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Evaluation of Air Pollutıon Caused by the Uncontrolled Urbanization: A Case Study from Samsun, Turkey

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Abstract

Urbanization is one of the major social changes sweeping the globe. Although many benefits originating from urbanization, a rapidly urbanizing world including Turkey faces intensified resource scarcity and environmental degradation. Among them, air pollution is the major issue that has been affecting human health, agricultural crops, forest species, and ecosystems. Turkey has experienced a progressive degradation in air quality as a consequence of rapid urbanization over the last two decades. In particular, the levels of air pollutants are increasing rapidly in urban areas of Turkey as many developing countries. The city of Samsun is situated at the interface of developed and relatively underdeveloped sub-national regions of Turkey and has experienced rapid urbanization, which has generated urban problems, seeming unsolvable in the current institutional context. The aim of this study is to provide a broad overview of urban air pollution in Samsun which is a rapidly growing city in Turkey. It is targeted to emphasize the importance of reorganizing the institutional tools in a wide-angle perspective in order to generate coherent solutions to urban air pollution, and to enhance urban quality.

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1. Introduction

Rapid urbanization has become a major concern in many countries worldwide (Jaeger et al., 2010; Liu et al., 2011). Most people are not aware of that the overwhelming majority of the urban growth in the world today (over 95%) is taking place in developing countries, also referred to as less developed countries. Since 1950 the population living in developing world cities has increased fifteen fold. Nearly half the world's population now lives in urban settlements.

Rapid and often unplanned urban growth is the source for many of the environmental hazards faced by cities within the developing world (Cohen, 2006). Substandard housing on marginal land, crowding, solid and hazardous wastes, water pollution and over usage, inadequate sanitation services and motor vehicle traffic are all associated with rapid growth of urban centers (Moore et al., 2003). Air pollution is one of the other important problems in rapidly growing cities (Arku et al., 2008).

The dynamics of economic growth, industrialization and urbanization coupled with population growth are primarily responsible for air pollution (Chan and Yao, 2008). Air pollution is a serious problem especially in urban areas due to the concentration of people, both as perpetrators and victims of pollution. Air pollutants are responsible for a range of acute and chronic morbid effects and premature mortality in urban areas. Pollutants such as greenhouse gases have transboundary impacts such as ozone depletion and global warming which affect the health and livelihood of millions of people, particularly in the poor and developing countries.

Turkey is a developing country in which 68 million people are living with quite different socioeconomic and demographic features and dietary habits. According to the UN population growth projections, the population of Turkey expected to reach 92 million in 2025. One of the major challenges for Turkey is planning for population growth. Turkey has been affected by urbanization like other developing countries. Over the past 30 years, many cities of Turkey have experienced remarkably rapid economic development and social change, and this has significantly influenced urban life. Currently, over 45% of Turkey population lives in urban areas and the annual population growth rate are around 2.4% $year^{-1}$in urban areas compared around 1.7% $year^{-1}$in non-urban areas.

In Turkey, urban air pollution has increased rapidly with urban populations, numbers of motor vehicles, use of fuels with poor environmental performance, badly maintained roads and ineffective environmental regulations. As a result, millions of urban residents are exposed increasingly to air pollutants of urban origin.

Samsun is one of the largest cities in Turkey. Good transportation routes (The Black Sea Coast Highway, Çarşamba Airport, Harbor of Samsun and existence of a railway that can be developed), existence of rich subterranean waters, and large enough areas for the construction of factories are the reasons for rapid development. The most important Turkish port on the Black Sea, it is also a major tobacco-processing center and an agricultural market. Textiles, tobacco, and fertilizer are exported.

The aim of this study is to provide a broad overview of urban air pollution in Samsun which is a rapidly growing city in Turkey. It is targeted to emphasize the importance of reorganizing the institutional tools in a wide-angle perspective in order to generate coherent solutions to urban air pollution, and to enhance urban quality.

2. Air Pollution in Samsun

2.1. Topography and meteorology

The problem of air pollution is compounded by the topographical and meteorological factors. Mountains surround Samsun to the south with the Black Sea to the north (Figure 1). The mountains block the movement of Samsun's air and thus hinder the dispersion of air pollutants. Samsun is located between two deltas jutting out into the Black Sea. The deltas of Bafra and Çarşamba have been formed as a result of years of accumulation of alluviums carried by the Kızılırmak (the Red River) and Yeşilırmak (the Green River) rivers.

