

## **AIR QUALITY IN URBAN AREAS OF CENTRAL MACEDONIA, GREECE**

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**Abstract.** The concentration levels of primary (CO, SO<sub>2</sub>, and total suspended particulates (TSP)) and secondary (NO<sub>2</sub> and O<sub>3</sub>) pollutants in the atmosphere of seven cities (Thessaloniki, Moudania, Serres, Kilkis, Edessa, Veria and Katerini) of Central Macedonia – Greece, during the period 1996–1997, are examined in this paper. The levels of the air pollutants are lower than the air quality standards in the most of the cases. The urban areas with higher population and vehicle fleet present relatively higher levels of CO and NO<sub>2</sub>, but lower levels of O<sub>3</sub>. The values of TSP are significantly higher in urban areas where the vehicle traffic and mainly the diesel car contribution are higher.

*Keywords:* urban area, primary and secondary air pollutants.

### **AIMS AND BACKGROUND**

The Region of Central Macedonia is the greatest region of Greece in surface and the second in population. This region is divided administratively in seven Prefectures: Thessaloniki, Chalkidiki, Serres, Kilkis, Pella, Imathia and Pieria.

The total population of Central Macedonia reaches almost two million inhabitants and more than half of them lives in the Prefecture of Thessaloniki. The population of the region is mainly urban (more than 60%) and its vehicle fleet constitutes about 15% of the Greek fleet. The greatest part of the region vehicles (about 11 % of the Greek fleet) are presented in the urban area of Thessaloniki.

The temporal evolution of the air pollution sources in Greek urban areas is characterized by the continuous increase of the vehicles fleet and mainly the new technology passenger cars equipped with three-way catalytic converters, which are almost the half of the total passenger cars. The air pollution trends show a significant temporal decrease of the primary pollutants and a slight increase or stabilization of the secondary pollutants<sup>1-4</sup>.

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The concentration levels of primary and secondary pollutants in the atmosphere of seven urban areas of Central Macedonia, during the period 1996-1997, are examined in this paper.

## EXPERIMENTAL

The examined air pollutants are: CO (carbon monoxide), SO<sub>2</sub> (sulphur dioxide), TSP (total suspended particulates), NO<sub>2</sub> (nitrogen dioxide) and O<sub>3</sub> (ozone). The CO is measured by the non-dispersive infrared radiation absorption method, the SO<sub>2</sub> by the fluorescence method, the TSP by the high volume air sampler method, the NO<sub>2</sub> by the chemiluminescence method, and the O<sub>3</sub> by the ultraviolet radiation absorption method according to the reference methods of the Hellenic State and the directives of the European Union.

The air pollutant concentrations resulted from a mobile air quality monitoring station for the 6 cities: Moudania, Serres, Kilkis, Edessa, Veria and Katerini and a stationary air quality monitoring station for the city of Thessaloniki. All the monitoring stations are operated by the Ministry of Macedonia — Thrace<sup>5-6</sup>.

The measurements by the mobile station have been realized during 60 days of the period 1996-1997, in every city and they covered equally the cold and warm period of the year. The measurements by the stationary monitoring station covered all the 1996-1997 period.

The monitoring stations were located in the urban areas of the above mentioned cities and their characteristics are the following:

- Thessaloniki (capital city of the Thessaloniki Prefecture): Dimokratias Square, centre of the city, the most important cross-roads of the city, high traffic load and very important traffic of urban transport bus.

- Moudania (important touristic city of the Chalkidiki Prefecture): city central square, very high traffic mainly during the summer period.

- Serres (capital city of the Serres Prefecture): city commercial centre, near to the urban transport bus central station.

- Kilkis (capital city of the Kilkis Prefecture): city commercial centre, near to the inter-urban transport bus station.

- Edessa (capital city of the Pella Prefecture): city commercial centre, on a high traffic road mainly during summer.

- Veria (capital city of the Imathia Prefecture): city commercial centre.

- Katerini (capital city of the Pieria Prefecture): city commercial centre, a high density population area.

## RESULTS AND DISCUSSION

The average concentrations of  $\text{SO}_2$  are very low (below the EU limit value and guideline) in the most of the urban areas of Central Macedonia during the examined period (Fig. 1). The significantly high levels observed in Serres city centre could be attributed to the presence of the urban transport bus central station in the neighbourhood of the monitoring station leading to a high traffic of diesel engine buses, which are important sources of  $\text{SO}_2$  emissions.

The urban areas with the highest population and vehicle fleet (Thessaloniki and Serres) and the Moudania area with a very high touristic traffic in summer, present TSP concentrations above the EU air quality standard:  $150 \mu\text{g}/\text{m}^3$  (Fig. 2). The contribution of the urban transport bus traffic (diesel vehicles) in the Thessaloniki and Serres examined areas and the inter-urban transport bus traffic (diesel engines) in the Moudania area could be considered as a very important factor for the observed TSP levels.

