Noise and air pollution from urban traffic

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Abstract

Together with the atmospheric emission of pollutants, noise can affect the health of the population. In particular, urban traffic is important when considering population health, because of its proximity to the receptors. In comparison with other pollutants, the control of environmental noise has been hampered by insufficient knowledge of its effects on people and of dose-response relationships, as well as by a lack of defined criteria. Due to the high levels of external noise and interior noise, the difficulties are in communication and a series of nonspecific symptoms: irritability, headache, palpitations, sleep disorders, stress. Concerning air pollution, the health of the population is directly influenced by primary emissions or atmospheric transformation from motor vehicles. Few studies have characterized the spatial correlation between both factors, air pollutants and noise, thus this paper, based on urban noise measurements, presents preliminary data on noise levels in a European capital and a discussion where interactions with air quality are dealt with. Data demonstrates that the urban structure of the analysed city cannot guarantee an adequate protection of the population against noise, because of the interactions between neighbouring areas.

Keywords: urban traffic, emissions, noise, atmospheric pollution, environment.

WIT Transactions on Ecology and The Environment, Vol 191, © 2014 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/SC141162

1 Introduction

Urban traffic represents one of the most polluting factors for the environment [1, 2]. Even talking about the analyses of air emissions from motor vehicles or the noise due to the vehicle private and public use, urban traffic remain one of the main studied topic [3, 4]. Many strategies are proposed in the literature in order to minimize the future costs of effects on health and on the environment, but the issue is faced with different criteria around the World [5–7].

European Union imposes more restrictive limits for the maximum values admitted for air emissions and noise through the following directives 2008/50/CE (quality of environmental air), 96/62/CE (assessment and quality management of environmental air), 2008/1/CE (the prevention and integrated control of pollution) and 2002/49/EC (assessment and noise control) [8].

The number of vehicles world-wide is growing by about 5% per year, far faster than the global human population which has been increasing by 2% per year. For 2030 the estimated total vehicle numbers (cars, trucks, buses and motorcycles) is about 300 millions in Western Europe and North America, despite regions like Asia and Latin America where around 100 million vehicles are estimated [9].

The health of population is directly influenced by the primary emissions or/and by the atmospheric transformation of them (NO_2, O_3, SO_2, PM, CO, Pb, PAHs, etc.). The emissions from the motor vehicles depends on the used fuel, on the type and operating condition engine and whether it uses any emission control device. Pollutant effects may also vary across population groups, especially the young and the elderly may be susceptible to deleterious effects; persons with asthma or other pre-existing respiratory or cardiac diseases may experience aggravated symptoms upon exposure [10].

Noise has always been an important environmental problem for people. In history time, it is known that horse carriages and horseback riding were not allowed at night in certain cities to ensure a peaceful night's sleep for the city dwellers. But, the noise problems and the impact on human health from the past are incomparable with those of a modern society [11]. A huge number of motor cars constantly travel through our cities and the countryside. Heavily-laden lorries with diesel engines badly silenced for engine and exhaust noise are present in cities and on highways, day and night. In comparison with other pollutants, the control of environmental noise has been hampered by insufficient knowledge of its effects on human and of dose-response relationships, as well as by a lack of defined criteria. The effects of noise in developing countries are just as widespread as in developed countries and the long-term consequences for health are the same. Practical actions to limit and control the exposure to environmental noise are therefore essential.

Between 2010 and 2012, in Romania, a study regarding the impact of noise pollution to the population health was developed [12]. The main purpose was the assessment of subjective perception of discomfort produced by noise for 9 cities with a population between 100,000 and 250,000 residents. Results showed that in high traffic areas 66% of the residents are disturbed by noise, while for low traffic areas only 33% of the population considers vehicular traffic like a discomfort. The parking arranged near residential buildings and the lack of parking space cause discomfort for 41% of the population. Due to external interior noise a series of nonspecific symptoms were seen: irritability, headache, palpitations, sleep disorders, stress.

2 Material and methods

This paper presents an experimental activity made in order to determine the quality of life influenced by traffic, depending on the category of road for different urban areas from the point of view of noise exposure. Four case-studies are presented taking into account the road technical categories indicated in the STAS 10144/1-80 [13]:

- Case 1: (urban) highway (technical category I) with an admissible noise level of 85 dB(A);
- Case 2: reconnection road (technical category II) with an admissible noise level of 70 dB(A);
- Case 3: collecting road (technical category III) with an admissible noise level of 65 dB(A);
- Case 4: local road (technical category IV) with an admissible noise level of 60 dB(A).

