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NOISE CONTROL FOR A BETTER ENVIRONMENT

Urban planning, road types and noise pollution

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ABSTRACT

Urban planning is a powerful way for mitigating noise levels in cities around the world. The location of centers of interest and the management of road traffic are two of the main variables. Since both are close related, improvement actions taken in one of these methods sometimes can lead to a worsening in the other. A greater knowledge of the urban characteristics of cities and their relationship with the main sound sources could bring benefits to the sound environment in future urban planning actions. In this work, an urbanistic and acoustic study of the city of Talca (Chile) was carried out with the purpose of determining the relations between both groups of variables. The results showed that a set of 6 urban variables, some similar to those selected in a previous study in European cities, explained a variability percentage of 63% in the noise level.

Keywords: Urban features, Road traffic, Talca
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1. INTRODUCTION

A noise map is considered the main tool for determining the sound exposure of the population according to the European Noise Directive [1]. There are different methodologies for the elaboration of noise maps but, nowadays, the research is focused on calculation methods [2]. These calculation methods are frequently implemented in specific software whose licensing cost is usually high. In addition, calibration of these calculation methods requires in-situ measurements [3]. Therefore, current research has been aimed to the development of open-access software [4], in-situ measurement methodologies [4], low-cost devices [6][7], etc. The objective of many of these studies is not to compete with current software or calculation methods but to complement them to improve their application and accuracy or being a lower cost alternative with acceptable uncertainty.

The main source of noise in urban cities around the world is road traffic. In fact, most noise maps only evaluate this type of sound source. Road traffic noise varies spatially and temporally and the negative effects on health are related to this variability. There are also other sound sources that generate high sound levels [8] or that modify the spectral content of the urban sound environment [9]. This has encouraged research on the temporal variability of noise [10] and other sound sources [11][12].

Despite the advances in the assessment of urban noise, the implementation of action plans is still in its early stages. In this sense, actions must be taken on both the sound source and the urban-architectural environment that surrounds the source. For this reason, the relationship between urban features and sound levels is a very important issue to consider in urban planning [13].

In the present work, the relationship of variables associated with the road traffic sound source and the sound levels measured at different locations in the city of Talca (Chile) is presented. In addition, the relationship between urban variables and noise levels was analyzed. Both variables, either individually or jointly, can constitute models of sound prediction but they can also be a source of information on the possible benefits to the actions taken during planning, to the improvement of the sound condition of particular urban environments.

2. METHODS

2.1 Study area

The present work was carried out in the city of Talca (Chile). This city is located in the central region of Chile in the Maule District and it has a continental Mediterranean climate (see Figure 1). The urban population of the city is about 210.000 and the agriculture sector has a fundamental role in its economy. The central area of the city is characterized for having a square structure, so the denomination of the streets is North, South, East, and West where the central plaza is the source of their address numbering. The city has experienced an important growth in extension in the last decade because the type of construction is characterized by houses of one or two floors with a landscaped area. The main road communication of the country (Route 5) crosses the city from North to South (red line in Figure 1) and it is connected to the main urban roads transverse to it (4 Norte, 2 Sur, Av. San Miguel) or to those that surround the city (Av. Ignacio Carrera Pinto, Av. Lircay, Circunvalación Norte) (blue lines in Figure 2).

