Acta Technica Napocensis: Civil Engineering & Architecture Vol. 56, No. 4 (2013)
Journal homepage: http://constructii.utcluj.ro/ActaCivilEng
Special Issue: International Conference Sustainable Solutions for Energy and Environment-EENVIRO 2013.

Pollutant concentration study for Bucharest city in the perspective of the EU Air Quality Framework Directive

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(Accepted 11 October 2013; Published online 26 December 2013)

Abstract

Outdoor pollution is one of the key and decisive factors for keeping proper environment quality, as seen in the European directives. In this study, an eight year analysis was conducted for Bucharest city, in order to highlight the air pollutant concentration and the threshold exceeding for both human and vegetation. One of the largest monitoring networks was used, recording both pollutant concentration and meteorological parameters.

Rezumat

Poluarea aerului din mediile urbane este un factor decisiv in păstrarea calităţii mediului înconjurător, fapt dovedit şi de legislaţia şi directive UE. Acest studiu vizează o analiză a calităţii aerului în Bucureşti pe o perioadă de opt ani, pentru a evidenţia concentraţiile de poluanţi şi depăşirea limitelor maxime admise pentru protecţia umană şi a vegetaţiei. S-a folosit una dintre cele mai mari reţele de monitorizare, cu posibilitatea înregistrării în timp atât a concentrației poluanţilor cât şi a parametrilor meteo.

Keywords: Air pollution, Bucharest, Ozone, Directive 2008/50/EC, Threshold exceeding

1. Introduction

One of the major problems for the large cities represents the air pollution that leads for serious problems for the inhabitants and the environment. Crowded cities expose their inhabitants to a variety of pollutants, such as nitrogen oxides, sulfur oxides, ozone, particulate matter, carbon monoxide, cadmium, mercury, etc., exposure that could lead to severe health problems: cardiovascular, lung diseases, asthma attacks (1), leukemia and birth defects, etc. and could even lead to death in the case of sensitive persons (2). It is estimated that ozone related deaths in Netherlands were 990, 1140 and 1400, during June – August 2000, 2002, 2003 [3].

In order to reduce the pollution level, efforts were made through different directives and regulations. The New Air quality directive, Directive 2008/50/EC, merged all the existing legislation except for the fourth "daughter directive" (3). The assessment and management of air quality in Member States of the European Union is regulated by the Air Quality Framework Directive (European Union (EU), 1996) (3) with no changes to the existing air quality objectives after the merging of the legislation.

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In an effort to meet the EU air quality standards, Romania aligned its air quality regulation to the European Union with law no. 104/2011.

Air pollution is a complex process that varies in time and space, influenced by a variety of factors. For example, in the summer O3 levels are most strongly influenced by meteorological condition (4). Other meteorological parameters like wind speed, wind direction, temperature and relative humidity (5), season of the year, urban activity, industrial activity, geometry of the city and air transportation are also affecting ozone and other pollutant concentration.

This study aims at obtaining information about air quality over Bucharest, the capital of Romania and is the first study subjected to the wide evaluation of air quality.

Bucharest city, being the 10th largest city in the European Union and accounting 1,6 million inhabitants with over a million vehicles with 1.6 cars per inhabitant is one of the greatest urban congestions (10,6% of the country's population), with the air quality in a continuous degradation.
Air quality and meteorological monitoring was done using one of the largest monitoring network comprising eight fixed ground stations for air quality monitoring, placed in the urban area, as well as in the city limits with live and simultaneously data acquisition. Seven pollutants and metrological data were targeted (nitrogen oxides, sulfur dioxide, ozone, carbon monoxide, cadmium, particulate matter), being monitored for over eight years (2004 – 2011).

The present paper reports on ambient air pollution in urban and suburban areas of Bucharest city using data obtained by conventional monitoring of atmospheric pollutants concentrations.

Here we try to determine the statistics for ozone threshold exceeding, comparing with the EU norms and other European cities for different locations within the city of Bucharest.

