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MEASURING TRAFFIC NOISE IN GREECE

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Abstract. This paper presents the application of a method estimating traffic noise levels in the centre of a big Greek city. The method requires a series of measurements to be carried out from 8.00 a.m. to 20.00 p.m. for every day of the week. The duration of each single measurement has to be determined due to various factors while simultaneous measurements of traffic flow are also needed. The results of the measurements are used to calculate the equivalent continuous A-weighted sound level $L_{A_{eq},12h}$ (08.00-20.00). The noise level variations are attributed to the traffic flow changes and in addition a noise map of the examined area can be constructed. As an example, the case of Thessaloniki, a city with a population of about one million people, was studied. Three main roads of the city were examined during a whole month and measurements were conducted at a number of selected positions in each road for different traffic flow conditions.

Keywords: traffic noise measurements, noise mapping.

AIMS AND BACKGROUND

The last decades, noise has been seriously considered as a significant environmental issue. In many countries surveys conducted during the last 10-20 years showed that a substantial number of citizens complain that they live in a very noisy environment[1,2]. In the case of urban areas[3], apart from other noise sources, this is mainly due to transportation noise, i.e. road traffic noise, train noise and airplane noise, the first being the most serious noise source in most of the cases.

This paper describes a series of road traffic noise measurements in Thessaloniki city, which is the major center of Northern Greece. The city, with a population of about one million people, is divided in two parts, east and west, connected through a narrow shopping center with severe traffic noise problems. Therefore, the traffic noise measurements were conducted in this area.

The primary aims of this project were:

(i) to determine the traffic noise level by calculating the equivalent continuous A-weighted noise level $L_{A_{eq},12h}$ (08:00-20:00) (Refs 4, 5) and to compare these levels with the results of previous studies;

(ii) to construct the noise map of the area;

(iii) to examine the relationship between noise level variations and traffic flow changes;

(iv) to internet noise levels from 8:00 a.m. to 20:00 p.m.

EXPERIMENTAL

To achieve the above-mentioned goals three parallel streets located in the centre of the city were examined, namely Egnatia street, Tsimiski street and L. Nikis street, carrying most of the traffic in the shopping centre. Egnatia is a two-way street with three lanes in each direction, while Tsimiski and L. Nikis are both one-way streets with four and three lanes, respectively. High buildings are located on the both sides of Egnatia and Tsimiski, while in L. Nikis, which is parallel to the city promenade, high buildings are located only on one of its sides.

For each of these three streets, sic measurement locations were specified according to the traffic flow characteristics. A number of $L_{A_{eq}}$ measurements of 10 and 60 min conducted at the above eighteen locations for all actual traffic flow conditions. The measurements were carried out for every hour from 8:00 a. m. to 20:00 p.m. and for every day of the week except sunday. A type 1 sound level meter with A-weighting was used for all measurements following the procedure set by the Greek Standard Organization[6], a procedure similar to that set by the German[7] and British Standards[8]. This method implies that measurements are only made when the road surface is dry and the wind speed at the microphone in any direction is less than 10 m/s, the view of the road from the measurement point is substantially unobstructed ($\theta > 160°$) and the microphone is placed at a height of 1.2 m above the road surface and at a distance of 2 m from a building's facade. In addition, traffic flow was also recorded during measurements. In total, about 500 single measurements were conducted.

The measurement data collected were afterwards analyzed according to the following procedure. The value of $L_{A_{eq}}$ taken from a single measurement at a certain measurement location describes the noise level for a specific date, hour of day (for example from 13:00 p.m. to 14:00 p.m.) and traffic flow conditions. To derive the hourly A-weighted noise level $L_{A_{eq},h}$ from all the single measurements taken during the same hour of day the following steps have to be applied. The single measured values of $L_{A_{eq}}$ are corrected using the formula

$$\text{corrected } L_{A_{eq}} = \text{measured } L_{A_{eq}} + 10 \lg(N/N_m)$$

where N is the mean traffic flow of all measurements taken in this hour of day and N_m is the traffic flow during the corrected measurement. The mean value of the above corrected $L_{A_{eq}}$ levels gives the hourly A-weighted noise level $L_{A_{eq},h}$ which corresponds to the noise level of this particular hour of the day regardless the day of the week and the traffic flow conditions.

