AES BIOFLUX

Advances in Environmental Sciences - International Journal of the Bioflux Society

Methods and equipments used in the monitoring of the atmospheric pollutants in urban environment

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Abstract. The aerial gateway represents the carrier where through the fastest transport of pollutants takes place in the surroundings. The causes of atmospheric pollution are multiple - the anthropic activities, the natural sources (volcanic eruptions, fires, long distance transport of Saharan dust). In the urban environment, a significant source of lowering the quality of air is the road traffic. The present paper emphasizes the importance of measured data quality and the fact that they depend on measuring equipments and methods used. Both methods and measuring equipments used for the atmospheric pollutants should be used so that, the data obtained for a certain measuring point in the field, to be able to be compared with the existing data in the global network (E.g. AERONET Network–Aerosol Net-work).
Key Words: atmospheric pollutants, monitoring the air quality, global network.

Introduction. The atmosphere is made up by several layers that differ on each other, depending on the composition, temperature and steadiness. Therefore, starting with the Ground surface's, the first layer is called troposphere, followed by stratosphere, mesosphere and thermosphere, as pointed out in the Figure 1. Those layers are separated by transition zones, tropopause, stratopause, mesopause.

Troposphere is the basic layer of the atmosphere. Even though it is the slightest layer of the atmosphere; it concentrates the biggest part of the total aerial mass. Also, within this layer the most important phenomena and meteorological processes take place. The average height of troposphere is 10-12 km; in reality, it stretches between 8-9 km at Poles and 16-18 km at Equator (Figure 2). Different thickness of troposphere can be explained by centrifugal force effect (that impresses the rotation ellipsoid shape) as well as due to the fact that at ground level, the troposphere air is warm up different on latitude, and depending on those aspects, the column density varies.

At his turn, the troposphere is made up by: planetary border layer (between 1-3 km), middle layer or free troposphere (3-6 km) and height troposphere (6 km).

The planetary border layer stands as the layer from lower atmosphere, towards which the attention of all studies is pointed out by researchers, by meteorologists etc. In particular, when it is considered that the processes that take place at ground surface – e.g. in agriculture - where the vaporization can be estimated; in environmental processes – like pollutants emissions or even gases from cars; studies concerning the greenhouse effect; or studies concerning the turbulence agreement – extremely severe weather (Stefan 2004).

Atmospheric pollution generated by anthropic activities became not only a certitude but also o problem of humankind, determined by the alarming growth oh inhabitants and their needs, due to the diversification and socio-economical activities amplifying.

Alongside with other anthropic activities, the transport is a major source of pollution. Out of the transport area, the road transport has the most significant contribution, taking into account the fact that a big part of these activities take place within the cities with large crowds (agglomeration) of people. In the next 30-40 years, it is forecast that the number of kilometers run by each car will double, not even mentioning that the number of holders (occupants) on each car will decrease, as well as the number of new cars in the traffic will increase. This effect is caused by the mobility independence demand. The pollutants emitted by cars are presented in Figure 3 (burning gasses, particles broken out car tires, break liquid leaks, brake plates detachments).

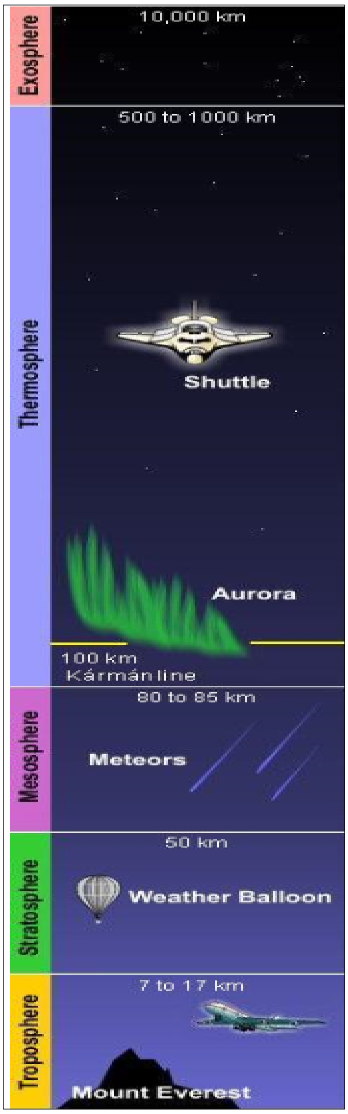

Figure 1. Vertical structure of atmosphere (www. en.citizendium.org).

