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EUROPEAN LEGISLATION ON AIR-QUALITY AND HEALTH; ISSUES RELATED WITH THE CITY OF ISTANBUL BASED ON AN INVENTORY OF EMISSIONS

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ABSTRACT

For atmospheric pollution, dose-response relationships are not easily established due to the limited number of effects which are usually well within the error margins of statistical analysis. With this work we are trying to forecast the health effects at the greater metropolitan area of Istanbul based on emissions and concentrations reported in scientific literature. This area has the second highest population in Europe and is one of the highest developing infrastructures where emissions are expected to change significantly during the coming years. The European legislation is also reviewed for air-quality, emission and health standards with which will be set the standards for future compliance.

Key Words: Urban Air-Quality, Emission Health, European Legislation, Istanbul.

1. RELEVANT LEGISLATION

Environmental policies for sustainable development in urban and rural areas are formulated so they meet environmental and economic objectives. These objectives can be expressed in various ways as applied to different time periods mostly with data following the temporal evolution of emissions. Ideally, the policies should cover reasonably long time periods since some of the effects (for example, on human health) may be partially cumulative in nature, and therefore air-quality and emissions in several consecutive years are of importance.

The European Commission with the Environment and Health Strategy in 2003 (COM (2003) 338 final) and the European Environment and Health Action Plan in 2004 (COM (2004) 416 final) has set the objectives to reduce among others the human exposure by environmental factors in the EU and to identify and prevent new health threats caused by the environment. In order to strengthen the capacity for policy making in this area researchers are called upon to recognize the novel potential of integrated assessments for monitoring atmospheric pollution and in deployment of new technological tools which attribute the pollutant concentrations to emission sources.

Relevant EU legislation with regards to emissions and air-quality are shown at Table 1 (http://europa.eu.int/comm/environment/legis_en.htm). There is shown an early emphasis on mobile-source regulation, other than heating and stationary source regulations. Then “optional harmonization” process was introduced which was then followed by examination of the ozone-forming VOCs and $NO_{x.}$ These were thought to be primarily mobile-source problems whereas acidifying sulphur dioxide emissions were thought to be primarily stationary-source problems.

Table 1. Extract of environmental legislation at EU.

Directives	Year	Main Provisions
90/313	1990	Established requirements for the public’s freedom of access to environmental information.
91/441	1991	Extended small-car standards of 89/458 to all size classes.
91/542	1991	Tightened heavy-duty diesel vehicle CO, HC, NOx standards. Established heavy duty diesel PM standards
92/72	1992	Requires O_3 monitoring. Sets health and vegetation-based O_3 concentration standards.
94/12	1994	Introduces more stringent limit values for all ambient pollutant concentrations. Reflects Auto/Oil study recommendations to evaluate all transportation-related policies according to cost/effectiveness guidelines.
96/61	1996	Integrated Pollution Prevention and Control Directive created multi-media permitting system.
96/62	1996	Air-Quality Framework Directive. Defines and sets objectives for ambient air quality. Requires assessment of ambient air quality and the availability of this data to the public, including alert notices when threshold values are exceeded. Requires maintenance of good air quality.
96/63	1996	Controls VOC emissions from petrol storage and distribution.

The objectives of the present work are to increase the current understanding of the situation at Istanbul, before commitments are taken for decreases in total emissions (or for assessing the effects of reduced trans-boundary fluxes). Based on a comparison of local emissions and air-quality in urban domains with similar population density a forecast is made about health effects at the metropolitan area of Istanbul. This area, with the second largest population in Europe, is one of the highest developing infrastructures where emissions are expected to change significantly during the coming years. Hence, it should be possible to demonstrate “dose-response” relationships at numbers which are outside the error margins of statistical analysis as is frequent the case in all other European domains. The add-value of this work is also the direct comparisons of emission inventories based on the technologies established during the AutoOil programmes.

