The Current Status of Traffic Nitrogen Oxides Pollution in Cluj – Napoca

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ABSTRACT

Assessing air quality in high urbanized areas and finding solution for most important pollutants (NO_x, CO, SO₂, VOC, PM, O₃, and heavy metals emissions) remains a challenge for authorities and public in aimed areas. The harmful effects upon humans and environmental health is the reason of all concerns. Lots of studies have been developed, in this area, worldwide. Majority of these state that traffic is the most important source of air pollution in crowded cities. The aim of this study consists in establishing the status quo of NO_x pollution status in Cluj – Napoca. NO_x air pollution was quantified during a year period (2013), in two locations correspondent to high traffic and position of automatic air quality monitoring stations placed by The Agency of Environmental Protection Cluj. Parameters were monitored using a mobile equipment. The average values of the analyzed parameters are different function of monitoring point. We noticed statistically significant differences between monitoring points, but in all cases the average concentrations are over the maximum admitted annual limit, 30 ppb, respectively. Further research and more intense concerns are needed from both public and authorities, in order to diminish the nitrogen oxides quantity in environmental air.

Keywords: *air quality, traffic, urban areas, basic statistics.*

INTRODUCTION

Assessing air quality one of the most important issues that concerns urban authorities. The most important pollutants, which occur in large amounts in urban areas are: NO_x, CO, SO₂, VOC, PM, O₃ and heavy metals as Cd, Hg, Cu, Pb, etc. (Atkinson *et al.*, 2004; Oroian *et al.*, 2009). Their presence remains a challenge for urban authorities and inhabitants of these areas, also because complex reactions they are subject in atmospheric air (Atkinson *et al.*, 2004; Varotsos *et al.*, 2014). The harmful effects upon humans and environmental health is the reason of all concerns (Oroian *et al.*, 2009; Williams and Carslaw, 2011).

In this respect we mention that global concerns in this area resulted in a document called, "The

Gothenburg Protocol" signed in 1999, which aims to state the main rules in order to abate acidification, eutrophication and ground-level ozone, until 2010, where Romania is also part (http://www.unece.org/env/lrtap/multi_h1.html). This protocol was modified in 2012, by including Parts engagements concerning mitigation of air pollutants emissions until 2020, compared to 2005 (<http://www.anpm.ro/ro/web/apm-cluj/raportare-anuala/>). Within Gothenburg Protocol and modified provisions, we may also find measures for NO_x abatement. Concerning Romania specific case, they state that up to 2020, our country must mitigate NO_x emission by 45% compared to their amounts in 2005 (309,056), which means they must be lower than the threshold of 170,000 t/year (<http://www.>

anpm.ro/ro/web/apm-cluj/raportare-anuala/). According to the previously cited document, in our country, NO_x emissions are produced in majority by traffic (38.01%), and thermic and production of electric energy (24.73%).

Lots of studies have been developed, in this area, worldwide Grice *et al.*, 2009; Lefebvre *et al.*, 2014; Villena *et al.*, 2012). Majority of these state that traffic is the most important source of air pollution in crowded cities. One of the most important aspects of this situation concern the decrease of NO_x emissions, since adopting "The Gothenburg Protocol". So, if in UK these emissions decreased from 2004 up to 2009, in range of 1-2% (Carslaw *et al.*, 2011), in Romania, they recorded about 28% decrease (<http://www.anpm.ro/ro/web/apm-cluj/raportare-anuala/>).

Establishing the status quo of NO_x pollution status in two important areas from Cluj – Napoca, one industrial type other of urban type characterized by heavy traffic, during 2013, is the aim of our study.

MATERIALS AND METHODS

The experiments were carried out in Cluj-Napoca, town with a population of 304,509 inhabitants, according to last census from 2013, is a first rank municipality, being the second urban agglomeration in Romania, after Bucharest, the capital of the country

Two areas were taken into consideration and monitored, in order to quantify NO_x air pollution. These areas, also are automatically monitored by The Cluj-Napoca Environmental Protection Agency (CNEPA). They are located in Dâmboviței St. - Grigorescu District, and Cluj-Napoca center - Nicolae Bălcescu College (Fig. 1).

The NO_x concentrations were monitored using a mobile equipment, in the same week day, at the same hour intervals 12.00 – 14.00, respectively. Data from the Cluj-Napoca Environmental Protection Agency Report for 2013 - Air Quality are also used in order to compare our monitoring results with official data.

