

## **DATA ANALYSIS OF FUEL CONSUMPTION AT SMALL SCALE INDUSTRIAL FACILITIES AND POTENTIAL EFFECTS ON AIR POLLUTION IN ISTANBUL CITY**

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**Abstract.** Sulphur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), hydrocarbons (HC) and particulates (PM) are the vital parameters determining of air quality and production – consumption cost control of fuel and energy. Within the scope of these indicators and to rationalize its effects scientifically and, moreover, taking into account the geographical layout and industrial regions, population density and meteorological indicators of Istanbul city have been restudied on predictable and experimental scale. It is also aimed to study, with the help of the emission measurements of Istanbul University, Department of Environmental Engineering, Air Pollution Laboratories, the mathematical relations (by regression analysis method) between the fuel types used in Istanbul and the above mentioned potential effect on air quality indicators according to industrial sectors. Finally, some statistical evaluations of the raw emission measurements (based on the European region of Istanbul city) which is obtained from Istanbul Municipality (during 1994-1999 years) are also given in this paper.

**Keywords:** air polluters, industrial facilities, chimney gas measurements, number 4-6 fuel oil, statistical analysis.

### **AIMS AND BACKGROUND**

Air pollution which was the problem of industrialized countries first has become our problem since the middle of this century. Today, as a result of rapid growing population, activities and development of the industrialization, air pollution is increasing. For this growing air pollution, it is still discussed how people can be successful to prevent the pollution. The factors such as planless building of former generation and wrong industrialization investment for people to live in a polluted city on the further of the limits were considered as dangerous for people's health.

According to that, in this work, data of chimney gas measurements of some small scale industry facilities that exist in eight different counties of the European region of Istanbul city has been evaluated, incidence of residential and industrial areas has been taken into account. The levels of characteristic emission values, and chimney gas blowing and burning profit of either fuel species and burning qualification or present burning units of industrial facilities have been examined.

Further, the measurements made recently by Istanbul Metropolitan municipality (1995-1999) have been evaluated with raw emission data, by regression mathematics and emission values levels and their possible effects on Istanbul city air pollution have been also examined.

## THE DATA OF CHIMNEY GAS MEASUREMENT AND THEIR EVALUATION

*Measurement methods.* The characteristic air pollutants ( $\text{SO}_2$ ,  $\text{NO}_2$  and particulate matters) were measured by MRU 95/2D, MRU 95/3CD, Dwyer gas control set, dust tools.

In the chimney gas measurements of Istanbul University Environmental Engineer Department, the pollutants as  $\text{CO}$ ,  $\text{SO}_2$ ,  $\text{NO}_2$ , and PM (particulate matter) were obtained and evaluated according to air quality keeping regulations.

This work contains the measurements between years of 1997-1998 at total 86 industrial facilities, using fuel oil, natural gas and coal at 5 different work branch at 8 different counties of the European region of Istanbul city (Bagcilar, G. Osmanpasa, Eyup, Sisli, Avcilar, Kagithane, and Kucukcekmece counties).

*The data analysis and evaluation of air pollutant.* In this work that was realized between 1997-1998, 86 chimney gas data have been evaluated, the industrial facilities that use natural gas and coal have not been evaluated because there is not enough data, and only those measurements of fuel oil (numbered 4) using industrial facilities were accepted as basic<sup>1</sup>.

According to fuel quality, especially  $\text{SO}_2$ ,  $\text{NO}_2$  and PM values levels of chimney gas measurement data have been explained and evaluated in Figs 1-3, because they are the most important pollutant emission values.

