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PRESENT PROBLEMS REGARDING URBAN ROAD TRAFFIC NOISE AND MITIGATION POSSIBILITIES

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Key words: noise, road traffic, urban, protection.

Abstract: Noise level measurements performed in several locations in Bucharest for high road traffic conditions are presented with relevant details. Calculation methods give comparable data sets for the different studied locations. Some applicable measures for noise mitigation are analysed, comparing estimated results and looking for significant effects.

Introduction

Studies for inhabited areas protection against road traffic noise became important because of the continuous increase of the number of road vehicles.

Road traffic noise comes from a permanently variable combination of different sources: cars, buses, trucks, trolleybuses, trams, motorcycles. Noise is generated by motion over the pavement, by engines and exhaust pipes. Noise level depends on speed, specific features of the vehicles, their technical condition, local characteristics of the traffic flow.

Noise attenuation depends on distance from the source, but it is also influenced by roadway, buildings and obstacles (including the neighbor cars).

Structures reduce or block noise propagation behind them, and increase noise level in front of them due to reflection phenomena, depending on geometrical features and surface characteristics. There are many factors that influence noise level on streets and permanent changes, so that field studies are absolutely necessary in order to get noise data for real traffic and urban road conditions.

1. Present noise levels measured on main streets

Noise level was studied in several locations in Bucharest, looking for high traffic conditions.

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Location 1 is in the area where Şoseaua Virtuţii crosses Calea Apeductului. These streets have vehicle traffic in both directions, as usual for most streets. Şoseaua Virtuţii can be considered a U-shaped street, having P+8 high buildings on each side. There are tramways along Şoseaua Virtuţii, with concrete plate support, in the middle of the street, and vehicles pass along side ways.

The buildings have complex front shapes as can be seen in Figure 1.

Fig. 1 - Morning traffic near the area where Şoseaua Virtuţii crosses Calea Apeductului

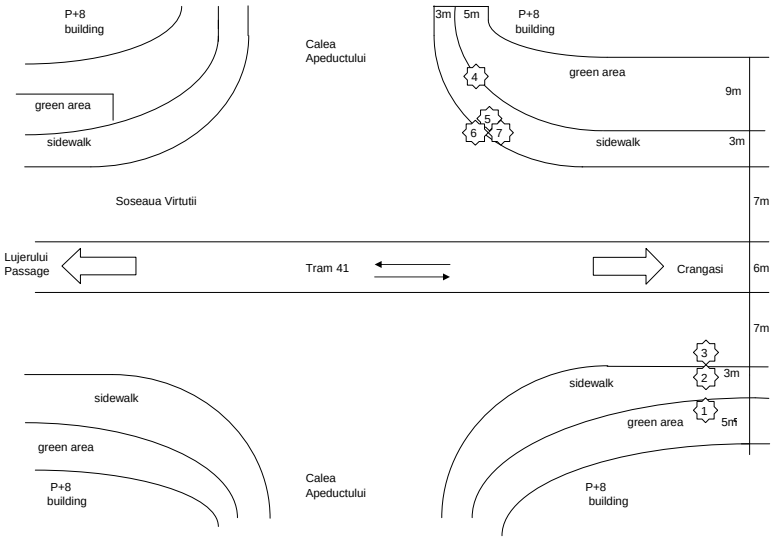


Fig. 2 - Location 1: Cross area of the streets Şoseaua Virtuţii and Calea Apeductului, and measurement points

Road traffic in one direction on Calea Apeductului in the morning was congested, with slow velocity; stop at the cross area and intermittent flow at about 30 seconds intervals. 87 vehicles passed in 10 minutes, including 3 minibuses.

On the other direction, 10 vehicles were observed, including 1 bus, 1 minibus and 3 trucks. Vehicles stop before the cross area.

Şoseaua Virtuţii is considered street of 1st technical category, main street, according to STAS 10009-88 regarding Urban Acoustics. Therefore, allowed limits for equivalent noise level Leq are 75…85 db(A).

For Calea Apeductului, considered street of 3rd technical category, collecting street, according to STAS 10009-88, allowed limit for equivalent noise level is 65 db(A).