Next, the A-weighted noise level covering the period from 8:00 a. m. to 20:00 p. m. $L_{A_{eq},h}$ (12 hour), has to be calculated. This level corresponds to the overall noise level for a specific measurement location. In order to derive $L_{A_{eq},h}$ (12 hour) the previously calculated noise levels $L_{A_{eq},h}$ have to be corrected using the relation

$$\text{corrected } L_{A_{eq},h} = \text{measured } L_{A_{eq},h} + 10 \lg(N/N_t)$$

where N signifies the mean traffic flow from 8:00 a. m. to 20:00 p. m. and N_t is the traffic flow during the corrected measurement. Then, the value of overall $L_{A_{eq},h}$ (12 hour) is given by the arithmetic mean of the 18 one-hourly corrected values $L_{A_{eq},h}$.

RESULTS

Following the aforementioned procedure of data analysis the noise map shown in Fig. 1 was constructed. The map shows the values of $L_{A_{eq},12h}$ (08:00-20:00) across the three examined streets together with the measurement locations. The exact limits of these values are also given in Table 1. Egnatia street presents the highest noise levels while the corresponding values are lower by 1 dB(A) and 2 dB(A) for Tsimiski street and L. Nikis street, respectively.

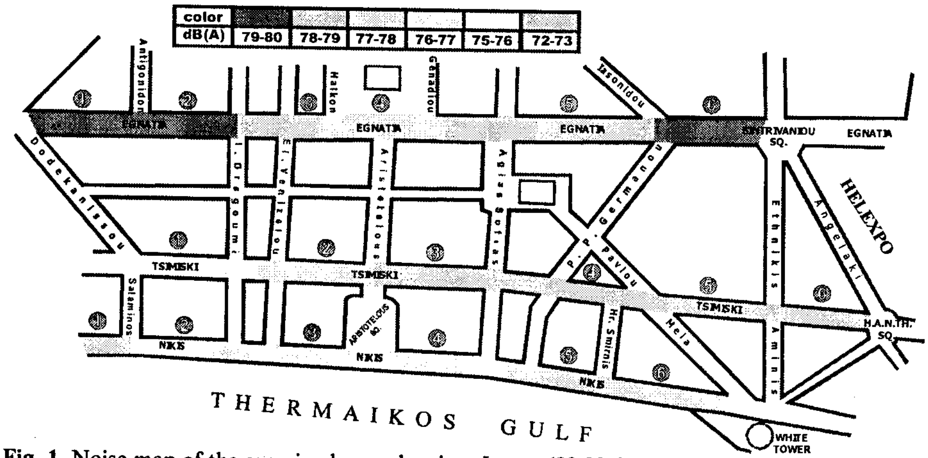

Fig. 1. Noise map of the examined area showing $L_{Aeq,12h}$ (08:00-20:00)

The noise map also indicates that noise level $L_{A_{eq},12h}$ (08:00-20:00) strongly depends on the topology of the area around the measurement location. More specifically, in the case of open spaces a decrease of 1-2 dB(A) is noticed due to the lack of reflections. This occurs at location 4 at Egnatia street, between locations 2 and 3 at Tsimiski street and between locations 3 and 4 at L. Nikis street. Location 1 at L. Nikis street, with no surrounding buildings, has the lowest level of 72.5 dB(A). As it has been noted, L. Nikis street lies in parallel with the city promenade and it is built only at one of its sides; thus, due to the lack of reflections L. Nikis street has the lowest noise level.

Table 1. Noise level $L_{Aeq,12h}$ (08:00-20:00) variations for all streets

Street	$L_{A_{eq},12h}$ (08:00-20:00) in dB(A)
Egnatia	from 77.5 dB(A) to 79.3 dB(A)
Tsimiski	from 76.7 dB(A) to 78.9 dB(A)
L. Nikis	from 75.7 dB(A) to 77.1 dB(A)

Figure 2 shows some additional typical results obtained from measurements and data analysis. Figure 2*a* shows the variations of hourly $L_{A_{eq},h}$ together with the hourly mean traffic flow as a function of the hour of the day. These results are given for measurement location 5 in this figure, for all three streets while eighteen such diagrams, one for every measurement location, have been produced. The overall noise level $L_{A_{eq},12h}$ (08:00-20:00) and the daily mean traffic flow in the six measurement locations for all three streets are given in Fig. 2*b*.

