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Air pollution analysis in western Romania and the necessity of complementary vertical resolved LIDAR observation

I. VETRES[*], I. IONEL, F. POPESCU, N. LONTIS
"Politehnica" University of Timisoara, Faculty of Mechanical Engineering, Timisoara, Romania

The Western part of Romania is one of the most developed industrial areas of Romania, with many urban agglomerations. Thus, the regional air pollution monitoring and assessment are of exclusive importance for the sustainable development of the society in the region. This article is focusing on the identification of the air pollution regimes and types, as well as on the main driven factors. Representative ground measurements data sets of O_3, NOx, SO_2 and PM10, will be analyzed and presented, in the context of regional photochemistry potential. The effect of the traffic trough an urban region will be also analyzed. Finally, the author will demonstrate the complementarily necessity of the LIDAR based observations, for an appropriate and more complex evaluation of the vertical mixing structures and planetary boundary layer dynamics, where the atmospheric pollution events and reactions are mainly located.

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1. Introduction

The main purpose of the research is to identify the air pollution regime, its typology in the Timisoara city and the major sources of the pollution. Industry and the enhancement of the local development represent the biggest contribution to the environmental pollution by great quantity of gaseous, liquid and solid pollutants released in the air, water and soil. The household input is not negligible, as well.

Air pollution has been generated by natural and antropic sources, as long as the human being developed into a civilized one, with more and more need for energy consumption and comfort need. Humans become the dominant inhabitants on Earth, with expansion and development tendencies, as well as modern progress was registered. Atmospheric pollution becomes significant with the development of big cities, representing a simultaneous process connected with large industrial activities. Additionally, small-scale air pollution sources from ancient times developed and scattered within cities. From the earliest times, urban air pollution was seen as a potential source of health problems and particularly having a stronger effect on children and aged persons [1].

Modernization and progress have led to air getting more and more polluted over the years. Industries, vehicles, population increase and urbanization are some of the major factors responsible for air pollution. The two main sources of pollutants in urban areas are transportation (predominantly automobiles) based on internal combustion engines and fuel combustion in stationary sources, including residential, commercial and industrial heating and cooling devices and fossil or C-lean fuelled power plants. Motor vehicles generate considerable levels of carbon monoxide (CO) and are a major source of hydrocarbons (HC) and nitrogen oxides (NOx), even when the exhaust is generated by modern engines, as the traffic density is high. The fuel combustion in stationary sources is the dominant source of sulphur dioxide (SO_2) [2] pollution, but also modern industry devices is considered as major source but for species such as HC and particular volatile organic carbons (VOCs). In summer time, photochemical complex processes are enhanced based on the coupling of VOCs and NOx, thus resulting a secondary pollutant as the troposphere ozone (O_3) [2] is considered. The effects which transport has upon human health the most important are those related to the harmfulness of exhaust gas that contains NOx, CO, SO_2, CO_2, volatile organic compounds, and particle matter (PM) loaded with heavy metals (lead, cadmium, copper, chrome, nickel, selenium, zinc).

By the year 2008, in situ measurements were conducted in different relevant locations in Timisoara, locations characterized by low, intense or even no traffic, in order to identify the traffic influences on air quality. Point monitor measurement equipments were used for continuous on-line monitoring of the pollution levels at ground surface, thus allowing the identification of pollution sources' direct effects. The measuring methods are all according CEN standards and accepted on European level [3]. The usefulness of these measured values and the information generated by the processing of the data is not always sufficient relevant information. The main reason is connected with the process of identifying, at regional scale, the dynamics of the atmosphere over the urban area and more particular, the aerosols height distribution and their influence upon the air pollution regimes, over the Timisoara city, in the Western part of

Romania. Measurements of urban air pollution are usually limited to a few locations in the city area, and further they are complementary analyzed. Monitoring stations are often situated in streets with significant traffic or in places where severe pollution problems are expected. Such measurements are naturally influenced by the local conditions and special careful analyzing methods must be taken in interpretation of the results. But using LIDAR and Wind Profilers systems, it is possible to evaluate the vertical mixing structure, planetary boundary layer dynamics and heights as well, or to identify local and regional pollutant fluxes, thus offering supplementary information about air quality and identifying better the regional scale behavior. It is recommended to evaluate also the regional dynamics. Lidar measurements indicate the position of aerosol layers and according to this information it is possible to apply trajectory models for investigating their location.