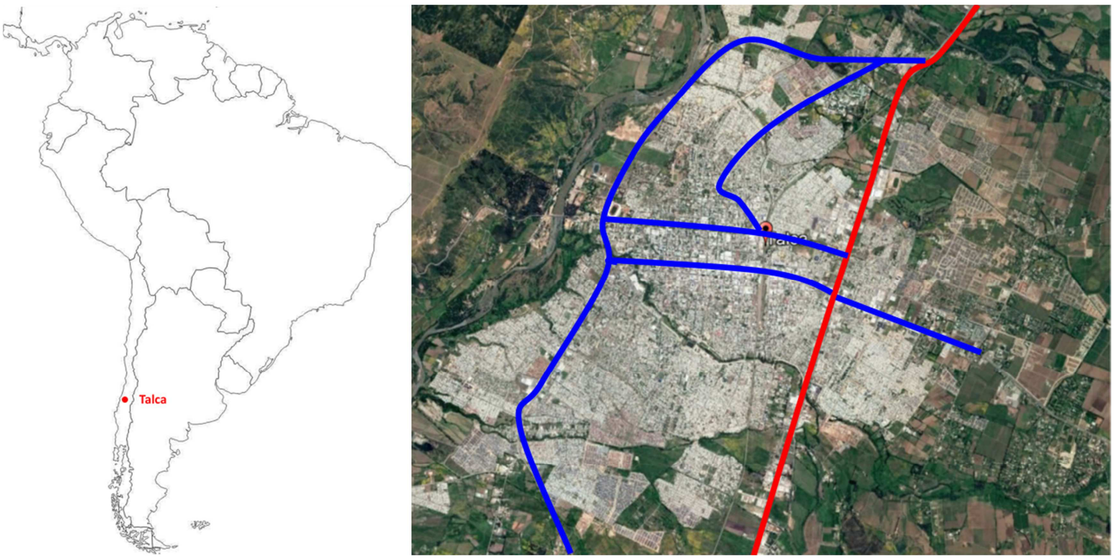

Figure 1. Location of the city of Talca (Chile)

2.2 Urban and acoustic measurements

In-situ sound measurements were carried out in different types of roads in the city. The definitions of the Categorization Method were used for the stratification of urban roads [14]. Thus, five types of routes with different functionality were used in the study. A number of locations were sampled in each type of road by considering the length and variability of them, resulting in a total of 150 sampling points. The A-weighted equivalent sound level recorded during the daytime period from 7:00 to 23:00 was analyzed in this study. All the recommendations given in the international standard ISO 1996-2 were followed with respect to the situation and type of measurement equipment [15].

During the measurements, variables associated with the sound source (flow, type and speed of the vehicles) were registered simultaneously. Urban variables were also registered during and after the sound measurement campaigns. In this preliminary study, 40 urban variables were analyzed. These variables were related to geometry (width, average height of buildings, etc.), usage (presence of shopping centers, education buildings, etc.), location (distance to the city center) and street's conditions (type and condition of pavement).

3. RESULTS AND DISCUSSION

3.1 Road traffic variables

The flow of vehicles is generally the variable that explains the larger variability of sound levels recorded in urban environments. Regardless of the type of road, a relationship between the number of vehicles and the noise level can be observed (see Figure 2). Similar results have been reported in other Iberoamerican cities [16]. Although the public transport composed of heavy vehicles is frequently used by citizens, the percentage of light vehicles is considerably higher. Thus, the correlation between noise and light vehicles is higher than the corresponding correlation with heavy vehicles.

