Research of NO_x and PM10 pollutants in Cluj-Napoca with the mobile system for mitigating public health risks

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Abstract. The present research is conducted in order to show the possibilities of creating a smart and advanced mobile system capable of investigations regarding the chemical composition of the atmospheric air in the metropolitan areas using flexible technologies and some part of the existing infrastructure. Experimental measurements are made using a mobile station for data recording connected to the internet and with a link to the air quality stations. Taking into consideration the values of different chemical compounds within the atmospheric air, the data processing station may create a chemical map indicating the higher risk of air toxicity. Nitrogen oxides and particulate matter are some of the essential chemical pollutants generated these days by modern industries and transportation activities. By installing the proper technologies and networking capabilities on a current car the research team has made a practical investigation of actual chemical values in the metropolitan area of Cluj-Napoca by accessing the NO, NO_2, NO_x, and PM 10 data retrieving lines. Necessary changes in hourly retrieved data show that road traffic and other human activities do change the air quality level and its chemical composition. An air map is provided for some moments of the day, including the four stations in Cluj-Napoca city. The practical research is intended to present the technological capability and its embedding potential for the new series models of cars which may thus indicate a proper route in order to avoid critical points and to reduce the toxic chemical overload of some areas.

1. Introduction

Today, when health is a global concern investigating air quality is one of the most important activities that may be done. The air intake is more important than water and food ingestion due to the fact of the frequency of this act and its importance for each living being. Atmospheric air is the first, and the most important transfer supports for disease agents, both biologic and physic-chemical origins, making it more important for scientific research and engineering.

There were already developed a series of applied experiments and testing for improving diagnostic devices and systems in polluted metropolitan environments with nitric and carbon oxides [1], but further research of the problem is needed. Some pollutants [2] are quite closely related to the operation of transport vehicles and their internal combustion engines [3, 4]. Temperature, pressure and engine speed have an important influence on the operating regime [5], but in order to optimize the engines, either conventional ones or the alternative types, an experimental approach must be considered [6, 7]. Researching the actual operating values and their influence upon emissions [8], as well as their on-board display [9], could support the analysis of chemical composition with portable devices in order to gain the environmental quality profile [10] and the status of the embedded after-treatment system [11]. Using

precise sensing methods [12] and equipment [13] gas composition may be established, and specific compounds may be identified or precisely located.

Figure 1 presents the state-of-the-art images regarding the chemical pollution of the atmospheric air (a) and environmental mapping with portable profile-mapper of air quality (b) in order to optimize transportation activity [14].

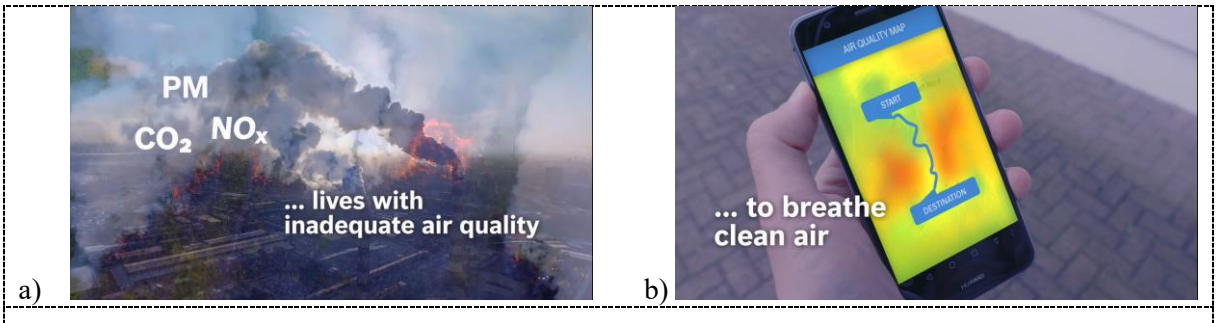

Figure 1. Capture of air pollution in today industry (a) and environment investigation device (b) [14].

2. Research methodology, materials and results

Today's fast networking and advanced mobile systems allow the researchers and the engineers to develop new smart applications for environmental investigations and atmospheric chemical profile. The reference methodology applied when measuring the nitrogen dioxide and nitrogen oxides has been the one given by the standard SR EN 14211 known as the Ambient air quality. Standard applied method for investigating the actual values of both nitrogen dioxide and nitrogen monoxide is with chemi-luminescence. The applied method for the sampling and determining of PM_{10} and $PM_{2.5}$ actual values is the one specified in the standard EN 12341 Ambient air - Standardized methodology for gravimetric measurement to determine the PM_{10} or $PM_{2.5}$ mass fraction of particulate matter in suspension [13]. NO_x and PM_{10} are generated by road-traffic and industry, both investigated here.