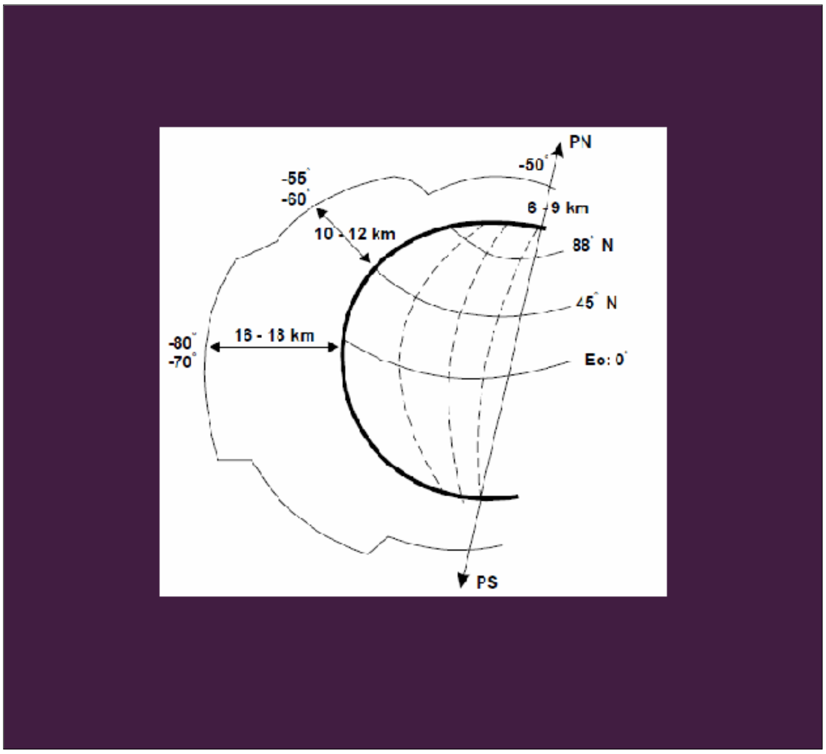

Figure 2. The thickness of troposphere at different heights (Stefan 2004).

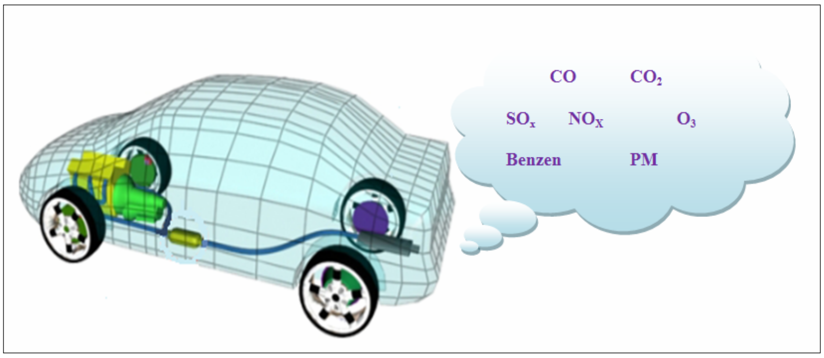

Figure 3. Pollutants generated by cars.

The emissions generated by cars can cause major health damages to asthma suffering persons, as well as breathing and cardio problems, increasing in this way the mortality rate in exposed people case. According to studies made by International Agency of Cancer Research, the benzene and emission particles are considered as carcinogenic (www.eco.iarc.fr).

The problem of atmospheric pollution is a complex one. The composition of polluted air varies very much depending on the geographical area, the geometrical configuration of pollution sources, meteorological conditions (temperature, humidity, light intensity), as well as other aspects of the studied area, as pointed out in the Figure 4.

In urban areas, the mechanic turbulences at street level prevail; and atmospheric turbulence taking place over the street level, in the upper part of the buildings (Roedel 1992).