Figure 1. Geographic Layout of Samsun, Turkey

Samsun has a typical continental climate with four distinct seasons. In 2011, the lowest monthly average temperature was 7 ^{o}C in February and the highest monthly average temperature was 27 ^{o}C in August. Domestic heating usually starts in the beginning of November and ends in the following April. The utilization rate of domestic heating tools in urban and rural areas of Samsun are given in Figure 2. As seen in Figure 2, the highest utilization rate for heating is coal in urban areas. The high air pollution in the winter is mainly due to domestic heating (Wang et al., 2005; Duan et al., 2006). There were 140 rainy days. The frequent rain removes air pollutants effectively. Samsun is humid and the highest average relative humidity is 80%. High temperature and relative humidity conditions in the summer favor the transformation of air pollutants, resulting in some episodes with high concentrations of secondary pollutants (He et al., 2001; Yao et al., 2003; Shao et al., 2006). In addition, the annual average number of foogy days (with visibility less than 1 km) in Samsun was 4 days in 1985. The number of foggy days has substantially increased from 4 to 20 days in Samsun over the last 25 years due to increasing air pollution. The liquid water content in fog droplets is expected to be much higher than that in the

atmospheric aerosols present during fogless weather, and fog can promote the transformation of air pollutants (Chan and Yao, 2008).

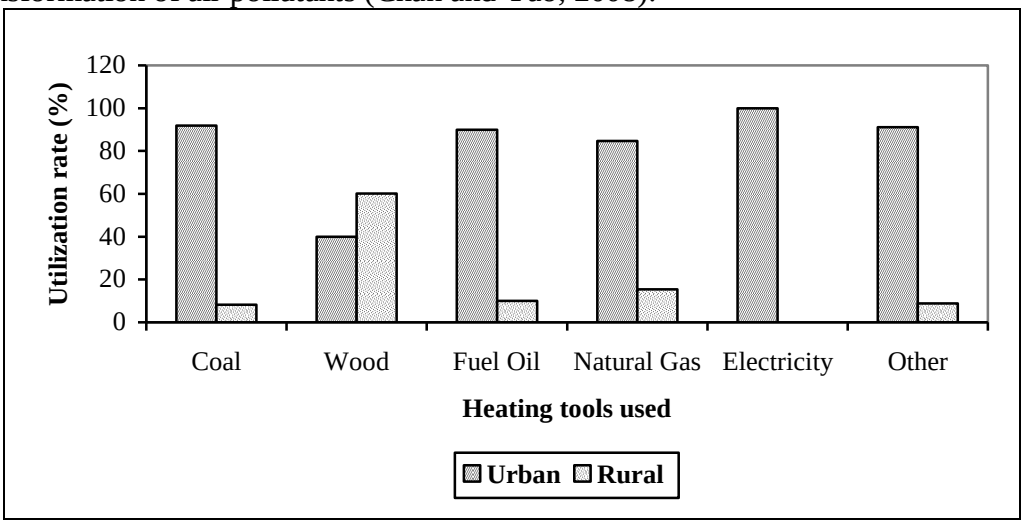

Figure 2. The utilization rate of heating tools in urban and rural areas of Samsun

2.2. Urbanization trends

Samsun is the 14th largest province of Turkey with 1209137 in habitants, according to the 2010 census. Of theese population, 635254 in habitans live in the urban areas. Samsun has experienced and unusual urbanization due to recent in-migration from the rural areas. Recently, Samsun has faced a high urbanization rate.

The proportion of the Turkish population living in urban areas has been increasing rapidly since the end of the Second World War. While the metropolitan population was 24% of the total Turkish population in 1945, it increased to 58% in 1985 and reached 65% in 2000.

In 1927, one-fourth of the population of Samsun lived in urban areas. At that time, there were only arround 55.5 thousand people living in urban areas. Continued urbanization over the last 80 years has resulted in a situation where by close to 65% of Samsun's population. Compared against the rapid rise in the urban population, the growth of Samsun's rural population has been relatively slow. Population increase and distribution of population in Samsun between 1940 and 2010 are shown in Figure 3.

In the earlier waves of industrialiaziation, rapid urban growth was largely fueled by rural-to-urban migation. Throughout the developing world, the factors driving rural-to-urban migration are complex. Migrants are not only pullet towards cities by the prospect of jobs and higher incomes, they are also pushed out of rural areas by such factors as poverty, lack of land, declining agricultural work, war, and famine. In cities of Turkey today, however, the natural increas of the urban population is at least as important as migration (Kaya and Curran, 2006). The stress on the Black Sea has not been the highest mainly due to unable to find work and to generate enough income. In Samsun where is located in the Black Sea region, the out-migration is higher than the in-migration because of the theese factors. Also, the in-migration is generally from the rural to urban.