It is known from environmental research that the presence in the atmosphere of one or more contaminants in such quantity and for such duration is harmful to human health or welfare, animal or plant life. The air contamination occurs by the discharge of harmful substances from different sources (stationary, mobile, point or surface). Air pollution causes health problems and damages the environment and property, as well inhibits the sustainable development of a society in progress. It caused already the depletion of the protective ozone layer of the atmosphere as well as the irreversible green house effects, which are leading to climate change [1].

The Timisoara city is located at the intersection of the parallel 45°47' North latitude with the meridian 21°17" East longitude. The city has a moderated continental-temperate climate and is influenced by the ancient soil bog land thus its general features are marked by the diversity and irregularity of the atmospheric processes, and for sure temperature inversions, not sufficient investigated yet. The number of cars in Timisoara city is increasing every year, this tendency being presented in Fig. 1.

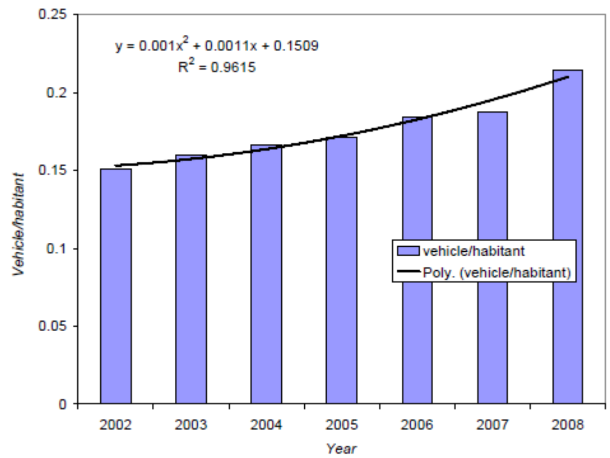

Fig. 1. Number of cars versus the number of the Timis inhabitants [12].

2. Experimental

By the year 2008, there were conducted specific air quality campaigns with the mobile laboratory from the Politehnica University of Timisoara (http://www.mediu.ro), according ISO CEN methods. Relevant measurements in representative important points in Timisoara city (pointed in Fig. 2) were accomplished, the locations and the periods of the measurements' campaigns being represented by Table 3. The principal atmospheric compounds that have been monitored are SO_2, NOx, CO, CO_2, O_3, PM10, CH_4, VOC and TCO (Total organic carbon), in accordance to [3], [4], by applying standardized measuring methods.

Table 3. Measurements location and characteristics.

Nr. crt.	Location	Period	Characteristics of depicted pollution sources
1	Village Museum	16.04.08-22.04.08	Urban
2	Botanic Park	23.07.08-30.07.08	Urban + traffic
3	Divizia 9 Cavalerie nr.17 Street	04.08.08-11.08.08	Urban + traffic
4	Torak, Kuntz Street	17.09.08-23.09.08	Urban
5	Electromotor industrial park parking	13.10.08-20.10.08	Urban + traffic
6	Timisoara Mall parking (vicinity)	5.11.08-12.11.08	Urban + traffic
7	Cet South Power Plant industrial platform	13.11.08-20.11.08	Urban + industrial point

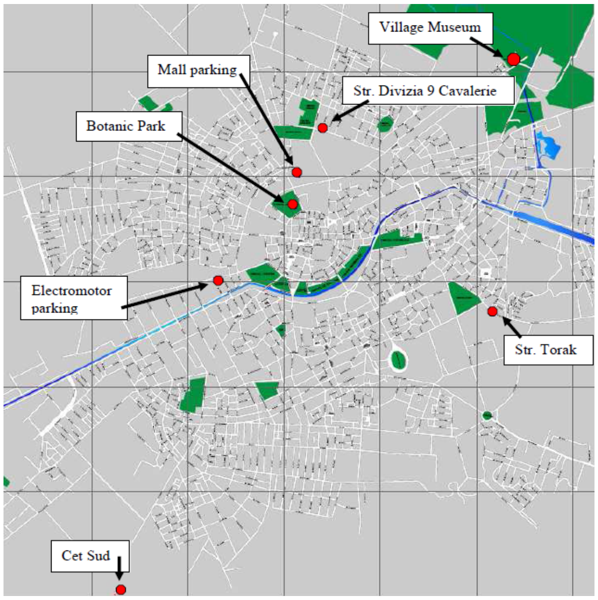

Fig. 2. Timisoara city map with measurements point locations.

