0.0	6.7	6.7	6.7	20.0	0.0	1.0	0.0
	19	13.3	6.7	6.7	0.0	6.7	13.3	6.7	0.0	0.0	13.3	0.0	0.0	6.7	0.0	20.0	6.7	1.1	0.0
	20	0.0	0.0	0.0	26.7	13.3	6.7	6.7	0.0	6.7	0.0	6.7	0.0	0.0	0.0	6.7	26.7	1.1	0.0
	21	6.7	0.0	6.7	6.7	26.7	13.3	6.7	6.7	0.0	6.7	0.0	0.0	13.3	0.0	6.7	0.0	1.1	0.0
	22	20.0	6.7	0.0	20.0	20.0	6.7	6.7	0.0	0.0	0.0	6.7	0.0	0.0	0.0	6.7	0.0	1.2	6.7
	23	26.7	6.7	0.0	20.0	13.3	13.3	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.9	6.7
	24	6.7	0.0	6.7	13.3	26.7	26.7	6.7	6.7	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	1.1	0.0
	Average	6.7	3.5	3.8	15.7	17.7	8.4	4.7	1.5	6.1	1.7	2.3	1.2	4.7	4.4	8.1	7.0	1.1	2.6
	mid-night	4.2	2.8	5.6	14.1	21.1	14.1	9.9	1.4	9.9	0.0	1.4	0.0	1.4	0.0	4.2	7.0	1.0	2.8
	early morning	2.4	0.0	7.1	16.7	19.0	9.5	2.4	2.4	7.1	0.0	0.0	2.4	4.8	4.8	4.8	9.5	1.0	7.1
	morning	4.8	0.0	4.8	31.0	35.7	2.4	0.0	0.0	7.1	0.0	2.4	2.4	0.0	0.0	4.8	2.4	1.2	2.4
	afternoon	5.4	7.1	3.6	16.1	8.9	7.1	0.0	0.0	7.1	3.6	3.6	0.0	7.1	10.7	8.9	10.7	1.3	0.0
	evening	7.0	4.7	0.0	7.0	11.6	4.7	0.0	2.3	4.7	2.3	4.7	2.3	11.6	14.0	14.0	7.0	1.4	2.3
	night	2.2	4.4	2.2	13.3	14.4	8.9	8.9	2.2	2.2	3.3	2.2	1.1	4.4	1.1	11.1	5.6	1.1	2.2
	December	4.2	0.0	2.1	25.0	22.9	10.4	14.6	2.1	10.4	0.0	0.0	0.0	6.3	0.0	2.1	0.0	1.2	0.0
	January	7.1	4.6	4.2	10.4	13.8	8.8	3.8	1.7	6.7	2.5	3.3	1.7	5.4	3.8	9.6	9.6	1.1	3.3
	February	2.1	0.0	4.2	33.3	35.4	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	6.3	0.0	1.1	2.1
	March	37.5	12.5	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	12.5	12.5	0.9	0.0

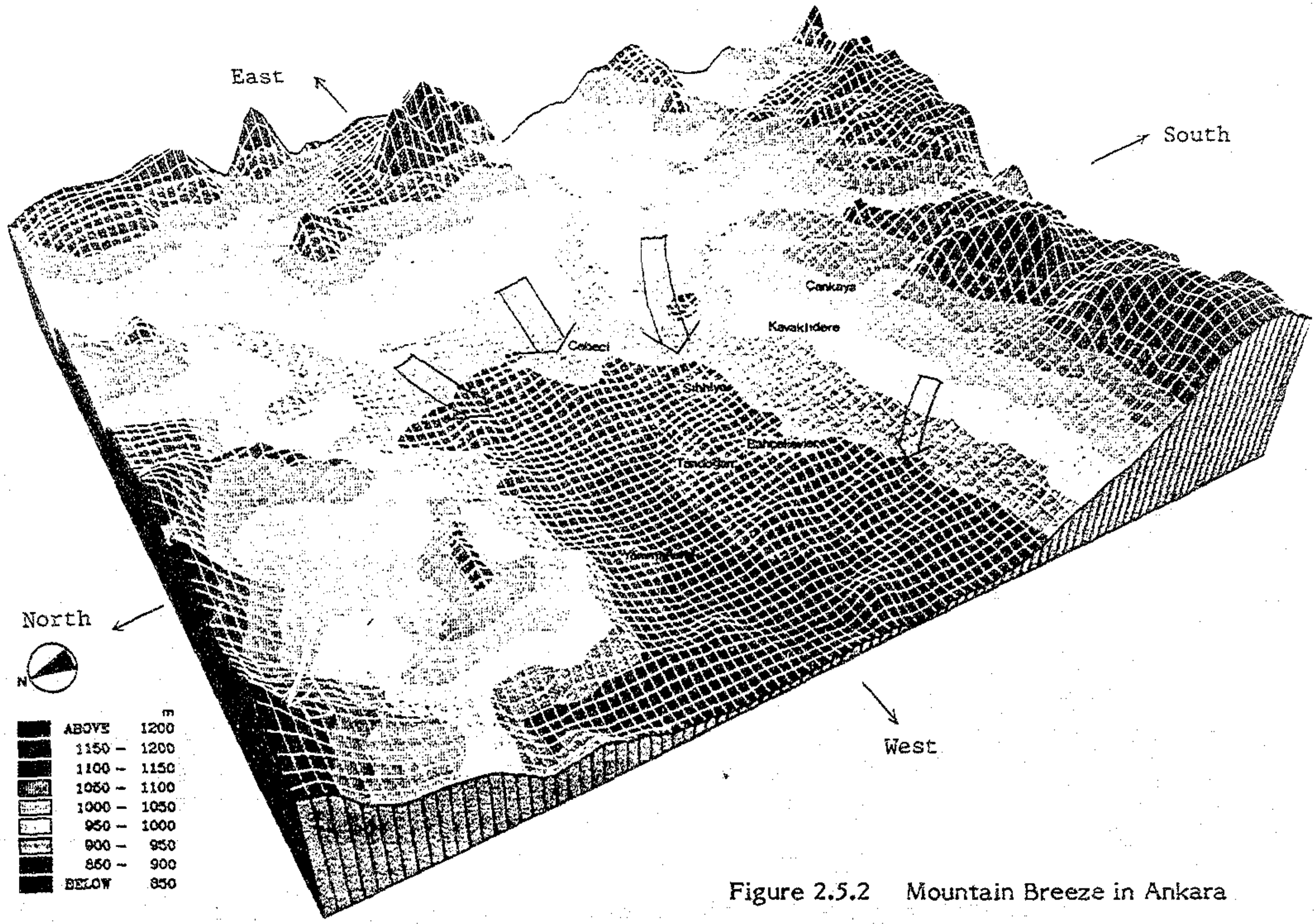


Figure 2.5.2 Mountain Breeze in Ankara

2.5.3 Analysis of the Particular High Concentration Period

For the analysis of the time variation of pollutant concentration in relation to the meteorological factors, the period from December 19 to 22, 1984 is taken as an example.

Peak of pollutant concentration in this period appeared independently over the 20th and the 21st in the continuous monitoring at all the stations (see Figure 2.2.1). During this period vertical profiles of air temperature were also measured in the upper-layer meteorological observation. The surface weather charts at 9:00 a.m. on the December 20 and the December 21 are shown in Figure 2.5.3.

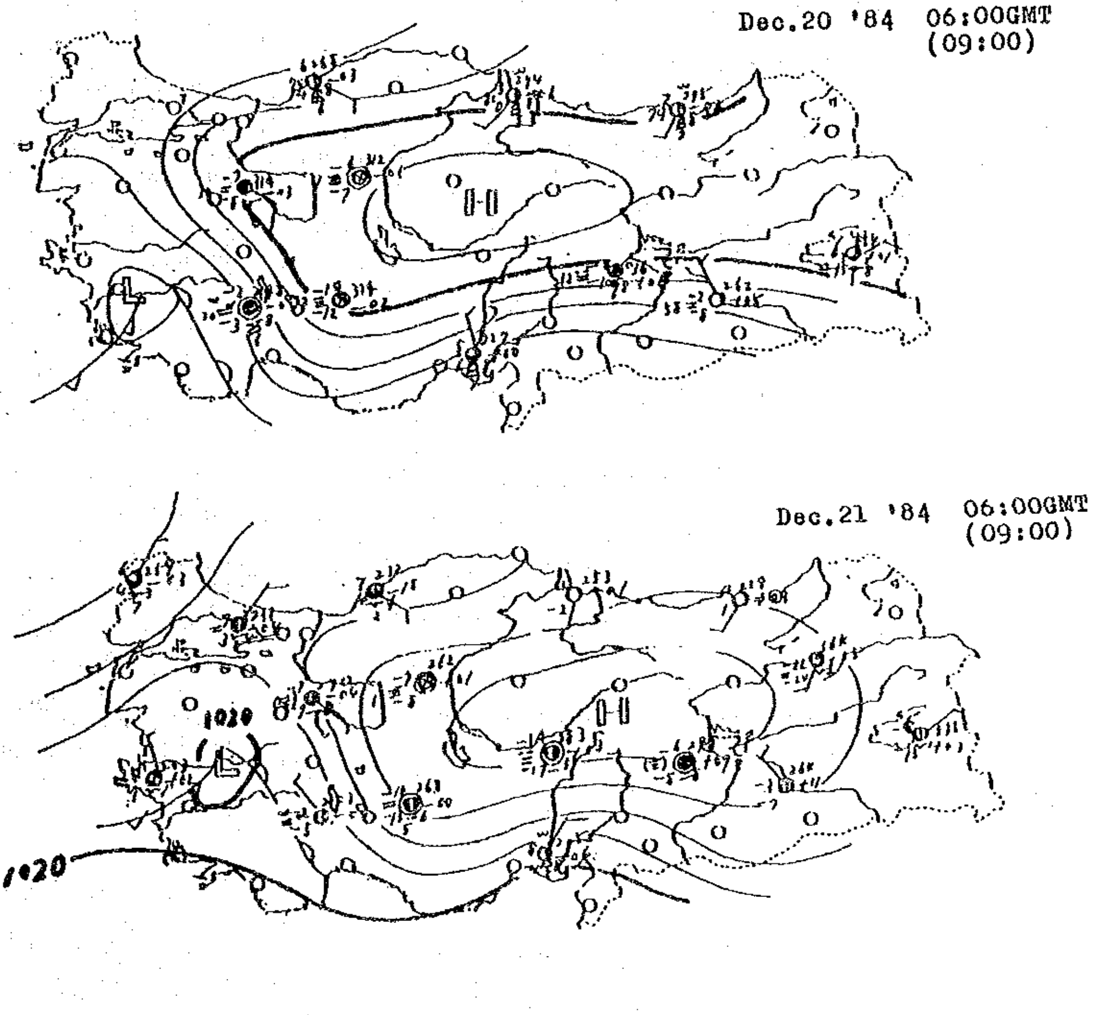


Figure 2.5.3 Surface Weather Charts at the time of High Concentration

As it is seen from the weather charts, the whole Central Anatolian Region is covered by the anticyclone which is moving slowly from west to east.

Figure 2.5.4 shows the time-variation of the SO_2 concentration and the mixing depth estimated from the vertical profile of temperature during this 4-day period.

Concentration of SO_2 began to increase in the evening of the 20th and became highest on the 21st having two peaks in the morning and evening, and began to decrease on the 22nd. Meanwhile, the mixing depth began to decrease gradually at night on the 19th, and became smallest during the hours of mid-night and early morning over the 20th to 21st, and then began to increase.

Characteristics of these variation patterns can be summarized as follows.

i) A definite correlation is observed between the SO_2 concentration and the mixing depth. The smaller the mixing depth, the higher the concentration becomes.

ii) SO_2 concentrations are high at Yenimahalle, Bahcelievler, and Kavaklidere showing the two-peak pattern similar to that of emission source strength.

iii) Different from these areas, a peculiar time-variation in pollutant concentration was observed at Cankaya where SO_2 concentration was generally low being around 100 - 200 ppb during the days of the 20th and the 21st, but it became high suddenly for a few hours (15:00 - 16:00 and 22:00 - 23:00 on the 20th and 9:00 - 10:00 on the 21th). At these hours, wind speed was about 1.0 m/s and wind direction was NW-N or ENE. Judging from the fact that these peaks appeared with a time-lag of about one hour from those at Kavaklidere situated to the north, it is inferred that the high concentration in Cankaya was caused by the pollutants transported from the direction of the central area of the City.

As described above, occurrence of high concentration is greatly affected by mixing depth. When an invension lid is formed at a certain height in the atmosphere, mixing depth decreases with the increase in local altitude. Therefore, at a high-altitude site like Cankaya, pollutant concentration may rise radically even if the amount of pollutant emission around that site is relatively small.

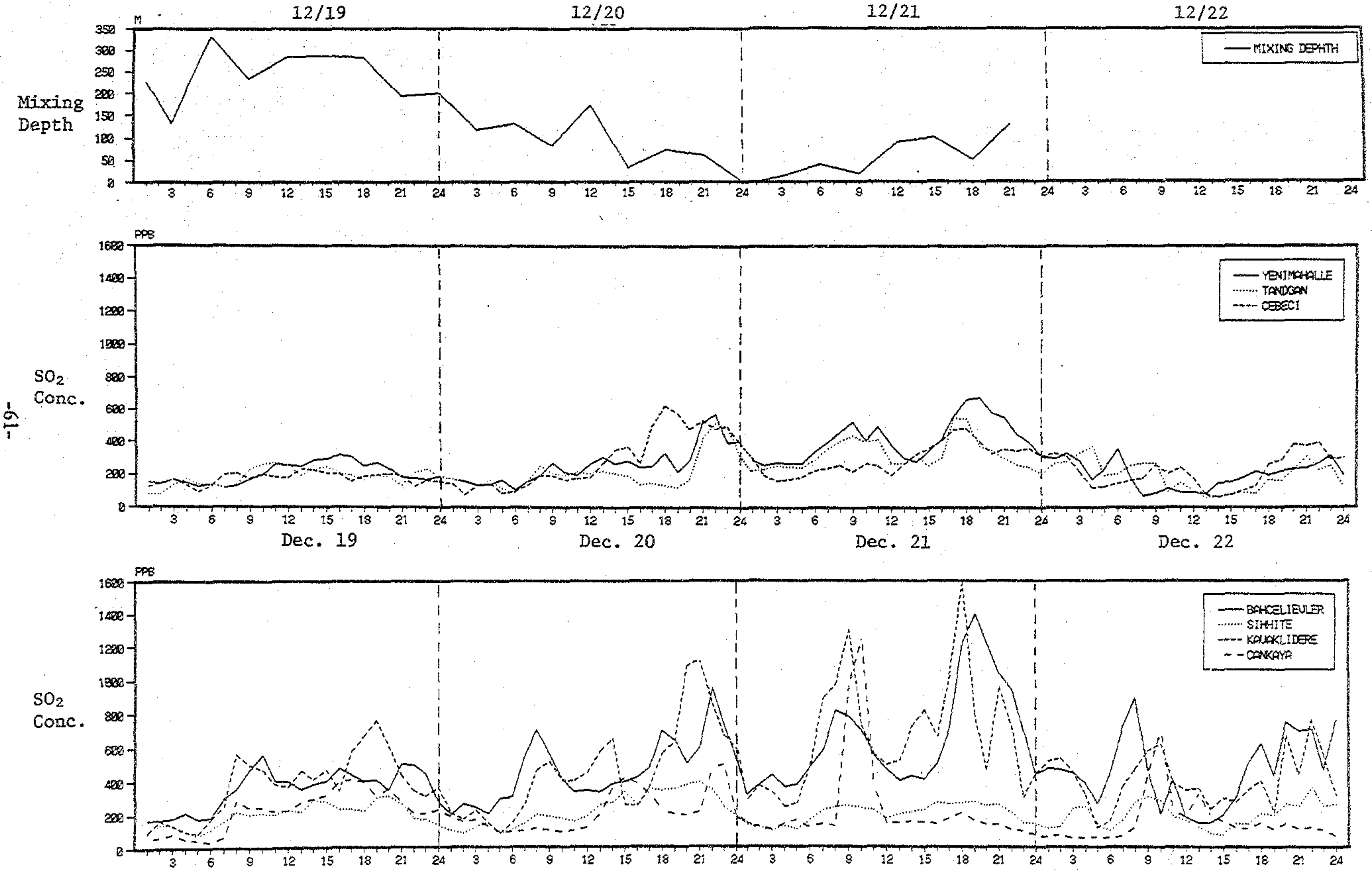


Figure 2.5.4 Time-Variation of SO_2 Concentration and Mixing Depth (Dec. 19 -22, 1984)

2.6 DISTRIBUTION OF POLLUTANT EMISSION

2.6.1 Stationary Sources

(1) Combustible Sulfur Content in Lignite

Content of combustible sulfur was determined for the ungraded and the laved lignite used in Ankara as heating fuels, based on the following analytical results.

a. Results of the analysis made in Japan on the samples taken from 1 ton of ungraded lignite and 1 ton of laved lignite donated by the Turkish side.

b. Results of the analysis made by the Turkish side on the same kinds of lignite as a. above.

c. Results of the flue gas analysis made by the Study Team in Ankara as a part of the emission source survey.

d. Results of the analysis made in Japan on the samples of lignite used in the combustion test in the Phase I of the Study, and on the samples collected from the Tuncbilec coal mine in the Phase II of the Study.

A summary of the results of a., b., and c. mentioned above are shown in Table 2.6.1, and the results of d. are shown in Table 2.6.2.

From these results, the average values of sulfur content in the ungraded lignite and laved lignite are determined as shown in Table 2.6.3.