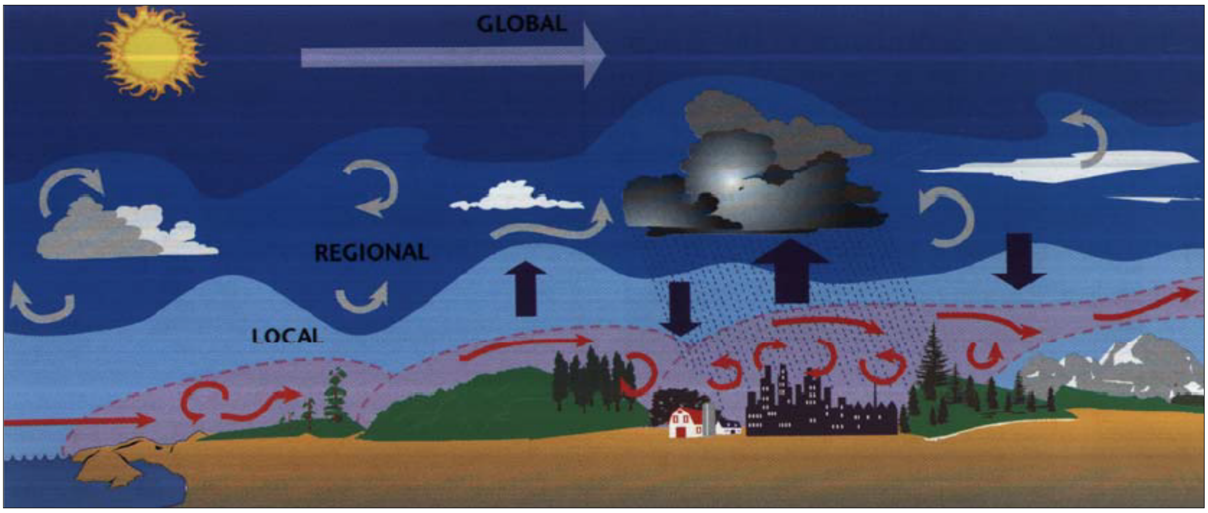

Figure 4. Mass air circulation at different scales (local, regional) (Climate and Urban Development 1996).

In Figure 5 is presented the pollutants analyze on vertical level:
- the first layer can be found in the immediate borderland (contiguity) of the soil, being a major source of dust;
- the second layer can be found above average level of buildings in town and comes out from chimney smoke emission;
- the third layer is situated at 40-60 m, where all emissions coming from height industrial chimney are concentrated.

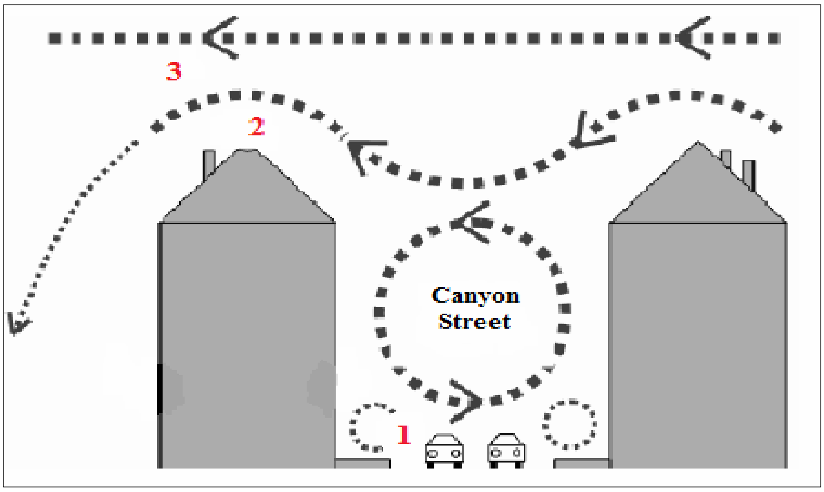

Figure 5. Pollutants analyze on vertical level (Merkel et al 2007).

Passing over from pure air to polluted air takes place slowly, due to geographic position, meteorological factors, wind, etc. Pollutants dispersion in atmosphere is a dangerous phenomena, hard to be forecast and having unpredictable effects.