Summarising the data in Figs 1-3, the following evaluations have been obtained:

- There are significant differences between the values of  $\text{SO}_2$  that measured as 1200-1750  $\text{mg}/\text{m}^3$  in 1997 and 1700-2300  $\text{mg}/\text{m}^3$  in 1998 (Fig. 1). The crossing the border value of air quality 1700  $\text{mg}/\text{m}^3$  \* is attracting attention. It is bringing up that the sulphur value of this fuel oil numbered 4 was over 1.5%. The nomogram<sup>1</sup> that has been prepared to predict the  $\text{SO}_2$  emission amount according to fuel oil ( $F_c$ ) and sulphur that it is the characteristic of fuel, ashes ( $A_k$ ), confirms the ideas about this subject. These quite high values are between 1.0-1.7% for 1997 measurement data and 2-3.5% for 1998 measurement data (Fig. 3)<sup>1</sup>.

- Another important evaluation is the finding of the values of  $\text{SO}_2$  between 200-450  $\text{mg}/\text{m}^3$ , and  $\text{NO}_2$  between 130-280  $\text{mg}/\text{m}^3$ . As one can see, there is a noticeable reduction in the emissions when a filter is used in the burning chimney.

- The evaluation of similar examinations for values of PM (particulate matter) and  $\text{SO}_2$ , reveals linear relation between these values and the correlation coefficients  $r^2 = 0.792-0.908$  (Fig. 3). There is an interesting increment trend between

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\* According to Turkish Air Quality Protection Regulations, it is stated that at industrial facilities that use liquid fuel and 3% volume oxygen with power until 300 MW, chimney gas border value of  $\text{SO}_2$  is 1700  $\text{mg}/\text{m}^3$ , at establishment with power of 50 MW the border value of  $\text{NO}_2$  is 800  $\text{mg}/\text{m}^3$  (in old establishment it is 1000  $\text{mg}/\text{m}^3$ ).