Table 2.6.1 Combustible Sulfur Content in Lignite

Unit: %

Source of result / Kind of lignite	Analysis by Japanese side	Analysis by Turkish side	Flue gas analysis by Study Team
Ungraded	2.7	2.68	2.58
Laved	0.95	1.49	0.79

Note 1) "Ungraded lignite" refers to the lignite extracted from the open mines with subsequent screening out of the sizes below 30 mm, mannual removal of stony and muddy lumps, but without washing.

2) "Laved lignite" refers to the lignite extracted from the underground and open mines different from that of 1) with the subsequent screening and washig to remove soil, mud, and stones. It's ash content is lower than that of ungraded lignite.

Table 2.6.2 Total Sulfur Content in Lignite

Ungraded lignite

Samples		Total S (%)
P-I	Vali Dr. Resit Sok.	2.0
	And Sok. No.3	3.1
	Y. Ayranci Hasder Sok.	2.3
	Tireboln Sok.	2.7
P-II	Hava Sok.	2.7
	MTA stove	3.3
	MTA boiler	2.3
Tunc-bilec coal mine	Screening plant (30-400mm)	2.3
	ditto (30 mm)	3.1
	Open mine A (4 samples mixed)	3.3
	Open mine B (2 samples mixed)	3.1
	Screening plant hopper (3 samples mixed)	3.0

Laved lignite

Samples			Total S (%)
P-I		Pembe Kosk	1.0
P-II		Pembe Kosk	1.8
Tunc-bilec coal mine	Washery (size)	10 mm	2.1
		10 - 18 mm	1.9
		18 - 50 mm	1.8
		50 mm	1.3
	Sampled from under-ground layer (height)	0 - 1.3 m	0.8
		1.3 - 2.6 m	1.2
		2.6 - 3.9 m	1.5
		3.9 - 4.2 m	0.8
		4.2 - 6.5 m	1.2

Note: P-I and P-II indicate the samples of lignite used in the combustion test in Phase-I and Phase-II, respectively.

Table 2.6.3 Combustible Sulfur Content in Ungraded Lignite and Laved Lignite

Ungraded Lignite	Laved Lignite
2.7%	1.4%

(2) Combustible Sulfur Content in Fuel Oil, Coke, and Coke-Briquette

Content of the combustible sulfur was determined for fuel oil, coke, and coke-briquette used in Ankara based on the following data.

a. Analytical results obtained from the Ankara Briquette Factory Laboratory

b. Results obtained through the flue gas analysis made by the Study Team in Ankara

c. Estimates supplied by the General Directorate of Environment, Turkey, and the data released by the General Directorate of Petroleum Office, Turkey.

The combustible sulfur contents in the fuels according to the data sources mentioned above are shown in Table 2.6.4.

Table 2.6.4 Combustible Sulfur Contents in Fuel Oil, Coke, and Coke-Briquette

Analysis by Ankara Briquette Factory Laboratory	Flue gas analysis by the Study Team	Data supplied by the Turkish authorities (for 1983/1984)		
Coke-briquette	Fuel oil	Coke	Coke-briquette	Fuel oil
Coke powder briquette 0.69%	0.96%	0.5%	0.6%	0.9%
Coke graded briquette 0.69%	0.97%			
Coke briquette for plant 0.69%				

(3) Quantity of Emission of SO_2 from the Stationary Sources

The amount of the fuels used and the SO_2 emitted during the heating season of 1984/85 were determined based on the sales records of the Turkish Coal Board and the Turkish Petroleum Office, the consumption statistics of heavy oil in Ankara and its vicinity published by the Turkish authority, and the estimates made by the General Directorate of Environment. Quantity of the SO_2 emission was then computed. The results are shown in Table 2.6.5.

Table 2.6.5 Fuel Consumption and SO_2 Emission from Stationary Sources in the Winter of 1984/1985

Kind of fuel	Consumption in the city (ton)	Average sulfur content (%)	SO_2 emission (ton)
Ungraded Lignite	837,000	2.7	45,200
Laved Lignite	275,000	1.4	7,700
Coke	124,000	0.6	1,490
Fuel oil	220,000	0.9	3,960
Coke-briquette	13,000	0.6	160
Total	-	-	58,510

2.6.2 Mobile and Other Sources

(1) Diesel-Fueled Automobiles

As it was confirmed by the analyses of the automobile exhaust gases conducted as a part of the on-site emission source survey, emission of SO_2 from the gasoline-fueled automobiles is negligible. Therefore, only diesel-fueled automobiles will be considered. Assuming conservatively that the whole amount of the diesel sold in the City was consumed by the diesel-fueled automobiles or other consumers within the City, the amount of SO_2 emission in the winter of 1984/85 is estimated to be as follows:

Annual diesel consumption	:	295,000 tons (estimated for 1984)
Consumption during 5 months in the winter	:	295,000 x 5/12 = 123,000 tons
Sulfur content in the diesel	:	0.35% (postulated)
Amount of SO_2 emission during the winter	:	123,000 x 0.0035 x (64/32)* = 861 tons

(* Molecular weights of SO_2 and S are 64 and 32, respectively.)

(2) Trains

Bituminous coal and lignite are said to be used in the trains. Since the details are not known, a rough estimation is made using the data in 1969 reported in the study of NATO[1].

According to the said study, emission of SO_2 from trains was 620 t/yr in 1969. Assuming that the emission has increased by the present in proportion to the increase in population, the following estimate can be made:

SO_2 emission in 1969	:	620 tons/yr
Population of the City in 1969	:	1,170,000 (estimated)
Population of the City in 1984	:	2,050,000 (estimated)
Population ratio 1984/1969	:	1.75
SO_2 emission in the winter of 1984/85	:	620 x 1.75 x 5/12 = 452 tons

(3) Total

The total quantity of the SO_2 emission from mobile sources in the winter of 1984/85 is estimated to be 1,313 tons that is about 2.2% of the quantity emitted from the stationary sources shown in Table 2.6.5.

---

1) NATO, Air Pollution - Guidelines to Assessment of Air Quality (Revised) N.6, Appendix A - Assessment of Air Quality in Ankara, Turkey, August 1972.

(4) Summary

The results of the study on the mobile emission sources can be summarized as follows:

a. From the on-site analysis of automobile exhaust gas, emissions of SO_2 and PM from a gasoline-fueled car is negligibly small as compared with those from a diesel-fueled automobile.

b. Quantity of SO_2 emission from the mobile sources (diesel fueled) during the winter of 1984/85 estimated based on the annual consumption of diesel and the result of the past study is about 1,313 tons which corresponds to 2.2% of that from the stationary sources.

c. According to the traffic volume survey conducted at 5 locations on the major roads in Ankara City, variation of the traffic volume of the diesel-fueled automobiles by hours is small. Considering the small quantity of SO_2 emission from the mobile sources as estimated above, it can be assumed that the two-peak pattern of the pollutant concentration observed in Ankara City is mostly caused by the heating of buildings and houses. Contribution of mobile sources to the air pollution is negligibly small.

As far as the concentration of SO_2 in the winter is concerned, influence of mobile sources is found to be small. Considering the lead time of pollution control measures and reduction rate of pollutant emission aimed at in this Study, and also considering the limit in precision of the prediction methods, factors related to the mobile sources are negligibly small, and therefore, will be excluded from the consideration in the subsequent studies.

2.6.3 Geographical Distribution of Sulfur Dioxide Emission

Based on the aforementioned results, geographical distribution of SO_2 emission in Ankara in the winter of 1984/85 was computed in the manner described below.

a. Using a topographical map of Ankara made by aerial photos with the scale of 1 : 15,000, the area was divided into 500-m square elements. The number of buildings counted in each square element was classified into 3 categories, large, middle, and small to obtain the distribution of buildings.

b. The regional amounts of supply of coke, lignite, and coke-briquette for household stoves were allocated to each element taking the building distribution into account.

c. The regional amount of supply of lignite (ungraded lignite 75%, and laved lignite 25%) and fuel oil for heating boilers were allocated to each element taking the building distribution into account.

d. From the results of b. and c. above, amount of each kind of fuel was totaled for each element. Using an emission factor of SO_2 for each kind of fuel, the total emission of SO_2 was obtained for each element.

The geographical distribution of SO_2 emission thus obtained is shown in Figure 2.6.1.

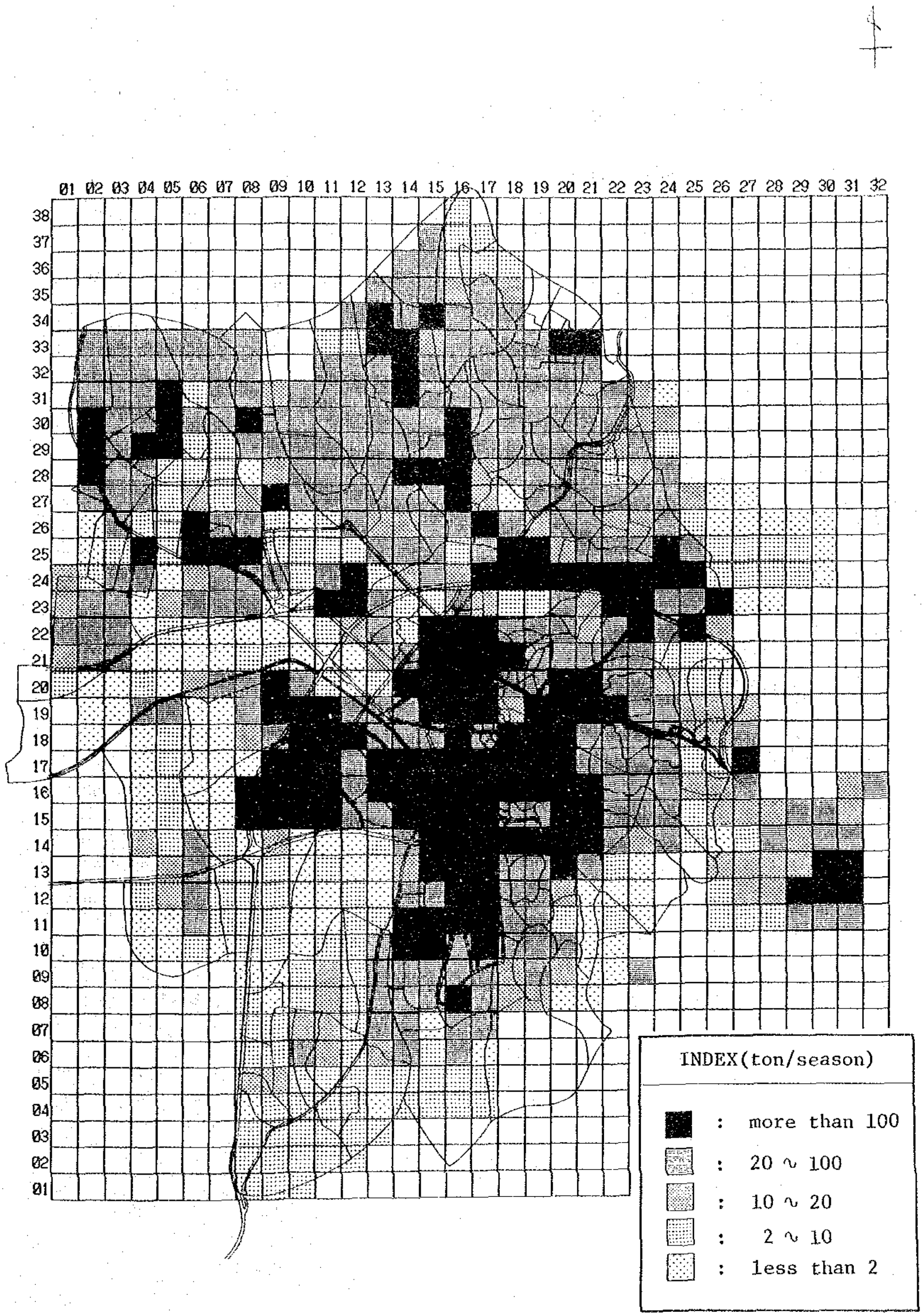


Figure 2.6.1 Geographical Distribution of SO_2 Emission
(Winter of 1984/1985)

2.7 RESULTS OF THE AIR QUALITY SIMULATION UNDER THE EXISTING CONDITION

2.7.1 Concentration Distribution

(1) Winter Average Concentration

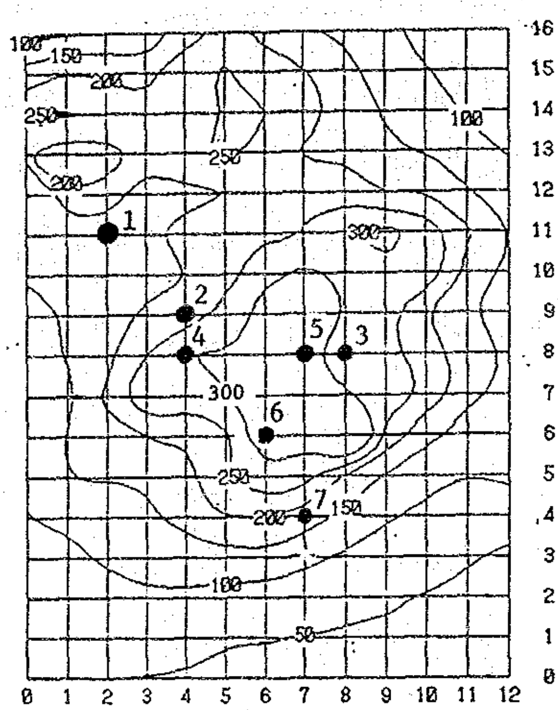
Distribution of the average concentration simulated for the period of the air quality monitoring in the winter of 1984/1985 is shown in Table 2.7.1 and Figure 2.7.1. Locations of the monitoring stations are also shown in the Figure.

Table 2.7.1 Computed Winter Average Concentration of SO_2

(unit: ppb)

	0	1	2	3	4	5	6	7	8	9	10	11	12
16	83	97	105	117	178	220	188	159	139	116	83	71	62
15	174	198	193	187	226	254	225	202	165	127	103	83	71
14	248	254	235	225	237	252	251	215	182	145	118	96	81
13	205	178	186	221	234	255	238	197	185	163	146	114	97
12	178	210	212	187	187	202	226	238	227	201	193	154	119
11	178	183	181	185	213	207	237	252	287	314	278	207	146
10	153	155	157	180	202	226	290	307	292	283	280	189	135
9	135	156	177	209	227	273	317	325	297	278	206	159	130
8	127	152	189	250	297	306	349	316	283	273	223	176	139
7	113	142	200	284	284	299	310	325	303	289	232	165	129
6	115	152	181	200	210	246	327	326	423	238	167	128	128
5	112	149	154	161	186	242	281	270	199	147	115	103	112
4	98	108	123	140	164	197	203	175	139	106	90	77	65
3	82	92	105	115	127	131	130	112	93	76	64	54	45
2	73	79	87	92	90	84	76	71	63	56	48	42	36
1	62	65	65	65	63	54	52	49	45	42	39	34	30
0	51	51	51	49	46	39	37	36	34	33	31	28	26

(1km x 1km mesh)



unit: ppb
mesh: 1km x 1km

1. Yenimahalle
2. Tandogan
3. Cebeci
4. Bahcelievler
5. Sihhiye
6. Kavaklidere
7. Cankaya

Figure 2.7.1 Winter Average SO_2 Concentration Isopleths

(2) 24-Hour Mean and One-Hour Mean Concentration at the Time of High Concentration

Concentration isopleths of SO_2 for 24-hour mean and one-hour mean under the condition of high concentration occurrence are shown in Figures 2.7.2 and 2.7.3, respectively.

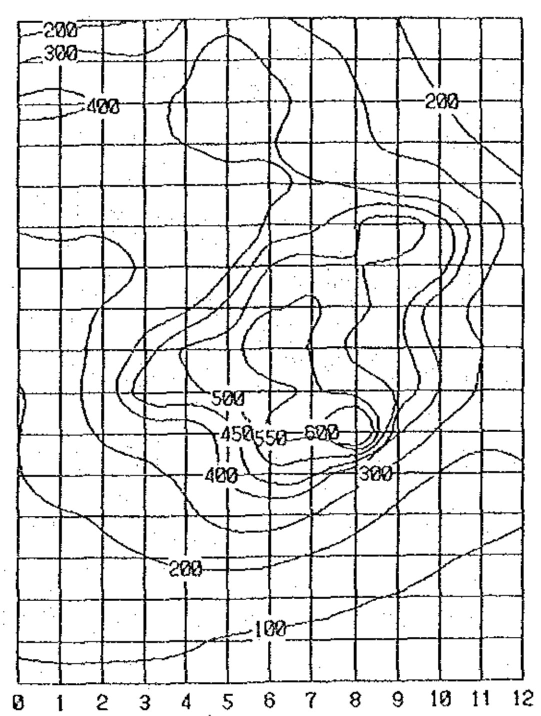


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Figure 2.7.2

Concentration Isopleths of SO_2 for High 24-Hour Mean

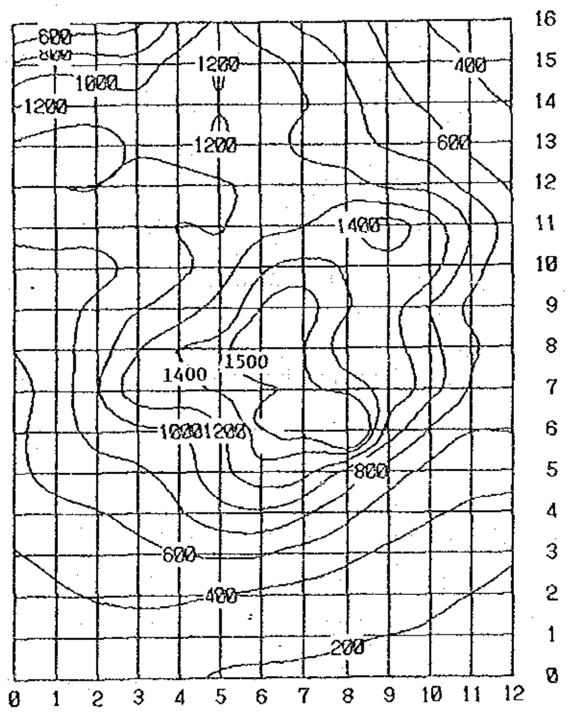

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Figure 2.7.3

Concentration Isopleths of SO_2 for High One-Hour Mean

2.7.2 Contribution Factors of Emission Sources

Contribution factors of small and medium height emission sources on the concentration of SO_2 at each monitoring station are shown in Table 2.7.2.

