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**ASSESSMENT OF THE AIR POLLUTION AT THE INDUSTRIAL STATIONS
IN METROPOLITAN AREA OF BUCHAREST**

The assessment of the level of NO_x concentration in industrial stations Titan, Berceni and Drumul Taberei from Bucharest urban area is the aim of this paper. The study has been performed for the all the four seasons: winter, spring, summer and autumn, for year 2015. In this study it was take in consideration the variation of pressure, temperature, meteorological parameters across the year. The measurement shows that the highest NO_x concentrations occur in the winter and autumn periods, due to unfavorable meteorological dispersion conditions and due to the traffic and operation of thermal power plants in the cold seasons. These thermal power plants, in Bucharest, operate on natural gas, because plants have been refurbished. Generally, the results show that the industrial stations are the main contribution when the NO_x exceed the limit value, according to Law 104/2011. This exceeded of limit value together with meteorological condition and development of industry affect the human health, affect vegetation. This type of study of spatial and temporal variability of pollutant concentrations allows evaluating the requirements of air quality models to represent the key effects.

Keywords: pollutants, spatial and temporal variability, industrial, meteorological conditions.

1. Problem statement and Analysis of the recent researches and publications

Air pollution was first perceived as a local problem in urban industrialized areas, hence taller smoke-stacks for industries and power plants were a ready solution.

The largest source of pollution in most urban areas is represented by the industrial sources and road traffic. In urban areas, where the population is very numerous and the traffic is relatively high, the exposure of people to the concentrations related traffic is significant [1].

Industrial revolution represents the threshold from which the level of pollution grew fast as a result of increased energy needed for the production of steam power engine. In the 19th century, coal became the main used fuel causing a significant increase in smoke and ash released into atmosphere [2].

Air pollution is mainly a wintertime problem related to stagnant meteorological conditions during synoptic high-pressure situations. Limit levels of NO_x in Romania are also defined in the Law 104/2011 which relates to air quality [3].

The aim of our paper is to assess the concentration levels of NO_x for year 2015 at industrial station stations Titan, Berceni and Drumul Taberei from Bucharest urban area. The characteristics of the site and the data from industrial stations used were presented in *Section 2*. The assessments of the level of pollution taking account of meteorological data are presented in *Section 3*. In final of the paper some conclusions were presented.

2. Statement of the problem and its solution

2.1. Data

Bucharest is Romania's capital and at the same time the largest city and the main political, administrative, economic, financial, banking, educational, scientific and cultural Centre in Romania.

The city of Bucharest is located in the southern part of Romania, with a population of 1.92 million permanent residents. The city is situated at an altitude of 60...90 m, the rivers Dambovita and Colentina, 44°25'50" north latitude (as Belgrade, Geneva, Bordeaux, Minneapolis) and 26°06'50" east longitude (as Helsinki or Johannesburg), about 60 km from the Danube, 100 km and 250 km from the Carpathians to the Black Sea.

2.2. Characterizing of stations for measurements

In Bucharest area are eight automatic stations for monitoring air quality. These stations are: 2 traffic stations (Cercul Militar and Mihai Bravu), 3 industrial stations (Titan, Berceni and Drumul Taberei), 1 urban background station (Environmental Protection Agency) and 2 regional background stations (Balotesti and Magurele). Figure 1 present the distribution of the air quality monitoring stations from Bucharest [4].

The study has been performed for evaluation of the air quality at the industrial stations (Titan, Berceni and Drumul Taberei) for all the four seasons: winter, spring, summer and autumn, for year 2015. In this study it was take in consideration the variation of pressure, temperature, meteorological parameters across the year.

2.3. Characterizing of meteorological data

Bucharest climate is moderate continental, with an average annual temperature 10...11 °C; western and southern influences explains the long and warm autumns, of mild winter days of early springs. The average monthly temperature records lowest in January, with an average of -3 °C. Summer is very hot in July the average temperature is 23 °C, sometimes even reach 35...40 °C. Rainfall is low, averaging 585 mm per year, but higher flow summer: the highest monthly average amounts of rainfall in June (about 85 mm), and lowest in March (15 mm).