Details on the location of the monitoring sites (all in Bucharest, Romania) are reported in Figure 1 that concerns the following:

- Case 1 – Calea Vacaresti (Vacaresti street) and measuring point at the limit of a residential area;
- Case 2 – Str. Cutitul de Argint and measuring point at the limit of a residential area;
- Case 3 – Str. Intrarea Doinei and measuring point at the limit of a residential area;
- Case 4 – Str. Smardan and measuring point at the limit of a residential area.

Monitoring the noise level was achieved using a sound level meter integrating SLM SOLO 01, 01dB mark Metravib-France, microphone brand MCE 215, manufactured by GRAS. The device respects European standards, such as: IEC 60651 – Class 1, IEC 60804 – Class 1, IEC 1260 – Class 1, ANSI S1.11 and ANSI S1.4.

In order to measure the sound level, the A-weighted average sound pressure level over a specific period of time was used. For the considered case-studies, the following formula was used in order to measure the total sound energy during the period T:

$$Leq = 10\log_{10}\left[\left(\frac{1}{T}\right)\int_0^T 10^{\frac{L_p(t)}{10}}\,dt\right] dB(A)$$

Figure 1: Location of the monitoring sites in Bucharest (modified from Google Maps).

3 Results

Concerning the *first case*, urban highway, defined as the first road category, the measurements were made during the day time in order to analyse the traffic noise for the residential areas. From Figure 2 it can be observed that, in the reported example, in the measurement point the values for L_{eq} is 80.6 dB(A) that means it is below the limit. But, even the noise level is below the limit of 85 dB(A), it can affect the acoustic comfort on the residential areas. At the measurement time, the close residential area was unprotected against the noise that means the health of the people can be influenced by the traffic road.

File	dBTrait32					
Start	03/28/12 13:50:32					
End	03/28/12 13:55:32					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#1782	Leq	A	dB	80.6	60.3	92.0

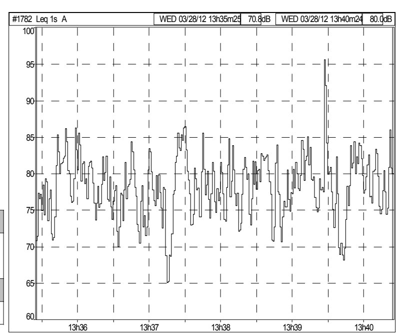

Figure 2: Noise level – day measurements – first road category.

Indeed, concerning the residential area close to the urban highway, in Figure 3 it can be observed a value of L_{eq} = 75.7 dB(A) instead of 50dB(A) or less, as required for residential locations. Thus, in this area it is recommended to take some actions in order to reduce the noise level below the residential limit.

File	dBTrait33					
Start	03/28/12 13:58:49					
End	03/28/12 14:03:49					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#1782	Leq	A	dB	75.7	63.5	83.2

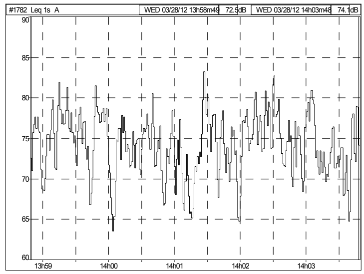

Figure 3: Noise level – day measurements for residential area in vicinity of a I cat. road.

The *second case* is allocated for a connection road where the admissible limit is 70 dB(A). Data are reported in Figure 4. The road is placed in where the noise level is increased by other type of noise sources like commercial activities. The negative effect on a close residential area are shown in Figure 5.

File	dBTrait1					
Start	24.06.11 20:12:34					
End	24.06.11 20:15:34					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#443	Leq	A	dB	68,2	59,8	77,6

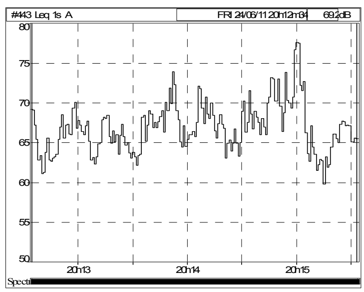

Figure 4: Noise level – day measurements – second road category.

File	dBTrait5					
Start	24.06.11 20:37:29					
End	24.06.11 20:40:29					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#443	Leq	A	dB	58,2	52,8	65,9

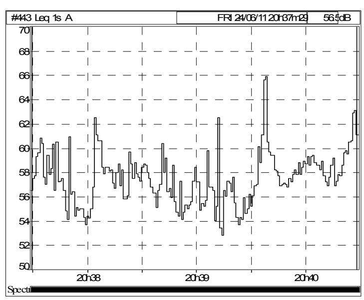

Figure 5: Noise level – day measurements for residential area in proximity of a II cat. road.