Table 2.7.2 Contribution Factors of Emission Sources

Station	Small-height emission sources (%)	Medium-height emission sources (%)
Yenimahalle	53.0	47.0
Tandogan	34.0	66.0
Cebeci	36.1	63.9
Bahcelievler	24.5	75.5
Sihhiye	32.9	67.1
Kavaklidere	29.0	71.0
Cankaya	31.5	68.5

As shown in Table 2.7.2, contribution of small-height emission sources to the pollutant concentration at Yenimahalle is 53%, but the contribution of small-height emission sources to the other stations is much lower, the factors being around 30%. These differences are considered to be due to the regional differences in the degree of urbanization.

2.7.3 Results of the Time-Dependent Simulation

Computations were made to simulate the time-variation of the SO_2 concentration at each monitoring station for the period of the December 20 and 21, 1984 when pollutant levels were very high. The results are shown in Figures 2.7.4 and 2.7.5 in comparison with the measured results. The simulated and measured values shown are in 3-hour running mean concentration since the conditions of wind field and inversion lid were applied by every three hours.

It is considered that variation patterns simulated agree, in general, with those measured. However, relatively large differences are seen in mid-night and afternoon. It is considered to be due partly to the time-distribution of emission used in the simulation that was determined based on the data obtained through the on-site questionnaire about the combustion hours, while the actual condition may

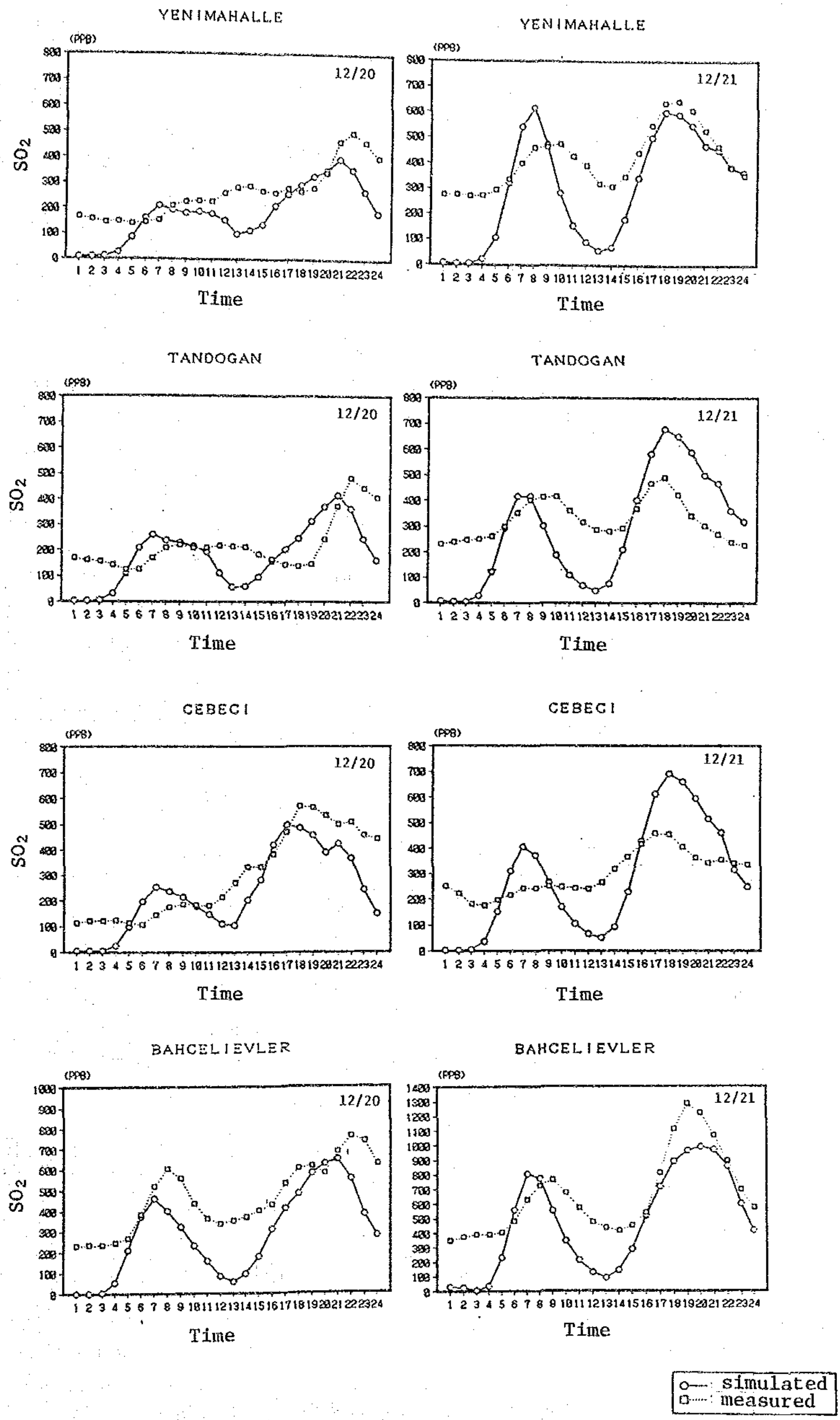


Figure 2.7.4 Results of the Time-Dependent Simulation of SO_2 Concentration (No. 1)

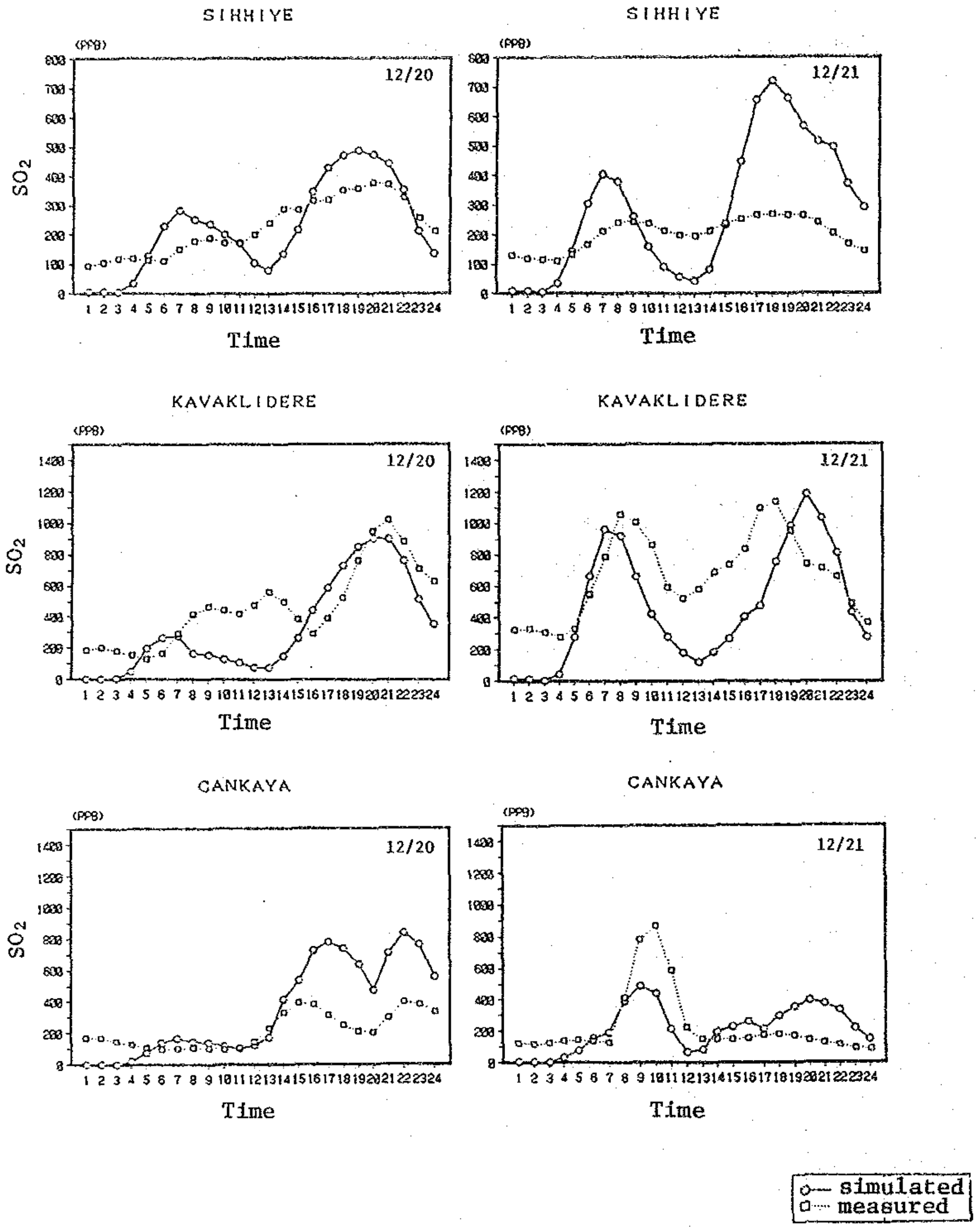


Figure 2.7.5 Results of the Time-Dependent Simulation of SO_2 Concentration (No. 2)

be that emission was continuing, though in a less extent, during those hours even though combustion was not intended, and partly to the ability of the simulation model in which effect of the retention of pollutants was not sufficiently expressed.

It is considered, however, that the simulation model developed here is able to express the degree of effect of emergency measures, with a sufficient degree of accuracy, in comparison with the no-measure case.

A detailed description of the simulation models developed and used in the analyses in this Section will be found in the Appendices.

2.8 SUMMARY

On the basis of the analysis made on the present state of air pollution as described in the preceding sections, the mechanism and characteristics of the air pollution in Ankara can be summarized as follows.

i) From the results of analysis on the local and temporal patterns of variation in concentration, atmospheric stability in relation to concentration, and correlation between the concentration of SO_2 and PM, major sources of pollutants in Ankara City are considered to be small and medium height sources such as stoves and boilers for heating.

ii) Analyses on the relation of wind speed and wind direction to pollutant concentration indicate that the concentration at a particular area is affected largely by the sources in the immediate vicinity. And it further supports the indication in i) that the small or medium height of the sources is the major cause of occurrence of high concentration.

iii) Due to the basined topography, wind speeds are low and pollutants are detained near the sources.

iv) Refrigeration of the ground level due to the heat radiation during the night tends to cause the ground level inversion. Inversion remains at certain height even after the rise of ground level temperature bringing forth the state at which pollutants are confined under the lid resulting in high concentration.

v) Strong correlation exists between pollutant concentration and mixing depth, that is, the smaller the mixing depth, the higher the concentration becomes. Depending on the state of prevailing mixing height, abnormally high concentration may occur even at Cankaya station, as observed, where the strength of the pollutant emission is relatively low but the altitude is higher than central areas of the City.

vi) In planning suitable countermeasures against the air pollution in Ankara, a priority should be given to the control of SO_2 rather than PM, since concentration of SO_2 often exceeds the emergency levels at present and many of control measures for SO_2 are also effective in reducing the emission of PM.

CHAPTER 3 PRESENT STATE OF AIR POLLUTION CONTROL

Chapter 3 PRESENT STATE OF AIR POLLUTION CONTROL

3.1 ORGANIZATIONS RESPONSIBLE FOR OR RELATED TO AIR POLLUTION CONTROL

A number of governmental or non-governmental organizations are involved in various fields of air pollution control such as air quality monitoring, study of control measures, and planning and implementation of specific measures.

These organizations and their roles in dealing with the air pollution problem in Ankara are described below.

3.1.1 Central Governmental Bodies

(1) General Directorate of Environment (GDE)

GDE is attached to the Prime Ministry, and is the main responsible body and the authority dealing with air pollution control in Ankara in cooperation with related governmental and non-governmental organizations. GDE is presently organized as that shown in Figure 3.1.1 constituted by a Director General, four main service units, one consultation unit, and two auxiliary units. The total number of personnel is 74 including a Director General.

Director General

- Main Service Units
  - Department of Organization and Finance (8)
  - Department of Environmental Standards (6)
  - Department of Technology (8)
  - Department of Foreign Affairs (5)
- Consultation Unit
  - Department of Research, Planning and Coordination (7)
- Auxiliary Units
  - Department of Administration and Financial Affairs (33)
  - Department of Personnel Affairs (6)

Note: Figure within the parentheses indicates the number of personnel including a director.

Figure 3.1.1 Organization of General Directorate of Environment

(2) Public Health Institute (PHI)

PHI is attached to the Ministry of Health and Social Affairs, and its responsibility related to the air pollution in Ankara includes monitoring of ambient air quality at 16 stations. Results of the monitoring at 16 stations are reported daily to GDE and are transferred to the Provincial Government of Ankara.

(3) General Directorate of State Meteorological Works (SMW)

SMW is in charge of meteorological observation and weather forecast. These data are transferred daily to the Provincial Government of Ankara.

(4) Ministry of Energy and Natural Resources (MENR)

There are two attached organizations and one department under MEUR that are directly or indirectly related to the control of the air pollution in Ankara.

i) General Directorate of Turkish Coal Board (TKI)

TKI (Turkish abbreviation) is the major organization responsible for mining and distribution of coals in the whole country. They are to supply lignite and coal of the best quality to Ankara especially for domestic heating, as well as for industry.

The responsible unit beloging to TKI for sale and distribution of coals is Coal Sale and Distribution Establishment (KST in Turkish abbreviation).

ii) General Directorate of Mineral Analysis and Research (MTA)

In MTA (Turkish abbreviation), Division of Fuels in the Department of Technology and Laboratory is conducting research studies on fuels and combustion systems with boilers and stoves.

iii) Department of Energy in MENR is responsible for making the program of training boiler operators on operation and maintenance of boiler systems. This task is carried out in cooperation with the Municipality Police Directorate and the Ministry of Education, Youth and Sports.

(5) Ministry of Education, Youth and Sports (MEYS)

General Directorate of Apprentice and Public Education attached to MEYS is executing the program of training boiler operators in cooperation with the governmental bodies mentioned above.

(6) Turkish Council of Scientific and Technical Research (TUBITAK)

TUBITAK (Turkish abbreviation) is attached to the Prime Ministry. Building Research Institute of TUBITAK is conducting various research works including means of fuel saving in the existing buildings and improved design criteria for new buildings.

3.1.2 Provincial Government of Ankara (PGA)

Governor of provincial government is appointed by the Minister of Interior Affairs. Provincial directors of various departments under the governor are appointed by the relevant Ministries of the Central Government. Important decisions at provincial level are made at the Board of Provincial Administrators (BPA) constituted by the governor and provincial directors. Each year in Ankara PGA, according to the decision of BPA, proclaims specific measures to be taken within the boundary of Ankara Metropolitan Municipality against the air pollution in the winter season. These measures include the regular measures to be taken at ordinary times and the emergency measures to be taken corresponding to each of four emergency levels specified in terms of the concentrations of SO_2 and PM (particulate matter). BPA decides, based on the information of weather forecast of SMW and levels of SO_2 and PM measured by PHI and reported by GDE, whether to proclaim an emergency level. The announcement is to be made through radio and television, and has ever been made once in January 1982.

3.1.3 Ankara Metropolitan Municipality

Several number of internal and external organizations of Ankara Metropolitan Municipality (AMM) are directly or indirectly involved in the control of air pollution in Ankara.

(1) Directorate of Electricity, Gas and Omnibus (EGO)

EGO is conducting studies on the development of a city gas plant for district heating and on the air pollution due to the automobile exhaust gas and its control.

(2) Ankara Master Plan Bureau (ANPB in Turkish abbreviation)

ANPB is responsible in drawing master plan for the development of Ankara metropolitan area. In the master plan making, considerations are being given to the mitigation of air pollution, e.g., planning City development toward the west not to aggravate the air pollution in the central part of the City.

(3) Urban Reconstruction Directorate (URD)

URD is in charge of actualization of the development plan drawn up by ANPB. Their activities include inspection of application for building construction in accordance with various building regulations including those of thermal insulation. URD issues a construction permit only when the application suffices requirements of these regulations.

(4) Municipality Police Directorate (MPD)

MPD's tasks include inspection of combustion method and maintenance of heating boiler systems, and inspection of newly constructed buildings in accordance with the building regulations.

3.1.4 Non-Governmental Organizations

Among non-governmental organizations dealing with environmental problems in Turkey, the most prominent one is the Environmental Problems Foundation of Turkey (EPFT). Their range of activity covers various fields in the subject of environmental protection such as problem finding, search of solution, proposal in legislation, and public education. EPFT played an important role in the amendment of the Constitution in 1982 to include an article of environmental protection, or in the enactment of the Environment Law of 1983 by proposing a draft of the law. As to the air pollution problem of Ankara, EPFT has been maintaining the need of the study of comprehensive abatement plan, and has been proposing the increase of supply of electricity and city-gas as a part of the plan and has begun the study of costs of these measures in October 1985 by organizing a project team consisting of the experts in the various fields.

There are also other non-governmental organizations dealing especially with developing public awareness and participation in the environmental subjects. Among them, Turkish Association for Natural Protection (TTKD in Turkish abbreviation) is the most important one being the oldest non-governmental Turkish association established for environmental purposes. TTKD is participating very actively to the activities of international environmental organizations.

3.2 PRESENT SOURCE CONTROL MEASURES

3.2.1 Measures Proclaimed by the Provincial Government of Ankara

The measures to be taken against the air pollution of Ankara in winter are proclaimed each year by the Provincial Government of Ankara at the beginning of the season. Those measures proclaimed on December 7, 1984 in the Official Gazette No. 18598 for the winter of 1984/1985 are described below.