2. Method

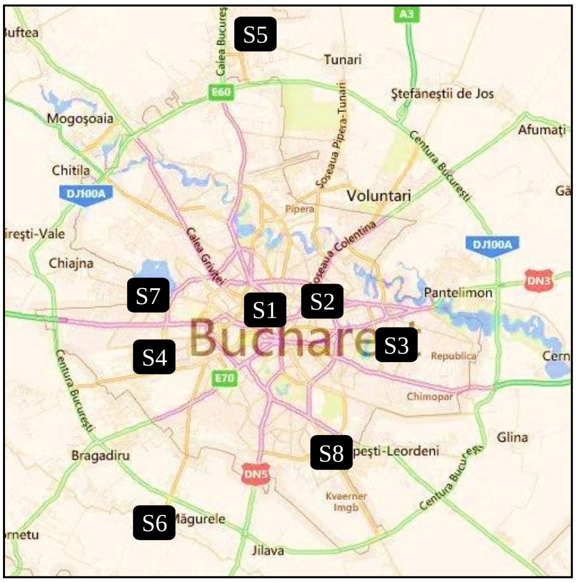
2.1 Studied City

Our study is oriented towards the pollution monitoring in Bucharest, the largest city of Romania and it's capital, located in the southeast part of the country (44°25′57″N 26°06′14″E) with over 2 million residents. Several lakes stretch across the northern parts of the city. In winter the temperature falls below 0°C, while in the summer, its average value is 23°C (July and August) with low precipitation and humidity. Bucharest has a transitional climate, with both continental and subtropical influences with windy climate.

2.2. Sampling locations

In order to investigate the pollution level a monitoring network was set up stretching along different parts of the city, recording the following pollutant concentrations: nitrogen oxides, sulfur dioxide, ozone, carbon monoxide, cadmium and particulate matter. A total of eight pollution monitoring stations forms the network, part of the larger Romanian Network for Air Quality Monitoring (RNMCA) launched in 2004, which operates under the supervision of the Romanian Ministry of the Environment and the National Agency for Environmental Protection (ANMP).

Each monitoring station (Figure 1) records the atmospheric pollutants concentrations along with seven meteorological parameters: wind direction, wind speed, relative humidity, temperature at 2m and 10m, solar radiation and atmospheric pressure within the urban and suburban areas of Bucharest.



a. Network stations locations

b. Photo of the monitoring station S2

Fig 1. Bucharest air quality monitoring network

Table 1: – Real time monitoring stations

Station	Area	Station category	Placement details
S1	Cercul Militar	Traffic	downtown
S2	Mihai Bravu	Traffic	downtown
S3	Titan	Industrial	outskirts
S4	Drumul Taberei	Industrial	outskirts
S5	Baloteşti	Peripheral	outside; 9.63km north from the city ring road
S6	Măgurele	Peripheral	outside; right after the city ring road
S7	Lacul Morii	Peripheral	outskirts
S8	Berceni	Industrial	outskirts

2.3. Instrumentations and measurement protocol

Each measuring station is comprised of air conditioned trailers or containers that houses analyzers, gas tanks for calibration and a computer based data storage and sampling control.

The NO and NO2 concentration measurements were based on chemiluminescence phenomenon [10], O3 concentrations and SO2 concentrations were recorded using the principle of absorption of light law which passes the probe through a constant length chamber with a beam of UV monochromatic radiation applied, CO concentrations were measured using nondispersive infrared sensor, PM10, Pb and Cd were sampled using a low volume sampler and gravimetrically measured afterwards.

All the measurement instruments used for gas analyses are characterized by a span drift of less than

1% and a zero drift of less than 1 ppb for a 7 day period, leading to precise measurement values in the usual measuring range of 0-100 ppb.

Meteorological data was recorded using sensors mounted 2 m above the roof of each monitoring station. Wind direction was measured by means of a gonio-anemometer sensor. Wind speed was measured by means of a wind vane tacho-anemometer. The temperature and relative humidity were measured by means of a normalized output thermo-higro-meter, consisting of a Pt100 thermo resistance for temperature measurements and a capacitive plate as the humidity sensor. Atmospheric pressure was measured by means of a piezoelectric sensor and solar radiation was measured by means of a pyranometer radiation sensor.

With the use of the calibrator and a zero air generator, the analyzers are calibrated once a day to insure minimum drift errors. Measurement data is stored locally at the measurement stations and a remote server located at the Bucharest Agency for Environment Protection (ARPMB) receives data from all the pollution measuring stations every hour by means of GSM modem.