Tab.1 - Measured noise levels in points of location 1 in the morning

Crt. No.	**Noise measurement points**	**Measured noise levels [dB]**	**Equivalent noise level (Leq) [dB(A)]**	**Allowed limit for Leq [dB(A)]**
1	Point 1 hour 7^{40}	64.4 – 83.5	71.0	according to STAS 10009-88 75…85
2	Point 2 hour 7^{50}	62.3 – 77.5	69.8	according to STAS 10009-88 75…85
3	Point 3 hour 8^{00}	65.7 – 73.4	70.3	according to STAS 10009-88 75…85
4	Point 4 hour 8^{15}	60.6 – 73.2	68.0	according to STAS 10009-88 75…85
5	Point 5 hour 8^{20}	65.3 – 83.9	76.3	according to STAS 10009-88 75…85
6	Point 6 hour 8^{25}	66.3 – 95.4	83.8	according to STAS 10009-88 75…85
7	Point 7 hour 8^{30}	61.3 – 81.6	71.2	according to STAS 10009-88 75…85

Noise level was measured in 4 points in the evening (Tab. 2) between hours 20^{15}-20^{35}, counting also the number of passing road vehicles. Along one direction on Şoseaua Virtuţii, road traffic was fluent and comprised 218 vehicles in 10 minutes, including 4 trams, 2 trucks, 10 minibuses.

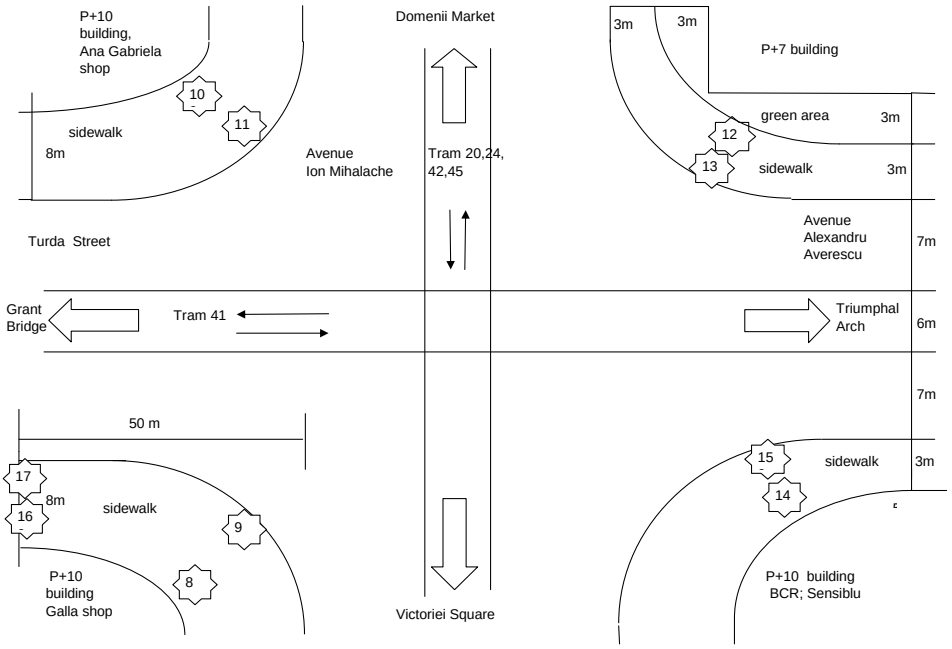
In the opposite direction, road traffic on Şoseaua Virtuţii was fluent, 287 vehicles passing in 10 minutes, including 4 trams, 2 buses, 4 trucks, 12 minibuses and 3 motorcycles.

Road traffic on Calea Apeductului in the evening was reduced. 10 vehicles (including 2 minibuses) passed in one direction in 5 minutes, and 6 vehicles (including 1 minibus) passed in the other direction in 10 minutes.