(1) Regular Measures

The measures to be taken regularly during the winter season within the Municipality area of Ankara are specified as follows.

i) The liquid fuel boiler systems in the existing buildings shall not be converted to the solid fuel systems. The solid fuel shall not be used in the heating systems in new buildings.

ii) Transport and sale of the solid and liquid fuels to be used in stoves and boilers in Ankara shall be done by the Turkish Coal Board (TKI), the Turkish Petroleum Refinery Association (TUPRAS), and General Directorate of Petroleum Office. Any other organization or person shall not be engaged in these activities.

iii) In Ankara, (a) coke shall be used in stoves where possible and, if in short supply, may be substituted by laved lignite or imported coal; (b) laved lignite or imported coal shall be used in the solid fuel boilers; and (c) high quality fuel shall be used in the liquid fuel boilers.

iv) Ignition time for boilers and stoves in the morning shall be 7:00 - 7:30 in the districts of Maltepe, Sihhiye, Yenisehir, Kizilay, Bakanlklar and Kocatepe, and 6:00 - 6:30 in the other districts, and that in the afternoon shall be 14:00 - 15:00 in all the districts. During the other time period, boiler burning may continue depending on the air temperature by the methods that do not emitt smokes.

v) Stoves and boilers may be burned when the outside air temperature is below 12°C. After the room temperature reached 18°C, boilers and stoves shall be burned at a minimum level.

vi) On holidays, stoves and boilers in the official buildings except hospitals, boarding schools, student dormitories, old people's homes, bus terminals, and police stations shall not be used. After 20:00 o'clock on the last day of religious holidays (3 to 4 days usually) and on Sundays, stoves and boilers shall be used at a minimum level so as not to emitt smokes. Boilers for which a complete extinguishment is techically a problem shall be used at a minimum power rate.

vii) All motor vehicles emitting black smokes shall not be used.

viii) Diesel-fueled official motor vehicles, public buses, and trucks transporting coals and sands used in the City shall use the low-sulfur diesel oil (motorin) so that the emission of SO_2 can be reduced. Control works for this purpose are mandated to the district transportation authorities and Ankara Metropolitan Police Directorate.

ix) Solid wastes shall not be burned in the gardens or on the streets.

(2) Warning Levels and Emergency Measures

i) Warning Levels

The warning levels at which emergency measures are to be taken are specified in terms of the concentration values of SO_2 and PM as shown in Table 3.2.1.

Table 3.2.1 Warning Levels of Pollutants for Emergency Measures

Warning Level	SO_2(μg/m^3)	PM(μg/m^3)
1st level	700	400
2nd level	1,000	600
3rd level	1,500	800
4th level	2,000	1,000

Note: Figures listed above indicate the 24-hour concentration values. When prevailing relative humidity exceeds 90%, the values shown above are to be cut by 10%.

Weather forecast of SMW and monitoring results of PHI in SO_2 and PM are reported to the Health Department of the Provincial Government every day. When the concentration of SO_2 is observed to be increasing to reach a specified level, the Provincial Government, after consultation with GDE, is to take emergency measures.

ii) Emergency Measures

The emergency measures to be taken at each warning level are specified as shown in Table 3.2.2. During the winter period of 1984/1985, however, the emergency was not proclaimed.

(3) Maintenance of Combustion Facilities

Measures to be taken by boiler operators, building managers, and their employers are specified as follows.

i) Works to be Done by Boiler Operators

a. Combustion shall be made by suitable method for the type of boiler, and boiler diaries shall be kept. Boiler rooms shall be kept clean, and all the necessary tools shall be properly maintained so that they can be used any time.

b. Flues shall be cleaned twice a week for lignite boilers and once a week for oil boilers.

Table 3.2.2 Emergency Measures at the Warning Levels

Warning Level		Emergency Measures
1st level		In addition to the regular measures,
	i)	Soot and smoke emissions from the non-sanitary installations belonging to the 2nd and 3rd classes shall be reduced by 50%.
	ii)	Stoves and central heaters (boilers) shall not be used for more than 4 hours each in the morning and afternoon in total of 8 hours per day.
2nd level		In addition to the measures to be taken at the 1st level,
	i)	Soot and smoke emissions from the 1st class non-sanitary stallations shall be cut by 50%.
	ii)	Stoves and central heaters (boilers) shall not be used for more than 3 hours each in the morning and afternoon in total of 6 hours per day
3rd level		In addition to the measures to be taken at the 2nd level,
	i)	Passenger cars having even plate number can be used only on the even days, and those with odd number can be used only on the odd days.
	ii)	Elementary schools and junior high schools shall be closed.
	iii)	All the non-sanitary stallations shall not be operated.
	iv)	Stoves and boilers shall be used for 3 hours per day continuously.
4th level		In addition to the measures to be taken at the 3rd level,
	i)	All the schools and public and private offices shall be closed.
	ii)	All the motor vehicles except the vehicles of Government, military, firestation, and diplomatic corps, the vehicles transporting necessities, ambulances, and taxis shall not be used.
	iii)	All the work activities except production of necessities and those directly related to the public health shall be stopped.
	iv)	All the stoves and boilers shall not be used. Hospitals and buildings related to the public health may use electric heaters with necessary precautions.
	v)	Hospitals shall secure the necessary number of beds, medicines and materials for the treatment of patients.
	vi)	All the ambulances within the metropolitan municipality area shall be placed under the control of the Department of Health of the Provincial Government of Ankara.

c. Any failure found in the boiler system shall be immediately informed to the manager to be repaired promptly.

d. Windows of the boiler room shall be kept open.

ii) Responsibilities of Managers of Official Buildings and Apartment Buildings and Their Employers

a. Works of boiler operator in the boiler room shall be supervised and inspected once a week.

b. Necessary measures shall be taken against the failures of the boiler system.

c. Fine paid due to the fault of boiler operator or manager shall not be added to the management cost of apartment.

d. Cleaning of building stack made twice per year shall be confirmed and documented. The document shall be submitted to TKI at the time of delivery of fuel.

(4) Measures to be Taken by Governmental Bodies

i) Announcement of Warning Level and Emergency Measures

The Department of Health of Ankara Province shall, based on the information transferred from SMW and PHI, opinion of GDE and the decision of BPA, take necessary steps for the excecution of the emergency measures corresponding to the level of warning. Measures to be executed shall be announced through the television, radio and newspapers. Programs shall be prepared in television and radio for the public education on the execution of the emergency measures.

ii) Control Service

Control services shall be carried out by the environmental health specialists in the Department of Health of the Province in cooperation with the assigned members of Ankara Municipality Police

Directorate. The Provincial and Municipal Police Directorates shall provide automobiles,materials, manpowers and technical assistance when necessary. The Anakara Metropolitan Municipality area is divided into ten districts for the effective conduct of the control service. Ten environmental specialists and ten policemen are assigned with ten automobiles for the control service. The service shall be continued on Saturdays and Sundays by five teams. Boilers and stoves that are used not in accordance with the regulations shall be extinguished, and necessary legal measures shall be taken against the violation of laws.

3.2.2 Building Construction Control

(1) Controls in Location and Size of Building

In order to keep the quantity of air pollutant emission under control, the Metropolitan Municipality adopted a policy that does not permit the construction of new buildings within the central part of the city with the area of about 6,000 ha. In the case of the reconstruction of apartment, the maximum number of floors permitted for the construction is specified to be five. The Municipality authority expects that applying this policy the emission of air pollutant due to domestic heating will not increase significantly in the future.

(2) Thermal Insulation Requirement

In order to save the consumption of heating fuels and thereby reducing the emission of air pollutant, the Turkish Government promalgated the regulations of the thermal insulation for new buildings in 1981 and for existing buildings in 1984. In these regulations, the whole country is divided into four regions according to the climatic characteristics, and four sets of specifications for thermal insulation are to be applied separately to these regions.

In Anakara, the municipal authority is undertaking the task of guidance and enforcement of these regulations. For the new buildings, the enforcement of the regulations have been generally worked out, and the gradual appearance of its effect is expected in the future. In the case of the existing buildings, however, the enforcement of the regulation has been facing difficulties mainly because of economic constraints, and the authority is groping the means for its promotion.

3.2.3 Factory Control

In Turkey, factories (non-sanitary installations) are categorized into first, second, and third classes by type and size in order of degree of impact that may be excerted on the environment. In Ankara, new installation of the first class factories, whose impact potentials are highest among the three classes, is not to be permitted within the municipality boundary. Industrial zones presently under development or planned to be developed in the future are situated largely in the western part (called as the Western Corridor) of the city where the topographic and geographic conditions are considered to be favorable to prevent the air pollution. Some of medium and smaller industries have relocated their factories from the central part of the City to the zones in the western corridor.

3.3 AIR QUALITY MONITORING SYSTEM

3.3.1 Monitoring Organization

The following is the organization of the department in the Public Health Institute that is in charge of monitoring air quality in Ankara City.

Environmental Health and Research, School of Public Health

- (1) Air Pollution and Education Research Laboratory
  - a) Semi-automatic Sampler Section
    - Pharmacist (1)
    - Laboratory technician (1)
    - Chemical technician (1)
  - b) Telemeter System Section
    - Chemical analyst (1)
    - Pharmacist (1)
    - Chemical technician (1)
  - c) Observatory Car Section
    - Chemical analyst (1)
    - Chemical technician (1)
  - d) Japanese-made Automatic Instrument Section
    - Chemical technician (2)
  - e) Automatic Instrument Section
    - Chemical analyst (1)
    - Chemical technician (1)
    - Assistant (1)
- (2) Water Quality and Microbe Laboratory
  - Analyst (1)

(to be continued)

(continued)

- (3) Environmental Labor Health Laboratory (3)
- (4) Detergent Control Laboratory (5)
- (5) Drinking and Mineral Water Analysis Laboratory (4)
- (6) Noise Laboratory (1)
- (7) Industrial Waste and Water Pollution Laboratory (3)

Note: Figures within the parentheses indicate numbers of personnel.

The school is composed of seven laboratories under a director and Air Pollution and Educational Research Laboratory is in charge of Measurement of air pollution in Ankara City. This laboratory consists of 13 members. (2 pharmacists, 3 analysts, 7 technicians, and 1 assistant) The organization itself is divided into several specialized sections, but the whole laboratory is in charge of measurement of air quality.

The measurement of air quality is divided into two parts; (i) retrieval of sample air from 16 monitoring stations, and (ii) analysis of the retrieved sample air and prescription of chemical reagents.

Organizationally, staff members are also divided into two groups. Retrieval of sample air is conducted by 7 technicians, and analysis and prescription of chemical reagent is conducted by 4 chemical analysts and a pharmacist.

As a routine work, two groups consisting of two technicians retrieve the samples in the morning, and then SO_2 and dust analyses are conducted by a team of two members --- one is a pharmacist, and the other, a chemical analyst.

The sample air retrieval is made every day except on Saturdays and Sundays during the winter time when the air is highly polluted. In other seasons, it is made every 2-3 days. The result of analysis is conveyed to the GDE by telephone.

3.3.2 Monitoring Stations

Fifteen monitoring stations are distributed in Ankara City, and in addition to these, one station is situated in the suburban area of Golbasi as their background station.

Names of these monitoring stations are shown below. (At the underlined sites Japanese-made instruments are installed in parallel with the Turkish ones.)

1	EMEK	9	ABIDINPASA
2	<u>BAHCELIEVLER</u>	10	KIZILAY
3	<u>TANDOGAN</u>	11	KUCUKESAT
4	<u>YENIMAHALLE</u>	12	<u>KAVAKLIDERE</u>
5	SITELER	13	ASAGI AYRANCI
6	ULUS	14	<u>CANKAYA</u>
7	Y. BEYAZIT	15	<u>SIHHIYE</u>
8	<u>CEBECI</u>	16	GOLBASI

Location of these stations is shown in Figure 3.3.1.

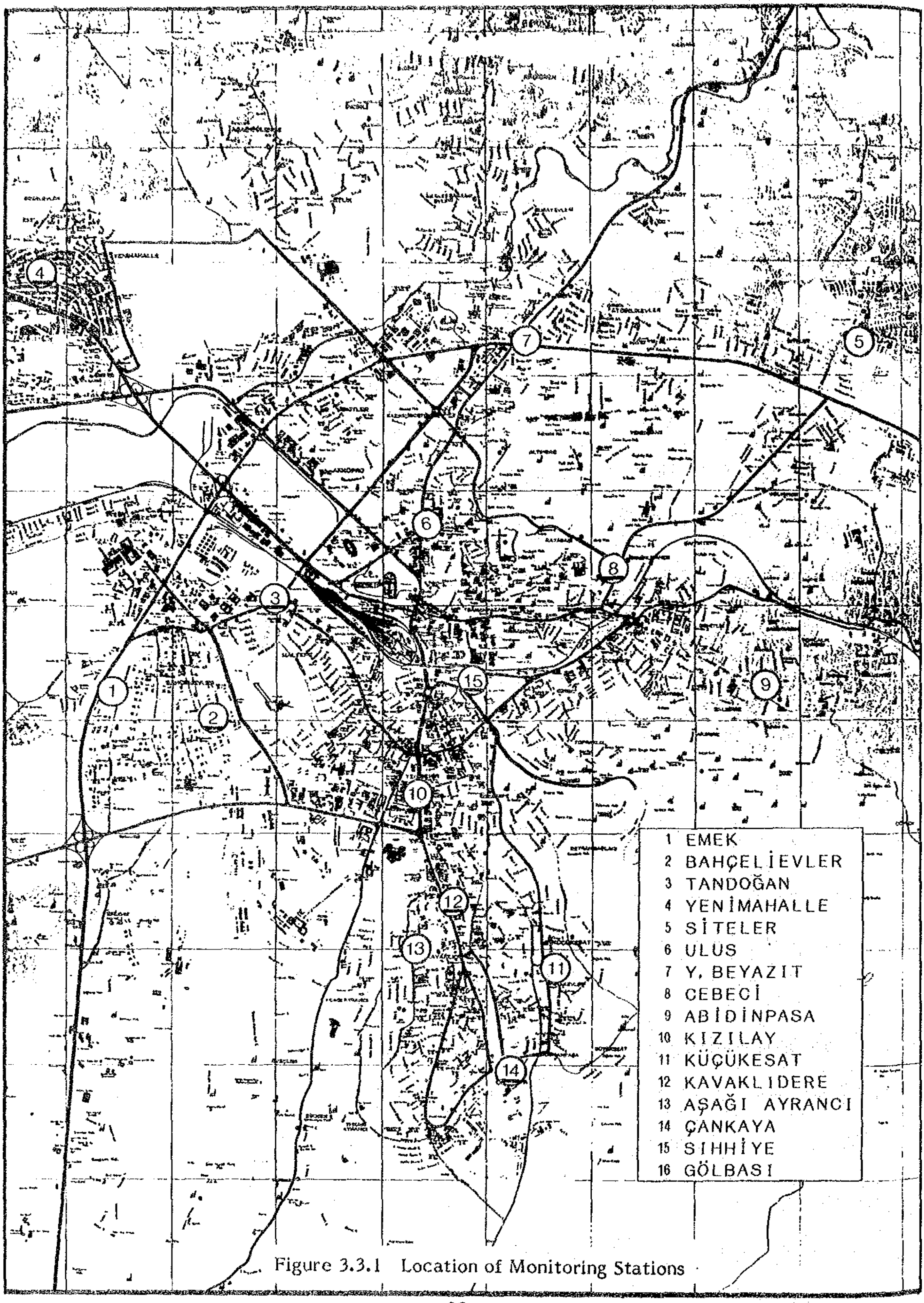


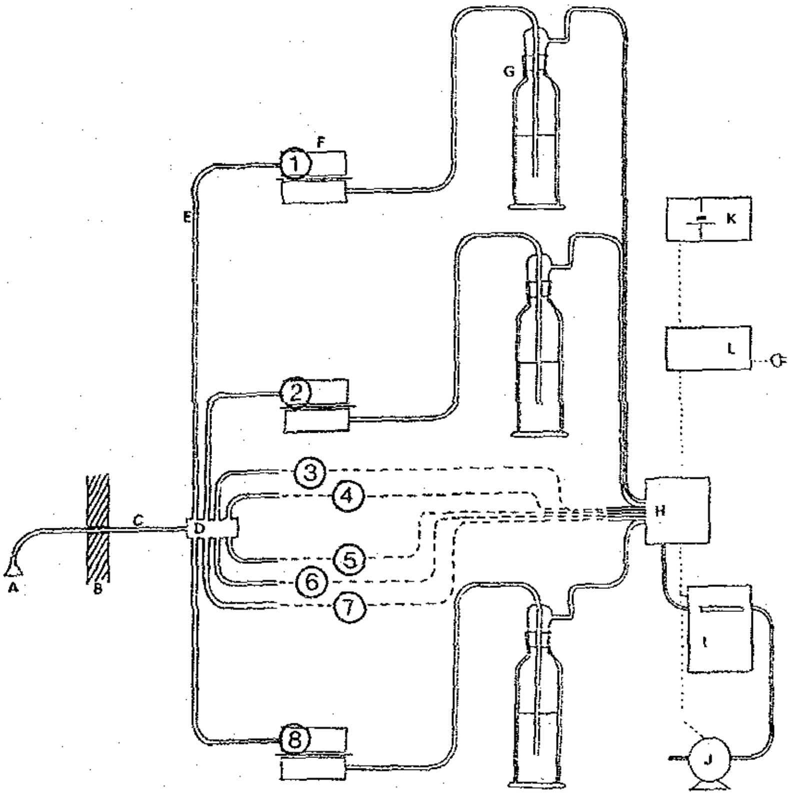
Figure 3.3.1 Location of Monitoring Stations

3.3.3 Methods of Sampling and Analysis

(1) Sampling Instrument (Semi-automatic Sampler)

At the Public Health Institute, semi-automatic samplers in conformity with the British Standards (manufactured by UDK, Britain) are installed for the sampling of SO_2 and dust in the air for eight days with unmanned operation.