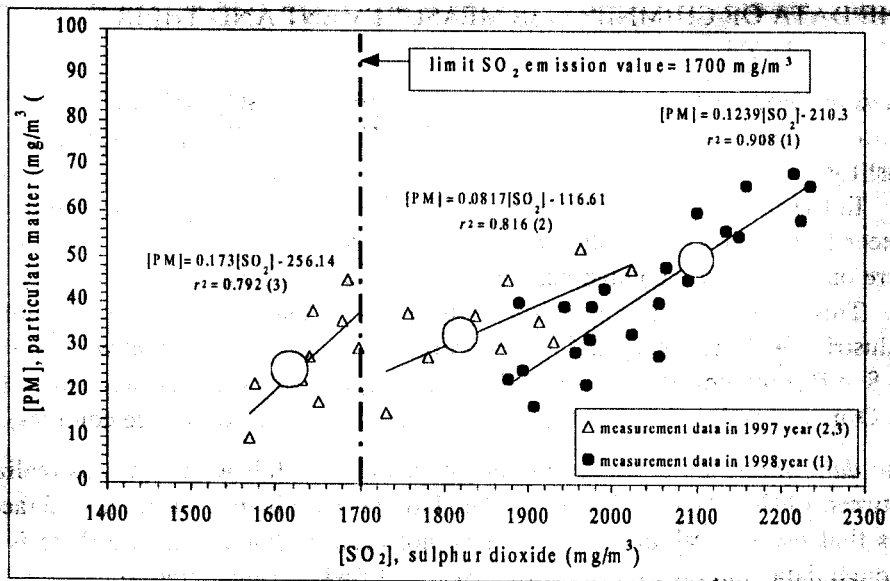


Fig. 1. Relationship between  $\text{SO}_2$  and PM emissions

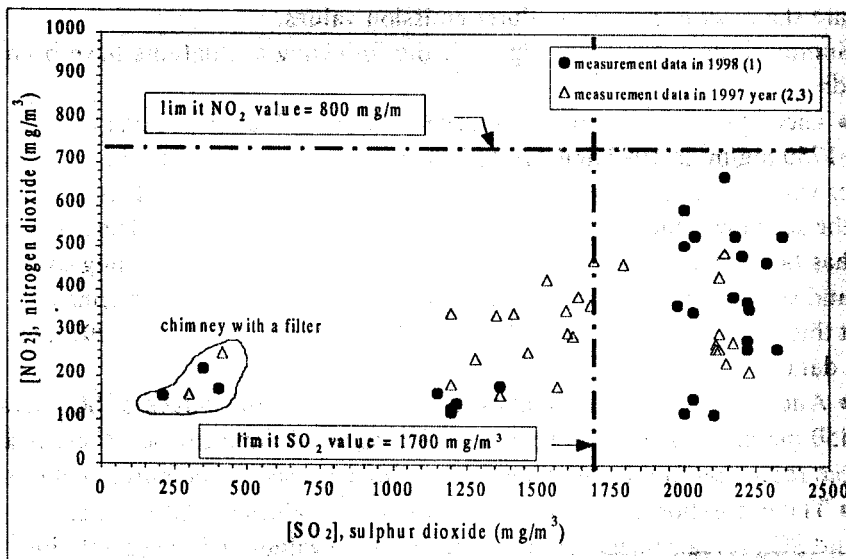


Fig. 2. Relationship between  $\text{SO}_2$  and  $\text{NO}_2$  emissions

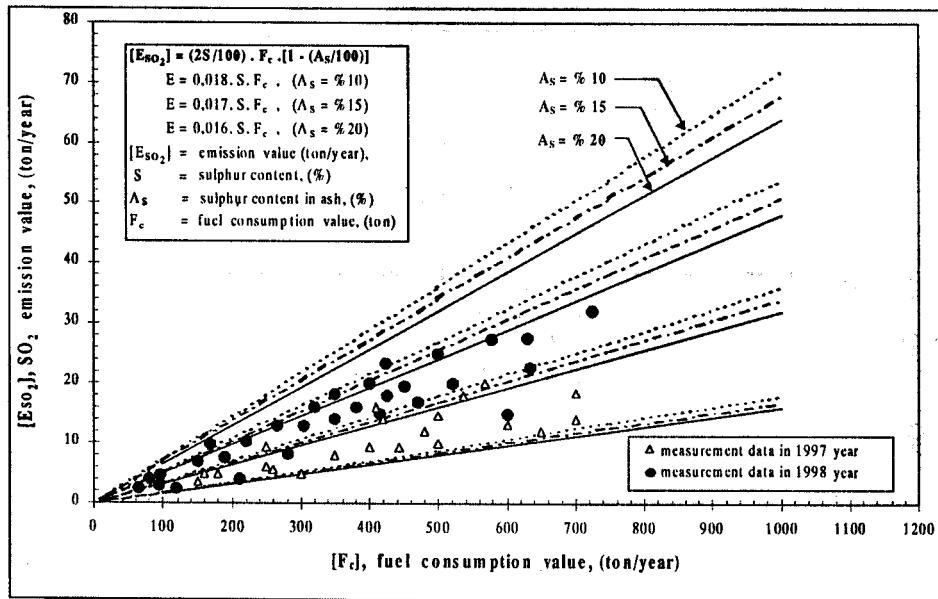


Fig. 3. Predication nomogram of SO<sub>2</sub> emission value according to fuel consumption (F<sub>c</sub>) and sulphur content (S) and sulphur content in ash (A<sub>s</sub>)

