ROAD TRAFFIC NOISE REDUCTION BY VEGETATION IN THE RING ROAD OF A BIG CITY

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1. INTRODUCTION

Noise is not simply a local problem, but global issue that should concern us all [1,2]. Sound pollution continues to expand with an increasing number of complaints from the residents. Most people are usually exposed to more than one source of noise of which motorway noise is the main source [3].

The aim of this research is to locate and to evaluate the effect of vegetation on the reduction of circulatory noise that emanates from highways. In particular:

1. Is circulatory noise decreased by vegetation and if yes by how much?
2. Which are the characteristics of vegetation (type, structure) that affect the reduction of circulatory noise?
3. What is the necessary treatment to be applied to vegetation for a great reduction in circulatory noise?

Figure 1. *The ring road of Thessaloniki*

2. MATERIALS AND METHODS

This study was designed to investigate the traffic noise attenuation by vegetation along the ring road of Thessaloniki.

Measurements were taken at two sample plots, each one 500m^2, in different areas near residential zones. The first plot is grassland while the second is forest of *Pinus brutia*. Both areas were 4 metres higher than the road and level (0-5%). The terrain was selected so that the two areas would be roughly similar. In this way the sound distribution was not differently influenced.

Noise intensity was measured using the Sound level Meter 407735 Extech Instrument, which has 2 measurement standards A and C, and we used only the A-standard [4]. The instrument was placed in height of 1,8 m above the surface as it is proposed by FHWA [5] and was turned to face the road.

In both plots a straight line of measurement was made at right angles from the road to point 60 metres away. Measurements were made in 7 places every 10 metres along this line, starting at the edge of the road at point 0 [6,7].

Figure 2. *Sound level Meter 407735 Extech Instrument.*

Figures 3 & 4. *Grassland and forest.*

In every place seven measurements were taken, each of 5 minutes duration. This was done 35 times in both plots over a period of 2 months from 9.00 a.m. to 2 p.m. In total 245 measurements were taken in each plot.

In the forest plot it was measured the main silvicultural parameters of the trees: height in m, diameter in cm and the crown length in m. The height and the crown length of trees were measured with the altitude Haga.

All the measurements were computer registered with the use of statistical package of SPSS version 12.0 for windows. To check the effect of the vegetation factor on dependent variable highway noise the t-test was used and the test Levene was used to check the homogeneity of fluctuation.

3. RESULTS

The mean circulatory pressure is 120.28(±7.67) vehicles/min, the number of big vehicles is 30.00(±1.95) vehicles/min and the proportion of heavy vehicles 24.85(±0.50) (all the measurement are represented as mean±s.e.). From 9 a.m. to 2 p.m. the Thessaloniki ring road is particularly busy and there is a high proportion of lorries.

3.1 Description of vegetation

The grassland is degraded with plants of families *Compositae*, *Solanaceae* and various other broadleaved plants. Horses occasionally graze there. The vegetation of the forest is reforestation of *Pinus brutia* with planted at 3x3m intervals. There are no bushes under the crown of the trees, only a few plants. The main silvicultural parameters of the green belt were: tree height 8.68(±0.22)m, tree diameter 18.94(±0.78)cm, the crown started above ground at 1.04(±0.17)m and finally the total crown length was 6.72(±0.19)m (all measurements are represented as mean ±s.e.).

3.2 Reduction of noise intensity

A presentation of the statistical analysis results in the two plots is given in the table 1 and the figures 5, 6, 7, 8.

Table 1. *Statistical analysis results of noise intensity values.*
The values that are not followed by the same letter differ significantly (a=0.05, t-test).

Plot	Distance from the road (m)	Mean (dB)	Median (dB)	Standard Deviation	Min (dB)	Max (dB)	Range	Coefficient of variation
Grassland	0	78.36^a	78.40	0.86	76.1	81.0	4.9	1.09
	10	71.80^a	72.35	1.27	69.3	73.3	4.0	1.76
	20	68.07^a	68.00	0.49	67.3	68.8	1.5	0.71
	30	65.50^a	65.50	0.28	64.7	66.0	1.3	0.42
	40	63.96^a	63.75	0.64	63.0	65.3	2.3	1.00
	50	61.94^a	61.80	0.50	61.1	63.2	2.1	0.80
	60	60.50^a	60.45	0.68	59.3	61.9	2.6	1.12
Forest	0	78.70^a	78.55	0.69	77.6	80.4	2.8	0.87
	10	69.56^a	69.60	0.20	69.0	69.9	0.9	0.28
	20	65.43^a	65.40	0.29	65.0	66.0	1.0	0.44
	30	62.51^a	62.50	0.26	62.0	61.1	1.1	0.41
	40	59.50^a	59.50	0.27	59.0	59.9	0.9	0.45
	50	56.51^a	56.60	0.26	56.0	56.9	0.9	0.46
	60	54.72^b	54.60	0.54	54.2	57.7	3.5	0.98

From table 1, the following was observed: At the distance 0m from the road, the factors of variation which are the unique characteristics of relative dispersion are big and in both cases. In the forest its value is 0.87, smaller than the value of 1.09 in the grassland.