Only standardized modern equipments were used for measurements of the pollutants mentioned. Thus the SO_2 concentration was recorded with HORIBA APSA370 instrument that functions on a fluorescence method and with HORIBA APNA350E, additionally. The analyzing method used by HORIBA APNA350E for NOx concentration is based on chemiluminescence principle and the referential calculation. The CO concentration was recorded with HORIBA APMA-350E, this instrument using the NDIR principle (cross flow modulation, non-dispersive infrared absorption technology). CO_2 was measured with Greisinger EBG-CO2-1R equipment. By ultra-violet-absorption method (NDUV) integrated in HORIBA Apoa-350E there was measured the O_3 concentration and for PM_{10} it was used SVEN LECKEL LSV3 based on dust filter collection [3], [4], [5], [7], [8].

3. Results and discussion

The monitoring campaign lasted for 7 days and during this period there were recorded hourly average of the pollutants mentioned above. The data from this campaign are presented in the following charts. Hourly average of O_3, SO_2, NO, NO_2, NOx and PM_{10} are represented for all 7 campaigns of measurements in Fig. 3. Fig. 4 presents the hourly average of methane (CH_4), volatile organic compounds (VOC), total organic carbon (TOC) and CO. The PM_{10} concentration, daily average chart is indicated by Fig. 5. The data were converted to normal conditions for reference.

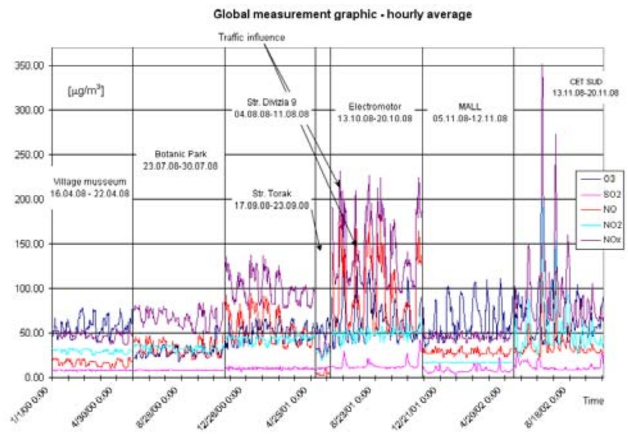

Fig. 3. Hourly average values recorded for the species O_3, SO_2, NO, NO_2, NO_x and PM10, in [$\mu g/m^3$].

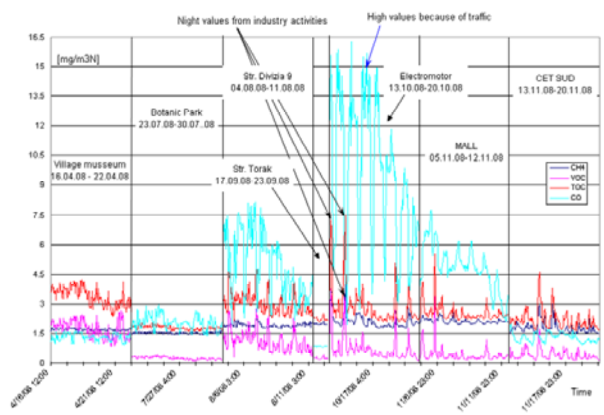

Fig. 4. Daily average values recorded for the species CH_4, VOC, TOC, CO, in [mg/m^3].

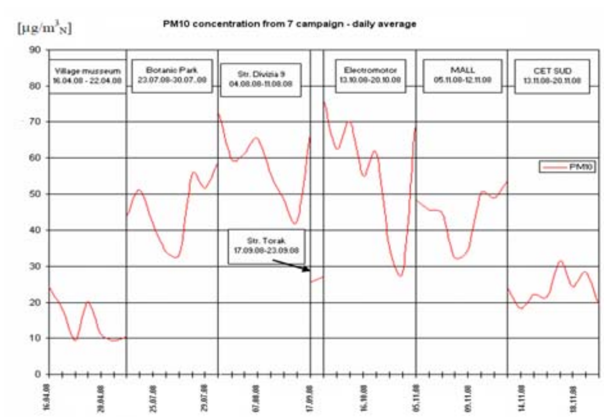

Fig. 5. Daily average values for PM10, in [$\mu g/m3$].

