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ASSESSMENT OF AMBIENT AIR QUALITY IN ESKISEHIR, TURKEY

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ABSTRACT

In this study, air quality in Eskisehir was evaluated in terms of such pollutants as SO_2, PM, NO_2 and O_3. SO_2 and PM concentration levels in Eskisehir have been monitored since 1986 and these data were provided from the national ambient air monitoring network. Ambient NO_2 levels since January 2004 and ambient ozone levels since November 2004 have been monitored by use of passive samplers in the study area of this work. All these data were considered for ambient air quality assessment. Concentration relationship between pollutants themselves and the relationship between concentrations and meteorological parameters were discussed. Additionally, monitored data were compared against the limit values in the regulations.

Key Words: Air Quality, Sulphur Dioxide, Nitrogen Dioxide, Ozone, Particulate Matter

1. INTRODUCTION

Urban air pollution and its impact on urban air quality is a widely recognized problem. Many cities in the world are exposed to high levels of air pollution. The two most important reasons of local and global changes in the air quality are population and urbanization.

The current situation of the air quality in the world indicates that SO_2 maintains a downward trend, NO_2 maintains levels very close to those of World Health Organization (WHO), while as PM is a major problem in almost all Asian countries exceeding 300 $\mu g/m^3$ in many cities and ozone shows average values that exceed the selected guideline values demonstrating that it is a global problem (Baldasano et al., 2003).

Air quality in urban areas continues to be a growing concern in terms of its health and environmental impacts. Different sources of urban air pollution such as road traffic, heating and industry, with the road traffic being a dominant source also increase by the rate of increase in population and urbanization.

Major urban air pollutants, including sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM) and ozone (O_3) emitted to the atmosphere are subject to mixing, transport and transformation processes. Chemical interactions can produce harmful pollutants such as nitrogen dioxide which evolves from the oxidation of nitric oxide by ozone. Photochemical reactions can lead to ozone which is an extremely reactive chemical that has been shown to reduce visibility and have harmful effects on human health, commercial crops, and natural areas. It is also one of the most important gaseous component of photochemical smog. High levels of PM are significantly associated with adverse health effects, ecosystem damage, and degraded visibility (Wise and Comrie, 2005). SO_2 originating particularly from the combustion of sulphur-containing fossil fuels (principally coal and heavy oils) has also negative effects on human health, vegetation and some materials (MPAP, 2004).

Scientific researches have shown that long-term exposure to these pollutants above a specific level may cause effects which may differ from those mentioned above. Therefore, most of the countries in the world have established air quality regulations such as WHO, the European Union Air Quality Framework and Daughter Directives, the UK Air Quality Strategy (Lim et al., 2005). In this case, monitoring studies gain more importance in order to observe the effectiveness of air quality control regulations, improve air quality management efforts and detect long-term air quality trends.

The existing air quality information in Turkey is either limited to only a few pollutants or is not spatially and/or temporally representative of the current situation due to rapid growth of the urban areas. There are national air quality standards established for such pollutants as SO_2, NO_2, PM, O_3, etc.

Although SO_2 and PM have been monitored at multiple points within the Turkish ambient air monitoring network, other pollutants such as NO_x and O_3 could have been monitored at only a limited number of points. The expansion of the national ambient air monitoring network and adding new components to this network tasks require large investments and additional operational expenses. Therefore, there is an urgent need of adopting inexpensive, simple and reliable methods for air quality monitoring in Turkey. This need can be fulfilled by such methods as passive sampling which is simple, inexpensive and provide possibility for the determination of pollutant distribution over a large area.

A few air quality monitoring studies were carried out in Eskisehir in the past except the monitoring of SO_2 and PM by monitoring network since 1986. In 1990–1995, NO_2 measurements were carried out at Anadolu University Yunusemre Campus by Air Pollution Research Group at Chemical Engineering Department. Proceeding NO_2, O_3 and BTX monitoring studies that were carried out in 2003 and 2004 were conducted discontinuously.