All the measured data is validated through a technique that checks for inconsistencies both locally at the measurement station and at the remote server

3. Results and discussion

Processing the data, one can notice in fig. 2 that outside the urban congestion, there is an increase in O_3 concentrations possibly due to low traffic, station no. 5 recording the maximum O_3 concentration. Low O_3 concentration was recorded downtown, station no. 1 and no. 2 recording the minimum O_3 concentrations.

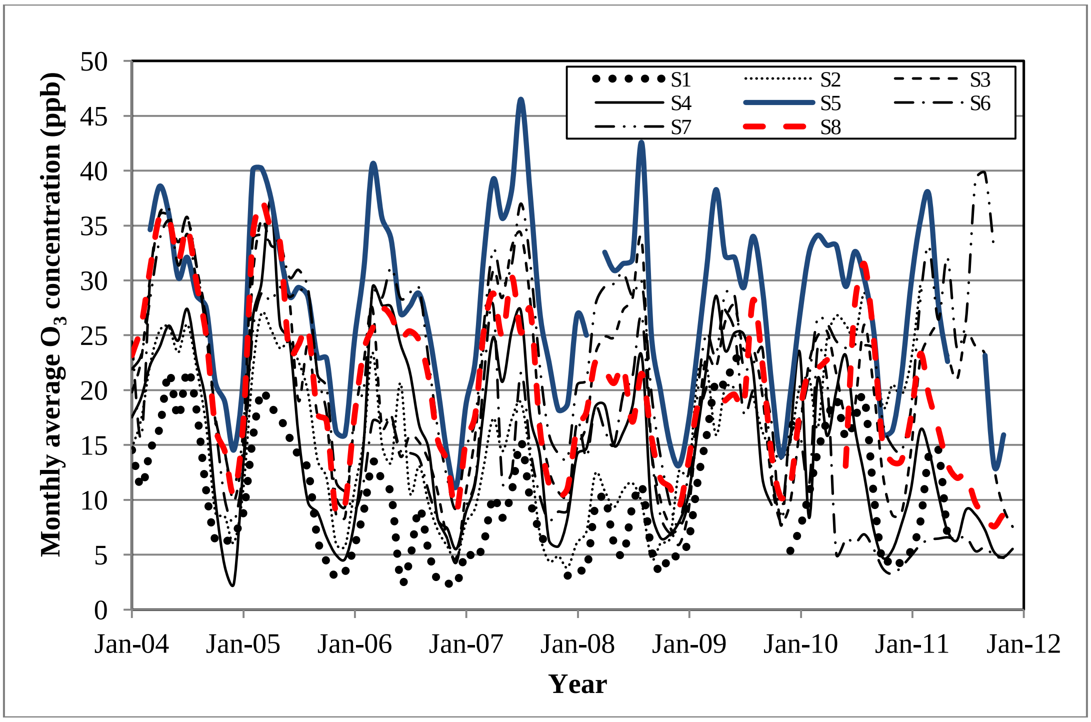


Fig. 2 - Annual variation of ozone concentration

The other stations reported concentration values within the limits, with high values when reaching city limits. We would expect to have similar trends for all stations with respect to location but two stations had different trends, contrary to expectations. Station no. 6 located outside Bucharest recorded lower O_3 concentrations compared to other stations located outside the city and also station no. 7 showed a different trend, recording higher ozone values when compared to other stations within the city, possibly due to the location near Morii Lake.