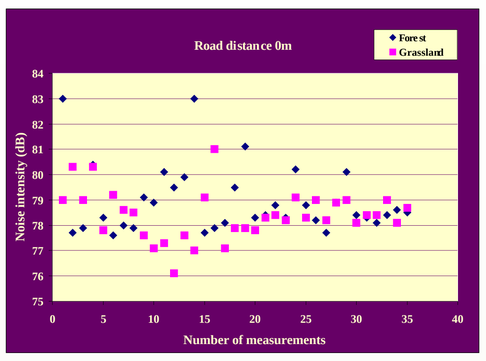

Figure 5. *Noise intensity at the grassland and at the forest at point 0.*

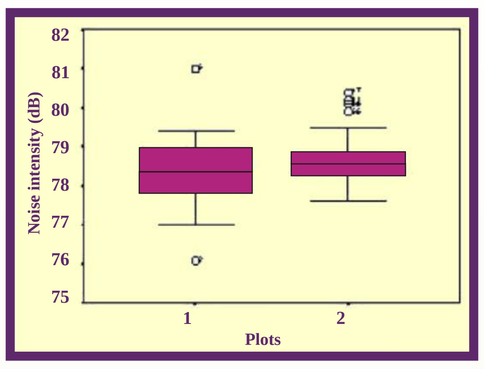

Figure 6. *Box-and-whisker plots of noise intensity at the grassland (1) and at the forest (2) at point 0.*

At the distance of 60m from the road the factors of variation of noise intensity and in the two areas are roughly equal. This is due to the gap that exists in the forest from 50-60m, therefore there is no positive effect of the crown of trees and the sound behaves as in a region that does not have high vegetation.

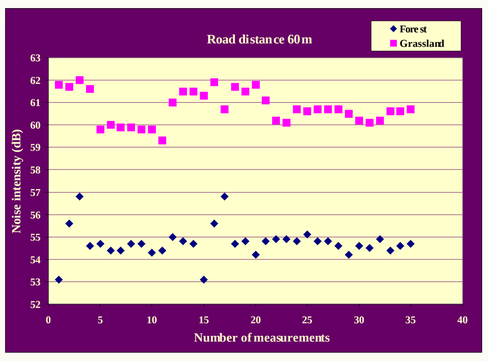

Figure 7. *Noise intensity at the grassland and at the forest at point 60.*

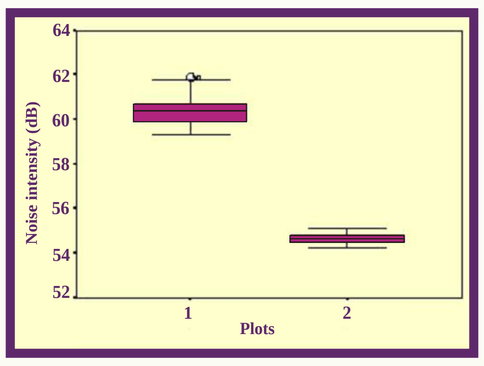

Figure 8. *Box-and-whisker plots of noise intensity at the grassland (1) and at the forest (2) at at point 60.*

The box-and-whisker plot shows a graphic presentation of information on the distribution of data that are examined. The values of inferior and superior percentile (25th and 75th percentile) determine the beginning and the end of the box-and-whisker, which contains the intermediate 50% of prices of data. The horizontal line that cuts the box-and-whisker depicts the median.

4. CONCLUSIONS

The levels of noise pollution in the ring road of Thessaloniki are above the limits stated by Greek legislation 29087/2295 (67 dB). This is due to the high speed of vehicles, to the amount of traffic and to increased passage of heavy vehicles.

By the analysis of the results, it can be understood that the vegetation functions as a plant noise barrier decreasing the noise intensity.

- The vegetation can decrease satisfactorily the traffic noise intensity in streets with rapid circulation. In the area of green with reforestations of *Pinus brutia* a bigger reduction was observed at 6 dB 60 m than in the grassland surface.
- The reduction of noise pollution is judged satisfactory here because areas of green exist in most places on both sides of the road.
- In the existing areas of green that are found along the ring road, the high vegetation constitutes only of trees of *Pinus brutia* with the following characteristics: mean height of trees is 8.68 m, mean crown lenght 6.72m and mean breast diameter is 18.94cm.

5. PROPOSALS

- Evergreen bushes (2-3 metres height) should be planted in rows close to the road edge. *Ligustrum vulgare*, *Pitosporum tobira*, *Pyracantha coccinea* and *Phillyrea latifolia* are suggested [8]. Then a tree barrier should be planted. These trees must be of at least 15 metres height when mature. This combined green zone must be at least 20 metres in depth.
- As well as coniferous trees, deciduous trees may also be planted such as *Cercis siliquastrum, Celtis australis*, *Fraxinus ornus*, *Ostrya carpinifolia*, *Carpinus orientalis* and *Acer campestre*. Also it should be used the suitable tree species according to the prevailing circumstances in the urban and periurban environment [9,10,11,12]. It is suggested avoiding the use of *Olea europea* as its blossom is an allergenic. It can only be used if pruned regularly so that it does not blossom, but also dense hedges are formed.
- In areas where the space available does not suffice to establish a green belt, the creation of man - made sound barrier and vegetation is proposed. The barriers with vegetation added constitute an attractive alternative to the usual constructions both in appearance and maintenance.

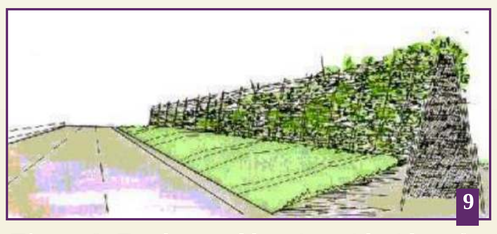

Figure 9. *Earth sound barrier with sides of willow branches*

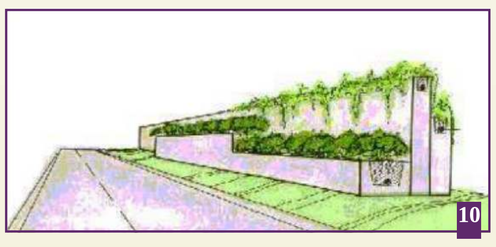

Figure 10. *Sound barrier walls with flower beds planted with trees and shrubs.*

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