In this study; (a) monitoring results of the pollutants SO_2, NO_2, PM and O_3 in Eskisehir were presented, (b) collected data were compared with the regulations of different countries (Turkey, WHO, EPA, etc.) and also with those of other national cities, (c) the relationship between related pollutants such as NO_2 and ozone, and also between atmospheric concentrations of the pollutants and meteorological parameters (temperature, wind) were determined.

2. MATERIALS AND METHODS

In this study, air quality in Eskisehir was identified by the monitoring results of main pollutants such as SO_2, NO_2, PM and O_3. Eskisehir is a rapidly developing intermediate size Turkish city, situated in the Northwest of the Central Anatolia, with a population of approximately 500,000 inhabitants. Mainly the traffic and heating are considered responsible for the pollution in the city. After 1998, natural gas has been introduced for domestic heating purposes by the 50 % of the residencies in the city.

SO_2 and PM have been included in the Turkish ambient air monitoring network for two points in Eskisehir. Because NO_2 and O_3 were not included in that monitoring network, later attempt has been found necessary to monitor spatial and temporal distributions of these pollutants in the urban area of Eskisehir. For this purpose, passive sampling method has been applied since January 2004 for NO_2, and since November 2004 for O_3. Six sampling points were selected from different sites of the city. Because NO_2 is mostly originated from the traffic, all the sampling points were selected in a way to have different levels of traffic density in accordance with results of emission inventory study carried out for Eskisehir (Cinar, 2003). Ozone monitoring has been started at the same sampling points to observe the relationship between NO_2 and ozone concentrations. An automatic ozone analyser was available at one sampling point (Anadolu University Iki Eylul Campus) to monitor daily and hourly changes in the O_3 concentrations.

Figure 1 shows the study area and sampling points on the map given for Eskisehir.

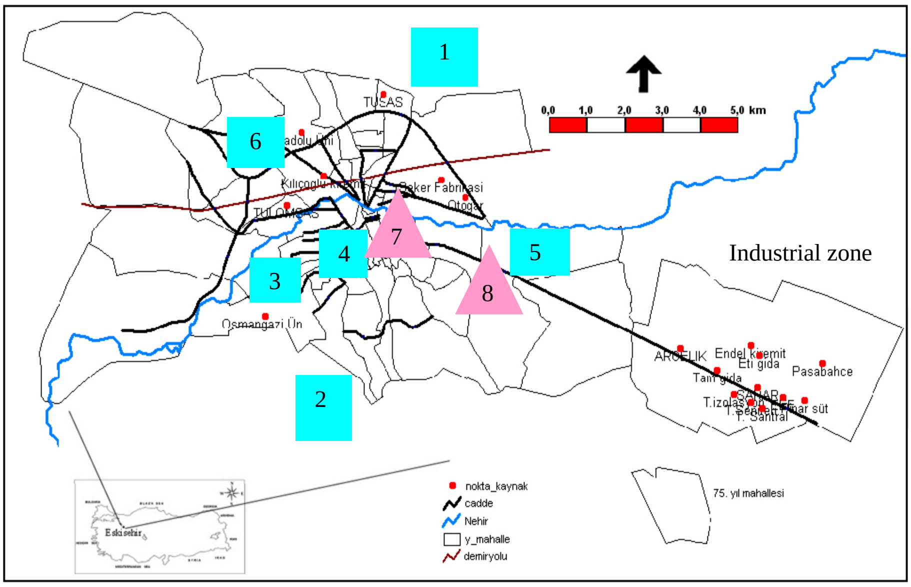

Figure 1. Study area and sampling points

NO_2 & O_3 **:** (1) Anadolu Univ.Iki Eylul Campus, (2) Universite Evleri, (3) Ataturk Boulevard (4) M. Kemal Ataturk Street,(5) Cifteler Street, (6) Tepebasi
SO_2& PM **:**(7) Koprubasi, (8) Cifteler Street

Measurements for collecting weekly average data were carried out at six sampling points for both NO_2 and ozone by using passive sampling method. Following the sampling, analyses of the samples were conducted by using spectrophotometric method for NO_2 and ion chromatographic method for ozone. Concentration data for SO_2 and PM were gathered from national ambient air monitoring network (State Institute of Statistics, SIS).

