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Case study on The Assessment of Air Quality and Pollution in a Sensitive Area of Bucharest

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Abstract. Monitoring air quality in urban areas is essential due to increased pollution and health hazards. In this study, the air quality in the busiest area of Bucharest's central was assessed, and the main car-related pollutants, NO_2 and PM10, have been examined in relation to the influence of meteorological parameters. During the measurement campaign, the monitored NO_2 pollutant concentration values did not exceed the limit value (LV), and the measured NO_2 exceeded this limit on day 1. Although the monitored NO_2 concentrations had the same pattern as the measured NO_2 concentrations; however, there is a delay in the amplitude of the values, which can be explained by the location of each measurement point in relation to the main source of pollution. The particulate matter PM10 showed exceedances of the daily limit values (DLV) in conditions of intense traffic, and the decrease in concentrations was related to the conditions of increased precipitation and humidity. In order to adopt the most effective measurements to reduce pollution in metropolitan areas, it is crucial to evaluate the air quality and identify the primary sources of pollutants.

1 Introduction

Over the last three decades, significant progress has been made at European level on air quality, thanks to the joint efforts of the European Union (EU) and national, regional, and local authorities in the Member States. According to conclusions published by the European Commission (EC) in 2022, the number of deaths attributed to air pollution decreased by 70% between 1990 and 2021. However, air pollution remains a significant problem, particularly in densely populated urban areas [1, 2].

The main objective of the research was to examine the air quality in sensitive urban areas to demonstrate the importance of implementing pollution mitigation and control measures. Although the RNMCA (*The National Network for Air Quality Monitoring*) exists at the national level [3] it currently consists of only 8 monitoring stations for the city of Bucharest (operational since 2004), and the data provided by the network represents the air quality only within its radius (100 m for the traffic monitoring stations).

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The accumulation of pollutants in certain residential areas is influenced by both topographical and meteorological factors [4]. In this context, in order to identify suitable methods to improve local air quality, it is necessary to monitor emission sources and air quality in the target areas, in addition to evaluating the impact of meteorological parameters on the accumulation of pollution during specific time periods [5, 6].

The monitoring campaigns conducted by National Institute for Research and Development in Environmental Protection (INCDPM) examined the air quality in densely populated urban regions with heavy traffic and sensitive areas, such as schools. The data obtained from the monitoring of air quality parameters, meteorological parameters, and the major emission sources identified in the immediate vicinity of “Gheorghe Lazar” National College of Bucharest, were examined, and are discussed in this article.

2 Methodology

On Regina Elisabeta Boulevard, the "Gheorghe Lazăr" National College was selected as the sensitive area for this study. The data collected by INCDPM’s auto laboratory and the data provided by the B6 RNMCA station located at the Military Circle were compared in the air quality study. The location of the station is Calea Victoriei, nr.32-34 (44.44° Latitude; 26.10° Longitude) [7].

For the air quality assessment, parameter monitoring campaigns spanned over seven consecutive days. Parallel to the campaign to measure air quality parameters, the number of automobiles transiting the area was also monitored. This type of investigation is frequently used in the field, both nationally and internationally [8, 9]. For instance, in China, to assess the impact of traffic in an experiment to determine PM10 concentrations as a function of distance from the source, during monitoring the number of vehicles passing on the Qianjin road in both directions was recorded three times per hour for one minute, along with the number and time of passing trucks [10]. In our case, the number of cars was calculated by counting, in the location where the auto laboratory was positioned, taking both directions of traffic into account.

The study was concluded by analysing the variation of NO_2 and PM10 concentrations in relation to various monitored meteorological parameters, including temperature, relative humidity, precipitation, atmospheric pressure, and wind speed.

The functional characteristics of the B6_RNMCA station represented in Fig. 1 are as follows:

- evaluates the impact of traffic on air quality;
- the radius of the representative area is 10 to 100 metres;
- the pollutants monitored include sulphur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), ozone (O_3), volatile organic compounds (VOC), particulate matter (PM10 and PM2.5) and metals.