2. HEALTH IMPLICATIONS

For the domain of Istanbul it is difficult to carry out full scale epidemiological studies for assessing the importance of atmospheric pollution to the population health. Monitoring data for ozone and particulate matter are only emerging in the scientific literature now so for the purposes of this study we will utilise ambient air $NO_{2.}$ This is in large part derived from the oxidation of NO, the major source of which is combustion emissions, mainly from vehicles. NO_2 is therefore a clear indicator for road traffic. NO_2 is also subject to extensive further atmospheric transformations that lead to the formation of O_3 and other strong oxidants that participate in converting NO_2 to nitric acid and SO_2 to sulphuric acid and subsequent conversions to their ammonium neutralization salts.

The current WHO guideline values for NO_2 1-hour level are 200µg/m3 and for the annual average 40 µg/m3. Since the previous review, only a small number of additional human exposure studies have been carried out. Health risks from nitrogen oxides may potentially result from NO_2 itself or its reaction products including O_3 and secondary particles. Oxides of nitrogen destroy organic matter such as human tissue. Animals exposed to NO_x are less able to ward off bacterial infections and die more often. Their susceptibility to viral infection increases, exposure to high levels of NO_x for weeks causes emphysema-like changes in the lungs of animals. Children aged 12 and younger who are exposed to NO_x have more respiratory illness (Harrington et al., 1985). Those exposed to high levels of NO_x outdoors had more colds that settled in their chests, chronic wheezing and cough, bronchitis, chest cough with phlegm, and episodes of respiratory illness (Hasselblad et al., 1992).

Epidemiological studies of NO_2 exposures from outdoor air are limited in being able to separate direct and indirect risks to human health. Evidence of the health effects of NO_2 by itself thus comes largely from toxicological studies and from observational studies on NO_2 exposure indoors. The studies of outdoor NO_2 may be most useful under the following circumstances:

- Evidence for NO_2 effects assessed at fixed levels of exposure to other pollutants
- Evidence for modification of PM effects by NO_2, possibly indicating potential consequences of HNO_3 vapour and/or PM nitrate.

Indeed, some additional emphasis might be given to NO_2 as a marker for traffic and industrial-related air pollution and an important source of a range of more toxic pollutants that probably act in combination to produce adverse health effects.

3. THE URBAN INFRASTRUCTURE

For the identification of health effects due to environmental factors it is necessary to look in domains with high population concentrations. In Europe apart for the Greater metropolitan area of Moscow the three largest areas are the metropolitan areas of Istanbul, Paris and London (Bliss, 2000). Among those areas, Istanbul has a warmer climate closer to Mediterranean for this reason for realistic emission comparisons we also include at this study the domain of Athens. The populations at these domains are summarised at Table 2 (www.factbites.com/topics/):

Figure1 also shows the population density at the Istanbul, Paris and London which are the second, third and forth most populous urban areas in Europe. The population density is homogeneously processed from the census data of early 2000s with a locally developed algorithm with a spatial resolution of 1x1 km2. As seen from Tables 2 and 3 and from Figure1, the Greater Metropolitan area around Istanbul is expected to have increases in urbanisation rate due to continuing immigration. In addition the increased rates of industrialization are expected to increase the rate of unwanted urban pollution in the atmosphere.

Table 2: Population Comparisons

Domain	Population (million inhabitants)	Max Population Density (inhabitants/km^2)
Istanbul	11.000	40523
Paris **Greater Met. Area**	2.147 11.174	23125
London **London Greater Met. Area**	7.172 13.945	7982
Athens	3.762	30207