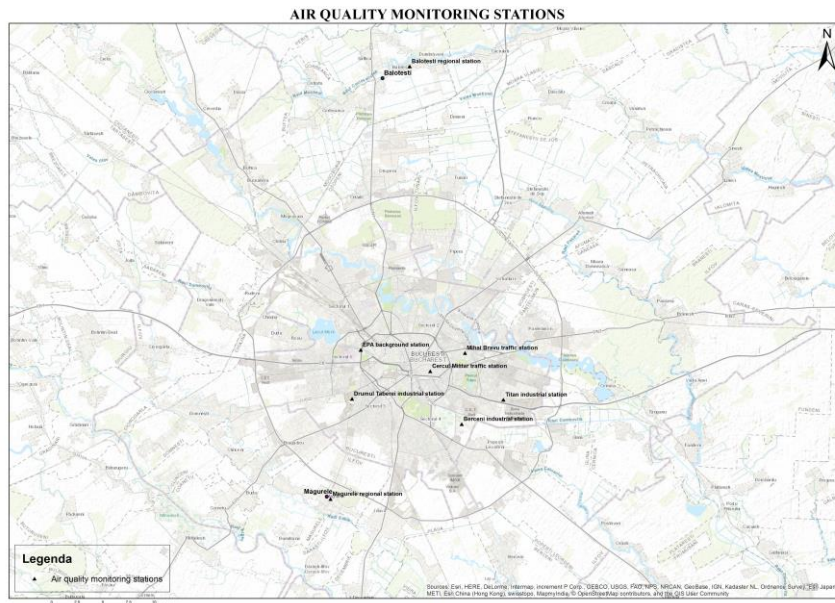


Figure 1 – The distribution of six measurement stations in Bucharest

Distribution of annual wind rose for three industrial automatic stations is represented in figure 2, 3 and 4 [5].

From the analysis of wind rose diagram for industrial Berceni and Titan stations the predominant

wind direction is from North West and South East and from North to South East.

From the analysis of wind rose diagram for industrial Drumul Taberei the predominant wind direction is from north-east to south-west.