Tab. 2 - Measured noise levels in points of location 1 in the evening

Crt. No.	Noise measurement points	Measured noise levels [dB]	Equivalent noise level (Leq) [dB(A)]	Allowed limit for Leq [dB(A)]
1	Point 1 hour 20^{15}	63.1 – 72.4	67.3	according to STAS 10009-88 75…85
2	Point 3 hour 20^{20}	66.3 – 83.6	77.9	according to STAS 10009-88 75…85
3	Point 4 hour 20^{25}	58.6 – 74.2	68.5	according to STAS 10009-88 75…85
4	Point 5 hour 20^{30}	65.0 – 78.2	73.6	according to STAS 10009-88 75…85

Fig. 3 - Location 2: Cross area of the streets Turda, Ion Mihalache Avenue and Alexandru Averescu avenue, and measurement points



Noise levels were measured in 10 points numbered from Point 8 to Point 17, in the morning, at noon and in the evening (Fig. 4, Tab. 3). The number of vehicles was also observed.

Fig. 4 - Cross area of Turda Street, Ion Mihalache Avenue and Alexandru Averescu Avenue

The measured values are generally within the allowed limits for the streets. The highest noise values were observed in the morning, when road traffic is most congested.

Similar noise measurements were carried out in many other locations on streets with high road traffic.

Location 2 is in the area where Turda Street crosses Ion Mihalache Avenue and Alexandru Averescu Avenue (Fig. 3). These are U-shaped streets, having P+10 or P+7 buildings on their sides.

Noise level was measured in 7 points shown in Figure 2, in May between the hours 7^{40}-8^{35} in the morning and between the hours 20^{15}-20^{35} in the evening (Tab.1). Traffic flow rate was also counted during the measurements on Şoseaua Virtuţii and Calea Apeductului.

Road traffic in the morning was congested. 290 vehicles were counted passing with slow velocity along one direction on Şoseaua Virtuţii in 10 minutes, including 3 trams, 4 buses, 5 trucks, 7 minibuses, 5 motorcycles and 1 ambulance. Traffic in the opposite direction was normal, with average velocity. 250 vehicles were observed in 10 minutes, including 4 trams, 3 buses, 5 tractors with trailer and a loader of Fadroma type, 6 trucks, 10 minibuses and 6 motorcycles.

Tab. 3 - Measured noise levels

Crt. No.	Noise measurement points	Measured noise levels [dB]	Equivalent noise level LQE [dB(A)]	Allowed limit for Leq [dB(A)]
1	Point 8			according to STAS 10009-88
	hour 9^{00}	63.0 – 77.2	69.7	75…85
	hour 12^{30}	62.6 – 74.2	68.9	75…85
	hour 19^{00}	62.6 – 74.4	69.4	75…85
2	Point 9			according to STAS 10009-88
	hour 9^{05}	64.3 – 78.8	70.8	75…85
	hour 12^{35}	62.7 – 73.6	66.9	75…85
	hour 19^{05}	65.7 – 82.3	73.7	75…85
3	Point 10			according to STAS 10009-88
	hour 9^{10}	62.8 – 73.0	67.7	75…85
	hour 12^{40}	65.8 – 75.5	70.6	75…85
	hour 19^{10}	61.5 – 71.3	65.9	75…85
4	Point 11			according to STAS 10009-88
	hour 9^{15}	66.6 – 83.1	74.1	75…85
	hour 12^{45}	62.6 – 73.6	67.9	75…85
	hour 19^{15}	64.0 – 79.7	71.2	75…85
5	Point 12			according to STAS 10009-88
	hour 9^{20}	63.9 – 78.3	70.3	75…85
	hour 12^{50}	65.9 – 78.7	70.5	75…85
	hour 19^{20}	59.7 – 78.7	69.8	75…85
6	Point 13			according to STAS 10009-88
	hour 9^{25}	66.5 – 87.4	73.5	75…85
	hour 12^{55}	66.5 – 81.0	74.5	75…85
	hour 19^{25}	67.5 – 78.9	73.0	75…85
7	Point 14			according to STAS 10009-88
	hour 9^{30}	64.0 – 79.3	72.7	75…85
	hour 13^{00}	63.5 – 78.5	71.0	75…85
	hour 19^{30}	62.1 – 76.5	67.8	75…85
8	Point 15			according to STAS 10009-88
	hour 9^{35}	64.5 – 83.7	74.2	75…85
	hour 13^{05}	65.3 – 85.9	73.5	75…85
	hour 19^{35}	65.6 – 74.9	70.8	75…85
9	Point 16			according to STAS 10009-88
	hour 9^{40}	65.5 – 74.6	69.5	75…85
	hour 13^{10}	61.6 – 72.3	67.8	75…85
	hour 19^{40}	61.0 – 70.4	65.8	75…85
10	Point 17			according to STAS 10009-88
	hour 9^{45}	63.1 – 81.6	71.1	75…85
	hour 13^{15}	64.7 – 74.7	71.9	75…85
	hour 19^{45}	61.5 – 77.6	70.7	75…85