As illustrated in Figure 3.3.2, this equipment consists of inlet tube, filter, impinger, sample selector, dry gas meter, suction pump, and storage battery.



A	Inlet funnel	G	Impinger (Gas washing bottele)
B	Outsid wall	H	8 Channel sample selector
C	Inlet tube	I	Dry gas meter
D	Manifold	J	Suction pump
E	Inside tube	K	Storage battery
F	Filter case	L	power source

Figure 3.3.2 Semi-automatic Sampler

The sample air flows into the inlet tube which is placed about 1 meter from the building wall and goes out through the sample selector, dry gas meter, and suction pump.

The following materials are used for these parts.

Part	Material
Inlet Tube, Internal Piping	Flexible PVC
Manifold	Alminum
Pipe attached to Manifold, Filter Holder	Rigid PVC
Impinger	Glass
Paper Filter	Whatman No. 1 manufactured by Whatman Company

This instrument needs electricity to operate the suction pump and the timer, and is equipped with a lead storage battery for use at the time of power breakdown.

Dust is sampled on the surface of the filter fixed to the filter holder, and SO_2 is reacted with absorbent liquid in the impinger. These samples are brought to the laboratory for analysis.

As illustrated in Figure 3.3.2, 8 sets of filter holders and impingers are attached to the instrument.

The sampling circuits are switched on and off from one to another every 24 hours by the sample selector which is mounted with a timer, enabling unattended 8 day consecutive operation.

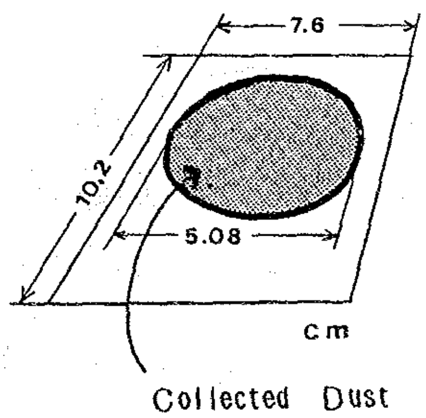
The sampling condition is that amount of SO_2 absorbent liquid is 75 ml and that the flow volume of sample air is about $2m^3$/day.

(2) Analysis and Prescription of Reagents

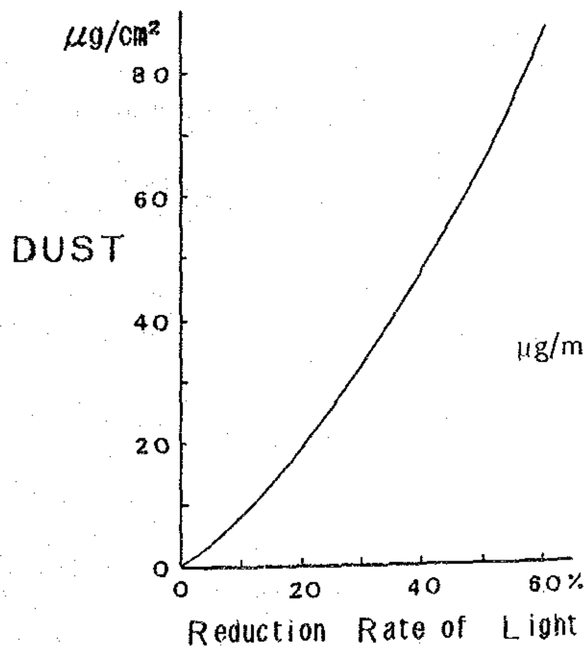
i) Dust Analysis

Whatman-made No. 1 filter paper (7.6 x 10.2 cm) is used. Dust is sampled in circular shape on the filter paper with a diameter of 5.08 cm. Smoke Stan-made Reflectometer diffusion system Model 4 is employed as an analyser.

The prindiple of this analyser is as follows:



The sampled dust is irradiated with light and the decreased amount of light in reflection is calculated in comparison with the amount of the reflected light irradiated against the unused paper. In reference to the calibration curve (Ringerman Index Chart) the weight of dust per one unit area is obtained. And from the whole surface area of the sampled dust and volume of sampled air, the weight of the dust per one m^3 is calculated.



Calculation

$$\mu g/m^3 = \frac{\mu g/cm^2 \times 0.92 \times \overbrace{\pi \times 2.5 \times 2.5}^{\text{total surface area of dust}}}{\text{Flow rate } (m^3)}$$

Figure 3.3.3 Ringerman Index Chart

ii) SO_2 Analysis

SO_2 in the ambient air is absorbed by the absorbent solution (0.3% hydrogen peroxide: pH 4.5) as a result of reaction with hydrogen peroxide (H_2O_2) when SO_2 passes through it.

$$SO_2 + H_2O_2 \longrightarrow H_2SO_4$$

The analysis is conducted by neutralization titration method. Mixed indicator (Bromcresol Green Methyl Red (B.D.H. Indicator)) is dropped on the retrieved absorbent liquid, and titrated with the 0.01 normal solution of sodium carbonate (Na_2CO_3) using an automatic burette. The titration is continued until the color of the indicator becomes somber gray (pH 4.5).

$$H_2SO_4 + Na_2CO_3 \longrightarrow H_2CO_3 + NaSO_4$$

In case the pH value has exceeded the designated value of 4.5 reversal titration is conducted using 0.01 normal hydrochloric acid.

The reason for fixing the designated value of pH at 4.5 is to avoid the influence of carbon dioxide. The amount of the titrant required for the neutralization analysis is not measured by ml, but by counting the number of drops that come down from the burette.

iii) Prescription of Reagents

Absorbent liquid used for measuring SO_2 is 0.3% solution of hydrogen peroxide. It is made from deionized water, and 30% solution of H_2O_2, and is adjusted to have the pH value of 4.5 by use of 0.01 normal sulfuric acid.

High quality reagents manufactured by Merk (West Germany) and the indicators manufactured by B.D.H. (Britain) are used.

3.3.4 Maintenance of Measuring Apparatus

(1) Measured Values of SO_2

In parallel with the Turkish measuring instruments at 7 monitoring stations, the Japanese-made instruments were installed and SO_2 concentration was measured.

Table 3.3.1 shows the mean values of SO_2 at the 7 monitoring stations measured by the both instruments during the period of 82-86 days as from the middle of December 1984 through the middle of March 1985.

Table 3.3.1 Monitoring Results of SO_2 by Turkish and Japanese Sides

Station	Turkish Side (ppm)	Japanese Side (ppm)	Correlation Coefficient	Number of data
1. Cebeci	0.0726	0.1466	0.255	86
2. Bahcelievler	0.0779	0.3569	0.058	86
3. Tandogan	0.0833	0.1381	0.406	86
4. Yenimahalle	0.0720	0.1773	-0.102	85
5. Cankaya	0.0691	0.1525	0.255	85
6. Kavaklidere	0.1181	0.3392	0.500	86
7. Sihhiye	0.0811	0.1823	0.270	82
Whole			0.364	596

Note 1) To adjust with the measuring time-belt of the Turkish side, one-hour values of Japanese side from 11:00 a.m. to 11:00 a.m. were used to obtain one-day mean values.

2) Correlation coefficient is 1.00 if the values of both side are the same.

3) The following formula was used in the calculation of correlation coefficient (R).

$$R = \frac{\sum_{i=1}^{n}(Xi-\overline{X})\cdot(Yi-\overline{Y})}{\left(\{\sum_{i=1}^{n}(Xi-\overline{X})^2\}\{\sum_{i=1}^{n}(Yi-\overline{Y})^2\}\right)^{1/2}}$$

As shown above, the values measured by the Turkish side are, one the whole, considerably lower than those by the Japanese side.

The correlation coefficient is notably low and its value differs largely from site to site. The Japanese side used automatic analysers based on solution conductimetry, while the Turkish side used semi-automatic analysers based on neutrlization titration. But these extremely low correlation values can not be attributed totally to the difference of analytical methods or instruments. In search for the causes of such differences, the following items were investigated.

i) adsorption of SO_2 on the material of the sampler parts
ii) problems in the maintenance of the sampler
ii) problem in the analytical method

(2) Adsorption of SO_2 on the Sampler Parts

Table 3.3.2 shows the materials of the parts of the air sampler employed by the Japanese and the Turkish sides.

Table 3.3.2 Difference of Materials used for the Sampler

Components	Japanese Side	Turkish Side
Inlet Tube	Teflon	Flexible Polyvynil Chloride (PVC)
Internal Piping	Teflon and Glass	same as above
Filter Holder	Rigid PVC	Rigid PVC
Filter	Teflon	Cellulose
Manifold	--------	Alminum, and Rigid PVC

Figure 3.3.4 shows the rate of adsorption of SO_2 on materials used in filters and filter holders.

The figure indicates the changes in the measured values after passing SO_2 (0.15 ppm) through the filters and holders of various materials.

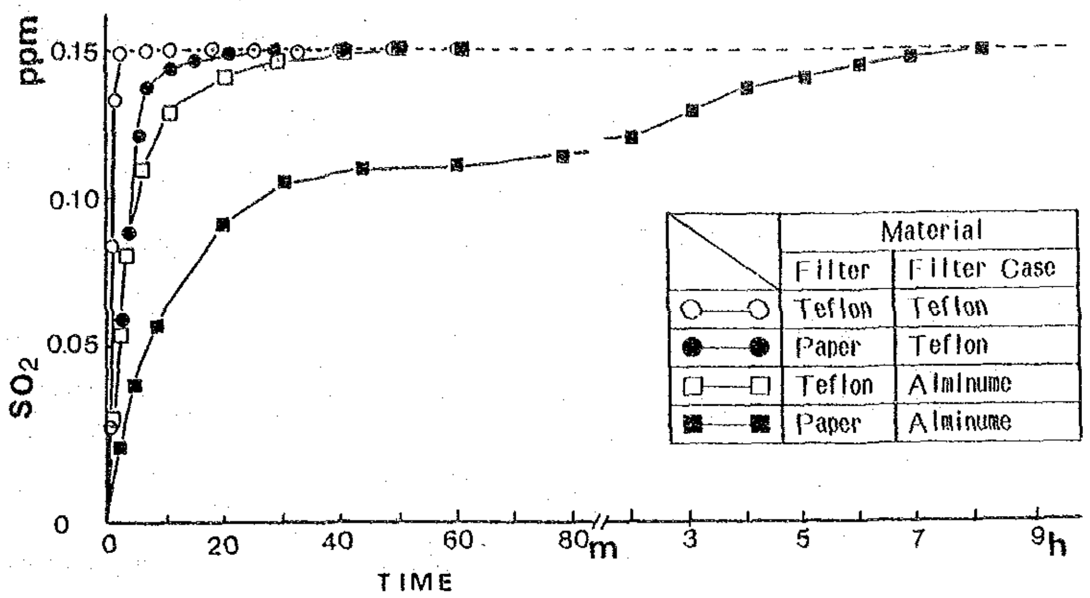


Figure 3.3.4 Rate of Adsorption of SO_2 on Filters and Holders by Material

Figure 3.3.5 shows the result of the SO_2 adsorption test conducted on materials used in the inlet tube.

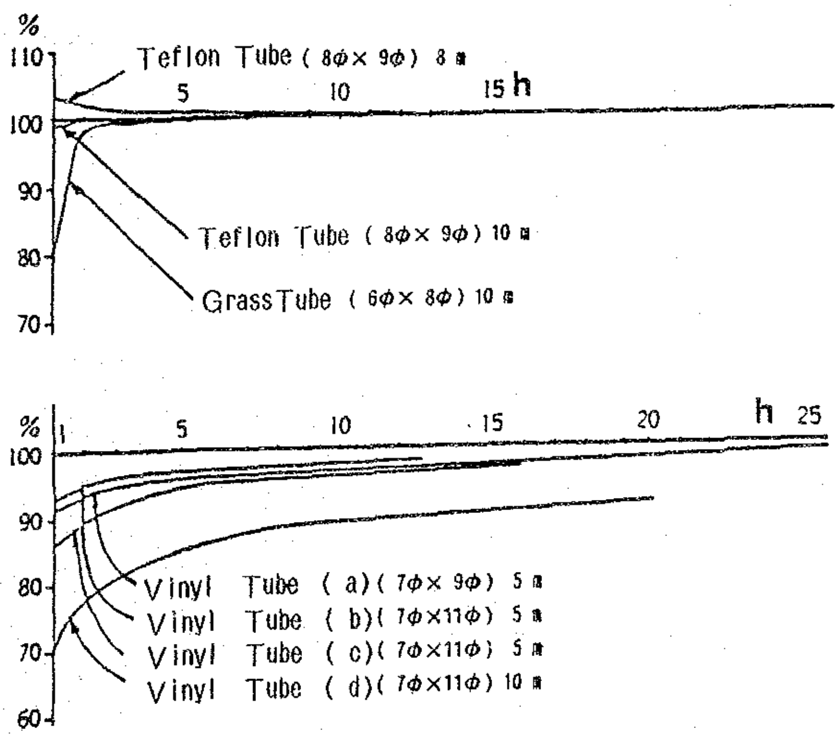


Figure 3.3.5 SO_2 Absorbency Rate of Inlet Tubes by Materials

The Teflon tube reached the 95% response in an instant while 2-7 hours were required for the polyvynil chloride tube to reach this point.

As shown in these examples, it is important in the measurement of SO_2 to select carefully the materials of the parts.

(3) Problems in the Maintenance

Air leakage was found in the measuring instruments of the Turkish side. Leakage in the closed system can be easily found. If bubbling continues when the inlet tube is closed, there is leakage.

At some monitoring sites, though the inlet tube was broken and air intake was impossible, bubbling was taking place. Filter holders that were not in use were not tightly fixed. Connectors at the outlet and inlet of the impingers were not connected. In other cases, PVC pipes were loosely attached to the manifolds. Bubbling was taking place even though the inlet tube was choked with cotton-like dust.

As illustrated in Figure 3.3.2, eight sampling circuits and an inlet tube are connected together by way of the manifold. If air intake is impended on the inlet side and there are some factors that would cause leakage in the seven other unused circuits, the air inside the room can easily flow into the instrument circuits.

Even after checking and fixing these parts of the system, the leakage was not stopped. There is a possibility that leakage was taking place in the sample circuit selector which selects one among 8 circuits.

To solve these problems, it is desired that regular replacement of parts and washing be made and that observation system under which measurement and analysis can be constantly made in the best condition be established.

(4) Problems in the Analytical Method of SO_2

In case of titration analysis, the result is usually obtained by reading the graduations on the burette. As mentioned before, at the Public

Health Institute, the volume of a liquid drop that comes down from the tip of the burette is measured beforehand, and titration analysis is conducted by counting the number of liquid drops.

This method is likely to cause calculation errors or individual differences depending on the range of SO_2 concentration.

The reason for using such method may be that the graduations on the burette are not accurate enough. For example, it was observed that the volume according to the graduation from 10ml to 11ml and that from 20 ml to 21 ml were different.

It is suggested that more accurate semi-micro burette be introduced and titration analysis be conducted by reading graduations, which will lead to improvement in accuracy.

(5) Considerations in Maintenance

The measured values of air pollutant concentration are the fundamental data in planning air pollution control measures, and therefore, maintenance of the monitoring instruments is of great importance as it is related to the protection of the health of the citizens in Ankara.

However, as pointed out above, there seemed to be much work to be done for the improvement.

In addition to the improvements mentioned above it is suggested to make more effort in such works as the preparation of check-point manuals and regular cross-check of measuring instruments by use of the standard SO_2 gas (it is economical to use the permeation tube method) in order to achieve more reliable measurement.

CHAPTER 4 STUDY OF SOCIO-ECONOMIC CONDITIONS

CHAPTER 4 STUDY OF SOCIO-ECONOMIC CONDITIONS

4.1 TREND OF SOCIO-ECONOMIC INDICATORS

4.1.1 Population

(1) Total Population

Ankara City had a total population of about 1.88 million in 1980. This was around 65% of Ankara Province's 2.85 million, and about 4.2% of the Turkey's total of 4.74 million. The population increased since 1935 by about 1.75 million at the average annual growth rate of 6.3% for the past 45 yeas (1935-1980); whereas the average annual increase in Ankara Province was 3.8% and in Turkey 2.3%. The population of Ankara City in 1980 was about 15.4 times that in 1935. However, the rate of the population growth decreased after 1975 through 1980. A similar trend is seen in Ankara Province and the whole Turkey (refer to Figure 4.1.1 and Table 4.1.1).

(2) Population by Age Groups

The population ratio of Ankara City by three age groups is shown in Figure 4.1.2. The percentage of the working age group (15 -64 years) is 60%, the juvenile age group (0 - 14 years) 36%, and the old age group (65 and above) 4%. In another view, the ratios of Ankara City's dependent age groups of 0 - 14 and 65 and above are lower than those of the whole country, and the ratio of the City's working age group is 4% higher than that of Turkey. Furthermore, for the period 1975 - 1980, the ratio of working age group increased slightly, while that of the juvenile group decreased.