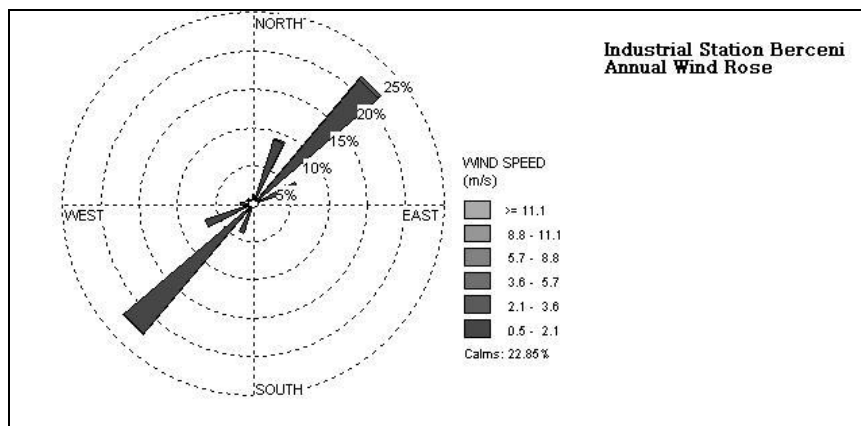


Figure 2 – Annual wind rose at Station Berceni

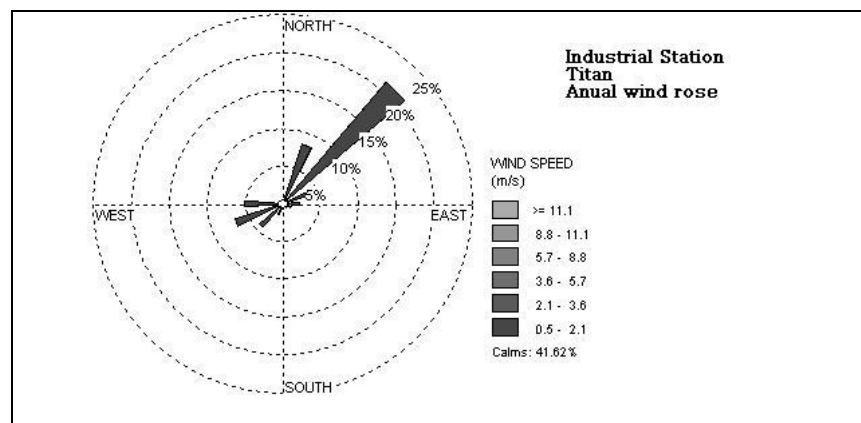


Figure 3 – Annual wind rose at Station Titan

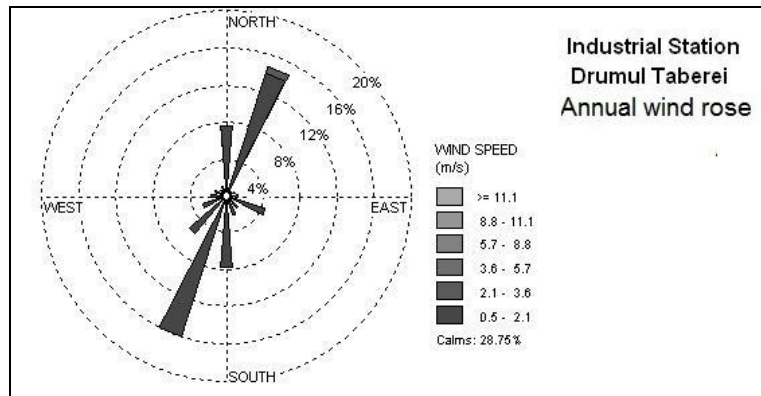


Figure 4 – Annual wind rose at Station Drumul Taberei

3. Results and discussions

3.1. Description of power plant across from industrial monitoring stations

Power plants are major sources of air pollution in Bucharest, through the operation mode with liquid fuels witch having a high sulfur content, spilling into the atmosphere large quantities of SO_2 , NO_x , CO , CO_2 , dust, smoke, fly ash [6].

In this article the pollution sources is represented by the power plants close to industrial monitoring stations (Berceni, Titan and Drumul Taberei). This power plants are: South Power Plant close to automatic monitoring stations Titan, Progresu Power Plant close to automatic monitoring station Berceni and Power Plant Grozavesti close to automatic monitoring station Drumul Taberei. These power plants works on natural gas, and the resulting pollutant from combustion is nitrogen oxides [7].

3.2. Analysis of NO_x concentration measured at automatic monitoring station in winter, spring, summer and autumn

Titan industrial station is located in the east of Bucharest. The following figures show the variation of NO_x concentrations measured at industrial automatic station Titan (pollutions from Power Plant South, residential sources (residential heating and traffic)).

Winter season (figure 5): limit value is exceeded in all the winter months, the limit is $30 \mu g/m^3$. It recorded large increases in December and February; the amount goes up to $280 \mu g/m^3$. For the spring season (figure 6), the highest value is over $100 \mu g/m^3$ and recorded in March, when it is still cold, and people use wood, natural gas for heating.

In summer, the concentration values (figure 7) are exceeded in particular due to traffic since plants produce only hot water, and only used for heating the population. In autumn (figure 8) NO_x concentrations are exceeded, due to the operation of power plant, concentration values are up to maximum values up to $100 \mu g/m^3$.

Berceni industrial station is located in the south of Bucharest. The following figures show changes in concentrations measured at industrial automatic station Berceni (pollution from Power Plant Progresu and from residential sources).

