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Trees, shrubs and lawn: Acoustic effects in urban parks

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Abstract

Acoustic pollution is an important environmental issue for city quality indexes. Policy development attempts to assess and control noise levels through zoning, which is specified in the 'noise map'. Citizens are entitled to reliable acoustic index regarding these levels in city parks. The available mapping systems are based on numerical models which do not take into account sound attenuation that green areas can generate. Urban parks are composed of multiple elements and coverage including trees, shrubs, grasslands, soils and pavements, all having a different effect on sound waves. By means of the following paper, The main factors that influence acoustic quality in urban parks will be investigated. In addition, a model to assess the influence of vegetation surfaces will be also proposed.

Palabras clave: environment, acoustic, vegetation, lawn, trees, parks, green areas.

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Árboles, arbustos y césped: efectos sonoros en parques urbanos

Resumen

La contaminación sonora es un asunto ambiental importante para los índices de calidad de la ciudad. Mediante el desarrollo de políticas, se intenta evaluar y controlar los niveles de ruido a través de la zonificación, que se especifica en el "mapa de ruido". Los ciudadanos tienen derecho al índice acústico confiable con respecto a estos niveles en los parques de la ciudad. Los sistemas de mapeo disponibles se basan en modelos numéricos que no toman en cuenta la atenuación del sonido que las áreas verdes generan. Los parques urbanos están compuestos por múltiples elementos y coberturas tales como árboles, arbustos, grama, suelos y pavimentos, todos ellos con efecto diferente en las ondas sonoras. En el presente artículo, se investigaron los principales factores que influyen en la calidad acústica en los parques urbanos. Además, se propone también un modelo para evaluar la influencia de las superficies de vegetación.

Keywords: ambiente, acústico, vegetación, césped, árboles, parques, áreas verdes.

Introduction

Noise is a pollutant of the first order as well as a crucial problem for the quality of life in cities. European Commission and World Health Organization (WHO) data indicate that European citizens are exposed to high sound levels.

The evaluation of the acoustic index into urban green areas is being overstated. These spaces are considered to be used for citizens seeking to isolate themselves from the city. Nevertheless, it is not always the same case. Vegetation (tree, bush, lawn) absorbs the impact of city noise levels and therefore noise maps should represent this aspect (Ochoa, 1999).

In 2002, authorities responded to this situation due to the continuous growth of urban areas which clearly needed an environmental assessment and management. Member States are obligated to collect information and perform strategic noise maps with Action Plans.

The development of a basic concept for environmental noise and its effects, along with measures to establish a preparation plan for noise maps could provide a new acoustic index. In the same way, it may also provide technical specifications for measurement defined by means of this regulation. This advance will be adapted to the noise indicators of L_{den} and L_{night} (EUROPEAN DIRECTIVE 2002/49).

This normalization will allow the study of acoustic levels in different spaces within a city, and categorize them according to legally defined and homogeneous criteria.

Main lines of research show that there have been many studies on sound propagation in masses of vegetation, the incidence of different types of soils and other acoustic factors (Bullen, 1982). Even with 50% of tree coverage, there were values of average levels of noise about 3 decibels lower than those that had no masses (Ochoa,1999).

Other scientists evaluated the effects of trees (Cook, 1971) or soil (Tarrero, 1999) type on the propagation of sound. When the sound propagation occurs near the ground there are factors that increase the absorption.

Outdoor acoustic data are conditioned by the influence of many variables, which should be taken into account, when assessing the results.

- Steep
- Obstacles
- Natural shields
- Leveled
- Linear morphology

Therefore, measurements into green areas provide us information conditioned by the above mentioned factors and its own design characteristics: composition of elements and coverage (type of soils, vegetation density, phytosanitary status and the presence of deciduous or evergreen trees).

The objective of this article is to put forward the differences between official noise maps and experimental data into the parks, in order to indicate the influence of vegetation surfaces in noise abatement. Noise mapping systems are based on numerical models which do not take into account sound attenuation that green areas can generate. It´s necessary to get new experimental measurements. Analyzing the numerical model and variables that affects in green areas, we can contribute an equation that checks these sound effects.