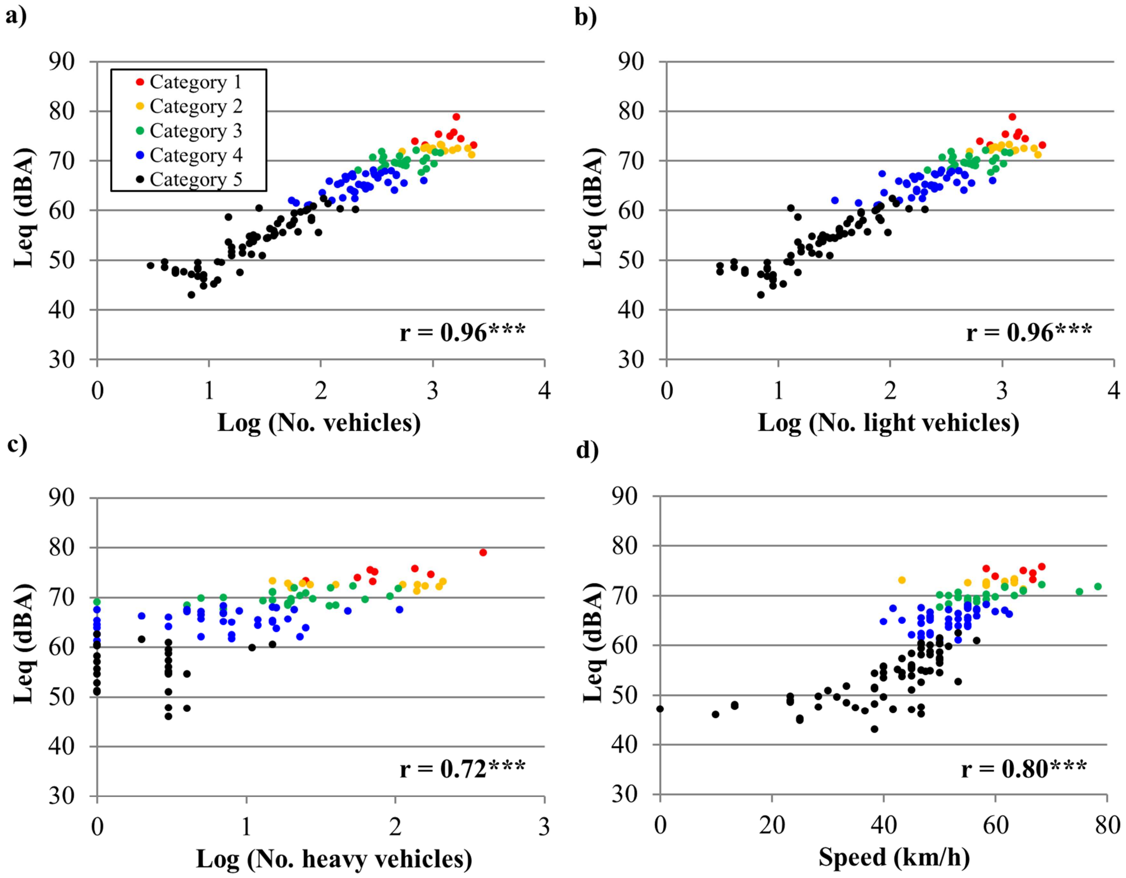

Figure 2. Relationship between number of vehicles, speed and equivalent sound level

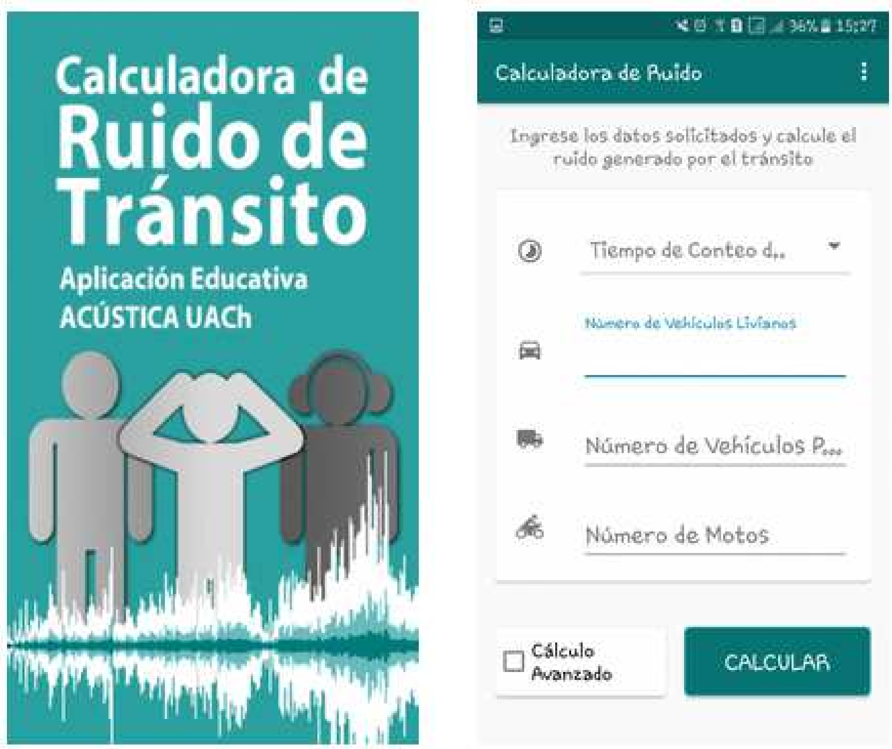

Figure 3. Screenshots of the app "Traffic Noise Calculator" [17]

The correlation coefficient between the number of vehicles (without segregating the type of vehicle) and the noise levels is high (see Figure 2a). Some studies have established equivalences between heavy and light vehicles, resulting in an increase in the correlation coefficient [7][18]. In addition, this regression model can be used to predict noise with acceptable uncertainties. Some of these models have been included in smartphone applications for educational purposes. "Traffic noise calculator" is an example of these applications (see Figure 3).

Another variable to consider in the variation of sound levels is the vehicle' speed. The average speed of the vehicles gradually increases from Category 5 (urban residential roads) to Category 1 (main urban roads used to communicate this city with other cities). Therefore, the speed and noise levels also report a high correlation coefficient.