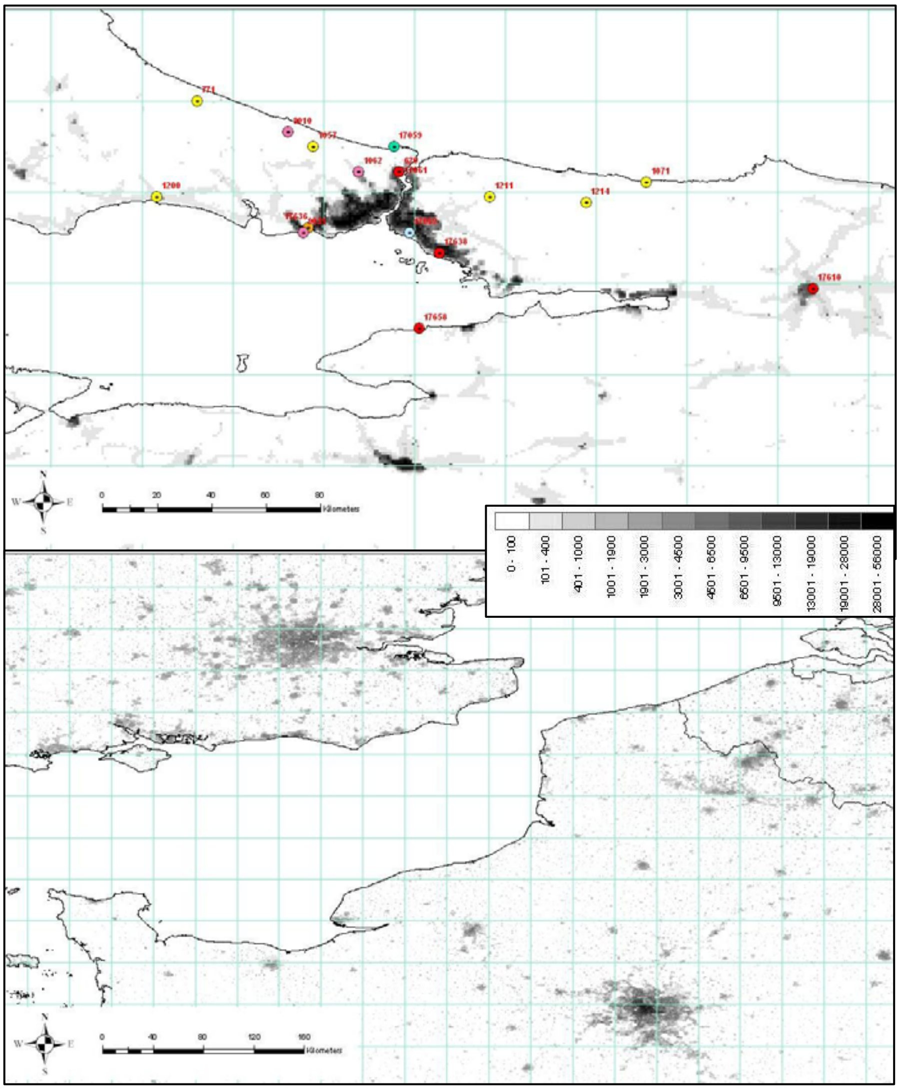

Figure1. Population density per km^2 at large European urban areas.

Table 3 also shows information concerning the general urbanisation trends based on national statistics (www.factbites.com/topics/). At this table, population growth rate is the average annual percent change in the population, resulting from a surplus (or deficit) of births over deaths and the balance of migrants entering and leaving a country. The growth rate is a factor in determining how great a burden would be imposed on a country by the changing needs of its people for infrastructure, resources and jobs. It is also a parameter which is associated with urban emissions and how these will change in future years.

Table 3: National trends on population changes.

Population Data	Turkey	France	UK	Greece
Population Growth Rate (%)	1.09	0.37	0.28	0.19
Urbanisation (%)				
1975	41.6	73.0	88.7	55.3
2001	66.0	76.0	90.0	60.0
2015	71.8	78.4	90.8	65.1
Pop. Living in Urban Areas (%)				
2003	66.0	76.0	89.0	61.0

The urbanisation rate is based on estimates and projections of urban and rural populations as given by the Population Division of the United Nations Secretariat and published every two years. Urban-rural classification of population in internationally published statistics follows the national census definition, which differs from one country or area to another. National definitions are usually based on criteria that may include any of the following: size of population in a locality, population density, distance between built-up areas, predominant type of economic activity, legal or administrative boundaries and urban characteristics such as specific services and facilities. Population living in urban areas is the actual percentage of people living in urban areas during 2003.

