AIR POLLUTION PROBLEM IN ISTANBUL, TURKEY AND STRATEGICAL EFFORTS IN AIR QUALITY MANAGEMENT

Aysel T.ATIMTAY[†] and Selahattin INCECIK[‡]
[†] Middle East Technical University, Department of Environmental Engineering, 06531, Ankara, Turkey (aatimtay@metu.edu.tr)
[‡]Istanbul Technical University, Department of Meteorology, Maslak 80626, Istanbul, Turkey (incecik@itu.edu.tr)

ABSTRACT

Istanbul is one of the world's largest metropolitan areas, containing nearly 13 million inhabitants. The city (41^{o}N, 29^{o}E) is located on both continents, Asia and Europe. The Bosphorous Strait lies between the European and Asian sides of the city. Istanbul is the economical, cultural, and financial center of Turkey.
Pollution sources are domestic heating, traffic and industry in the city. There are about 1.7 million registered cars. Recently, motor vehicles are the major source of a number of air pollutants, like CO, NOx, HCs, lead and VOCs depending on increasing number of car.
The air quality of Istanbul has been a major concern since the early 1980s. The city has experienced severe air pollution problems in 1980s. SO_2 concentrations, first time, exceeded 3000 μg/m^3 on 18th January, 2001 under stagnant air conditions. Usage of poor quality lignite was banned in late 1993. The fuel switching from coal to the natural gas has gradually improved the air quality. Today, SO_2 and TSP levels are below the national air quality standards. However, a new air pollution type has appeared in the city that is the "photochemical pollution". Surface ozone concentration is increasing in the city depending on increasing number of cars that use mostly gasoline and poor dispersion conditions.

This paper will give an overview on the air pollution history of Istanbul and how this pollution problem has been tackled throughout years by applying various strategies. The difference between the air quality of Istanbul today and ten years ago will be highlighted.

Keywords: Air pollution in Istanbul, Air quality management, History of applied strategies

INTRODUCTION

Istanbul is one of the world's largest metropolitan areas, containing nearly 13 million inhabitants. It is located in a basin of approximately 5700 km^2 area as shown in Fig.1. The city is located at 41^{o}N, 29^{o}E latitudes and lies on both continents, Asia and Europe. The Bosphorous Straight, about 1.5 km wide and 56 km long, divides the city into two parts in the north-south direction. The European side is on the west and the Asian side is on the east of Bosphorous Straight. More than 60% of the population lives on the European side and the rest lives on the Asian side of the city. Istanbul is the cultural, economical and financial center of Turkey.

During the last 30 years the rate of industrialization of the country has increased every year and based on this industrialization Turkey has experienced very rapid urbanization. Especially the cities on the west part of the country have developed and their population has increased at a very fast rate due to the influx of population from the other cities. Istanbul was

the city that took the largest immigration of people from Anatolian towns. Two thirds of the population growth of Istanbul is estimated to be due to this immigration. Istanbul is the most populated city in Turkey. The change of population of Istanbul with respect to years is shown in Fig.2. As can be seen from the figure, the population has been doubled in 20 years between 1980 and 2000.