Each moment, on each corner on Earth, air quality can be deteriorated, without the opportunity for humankind to interfere. Investigating air quality is connected to measurements at ground level, satellite measurements.

Material and Method. This study refers to data provided by the Environmental Protection Agency Cluj on particulate matter concentrations which were obtained by gravimetric methods. A complementary application of standard measuring methods for atmospheric pollutant concentrations are optical measuring methods of concentrations.

Measurement optical method is direct solar photometry (Liou 2002). Concrete procedure use in this study is performed to extract information from the database international network AERONET (Aerosol Robotic Network), in order to detect atmospheric aerosol by photometric means. Extracted data were collected with instruments in the last generation solar photometers - photometers manufactured by CIMEL (CIMEL Electronique, www.cimel.fr).

The equipments and methods used for monitoring the atmospheric pollutants must be used so that, for a certain measuring point, the data obtained from measurements taken at ground level, to be found in national network data, international or global network data.

The present study intends to make a correlation between data obtained from Environment Protection Agency Cluj and data achieved from global network AERONET. Area chosen for study is Cluj city, Marasti neighborhood. The study was based on the correlation of <10 µm diameter material particle concentration (so called fraction PM_{10} of aerosol), measured at ground level, with AOD values.

Atmosphere investigation methods are substantiated by designing a wide range of independent measuring devices in connection with the limits imposed by in force legal regulations regarding accepted maximum concentrations, but also for the developing stage of “clean” non-polluting technologies.

According to Law no. 104 from 15/06/2011 (www.mmediu.ro), the standard specifications for atmospheric pollutants are presented in the Table 1 (www.calitateaer.ro).

Table 1

Legal standard specifications and reference methods regarding atmospheric pollutants (Source: www.calitateaer.ro)

Pollutants	*Threshold values for human health protection*	*Standard Measuring Methods*
SO_2	350 µg/m^3 (hourly limit value); 125 µg/m^3 (daily limit value)	Fluorescent in UV
NO_x (NO/NO_2)	200 µg/m^3 NO_2 (hourly limit value); 40 µg/m^3 NO_2 (annual limit value)	Chemilumnescence
CO	10 µg/m^3 (maximum daily value of 8 hours averages)	Spectrometry in IR non-dispersive
PM (PM_{10}, $PM_{2.5}$)	PM_{10}: 50 µg/m^3(daily limit value); 40 µg/m^3(annual limit value); $PM_{2,5}$: 25 µg/m^3(annual limit value – deadline 1.01.2015); 20 µg/m^3(annual limit value – deadline 1.01.2020)	Gravimeter Method; testing procedures in the field
Benzene (C_6H_6)	5 µg/m^3 (annual limit value)	-
Lead/Plumbum (Pb) and other toxic metals (Cd, As, Ni, Hg)	Pb: 0.5 µg/m^3(annual limit value); As: 6 µg/m^3(target value); Cd: 5 µg/m^3 (target value); Ni: 20 µg/m^3(target value)	Can be found in the PM_{10} fraction for abeyance particles

A complementary application of standard measuring methods for atmospheric pollutant concentrations are optical measuring methods of concentrations. Satellite remote sensing and solar photometry contributes to achieving pollutants concentrations throughout associated sizes.

Therefore, the equipments and methods used for monitoring the atmospheric pollutants must be used so that, for a certain measuring point, the data obtained from measurements taken at ground level, to be found in national network data, international or global network data (for example AERONET network that provides a data base regarding the micro-physic and radioactive parameters of aerosol, accessible for public; this international network covers the whole dry surface of Earth).