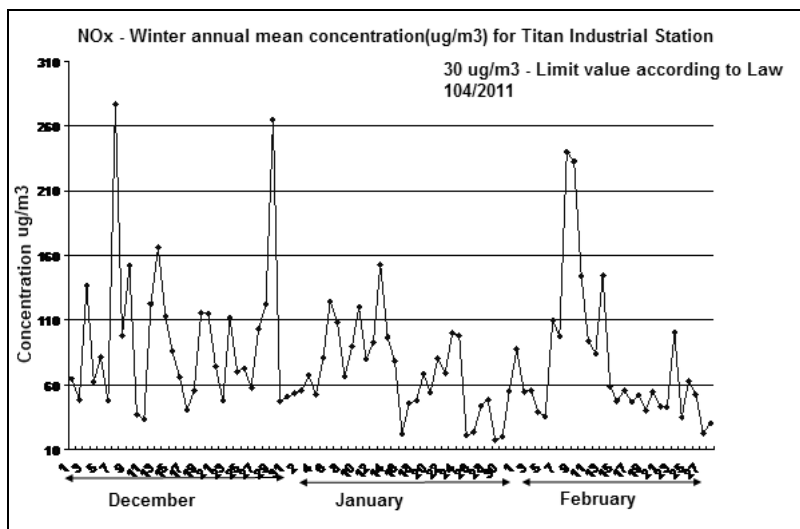


Figure 5 – Winter annual concentration

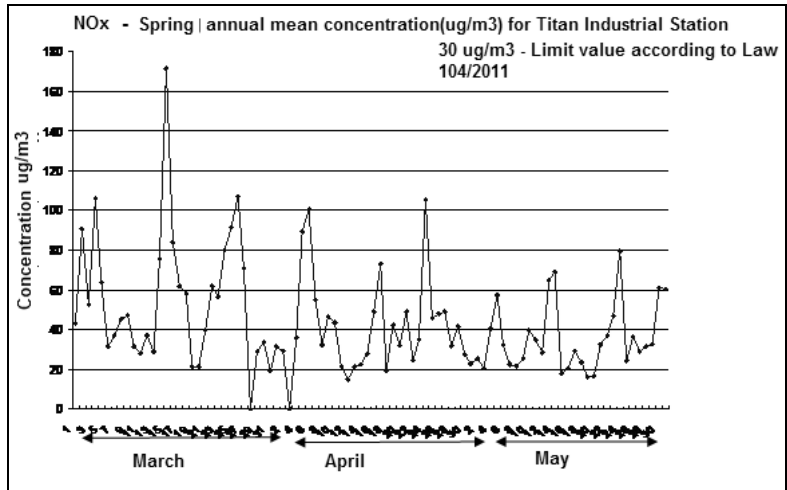


Figure 6 – Spring annual concentration

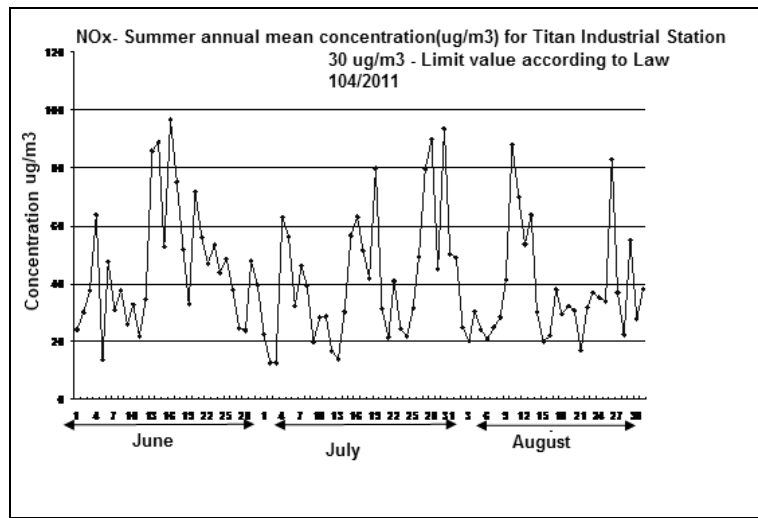


Figure 7 – Summer annual concentration

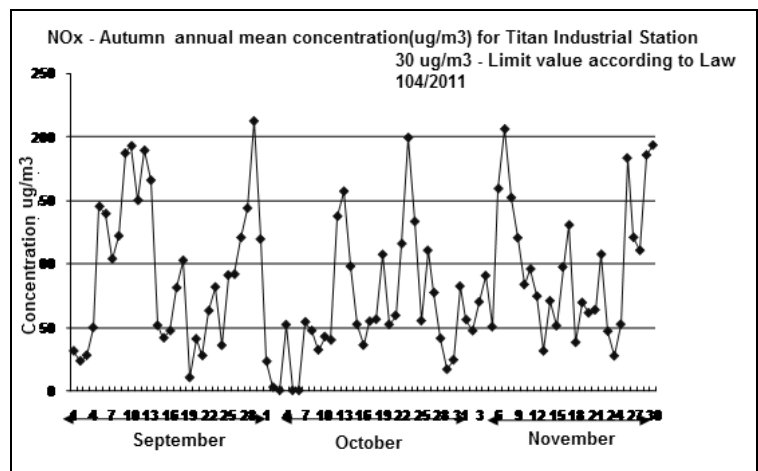


Figure 8 – Autumn annual concentration

Analyzing the chart (figure 9) for the winter season, the limit value is exceeded in December and February, concentrations reaching up to about 200 $\mu\text{g}/\text{m}^3$. For the spring season (figure 10), the highest value is

140 $\mu\text{g}/\text{m}^3$ and recorded in March. Also in March a few values were not recorded, possibly due to downtime analyzers. As we approach the summer concentrations of pollutants decreases.

