Observations, data analysis and modelling studies on air pollution in Turkey

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Abstract

In this study, some of the work that was carried out in Turkey on air pollution is assessed. First of all, legal arrangements made on air pollution and control of air pollution are reviewed. The observations made on air pollution are classified into four major categories. The studies, in which emissions data obtained from the observations are analysed, examined splitting them up into three groups. It is realised that the studies on modelling of air pollution, although extensive, are rather insufficient.

1 Introduction

The problem of air pollution and control of it in Turkey, first time dealt with the "General Public Health Law" in 1930's and this law nearly fifty year had been applied. In 1983, a new "Environmental Law" put into practice because of the matter of air pollution take part in the above mentioned law was so far away to satisfy requirements of rapidly developing Turkey. In addition to this law, "Air Quality Protection Regulations(AQPR)" also put into practice in 1986. The regulations, which are still in use, approach the solution of air pollution problem with control of emissions.

Toward end of 1970's, air pollution reached to harmful levels for human health in some big cities such as Ankara, İstanbul, Bursa, etc. There upon, Turkish researchers concentrated their studies on the subject of prevention of air pollution in Turkey. In this work, studies done on the observations of air pollution, analysis and modelling of observation data will be assessed.

2 Studies on Air Pollution

In the beginning, effects of air pollution were being felt only big cities. Turkish Mechanical Engineer's Association also determined name of a congress that is held by themselves in 1969 as "Congress of Cleaning of Air in Big Cities". These initial studies generally were emphasizing the importance of the subject and defining the concept in generic. But, most of the time these were describing the studies done outside of Turkey. In 1977, a few researcher considered air pollution problem in the Congress of First National Heat Science and Technique held by Turkish Society for Heat Science and Technique. In 1979, the society tried to attract the attention of researchers and managers on to air pollution problem with holding a seminar on alternative energy sources and environmental problems. Intensifying of air pollution specially in Ankara, and Istanbul caused to increase of air pollution studies. As a result of this, the necessity to hold symposiums related with air pollution came out in the begining of 1990's.

2.1 Observations

Generally, observations made on the subject of air pollution in Turkey can be split into four major group;

i. measurements made in the atmospheric air on the residential areas,
ii. measurements of motor vehicle's exhaust gas emissions,
iii measurements of smoke emitted by chimneys of heating plants,
iv. measurements of pollutants discharged into atmosphere by the industrial plants.

Measurements of air pollution in the atmosphere of residential areas usually made by fixed measurement stations which connected to Ministry of Health and Ministry of Environment. However, in some big cities such as Ankara, and Istanbul, both fixed and mobile stations are used. In the measurements, daily and annual means are taken into account, and these means are reported to National Statistical Institute. The results are used both for studies of preventing air pollution in the residential areas and they are also presented in monthly published bulletins in order to help researchers who study on the subject.

Müezzinoğlu[1] reported that SO_2 and PM emissions values measured in urban areas always exceed the long term limits of the RPAQ at seven months of the year(Figure 1). This shows that air pollution in Turkey has an important place among the environmental problems.