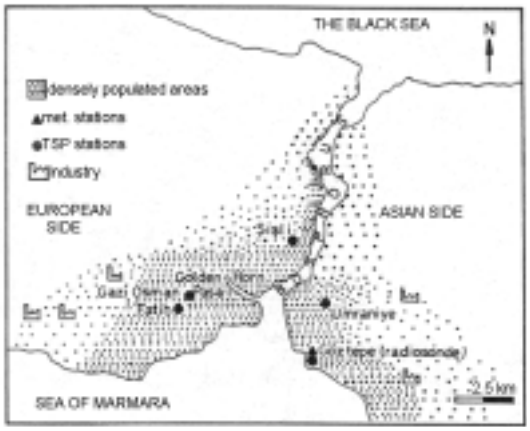


Figure 1. Location of Istanbul

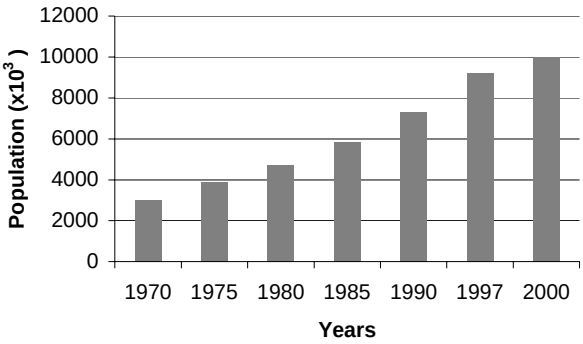


Figure 2. Population of Istanbul

Climate and Topography in Istanbul

The climate of Istanbul is generally Mediterranean with the Black Sea being warm in summer and cool in winter. The pressure patterns over the Mediterranean Sea and surrounding land area is known to be controlled by the Eurasiatic high-pressure axis, the subtropical high and its extension over North Africa, and the belt of low pressure over the Mediterranean Sea. The daily mean temperature in winter is 6.3^{o}C, and 22.4^{o}C in summer. The coldest month is January and the warmest month is August. The usual minimum temperature in winter is 3.4^{o}C and the maximum temperature in summer is 27.7^{o}C. The annual mean rainfall is about 700 mm and the annual mean relative humidity is 75%. Insolation in the city is usually strong. Daily average values are on the order of 6400 W/m^2 in summer and 1200 W/m^2 in winter (Topcu et al., 1995). The predominant wind directions are N/NE and SSW/SW in the city.

History of Air Pollution in Istanbul

The rapid urbanization of the city has brought many problems together. Not only the rapid increase of the population due to influx of the people from other cities, but also the establishment of many small and medium sized industries around Istanbul, caused many environmental problems, like air pollution, water pollution, solid waste and noise problem. The industry as well as the inhabitants mostly burned fuel oil to produce energy before 1970's. However, with the energy crises of 1970's and tremendous increase in the oil prices, the fuel was switched from oil to coal. The coal used was mostly local Turkish lignites and these lignites are high in sulfur and ash content, but low in calorific value. The combustion of coal in an uncontrolled manner produced a lot of SO_2 and particulate emissions. In those days there was no Air Pollution Control Regulation available and since there was not any pollution

monitoring network or single stations, the level of pollution concentrations is unknown. The Environmental Law was passed through the Parliament in 1983 and the Air Pollution Control Regulation was issued in 1986.

Dense air pollution in the city and some unofficial episodes have received wide public attention beginning in early 1980s. This problem alleviated especially in winters and there were a lot of complaints about the government for doing nothing for the solution of the problem. The main reason for the problem was use of poor quality local lignites for heating. The estimated amount of coal used in 1990 was about 6 million tons. However, the local authority (the Governor of the city) has started a very strict control program for the use of poor quality lignites in the city in mid-1994 for domestic heating. Thus, the use of lignite decreased to 0.6 million tons in 1998. Furthermore, high quality coal with less than 1% S was imported and the use of low quality lignites in the city was banned. Also, Natural Gas agreement was signed with USSR in 1984, and the usage in the city was initiated in late 1992 and gradually increased from 150 000 m^3 in 1993. Since 1993 the usage of natural gas in the city gradually increased and in 1995 about one third of the city center was using natural gas.

The industry around Istanbul has also started to switch fuels and the air pollution due to industry has also decreased.

Monitoring Network in Istanbul

The first air pollution study of Istanbul was done by Tebbens (1970). Based on this work the first attempt to establish an air pollution monitoring network was initiated in 1974 with UNEP and WHO collaboration (Mage et al., 1996). The network was designed to measure SO_2 and suspended particulate matter concentrations in the air. However, the realization of the network was delayed. A systematic monitoring network was established in 1985 with 7 stations in the city by the Ministry of Health (Hifzisihha Institute). The network provided daily SO_2 and TSP measurements. The measurements taken in 1985 showed that Istanbul has a serious air pollution problem due to domestic heating, industry and traffic. The pollution was more severe especially in the regions of densely populated settlements. For example in the southern part of the Bosphorous (Topcu et al., 2001).