(3) Population and Population Density by District

Ankara City consisted of four (4) districts in 1980, namely; Merkez ilce, Altindag, Cankaya, and Yenimahalle. The central business district (CBD) and its environs were divided into 33 zones based on

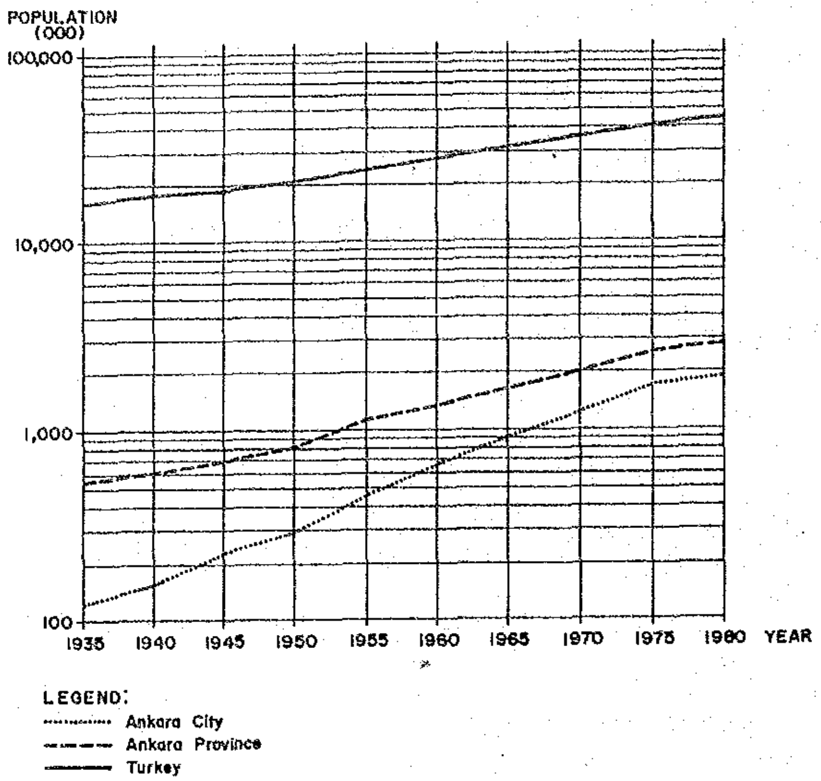


Figure 4.1.1 Trend of Population (1935 - 1980)

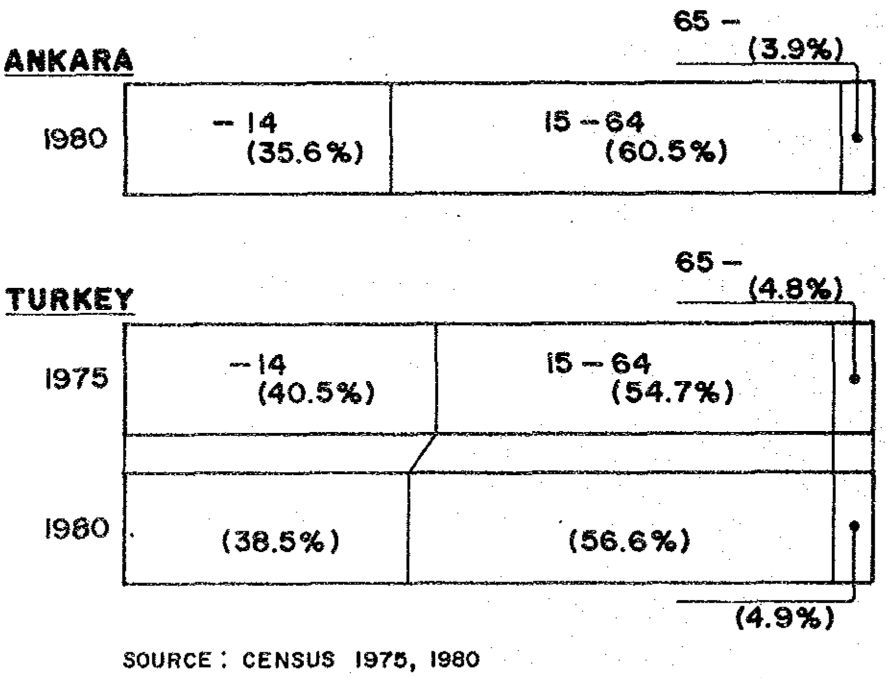


Figure 4.1.2 Percentage of Population by Age Groups

Table 4.1.1 Trend of Population

Item / Year	Ankara City			Ankara Province			Turkey	
	Population	AGR (%)	Share (%)	Population	AGR (%)	Share (%)	Population	AGR (%)
1935	122,270	-	0.76	534,025	-	3.3	16,158,018	-
1940	157,242	5.2	0.88	602,965	2.5	3.4	17,820,950	2.0
1945	226,712	7.6	1.21	695,526	2.9	3.7	18,790,174	1.1
1950	288,536	4.9	1.38	819,693	3.3	3.9	20,947,188	2.2
1955	451,241	9.4	1.88	1,120,864	6.5	4.7	24,064,763	2.8
1960	650,067	7.6	2.34	1,321,380	3.3	4.8	27,754,820	2.9
1965	905,660	6.9	2.89	1,644,302	4.5	5.2	31,391,421	2.5
1970	1,236,152	6.4	3.47	2,041,658	4.4	5.7	35,605,176	2.6
1975	1,701,004	6.6	4.22	2,585,293	4.8	6.4	40,347,719	2.5
1980	1,877,755	2.0	4.20	2,854,689	2.0	6.4	44,736,957	2.1

Source: Census

Note: AGR - Annual Growth Rate

the analysis and planning zones determined by the Ankara Master Plan Bureau. These are shown in Figure 4.1.3.

The population of Merkez ilce in 1980 was approximately 77 thousand; Altindag, 609 thousand; Cankaya, 922 thousand; and Yenimahalle, 270 thousand. These and population density are shown in Table 4.1.2. Markedly, Cankaya's population is 50% that of the total city population.

In the ten-year period of 1970-1980, the population of Merkez ilce decreased by the annual rate of 4.0%, while the population in the other three districts increased. Significantly, Yenimahalle's population grew at an annual average rate of 7.3% and even doubled for the 10-year period.

The comparative figures for population and number of households in the 33 zones are shown in Table 4.1.3, and Figures 4.1.4 and 4.1.5. The total population of the 33 zones is 1.80 million in 1980, while the total number of households is 0.48 million. From these, the average

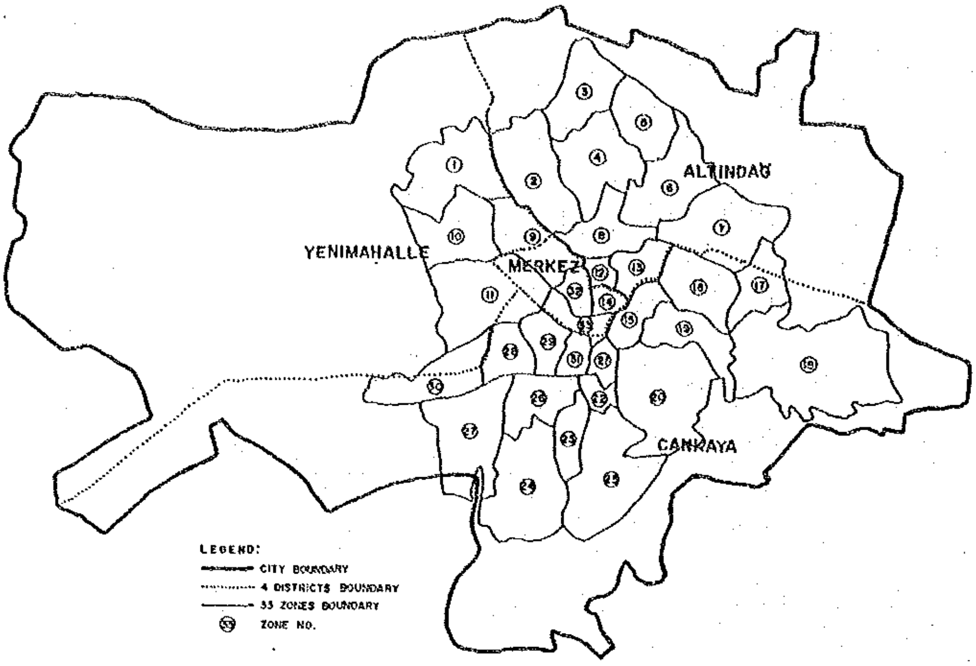


Figure 4.1.3 Administrative Boundaries in Ankara City

Table 4.1.2 Population of Four Districts in Ankara City

	Area (sq.km.)	City Population					
		1970		1975		1980	
		Population	AGR	Population	AGR	Population	AGR
Merkez ilce	369	114,419		94,964	3.7	77,168	4.1
		9.3		5.6		4.1	
Altindag		335,096		512,392	8.9	608,689	3.5
		27.1	(1,218.2)	30.1	(1,646.0)	32.4	(1,858.7)
Cankaya	1,672	653,290		895,005	6.5	921,882	0.6
		52.8	(390.7)	52.6	(535.3)	49.1	(551.4)
Yenimahalle	1,354	133,347		198,643	8.3	270,016	6.3
		10.8	(98.5)	11.7	(146.7)	14.4	(199.4)
Total	3,395	1,236,152		1,701,004	6.6	1,877,755	2.0
		100.0	(364.1)	100.0	(501.0)	100.0	(553.2)

Source: Census 1970, 1975, 1980

Note: Figures in parentheses show the population density.
AGR - Annual Growth Rate

number of members per household is found to be 3.8 and population density to be 103 persons per hectare.

The high population density zones are evenly distributed from the CBD to the western and southern parts of the City. In addition, population in the outskirts of the City increased rapidly for the ten years from 1970 to 1980.

In zones 1, 4, and 5, population increased by more than 2.5 times from 1970 to 1980. In Ulus (Zones 32), the City's oldest center, the population decreased markedly from 36,429 to a third, 13,551 for the same period.

The annual average rates of population growth by the zones for the same period are shown in Figure 4.1.6.

Table 4.1.3 The Population and Household of 33 Zones in Ankara City (1970, 1980)

No.	Name	Area (ha.)	1970			1980					
			Pop.	*1	Share	Pop.	*1	Share	*2	Household	*3
1	Karsiyaka	983.25	54,070	54.99	4.5	111,602	113.50	6.2	7.5	30,481	3.66
2	Etlik	855.00	35,195	41.16	2.9	79,762	93.29	4.4	8.5	19,901	4.01
3	Senatoryum	565.50	25,283	44.71	2.1	55,651	98.41	3.1	8.2	13,490	4.13
4	Keciören	687.50	42,289	61.51	3.5	113,388	164.93	6.3	10.4	27,032	4.19
5	Aktepe	464.50	24,131	51.95	2.0	65,754	141.56	3.7	10.5	16,890	3.89
6	Hasköy	556.50	31,345	56.33	2.6	66,831	120.09	3.7	7.9	20,152	3.32
7	Siteler Ulubey	543.75	35,535	65.35	3.0	58,106	106.86	3.2	5.0	13,421	4.33
8	Ziraat Fak Adiatterler	575.50	43,957	76.38	3.7	63,987	111.19	3.6	3.8	19,693	3.25
9	Aldoapra Varlik Mah	527.40	25,920	49.15	2.2	25,672	48.68	1.4	0.1	6,911	3.70
10	Y. Mahalle Demetorler	578.00	43,951	76.04	3.7	52,995	91.69	2.9	1.9	16,144	3.28
11	A.O.C. Gazi Mah	1,050.25	15,578	14.83	1.3	18,277	17.40	1.0	1.6	5,717	3.20
12	Altindag	111.15	44,953	404.44	3.7	44,953	404.44	2.5	0	15,680	2.87
13	Aktas Asmezarlik	264.40	60,257	227.90	5.0	60,257	227.90	3.4	0	15,920	3.78
14	Samanpazari Eski Ank	112.50	37,307	231.62	3.1	29,545	262.62	1.6	2.3	9,840	3.00
15	Cebeci	206.65	55,019	192.04	4.6	84,503	295.07	4.7	4.4	23,765	3.56
16	Gukeron Guheren	593.10	74,636	125.84	6.2	94,996	160.17	5.3	2.4	21,837	4.35
17	Karaagac	423.45	-	-	-	-	-	-	-	-	-
18	Kayas	1,250.00	40,188	32.15	3.2	81,146	64.92	4.5	7.3	18,713	4.34
19	Mamak	466.75	46,885	100.45	3.9	93,863	201.10	5.2	7.2	22,249	4.22
20	Akdere Imrahorturkoa	1,331.25	71,017	53.23	5.9	90,473	67.81	5.0	2.5	23,700	3.80
21	Incesu Seyranboglari	128.25	41,732	325.40	3.5	53,153	414.45	3.0	2.4	16,734	3.18
22	K. Ease Karakildere	172.35	44,265	256.83	3.7	56,168	325.89	3.1	2.4	12,380	4.54
23	Ayranci	291.82	36,934	126.56	3.1	68,112	233.40	3.8	6.3	13,947	4.88
24	Cankaya Yildiz	850.00	32,962	38.78	2.7	68,938	81.10	3.8	7.7	12,709	5.42
25	Dikmen Orecler	983.75	44,266	45.00	3.7	56,168	57.10	3.1	2.4	10,573	5.31
26	Devlet	421.42	-	-	-	-	-	-	-	-	-
27	Balgart Cukurambar	792.50	20,221	25.52	1.7	26,011	32.82	1.4	2.5	6,446	4.04
28	Bahcelither Emek	301.40	55,160	180.01	4.6	62,918	208.75	3.5	1.3	25,226	2.49
29	Maltepe Anittepe	264.15	37,157	140.67	3.1	42,383	160.45	2.4	1.3	13,600	3.12
30	Sogutozu	539.35	2,809	5.21	0.2	9,355	17.34	0.5	12.8	1,619	5.78
31	Yenisehir	162.45	32,200	198.21	2.7	32,200	198.21	1.8	0	10,149	3.17
32	Ulus	162.67	36,429	223.94	3.0	13,551	83.30	0.8	9.4	4,651	2.91
33	Kultur Alesi Gitarki	221.85	14,927	67.28	1.3	16,957	76.43	0.9	1.3	5,679	2.99
	Total	17,529.36	1,206,608	68.83	100.00	1,797,755	102.56	100.00	4.1	475,379	3.78

Source: Population survey of Ankara City in 1980 (based on 319 election districts)

Note: *1 - Population Density (persons/ha.)
*2 - Annual growth rate (1970-1980) (%)
*3 - Average household members (persons/household)