Fig. 1. B6_RNMCA station for air quality parameters measurement

The distance between the monitoring area and the B6 station site was 520 metres. Analysing the functional characteristics of the B6 station, it can be concluded that its representativeness radius does not include the area where the air quality study's developers conducted surveillance, as shown in Fig. 2.

Fig. 2. Spatial distribution of the study area

Given the fact that there is a school in the vicinity of the monitoring area and that the nearby esplanade is frequented daily by a significant number of pedestrians, it was desired to correlate the values measured by B6 with those monitored by INCDPM at about 100 m from "Gheorghe Lazăr" National College and approx. 5m from Queen Elisabeth Boulevard. The comparison was made for the specific road traffic indicators (NO_2 and PM10).

The pollutant concentrations measured by B6 were downloaded from the website database: http://www.calitateaer.ro/public. The INCDPM car was located opposite the school, approximately 10 metres from the road (Latitude: 44.434811°, Longitude: 26.092083°).

The traffic near the college was estimated by counting the number of vehicles, taking into consideration Queen Elisabeth Boulevard's single three-lane traffic route. Throughout the monitoring period, the measurements were performed continuously. During the monitoring campaign, data on the number of vehicles per day and per hourly intervals that passed through the area were evaluated as an hourly percentage of the total daily number.

3 Results and discussion

In the following graphics are represented the hourly evolution of NO_2 in relation with traffic the meteorological parameters (measured and monitored) for the day one, where the maximum concentrations were recorded, and the day 5 for comparison, where the precipitations start.

In Fig. 3 is represented the vehicles number for each hour in relation with the hourly concentrations of NO_2 for the day 1.

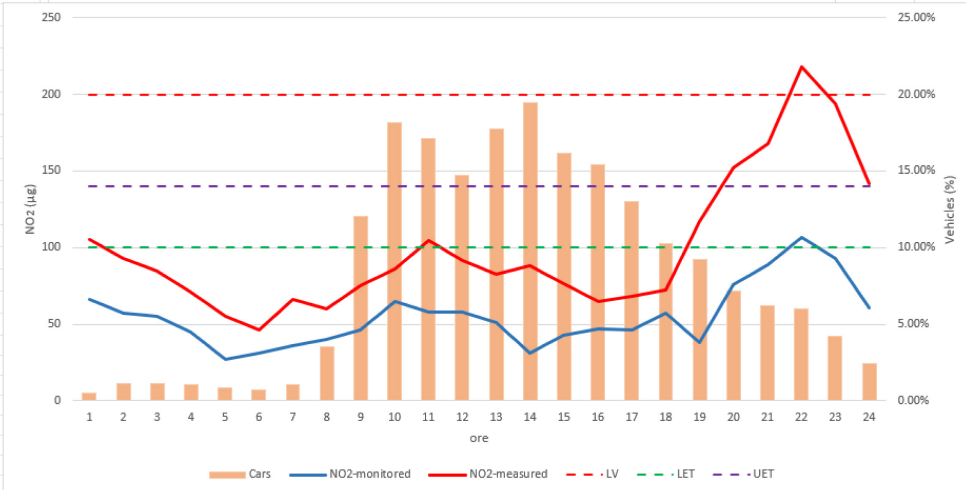

Fig.3. Hourly NO_2 concentrations in comparison with the number of vehicles recorded in each hour for the day 1

According to the data presented, the pollutant reduction can be observed in the first hours, when the number of vehicles is the lowest. In the time interval 9-18, when the traffic was increased, an increase in the monitored and measured pollutant is observed, followed by fluctuations that reach the lower emission threshold (LET) of the monitored NO_2 at 10 p.m., while the measured NO_2 values exceed the limit value (LV). It can be noted that, although the traffic is continuously decreasing, the values of the pollutant concentrations have an increasing trend, going to decrease only in the last 3 hours of the day.