Results and Discussion. According to Shaw (1983), solar photometers use a certain number of channels, depending on the device model. The Photometer assigned to AERONET uses 8 channels or band (wave length) (340 nm, 380 nm, 440 nm, 500 nm, 675 nm, 870 nm, 1020 nm, 1640 nm). In Figures 6 and 7, the AOD and Angstrom parameters are presented. AOT or AOD represent the optical thickness of aerosol (depth) and it represents a measure for the concentration of aerosol on air column depending on the band:

$$AOT(\lambda)_{\lambda} = \tau \qquad (1)$$

It is a standard parameter measured by solar photometer solar. Optical depth entering (grip) (T_{λ}) is also called turbidity. The addiction (dependency) relation between turbidity and band of the incidence radiation is complicated, due to atmospheric component diversity. So, the Angstrom equation of turbidity is used, in which the dependency by the band is reduced to a backwards proportionality with a power of the band (Stefan et al 2008):

$$\tau_{\lambda} = b\lambda^{-Å} \qquad (2)$$

where b: turbidity coefficient; Å: Angstrom parameter. Angstrom exponent has the following expression: $Å(\lambda) = -\, d\,(\ln\tau_{\lambda})/d\,(\ln \lambda)$ (3)
Parameter Å is an indicator of atmospheric particles that determine the AOT. Therefore, for Å>1 fine particles can be found (Kaufman 1993).

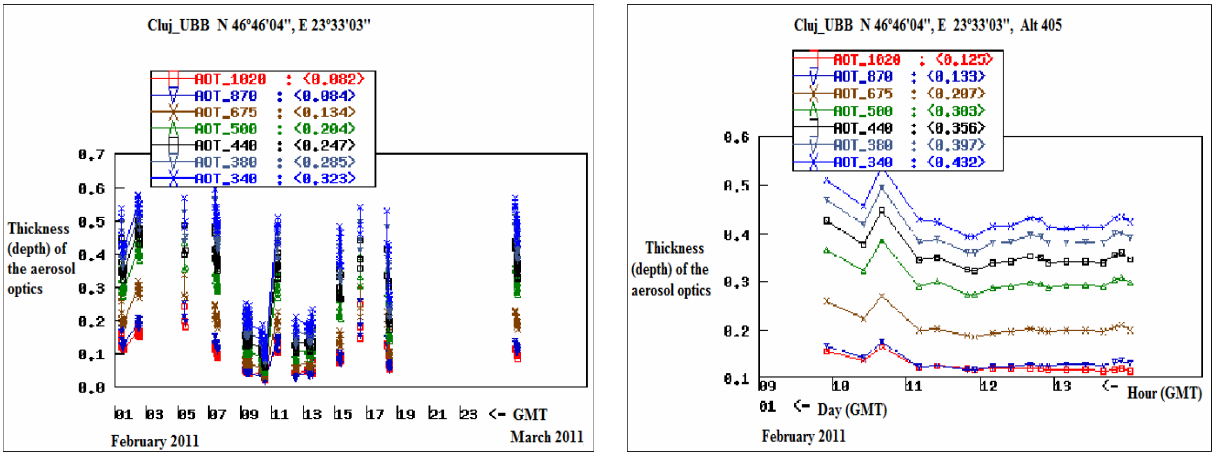

Figure 6. Daily distribution of AOD parameter (left chart) respectively hourly distribution (right chart), according with data from AERONET for February 2011 (Cluj_UBB Station N 46°, E 23°) (http://aeronet.gsfc.nasa.gov/).