The *third case,* is a collecting road with a limit of 65 dB(A), according with STAS 10009-88 – Urban Acoustics. In Figure 6 it can be observed that the measurements gave a L_{eq} = 67.9 dB(A). In this case the close residential area taken as a reference does not need special actions in order to reduce the noise level because of a value (Figure 7) equal to L_{eq} = 47.8 dB(A).

File	dBTrait7					
Start	04/03/12 15:00:48					
End	04/03/12 15:03:48					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#1782	Leq	A	dB	67.9	59.2	78.1

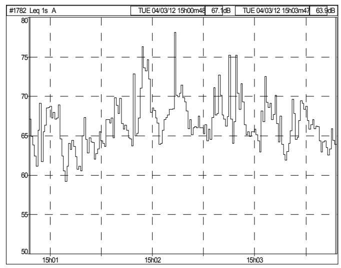

Figure 6: Noise level – day measurements – third road category.

File	dBTrait3					
Start	04/03/12 14:51:59					
End	04/03/12 14:54:59					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#1782	Leq	A	dB	47.8	43.4	53.4

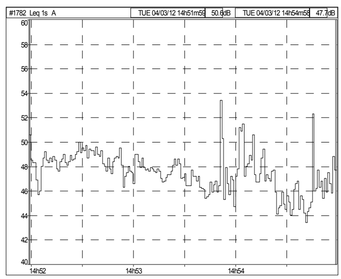

Figure 7: Noise level – day measurements for residential area in proximity of III cat. road.

The *forth case* concerns a small street for local use. Here any noise source can influence significantly the L_{eq} value. According to the standard STAS 10009-88 – Urban Acoustics, L_{eq} = 60dB(A) is the upper limit. The measured value are close to the limit (Figure 8).

File	dBTrait6					
Start	04.04.11 11:48:34					
End	04.04.11 11:51:34					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#1782	Leq	A	dB	60,1	52,8	75,7

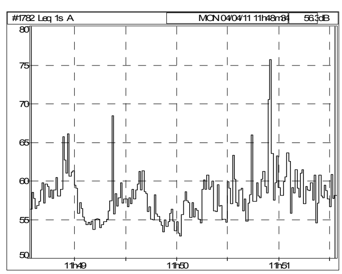

Figure 8: Noise level – day measurements – fourth road category.

The criticalities induces on a close residential area are shown in Figure 9. The limit is slightly overcome. However it must be taken into account that the dB(A) scale is a logarithmic one, thus an extra of 3 dB means doubling the sonic power.

File	dBTrait7					
Start	04.04.11 11:54:04					
End	04.04.11 11:57:04					
Channel	Type	Wght	Unit	Leq	Lmin	Lmax
#1782	Leq	A	dB	63,2	59,3	72,2

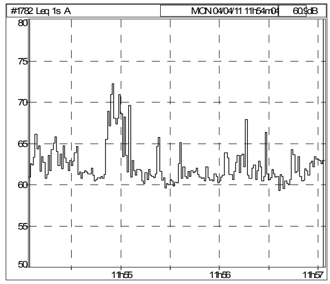

Figure 9: Noise level – day measurements for residential area close to a IV cat. road.

Thereby, if a comparison is made, the results presented as example demonstrate the negative interactions between urban areas with different destination: an overall comparison is reported in Figure 10. In practice, the case studies show that the criteria of urbanisation adopted in the monitored city cannot guarantee an adequate protection of the population against noise.

Figure 10: Comparison of limits and measured values (cases/categories from 1 to 4).

Only recently the scientific literature has started to characterise the spatial correlation between noise and air pollution. Only few studies tried to summarise the human exposure to these two factors into one parameter [10]. These studies indicate that the correlation structure between outdoor traffic – related noise and air pollution may depend on local factors, thus differ between cities. Whether and to what extent the correlations may vary among cities has not been clearly investigated yet. Therefore, a future step of the present study could be to evaluate the correlation between the annual average concentration of measured nitrogen dioxide (NO_2) and the long-term average level of traffic-related noise taken at different locations. Bucharest can be an interesting case-study as the organisation of the traffic pathways is under a fast evolution. NO_2 can be considered a tracer of the presence of traffic. This double information (noise and traffic tracer) could help decision makers to set the priorities of intervention. To this concern a controversial role is played by the artificial barriers: a technical literature has been developed mainly in term of noise mitigation; their role as air pollutant mitigation options seems to be limited to the very close area beyond them, but additional researches should be developed in order to set design criteria useful for taking advantage of this characteristics. However the complexity of the topic is pointed out, for example, in a recent study developed in Spain [14]. In that research, the substantial correlation found between the long-term average of traffic-related 24h noise levels and the annual average of NO_2 concentrations, as well as the many common determinants of the spatial distribution of both factors, suggests that noise could confound the long-term effects of road traffic air pollution on cardiovascular health and vice-versa. Apparently low correlations between these factors, as published in some other studies, may be due to differences in the urban structure or to the different indicators used compared with the Spanish study.