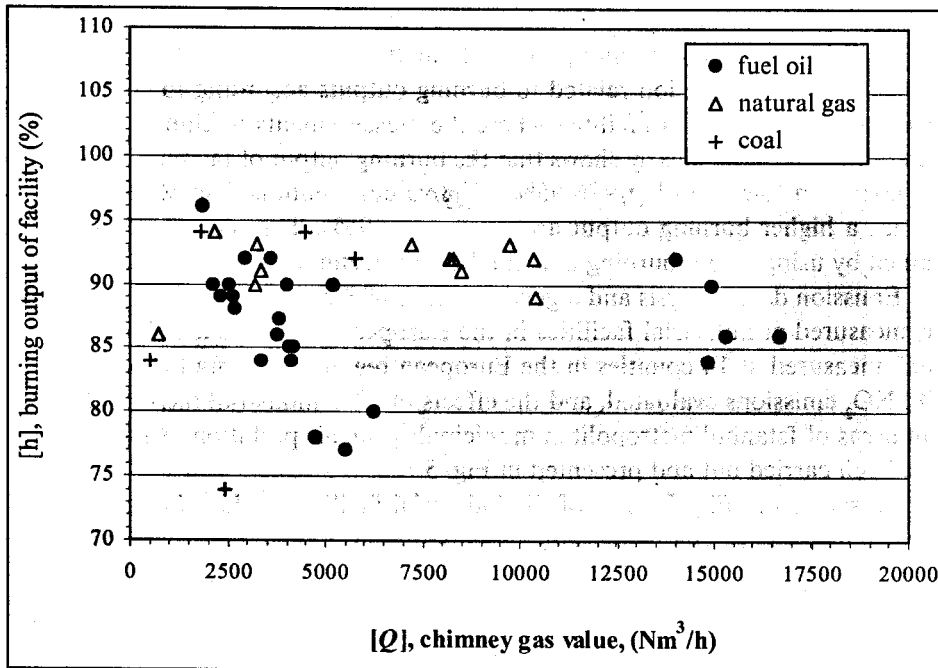


Fig. 4. Emission data analysis measured at industrial facilities in the European region of Istanbul city (for 14 countries), in 1997<sup>2,3</sup>

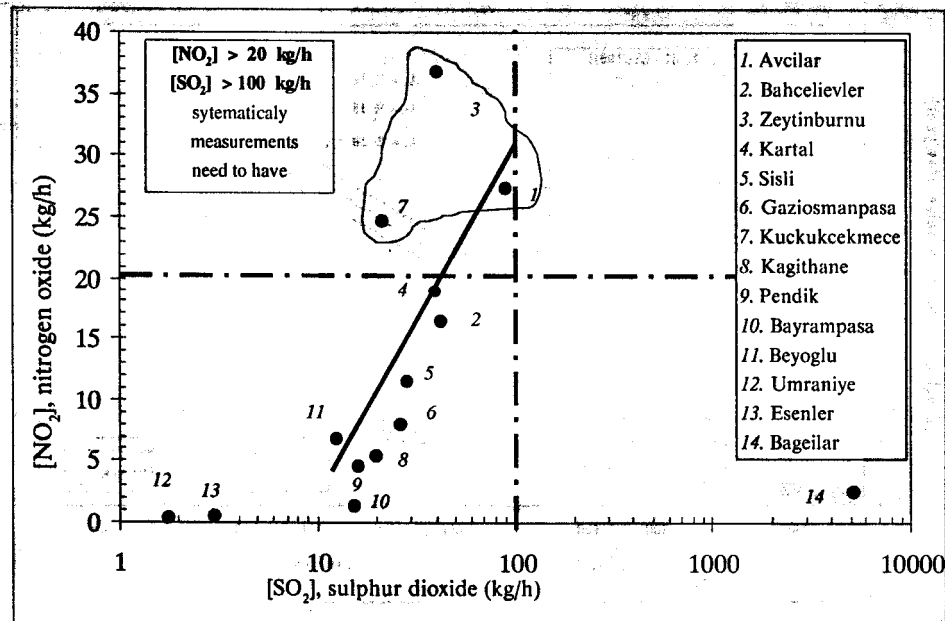


Fig. 5. Evaluation of related to burning outputs according to chimney gas value of burning unit of industrial facilities

1998 and 1997 measurements, especially when the values of  $\text{SO}_2$  are related to the increase of sulphur content and particulate matter.

There is an evaluation related to burning outputs according to chimney gas blows of burning units of facilities where the measurements of chimney gas have been done (Fig. 4). It clearly shows that the burning output of facilities on fuel oil and coal is in lower level ( $\eta=76-95\%$ ). The values mentioned show that natural gas has a higher burning output around  $\eta = 90-95\%$ . This situation can be explained by using of old burning and combustion technology.