Basic statistics and Box-Plot diagrams were used in order to emphasize the monthly NO_x means in monitored points, and dispersion parameters. ANOVA test was implemented for calculation of significance of differences between monitoring places, and industrial area located in Dâmboviței St. (Grigorescu District), and an urban

Fig. 1. Cluj-Napoca map (<https://www.google.ro/search?q=cluj-napoca&biw=1127>)

area characterized by high traffic, Cluj-Napoca center (Nicolae Bălcescu College), respectively. STATSTICA Software, v.8.0 for windows, was used for data processing.

RESULTS AND DISCUSSION

The monthly means of NO_x values are different function of monitoring point. The highest means recorded in experimental point located in Dâmboviței St. (Grigorescu District), an industrial area (Tab. 1, Fig. 2), are reported in autumn and winter months, December (55.33 ppb), January (47.67 ppb), November (45.67 ppb), October (42 ppb), and February (41. ppb). The lowest NO_x average value (16.67 ppb), is reported in July (Tab. 1, Fig. 2).

The Box-Plot diagram concerning NO_x emissions recorded in Dâmboviței St. located in Grigorescu District, in industrial area, emphasize a normal distribution of data, but with highest dispersion on April and June, and lowest in February, March, and May (Fig. 2).

Concerning monthly means of NO_x values reported in town center (Nicolae Bălcescu College) in 2013, we note, similarly with results recorded in experimental point located in Dâmboviței St. (Grigorescu District), that they correspond to winter and autumn months (Tab. 2, Fig. 3). Thus, they correspond to the following values: 86.67 ppb (January), 84.67 ppb (October), 81 ppb (December), 78.67 ppb (February and November). The lowest NO_x average value (44.67 ppb), is reported in May (Tab. 2, Fig. 3).

The Box-Plot diagram concerning NO_x emissions recorded in town centre nearby Nicolae Bălcescu College emphasize a normal distribution of data, but with highest dispersion on January, March and August, and lowest in July, and December (Fig. 3).

The differences emphasized in dispersion sizes, reported in specific months of the year, may

be explained by climatic conditions (temperature, dew point, atmospheric pressure, wind direction and velocity, humidity, rainfall regimen, etc.) specific for each period.

If we take into consideration the yearly mean values of NO_x emissions recorded in both monitored points, of 33.92 ppb in experimental point located in Dâmboviței St. (Grigorescu

Tab. 1. Basic statistics for the evolution of NO_x occurrence in Cluj-Napoca, monitored in Dâmboviței St. (Grigorescu District), during 2013 (ppb)

Month	N	Mean, ppb	Standard deviation	Standard error of mean
January	5	47.67	1.45	0.65
February	5	41.00	0.58	0.26
March	5	37.00	0.58	0.26
April	5	30.00	2.89	1.30
May	5	20.67	0.33	0.15
June	5	26.33	3.18	1.43
July	5	16.67	1.76	0.79
August	5	20.33	0.88	0.39
September	5	24.33	1.86	0.83
October	5	42.00	1.53	0.69
November	5	45.67	1.20	0.54
December	5	55.33	1.45	0.65

Var 1-January; Var 2-February; Var 3-March;Var 4-April;Var 5-May;Var 6-June;Var 7-July; Var 8-August;Var 9-September;
Var 10-October;Var 11-November;Var 21-December;

Fig. 2. The Box-Plot diagram concerning NO_x emissions recorded in Dâmboviței St. (Grigorescu District) – industrial area

District), and 66.94 ppm in town center (Nicolae Bălcescu College) in 2013, respectively, we note normal distributions, but the difference between means, of 33.92 ppb is very significant, at $p < 0.001$ (Fig. 4).

These differences between the yearly means of NOx emissions in monitored points are determined by the specific of the areas. The monitoring point

located in Dâmboviței St. (Grigorescu District) is one of industrial type with moderated traffic. Thus it can be explained the difference between the mean value of 33.92 ppb NOx reported for this area in 2013, compared with 66.94 ppm NOx, mean value reported for NOx emissions, in 2013, in town center (nearby Nicolae Bălcescu College), area characterized by heavy traffic.