Location 3 is in the cross area of Ion Mihalache Avenue and P. I. Pavlov Street, where there are also other streets. There are green areas with trees and shrubs in front of the buildings on one side. Ion Mihalache Avenue can be considered L-shaped street in this area (Fig. 5). Buses and trams pass along Ion Mihalache Avenue, together with other vehicles.

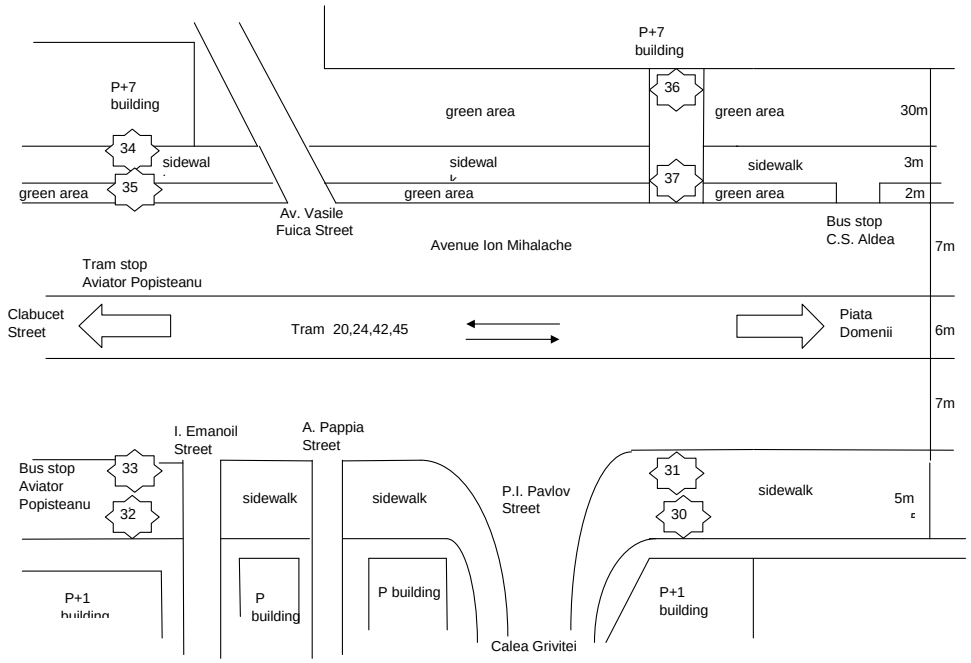


Fig. 5 - Location 3: Cross area of Ion Mihalache Avenue and P. I. Pavlov Street

Noise levels were measured in 8 points, numbered from 30 to 37, on Ion Mihalache Avenue, and in 2 points (numbered 38 and 39) on P. I. Pavlov Street (Tab. 4), and also the number of road vehicles was observed, in the afternoon.

Noise levels on Ion Mihalache Avenue are generally within allowed limits and are higher than on P. I. Pavlov street.

The noise levels measured in the different locations, even if within the allowed limits for roads, are in some points 20-30 dB higher then the limits allowed in the standard for the inhabited building façade. This fact also resulted from the monitoring of exterior noise in Bucharest [1].