Observed pollutant concentrations were compared with Turkish and other international air quality standards. The relationship between NO_2 and ozone concentrations was determined by sampling these two pollutants at the same point and during same period. By using the concentration data particularly for ozone, the relationship between atmospheric concentrations and some meteorological parameters (temperature, wind etc.) were also determined.

3. RESULTS AND DISCUSSION

Figure 2 presents annual emissions of the pollutants and their source contributions in percentages for Eskisehir.

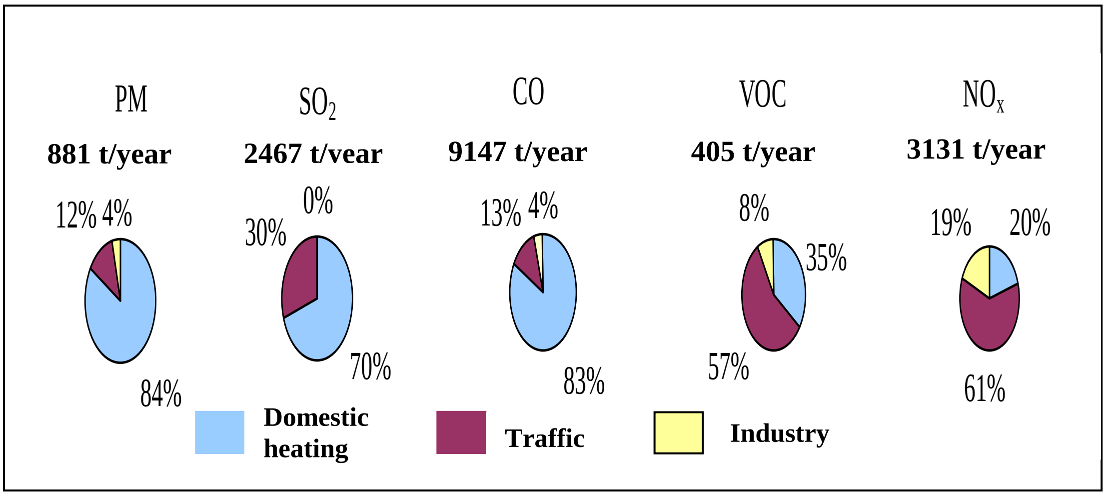

Figure 2. Emissions and sources of ambient air pollutants for Eskisehir

Annual PM and SO_2 trends between 1992-2001 for Eskisehir are indicated in Figure 3. Figure 4 shows monthly PM and SO_2 concentrations for 2002.