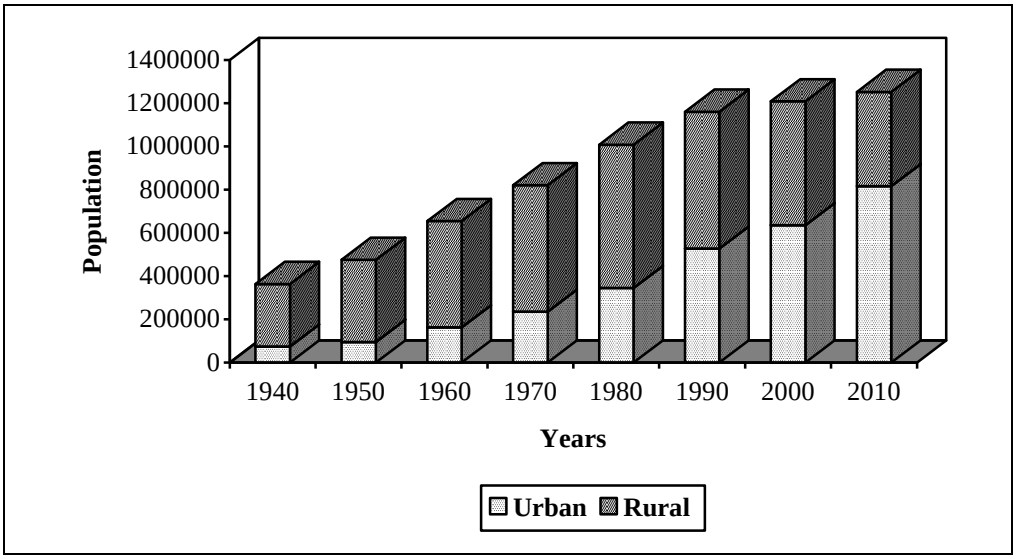

Figure 3. Urban and rural population in Samsun

2.3. Industrial activities

Principal sources of air pollution are the industrial activities or processes releasing large quantity of pollutants in the atmosphere. These pollutants mainly come out from:
(a) various industries like, power plants, chemical plants, other manufacturing facilities, motor vehicles, etc.;
(b) Burning of wood, coal in furnaces and incinerators;
(c) oil refining industries;
(d) various industries such as cement plants, ore / stone crushing units, mining industries, etc.;
(e) waste deposition for landfills which generate methane.

The major winds blow from the east and southeast, where most of the industries are located. The air pollutants are carried into the central areas by wind. In Samsun, large scale industries generally apply pollution control processes, while most of the small and mid-sized industries do not install pollution control equipment. This increases the emission of pollutants, especially in the industrial areas, which in some cases contributes specific pollutants to the air. Moreover, small industries are generally located in urban areas where emission control is more problematic.

There are many sources of potential air pollution including three major factories, rubber and plastic industry, fertilizer industry and several metal industries. Among them, the industrial boilers, which are used for heat production, have a significant role in the ambient air pollution because a large number of the boilers are in operation with no emission control system in the area. The boilers generally use coal, fuel oil numbers 4, 5 and 6, and natural gas as a fuel. Distribution of the boilers according to the fuels shows that boilers with gaseous fuels are preferred more, possibly due to the restrictions set by the Turkish Ministry of Environment related to the SO_2 emissions and the availability of natural gas in Samsun. A comparison of

emission factors shows that particulate matter and SO_2 emissions from the natural gas-using boilers are lower.

2.4. Motor vehicles and transportation

Air pollution from road transport is of continuing concern, despite measures to control emissions, as traffic volumes continue to increase. Motor vehicles such as personal cars, commercial vehicles, and motorcycles are mobil sources and emit a complex mixture of airborne pollutants, many of which may have ecological effects. These include nitrogen oxides (NOx), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), metals, and particulates. Ammonia (NH_3) and nitrous acid (HONO) are also potentially important, particularly at the roadside (Truscott et al., 2005; Bignal et al., 2008).

By the end of 2011, there were 244.2 thousand vehicles registered in Samsun, compared to 104.9 thousand in 1995, an increase of almost 139.3 thousand vehicles or 57% (Figure 4). These conditions have caused severe congestion in almost all parts of the highway network and corridors, particularly in urban areas, and inevitably the environment in these areas has deteriorated due to exhaust emissions from motor vehicles (Afroz et al., 2003).