The experimental research car is a series model available at the Technical University of Cluj-Napoca. It was equipped with a mobile advanced system having internet connection capabilities and data transfer via Wi-Fi, as shown in figure 2. It has a wheel train 1, an internal combustion engine 2, a clutch 3, gearbox 4, clutch control 5, engine unit 6, transmission control 7, traction control 8, on-board instrument cluster 9, steering system 10, axle drive 11, exhaust control 12, radar system 13, air quality check point 14 (metropolitan chemical measurement station CJ1), 15 satellite connection. Applied research is showing the hourly levels that may impact the public health and are a risk factor for life.

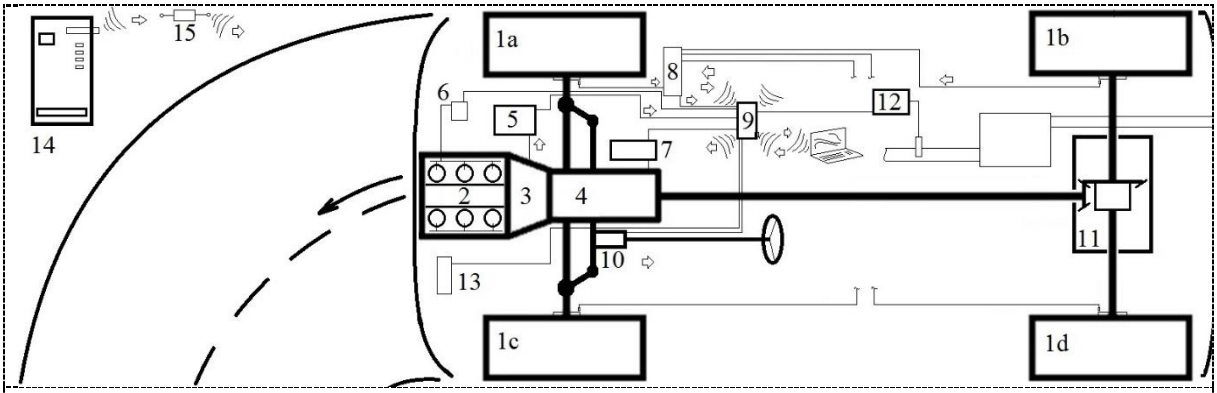

Figure 2. Schematics of the research methodology and equipment placement in the testing structure

In figures 3 to 10 are shown the experimental measurements with the mobile advanced system regarding the air quality check with flexible automotive technology in relation to the infrastructure.

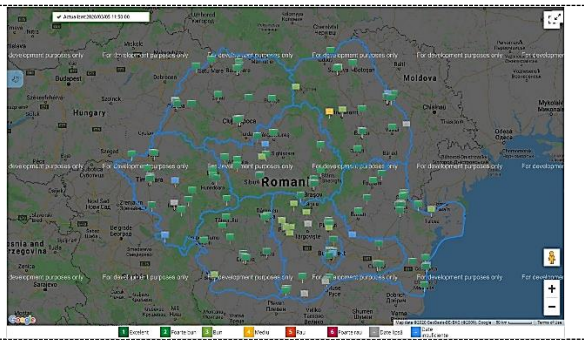

Figure 3. Romania air quality map before noon.

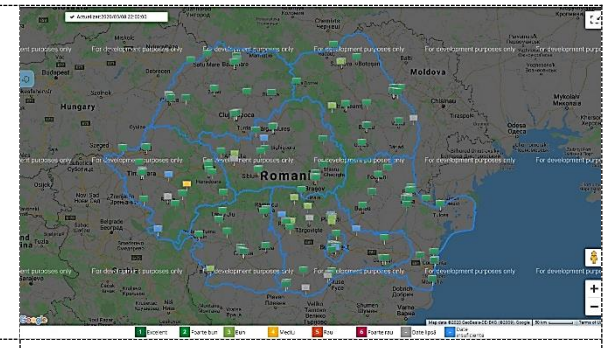

Figure 4. Country's evening air quality map.