4 Conclusions and outlooks

The main source of noise for the environment remains the traffic noise before the industrial noise and the domestic one. According to the definition of health given by World Health Organization, subjective annoyance should be considered an important health effect. Noise standards should relate to extent of the effect on the population, like what percent of population must suffering serious sleep disturbance can be considered as acceptable. Recent researches aim to propose an integrated approach in order to take into consideration both the parameters (noise and air pollution) but additional studies should be developed in order to increase the knowledge of the sector.

References

[1] Stroe, C., Panaitescu, V., Ragazzi, M., Rada, E.C., Ionescu, G., Some consideration on the environmental impact of highway traffic, *Revista de Chimie*, **65(2)**, pp. 152-155, 2014.

[2] Schiavon, M., Antonacci, G., Rada, E.C., Ragazzi, M., Zardi, D., Modeling human exposure to air pollutants in an urban area, *Revista de Chimie*, **65(2)**, pp. 61-64, 2014.

[3] Ciuta, S., Schiavon, M., Chistè, A., Ragazzi, M., Rada, E.C., Tubino, M., Badea, A., Apostol, T., Role of feedstock transport in the balance of primary

PM emissions in two case-studies: RMSW incineration vs. sintering plant, *UPB Scientific Bulletin*, **74(1)**, serie D, pp. 211-218, 2012.
[4] Ragazzi M., Rada, E.C., Multi-step approach for local environmental impact comparison among conventional and innovative MSW thermo-chemical treatments, *Chemosphere*, **89(6)**, pp. 694-701, 2012.
[5] Ionescu, G., Apostol, T., Rada, E.C., Ragazzi, M., Torretta, V., Critical analysis of strategies for PM reduction in urban areas, *UPB Scientific Bulletin*, **75(2)**, serie D, pp. 175-186, 2013.
[6] Torretta, V., Raboni, M., Copelli, S., Rada, E.C., Ragazzi, M., Ionescu, G., Apostol, T., Badea A., Application of strategies for particulate matter reduction in urban areas: an Italian case, *UPB Scientific Bulletin*, **75(4)**, serie D, pp. 221-228, 2013.
[7] Torretta V., Rada, E.C., Panaitescu, V.N., Apostol T. Some consideration on particulate generated by traffic, *UPB Scientific Bulletin*, **74(4)**, serie D, pp. 141-148, 2012.
[8] Schwela, D., Olivier, Z., Urban traffic pollution, E&FN Spon, 2003.
[9] Health Effect Institute, Air pollution, the Automobile and public health, National Academic Pres, Washington D.C., 1988.
[10] Heimann, D., Clemente, M., Elampe, E., Only, X., Miège, B., Defrance, J., Baulac, M., Suppan, P., Schäfer, K., Emeis, S., Forkel, R., Trini Castelli, S., Anfossi, D., Belfiore, G., Lercher, P., Rüdisser, J., Uhrner, U., Öttl, D., Rexeis, M., de Franceschi, M., Zardi, D., Cocarta, D., Ragazzi, M., Antonacci, G., Cemin, A., Seibert, P., Schicker, I., Krüger, B., Obleitner, F., Vergeiner, J., Grießer, E,. Botteldooren, D., Renterghem, Van, T., Air Pollution, Traffic Noise and Related Health Effects in the Alpine Space, University of Trento, DICA, pp. 335, 2007.
[11] Rada, E.C., Cirlioru, T., Panaitescu, V., Grigoriu, M., Ragazzi, M., Environmental noise and influence on the people in urban areas, Proceedings of the International Conference on Risk Management, Assessment and Mitigation (RIMA'10), pp. 154-160, 2010.
[12] Report of the Romanian National Institute of Public Health, 2013.
[13] Romanian Standard Regulation STAS 10144/1-80.
[14] Foraster M., Deltell A., Basagana X., Medina-Ramo M., Aguilera I., Bouso L., Grau M., Phuleria H.C., Rivera M., Slama R., Sunyer J., Targa J., Kunzli N. Local determinants of road traffic noise levels versus determinants of air pollution levels in a Mediterranean city, *Environmental Research*, **111**, pp. 177-183, 2011.