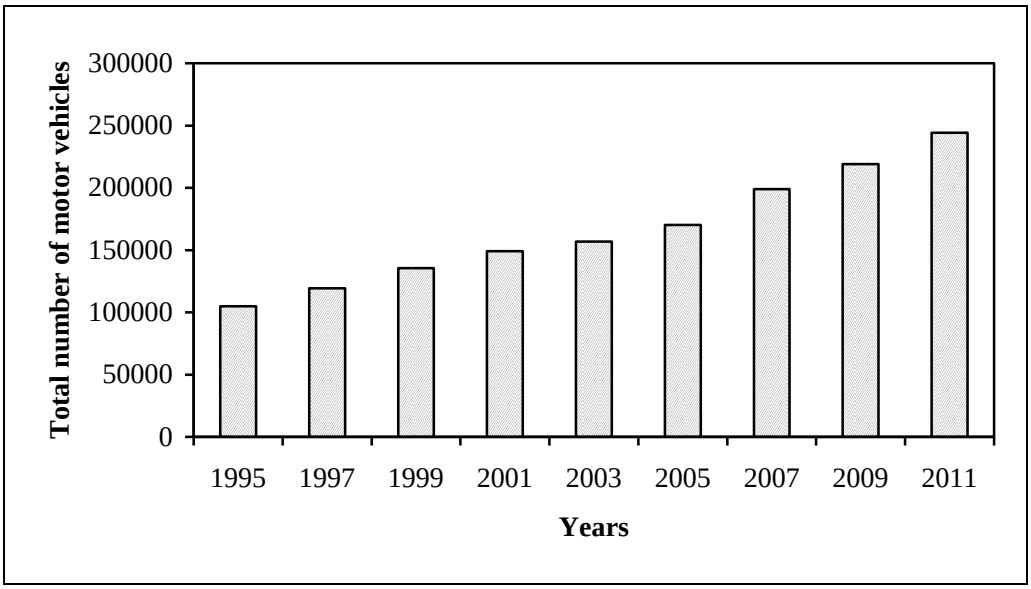

Figure 4. Annual variations in the motor vehicles in Samsun

2.2. Air pollutants

Sulpfur dioxide (SO_2) and particulate matter (PM_{10}) concentrations are monitored by Turkish Ministry of Environment and reported by Turkish Statistical Institute.

SO_2 is produced by combustion of sulpfur-containing fuels such as coal and fuel oils. SO_2 also produced in the process of producing sulfuric acid and in metallurgical process involving ores that contain sulpfur. Sulphur dioxide can cause

breathing difficulties. It is toxic to plants and can cause acid rain when it reacts with moisture in the air. Acid rain damages trees and other plants, and it can also affect the soil.

Annual variations for SO_2 concentration in Samsun are shown in Figure 5. As shown in Figure 5, the annual average of SO_2 concentration gradually decreased from 132 $\mu g/m^3$ in 1990 to 7 $\mu g/m^3$ in 2010. In 2002, SO_2 concentration was sharply increased since a mobile power plant was constructed. This plant was operated only one year. Limit SO_2 concentration is 250, 50 and 80 $\mu g/m^3$ acoording to the National (Turkish), WHO and EPA Ambient Air Quality Standards, respectively. After 2004, the annual average of SO_2 concentration is at a safe level based on above standards.