Tab. 4 - Measured noise levels

Crt. No.	Noise measurement points	Measured noise levels [dB]	Equivalent noise level (Leq) [dB(A)]	Allowed limit for Leq [dB(A)]
1	Point 30 hour 15^{30}	60.8 – 77.8	71.6	according to STAS 10009-88 75…85
2	Point 31 hour 15^{35}	64.2 – 76.3	71.2	according to STAS 10009-88 75…85
3	Point 32 hour 15^{40}	60.3 – 71.8	67.8	according to STAS 10009-88 75…85
4	Point 33 hour 15^{45}	61.2 – 79.0	71.8	according to STAS 10009-88 75…85
5	Point 34 hour 15^{50}	58.8 – 74.3	64.6	according to STAS 10009-88 75…85
6	Point 35 hour 15^{55}	58.3 – 78.0	70.7	according to STAS 10009-88 75…85
7	Point 36 hour 16^{05}	57.5 – 62.6	60.5	according to STAS 10009-88 75…85
8	Point 37 hour 16^{10}	57.1 – 77.2	70.4	according to STAS 10009-88 75…85
9	Point 38 hour 16^{45}	49.1 – 72.0	62.2	according to STAS 10009-88 60
10	Point 39 hour 16^{55}	49.1 – 72.5	61.1	according to STAS 10009-88 60

2.Estimations of noise level on streets with high road traffic

Taking into consideration the presence of buildings on both sides of the streets where noise was measured, a simple formula was used, having the following structure [2]:

$$L_{ech} = A + 10\log\left(Q_{VU} + BQ_{VG}\right) - 10\log l + k$$

where Q_{VU} is the representative flow of light vehicles per hour

Q_{VG} is the representative flow of heavy vehicles per hour

B is a noise equivalence factor between light vehicles and heavy vehicles

l is the total street width between opposite high buildings

k is a correction term (e.g. for height, velocity, etc.)

A is a calibration parameter.

Noise level estimation using this method for the studied locations gives results that are generally close to measured values for most of the observed traffic

situations. However, the range of measured values is influenced by the heterogeneity of the light vehicles flow, and also of the heavy vehicles.

Moreover, different results occurring sometimes at comparable traffic flow values can be explained by differences of other data (especially various velocities during time intervals when vehicles start or stop), because the method was tested for conditions that are difficult to be characterized, with traffic pulses, sometimes far from a fluent traffic situation (Fig. 6, 7, 8).

It is important to remark that traffic velocities in the studied locations are highly variable.

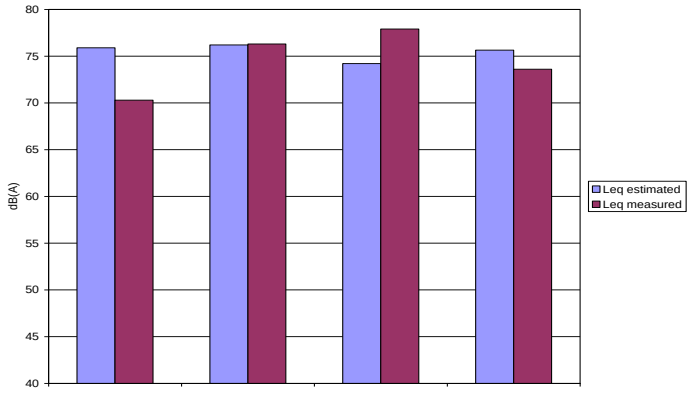


Fig. 6 - Measured and estimated noise in points of Location 1 – Şoseaua Virtuţii

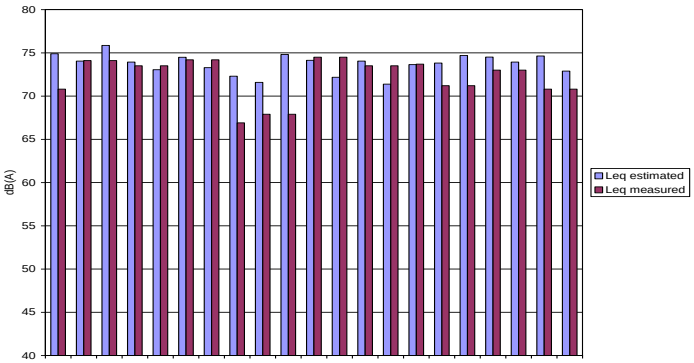


Fig. 7 - Measured and estimated noise in points of Location 2 – Ion Mihalache Avenue at crossing with Turda Stree