Tab. 2. Basic statistics for the evolution of NOx occurrence in Cluj Napoca, monitored town centre (Nicolae Bălcescu College), during 2013

Month	N	Mean	Standard deviation	Standard error of mean
January	5	86.67	7.64	1.98
February	5	78.67	3.21	0.83
March	5	67.33	6.66	1.72
April	5	54.33	4.04	1.04
May	5	44.67	4.51	1.17
June	5	52.00	4.00	1.04
July	5	51.00	2.00	1.35
August	5	51.00	6.56	1.70
September	5	73.33	4.16	1.08
October	5	84.67	5.03	1.30
November	5	78.67	3.21	0.83
December	5	81.00	2.00	0.52

Var 13-January; Var 14-February; Var 15-March; Var 16-April; Var 17-May; Var 18-June; Var 19-July; Var 20-August;

Var 21-September; Var 22-October; Var 23-November; Var 24-December;

Fig. 3. The Box-Plot diagram concerning NOx emissions recorded in town centre (Nicolae Bălcescu College) – urban area

These results are in concordance with situation reported in our country concerning the difference between NO_x emission amounts in industrial areas and traffic (<http://www.anpm.ro/ro/web/apm-cluj/raportare-anuala/>). In our study, the NO_x mean emission by 2013 recorded in an industrial area Dâmboviței St. (Grigorescu District) is by 49.32% lower compared with NO_x mean emission by 2013, recorded in town center

(nearby Nicolae Bălcescu College), which is an area characterized by heavy traffic.

If we compare the means of NO_x emissions in 2013 in both monitored points with those reported by the Cluj-Napoca Environmental Protection Agency (Fig. 5), we notice differences. The NO_x mean emission by 2013 resulted from our study for the industrial area located in Dâmboviței St. (Grigorescu District), of 33.92 ppm NO_x, is by 21.75% higher compared to the value reported by

Var 25- Dâmboviței St. (Grigorescu District); Var 26- town center (Nicolae Bălcescu College)

Fig. 4. The Box-Plot diagram concerning NO_x emissions recorded in studied monitoring places located in Cluj-Napoca

Fig. 5. The means of NO_x emissions recorded in studied monitoring places located in Cluj-Napoca, according to measured data of experimental results, and data reported by The Cluj-Napoca Environmental Protection Agency (CNEPA)

Cluj-Napoca Environmental Protection Agency for the same year, meaning 26.54 ppm NO_x.

Concerning NO_x mean emission by 2013, resulted from our study for town center (nearby Nicolae Bălcescu College), of 66.94 ppm NO_x, is by 6.86% higher compared to the value reported by Cluj-Napoca Environmental Protection Agency for the same year, meaning 62.35 ppm NO_x (Fig. 5). Results of both studies show that NO_x emissions expressed as yearly means are superior to annual limit value, of 30 ppb, established by Romanian legal frame in Law 104/2011 (Fig. 5).

These differences between the results of our study and those reported by Cluj-Napoca Environmental Protection Agency, concerning the mean NO_x amounts expressed by year 2013 in both monitored points may be explained by the sampling procedure. If Cluj-Napoca Environmental Protection Agency sampling is performed continuously with automatic air quality monitoring stations, our study developed a discontinuous sampling protocol, performed with a mobile device, in rush hours. Thus, the biggest NO_x emission means resulted from our study are justified.

In above described sampling conditions, the low difference (6.86%) between the yearly mean of NO_x emissions reported by our research and that reported by Cluj-Napoca Environmental Protection Agency, emphasize that by entire day interval the Cluj-Napoca urban areas are characterised by heavy traffic.

CONCLUSIONS

The NO_x emissions monitored in two important areas of Cluj-Napoca town, by ours study and official institution represented by the Cluj-Napoca Environmental Protection Agency, in the year 2013, expressed as yearly means, have superior values compared with limit value stated by present national regulations, which is in amount of 30 ppm.

The mean value of NO_x emissions reported by our study is of 33.92 ppm for Dâmboviței St. (Grigorescu District), and 66.94 ppm for town center (nearby Nicolae Bălcescu College). The mean value of NO_x emissions reported by Cluj-Napoca Environmental Protection Agency are 26.54 ppm for Dâmboviței St. (Grigorescu District), and 62.35 ppm for town center (nearby Nicolae Bălcescu College), the differences being explained by sampling approaches.

Further research and more intense concerns are needed from both public and national and regional authorities, in order to diminish the nitrogen oxides quantity in environmental air.

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