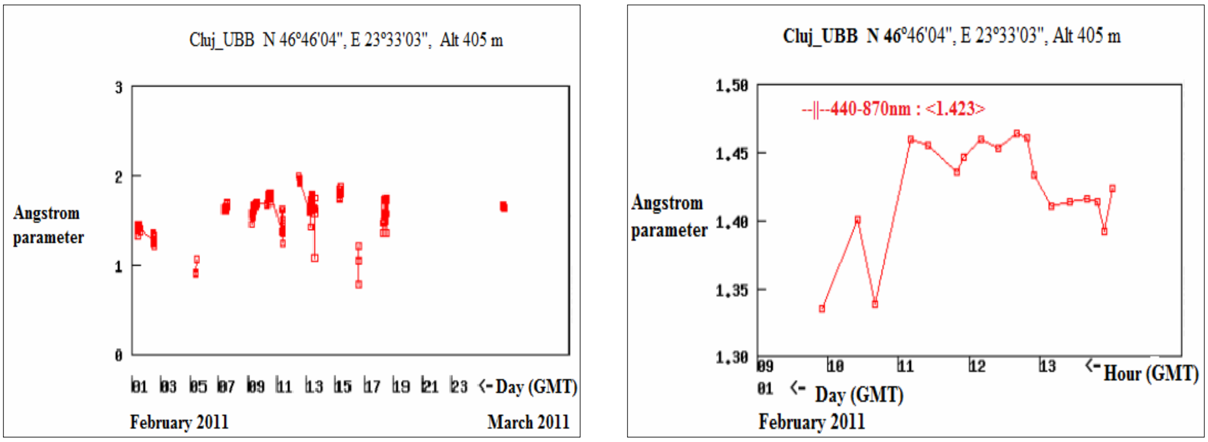

Figure 7. Daily distribution of Angstrom parameter (left chart), respectively timed controlled distribution (right chart), according to AERONET data for February 2011 (station Cluj_UBB N 46°, E 23°) (http://aeronet.gsfc.nasa.gov/).

In Figure 8 the AOT variations are presented for February 2011. The chart presented in Figure 9 represents the PM_{10} concentrations variation, stated at station CJ-1 in February 2011. The station CJ-1 is traffic type and it is placed nearby 25 meters distance from a merry-go-round Aurel Vlaicu Square, Marasti neighborhood. This area is characterized by a large traffic volume (10 000 cars/day) (Search Corporation 2007); nearby the monitoring station, a fuel station is situated. Also, in the surrounding area there are block of flats with most of apartments heaving their own heating centrals (boilers) – as supplementary polluting sources.

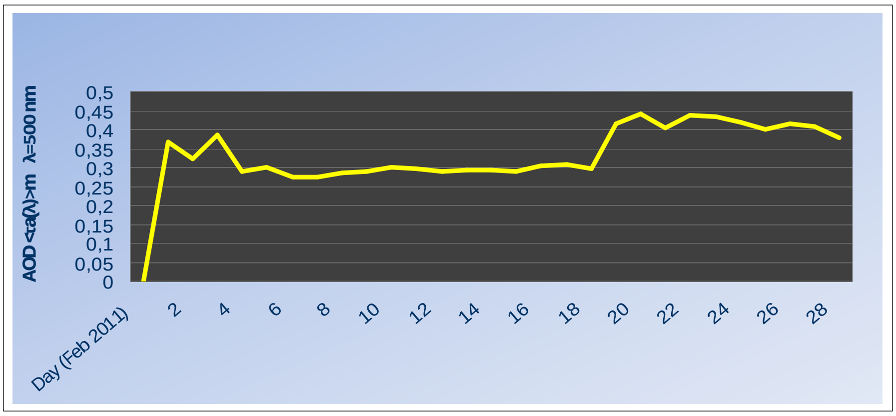

Figure 8. AOD Variations for February 2011.

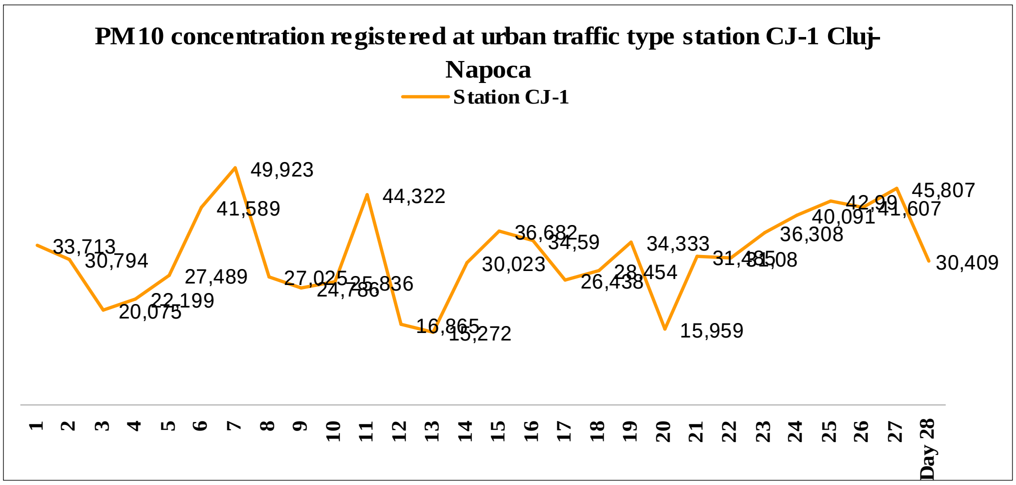

Figure 9. Graphic mapping of PM_{10} concentration variations PM_{10} inferred to February 2011 (data supplied by de Environment Protection Agency Cluj, www.apmcj.anpm.ro).