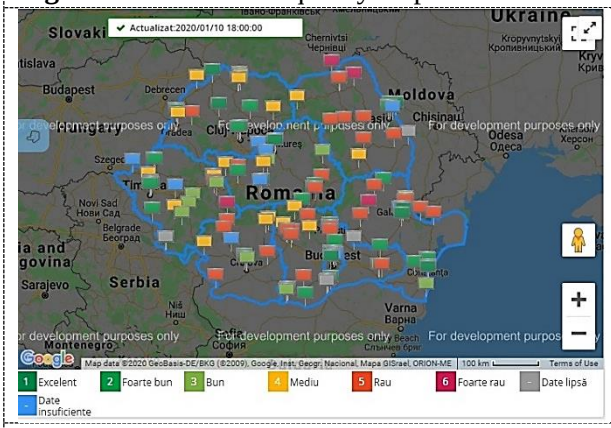

Figure 5. Air quality in the afternoon, at 18:00.

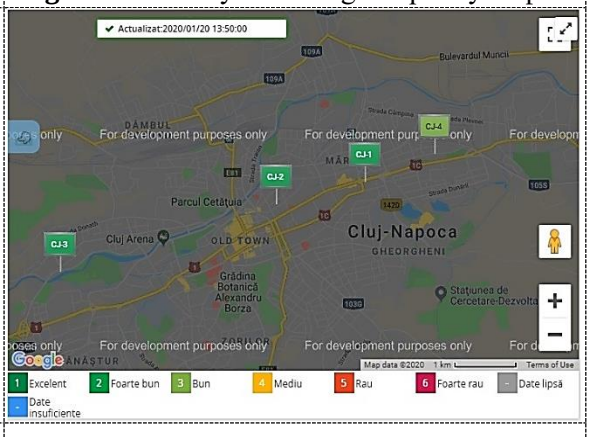

Figure 6. Measuring stations in Cluj-N. city.

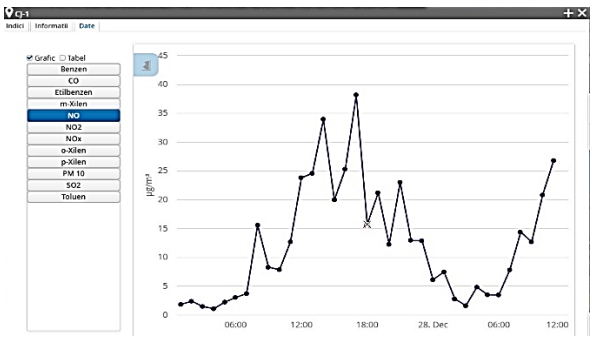

Figure 7. NO variation during 27 and 28 dec.'19

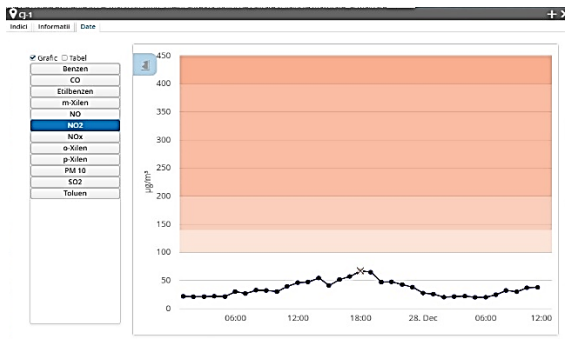

Figure 8. NO_2 variation in 27 and 28 dec.'19

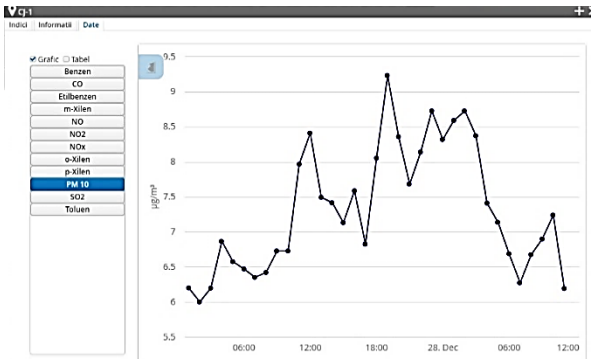

Figure 9. PM 10 variation in 27 and 28 dec.'19

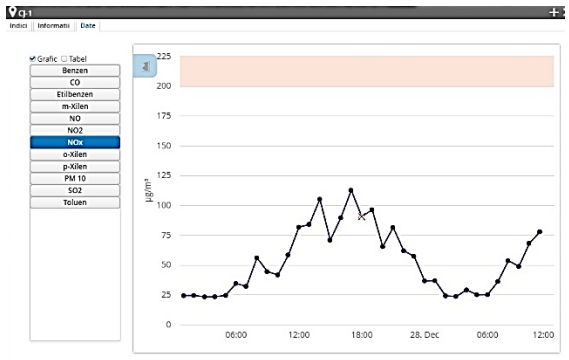

Figure 10. NO_x variation in 27 and 28 dec.'19

The tests were made for a prolonged period in order to take multiple sets of data.

