Asian Journal of Chemistry Vol. 19, No. 3 (2007), 1703-1708

Relationship Between Wintertime Atmospheric Particulate Matter and Meteorological Conditions in Diyarbakir (Turkey)

SAIT ERDOGAN, AKIN BAYSAL, OSMAN AKBA, MELEK MERDIVAN† and CANDAN HAMAMCI*
Department of Chemistry, Science and Arts Faculty, Dicle University
21280 Diyarbakir, Turkey
Fax: (90)(412)2488389; E-mail: candanh@dicle.edu.tr

This paper reported the changes in pollution concentration in Diyarbakir, Southeast region of Turkey in the winter half of the year from 1986 to 2004 and describes the relationships with meteorology. Particulate matter $(PM)_{10}$ is used as the example pollutant. Decrease in air pollution since 1994 was observed due to air pollution control and management strategies. The winters of 1988-1989, 1989-1990, 1990-1991, 1991-1992 and 1992-1993 were especially harsh in the number of pollution episodes.Linear regression results show that relative humidity and temperature provide the relationship with PM_{10} concentration.

Key Words: Diyarbakir, Particulate matter, Air pollution, Climate, Weather, Southeast Anatolia, Turkey.

INTRODUCTION

The process of identification of pollutants to their sources is an important step in air quality management. Diyarbakir, is the greatest settlement center in the Southeast Anatolia of Turkey, located near by Dicle (Tigris) river. The study examines particulate matter (PM) in Diyarbakir, Southeast Anatolia, Turkey. Particulate matter is a potentially harmful air pollutant. High levels of particulate matter are associated with adverse health effects, ecosystem damage and degraded visibility[1,2].

Air quality in the southeast Anatolia is influenced by a wide variety of factors as anthropogenic and biogenic. Anthropogenic sources of pollutants include emissions from automobiles, industry, wood or coal burning stoves and fireplaces[3]. Wildfires, airborne dust and soil particles and hydrocarbons emitted by vegetation are examples of biogenic influences[3-5]. Meteorological conditions appear to have the greatest impact on daily variations in air quality[6,7]. The linkage between weather conditions and pollutant levels can obscure the effects of changing emission levels over time.

†Department of Chemistry, Science and Arts Faculty, Dokuz Eylul University, Izmir,Turkey.

Wind speed, mixing height and relative humidity are the meteorological variables believed to exert the most influence on particulate concentrations[8]. While high wind speeds can increase ventilation, they are normally correlated with high PM_{10} concentrations because they allow the resuspension of particles from the ground, as well as long range transport of particulates between regions[8-13]. High PM_{10} concentrations are normally associated with dry conditions due to increased potential for suspension of dust, soil and other particles.

There are many asphaltite deposits around the southeast Anatolia of Turkey. They have been used for home heating, adding to local air pollution in the towns and cities of southeast Anatolia region. However, these asphaltites tend to be of poor quality as fuels due to the relatively high ash, sulfur and moisture contents[1,14-16]. Temperature inversions can cause serious pollution problems, not because they represent a source of pollution, but because they cause pollutants to accumulate in the lower atmosphere instead of dispersing[17-19].

The objective of this study is to investigate some relevant aspects, such as the levels of atmospheric particulate matter pollution and its sources on the basis of systematic measurements in Diyarbakir. For that reason the characteristics of meteorological and air quality of Diyarbakir city were presented and then the relationship of PM_{10} concentrations with the combination of meteorological parameters for 1986-2004 winter seasons was investigated.

EXPERIMENTAL

The particular matter and meteorological data for Diyarbakir were assessed for the winter half of the year from 1986 to 2004, depending on the data availability. Meteorological data were obtained from the National Climatic Data center. Meteorological variables of interest that were analyzed in this study monthly average wind speed, wind direction, temperature and relative humidity. The meteorological variables chosen for use in this study were based on data availability. PM_{10} dataset collected in national air monitoring station in Diyarbakir from 1986 to 2004. As a basis for comparison, winter season limit of Turkish Air Quality Protection Regulation for particulate matter can be used. For a 30 min period, the standard is 300 μg m^{-3} and for the daily average is 200 μg m^{-3}.