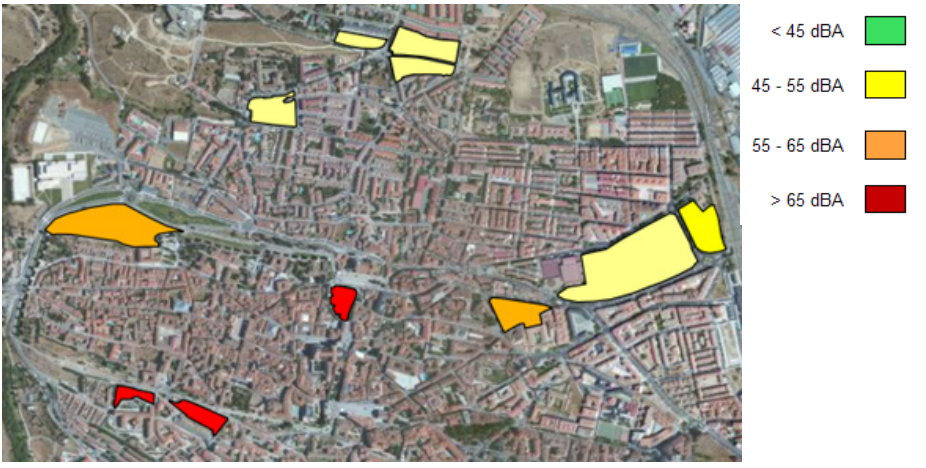
1. Methods

The biggest parks of the center of Avila have been selected. Avila is a small city in the north of Spain. These parks have enough area to analyze sound effects. It has only taken into consideration public parks, not private entities.

All green zones have an area between 1 and 4 hectares, with different coverage of trees, shrubs, grassland, and cement or paved. Thus, a twelve month study was developed in these 11 park areas.

Map1. Parks location

Overlaying a noise map data onto a location map, it demonstrates the results of the acoustic level for each park.



Map2. Noise map and acoustic level intervals. L_{day}.

When analyzing these data derived from the noise map, the average value of this interval of the legend results will be used.

Then, this plan of measurement, taking the center of a park shape, as a reference point, started. Nineteen measures at each receiver point were implemented, applying a sampling scheme which consists of a random series of data of LA_{eq} dBA, for 15 minutes, in different months, days and times, during a full year. The aim is to get a measurement for every day of the week, at least one in the morning and other one in the evening. It is always developed in according to measurement protocols established by official regulations. A total of 7980 minutes of records were registered.

Geographic information systems like QGIS give specific area for the 11 parks and their percentage surfaces allocation.

TABLE 1. Data summary

Park Nr.	Noise Map dBA	Experimental dBA	Discrepancy dBA	Trees&Shrubs surface %	Grass surface %
#1	67.5	56.53	**10.97**	0.50	0.38
#2	67.5	56.61	**10.88**	0.52	0.00
#3	62.5	54.84	**7.66**	0.00	0.99
#4	57.5	46.94	**10.55**	0.24	0.31
#5	57.5	51.34	**6.15**	0.14	0.85
#6	57.5	46.97	**10.52**	0.60	0.21
#7	62.5	51.41	**11.09**	0.68	0.28
#8	57.5	46.65	**10.85**	0.59	0.29
#9	57.5	46.49	**11.01**	0.60	0.27
#10	62.5	50.44	**12.05**	0.70	0.01
#11	67.5	56.91	**10.58**	0.44	0.32

2. Results

The cartography demonstrates parameters associated with green areas acoustic behavior is not taken into consideration. There is a discrepancy between numerical model data of the computer software used for noise map, and this experimental data reported.

This results show that there are phenomena that go beyond factors associated with the distance and slope. Green areas features like structures (trees, bush) and pavements (soil, sandpits, grassland) are important for acoustic effects.

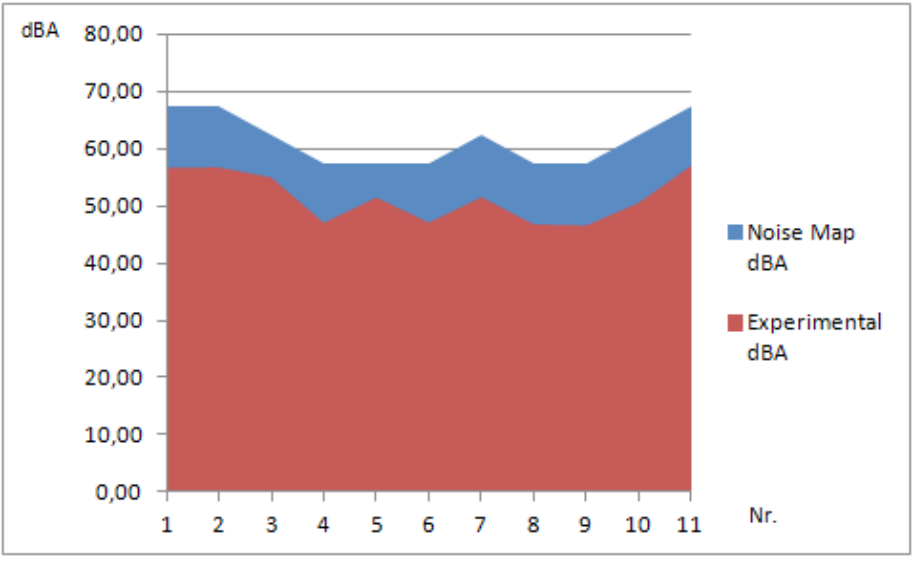


Chart 1. Comparison of performance

If a park coverage allocation is analyzed, parks with low influence of pavement have a big attenuation, because trees, shrubs and grasslands are very important for noise abatement.

When calculating the influence of the different coverages, it is regarded the discrepancy between trees, shrubs and lawn, using statistical analyst methods (ANOVA).

