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Measurement techniques of noise level in various urban scenarios. Day selection and representative period

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ABSTRACT

This work summarizes several years of measurements of the main noise sources present in large populations, specially the noise produced by the traffic in the city of Valencia. The study includes one-week monitoring in the period between the years 2012 and 2014 in three different types of scenarios (heavy, medium and low traffic). The aim of this work is firstly to determine the most representative measurement day under several approaches related to the type of day (working day, non-working day or full week), and to the different periods throughout the day (night, day and evening).

This permits to reach conclusions about the optimization of measurement techniques of the overall urban traffic noise, and will facilitate the measurement tasks in specific locations of the city of Valencia, characterized by specific traffic conditions.

1. Introduction

The objective of the European Parliament and Council Directive on the evaluation and management of environmental noise is to establish a new framework in the EU to evaluate and manage environmental noise exposure. Two indicators have been set in the proposal, L_{DEN} (equivalent level to *day-evening-night*) and L_{NIGHT} (equivalent level to *night*), the first of which is the basic noise indicator considered an "annoyance" indicator. In all cases, each indicator is considered the equivalent level of the relevant period determined throughout all its periods in a year. The European Union, with the objective to fight this acoustic pollution perceived by the population and within the framework of anti-noise pollution, establishes in the Directive 2002/49/EC [17] some foundations that enable:

- The determination of noise maps of the cities, depending on some common methods, in order to be able to inform the population and to apply action plans at a local level.
- The establishment of community measures to reduce noise emitted by its main sources, such as road traffic.

The Directive establishes for the calculation of strategic noise maps that the noise indicators L_{DEN} and L_{NIGHT} may be determined through calculations or measurements at the evaluation point, as long as the data are comparable and representative of reality.

It is in the estimation of this urban traffic noise indicator (L_{DEN}) where there is a difference among the various authors. While most of them use a dBA sound pressure level for a certain exposure time T (LAeq,T) for estimation, the time and the manner of conducting the measurements are different:

Standard practice, according to several authors, is to conduct short-term measures of a few minutes, 15 min, 30 min or 1 h, for some days or weeks, which may be random or continuous, and mostly working days [3,5–10,12,13,15,16,18,19,24,27,29,30–33,38]. Other authors, on the contrary, take continuous 24-h measurements [2,14]. Rather, measurement periods of several weeks [1,4,25,34,35]. While only a few studies analyze indicator variability from long-term measurements and for periods of one or several years, due essentially to the great increase in measurement costs when extending the study period [11,20,21,28,36,37].

This article lies within the activity framework of the estimation of long-term measures from other measures of a shorter duration. It is developed as part of the investigation works developed in the Doctoral Thesis "CONTRIBUTION TO THE STUDY OF THE SOUND LEVEL MEASUREMENT TECHNIQUES IN DIFFERENT URBAN SCENARIOS" [26], and it continues in the same line of action trying to contribute to the optimization of urban noise data collection

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methodology in the city of Valencia, without affecting the veracity of the results obtained. Therefore, as general approach of "optimization of measurement techniques", there are three specific objectives to be pursued:

(1) To obtain the day of the week in each period, which has the measurements that best reflect the reality of urban traffic noise in the city of Valencia, differentiating between working days and weekends.
(2) To select the time of the day in each period to conduct the measurements.
(3) To obtain the necessary measurement time in data collection.

Relevant analyses will be conducted for all these objectives taking into account the different traffic situations, heavy, medium and low traffic, and taking data measurement periods of equivalent urban noise level continuously recorded minute by minute throughout several weeks. In the first one of such analyses, the most favorable measurement day is determined, differentiating between working days and weekends in each of the three locations. In the second one, hour or time slot to optimally perform the measurement. Finally, in the third one, the necessary time for measurement is determined based on the stabilization time of the measure.