RESULTS AND DISCUSSION

PM_{10} (particulate matter less than 10 μm in size) concentration distributions have been investigated in order to assess air pollution in Diyarbakir during the winter season in which the concentration of PM_{10} had reached formidably high levels due to the consumption of low quality fossil fuels (mainly asphaltite) for residential heating. According to the Air Quality

Protection Regulation short term limit (STL) value is the maximum daily average value or is the value should not exceed 95% of all monitoring values are evaluated in descending or ascending order statistically. The STL value is 300 μg/m^3 for PM_{10} in Turkey. Long Term Limit (LTL) value is the arithmetic mean of the monitoring results which the specified values in the Air Quality Protection Regulation should not be exceeded LTL of particulate matter (10 microns or less) in one year is 150 μg/m^3. LTL value in winter season is 200 μm/m^3 for PM_{10}, in Turkey. To establish overall trends in particulate matter concentrations, monthly averages were graphed in Fig.1. There is a decrease after 1994 in monthly average particulate matter. The data in Fig.1 also show differences in pollution levels between months. Within the data set, the winters of 1989 to 1993 stand out as a particularly harsh years in terms of pollution. December, January and February are particularly worse months for high pollution concentrations. A decrease in particulate matter concentrations has been observed since the winter of 1994. The data in Fig. 1 also show differences in pollution between months. High pollution levels were much more frequent in December-February whereas high PM_{10} episodes during November, March and April occurred only occasionally. According to the State Institute of Statistics, with 276 μg m^{-3} particulate matter value in winter season in 1992-1993, Diyarbakir was the highest particulate contaminated city in Turkey[13]. Especially, long term limit value is not exceeded after the winter season of 1996-1997. This can be explained by the consumption of more high-quality fossil fuels.

Table-1 presents the corresponding meteorology taken at Diyarbakir National Climatic Data center. Ambient air temperature (T in ºC), relative humidity (RH in%), wind speed (WS in ms^{-1}) and wind direction are listed here. Wind is one of the most important vehicles in the distribution, transport and dispersion of air contaminants. The velocity of the wind determines the travel time of a particulate to a receptor and also the dispersion rate of air contaminants in a plume is inversely proportional to wind velocity. Range of meteorological conditions in Diyarbakir, winters from 1991 to 2004, are shown in Table-1. Wind direction provides little useful information. A combination of relative humidity in the range of 60-75%, temperature lower than 0ºC and wind speeds less than 2.8 m s^{-1} are consistently to cause severe pollution conditions in the months of December, January and February.

The relationship between wintertime PM_{10} and meteorological parameters was investigated by linear regression analysis. Table-2 gives the correlation between monthly average PM_{10} concentrations and meteorological parameters in Diyarbakir, winters from 1986 to 2004. Relative humidity and temperature show relationship with PM_{10} concentrations.

Correlations between relative humidity and PM_{10} concentrations are positive and high for the all winter seasons except 1995-1996 and 1997-1998. Temperature also shows strong correlations but negatively for analyzed all winter seasons. The correlation with wind direction is not valuable. For wind speed, it can be suggested that correlation is not much effective. Moderately negative correlation is seen in the winters of 1992-1993, 1999-2000, 2000-2001 and 2003-2004.