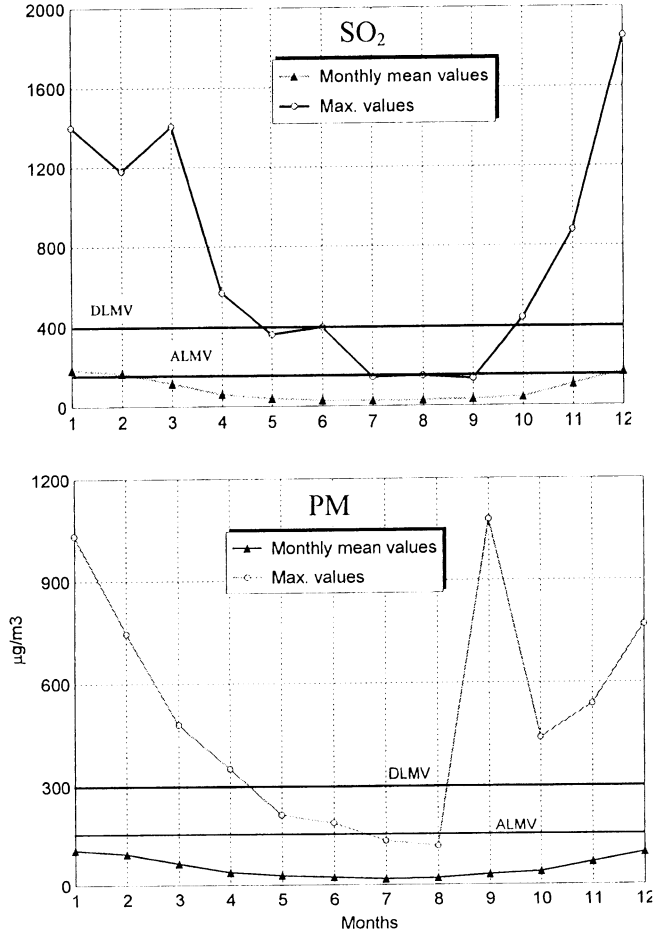

Figure 1:Monthly mean values of SO_2 and PM concentrations for the year 1994 in Turkey. (DLMV=Daily Limited Mean Value, ALMV=Annuel Limited Mean Value (Adapted from Ref. 1)).

Measurements of exhaust gas emissions of motor vehicles are made periodically (annually) either in fixed stations which connected to Ministry of Environment or fixed stations in some universities. All motor vehicles have to pass an exhaust emission test and have an exhaust emission test disc.

Measurements of amount of smoke emitted via chimneys of heating plants are made with mobile measurement stations which officially connected to Ministry of Health. The measurements can not be made

regularly and precisely because of deficiency of equipment and personnel.

Measurements of pollutants, which discharged into atmosphere from industrial plants, are made by universities that take the authority from the AQPR. As a legal enforcement, it is compulsory to make measure emission values periodically and to take necessary actions according to this measurements for industrial plants. The measurements can not be made in a regular basis because of insufficient supply of equipment and personnel.

Distribution of total pollution load between emission sources for Ankara are given as an example in Figure 2.

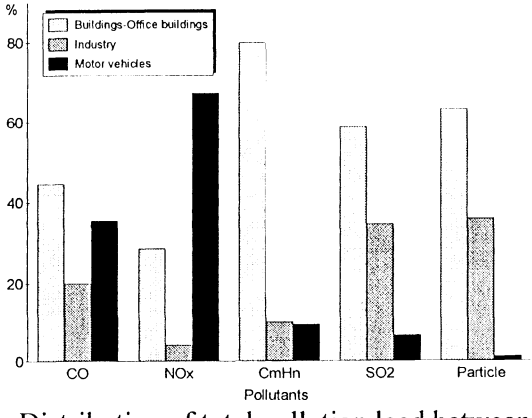

Figure 2: Distribution of total pollution load between emission sources. (Adapted from Ref. 2).

2.2 Data Analysis

The data that are obtained from air pollution observations were analysed by many researchers using statistical methods.

Important part of the studies made on air pollution are related with measurements and control of emissions caused by motor vehicles. İçingür et al.[2] are investigated the effects of injection pump adjustments and injection pressures of diesel engines on emissions. Batmaz et al.[4] are studied on the measurements of emissions and engine characteristics before and after the service for the spark ignition engines. Örnektekin et al.[5] are analysed measurement values of exhaust emissions of approximately 5000 vehicles. Assessments are made depend on monthly distribution of CO and HC emissions and the age of vehicles. Alp et al.[6] are examined particle matter pollution and effects on personnel near by

the Bosphorus suspension bridge turnstiles. Karel & Türkbaş[7] tried to design a dilution mini tunnel to measure exhaust gas particle matter emissions of diesel engines. Özkan & Doğu[8] are experimented a ceramic monolith catalytic converter in order to decrease carbon monoxide emissions in motor car exhaust gas. As a matter of fact, they asserts that CO conversion increased from %80 to %93. Bayındır et al.[9] are investigated the effects of using of LPG as an alternative fuel in automobile engines on CO and HC emissions. They report that LPG emits less emissions when it is compared with petrol engine emissions.

A group of researcher have also studied on emission measurements in Turkish industry. Among these studies, the most extensive one for an industry group was the work of Munlafalıoğlu et al.[10]. In this study, CO, NO_2, and PM are measured using standard measurement techniques and equipments in 48 existing cement plants in Turkey. After that, long term average dust concentrations have been shown by using ISCLT-32 model which is applied to a cement plant. Ercan et al.[11] are examined emission measurements made approximately in 200 industrial establishments by splitting them into seven categories. As a result, they emphasised that especially SO_2 and PM emissions are very high in industry. Döğeroğlu & Kara[12] analysed emission measurements taken from thirty different industrial type combustors in order to determine relationship between fuel type and emission values. Some other researchers[13,14,15] compared the emission measurements taken from cement plants with the legal emission limits for Turkey.

