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Study on the relation between urban planning and noise level

Guillermo Rey Gozalo [a], Juan Miguel Barrigón Morillas [b,*], J. Trujillo Carmona [c], David Montes González [b], Pedro Atanasio Moraga [b], Valentín Gómez Escobar [b], Rosendo Vílchez-Gómez [b], Juan A. Méndez Sierra [b], Carlos Prieto-Gajardo [b]

[a] Facultad de Ciencias de la Salud, Universidad Autónoma de Chile, 5 Poniente 1670, 3460000 Talca, Región del Maule, Chile
[b] Departamento de Física Aplicada, Escuela Politécnica, Universidad de Extremadura, Avda. de la Universidad s/n, Cáceres 10003, Spain
[c] Departamento de Matemáticas, Facultad de Ciencias, Universidad de Extremadura, Avda. Elvas s/n, Badajoz 06071, Spain

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ABSTRACT

Different streets of a city of Spain were randomly selected and analyzed, extracting 135 different urban variables. The urban variables were compared with measured noise levels, and the possible significance in the relationships among them was analyzed. From the variables with a significant correlation, a multiple regression model for urban traffic noise was developed, which allows explaining 63% of the variability of urban noise. In this regression model, only eight of the initial urban variables were included.

The obtained model was validated, and its prediction capacity was analyzed with 30 new randomly selected independent sampling points, showing a global uncertainty lower than 2 dBA, similar to that obtained in noise mapping techniques.

The proposed methodology could be extrapolated to other cities, and the obtained models could be an important tool for city planning agents.

1. Introduction

In the last centuries, the economic success associated with cities has led to an important growth in the population living in them [4]. In addition, how modern cities represent a savings of energetic aspects and a reduction in the pollutants emitted by citizens is considered [8]. Nevertheless, the urbanistic design of several modern cities, which is generally conditioned by road traffic, has produced an increase in noise pollution. Thus, a recent publication by the World Health Organization points out that noise pollution ranked second among a series of environmental stressors for the public health impact in European countries [16]. Adequate city planning could reduce the effect of this important environmental problem and, besides, could result in profits in terms of the reduction of other atmospheric pollutants, considering the known correlation between some of them [5,15].

The functionality of streets as a communication path among different parts of a city and between a city and other urban areas (an alternative concept to accessibility) has been shown to be associated with noise pollution [9]. Functionality is clearly conditioned by the urban planning of our cities. So, the geometry of the street, and the pavement type, street width, average street height, etc., are factors with influence on the use of a street. The influence of urban forms on vehicle transport or a street environment has been previously studied [12,3]. A model of urban noise has also been developed without propagation expressions but using the data of traffic flow and traffic conditions and some urbanistic variables [13].

To our knowledge, until now, no model for estimating urban noise based only on urban variables (and, thus, excluding variables related to traffic) has been proposed. This paper presents the first results achieved in this line. Obtaining a model like the one previously described could be an important tool for city planning agents, and, besides, it could help to improve the noise predictions of current noise maps. It is not an objective of our work to present a unique and comparable model but to begin the study of this possibility by analyzing a medium-sized town of Spain.

2. Methods

154 streets of the city of Cáceres (a medium-sized city located in the southwest of Spain with about 95,000 inhabitants) were randomly chosen (see Fig. 1). Previously, this city was also used in the initial development of a categorization method, which was applied afterwards to other cities with very different sizes and locations [1,9]. In each street, sound measurements were carried out in

* Corresponding author.
E-mail addresses: guille@unex.es (G. Rey Gozalo), barrigon@unex.es (J.M. Barrigón Morillas), trujillo@unex.es (J. Trujillo Carmona).