In Fig. 4 is represented the vehicles number for each hour in relation with the hourly concentrations of NO_2 for the day 5.

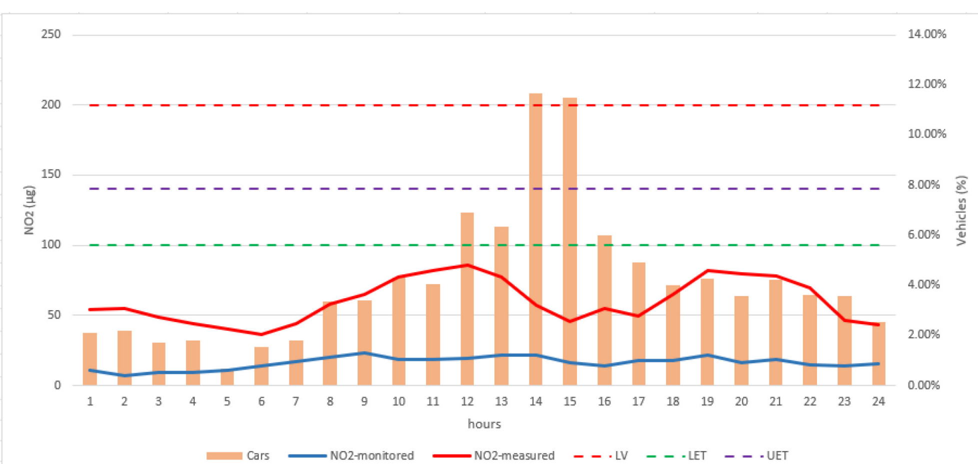

Fig. 4. Hourly NO_2 concentrations in comparison with the number of vehicles recorded in each hour for the day 5.

According to the data presented, the reduction of the monitored pollutant can be observed, compared to the previous days, without having fluctuations correlated with the traffic intensity. The values of the measured NO_2 concentrations show a decrease in the first hours, followed by an increase with a maximum point at 12 p.m., without following the variations in the number of cars in the second part of the day. The difference between the monitored and measured values can be distinguished, with a difference given by higher values for measured NO_2.

The monitored NO_2 concentrations had the same pattern as the measured NO2 concentrations; however, there is a delay in the values amplitude, which can be explained by the location of each measurement point in relation to the main source of pollution (520 m).

The graphs in Fig.5, Fig.6. and Fig.7 shows the hourly variations of the NO_2 parameter (monitored and measured) in relation to temperature, hourly relative humidity, and wind speed, monitored for day 5 of the campaign.