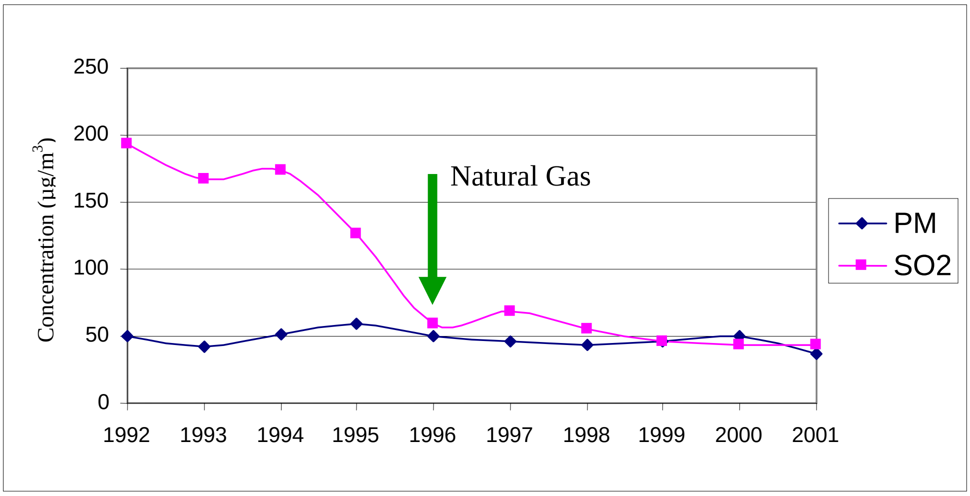

Figure 3. SO_2 and PM trends for the period 1992-2001

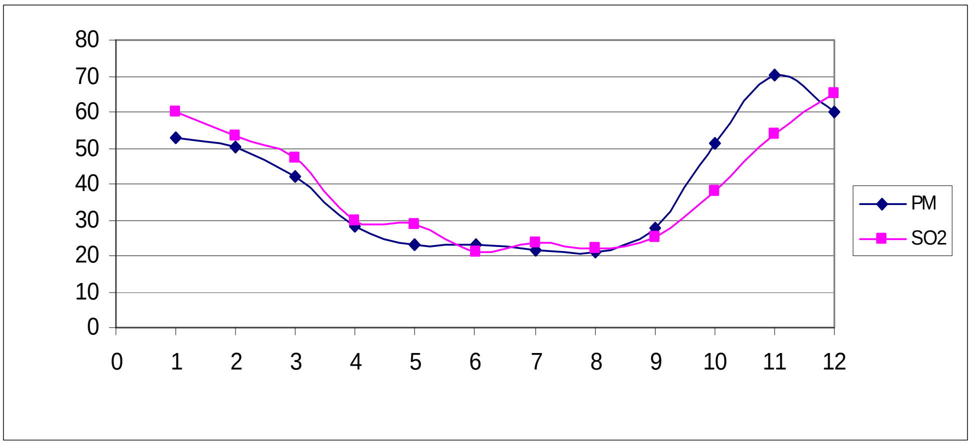

Figure 4. Monthly variations in PM and SO_2 concentrations in 2002

Figure 5 and Figure 6 show the variation in the monthly average NO_2 and ozone concentrations, respectively, at 6 sampling points for the years 2004 and 2005.