4. ATMOSPHERIC EMISSIONS

For the purpose of this work, and prior to assessing the risk from exposure to air-pollutants, it is essential to associate emissions to air quality. Hence, to assess what are the levels of expected annual concentration. For city of Istanbul the level of emissions are not easily found.

In Figure 2 are illustrated the emissions from NO_x (as NO_2), SO_x (as SO_2), CO and NMVOCs, at the EMEP grid corresponding to the centre of Istanbul. These emissions are examined from several years during 1980 to 2002. The Sectors of Emission Sources as provided by EMEP (Vestreng and Klein 2002 and Vestreng, V. et al., 2004) are as follows and do not include the emissions from Large Point Sources (e.g., power plants or large industries):

1-Combustion in energy & transformation industries, 2-Non-industrial combustion plants, 3-Combustion in manufacturing industry, 4-Production processes, 5-Extraction and distribution of fossil fuels and geothermal energy, 6-Solvent use and other product use, 7-Road Transport, 8-Other mobile sources and machinery, 9-Waste treatment and disposal, 10-Agriculture and 11-Other sources and sinks.

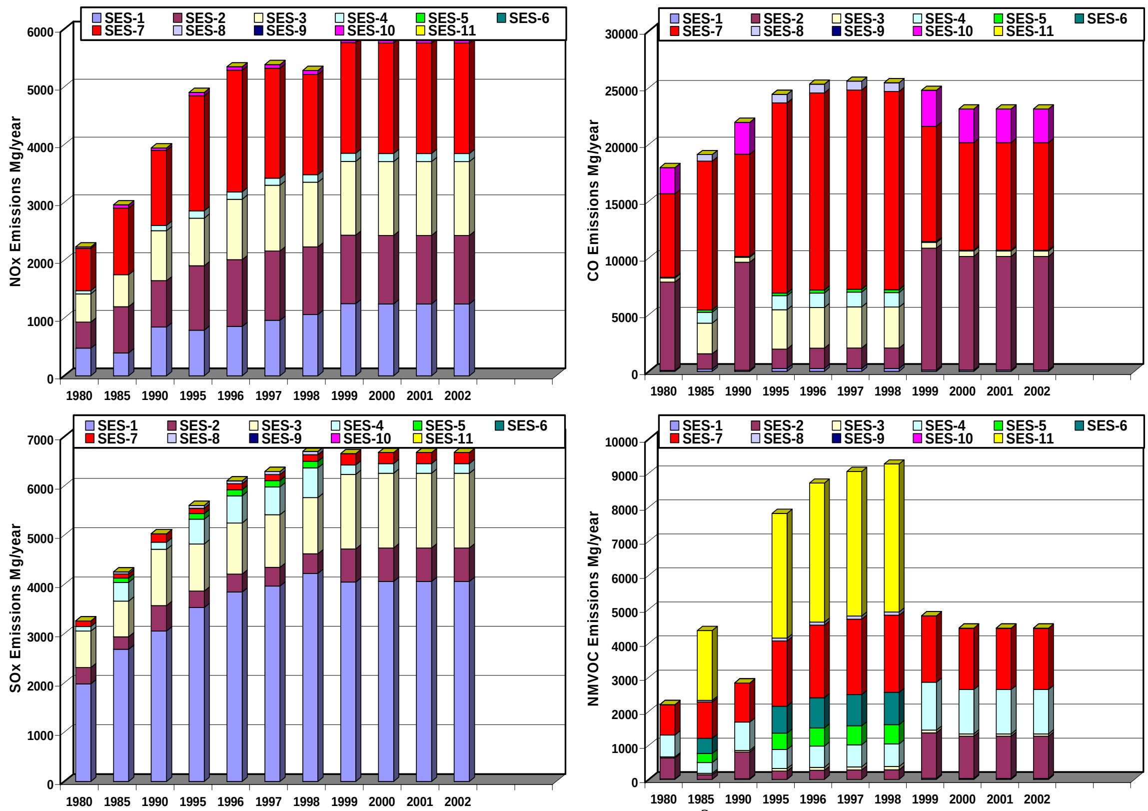

Figure 2. 1980-2002 Emissions at Istanbul in a 50x50 km^2 cell at “28.843°E, 40.823°N”