3.2 Urban variables

Most urban variables reported a significant correlation with the equivalent sound level. Table 1 shows only those variables with correlation coefficients with $p < 0.01$.

Table 1. Pearson correlation coefficients between urban variables and Leq (dBA) with p<0.01

Variables	**Description**	**r**
V_1	Length (m)	0.67
V_2	No. of shops	0.47
V_3	No. of lanes	0.65
V_4	Street width (m)	0.51
V_5	No. of traffic lights	0.46
V_6	No. of bus stops	0.46
V_7	No. of bus routes	0.43
V_8	Roadway width (m)	0.56
V_9	No. of restaurants	0.43
V_{10}	No. of schools	0.41
V_{11}	No of road signs of interest places	0.33
V_{12}	No. of industries	0.39
V_{13}	No. of green areas	0.34
V_{14}	No. of road intersections with preference	0.43
V_{15}	No of road signs to go to other cities	0.33
V_{16}	No. of petrol stations	0.35
V_{17}	No. of health centers	0.30
V_{18}	No. of government administrations	0.25
V_{19}	No. of police stations	0.28
V_{20}	Average height of buildings (m)	0.24
V_{21}	No. of crosswalks	0.33
V_{22}	No. of churches	0.31
V_{23}	No. of administration offices.	0.28
V_{24}	No. of sport fields	0.27
V_{25}	No. of pubs	0.24
V_{26}	No. of speed bumps	0.22
V_{27}	No. of hostels	0.21

Some of these urban variables can have correlation coefficients with respect to noise levels like those obtained with traffic variables. Therefore, given that these variables are not time-dependent and sometimes easy to obtain through Geographic Information Systems (GIS), they could be an alternative source of information on the noise levels in urban environments.

Table 1 shows variables related to the geometric characteristics of the urban road (e.g., length, width of the street, and width of the road) and the presence of places of interest (e.g., number of restaurants, gas stations, and green areas). Ballesteros et al. [19] estimated the noise level of leisure areas through some geometric characteristics of the street and the counting of leisure places. In addition, the geometric characteristics of the streets affect the perception of the soundscape [20].

Other characteristics related to the presence of heavy traffic (e.g., bus stops and bus lines) are also shown in Table 1. Public urban transport is very important in Chilean cities and quite used by the resident population for being fast and inexpensive. Finally, some characteristics associated with road traffic regulation and driver information (e.g., traffic lights, pedestrian crossings, road signs of places of interest) presented an important correlation coefficient.

From those urban variables that reported a significant correlation coefficient with the corresponding noise levels, a multiple regression analysis was carried out. The urban variables were selected by steps, considering their contribution to the variability of the noise level. The resulting multiple regression model is given by the following equation

$$L_{eq}\ (dBA) = 48.2 + 0.01V_1 - 2.40\ V_{11} + 3.17\ V_3 - 1.39\ V_6 + 0.15\ V_2 + 1.18\ V_5 \quad \text{(Equation 1)}$$

The coefficient of determination of Equation 1 was 0.63 which means that 63% of the variability of the noise levels is explained by the six urban variables selected.

This regression model (Equation 1) is comparable with that obtained in previous studies conducted in a Spanish city [21]. The variability explained is similar and urban variables such as the width of the road (in our study the number of lanes was selected to avoid collinearity), number of traffic lights, and presence of commercial areas were also chosen. Therefore, these results show the possibility of creating common urban models between cities of different locations.

4. CONCLUSIONS

The following conclusions can be drawn from the results of this study:

- The relationship between the traffic flow and noise levels is significant. This fact allows that simple regression equations can predict high percentages of the urban noise variability and that these equations can be used in mobile applications that allow the public to estimate the noise levels to which pedestrians who circulate next to urban roads are exposed.
- 27 urban variables related to “street location,” “urban land use”, “street geometry” and “circulation connectivity” had very significant relations with the sound levels. They are variables that are easily quantifiable and that any unqualified person or entity can register.
- A stepwise multiple linear regression model predicted significantly the 63% of the variability of the Leq (dBA). This model included the urban variables: length, number of road signs of interest places, number of buses, number of bus stops, number of shops, and number of traffic lights. The importance of some of these variables was reported in previous prediction models carried out in a

Spanish city. The results of this study could be important in urban planning models as an alternative to those that include variables such as traffic flow, traffic composition and vehicles speed or to complement these models.

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