The partial data base concerning NO_2 and PM10 actual values are given in figures 11 and 12. It is observed that before important events, such a Christmas, intense human and road activities are doubling the levels of NO_2 and PM_{10} emissions in comparison to actual holidays and 2020 lockdown.

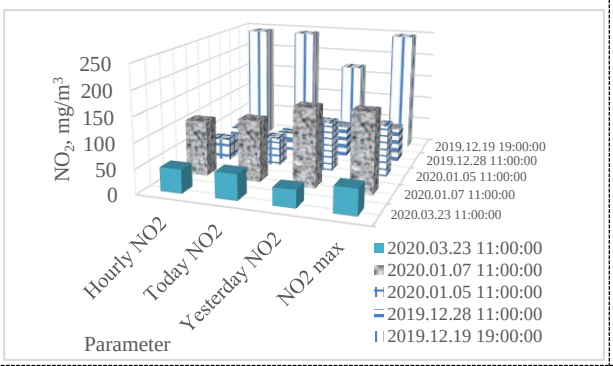

Figure 11. NO_2 values in dec.'19 and mars 2020

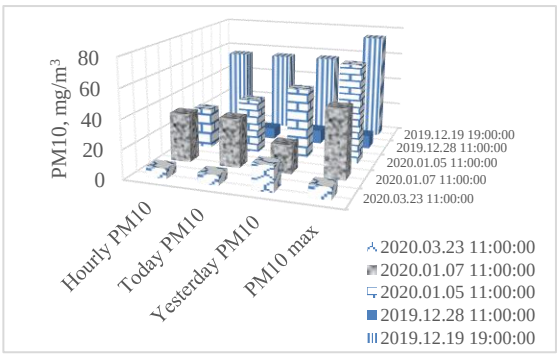

Figure 12. PM 10 values in dec.'19 and spring

The location specifications and investigated pollutants are presented in table 1, presenting the coordinates and addresses of the stations. Data from station CJ1 was represented graphically.

Table 1. Technical specifications for the air quality check points

Station CJ1	A. Vlaicu Street, no. 1; Latitude 46.78; Longitude 23.62; Altitude 336.00
Station CJ2	N. Bălcescu Street, no. 6; Latitude 46.78; Longitude 23.60; Altitude 336.00
Station CJ3	1 Decembrie 1918 Bvd., no. 1; Latitude 46.77; Longitude 23.55; Alt. 346.00
Station CJ4	Dâmboviței Street, no. 80; Latitude 46.78; Longitude 23.63; Altitude 323.00
Investigated Pollutants	NO, NO_2, NO_x, PM 10
Accuracy, [%]	98-100

Measurements taken with the equipment in experimental research allowed us to build a polynomial model on a multi-point determination as follows:

$$NO_2 = 22.779x^2 - 166.66x + 351.95 \quad (1)$$

where x is the timetable (day) measurement variable consisting in the type of working or holiday when taking the measurement, for a polynomial model of NO_2 evolution.

3. Conclusions and observations

The flexible system of measurement works properly and allows the receiver to access data from stationary infrastructure in order to gain insight of air quality in traffic at any given time. For development purpose the infrastructure gives access at this point to the 4 air quality check points in the city of Cluj-Napoca. These checkpoints may be accessed at any time regardless the location of the mobile receiver with the condition of internet connection being available.

For public health concerns hourly NO emissions increase in afternoon, which mean respiratory difficulties, irritations of the respiratory tract and lung's disfunctions such as emphysema. Lower values are recorded during the night fall and in the first hours of the day. The peak point for NO compounds and for PM10 were recorded around afternoon at 18 o'clock by connecting the flexible database with the measuring station from the metropolitan infrastructure. The investigation is required to be developed in order to complete database and expand the applied study.

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