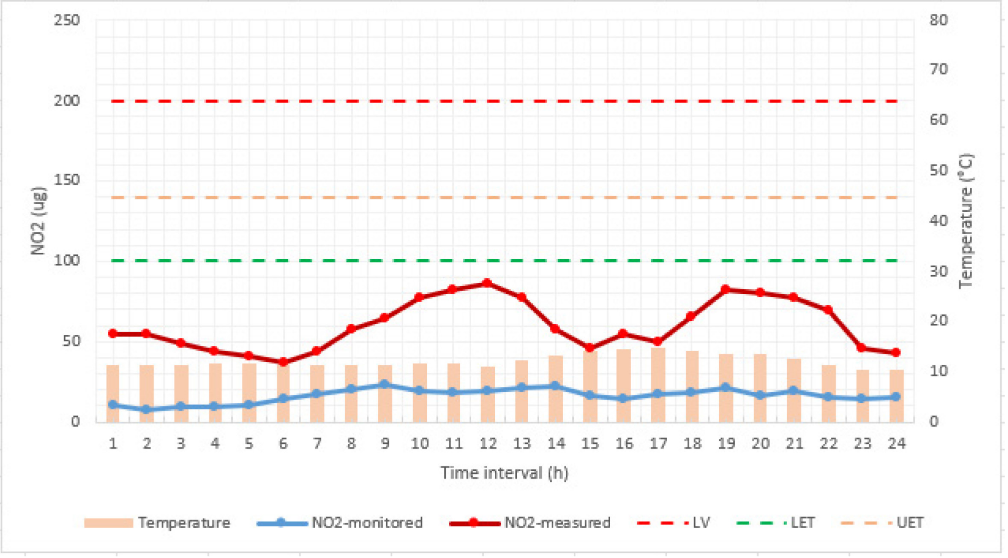

Fig.5. Variation of NO_2 concentrations and temperature on Day 5

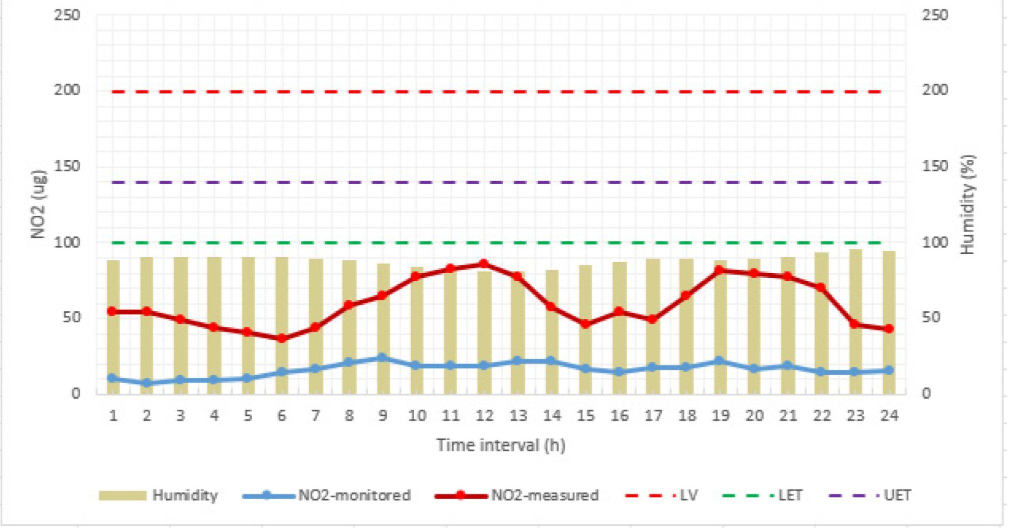

Fig.6. Variation of NO_2 concentrations and humidity on Day 5

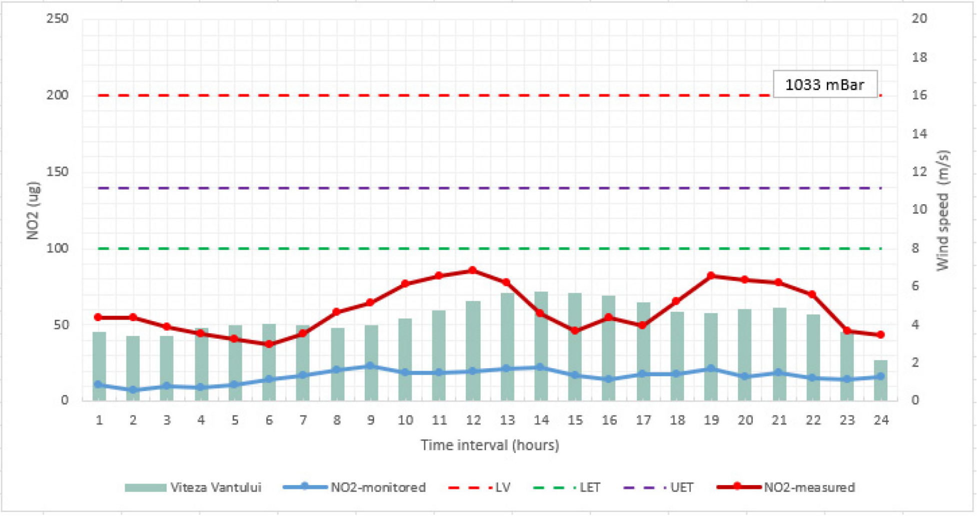

Fig.7. Variation of NO_2 concentrations and wind speed on Day 5

The variations of NO_2 concentrations, both measured and monitored, cannot be directly correlated with the variation of temperature and humidity. However, the low values recorded on days 5 and 6 for temperatures and humidity, as well as for NO_2 concentrations, may signal an influence of some associated meteorological parameters.