The average concentrations of CO are very low in all the urban areas of Central Macedonia during the examined period (Fig. 3) showing the important contribution of the new technology passenger cars in lowering the CO emissions. The urban areas with relatively higher population and passenger car fleet (Thessaloniki, Serres, Edessa and Veria) present relatively higher levels of CO. The Moudania touristic area has also relatively higher values than the rest two low traffic areas.

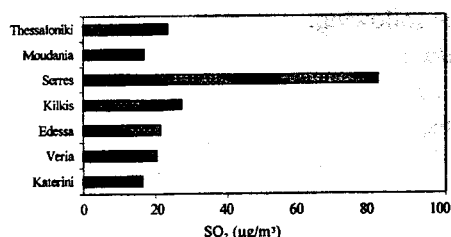


Fig. 1. Average concentrations of  $\text{SO}_2$  in the atmosphere of seven urban areas of Central Macedonia during the period 1996-1997

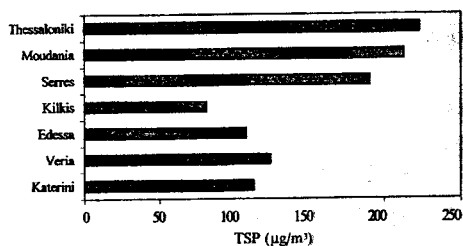


Fig. 2. Average concentrations of TSP in the atmosphere of seven urban areas of Central Macedonia during the period 1996-1997

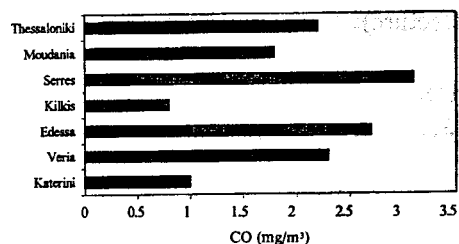


Fig. 3. Average concentrations of CO in the atmosphere of seven urban areas of Central Macedonia during the period 1996-1997

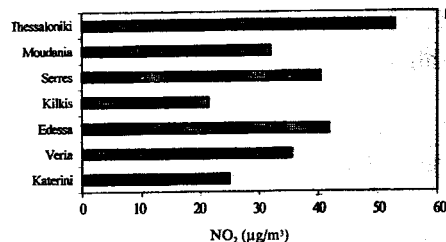


Fig. 4. Average concentrations of  $\text{NO}_2$  in the atmosphere of seven urban areas of Central Macedonia during the period 1996-1997

The NO<sub>2</sub> average concentrations present the same spatial distribution as in the case of CO: higher levels in the urban areas with relatively higher population and passenger car fleet (Thessaloniki, Serres, Edessa and Veria) (Fig. 4). This observation is related to the common origin of CO and NO<sub>2</sub> emissions, which are mainly the passenger cars.

The urban areas (Katerini, Kilkis and Moudania) with the relatively lower CO levels present higher O<sub>3</sub> average concentrations (Fig. 5). This is due to the known physicochemical behaviour of O<sub>3</sub>, which is a secondary photochemical pollutant, and when produced, presents higher values in the areas where the primary pollutants have low levels.

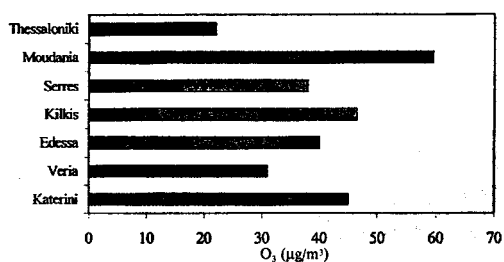


Fig. 5. Average concentrations of O<sub>3</sub> in the atmosphere of seven urban areas of Central Macedonia during the period 1996-1997

## CONCLUSIONS

The concentration levels of primary (CO, SO<sub>2</sub>, and TSP) and secondary (NO<sub>2</sub> and O<sub>3</sub>) pollutants in the atmosphere of seven cities (Thessaloniki, Moudania, Serres, Kilkis, Edessa, Veria and Katerini) of Central Macedonia – Greece, are lower than the air quality standards in the most of the cases. The urban areas (Thessaloniki, Serres, Edessa and Veria) with higher population and passenger car fleet present relatively higher levels of CO and NO<sub>2</sub>, but lower levels of O<sub>3</sub>. The values of TSP are significantly higher in urban areas (Thessaloniki, Serres and Moudania), where the vehicle traffic and mainly the diesel car contribution are higher.

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