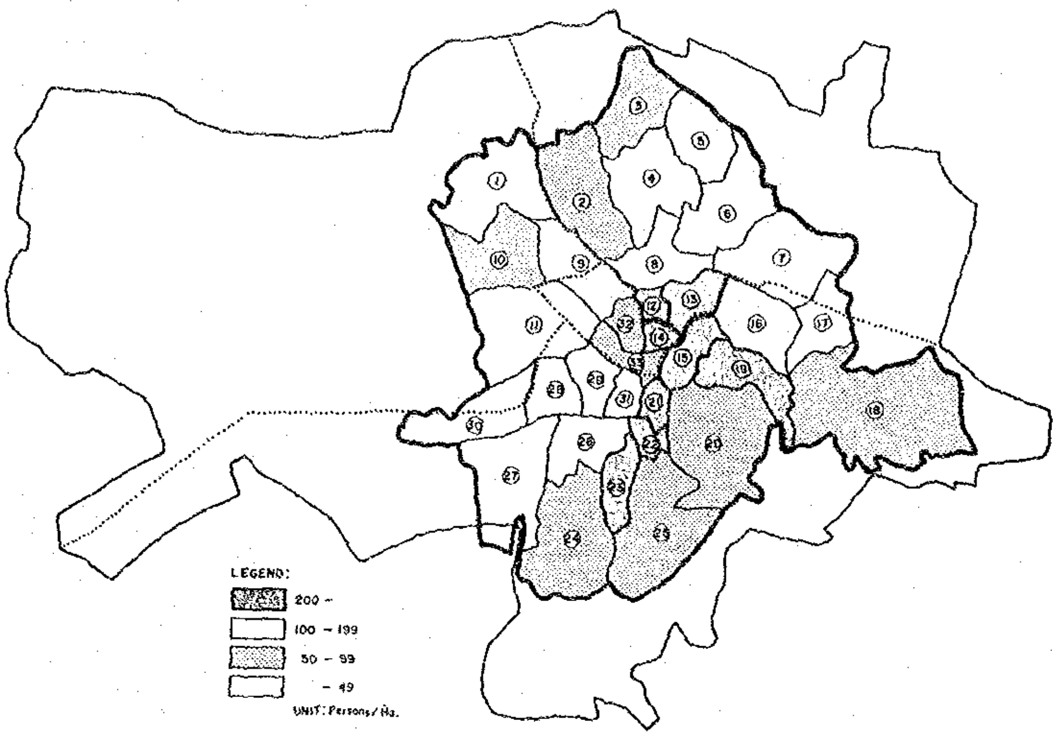


Figure 4.1.4 Population Density by 33 Zones, 1970

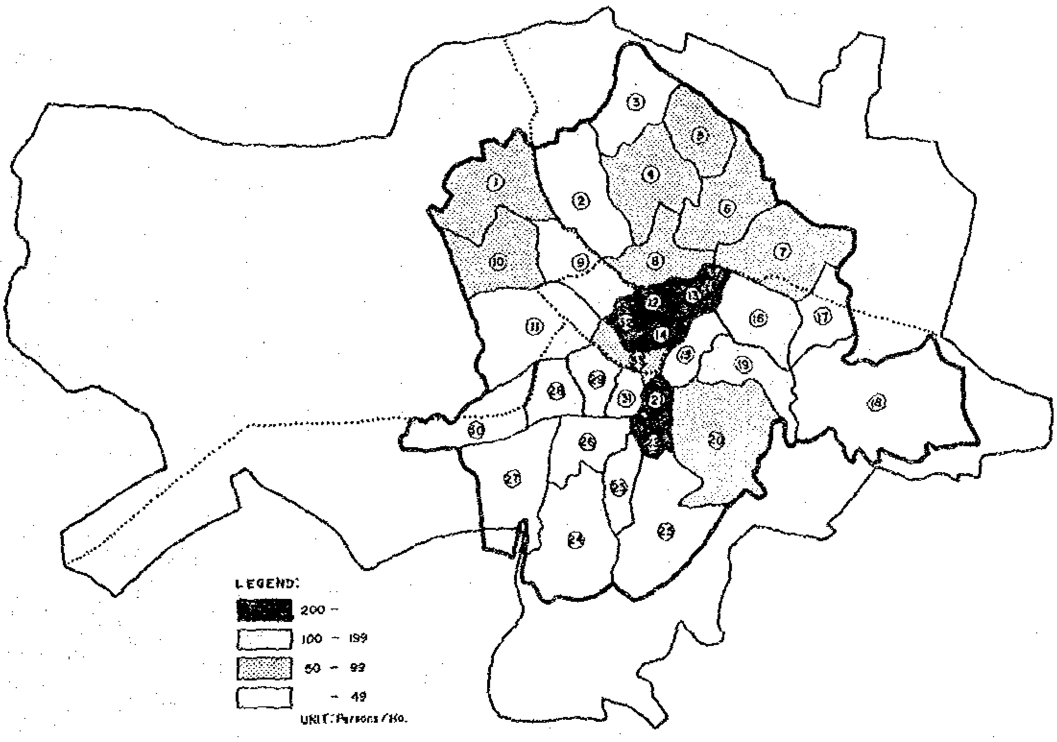
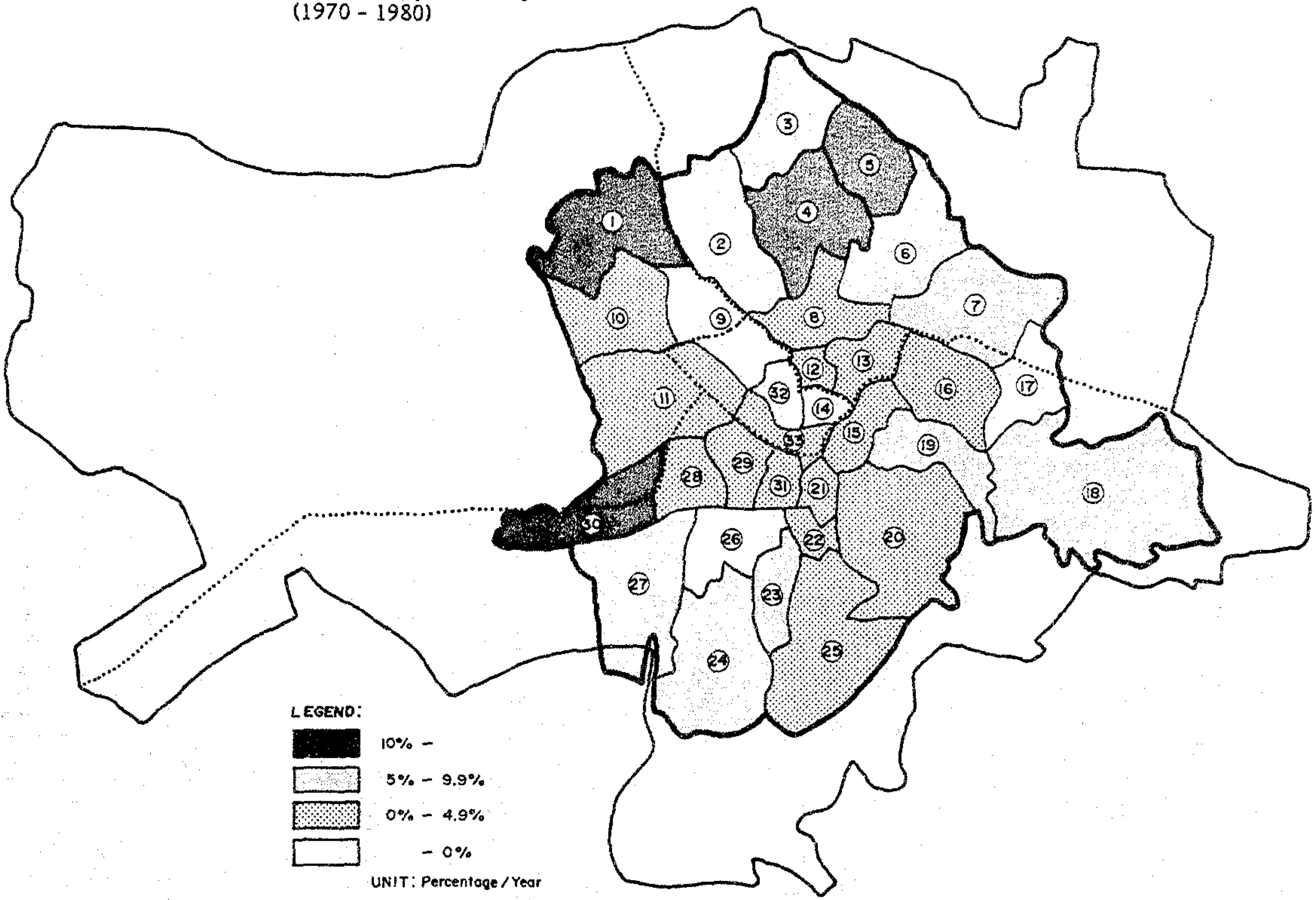


Figure 4.1.5 Population Density by 33 Zones, 1980

Figure 4.1.6 Annual Growth Rate of Population by 33 Zones
(1970 - 1980)



4.1.2 Household and Type of Dwelling

The total number of households in Ankara Province in 1980 was 574 thousand. Although the household growth rate had slowed down from 1975 to 1980, the number of households continued to increase at the rate of 4.2% per year. Of the total, 50% consisted of households with 3 - 5 members. The ratio of households with 6 or more members tended to decrease, while the reverse was observed in households with 4 members and below. The latter usually live in apartments, and the foremer in independent houses. (See Table 4.1.4.)

Table 4.1.4 Size of Household and Type of Dwelling (1970, 1975, 1980)

Size of Household	Total Household 1970		AGR	Total Household 1975		AGR	Total Household 1980		AGR	Type of Dwelling: Total Pop.	House	Apartment	Squatter house	Tent, barrack Cave, etc.
1	9,568	2.5	-	16,025	3.3	10.9	28,005 (100.0)	4.9	11.8	28,005	13,937 (49.8)	10,175 (36.5)	3,695 (13.2)	198 (0.7)
2	37,366	9.8	-	51,957	10.7	6.8	64,776 (100.0)	11.3	4.5	129,552	24,779 (38.3)	29,740 (45.9)	10,168 (15.7)	89 (0.1)
3	47,894	12.6	-	69,338	14.3	7.7	86,550 (100.0)	15.1	4.5	259,650	28,408 (32.8)	44,147 (51.0)	13,941 (16.1)	54 (0.1)
4	67,427	17.7	-	95,356	19.7	7.2	118,003 (100.0)	20.6	4.4	472,012	37,343 (31.6)	57,727 (48.9)	22,890 (19.4)	43 (0.04)
5	65,706	17.2	-	84,437	17.4	5.1	100,512 (100.0)	17.5	3.5	502,560	37,322 (37.1)	37,397 (37.2)	25,744 (25.6)	49 (0.05)
6	51,971	13.6	-	63,579	13.1	4.1	68,013 (100.0)	11.8	1.4	408,078	29,570 (43.5)	18,552 (27.3)	19,852 (29.2)	39 (0.06)
7	34,939	9.2	-	40,220	8.3	2.9	40,849 (100.0)	7.1	0.3	285,943	20,775 (50.9)	8,519 (20.9)	11,531 (28.2)	24 (0.06)
8	22,261	5.8	-	24,260	5.0	1.7	24,240 (100.0)	4.2	0.0	193,920	14,254 (58.8)	3,818 (15.8)	6,140 (25.3)	28 (0.1)
9	12,932	3.4	-	13,732	2.8	1.2	15,613 (100.0)	2.7	2.6	140,517	10,547 (67.6)	1,778 (11.4)	3,269 (20.9)	19 (0.1)
10+	31,432	8.2	-	25,132	5.2	4.4	27,562 (100.0)	4.8	1.9	362,403	21,708 (78.8)	2,070 (7.5)	3,753 (13.6)	31 (0.1)
Total	381,496	100.0	-	484,036	100.0	4.9	574,123 (100.0)	100.0	3.5	2,782,640	238,643 (41.6)	213,923 (37.3)	120,983 (21.1)	574 (0.1)

Source: Census 1970, 1975, 1980

Note: AGR - Annual Growth Rate

4.1.3 Number of Establishments

(1) Employment by Industrial Sectors

The total number of persons employed in Ankara City and Province are shown in Table 4.1.5. It is difficult to detect a significant trend due to the insufficient data: the 1970 data is available for Ankara City, while only the 1980 data are available for Ankara Province and the whole Turkey.

In 1970, employment by industrial sectors in Ankara City was composed of 5% primary, 20% secondary, and 75% tertiary. The last category, specifically government services, registered the highest percentage of employment and has notably given Ankara City a great potential for urbanization. The ratio of the total employment to the total population in Ankara City was 32%. The ratio of employment in the primary industry in Ankara Province was 28% in 1980, while that in the whole Turkey was 60%. These figures show urbanization of Ankara Province is more prominent as compared to the whole Turkey.

Table 4.1.5 Industrial Sectors in Anakara City, Ankara Province, and Turkey

Industry Sector	1970		1980				Remarks
	Ankara City		Ankara Province		Turkey		
	Number	%	Number	%	Number	%	
Agriculture	17,900	4.51	275,992	28.04	11,236,687	60.67	Primary
Manufacture	53,597	13.52	126,162	12.82	1,975596	10.67	Secondary
Construction	27,487	6.93	62,513	6.35	798,177	4.31	
Communications	26,048	6.57	48,824	4.66	531,278	2.87	
Trade	33,364	8.41	88,284	8.97	1,084,378	5.85	Tertiary
Service	238,112	60.05	385,432	39.16	2,896,206	15.63	
Total	396,508	100.00	984,207	100.00	18,522,322	100.00	

Source: 1970, 1980 Census

(2) Number of Establishments

The total number of establishments, the total floor area, and the total number of persons employed in Ankara City are shown in Table 4.1.6. Concentrated in the CBD of Ulus and Yenisehir is 46% of total number of establishments and 40% of total employed persons. The central business district is characterized as being twin-core structures with Ulus and Yenisehir. Ulus, located near the Citadel, is considered an extension of the older center of the City, while Yenisehir has been tagged as the "planned" new center of the Capital. Consequently, the sizes of establishments in the latter are larger (319 m^2 per establishment, 15.0 persons per establishment) than in the former (178 square meters per establishment, 6.9 persons per establishment).

Table 4.1.6 Number of Establishments, Floor Area, and Employees in Ankara City in 1970

Area	Total Floor Area (sq.m.)		Total Number of Establishments		Number of Employees		Floor Area/ Establishments (sq.m.)	Employees/ Establishments (persons)
		Share		Share		Share		
Ulus	971,445	55.8	5,465	31.9	37,913	20.7	178	6.94
Yenisehir	770,578	44.2	2,419	14.0	36,298	19.7	319	15.00
CBD Total	1,742,023	100.0	7,884	45.9	74,211	40.4	221	9.41
Ankara Total	-	-	17,140	100.0	183,555	100.0	-	10.71

Source: Ankara 1970-1990, Urban Development Strategy.

4.1.4 Land Use

(1) Land Use in Ankara City (refer to Figure 4.1.7)

Comprising of a total of 3,395 km^2, Ankara City's area is approximately 11.1% of Ankara Province's total area of 30,715 km^2. Areas of its four (4) districts of Merkez ilce (center of the City), Altindag (to the north), Cankaya (to the south), and Yenimahalle (to the west), are shown below.

The main road network is radial in pattern, extending from the City center to the north, west, south, and east, while a railroad runs from east to west. Land use, therefore, has been developed mainly along the railroad and main roads.

The distribution of existing major land use in categories is briefly explained below:

a) Residential - extending toward the north, east, and south from the existing downtown area.

b) Urban services - located in the eastern section of the downtown area and the western part of the city.

c) Central Business Area - concentrated in the CBD and composed of the twin-core structures with Ulus and Yenisehir.

d) Industrial and warehousing - found in the western part of the city.

e) Farm and open spaces - also found in the City's western part.

District	Area	%
Merkez ilce (Province center) Altindag	369 sq.km.	
Cankaya	1,672	49
Yenimahalle	1,354	40
Ankara City	3,395	100

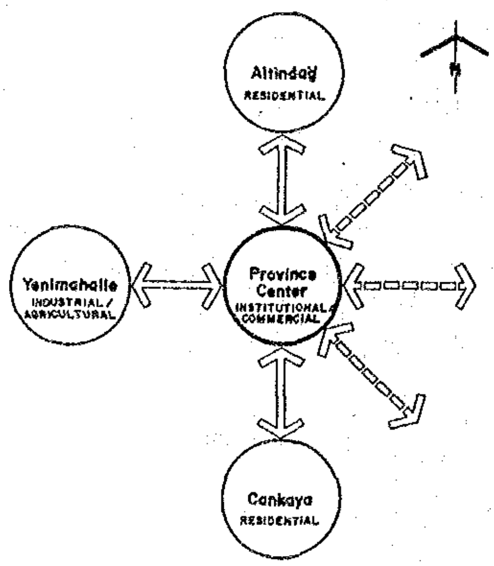
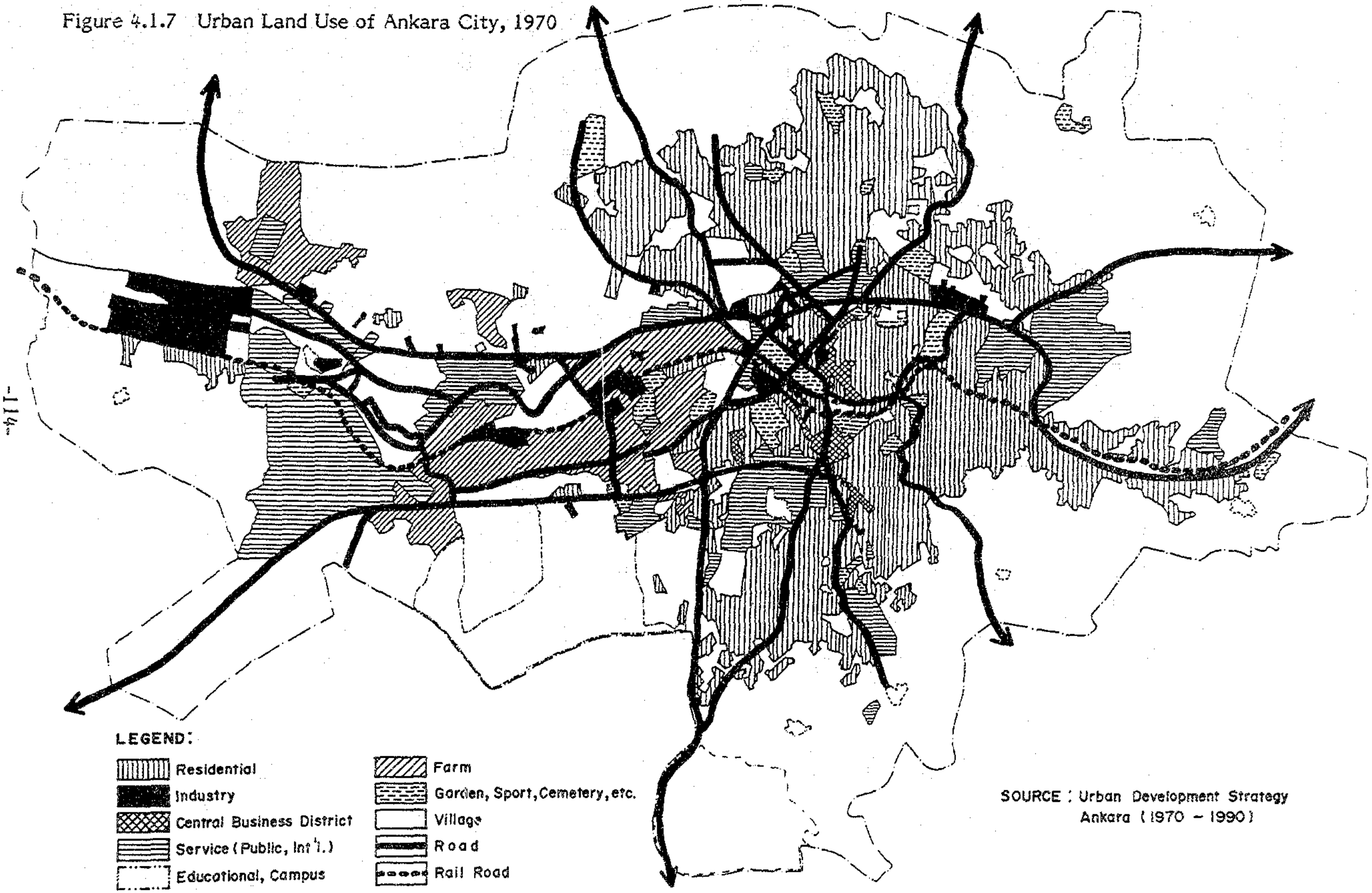


Figure 4.1.7 Urban Land Use of Ankara City, 1970



(2) Existing Land Use by District

Characteristic fetures of land use in the four districts of the City are presented below.

Merkez ilce (Province center)
This is actually the center of institutional and commercial activities of Ankara City and Province. Its recreation zone is located between its commercial/institutional and residential zones.

Altindag
Located in the northern part of the city, the land is used mainly for residences with parks adjoined. A large cemetery is also present.

Cankaya
Mainly residential located in the southern section of the City. However, commercial/institutional areas are also present along the trunk road running through the residential area. This district is well afforested, and the presidential palace and various embassy offices are present. In the southernmost section are the big educational institutions.

Yenimahalle
Located in the City's western section the land has been developed mainly for industry and agriculture extending from the east to west along the two main roads. Its residential area is located in the north, while many educational institutions are situated in the south. Open spaces also abound and this district has a great potential for future development.