The following graphs show the daily variations of PM10 (monitored and measured) in relation to the monitored daily meteorological parameters: temperature, relative humidity, and cumulative precipitation.

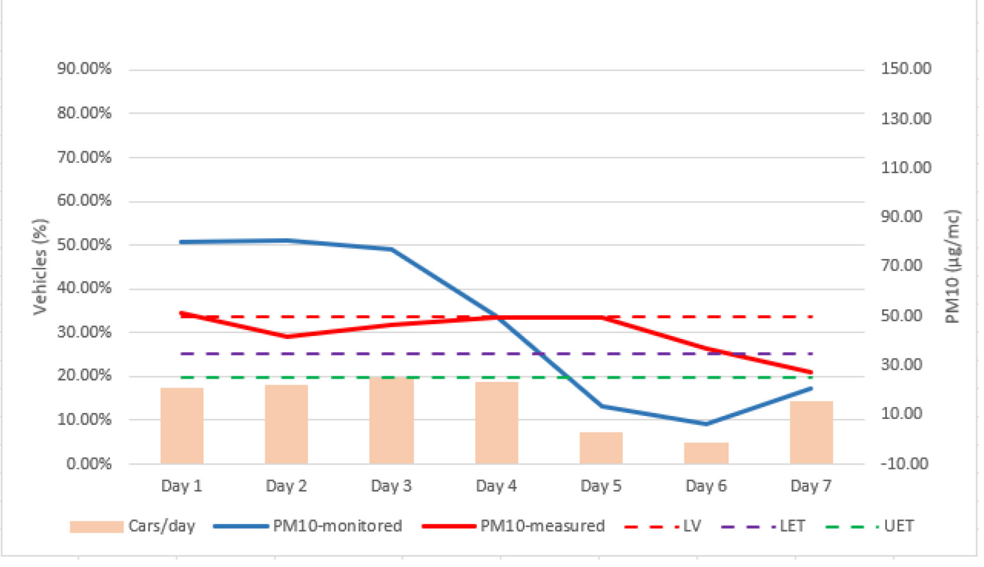

Fig.8. The variation of PM10 concentrations depending on the daily percentage of vehicles

According to the analysed data, in the first 3 days, the measured PM10 concentrations are found around the daily limit value (DLV), and the monitored PM10 concentrations exceed this limit, by more than 30 µg/m^3. Starting with day 3, the monitored PM10 drops to the DLV limit on day 4, respectively below the LET limit starting with day 5, when the number of cars registered a significant decrease. The measured values follow the decreasing trend with a gap of one day compared to the monitored ones. The analysis of traffic data and the variations of pollutant concentrations in relation to meteorological parameters will be presented in the following sections.