In mid-1989, 10 more stations were established in the city. However, due to some technical problems some of the stations did not operate between 1993 and 1995. In this network, daily values of TSP concentrations were measured by EEL reflectometer with the reflectivity method, and SO_2 concentrations were measured with the West-Geake method. During the winters of 1993/94 and 1994/95, 15 urban stations were operating in Istanbul. Recently, the Greater Istanbul Municipality formed another air pollution monitoring network. The new network measures air pollution parameters on hourly basis. Conventional parameters like TSP and SO_2 are measured in all stations. CO, NO_x and O_3 are only measured in two stations. The new network system consists of 10 measuring sites located in residential, commercial and industrial parts of the city (Topcu et al., 2001).

TSP Concentrations in Istanbul

The average winter (December, January, February) TSP levels for the 1986-1997 periods are shown in Fig.3. Winter TSP levels have increased from 1986 to 1989 (reaching a max. of 178 $\mu g/m^3$ in 1989. TSP levels remained around 170 $\mu g/m^3$ until early 1992. The relative contribution of the TSP emission for Istanbul in 1990 out of total TSP emission was 98.6%

and came from domestic heating and industry (Ministry of Environment, 1992). Furthermore, average winter TSP levels show a decreasing trend following 1993. There are several reasons for this variation. As discussed above, poor quality lignite was replaced with imported high quality coal and natural gas. The natural gas usage started gradually in part of the city (first in the Asian side) since late 1992. Lignite was finally banned for domestic heating in mid-1994. Besides, the control of emissions from exhaust gases of cars, trucks, and busses started in the city in January 1995. Therefore a decreasing trend in TSP is seen throughout the years.

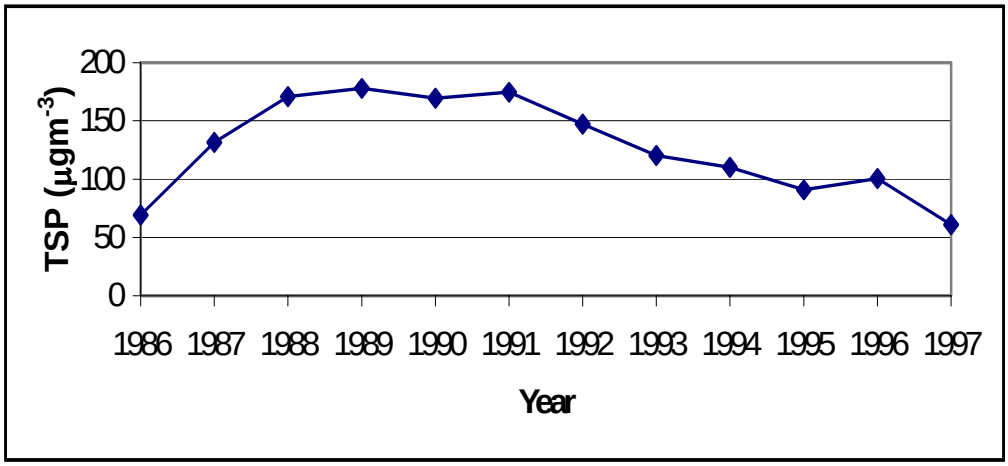


Fig. 3. Mean winter values of TSP concentration in ambient air of Istanbul (APCR, 1998)

SO_2 Concentrations in Istanbul

Annual SO_2 concentrations in Istanbul between the years 1988 and 2002 are given in Fig. 4. As can be seen from the figure, the annual average SO_2 concentration was about 175 µg/m^3 in 1988. Annual SO_2 concentrations have increased from 1988 to 1993 (reaching a max. of 220 µg/m^3 in 1992). The ambient SO_2 concentration limits given in the Turkish Air Quality Control Regulation (TAQCR, 1986) is **150 µg/m^3 for annual averages** and **400 µg/m^3 for daily averages**. It is quite obvious from the figure that the annual average values were far exceeded between the years 1988 and 1994. This was the alarming situation. As discussed above, poor quality lignite was mostly responsible for this problem. When poor quality fuel was replaced with imported high quality coal and natural gas, the SO_2 levels started to show a decreasing trend. Today the annual SO_2 concentration has gone down to about 25 µg/m^3.