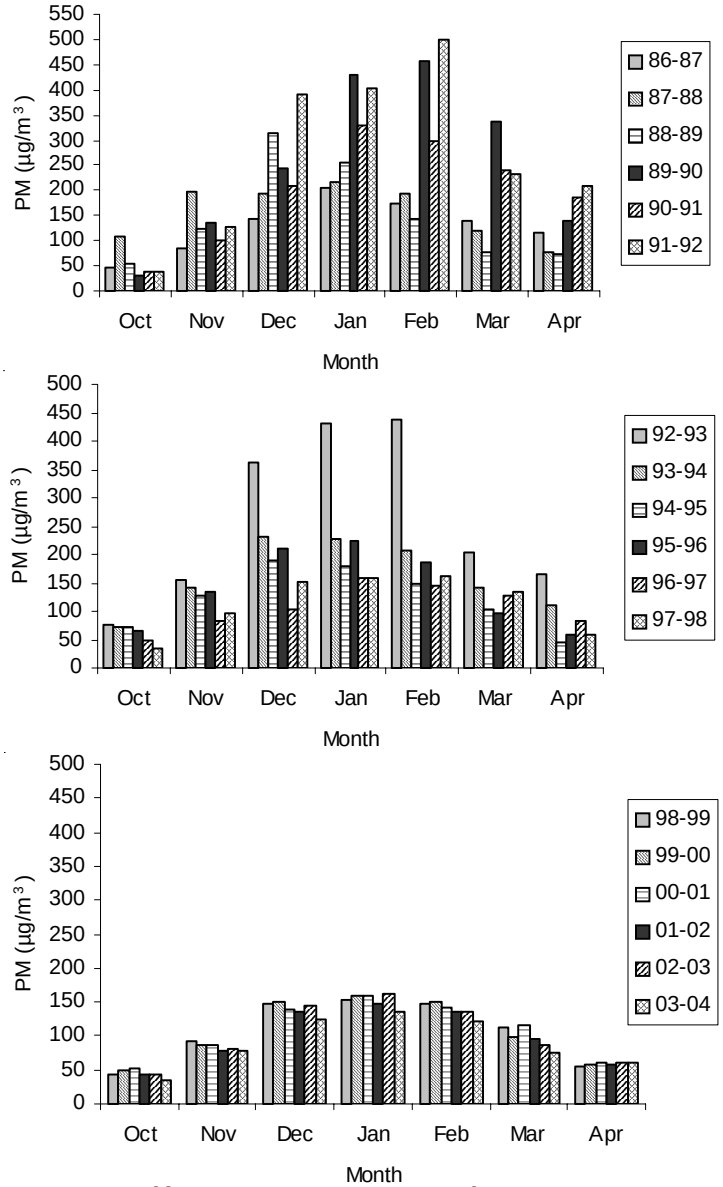

Fig. 1. Monthly average PM_{10} concentrations by winter season in Diyarbakir, Southeast region of Turkey

TABLE-1
RANGE OF METEOROLOGICAL CONDITIONS IN DIYARBAKIR, WINTERS FROM 1986 TO 2004

Winters Nov.-Mar.	Wind speed (m/s)	Wind direction	Temperature (ºC)	Relative humidity (%)
1991-1992	1.4-2.8	NNW-NW	-2.4-9.6	56-74
1992-1993	1.5-3.2	NNW-N	-0.7-7.4	54-76
1993-1994	1.4-3.2	NW-WNW	4.2-9.3	74-83
1994-1995	1.5-2.9	NNW	1.4-9.5	74-84
1995-1996	1.4-3.5	NW-ESE	2.3-8.0	68-81
1996-1997	1.4-3.4	NNW-SSW	0.6-9.4	66-81
1997-1998	1.5-3.2	NNW-N	0.5-9.1	58-79
1998-1999	1.5-2.4	NNW	4.5-12.5	59-79
1999-2000	1.5-2.4	NNW	1.3-9.8	41-74
2000-2001	0.8-2.0	NW-WNW	4.0-11.4	54-78
2001-2002	1.8-2.6	W-ENE	0.7-9.4	58-82
2002-2003	1.5-2.8	WNW-W	0.0-10.2	55-78
2003-2004	1.6-2.6	WNW	2.7-9.6	54-82

TABLE-2
CORRELATION BETWEEN MONTHLY AVERAGE PM_{10} CONCENTRATIONS AND METEOROLOGICAL PARAMETERS IN DIYARBAKIR

Winters Nov.-Mar.	Relative humidity	Wind direction	Wind speed	Temperature (ºC)
1991-1992	0.41	-0.11	0.03	-0.93
1992-1993	0.82	-0.19	-0.44	-0.92
1993-1994	0.80	-	0.21	-0.91
1994-1995	0.70	-	-0.25	-0.90
1995-1996	0.29	0.30	-0.20	-0.93
1996-1997	0.54	-0.57	0.04	-0.95
1997-1998	0.18	-0.38	0.13	-0.97
1998-1999	0.91	-	-0.42	-0.98
1999-2000	0.78	-	-0.46	-0.97
2000-2001	0.73	-0.14	-0.41	-0.94
2001-2002	0.43	-0.22	0.31	-0.92
2002-2003	0.85	-0.57	-0.23	-0.92
2003-2004	0.96	-	-0.52	-0.97

Temperature inversions can cause serious pollution problems due to the accumulation of pollutants in the lower atmosphere instead of dispersing. Temperature inversions combine with other factors such as wind frequency, wind velocity and terrain irregularities to increase the potential for air pollution problems in some regions of the southeast Anatolia of Turkey. Surrounding mountains, hills, ramparts or even buildings in Diyarbakir slow down and break up winds and lessen the horizontal

movement of air[14]. Facets of the local meteorology in Diyarbakir, which include low wind spreeds and surface-based inversions, compound the situation by inhibiting the dispersion of local emissions[17].

The population of Diyarbakir is over a million and the most of the population is young and there is unplanned growing in this city. Increased immigration from less developed regions and villages of country since 1990s, has been causing a rapid increase in the population that leads to uncontrolled settlement[20]. The increase in the urban population, the concentration of the fuels used for heating, changes in the form and size of buildings and density of city traffic have become the major factors causing air pollution in these areas.

The sources of emission become regional source instead of the feature of the point source, an account of the low capacity of air pollution control are being difficult. A decrease is particularly noticeable after 1996, when air pollution control and management strategies adopted by government and use of considerably clean fuel, increase in conscience of people. This research indicated that increased usage of electricity and high-quality coal in domestic areas significantly improved air quality[14-21]. An alternative may be using renewable energy sources, mainly solar energy in its direct and indirect forms.

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(*Received*: 25 January 2006; *Accepted*: 30 October 2006) AJC-5168