4.1.5 Population Forecast in Ankara City

(1) Total Future Population

The population forecast for the City, given below, is based on the analysis of existing conditions and on some development plans of the City. The forecast was made for the year 1995, the target year of this Project.

The dense population of Ankara City is the result of its high annual growth rate of 6.8% for the past 30 years (the growth rate of the whole Turkey is only 2.3% per year). This trend, however, slowed down for the 5 year-period of 1975 to 1980, with the City's annual population growth rate being only 2.0% while that of Turkey remained at 2.1%. This is mainly the result of decreasing population in the central areas of the City. The policy of banning construction of new buildings within the area of 6,000 hectare in the central part of the City greatly contributed to the phenomenon.

On the other hand, population in the western Yenimahalle district and the outskirts increased. Given the aforementioned trends, the following three methods were adopted to forecast population in Ankara City.

1) Regression Analysis (Linear function)
2) Regression Analysis (Logistic curve)
3) Analysis of percentage share of Ankara City in the total of Turkey

The results are shown in Table 4.1.7 and Figure 4.1.8.

Based on these results, the pollulation of Ankara City in 1995 is estimated to be 2.5 million.

Table 4.1.7 Population Forecast of Ankara City in 1995

Case	Forecast Method	Forecast Value (1995 Pop.)
1	Formula: P = A x t + B where , P : Population t : Year A : 40,852.24 B : -79,206,598.27 R : 0.956 (Coefficient of correlation)	2.29 million
2	Formula: $P = \frac{K}{1 + m \times e^{-at}}$ where, K : 3,040,000	2.60
3	The population share of Ankara City to that of Turkey has remained constant at 4.0% since 1975 and this trend is expected to remain in the future. Based on Turkey's 5th 5-year Development Plan, and assuming a constant rate of growth for Turkey of 2.1%, the population of Turkey has been established at 60.54 million. From the above assumption and figures, the population and Ankara City in 1990 may be calculated as follows: 61.54 mil. x 0.04 = 2.46 million ↑ Turkey's Pop. ↑ Ankara's share	2.46

It is forecasted that the population of Ankara City in 1995 will be 2.5 million that is the average of 3 cases as described above.

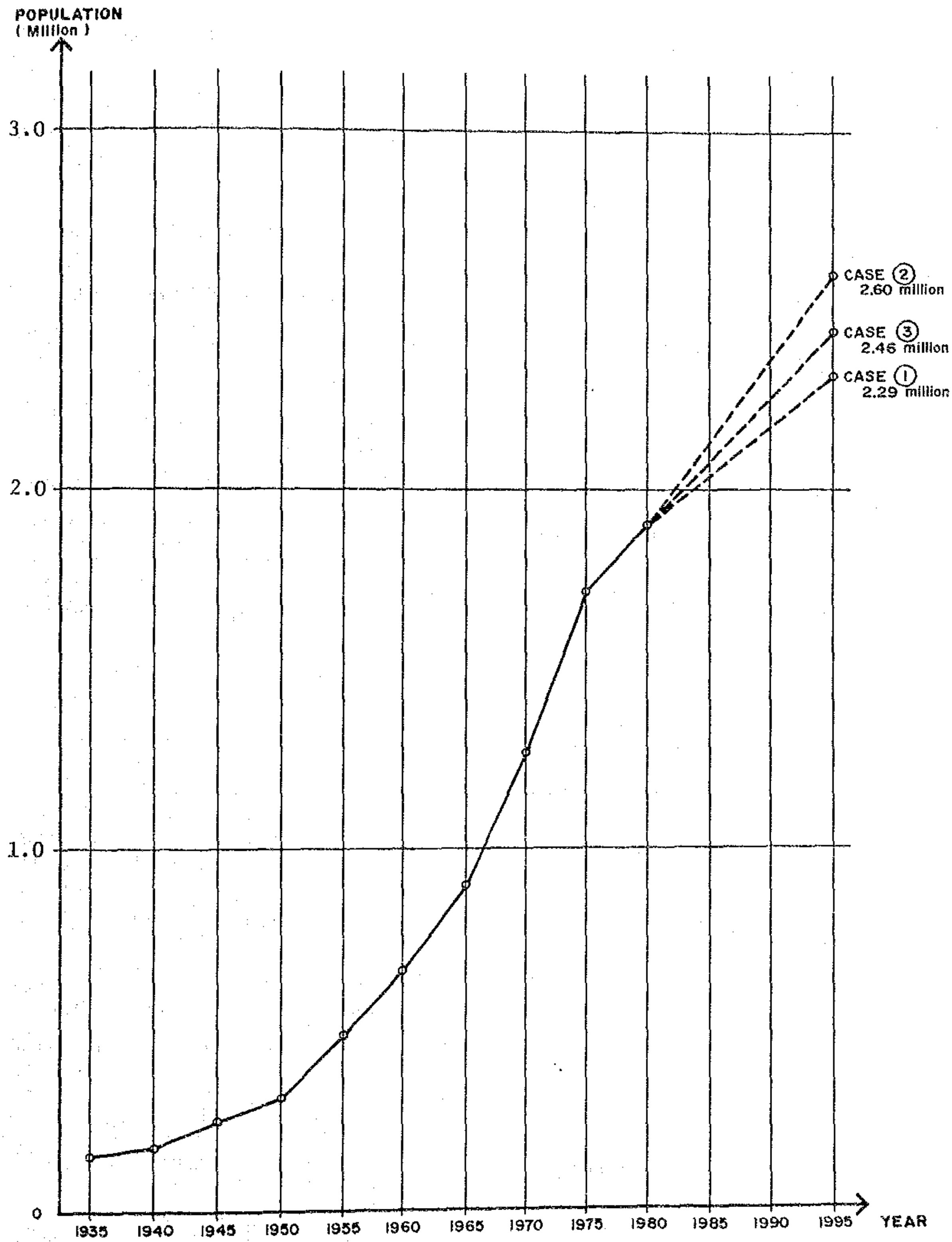


Figure 4.1.8 Population Forecast of Ankara City in 1995

(2) Future Population by Districts

The population forecast for the four districts of the City was made under the following assumptions.

i) The total population of Ankara City in 1995 will be 2.50 million.

ii) The population in the central areas shown in Figure 4.1.9 will remain constant.

iii) The housing development are underway in Batikent and in the southern outskirts of Cankaya. The other projects are planned in the western section of Yenimahalle.

a. Batikent and southern Cankaya housing project

Name of Project	Area (ha.)	No. of Housing Units	Population
Southern Cankaya	800	45,000	180,000
Batikent	1,400	55,000	220,000

b. Western Yenimahalle housing project

Name of Project	Area (ha.)	No. of Housing Units	Population
Enayaman Y.A.	1,200	43,000	193,500
E. Timesgut Y.A.	950	45,000 - 50,000	220,000
Gaygolu	350	12,000	52,000

It is expected that the ongoing Batikent and southern Cankaya housing project will be finished before 1995, while the Yenimahalle project has not been given any definite construction schedule yet.

iv) The population in Altindag will increase naturally.

Based on the assumptions given above, the populations forecasted for the City's four districts are shown in Table 4.1.8. Their break down into the 33 planning zones is shown in Table 4.1.9.

Figure 4.1.9 Zone with Constant Population

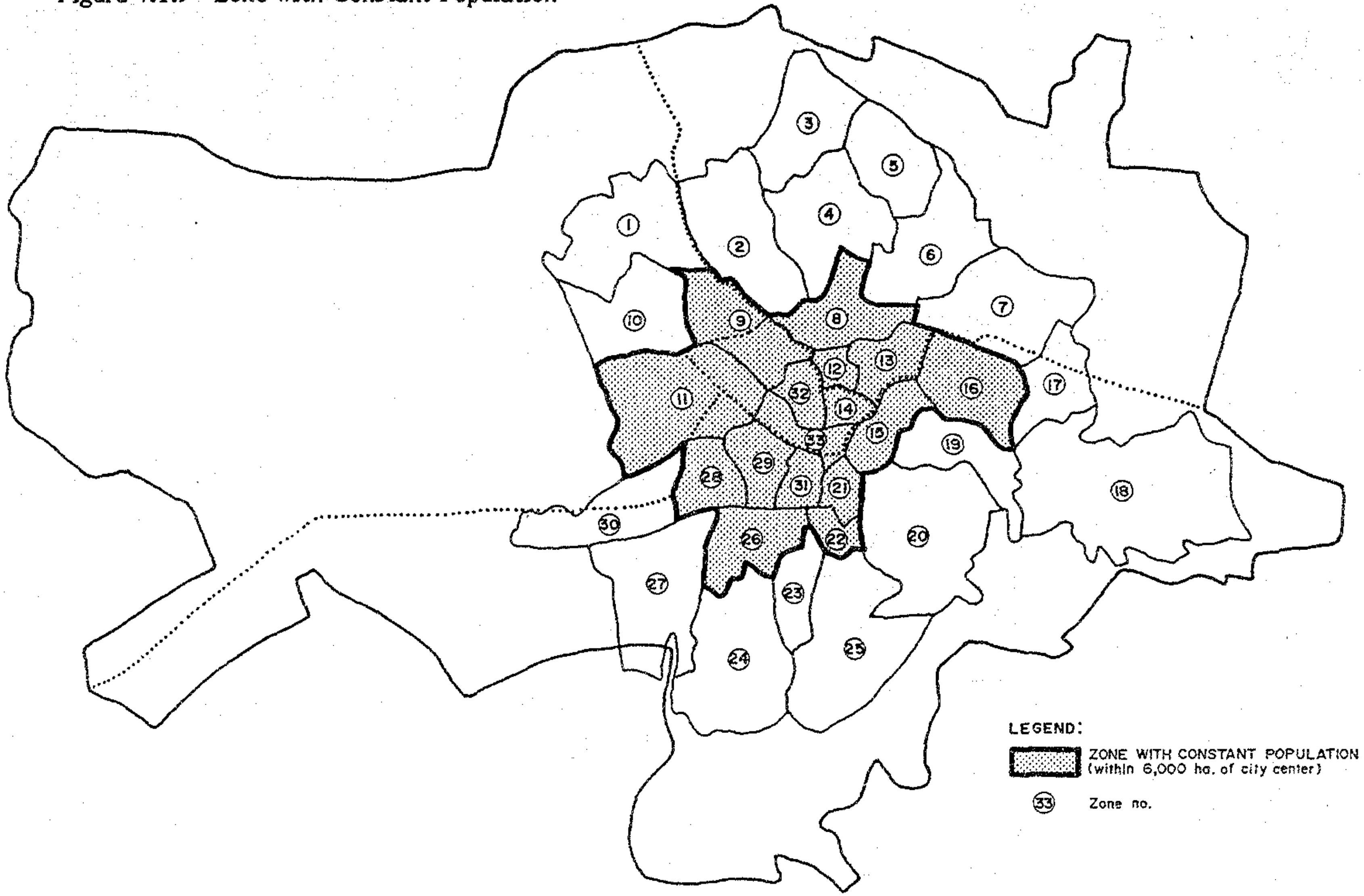


Table 4.1.8 Population Forecast by District

Name of District	Existing Population			Forecast Method	Forecast Value (1995 Pop.)
	1970	1975	1980		
Province Center	114,419	94,964	77,168	Constant value in 1980 —> 75,000	75,000
Yenimahalle	133,349	198,643	270,016	Increase population by the development of Bati-kent and Western housing project. —> 300,000	570,000
Cankaya	653,290	895,005	921,882	Increased in population by the development of housing project in southern outskirts. —> 200,000	1,122,000
Altindağ	335,096	512,392	608,689	Marginal population —> 733,000 = 2,500,000 - (75,000 + 570,000 + 1,122,000)	733,000
Total	1,236,152	1,701,004	1,877,759		2,500,000

Population Breakdown of 33 zones in 1995

Population by district
- Province Center = 75,000
- Yenimahalle = 570,000
- Altindağ = 733,000
- Cankaya = 1,122,000
- Total = 2,500,000

↓ ← City population outside of 33 zones 80,000 + 300,000 = 380,000

Population of 4 districts in 33 zones.
- Province Center = 75,000
- Yenimahalle = 190,000
- Altindağ = 733,000
- Cankaya = 1,122,000
- Total = 2,120,000

↓ ← It is assumed that the population within 6,000 hectares of CBD will not increase (refer to Figure4.1.9).

Refer to Table 4.1.9

Table 4.1.9 The Population and Household of 33 Zones in Ankara City (1970, 1980, 1995)

No.	Name	Area (ha.)	1970			1980						1995		
			Pop.	*1	Share	Pop.	*1	Share	*2	Household	*3	Pop.	Share	*1
1	Karsiyaka	983.25	54,070	54.99	4.5	111,602	113.50	6.2	7.5	30,401	3.66	111,602	5.3	113.50
2	Etlik	855.00	35,195	41.16	2.9	79,762	93.29	4.4	8.5	19,901	4.01	102,323	4.8	119.68
3	Senatoryum	565.50	25,283	44.71	2.1	55,651	98.41	3.1	8.2	13,490	4.13	71,392	3.4	126.25
4	Kecioren	687.50	42,289	61.51	3.5	113,388	164.93	6.3	10.4	27,032	4.19	145,400	6.9	211.58
5	Aktepe	464.50	24,131	51.95	2.0	65,754	141.56	3.7	10.5	16,890	3.89	84,353	4.0	181.60
6	Haskoy	556.50	31,345	56.33	2.6	66,831	120.09	3.7	7.9	20,152	3.32	85,734	4.0	154.06
7	Sittler Ulubey	543.75	35,535	65.35	3.0	58,106	106.86	3.2	5.0	13,421	4.33	74,541	3.5	137.09
8	Ziraat Fak Adiatterler	575.50	43,957	76.38	3.7	63,987	111.19	3.6	3.8	19,693	3.25	63,987	3.0	111.19
9	Aldoapra Varlik Mah	527.40	25,920	49.15	2.2	25,672	48.68	1.4	0.1	6,941	3.70	25,672	1.2	48.68
10	Y. Mahalle Demetorler	578.00	43,951	76.04	3.7	52,995	91.69	2.9	1.9	16,144	3.28	52,979	2.5	91.66
11	A.O.C. Gazi Mah	1,050.25	15,578	14.83	1.3	18,277	17.40	1.0	1.6	5,717	3.20	18,277	0.9	17.40
12	Altindag	111.15	44,953	404.44	3.7	44,953	404.44	2.5	0	15,600	2.87	44,953	2.1	404.44
13	Aktas Asmazarlik	264.40	60,257	227.90	5.0	60,257	227.90	3.4	0	15,920	3.78	60,257	2.8	227.90
14	Samanpazari Eski Ank	112.50	37,307	231.62	3.1	29,515	262.62	1.6	2.3	9,840	3.00	28,240	1.3	251.02
15	Cebeci	286.65	55,049	192.04	4.6	84,583	295.07	4.7	4.4	23,785	3.56	84,583	4.0	295.07
16	Gukeren Guheren	593.10	74,636	125.84	6.2	94,996	160.17	5.3	2.4	21,837	4.35	94,996	4.5	160.17
17	Karaagac	423.45	-	-	-	-	-	-	-	-	-	-	-	-
18	Kayas	1,250.00	40,188	32.15	3.2	81,146	64.92	4.5	7.3	18,713	4.34	114,366	5.4	91.49
19	Mamak	466.75	46,885	100.45	3.9	93,863	201.10	5.2	7.2	22,249	4.22	132,857	6.3	284.64
20	Aktere Imraberturkoa	1,334.25	71,017	53.23	5.9	90,473	67.81	5.0	2.5	23,780	3.80	128,063	6.0	95.98
21	Incesu Sayranboglari	128.25	41,732	325.40	3.5	53,153	414.45	3.0	2.4	16,734	3.18	53,153	2.5	414.45
22	K. Ease Karakildere	172.35	44,265	256.83	3.7	56,168	325.89	3.1	2.4	12,390	4.54	56,168	2.6	325.89
23	Ayranci	291.82	36,934	126.56	3.1	68,112	233.40	3.8	6.3	13,947	4.89	95,876	4.5	328.54
24	Cankaya Yildiz	850.00	32,962	38.78	2.7	68,938	81.10	3.8	7.7	12,709	5.42	97,246	4.6	114.41
25	Dikmen Orecler	983.75	44,266	45.00	3.7	56,168	57.10	3.1	2.4	10,573	5.31	79,440	3.7	80.75
26	Devlet	421.42	-	-	-	-	-	-	-	-	-	-	-	-
27	Balgart Cukuramban	792.50	20,221	25.52	1.7	26,011	32.82	1.4	2.5	6,446	4.04	36,981	1.7	46.66
28	Bahcelither Emek	301.40	55,160	180.01	4.6	62,918	208.75	3.5	1.3	25,226	2.49	62,918	3.0	208.75
29	Maltepe Anittepe	264.15	37,157	140.67	3.1	42,383	160.45	2.4	1.3	13,600	3.12	42,383	2.0	160.45
30	Sogutozu	539.35	2,809	5.21	0.2	9,355	17.34	0.5	12.8	1,619	5.78	9,355	0.4	17.34
31	Yenisehir	162.45	32,200	198.21	2.7	32,200	198.21	1.8	0	10,149	3.17	32,200	1.5	198.21
32	Ulus	162.67	36,429	223.94	3.0	13,551	83.30	0.8	9.4	4,651	2.91	12,688	0.6	78.00
33	Kultur Alesi Gitarki	221.85	14,927	67.28	1.3	16,957	76.43	0.9	1.3	5,679	2.99	16,957	0.8	76.43
	Total	17,529.36	1,206,600	68.83	100.00	1,797,755	102.56	100.00	4.1	475,379	3.78	2,120,000	100.00	120.94

Source: Population survey of Ankara City in 1980 (based on 319 election districts)

Note: *1 – Population Density (persons/ha.)
*2 – Annual growth rate (1970-1980) (%)
*3 – Average household members (persons/household)