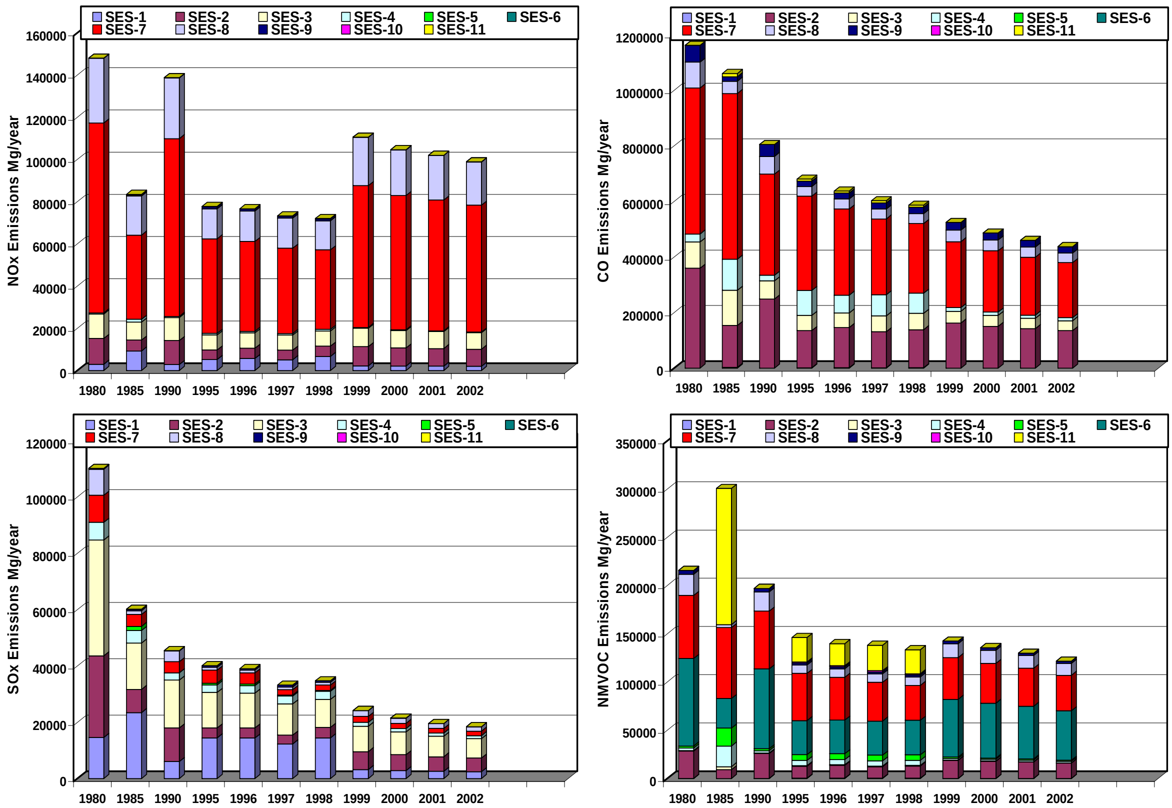

Figure 3. 1980-2002 Emissions at Paris in a 50x50 km^2 cell at “2.046°E, 48.820°N”.

It is evident from these figures that traffic is an important source for NO_x and CO, but also the important contribution of combustion in energy & transformation industries for NO_x and SO_x as well as the importance of non-industrial combustion plants for NO_x and CO.