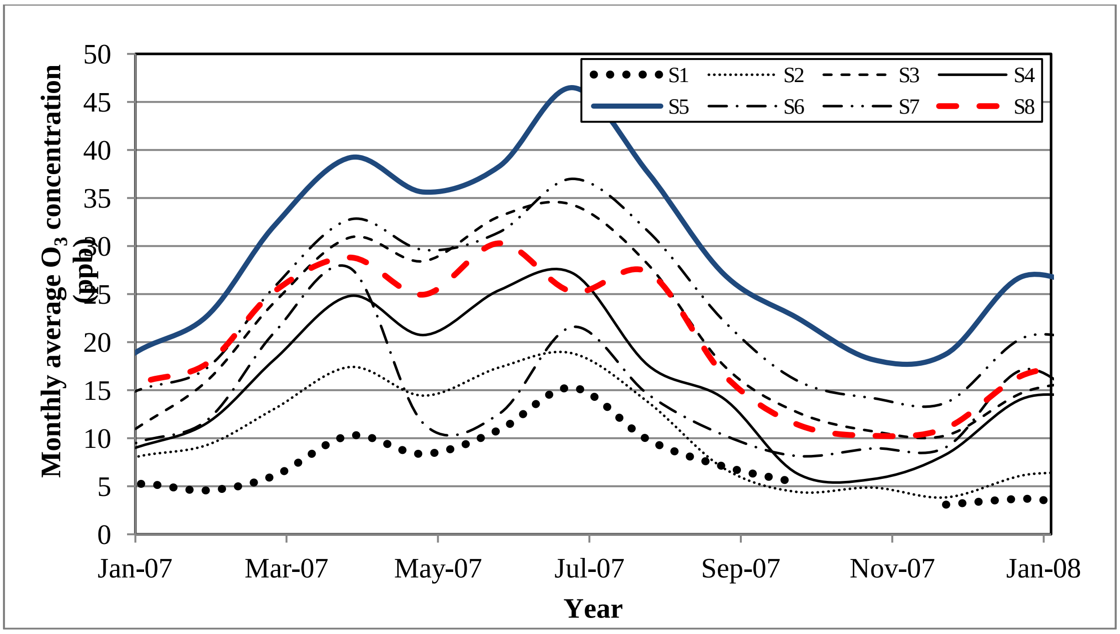


Fig. 3 – Annual Ozone variation (2007)

The ozone concentration variation shown in fig. 3 shows a clear increase in concentration in the summer, with peak values in July and a steady decrease towards winter.

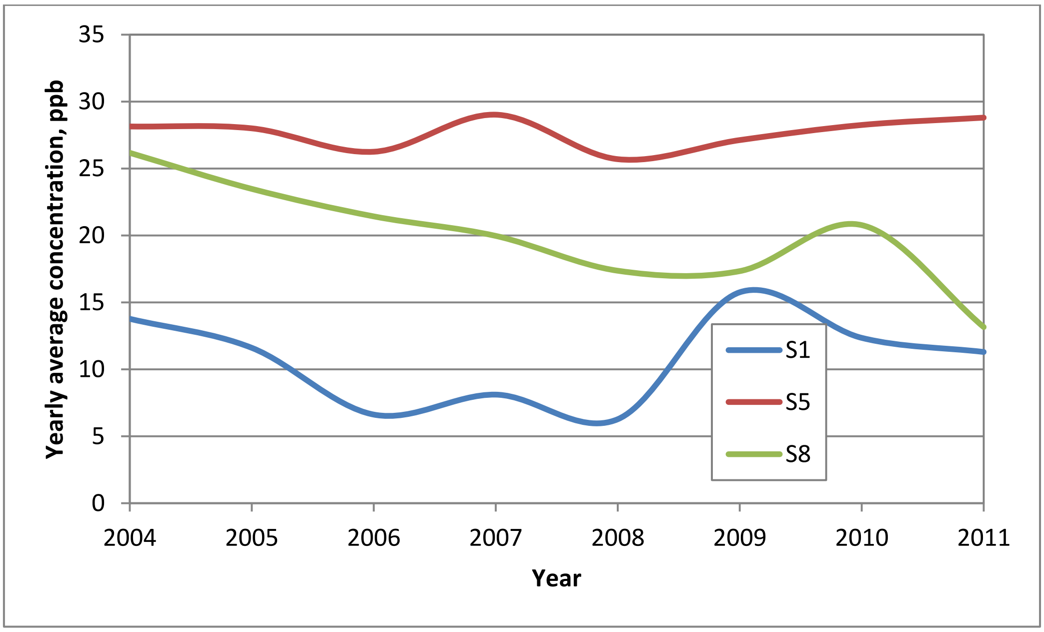


Fig. 4 – Yearly average O_3 concentration

The concentration trends resulted after averaging the yearly ozone concentration (fig. 4), shows a relative constant variation in time for stations no. 1 and 5. Only one station had a relatively steady decrease in time, station no. 5 located outside the city, with a one year only increase in concentration during 2004 – 2011.