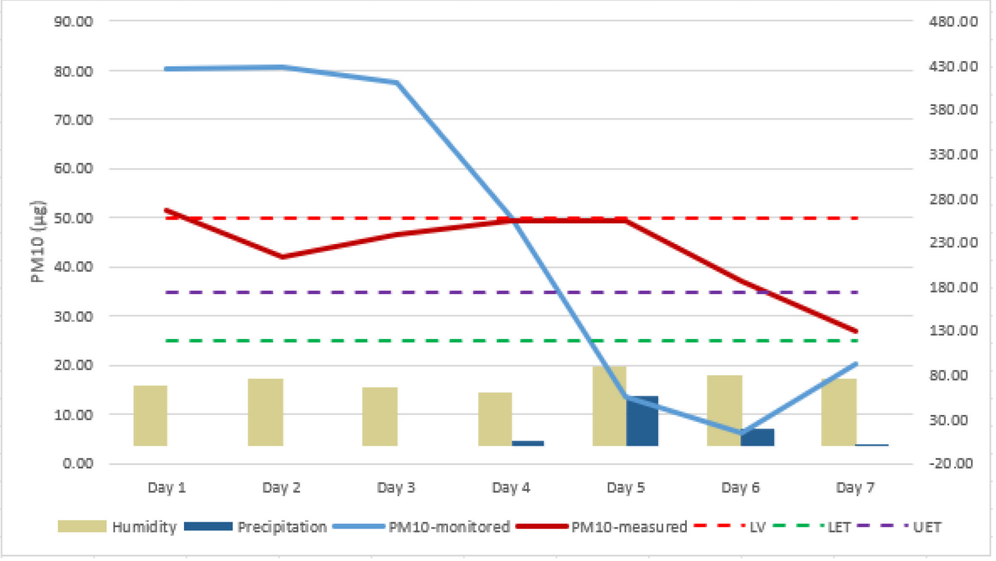

Fig.9. Variation of PM10 concentrations depending on humidity and precipitation

According to the analysed data, in the first 3 days, the measured PM10 concentrations are found around the DLV value, and the monitored PM10 concentrations exceed this limit, by more than 30 µg/m3. Starting with day 3, the monitored PM10 drops to the DLV limit on day 4, respectively below the LET limit starting with day 5, when significant precipitation of 56.39l/m2 was recorded, and the wind speed showed a slight intensification. The measured values follow the decreasing trend with a gap of one day compared to the monitored ones. The analysis of the daily variation of the temperature and the variations of the pollutant concentrations can signal an influence of some associated meteorological parameters, like the previous analysis regarding the influence of the meteorological parameters on the variation of the NO_2 concentrations. The significant decrease in PM10 concentrations monitored from day 5 can be influenced by the occurrence of precipitation starting from this day.

4 Conclusion

The purpose of this monitoring study is to analyse the air quality in sensitive areas of the urban agglomerations, to highlight the need to implement appropriate measures to reduce and control pollution. Thus, the hourly variation of NO_2 concentration estimated from monitoring activities revealed a fluctuating decrease in the first hours of the day (from 2 to 5 am) due to low traffic during the night, followed by an increase in the first hours of the morning (from 6 to 11 am); between 9 am and 17 pm, although traffic was higher than usual, no conclusions could be drawn regarding the evolution of pollutant concentration in relation to the number of vehicles. Even though there was a decrease in traffic in the evening (between 18 and 22 pm), the pollution level on day 1 was higher than the LET values; typically, the pollution level dropped in the last two hours. The monitored NO_2 concentrations have the same pattern as the measured NO_2 concentrations; however, there is a delay in the values' amplitude, which can be explained by the location of each measurement point in relation to the main source of pollution (520 m).

Regarding the PM10 concentrations, on the first day of the campaign, the monitored PM10 concentrations were higher than the DLV limit. They show a continued rising trend on day two, with LET values being exceeded. The highest number of cars per day was recorded on day three of the monitoring campaign, when PM10 concentrations exceeded both the LET and upper emissions threshold (UET). The pollutant reaches a peak on day 4, with concentrations above the DLV and reaching maximum levels. On day five, PM10 concentration levels drop but continue to be higher than the DLV and PM10 concentration values.

The study found a diurnal increase in temperature and a decrease in relative humidity over seven days, with higher levels observed on days 5 and 6. Wind velocity was relatively small for the first three days, but increased on day 4, which led to a reduction in NO_2 pollutant concentrations. The increase in wind speed may also influence significant variation in PM10 concentrations. Further investigation is needed to establish this dependence under different conditions.

Further investigations are necessary to monitor emission sources and air quality in several urban areas of interest, along with the analysis of the influence of meteorological parameters on the accumulation of pollution in different conditions, in order to identify the appropriate possibilities for improving air quality at the local level.

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