At Figure 3 are shown similar graphs for a similar size grid cell for the city of Paris. Noticeable are first the scale which is 20 times higher for CO and NOx, 10 times for SOx and NMVOCs. Here, again we have the importance of traffic for NOx and CO, but the lower importance of combustion in energy & transformation industries for NO_x and SO_x. Clearly the persistence of SO_x and NO_x emissions at the domain of Istanbul is also an important observation from comparisons in these domains.

Similar comparisons have been carried out for the centre cells of London and Athens. However, since the levels and the scale for these domains are similar the corresponding plots are not included here. Only indicative are shown at Figure4 the levels of total NOx and the traffic NOx emissions in all domains. It is evident from this figure that the percentage attributed to traffic is significantly less than the Paris and London and that the total emissions are significantly lower at Istanbul. Hence, as a first estimate from these comparisons are that the expected concentrations should be significantly those from what observed in those two of Paris and London. It is also expected that significant increases will be noticed when the ratio of 28 cars per 1000 people (State Institute of Statistics, 2005). A trend that is already observed with the recent rates of introducing new cars registrations at the Greater Area of Istanbul.

Despite the fact that the expected concentrations are to be lower, the fact that the population density at several cells at Istanbul are triple of those found in Paris and fact that emissions from traffic are to significantly higher means makes the domain of Istanbul ideal for establishing dose to health effects relationships.

Of significant importance remains the verification that those emission numbers represent reality. The best way of carrying out this process are construction of an emission inventory in higher resolution (1x1 km^2) and the aggregation of cells to a 50x50 km^2 resolution. In the absence of emission data from the open scientific literature the verification process can be carried out from the emission data quoted at www.nationmaster.com. The data are summarised at Table 4.

Table 4. National trends on emissions and concentrations

Emission/AQ Data	**Turkey**	**France**	**UK**	**Greece**
NO_x emissions per capita,	14.1	22.7	26.3	29.8
NO_x emissions per populated area	0.33	0.99	2.76	0.47
NO_x Change 1990-early 2000s (%)	48	-29	-43	11
SO_x emissions per capita	31.3	9.0	16.6	47.7
SO_x emissions per populated area	0.65	1.09	5.37	1.83
SO_x Change 1990-early 2000s (%)	33	-60	-73	4
Urban NO_2 concentration (1995)	9.45	56.61	64.47	64
Urban SO_2 concentration (1995)	87.02	13.89	21.96	34

At the aforementioned table, NO_x and SO_x emissions are expressed as NO_2 and SO_2 respectively. The units are Kg per capita (based on 2000 and 1990 census) and were obtained from OECD (www.oecd.org/dataoecd/11/15/24111692.PDF). For the emissions per populated land area, these are expressed in Gg/km^2. For this parameter were used the total emissions for each country by summarizing emissions data, originally available as a grid map with 1 deg x 1 deg cells. Air pollution is generally greatest in densely populated areas. To take this into account, were used the girded population of the world dataset available from CIESIN and calculated the total land area in each country inhabited with a population density of greater than 5 persons per km^2. This land area was then used as a denominator for the emissions data.

