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Atmospheric pollution

CORRELATIONS BETWEEN NOISE LEVEL AND POLLUTANTS CONCENTRATION IN ORDER TO ASSESS THE LEVEL OF AIR POLLUTION INDUCED BY HEAVY TRAFFIC

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Abstract. Bucharest is one of the most polluted cities in Europe, with a very high population density and intense traffic. Because many residential buildings and shopping centres are located near different busy roads and crossroads, the air pollution induced by traffic affects the inhabitants in the area. The level of air pollution needs to be constantly monitored in order to take appropriate measures when the concentrations exceed the limits. Most of the measurement techniques require time and expensive equipment, therefore, a big attention turned into finding an air pollution indicator that could be precise enough, easily and cheap to determine. The paper presents some preliminary studies regarding the correlation between noise pollution and the concentrations of NO_2, SO_2, CO. The measurements were conducted at different distances from some very busy roads and crossroads in order to determine a pattern. The data have been processed with a statistical analysis program in order to establish if the noise level can be used to assess the urban air pollution generated by traffic. Most of the results indicate a good correlation between noise and chemical pollutants. Noise level can be a good indicator for air pollution, especially for the situation when there is no need of a precise determination.

Keywords: noise, air pollution, road traffic.

AIMS AND BACKGROUND

The environment is an essential element of human existence and is the result of multiple interferences of natural elements with artificial elements created by human activity. Ensuring a proper quality of the environment, protecting it as a necessity of survival and progress is a matter of major current interest from the point of view of social evolution.

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Environmental protection and pollution reduction are important topics today, both for science and society. Environmental issues are extremely complex and cover all sectors: economic, social and political. Pollution, as it is known, is the contamination with materials harmful to health, quality of life or normal functioning of natural ecosystems.

Bucharest is one of the most crowded and polluted capitals in Europe. Economical evolution conducted to a very big rise in number of cars on the streets (almost two millions, including the ones in transit and supply vehicles)[1–3].

Noise, considered a very important part of environmental pollution, has a major negative impact on the quality of life in cities. The most frequent noise sources in urban environments are transport and industry. Traffic can have a very big contribution to environmental damage because of the noise and specific chemical products emitted in the environmental air: NO_2, SO_2 and CO.

Therefore, a correlation between noise level and chemical pollution caused by heavy traffic can represent a good instrument of environmental quality assessment[4–9].

This paper aims to: (a) identify the existence of a correlation between the noise level and the concentration of NO_2, SO_2 and CO from outdoor air; (b) establish the relationships between these indicators with the purpose to assess the environmental pollution, starting from noise level measurements. Monitoring data have been obtained during a case study conducted in July 15–18, in two locations in Bucharest.

EXPERIMENTAL

Sampling point. Two locations where chosen for the experimental part, both of them located in the south of Bucharest in areas without industrial activities, located nearby to two roads characterised by heavy traffic. In these conditions we can estimate that both noise and chemical pollution are resulted mainly from heavy traffic. Parallel measurements were chosen in order to identify the noise level and the concentration of NO_2, SO_2 and CO in both locations: Luica street (July 15–16 2014) and Giurgiului street (July 17–18), roads characterised by heavy traffic. In all locations the measurements were conducted in the same time, in three different points located at a certain distance from the road (Fig. 1), therefore:

– Location Luica: Point 1 was located nearby the street (geographical coordinates 44°22′37.05″N 26°06′21.54″E), so the influence of traffic is as big as possible; Point 2 is located behind a ten-storey block (geographical coordinates 44°22′40.55″N 26°06′19.24″E); Point 3 is located straight, perpendicular on the line of the road, at 100 m from Luica street (geographical coordinates 44°22′39.47″N 26°06′23.97″E).

– Location Giurgiului: Point 1 is located at the extremity of the sidewalk at the edge of the Giurgiului street (geographical coordinates 44°23′22.59″N

26°05′33.28″E); Point 2 was placed behind a vegetation curtain – close to a recreational park (geographical coordinates 44°23′20.84″N 26°05′36.57″E); Point 3 is also located nearby the vegetation curtain in a car parking (geographical coordinates 44°22′37.05″N 44°22′37.05″E). Locations and points are presented in Figs 1*a*, *b*.