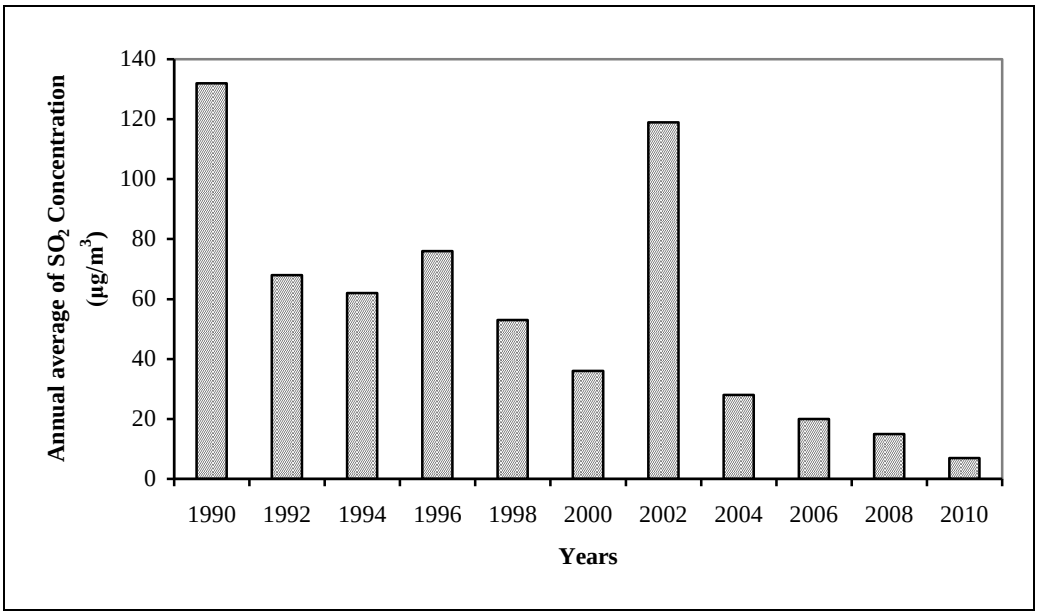

Figure 5. Annual variations for SO_2 concentration in Samsun

The number of days with SO_2 concentrations exceeding the Turkish Ambient Air Quality Standards decreased during the period of 1990-2010 in Samsun. The highest numbers of days of SO_2 concentrations occurred in 1990 with 22 days. Since 2005, there is not a day with SO_2 concentrations exceeding the national standards in Samsun.

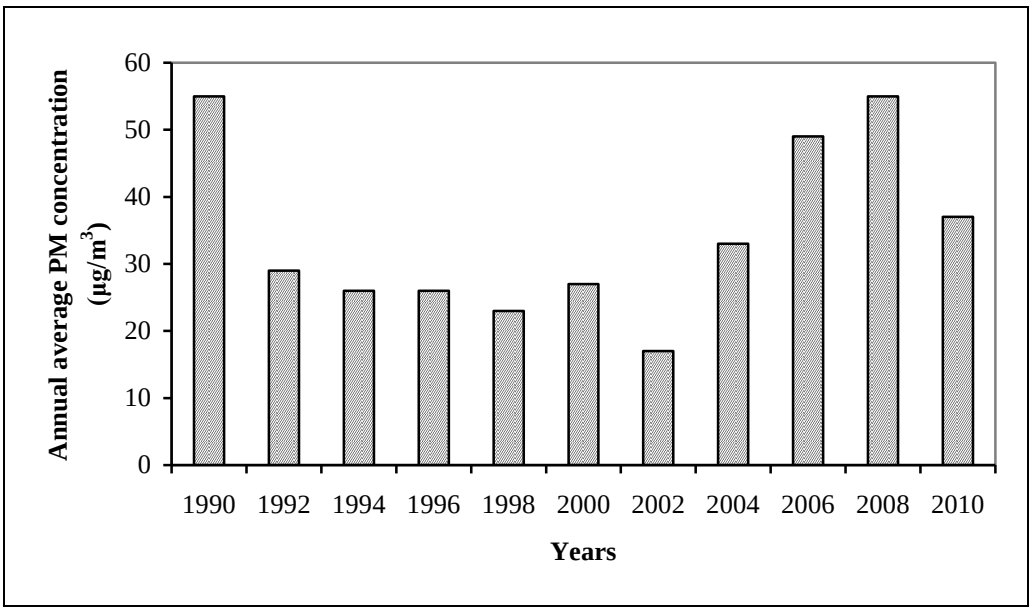

Figure 5. Annual variations for PM_{10} concentration in Samsun

PM_{10} is a criteria pollutant in the National Ambient Air Pollutant Standards. The inhalation of particles has been linked with illness and deaths from heart and lung disease as a result of both short- and long-term exposures. People with heart and lung disease may experience chest pain, shortness of breath, fatigue etc., when exposed to particulate-matter pollutants.

The annual average of PM_{10} varied between 17 and 55 $\mu g/m^3$ in 1990-2010 as shown in Figure 5. The annual average of PM_{10} was almost constant from 1992 to 2004, and was about 30 55 $\mu g/m^3$. Limit PM_{10} concentration is 150, 20 and 50 $\mu g/m^3$ according to the National (Turkish), WHO and EPA Ambient Air Quality Standards, respectively. PM_{10} concentrations do not exceed the National Ambient Air Quality Standards, while the concentrations exceed WHO and EPA Ambient Air Quality Standards in most of the years.

3. Conclusions

Rapid urbanization in many developing countries worldwide has become a major concern because of its detrimental effects on environment. In particular, air pollution is increasing rapidly in urban areas in many mega cities of the developing world. In Turkey, urban air pollution has increased rapidly with urban populations, industrialization, numbers of motor vehicles, use of fuels with poor environmental performance and ineffective environmental regulations. Therefore, there should be a strategic framework of action prepared by local planners based on the core principles of sustainable development.

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