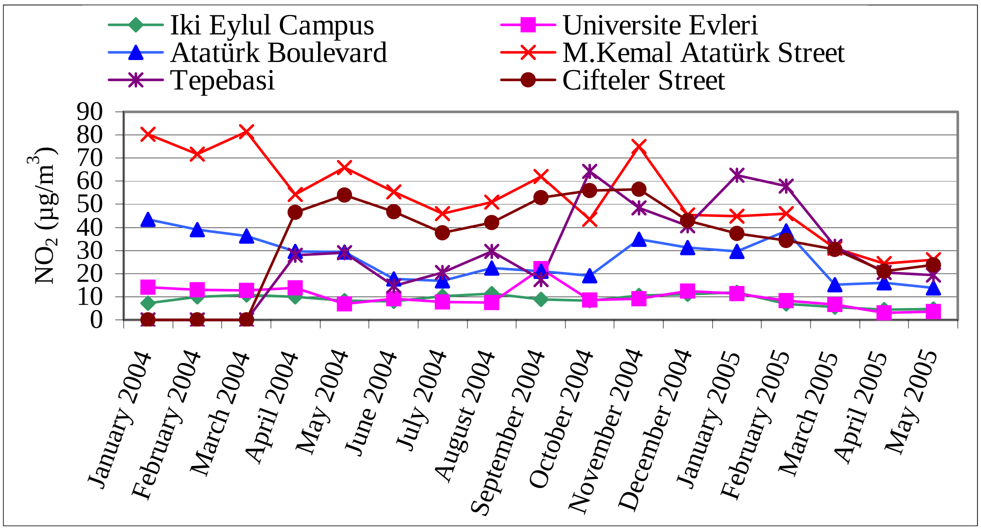

Figure 5. Monthly NO_2 averages for the period 2004-2005

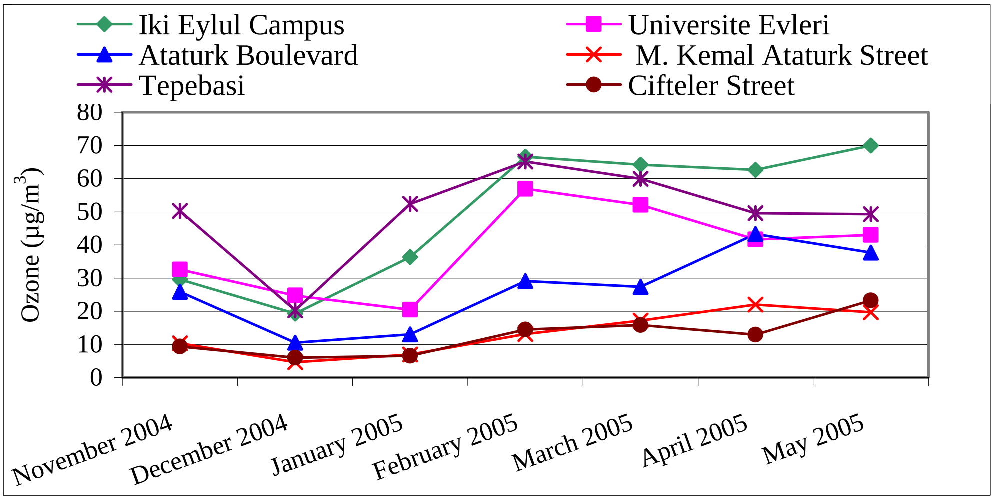

Figure 6. Monthly ozone averages for the period 2004-2005

Monitored data are being compared for the year 2004 with the national and international regulation standards in Table 1.

Table 1. Comparison of the data for SO_2, NO_2, O_3 and PM during 2004 with the national and international regulations in units of µg/m^3

Pollutant	Monitored data	Turkish Limits		WHO guidelines	EC regulations	EPA regulations
		Short term	Long term			
SO_2	51	400	150	125(24 h) 50(annual)	125(24 h) 50 (long-term)	365(24 h) 80(annual)
NO_2	32.66*	300	100	200(1 h) 40(annual)	50 (long-term)	100 (annual)
O_3	147**	240(1 h)	-	120(8 h)	-	235(1 h) 157(8 h)
PM_{10}	38	300	150	-	80(annual)	50(annual) 150(24 h)

*This data represents annual average value (2004) measured in the six sampling points
** Maximum hourly ozone concentration measured between April & June 2005

Figure 7 shows a typical relationship between NO_2 and ozone concentrations recorded at Anadolu University Iki Eylul Campus. Correlation between NO_2 and ozone concentrations is indicated in Figure 8. As expected, there is a reverse relationship between the two pollutant levels. When NO_2 concentrations are high (especially in the city centre), ozone levels are prevailing at low levels and when ozone concentrations are high (especially far away from the city centre), NO_2 levels are found low.