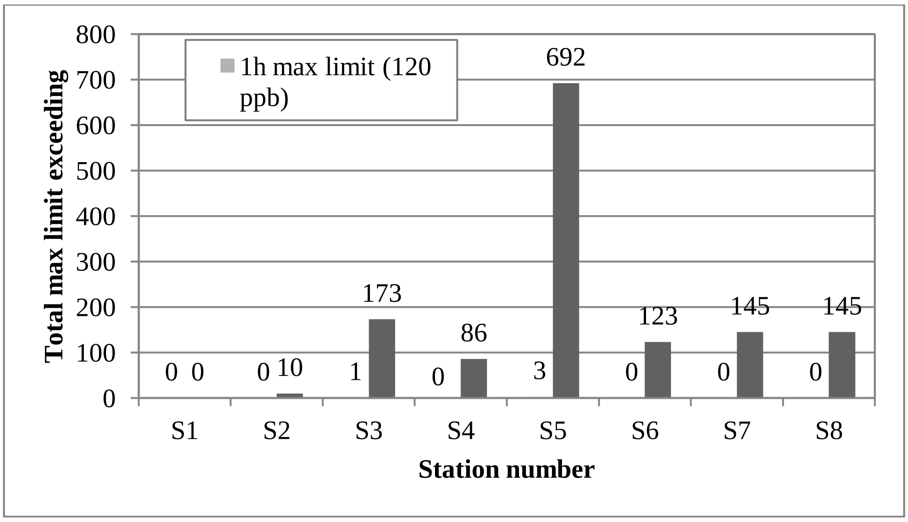


Fig. 5 – O_3 total maximum limit exceeding, 1h & 8h max limit during 2004 – 2011

Figure 4 presents the total number of maximum limit exceeding for all stations during 2004-2011, compared to the 1h maximum limit of 120 ppb and 8h maximum limit of 60 ppb for Ozone. Station no. 5 recorded over 690 times an abnormal O_3 concentration, exceeding the 8h maximum exposure limit. All stations recorded concentrations over the 8h maximum limit, with station no 2 and 3 having almost no exceeding in concentration limits.