Kaytakoğlu et al.[16] and İşli et al.[17] made an regression analysis in order to establish a statistical relationship between meteorological/ climatological parameters and the concentration of SO_2 and PM.

Many studies have been made on air pollution encountered in residential areas. The studies made on air pollution in some small cities for instance Erzurum, Balıkesir, Sivas, Diyarbakır beside big cities such as İstanbul, Ankara, Bursa, and İzmir are presented in various symposiums. But, most detailed study made by Özer et al.[18] for city of Bursa. In this study, the measurements that were performed, during 1985-1995, to determine the level of the concentrations of SO_2, smoke, trace elements and total suspended matter, have been compared with their standard values. Further, the effects of air pollution sources and natural gas consumption were explained by statistical operations and introducing the meteorological parameters.

The researcher, who emphasize that modifications will be made on burning systems will effect decreasing of air pollution, focused their work on this subject. Sivrioğlu et al.[19] showed that in case of using the boilers under suitable operating conditions will reduce particle

emissions. Durmaz & Topal[20] asserted that heat transfer areas of combustion chambers are unnecessarily big and if this will be reduced then, it is possible to decrease CO and PM emissions. Durmaz et al.[21] splitted up the heating systems used in Ankara to three different categories according to the fuel type and they compared the emission measurement values of different type of fuels. Durmaz et al.[22] are investigated thermal performance and emission behaviour of the commercial stoves used in domestic heating. They identified that the stoves without bucket have low thermal efficiency and low emission when lignite burned and the stoves with bucket have higher thermal efficiency and higher emissions. Upon this, they developed a new type of stove with variable combustion section geometry and they obtained considerable reductions on emission values. Topal & Durmaz[23] carried out a study to control SO_2 emissions of an industrial type atmospheric fluidized bed combustor. A similar type of work has been carried out by Bayat & Gibbs[24] to control of NO_x and N_2O emissions.

Apart from that, approximately thirty researchers published their theoretical and experimental studies on reducing SO_2 and NO_x emissions and dust collection systems. On the other hand, the effects of thermal insulation on reducing of air pollution are assessed approximately in twenty papers. In some studies, how usage of different type of fuel would effect air pollution are analysed and suitable fuels are proposed for domestic heating systems.

2.3 Modelling Studies

Var & Kara[25] who studied different atmospheric dispersion models established a short-term modelling in accordance with AQPR taking into account the combustion originated emission measurements conducted within the regional industrial plants.

Atak et al.[26] determined a cost efficient emission control precautions, which comply with the requirements of imposed regulations and consist of energy cycling technologies, combustion transformation, and application of emission control technologies, using EFOM-ENV energy-environment model.

Keskinler et al.[27] applied following model to identify effect of inversion on to SO_2 concentration.

$$C_i = A_0 - A_1T - A_2W - A_3P - A_4 C_{j-1} + A_5 \Lambda \quad (1)$$

Where, C_j = j daily SO_2 concentration, T : Temperature, W : Velocity of wind, P : rainfall, Λ : Stability parameter ($^oC/100m$). In this study, the values of R^2 and standard deviation are 0.95, 36.43 respectively.

Var et al.[28] compared the values obtained from the ATDL (atmospheric turbulence diffusion laboratory) model for SO_2 and particle matter and the values obtained from measurements for those. As a result of this, the following equalities established:

$$C_{SO2}(\text{calculated}) = 248.04 + 0.3130\ C_{SO2}(\text{measured}) \quad (2)$$

$$C_{PM}(\text{calculated}) = 289.00 + 0.2937\ C_{PM}(\text{measured}). \quad (3)$$

Ekinci et al.[29] gathered values of SO_2 emissions produced by domestic and industrial sources, and they calculated share of it in air pollution using winter time emissions and meteorological data with a software called ISCLT approved by American EPA.

Tayanç et al.[30] measured SO_2 concentration levels at different locations of İstanbul in order to obtain spatial distribution of air pollution by using of Kriging method. A spherical model developed using Kriging method is given below:

$$\gamma(h)= \gamma(h)+(3h/2a-h^3/2a)[\ \gamma(\alpha)-\gamma(0)] \quad (4)$$

Where, $\gamma(h)$ = semi-variance, a = range, h = distance between two observation points, $\gamma(\alpha)$ = nugget effect, $\gamma(\alpha) - \gamma(0)$ = sill. As a result of this model, dispersion of SO_2 concentration in İstanbul obtained and depicted in Figure 3.