Emission data analysis and a general critics of  $\text{SO}_2$ ,  $\text{NO}_2$  and particulate matter, measured at industrial facilities in the European region of Istanbul city, raw data\* measured at 14 counties in the European region of Istanbul city related to  $\text{SO}_2$ ,  $\text{NO}_2$  emissions evaluated, and the effects of 1240 industrial facilities in adjacent areas of Istanbul metropolitan municipality, on air pollution of Istanbul city have been carried out and presented in Fig. 5.

As seen from Fig. 5, most of the industrial facilities of Istanbul are located between Bagcilar, Avcilar, Kuckukcekmece, Bahcelievler, Zeytinburnu, Gaziosmanpasa, Bayrampasa, Sisli, and Esenler counties.

Among these 14 counties, the highest levels of  $\text{SO}_2$  polluter 5168 kg/h are recorded in Bagcilar and 104 kg/h in Avcilar. If it is evaluated according to number of industrial facilities, there are total 72 facilities in Bagcilar county and only

\* These data have been gotten from Environment Protection Department of Istanbul Metropolitan municipality as raw data and contain 1997.

10% (7 of them) have got emission permission. Rest of them, that mean 65 industrial facilities, work without any emission permission, which is evidenced by the highest SO<sub>2</sub> value of the mentioned county states.

If Fig. 5 is evaluated according to Regulations of Turkish Air Quality and Protection, that measurements of Bagcilar and Avcilar counties have to be carried out systematically because of their values of SO<sub>2</sub> > 100 kg/h and NO<sub>2</sub> > 20 kg/h.

## CONCLUSIONS

Some important results and evaluations obtained during this examination can be summarized as:

- A lot of parameters, as air pollution, excess population increase speed, insufficient and planless – sickly infrastructure, critical meteorological conditions that can be created during crooked urbanization, have to be analyzed (Fig. 1).

- There are 1240 small-middle sized industrial facilities in Istanbul that have to get emission permission. Only 7.3% of them (91) have got emission permission. 51% of them (627) do not apply for getting emission permission. There are need to work on comprehensive and consistent inventory for fuel species, quality and their burning units present situations of the mentioned industrial facilities and their distribution according to town (Fig. 1).

- The supervision function of local administrations has to be effective for preventing the using of high sulphur liquid fuels in industrial facilities, except 4 numbered fuel oil with sulphur content of 1.0-1.5% and is used prevalently.

- Especially in facilities on fuel oil and coal, the burning outputs are at lower levels ( $\eta = 76-95\%$ ). At natural gas, the mentioned values show more stable structure  $\eta = 9\%-95\%$ . This situation can be explained by using of old burning units at fuel oil and coal (Fig. 4).

- In particular, in city planning dominant wind, sunbathe position, green areas, combustion of fuels quantity and quality, chemical reactions on the surfaces of buildings and damages, should be paid attention.

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## REFERENCES

1. N. TOKGOZ: General Statistical Evaluation of Air Pollution for Istanbul City in 1980-1999 years. Researching Report, TMMOB Chambers of Mining Engineer, Branch of Istanbul, 22 p., October, Istanbul, Turkey, 1999 (in Turkish).
2. N. TOKGOZ, G. DEMIR, B. SOYHAN, U. ALVER, C. BAYAT: Data Analysis of Fuel Consumption at Istanbul City and General Evaluation for Air Pollution. In: 6th International Combustion Symposium, 6-8 October 1999, Istanbul, Turkey.
3. N. TOKGOZ, G. DEMIR, U. YAZGIC, C. BAYAT: Air Pollution Emission Data Analysis Based on the Fuel Consumption for Urban and Industrial Area in Istanbul City. National Air Pollution and Protection Symposium, Izmir Dokuz Eylul University, Environmental Engineering Department, p. 271-278, 27-29 October 1999, Izmir, Turkey (in Turkish).

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