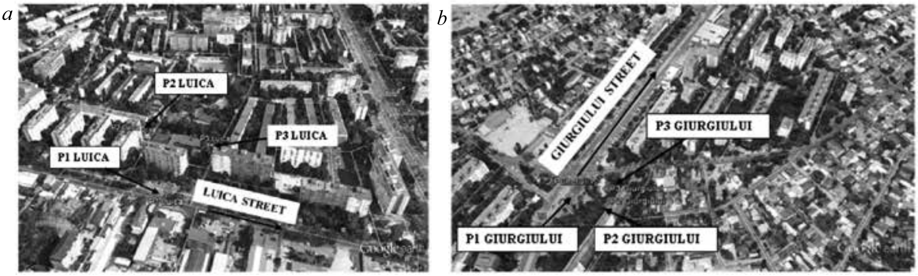

Fig. 1. Location LUICA and the points: P1, P2, and P3 – *a*; Location GIURGIULUI and the points: P1, P2, P3 – *b*

For the parallel continuous measurements in all three points were used three class 1 noise meters (one SOLO 01 Metravib and two Svantek noise meters, each of them provided with octave filter capable to determine the level of acoustical pressure depending on the frequency); the concentrations of chemical pollutants were continuously monitored, using two Graywolf analysers that can measure in parallel all three indicators, installed in points 2 and 3, one analyser Environment AF 22 for SO_2 and one analyser Environment MMS for CO and NO_2, installed in point 1. Air was sampled from 1.5 m height and the concentrations were recorded in hourly averages.

During the tests, in Luica location, the meteorological conditions were favourable for optimum monitoring, with a value of: 19°C for temperature, 1026 mbar for pressure, 70% relative humidity (RH) for humidity and the wind speed was 1.8 m/s blowing from north-east (from the source of pollution to the monitoring points). In Giurgiului location the temperature was 18°C, the pressure 1023 mbar, the relative humidity 70% and the wind speed 1.5 m/s blowing from north-west (from the source of pollution to the monitoring points).

RESULTS AND DISCUSSION

LEVEL OF CHEMICAL AND NOISE POLLUTION IN THE AREA

The monitoring results and the variation in time of NO_2, SO_2, CO and noise pollution are presented in Fig. 2 for Luica and Fig. 3 for Giurgiului.

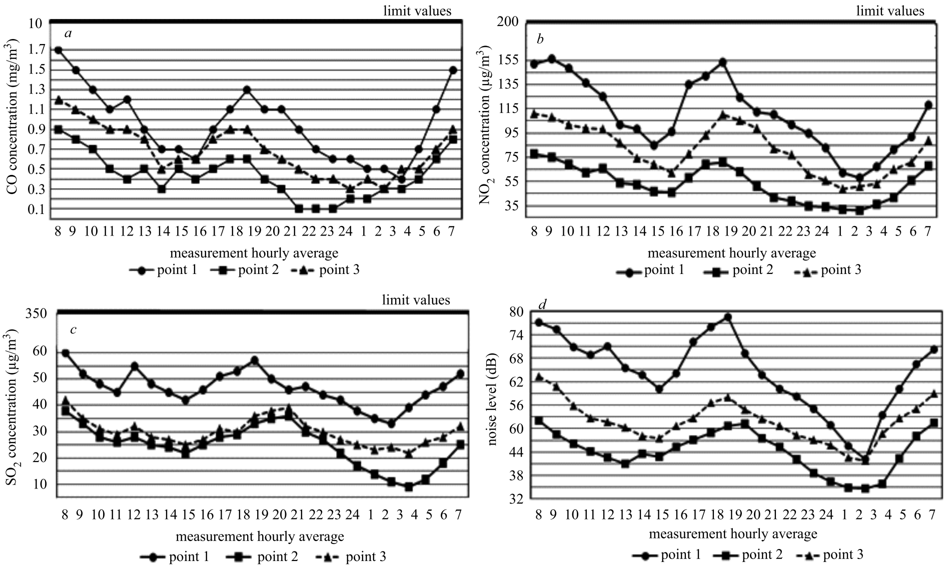

Fig. 2. Concentrations of: CO – *a*; NO_2 – *b*; SO_2 – *c*, and noise level – *d* for the points from Luica location

It can be observed that highest concentrations both for chemical pollutants and for noise level are found in point 1, the one located closest to the road. In points 2 and 3 the concentrations are smaller for all concentrations measured, because of the big block of flats located between the road and the monitoring place for point 2 and because of the big distance from the source of pollution for point 3.

The values for the concentration of NO_2, SO_2, CO and the noise level are very dependent by the point of measurement, as it can be seen in Figs 3*a*, *b* and *c*. Therefore, close to the road characterised by heavy traffic the concentrations of chemical pollutants and noise level are very high. The curtain of vegetation located close to this road is a very good damper for the level of noise and for the concentration of chemical pollutants, resulting a much lower pollution in points 2 and 3 compared with point 1 – the point located on the sidewalk of the road.