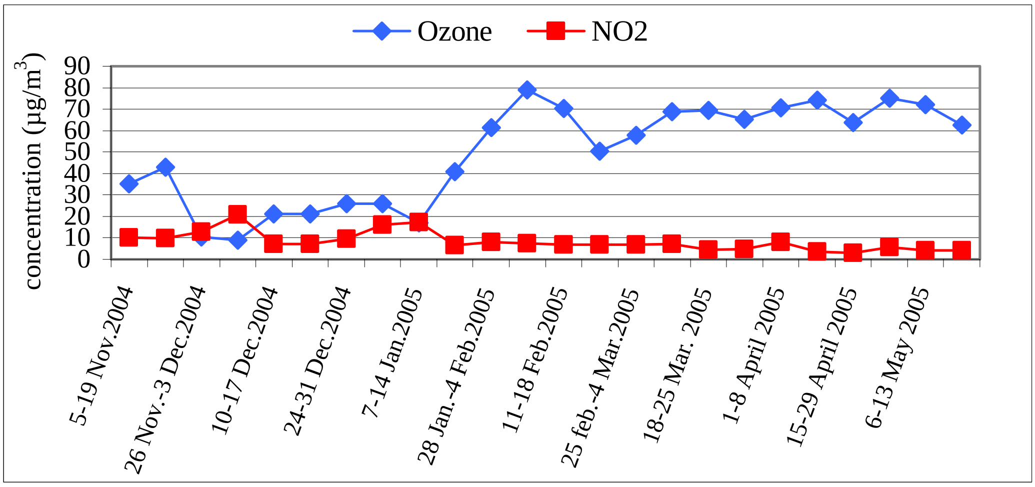

Figure 7. Relationship between NO_2 and ozone at Iki Eylul Campus

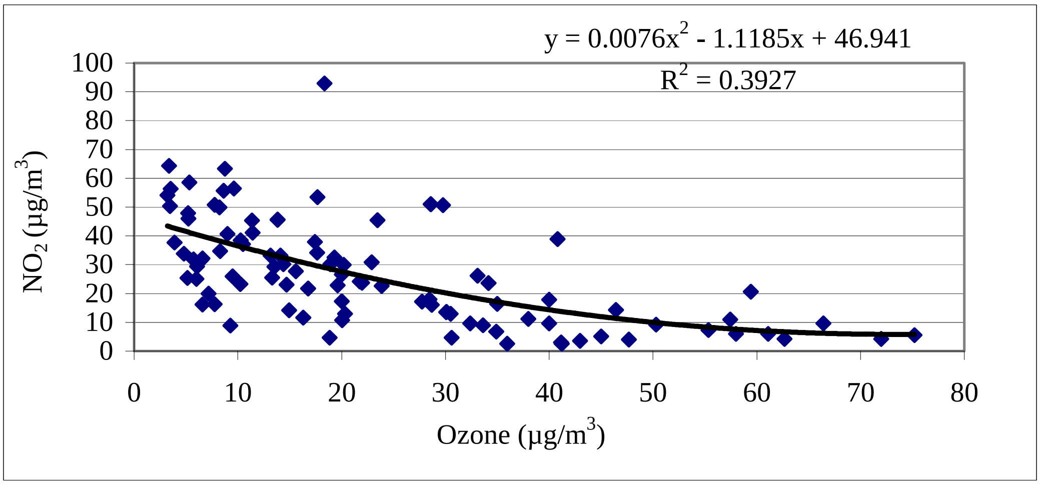

Figure 8. Correlation between atmospheric NO_2 & ozone concentrations in Eskisehir

Figure 9 indicates the changes in ozone values during a typical day for winter (January) and summer (June) seasons and, the temperatures given in Figures 9a and 9b belong to same hours. As is well known, ozone season starts in April. Figure 10 indicates maximum daily ozone concentrations during April 2005 and maximum values varied between 96-140 µg/m^3. Maximum ozone concentrations which were lower in previous months in winter season increased up to 155 µg/m^3 in June. As is expected, this value may increase to a much higher level during summer season.

4. CONCLUSION

In this study, the levels of SO_2, PM, NO_2 and O_3 were discussed for the identification of air quality in Eskisehir. Appearently, domestic heating is responsible for SO_2, PM and CO pollution, while traffic is responsible for NO_x and VOC pollution. Industry is the less important source for urban air pollution in Eskisehir.