Searched formula is $y^*=a+b_1x_1+b_2x_2$ where b_1 is the coefficient of trees and shrubs area and b_2 is the coefficient of grassland. According to data summary table, the numerical system to solve is:

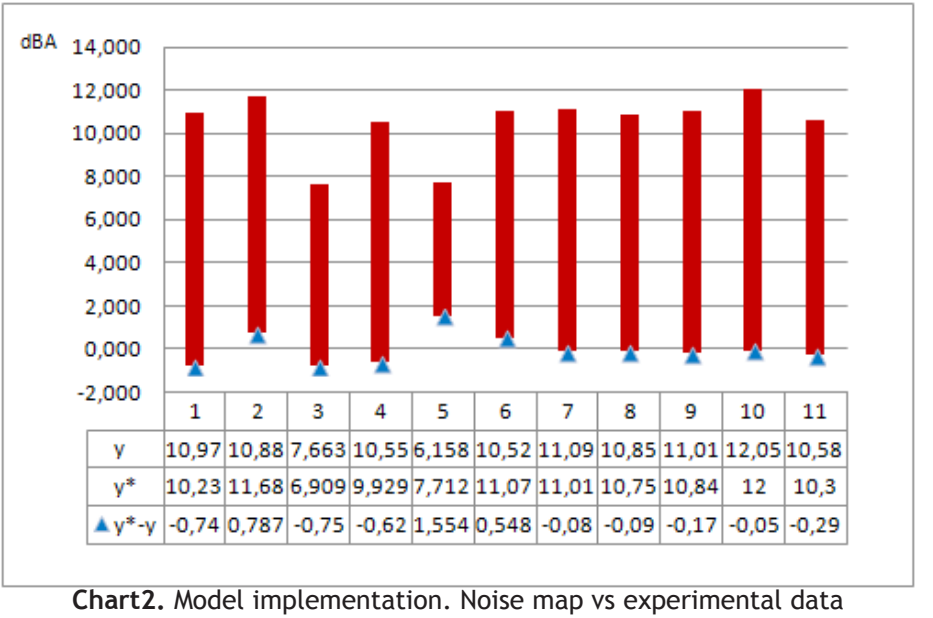
$?y=aN+b_1?x_1+b_2?x_2$ $?yx_1=a?x_1+b_1?x_1^2+b_2?x_2x_1$ $?yx_2=a?x_2+b_1?x_1x_2+b_2?x_2^2$	$112.37=11a+5.06b_1+3.96b_2$ $55.06=5.06a+2.87b_1+1.22b_2$ $35.71=3.96a+1.22b_1+2.37b_2$

Equation 1. Anova system

a = 10.52	b = 2.19	c = -3.63	$y^* = 10.52 + 2.19b_1 - 3.63b_2$

Equation 2. Anova outcome

Equation shows the magnitude of trees and shrubs area in noise abatement against grass surfaces. It is recommended to guarantee comparable results a correlation coefficient of 80% at least, in this case is $R^2 = 0,83$.



	1	2	3	4	5	6	7	8	9	10	11
y	10,97	10,88	7,663	10,55	6,158	10,52	11,09	10,85	11,01	12,05	10,58
y*	10,23	11,68	6,909	9,929	7,712	11,07	11,01	10,75	10,84	12	10,3
▲y*-y	-0,74	0,787	-0,75	-0,62	1,554	0,548	-0,08	-0,09	-0,17	-0,05	-0,29

Chart2. Model implementation. Noise map vs experimental data

New designs for gardens should consider sound propagation through vegetation surfaces in order to minimize the noise impact. For example, a park with this structure: 30% of trees&shrubs and 20% of lawn surface, it

could reach 10,45dBA of noise abatement inside, in regard to noise maps data.

Therefore, the green areas have to fit in town planning as environmental island to isolate citizens from the traffic noise.

Conclusions

This paper highlights that remains much to do in the adaptation of urban green spaces within the acoustic analysis. There are a lot of studies about the influence of different elements regarding sound impact into the parks.

Registered experimental data exceed the data determined by the noise maps. This factor shows the influence of different coverages, because the attenuations happen.

Trees and bush surfaces add noise abatement effects and if vegetation surface is increased in respect of total park area, might give lower sound levels inside. These elements must have a homogeneous distribution in the park´s shape, it´s not necessary a barrier forms. To increase 30% of trees&shrubs surface area in these parks allow to achieve a reduction of 0,66 decibels inside. On the other hand, lawn do not reduce the levels of noise.

Indeed, it is necessary to characterize the green areas acoustic conditions and include new variables associated with the presence of different types of vegetation and pavements. These parameters should be considered into numerical model and gardens design.

The software of noise maps like CadnaA or Predictor should also add new options to calculate the influence of the different types of coverage and their acoustical effects.

In the next future, other experiments will be conducted to employ a new technology adding a specific acoustic green factors for different applications to analyze outdoors noise.

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