The first objective or strategy is developed in this article, by presenting the conclusions obtained, and showing the remaining objectives in parallel articles. The ultimate objective is to find a working methodology that divides the city into areas characterized by the traffic conditions and enables performing the minimum possible number of measurements in each area. This is achieved by identifying the day that is most representative of the weekly sound level in each location during each period of the day, and by taking measurements on "optimum days". Consequently, planning measurements on optimum days would reduce the costs and increase the level of representation of the data according to the weekly level estimate. At the same time, it would enable to optimize any strategy suggested by different authors [11,14,20,21,32,34] to estimate annual sound levels, either taking continuous days or random days in the estimation. Thus for any of these strategies, the choice of optimum days will improve estimates obtaining the best possible prediction.

2. Methodology

Sound level measures relevant to the city of Valencia are taken as baseline for the development of this article (Valencia is the third most populated municipality of Spain, given its 797.028 inhabitants, while its metropolitan area has 1.774.201 inhabitants, which turns it into the third most populated metropolitan area in Spain). Such sound levels correspond to continuous one-week measures of equivalent A-weighted one-minute levels ($LAeq_{,1min}$), corresponding to three locations in the city of Valencia, one for each type of traffic. Below are their locations:

(1) LOCATION A: Av. del Puerto, 36, relevant to heavy traffic conditions.
(2) LOCATION B: Dolores Marqués St., 39, relevant to medium traffic conditions.
(3) LOCATION C: Camino de Vera S/N (building 5D), laboratory of Acoustic Engineering (UPV), relevant to low traffic conditions. Restricted access, only security, cleaning and maintenance vehicles allowed.

All data collected corresponds to full weeks randomly distributed during the years 2012, 2013 and 2014 (avoiding weeks with holiday periods). Location of heavy traffic will be performed during 10 weeks of full measurements. Location of medium and low traffic will be performed within 15 weeks. Measures are taken by the sound level meters of the brand Bruel & Kjaer, 2238 and 2250 models, which comply with the specifications in the regulations to execute these measures.

In Figs. 1–3 the sound levels registered throughout a week may be seen as an example for each of the three locations.

The first data analysis reveals that the measures throughout the week follow a pattern that is daily repeated in the three locations. Reaching, as is to be expected, lower sound level values for *night* periods, and higher sound levels for *day* and *evening* periods. Only in the third location corresponding the Polytechnic University does the daily pattern become less pronounced, occasionally, on the weekends. This circumstance could derive in different results for this location from the ones in other locations when analyses are conducted, by measuring sound levels only on working days, or also including the weekends.

With the objective to ensure and corroborate the results of the research and estimate the best measurement day, all measurements obtained are analyzed through three different methods, so that the results obtained in each of them may be contrasted:

(a) Analysis of the minimal differences ("min. ε").
(b) Statistical analysis of the error (ε): Box-Whisker diagrams ("Box-Whisker Plot").
(c) Statistical analysis of the error (ε): medians, typical deviations, probability ranges of 90% and probability of ±1 dB and ±2 dB (ε-Statistics).

All the information from each week is organized by date, and the level equivalent to each hour and day of the week organized

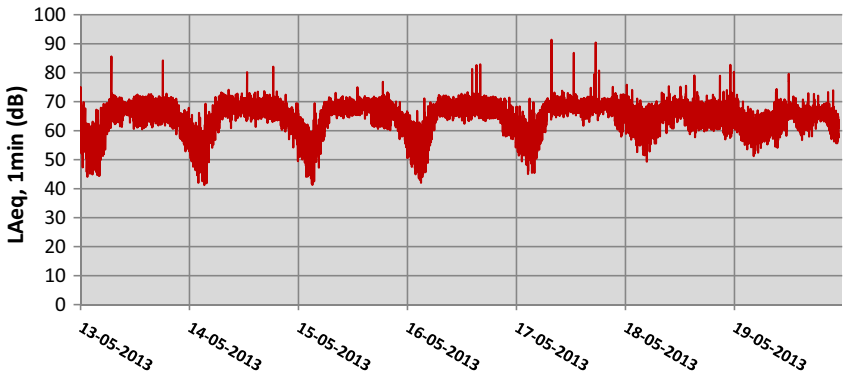

Fig. 1. Evolution of the sound level $LAeq_{,1min}$ – week 20 (2013) – Location A.