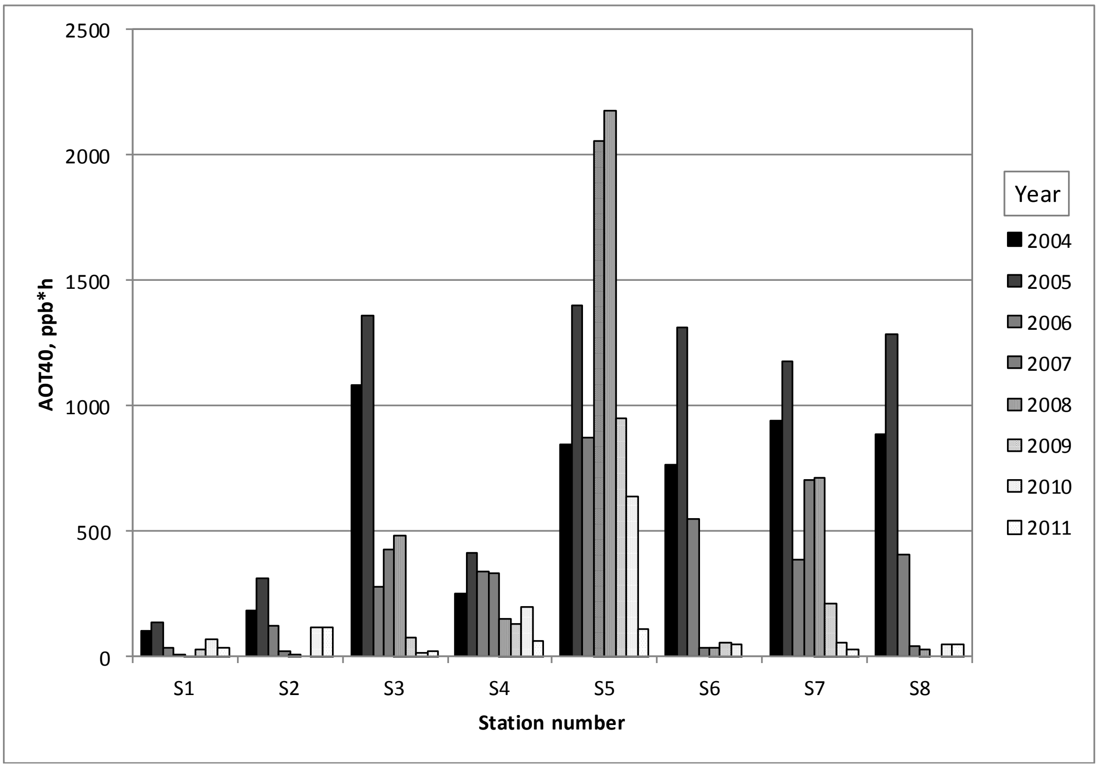


Fig. 6 – AOT40 values for the period May – July during 2004 – 2005

The AOT40 (accumulated dose of ozone over a threshold of 40 ppb) was computed from 1 May to 31 July and none of the station has exceeded the EU target value of 9000 ppb*h, nor the WHO guidline (or the EU long-term objective) of 3000 ppb*h. Comparing the results with other European cities, we can see that Bucharest has low AOT40 values, with high values at the suburban stations and low values recorded at the urban station.

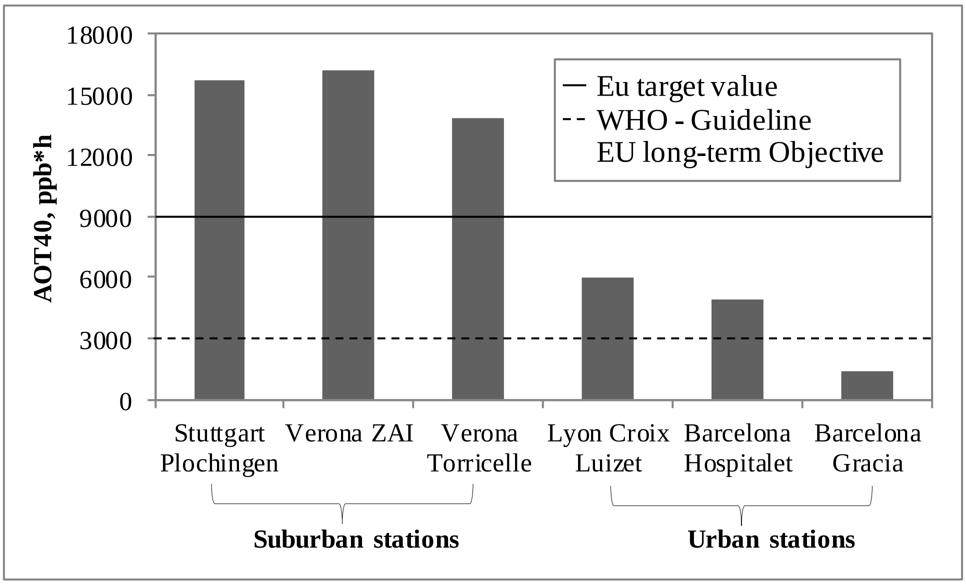


Fig. 7 – AOT40 values for the period May – July 2001 for European cities, urban and suburban stations [9]

4. Conclusions

Elevated ozone concentrations can be observed in many European cities, exceeding the limits set by national and European threshold values, possibly leading to health problems and vegetation damage. Our studied showed that ozone concentration levels in Bucharest differ from station to station, with low O_3 levels recorded at urban stations and higher levels recorded at suburban and outside the city stations. The concentration measured during 2004 – 2011 exceeded the limits set by the National and EU target values mainly at stations outside the city, but the concentration tends to decrease when comparing yearly average values with AOT40 values within the limits for the eight study.

Acknowledgements

The study was performed during the PN II RU TE 2011 3 209 project supported by Romanian Research Council (CNCSIS) and the financing organism UEFISCSU. We thank Romanian Environment Agency for the database with the pollutants concentrations and meteorological parameters for the Bucharest.

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