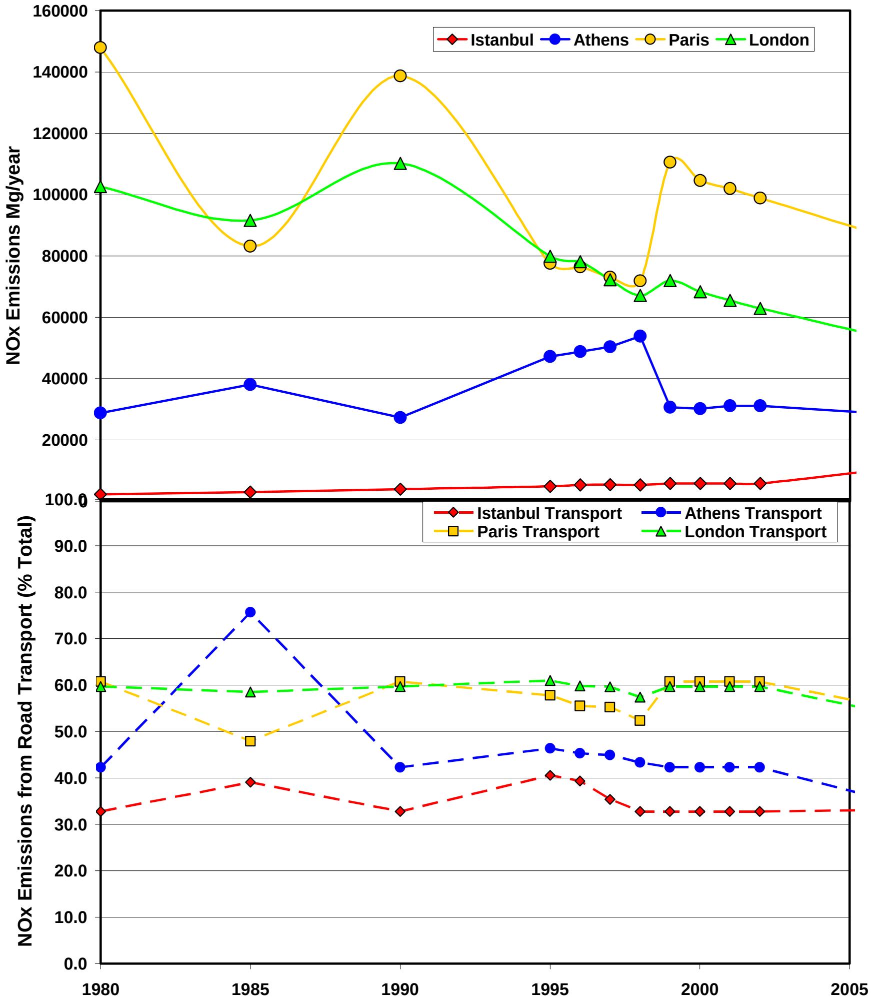

Figure 4. Comparison of NO_x emissions in equal size city cells. Upper graph corresponds to total emissions and the lower graph to the percentage of emissions from road transport.

For urban NO_2 and SO_2 concentration the units used were μg/m^3. The values were originally collected at the city level. Each nation varied in terms of the number of cities reported, so this data should be used with some caution. Within each country the values have been normalized by city population for the year 1995, then added together to obtain the total concentration for the given country.

It should be stated that in the recent years, the limitations set by the Istanbul Metropolitan Municipality have increased the usage of natural gas and quality coal for heating instead of under-quality coal. This ensured lower CO and SO2 levels especially compared to the previous years. Additionally, the industries within the city were moved to the organized industrial zones located outer parts of Istanbul.

5. PROJECTION OF HEALTH CASES

Systematic air-quality monitoring data are not easily available and for this reason the concentrations for necessary for assessing the health risk are taken from Onkal-Engin et al., 2004. In this study, data were collected at 6 different air monitoring sites, at Kagithane, Besiktas, Esenler, Sariyer, Fatih and Bagcilar. All sites were located on the European side of Istanbul and the population at this area is approximately 30% of the total population. This area has mostly residential areas and some industrial regions. Industrial activity takes place especially in Esenler region. Concentrations were measured by mobile vehicles equipped with air monitoring instruments. The data were collected daily and covered a period of 20 months, from January 2000 to August 2001. According to this work the NO_2 concentration ranged from 58 to 65μg/m^3.

As noted at section-2, the concentration-response relationships are not readily established for NO_2 from experimental or observational data. For acute effects of NO_2, the evidence comes primarily from human exposure studies. These studies are carried out with relatively small numbers of health volunteers do not provide easily any evidence in a range relevant to current standard setting. Associations have been observed only between NO_2 and mortality in daily time-series studies, but on the basis of present evidence these cannot be attributed only to NO_2 with reasonable certainty. However, since NO_2 is often highly correlated with levels of other ambient pollutants emitted by the same sources or related through complex atmospheric reactions, NO_2 will be used for the purposed of this study as a surrogate for unmeasured traffic related pollutants such as organic and elemental carbon or freshly emitted primary ultra-fine particles (WHO 2003, WHO 2005).