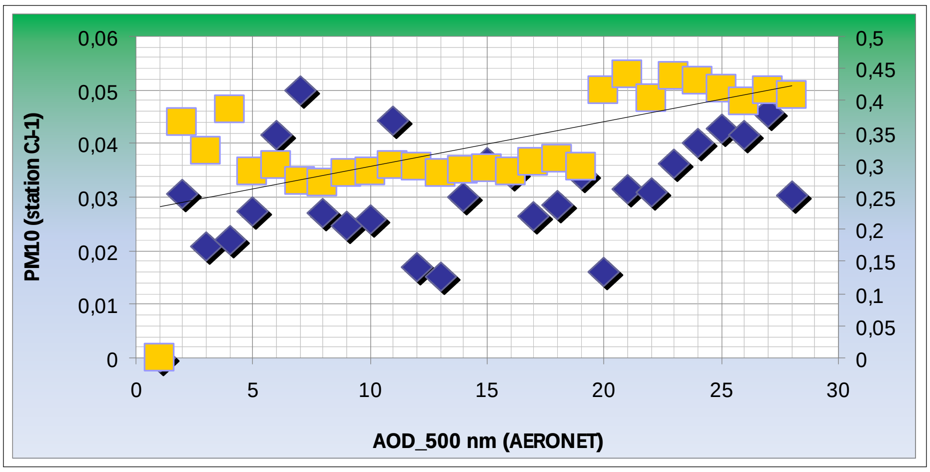

Figure 10. The correlation between PM_{10} and AOD 500 nm parameter for Cluj-Napoca area, February 2011 (Nisantzi et al 2011).

Calculating the linear correlation coefficient between PM_{10} and AOD_500 columnar (Figure 10), that is -0.6318. The very good correlation between AOD and PM_{10} indicates the possibility of using the linear regression parameters in monitoring the concentration of PM_{10} at ground level, also helped by solar photometry data, provided for example by AERONET Network or other satellites.

Conclusions. The air is indispensable for life on Earth and influences in a significant manner its quality. The pollutants action either directly, towards humankind by their inhalation, or indirectly, on the long run, by climate changing.

Therefore, the attention given to atmospheric pollution in general, and to urban environment in particular is very important. The car traffic from urban environment, together with other polluting sources must be the main solicitude of our century. The pollutants generated by car traffic can be found in constantly increasing quantities and present two major traits: first, their dismisison can be done near the soil, fact that leads to increased concentrations at; second, the emissions cover the whole locality surface, concentration differences depending on car traffic intensity and ventilation possibilities of the street.

Therefore, the research regarding the monitoring of the air quality in the inhabited environments is absolutely compulsory and demands developing new strategies for screening, alternative measures for local authorities regarding air quality (for example no usage of personal car during the week and use of common transport means, or bicycle); use of common transport means, introducing in the car traffic the ecological cars, use of alternative fuel, use of bicycle, etc. represent several handy (forthcoming) strategies in reducing the pollution.

Besides the measurements taken at ground level, global networks are designed to complete the data regarding the measured concentration in the field. Those networks stand as extremely efficient tool in accessing all on-line data, in real time, as well as accessing in time stored data. It provides as well the possibility of correlating and interpreting certain parameters, coefficients for characterizing the atmospheric column.

Acknowledgements. This paper was supported by the project "Improvement of the doctoral studies quality in engineering science for development of the knowledge based society-QDOC" contract no. POSDRU/107/1.5/S/78534, project co-funded by the European Social Fund through the Sectorial Operational Program Human Resources 2007-2013.

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Received: 20 February 2013. Accepted: 05 March 2013. Published online: 23 April 2013.
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How to cite this article:
Suciu A., Rusu T., 2013 Methods and equipments used in the monitoring of the atmospheric pollutants in urban environment. AES Bioflux 5(2):226-233.