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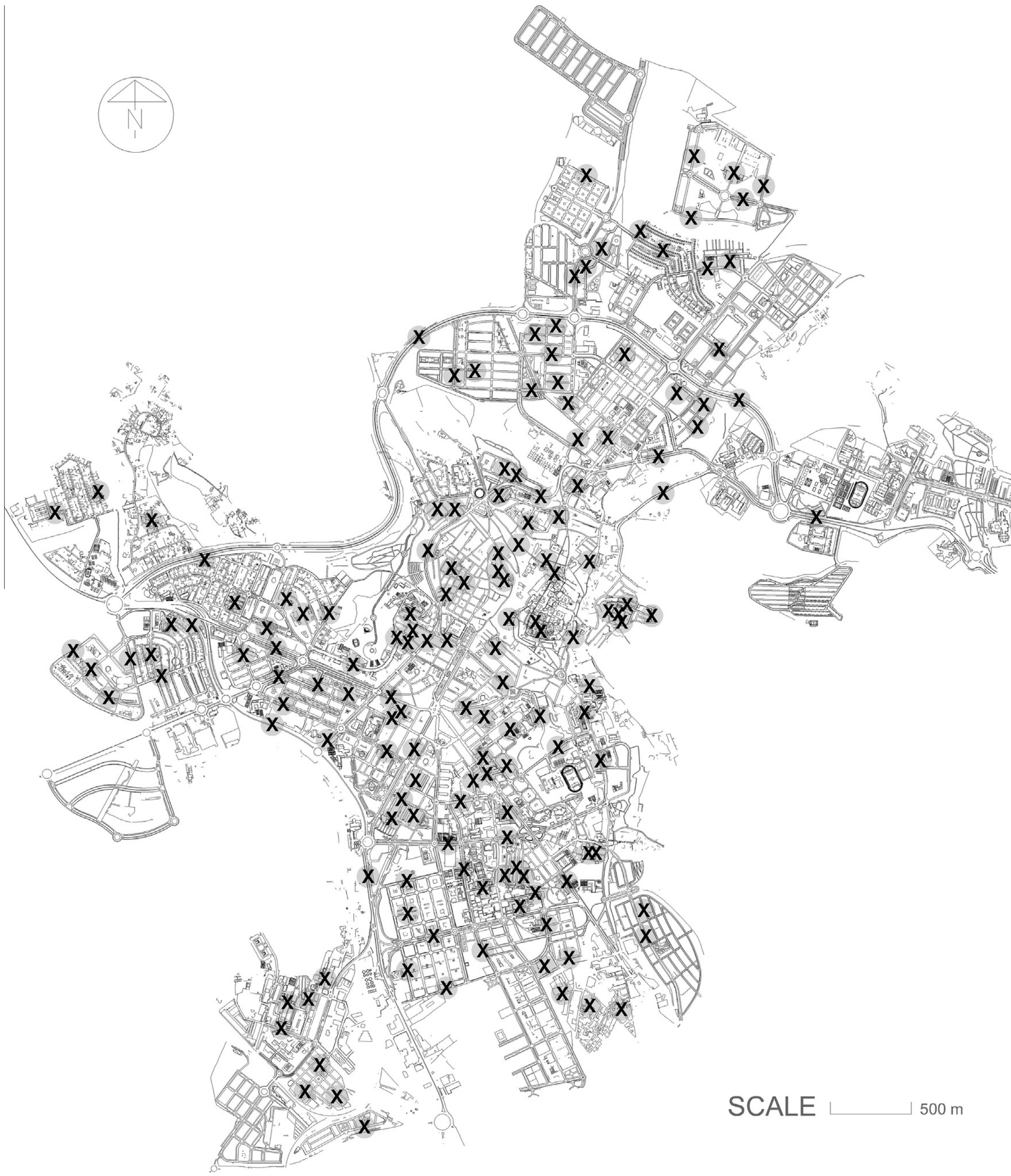

Fig. 1. Location of the sampling points in the city of Cáceres.

diurnal period (from 7 a.m. to 7 p.m.) following the Ref. [6] guidelines. Sound measurements were conducted in four different time periods throughout the diurnal period in distinct days to include the variability in the cycle of activity in the city. Moreover, each street was characterized by 135 urban variables, which could be classified in the following groups: (1) location of the street and demography, (2) urban land use, (3) street geometry, (4) circulation and connectivity and (5) public and private transport.

After characterization of the streets and noise measurements, the relationships among the urban variables (independent variables) and measured equivalent sound levels [Leq (dBA)] were analyzed. For this analysis, Spearman's correlation coefficient (R) was used. This non-parametric test was chosen as some of the studied variables did not present a normal distribution, and, in other cases, the small number of samples in some variables meant that the normality of the data was doubtful. This test was also used to study the possible relationship among independent variables (collinearity).

The urban variables with a significant correlation with sound levels (p-value < 0.05) and without collinearity among them [R^2 < 0.9 [7]] were chosen for the multiple linear regression model. The categorical variables and the quantitative variables with low frequency of occurrence (generally associated to the type of land use) were transformed into dummy variables (No = 0 and Yes = 1). Then, the potential impact of each urban variable on the estimation of the Leq (dBA) was analyzed. For this purpose, a stepwise multiple linear regression analysis was carried out. The model selected was stepAIC [14]. Although stepAIC labels the criterion in the output as "AIC", the Bayesian information criterion (BIC) was employed as a selection criterion. The AIC penalizes the number of parameters less strongly than the BIC does. The direction selection "backward/forward" and "forward/backwards" was used.