At the start of 2000s, Eskisehir community started using natural gas in their fuel-mixes for residential heating and industrial productions. Since then, there has been a significant decrease in SO_2 from 200-250 µg/m^3 to below 50 µg/m^3 and in PM from 140-150 µg/m^3 to below 40 µg/m^3. For the year 2004, average concentration values for SO_2 and PM were 51 and 38 µg/m^3, respectively. Monthly average NO_2 and O_3 concentrations were found to vary between 3-81 µg/m^3 and 5-70 µg/m^3, respectively.

The percentage of population exposed to NO_2 concentrations at levels between 60-100 µg/m^3 is 24 % in Western Countries, 15 % in Middle and East European Countries and 18 % as the world average. This study indicated that 29 % of Eskisehir's population was exposed to high NO_2 levels in 2004. But, since the railway system has started for public transportation in the city, at the end of 2004, NO_2 concentration levels, especially in the city centre, have decreased by an average ratio of 45 %.

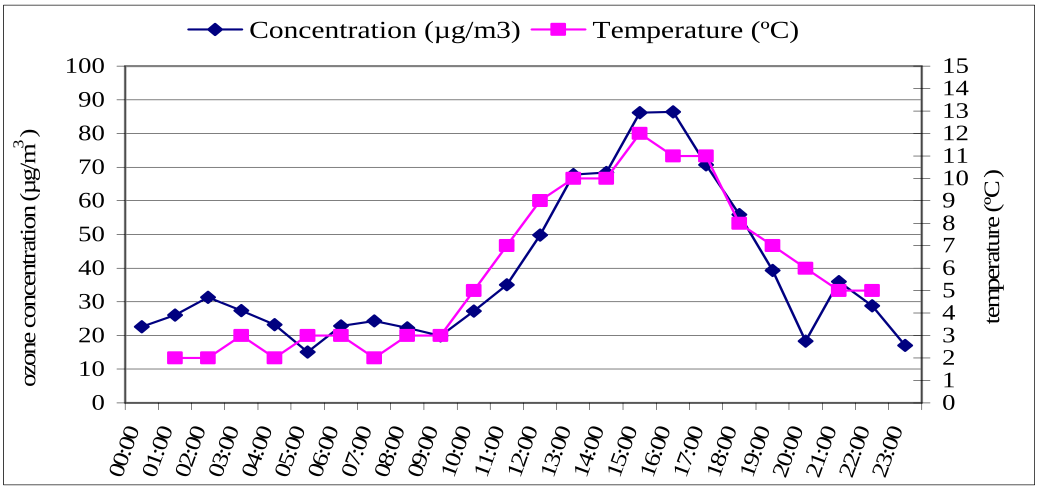

Figure 9.a) Hourly ozone concentration and temperature values corresponding to 01.01.2005

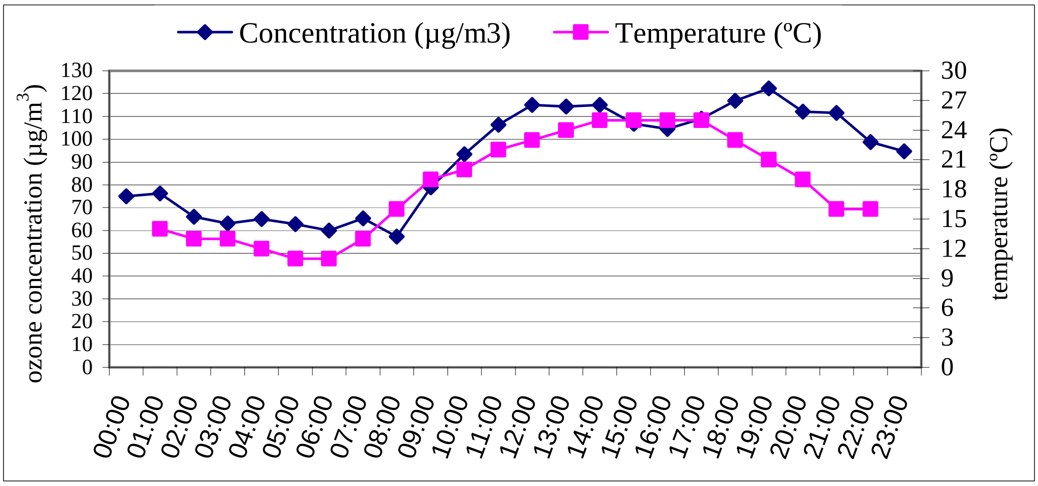

Figure 9.b) Hourly ozone concentration and temperature values corresponding to 13.06.2005