By comparison with the values imposed by the environmental legislation, Law 104/2011, it can be observed that the values are under the limits, for both locations[10].

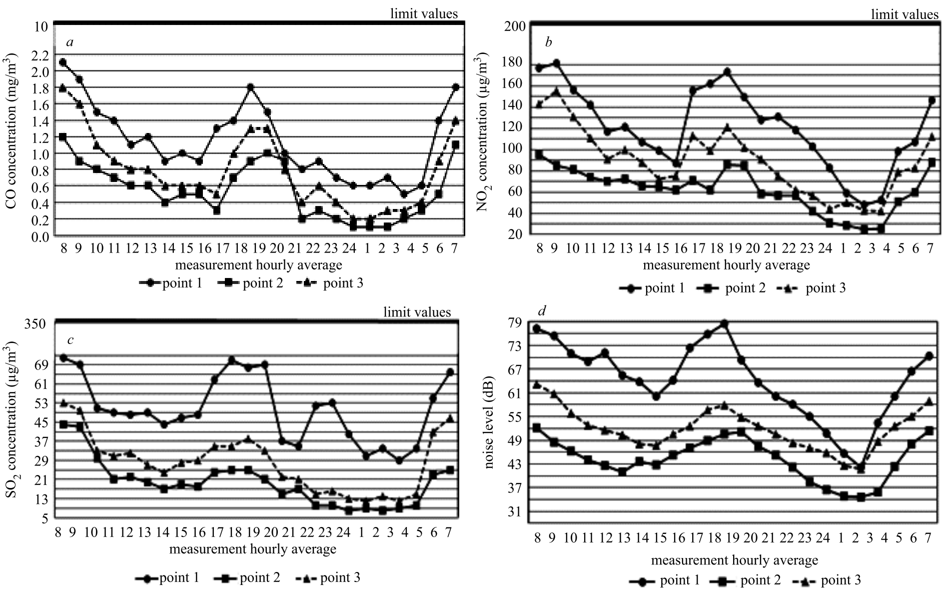

Fig. 3. Concentrations of: CO – *a*; NO_2 – *b*; SO_2 – *c*, and noise level – *d* for the points from Giurgiului location

STATISTICAL TREATMENT OF DATA

In order to identify and establish the correlations between the indicators monitored, the Pearson correlation test has been conducted[11,12]. The value of the Pearson correlation test can be used in order to consider how strong the correlation between two sets of data is; thus, for values of the coefficient comprised between ± (0.8 and 1) the correlation is very good, between ± (0.6 and 0.8) the correlation is good, between (0.4 and 0.6) the concentration is medium and for values between ± (0.2 and 0.4) and ± (0.0 and 0.2) the correlations are weak or very weak. The analysis was done separately for each point and for each area and the results are presented in Table 1.

Table 1. Results of the Pearson correlation analysis in both locations, *R*

R, Luica area																
	point 1				point 2				point 3				Luica area			
	noise	CO	NO_2	SO_2	noise	CO	NO_2	SO_2	noise	CO	NO_2	SO_2	noise	CO	NO_2	SO_2
Noise	1	0.84	0.92	0.95	1	0.68	0.85	0.8	1	0.88	0.82	0.76	1	0.88	0.94	0.92
CO	0.84	1	0.86	0.85	0.68	1	0.85	0.4	0.88	1	0.84	0.66	0.88	1	0.9	0.72
NO_2	0.92	0.86	1	0.87	0.85	0.85	1	0.73	0.82	0.84	1	0.88	0.94	0.9	1	0.88
SO_2	0.95	0.85	0.87	1	0.8	0.4	0.73	1	0.76	0.66	0.88	1	0.92	0.72	0.88	1

R, Berceni area																
	point 1				point 2				point 3				Berceni area			
	noise	CO	NO_2	SO_2	noise	CO	NO_2	SO_2	noise	CO	NO_2	SO_2	noise	CO	NO_2	SO_2
Noise	1	0.89	0.93	0.83	1	0.83	0.87	0.77	1	0.79	0.79	0.82	1	0.88	0.92	0.88
CO	0.89	1	0.87	0.87	0.83	1	0.9	0.78	0.79	1	0.88	0.9	0.88	1	0.9	0.88
NO_2	0.93	0.87	1	0.83	0.87	0.9	1	0.83	0.79	0.88	1	0.88	0.92	0.9	1	0.89
SO_2	0.83	0.87	0.83	1	0.77	0.78	0.83	1	0.82	0.9	0.88	1	0.88	0.88	0.89	1