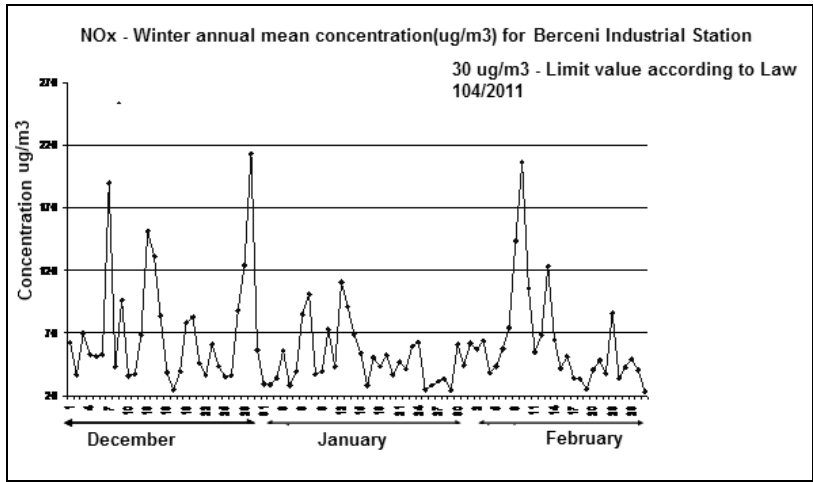


Figure 9 – Winter annual concentration

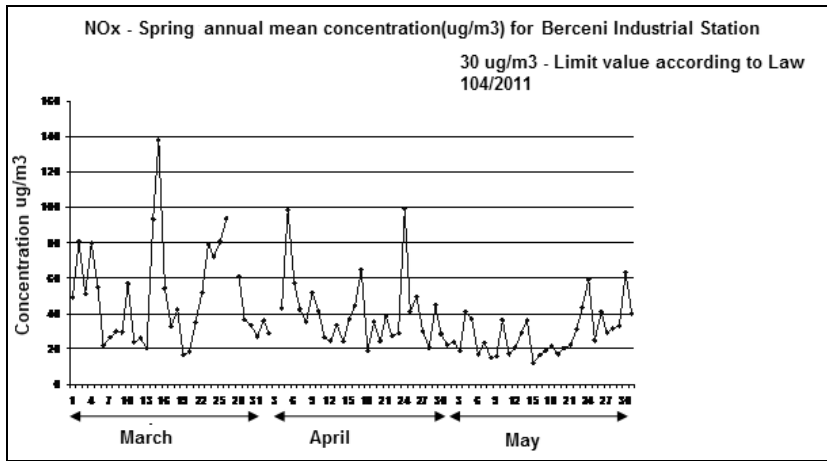


Figure 10 – Spring annual concentration

For the summer season (figure 11) records a few peaks in value of nearly 100 $\mu\text{g}/\text{m}^3$, these values are in July and August in a few days, possibly from damaging the analyzer or the increased flow of cars. In autumn (figure 12) NO_x concentrations are exceeded, due to the operation of power plant, concentration values are up to maximum values up to 100 $\mu\text{g}/\text{m}^3$.

Drumul Taberei Industrial Station is located in the west of Bucharest. The following figures show changes in concentrations measured at industrial automatic station Drumul Taberei (pollution from Power Plant Grozavesti and from residential sources (heating population and traffic)).