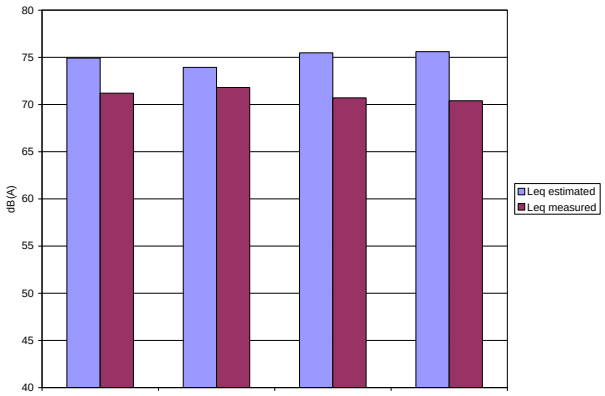


Fig. 8 - Measured and estimated noise in points of Location 3 – Ion Mihalache Avenue

3. Analysis of some possibilities to reduce noise level from urban road traffic

Field measurements and observations show that there are some noisier sources, e.g. some motorcycles, or some trucks. They are important for the noise level. For example, a source with 10 or 15 dB(A) higher noise level dominates the traffic noise (Fig. 9).

Maintenance and finally guiding the noisiest vehicles to other streets can reduce noise level on main streets of inhabited areas.

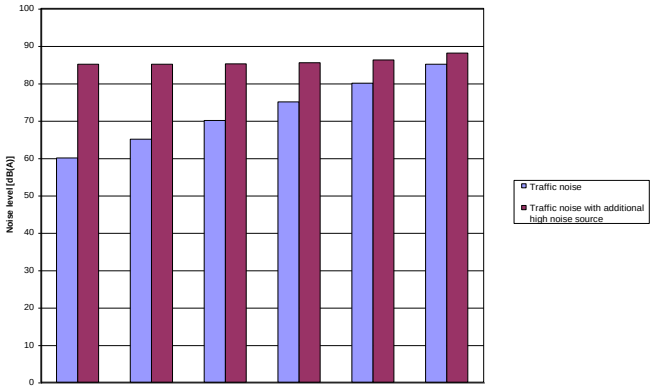


Fig. 9 Effect of a high noise source

Noise level depends on the total traffic flow (Fig. 10). There are some possible measures to reduce the traffic flow: guiding some incoming vehicle flows to other streets, time schedule of traffic lights so that to avoid simultaneous traffic in both

directions, guidance towards the use of vehicles with lower noise, increase of public transport capacity and coverage.

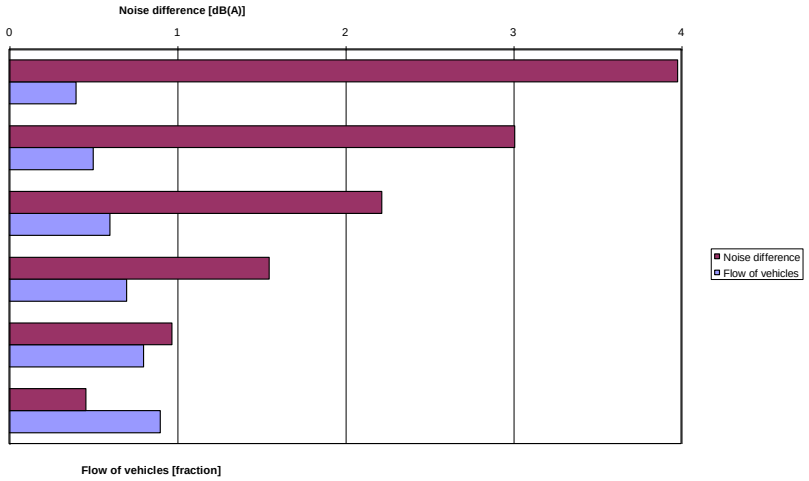


Fig. 10 - Differences of noise level for fractions of the total number of vehicles

If vehicles are guided to move along a larger street, noise level is lower at the buildings because of the distance increase (Fig. 11).