Based on the evidence from several Italian cities for the year 2004 and with urban measuring stations in close proximity to the kerbside the following relationship between concentration and heath effects is established. Compatible data have been produced by several other studies (Katsouyanni et al. 2001, Hoek et al. 2002, Stieb et. al 2002 etc), but for the indicative purposes of this work and because of the close similarity of the climatic conditions during 2004 the data from Figure5 are considered adequate.

Based on the population reported in table 1, the NO_2 concentration reported in reviewed literature (Onkal-Engin et al., 2004) and Figure5, it is reasonable to expect at least 4600 deaths that could be attributed to atmospheric pollution.

The fact that Istanbul has regions with the highest population density in Europe together with fact that the climate allows acute pollution episodes during the year make this domain ideal for identifying if there are health consequences from atmospheric pollution or not. These studies are beyond the scope of this introductory work. However, prior to the epidemiological studies it will be necessary to carry out detailed monitoring at various locations for several years (Skouloudis, 1997) in particular at hot spots locations according to an emission inventory with high spatial resolutions (at least 1x1 km^2). This will need to be followed by a detailed source apportionment of concentrations according to the methodology developed by AutoOil-2 (Skouloudis 2000, EC DG-ENV 2001).

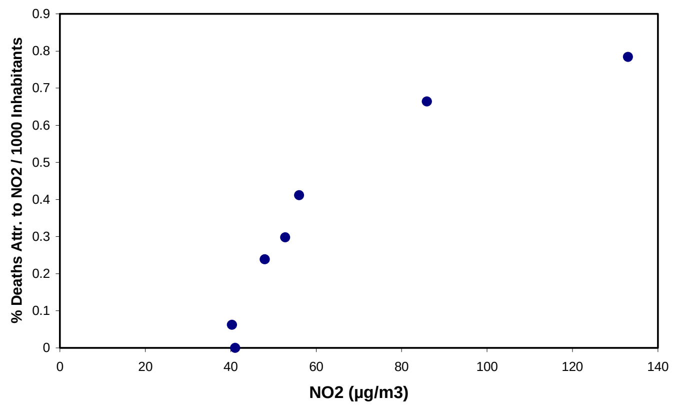

Figure 5. Deaths attributed to atmospheric pollution at Italian cities in 2004.

6. PROSPECTIVES AND FINAL REMARKS

The ultimate goal of any clean air policy is to develop strategies to reduce the risk of adverse effects on human health and the environment as a whole caused by ambient air pollution. With current data structure it is difficult to reveal the link between those effects. It well known from long-term studies that the spatial variation of NO_2 levels within a city and the absence of health data with high temporal resolution (less than days) have weaken the ability to detect effects of atmospheric pollution on population.

On the other hand, measurements from urban background sites and the planning of campaigns in cities with small population density or in areas where emission reductions were carried out such as in the Harvard Six City Study or the American Cancer Society Study have by definition little chance to provide evidence of relating air-pollution doses to health effects.

For these reasons, data from the city of Istanbul with the existence of very susceptible populations, with climatic conditions which are not of the Mediterranean extremes or of the cold European north, are of particular importance in identifying health effects. This city offers the ability to detect effects even if they are infrequent with the low but raising emissions observed in comparison to other European cities where significant emission reductions have been carried out. We may therefore be confronted with situations of identifying thresholds and hence modify the setting standards to protect public health.

Risk reduction strategies are and will continue to be powerful tools in promoting public health. However, these tools have large verification uncertainty when conducted in areas where the benefits are not quantifiable in significant population numbers. The development of such strategies requires not only qualitative, but also quantitative knowledge of relevant effects. For this reason a network for adequately reporting air-quality concentrations is essential. At the same time the geographical attribution of emissions need to be established and verification of exposure should be carried out with air-quality modelling tools.

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