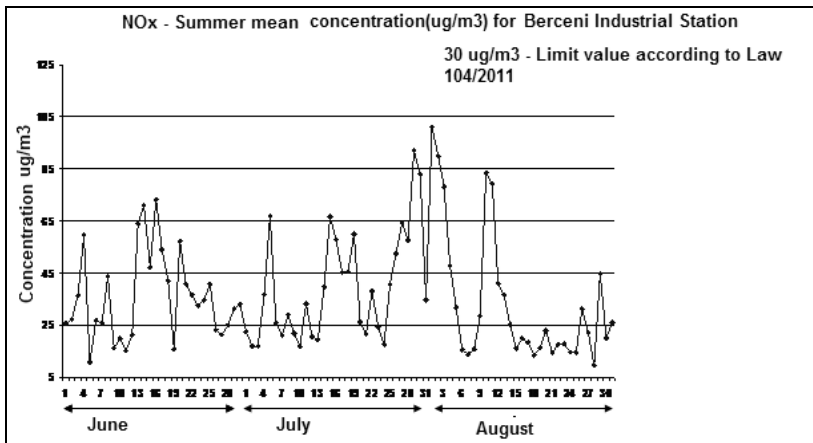


Figure 11 – Summer annual concentration

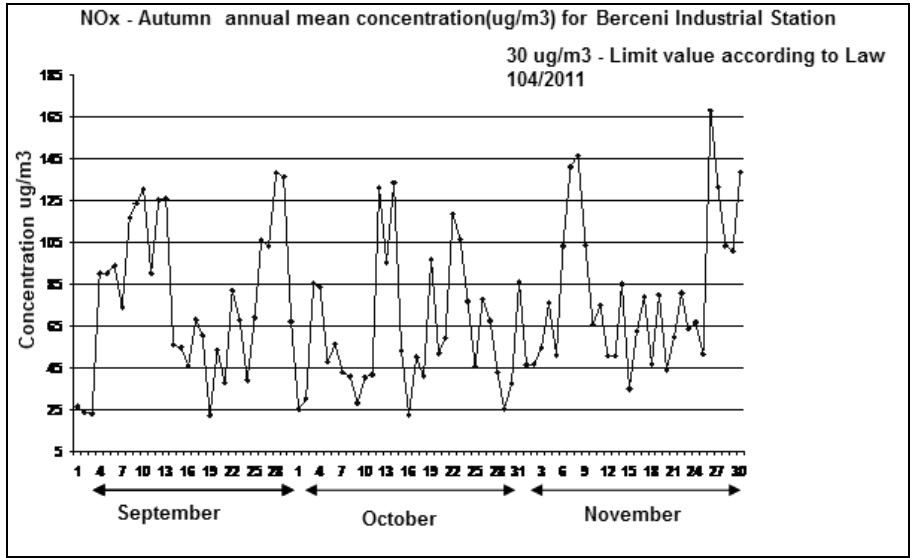


Figure 12 – Autumn annual concentration

The highest value of the concentration recorded in December (figure 13), reaching almost $400 \mu\text{g}/\text{m}^3$, and the major source of pollution is industrial sources (Power Plant Grozăvești) and traffic. The area is extensively circulated by cars passing to the west to exit on the highway, but also because it is underground and the number of cars, buses is higher.

For the spring season (figure 14), the highest value is $200 \mu\text{g}/\text{m}^3$ and recorded in March. Also in March a few values were not recorded, possibly due to

downtime analyzers. As we approach the summer concentrations of pollutants decreases.

In the summer season (figure 15) a few peaks are recorded in value in July because of traffic, and in August the concentrations is decrease because a lot of citizen going in vacation. For the autumn season (figure 16) there was a statistically significant increase concentration because in operation Power Plant Grozavesti and traffic. The highest value recorded in late November about $300 \mu\text{g}/\text{m}^3$.