The diagrams of Fig. 2 indicate that noise level $L_{A_{eq}}$ follows the changes of traffic flow. This is an expected result since according to the relevant literature under free traffic flow conditions the doubling of passing vehicles causes a 3 dB(A) noise level increase. However, in the streets under examination, conditions of traf-

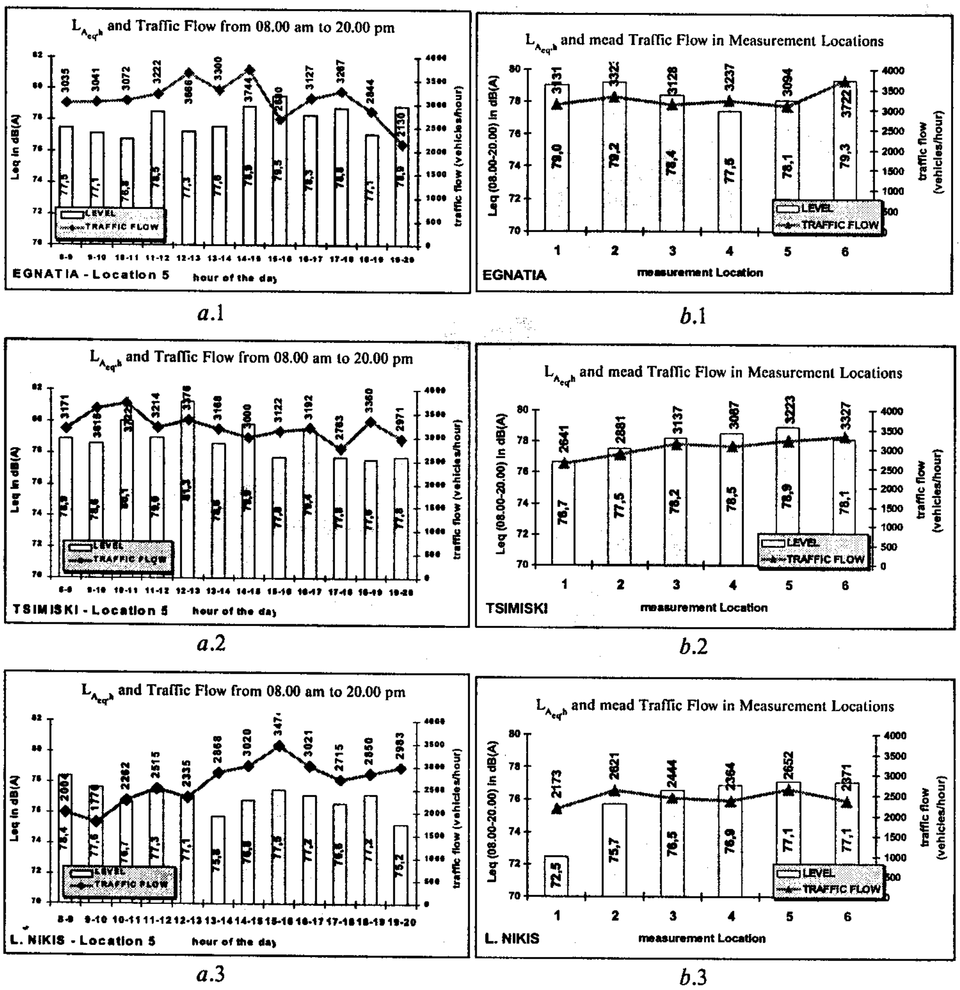

Fig. 2. $L_{A_{eq},12h}$ and hourly mean traffic flow in measurement location 5 for all three streets (*a*) and $L_{A_{eq},12h}$ (08:00-20:00) and daily mean traffic flow in the six measurement locations for all three streets (*b*)

fic jam instead of free flow occur very often. For that reason, the above mentioned tendency of the diagrams is not followed in some cases.

DISCUSSION

The results presented above show that, for the examined area, noise level $L_{A_{eq},12h}$ (08:00-20:00) was found between 75.7 dB(A) and 79.3 dB(A), if the special case of location 1 at L. Nikis is omitted. These levels lie well above the limit of Greek legislation, which is set at 67 dB(A). The observed difference of even more than 10 dB(A) in $L_{A_{eq},12h}$ (08:00-20:00) is considered dramatically high, since it is known from the literature that such high noise levels can cause substantial disturbances to the residents.

Comparing the results of the current study with the results of a previous study conducted in 1989 (Ref. 9), it can be observed that, in general, noise level $L_{A_{eq},12h}$ (08:00-20:00) remains the same. This finding can be explained as follows: the expected increase of noise levels due to the increase of traffic flow has been counterbalanced by the expected decrease of noise levels due to the substitution of the old noisy cars by new less noisy ones. It should be also noticed that the relationship between noise level $L_{A_{eq}}$ and the changes of traffic flow under traffic jam conditions merits further investigation and it could be the aim of a future study.

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