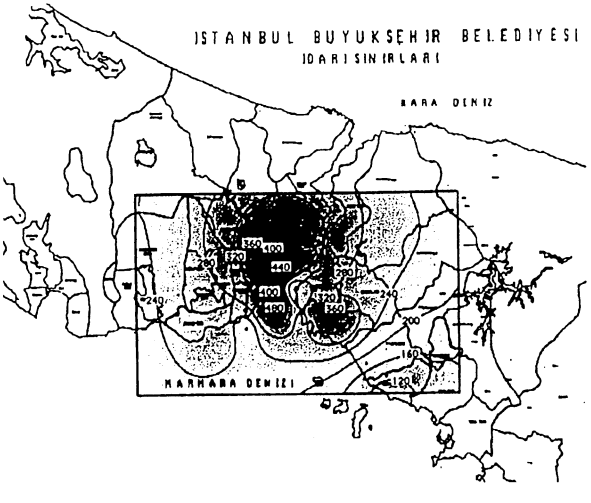

Figure 3: Distribution of SO_2 concentration for İstanbul in December 1993, $\mu g/m^3$ (Adapted from Ref. 30).

Emri & Çulfaz[33] were studied on modelling of sulphur dioxide pollution which generated by power plants. They used Gauss Distribution, Rollback, and Simple Area Source methods as modelling technique. They also compared the results obtained from the above mentioned models with each other and with the measured values.

Kaytakoglu & Var[34] were applied Gauss Plume and Puff modelling method in order to calculate dispersion of SO_2 discharged into atmosphere from Seyitömer power generating plant. Gauss puff model and Gauss plume model equalities are given below:

$$C(R,z)=\frac{Q\cdot P_x}{2\pi^{3/2}\cdot 3600\cdot\gamma}\left[\left(R^2+S(z-He)^2\right)^{-1}+\left(R^2+S(z+He)^2\right)^{-1}\right] \quad (5)$$

$$C(x,y)=\frac{Q\cdot P_x}{2\pi\cdot 3600\cdot\sigma_y\sigma_z u}\exp\left[\frac{-y^2}{2\sigma_y^2}\right]\exp\left[\frac{-He^2}{2\sigma_y^2}\right] \quad (6)$$

C= pollutant concentration at ground level, Q=mass flow rate, P_x=pollutant component in smoke, α,σ,γ = standard deviations, $R = x^2+y^2$, $S=(\alpha/\gamma)^2$, He = effective chimney height.

3 Discussion

Air pollution in Turkey results from domestic heating systems, motor vehicles, cement production plants, power generating plants, and other industrial establishments.

In heating systems, low calorific valued (1500-5500 kcal/kg) and high sulphur concentrated (%1-5) Turkish lignites are used[35]. Usually, it is not possible to control of SO_2 and PM in domestic heating with conventional stoves and central heating combustors.

According to a research, %6.39 of petrol engine motor vehicles in Turkey excessively pollutes the environment[5]. Precautions to prevent air pollution caused by motor vehicles are using of catalytic converter, unleaded petrol, and to make service of motor vehicles in a regular basis.

There exists 48 cement factories at present in Turkey with 33 million tonne cement production capacity. Turkey is second biggest cement producer in Europe and eighth biggest in the world with this capacity. PM emission in 35 cement factories out of 48 exceeds legal PM level[10]. For this reason, in cement factories not only the use of electrostatic dust filter should be increased but also periodical measurements made frequently.

Table 2. Production of electricity in Turkey[36].

Years	Thermal power plants (%)	Hydraulic power plants (%)
1973	21.0	79.0
1981	48.9	51.1
1989	58.0	42.0
1991	63.1	36.9

Majority of energy production of Turkey is provided by thermal power plants(Table 2). Only a few thermal power plant has desulfurisation units. Making common the use of the desulfirisation unit would reduce SO_2 pollution in a large scale.

Table 3. Daily mean limit values for SO_2 and PM.

Emissions	Legal limit in Turkey	Suggested by WHO
$SO_2(\mu g/m^3)$	400	250
$PM(\mu g/m^3)$	300	250

The limit values for SO_2 and PM in residential areas of Turkey are very high when they are compared with the limit values suggested by the World Health Organization (WHO) (Table3). Not only these limit values have to be reduced immediately, but also measurements must be taken more frequently.

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