Values over the allowable limits in case of NO_x (200 $\mu g/m^3$ daily limit [4]), CO (10 $\mu g/m^3$ daily limit) and PM10 were recorded in the area of ELECTROMOTOR parking place, which is obviously due to traffic, because is a zone with very high traffic concentration. The concentrations are very high between 8^{oo}-19^{oo} because of high number of cars, people are going to work or from work to home. The Romanian legislation limits the concentration for PM10 to 50 μg/m^3 daily value limit. In the Botanic Park the traffic influence exists but the value does not overpass the limit concentration for particles in suspension and the same result is identified in Divizia 9 Cavalerie Street Sporadic exceeding values of VOC and PM10 limits were encountered in the Mall parking lot but also in the CET SOUTH monitoring area, the limit of VOC and NOx were exceeded.

Increased VOC and TOC concentration (2 - 4 mg/m^3) levels were registered in the Village Museum area and Electromotor, especially by night, caused mainly by the industrial activity from the neighborhoods [4].

As Fig. 5 presents, relevant PM_{10} pollution is depicted also in green parts of the city. Even the measurements (episodes) were not accomplished at the same time, in all locations, the results are relevant, as in Timisoara this situations was found all the year long, with small changes, by other measurements too (http://www.calitateaer.ro) [13]. All the measurements are very clearly explained in several other reports and articles [5], [6], [7], [8].

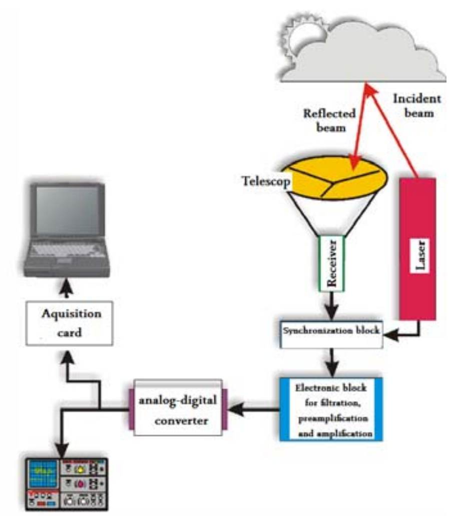

Fig. 6. Principles of functioning for Lidar systems [11].

In order to complete the local image of pollution pattern in urban area, one suggests using additional relevant novel techniques. Thus not only the temperature profile on vertical paths but also special development of clouds, their movements and particle content might be depicted. In addition to the point measurements, the author propose to investigate air quality and specific thermodynamic and meteorological parameters, on line, by one simultaneous use of LIDAR (Light Detection and Ranging) systems, as presented by Figure 6 [11]. LIDAR effectively detects and characterizes air contaminants, with best spatial and temporal resolution, locates the pollution sources and take correct actions to correct the problems while also helping in developing perspective strategies. Complementary, by applying a trajectory model or different dispersion models, one can characterize, at regional scale, the pollution regime, as well as the dynamics of the pollutants. The most obvious use is to track the evolution of a pollutant over time. Urban monitoring might be thus completed by on line LIDAR measurements, in a very modern way, in accordance to recent technical developments worldwide. Other relevant results might be analyzed from

LIDAR systems are well suited for the remote measurement of pollutants, with numerous applications depending on the purpose. The most obvious use is to track the evolution of a pollutant over time. If the LIDAR laser beam is oriented vertically, the device acts as a profiler. If one changes the vertical angle of the laser beam a succession of alignments is generated that, with the proper interpolation, can define a concentration plane. The profiler is the usual configuration of the LIDAR systems, providing very valuable information, such as the depth of the planetary boundary layer and the evolution of the concentration [14, 15].

4. Conclusions

The atmospheric environmental situation over the urban area is determined by a complex combination of anthropogenic pollution and meteorological factors. The main conclusion of this article is that identifying the local levels of pollution from in point measurements is possible and correct, but it’s hard to investigate it at regional scale, taking also vertical space (Boundary layer) in attention. By complementary using of the LIDAR system and trajectory or appropriate dispersion models, best and more complete investigations at regional scale might be developed, as the pollution regime and the dynamics of the pollutants are more accurate depicted. Traffic has a very important impact on the various pollutants concentration (CO, NOx and CO_2), between 8^{00}-19^{00}, within two main peaks, as typical for urban areas. In regions near industrial parks the level of COV, TOC and CH_4 are also very high and the sources must be depicted, even for VOC air concentrations no limits according Romanian standards are yet imposed.

LIDAR effectively detects and characterizes air contaminants with good spatial and temporal resolution, and thus one is able to locate the pollution sources and take correct actions to correct the problems and also develop perspective strategies.

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*Corresponding author: vetres.i@gmail.com