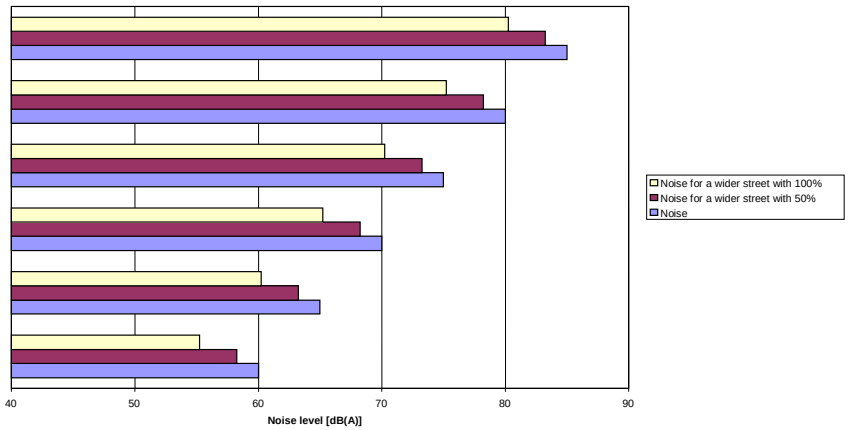


Fig. 11 - Reduced noise levels on wider streets

In some locations with high noise from road traffic, noise barriers can be used. They can result in significant noise reduction as observed in locations with such existing protection (Fig. 12).

According to the formula, reducing the total traffic flow on a main street leads to an estimated noise level decrease of up to 5 dB(A). Guiding road traffic to larger streets, noise level decreases by 2 – 5 dB(A).

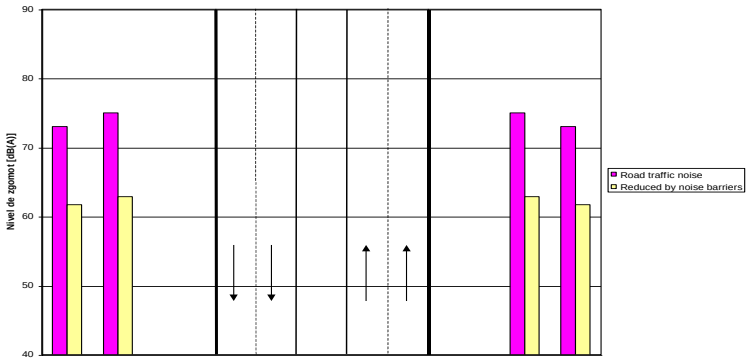


Fig. 12 - Effect of noise barriers

Guiding the noisiest vehicles to other streets results in significant decrease of noise, even with 10 dB(A) or more. Noise barriers are very effective, with generally more than 10 dB(A) decrease of noise level.

Conclusions

The results of noise level measurements in several locations in Bucharest show that the highest values are comparable for many main streets.

Noise levels from urban road traffic are high for inhabited areas and for people walking along the streets, even if noise is within the allowed limits for streets with high road traffic. Application of calculation methods also results in comparable data sets for the different studied locations.

Calculation methods can be used for analyzing possibilities of noise level mitigation at receptors because the calculated results are generally in agreement with most of the measured data sets of road traffic noise. Among possibly applicable measures, guiding the noisiest vehicles to other streets and introducing noise barriers where necessary can result in obvious decrease with 10 dB(A) or more, significantly lower in comparison to the present noise levels.

Bibliography:

Virginia Ciobotaru, Ana Maria Socolescu (2006), *Priorităţi ale managementului de mediu*. *(Priorities of environmental management).* Meteor Press, Bucureşti.

J. Quartieri, N. E. Mastorakis, G. Iannone, C. Guarnaccia, S. D'Ambrosio, A. Troisi, T.L.L. Lenza (2009), *A Review of Traffic Noise Predictive Models*, Recent Advances in Applied and Theoretical Mechanics, WSEAS Press.