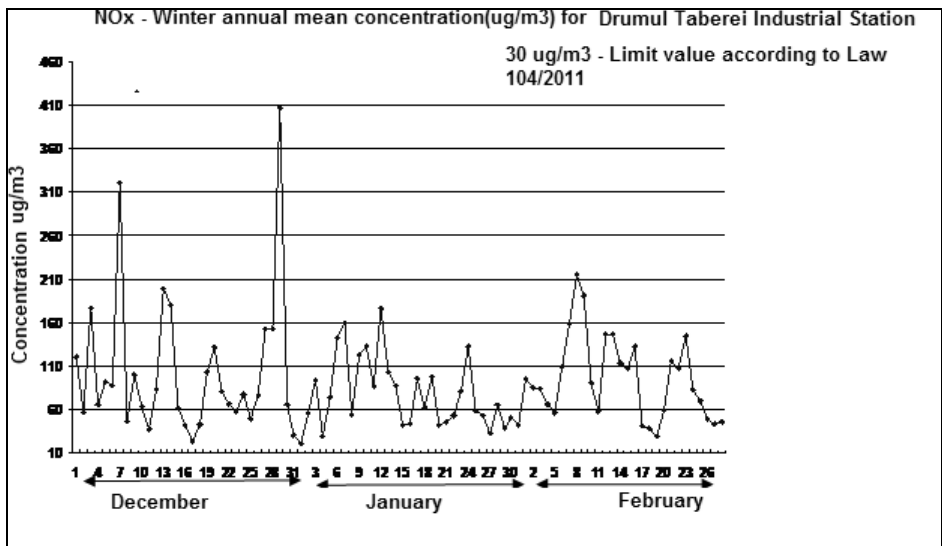


Figure 13 – Winter annual concentration

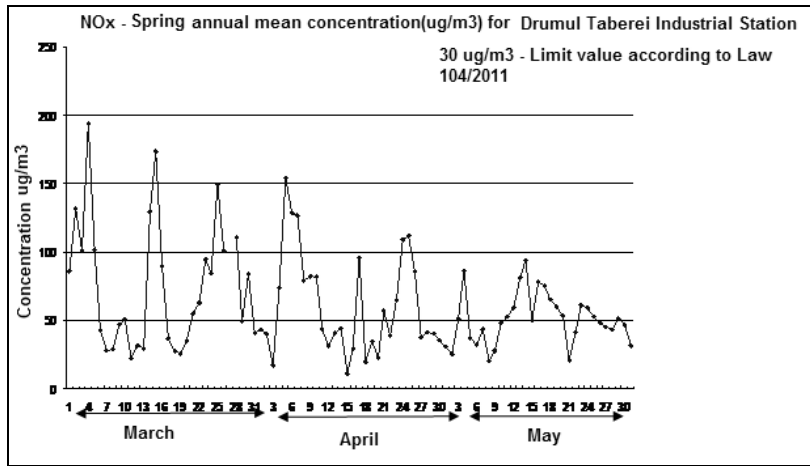


Figure 14 – Spring annual concentration

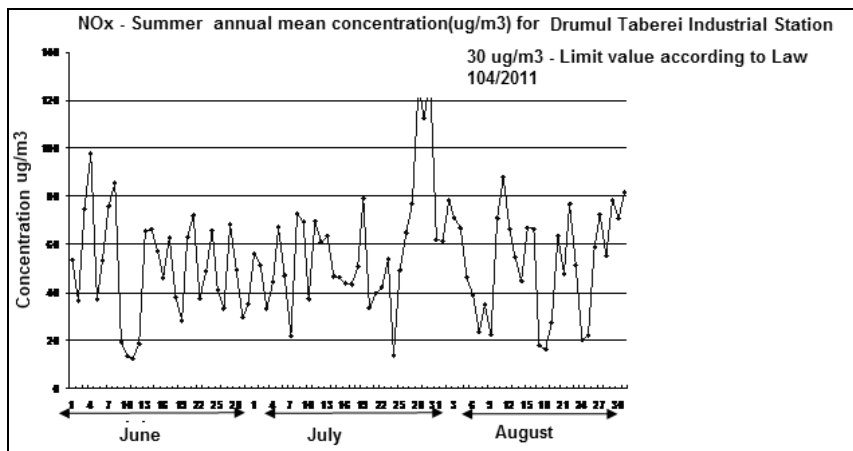


Figure 15 – Summer annual concentration

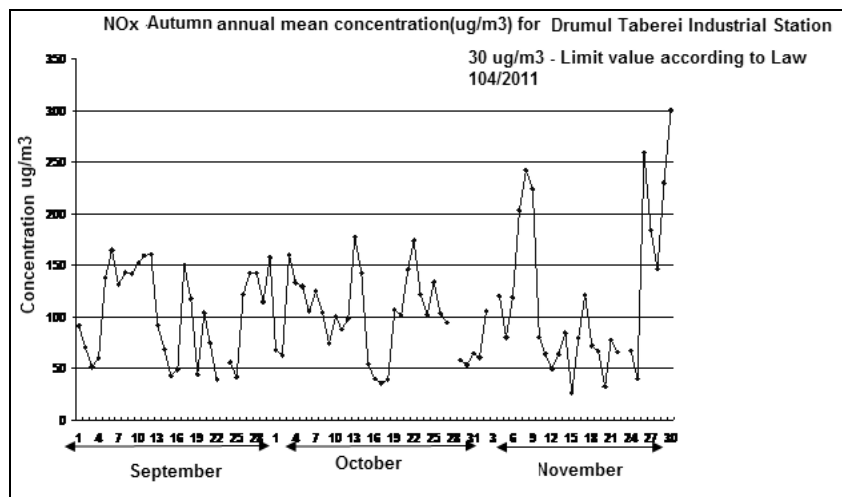


Figure 16 – Autumn annual concentration

Conclusion. This paper presents an experimental study about the sources of atmospheric pollution in the metropolitan area of Bucharest and observations are made based on computer programs developed by the authors, a prediction in concentration of polluting substance in a clearly defined geographical point. An Access database was developed obtain the needed

information provided by automatic monitoring stations which exist in given geographical areas, meteorological parameters for both the pollutants and for NO_x concentrations in the atmosphere.

Analyzing graphical representations of measured concentrations of nitrogen oxides from air quality

industrial automation stations monitoring, power plants represents the main industrial source of pollution during winter and autumn and in summer pollution comes from traffic.

Most pollution (pollution footprint) is represented by power plant Grozavesti, followed by South and Progresu power plants. Traffic impact is greater in the exit area of Bucharest, especially in the west and south.

In conclusion, it is necessary to modernize installation of power plants by replacing the pollution filters in order to reduce pollution levels.

Meteorological factors also play an important role, since pollution is influenced by the thermal inversion because of the existence of Dambovita River. Thermal inversion appeared in days when the water is cooler than the air, and winds are weak.

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ОЦІНКА ЗАБРУДНЕННЯ ПОВІТРЯ В РАЙОНІ ПРОМИСЛОВИХ СТАНЦІЙ МЕТРОПОЛІТЕНУ В БУХАРЕСТІ

Метою даного дослідження є оцінка рівня концентрації NO_x від промислових станцій Titan, Verceeni і Drumul Taberei в Бухаресті. Дослідження було виконано для чотирьох сезонів: зима, весна, літо й осінь 2015 р. У дослідженні враховані зміни атмосферного тиску, температури й метеорологічних параметрів впродовж року. Вимірювання показали, що найвища концентрація NO_x