As far as the unit fuel prices are concerned, the price for natural gas is the lowest among the other types of energy for 100 Kcal of energy supplied as shown in Fig. 5. Therefore, by switching from other types of energy to natural gas has also been advantageous from the cost point of view. The number of natural gas users both in residential places and in industry is given in Figures 6 and 7, respectively. The number of natural gas users has increased very fast from 1993 to 2004. Today in 2004 there are 2,500,000 users in residential places and about 550 users in industry (IGDAS, 2004).

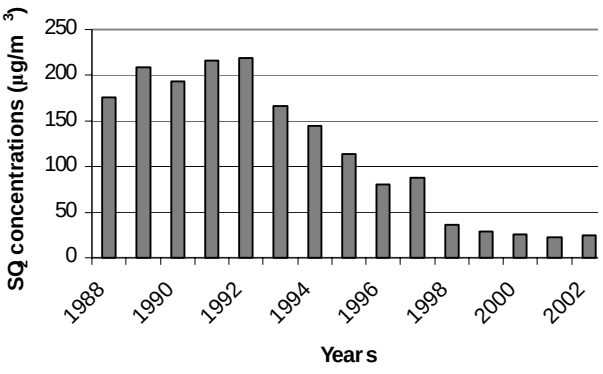


Fig. 4. SO_2 concentrations in Istanbul

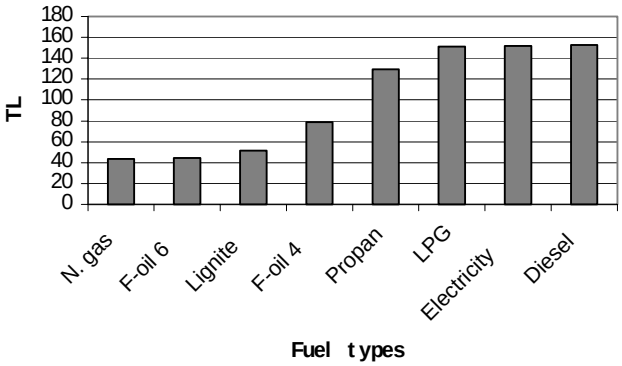


Fig. 5. Comparison of fuel prices for 100 Kcal (Dec. 2002)

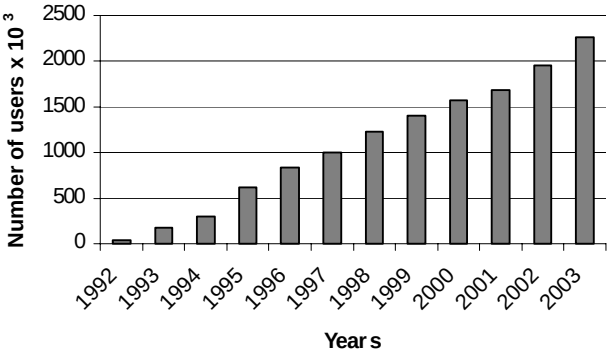


Fig. 6. Number of domestic N.G. users

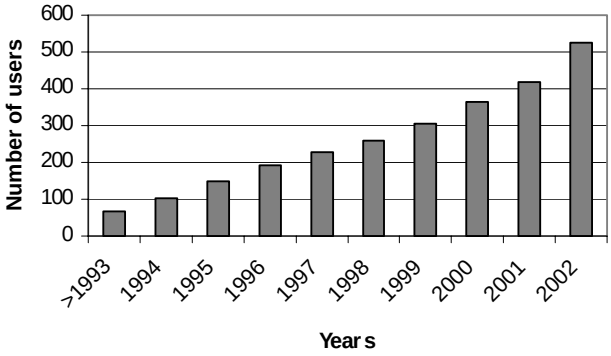
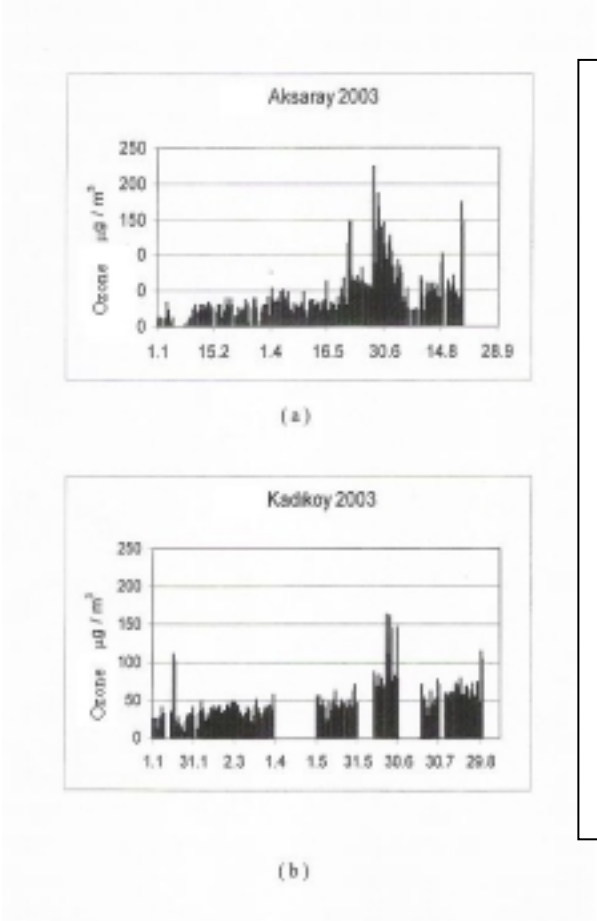