Analysing the results of correlation analysis for all three points from Luica location, a very good correlation can be observed between the noise level with CO in point 2 (R = 0.68), SO_2 in point 3 (R = 0.76) and very good for the rest of situations analysed (R value between 0.8 and 0.95). Best correlation can be observed between parameters measured in point 1, located very close to the road, the most important source of chemical and noise pollution; the greater the distance from the road, the weaker are the correlations. A possible explanation can be the block of flats located between the road and points of measuring, or some possible sources of pollution closer to the monitoring points[13]. At local level, because of the big number of monitoring sets of values taken in consideration for statistical treatment of data (72 sets of values), the values obtained for the Pearson correlation coefficient indicate only very good correlations (R between 0.88 and 0.94), better than in points 2 and 3 analysed separately. This proves once again the fact that, for the situation analysed, the noise pollution and chemical pollution are generated by the same major source of pollution: heavy traffic[14]. Similar results were obtained in Giurgiului location, with the mention that the values of correlation coefficients are smaller than in the other location. Even so, they are still in the same classes of correlation, good and very good.

Relations between the noise level and the concentration of NO_2, SO_2 and CO were established through linear regression and the results can be seen in Table 2; in Fig. 4 are presented the graphical representations of linear regression analysis between the level of noise and the concentration of NO_2 in both locations.

Table 2. Regression analysis results, R^2

	Noise			
	slope	intercept	R^2	mathematical relation
		Luica location		
CO	0.02829	–0.8225	0.77	$C_{CO} = 0.02829x - 0.8225$
NO_2	2.777	–67.05	0.88	$C_{NO_2} = 2.777x - 67.05$
SO_2	0.9707	–18.07	0.84	$C_{SO_2} = 0.9707x - 18.07$
		Giurgiului location		
CO	0.03576	–1.176	0.77	$C_{CO} = 0.03576x - 1.176$
NO_2	3.004	–77.44	0.84	$C_{NO_2} = 3.004x - 77.44$
SO_2	1.305	–40.25	0.77	$C_{SO_2} = 1.305x - 40.25$

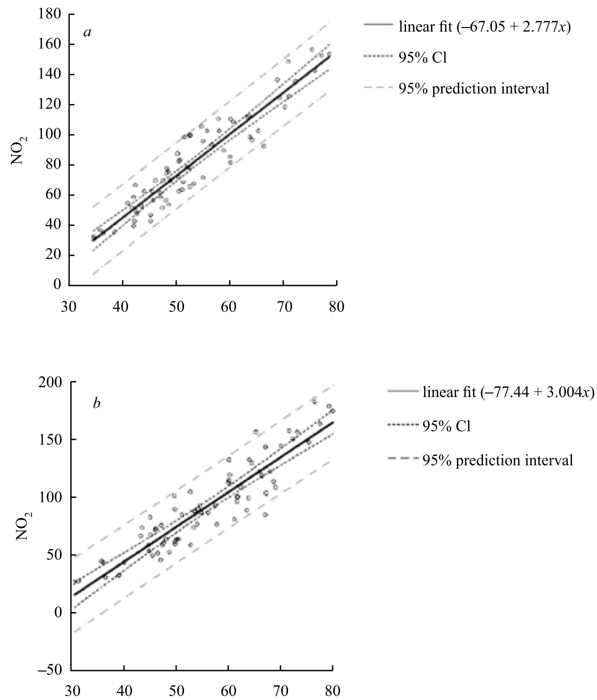

Fig. 4. Linear regression analysis between the level of noise and the concentration of NO_2 in Luica location (*a*) and Giurgiului location (*b*)

Results of regression analysis indicate that in proportions between 77 and 88% in Luica location and in proportions between 77 and 84% in Giurgiului the concentration of NO_2, SO_2 and CO from air varies proportionally with the level of noise; best prediction can be realised for the concentration of NO_2, in this case the values of R^2 are the highest, but also for SO_2 and CO the relations can be used in order to predict the level of chemical pollution from the area only monitoring the level of noise.

CONCLUSIONS

Noise and chemical air pollution from large urban areas represents a major problem both for the health of the people and for authorities. Continuous monitoring of the air quality and noise level, because of particularities of different areas from large cities need important investments for the acquisition and maintenance of automated analysers necessary to monitor each indicator. The results obtained in the tests presented in this paper reveal good and very good correlation between noise level and concentration of NO_2, SO_2 and CO in the air, in two areas of Bucharest where the most important common source of pollution is traffic. In these circumstances we believe that for urban areas in which the most important source of pollution is traffic (common source of noise and chemical pollution) by monitoring the noise level can be obtained important clues regarding the chemical pollution of air through relationships obtained using linear regression without being necessary to monitor all chemical pollutants.

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