спостерігається в зимовий і осінній періоди, через несприятливі метеорологічні умови й початок експлуатації теплових електростанцій в холодний сезон. Теплові електростанції в Бухаресті працюють на природному газі, оскільки підприємства були модернізовані. Результати показали, що промислові станції є головним джерелом перевищення граничного значення NO_x , встановленого Законом 104/2011. Перевищення допустимого значення концентрації шкідливого компонента у повітрі при певних метеорологічних умовах від промисловості, що розвивається, впливає на здоров'я людини і рослинність. Спосіб дослідження просторової й часової мінливості концентрацій забруднюючих речовин дозволяє оцінити моделі якості повітря для отримання ключових результатів.

Ключові слова: забруднюючі речовини, просторова й часова мінливість, промислові й метеорологічні умови.

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ОЦЕНКА ЗАГРЯЗНЕНИЯ ВОЗДУХА В РАЙОНЕ ПРОМЫШЛЕННЫХ СТАНЦИЙ МЕТРОПОЛИТЕНА В БУХАРЕСТЕ

Целью данного исследования является оценка уровня концентрации NO_x от промышленных станций Titan, Verceeni и Drumul Taberei в Бухаресте. Исследование выполнено для четырех сезонов: зима, весна, лето и осень 2015 г. В исследовании учтены изменения атмосферного давления, температуры и метеорологических параметров в течение года. Измерения показали, что самая высокая концентрация NO_x наблюдается в зимний и осенний периоды из-за неблагоприятных метеорологических условий и начала эксплуатации тепловых электростанций в холодный сезон. Тепловые электростанции в Бухаресте работают на природном газе, поскольку предприятия были модернизированы. Результаты показали, что промышленные станции являются основным источником превышения предельного значения NO_x , установленного Законом 104/2011. Превышение предельного значения концентрации вредного компонента в воздухе при определенных метеорологических условиях от развивающейся промышленности, влияет на здоровье человека и растительность. Способ исследования пространственной и временной изменчивости концентраций загрязняющих веществ позволяет оценивать модели качества воздуха для получения ключевых результатов.

Ключевые слова: загрязняющие вещества, пространственная и временная изменчивости, промышленные и метеорологические условия.