Fig. 7. Number of N.G. users in industry

Ozone Concentration in Istanbul

Although TSP and SO_2 problems seem to be solved in Istanbul due to fuels used mostly for heating purposes, there is a new problem emerging today due to traffic pollution as it is well known in all the big cities. There are about 1.7 million motor vehicles registered in Istanbul. These vehicles use of course either gasoline or diesel fuel. For the last five years there are cars, especially taxis operating with LPG or liquefied natural gas (LNG). Due to the rapid increase in the number of cars in the city, the emissions have increased drastically due to traffic in the city. Therefore, the main air pollution problem has decreased in wintertime due to domestic heating. However, the pollution due to traffic is a pollution year around and especially in summer time the photochemical pollution has started to occur in Istanbul. The ozone concentrations have not reached the limit value yet. However, there are some alarming situations on some days due to meteorological conditions.

The graphs in Figures 8 (a) and (b) show some daily ozone concentrations in two locations of the city. The first location is called Aksaray which is on the European side of the city. The second location is called Kadikoy and it is on the Asian side of the city. As it was mentioned before the density of the population is much higher on the European side. On the abscissa, the days that maximum ozone concentrations measured has been marked. The ordinate gives the maximum ozone concentrations in $\mu g/m^3$.



The concentrations shown on these figures are the highest ozone concentrations measured in the city since 1999. It is easy to note that the concentrations are higher on the European side than on the Asian side, because more than 60% of the total population lives on the European side of the city. It is interesting to note that on and about the 30th of June, 2003, ozone concentration has reached to 200-230 $\mu g/m^3$ in Aksaray. On the same dates the concentration on the Asian side has been about 150 $\mu g/m^3$. Also, high concentrations of ozone have been measured around 60-70 $\mu g/m^3$ in Aksaray on 14 August, 2003. However, there is a day where the concentration has been 170 $\mu g/m^3$. On the Asian side, in July and August ozone concentrations of 50-60 $\mu g/m^3$ have been recorded.

Fig. 8. Ozone concentrations measured in Aksaray and Kadikoy in 2003 (Incecik, 2004)

Strategical Efforts Made in Istanbul for Air Quality Management

- The local authority (the Governor of the city) has started a very strict control program for the use of poor quality lignites in domestic heating.
- The use of lignites was banned within the boundaries of the Istanbul Municiality.
- Natural Gas agreement was signed with the former USSR in 1984 and several other agreements followed this. Istanbul Gas Distribution Industry and Commerce Corporation **(IGDAŞ)** was founded in 1986 and started operation in 1989, in order (a) to establish infrastructure for natural gas, (b) to purchase and sale related material for natural gas, (c) to distribute the natural gas.

IGDAŞ started to distribute natural gas on January 1992, first on the Asian side of the city. Later on the distribution of the gas was expanded. Today 80% of the total gas imported is used in domestic heating and 20% is used in industry. IGDAŞ was awarded with TÜV ISO 9001-2000 quality certificate on March 2002.

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