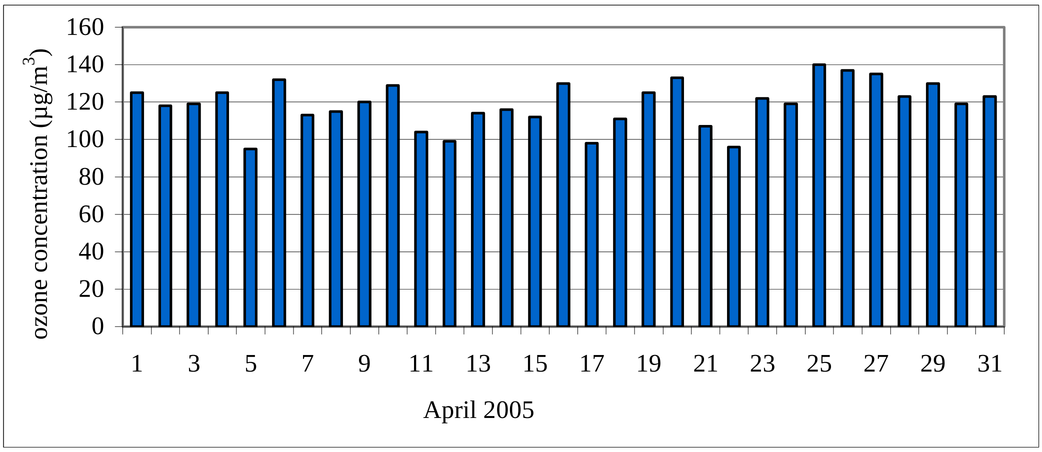

Figure 10. Daily maximum ozone concentrations at the beginning of ozone season (April 2005)

Hourly changes in the O_3 concentrations were monitored at a single sampling point in winter and summer seasons by automatic ozone analyser. The levels in winter were lower than that in summer season. Regarding the effects of meteorological parameters investigated, an increase was observed in the concentration levels with the increase in temperature. For summer season, two peaks are noticeable. Morning peaks, prevailing during morning to noon hours, occurs when calm or northeast wind direction is dominant. However, afternoon peaks correspond to northwest-west wind direction. When this profile is compared with the ozone concentration, it can be said that till noon hours local effects can be dominant but in the afternoon, pollutant transport by the northwest-west direction seems dominant.

Reverse relationship exists between NO_2 and O_3 concentrations. In the city centre, NO_2 levels were high while O_3 levels were low and in the regions far away from the city centre, O_3 levels were high while NO_2 levels were low.

For the year 2004, NO_2, O_3 and PM levels never exceeded national and international limit values. But, SO_2 concentration (51 µg/m^3) not exceeding the current Turkish limit value (150 µg/m^3), was slightly above the WHO and EC limit value of 50 µg/m^3.

When the measurement results are compared against those from other national cities such as Istanbul and Ankara, it can be noted that average annual NO_2 concentration prevails at 33 µg/m^3 level in Eskisehir, while it is around 40 µg/m^3 in Ankara, and monthly NO_2 concentration is 60-80 µg/m^3 in Istanbul. Winter season O_3 value for Eskisehir is around 30 µg/m^3 and 20 µg/m^3 in Ankara. The levels of NO_2 and O_3 concentrations in those cities are more or less the same.

5. ACKNOWLEDGEMENTS

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