PRACTICAL METHODOLOGY FOR FAST ENVIRONMENTAL FIELD MEASUREMENTS

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ABSTRACT

This paper presents an expedite methodology to make community noise field measurements To make field measurements (L_{Aeq} or L_{A50} related to the “day”, or “night” period) in a vast number of points and using large periods of sampling in every location, is a very large time consuming task. Therefore it would be very useful, in alternative, to know at what time during the day or night the measurements should be done but using a short time interval to achieve similar results as the ones found by long and regular measurements procedures. Following a large campaign of field measurements near the town of Porto (Portugal) the presented results show the time periods and measurements durations found for this speedy methodology that is based in the concept of "acoustic scenarios" also explained in the paper.

INTRODUCTION

In general, it is possible to systemize the problem in the following form:

Objective: To characterize noise in areas of great dimension.
Difficulties: Great variability, as in space as in the duration of the noise emissions; seasonality of many sound sources; very conditional sound propagation for the following aspects: topography, built areas, atmospheric conditions; characteristics of sound absorption of the surrounding surfaces; cost and specialization of the necessary means for the evaluation; characterization of the "noise annoyance" with attention to the "particular" and not to the "average", etc.

The goal was to develop a methodology to identify noise fields of very large dimension (county level) given a particular attention to the reliability/reproducibility of the results as well to the possibility to create an acoustic database of urban spaces. Only in this way it will be possible to guarantee the utility and effectiveness of the legal requirements and the statements regarding the politics of occupation of the urban soil.

In this methodology it is used standard equipment as well the large experience acquired by our Laboratory of Acoustics in this domain [4] in order to develop tools to the management of the urban environmental noise in an agile and efficient form.

The environmental objectives defined by the program AGENDA 21 [3] that, in short, regard the improvement of the population quality of life with the compatibility for a supported development have here full application as the ultimate objective of this work.

CHARACTERIZATION OF THE METHOD

The method consists of an integral analysis of noise (day and night) to be possible to have conclusions regarding the variation of the equivalent sound pressure level during the 24 hours of the day. After several analyses in representative places of an urban area, it will be possible to identify the cyclic variations of the noise and its origins. This information will allow to create a base of support to the elaboration of ways of monitoring the urban noise that do not involve exhausting (and costly) integral measurements in the totality of an urban area.

Equipment

Stations for continuous noise monitoring were set in different points of a Porto's suburban area with urbanistic and socio-economic affinities. The equipment used besides allowing long studies (several days) has the necessary robustness to face atmospheric adversities. There was used two different stations for continuous noise monitoring:

- B&K 2231 sound level meter connected to an outdoor microphone B&K 4184 with the B&K BZ7112 software "Short-term LAeq"
- B&K 2260 sound level meter connected to an outdoor microphone kit B&K UA 1404 (photo 1).

Photo 1 – Acoustic cell for environmental noise data acquisition

Data Sampling

The equipment was mounted in diverse stations in the zone of the great Porto significant of the SCENERY 03 (table 1). We are numbering the sceneries identified in urban area from 1 to n. The number 1 is related to cross ways in suburban ways number 2 is related with rural areas and now we are presenting scenery number 3 that is related with straight main roads in suburban areas with involving construction

Twenty-four hours measurements were carried through where the L_{Aeq} values were registered in intervals of 1 minute. The values are stored in the sound level meter and later sent for a PC. Measurements were done during 45 days in March and June 2001 enclosing every day of the week (in a average of 7 measurements per each day of the week (Monday the Sunday). The B&K 2231 *Short Term Leq* application software allowed the attainment of data listings and the elaboration of graphs for the variation of the sound levels during the time periods. For a more

detailed analysis of the evolution of the L_{Aeq} data, they were transferred from the PC operative system to the spreadsheet.

SCENERY 03	***Suburban ways with involving construction***
Population by parish	Between 50,000 and 75,000 inhabitants
Roads and streets	Traffic in the rush hour up to 180 vehicles per minute (12% trucks)
Industrial sources	Several in the region without implication in the local
Average height of the involving built area	Up to 9 m and 50% of occupation
Daytime Period	L_{A50} = 65,3 ± 1,7 dB L_{Aeq} = 67,0 ± 1,6 dB
Nightime Period	L_{A50} = 51,1 ± 3,2 dB L_{Aeq} = 59,9 ± 3,5 dB
CLASSIFICATION	*VERY NOISY ZONE [6]*

Table 1. - Characterization of noisy scenery consisting by linear stretch of suburban road

From the measured instantaneous values, daily means were calculated for the same days of the week. The daily average evolution of the describing parameters L_{Aeq} and L_{A50} as well as the standard deviation were calculated. The equivalent continuous sound level L_{Aeq}, was calculated from the "Short L_{Aeq}", that is, from the one minute *LAeq* according to following expression:

$$L_{Aeq} = 10\log\frac{1}{T}\int_0^T 10^{\frac{ShortLeq(t)}{10}}dt \quad \text{used as:} \quad L_{Aeq} = 10\log\frac{1}{T}\sum 10^{\frac{ShortLeq(t)}{10}}dt$$

The sound level not exceeded in 50% of the measurement time interval, L_{A50} was directly found from the Short L_{Aeq} calculating the 50% quartile of the period in analysis.

VARIANCE STANDARD DEVIATION AND PRECISION OF ESTIMATES

One of the main questions regards the precision of estimates once we have made simple measurements. To identify confidence intervals we began to determine variance and standard deviations of weekly measurements. Table 2 and 3 reproduces the cross evaluation of data from the seven days of the week

Analysis of variance and standard deviation between the seven days of the week data (LAeq) - day period -							
07:00h to 22:00h	Mon vs Tue						
	0,20534369	variance					
	0,45314865	st. deviation					
	Mon vs Wed	Tue vs Wed					
	0,19870014	0,272617141	variance				
	0,44575794	0,522127514	st. deviation				
	Mon vs Thu	Tue vs Thu	Wed vs Thu				
	0,15936891	0,211458042	0,226719349	variance			
	0,39921035	0,459845671	0,476150553	st. deviation			
	Mon vs Fri	Tue vs Fri	Wed vs Fri	Thu vs Fri			
	0,14842262	0,233700027	0,21597615	0,183673477	variance		
	0,38525657	0,483425306	0,464732342	0,428571437	st. deviation		
	Mon vs Sat	Tue vs Sat	Wed vs Sat	Thu vs Sat	Fri vs Sat		
	1,02931912	0,875209735	1,095407811	0,912184479	1,12001957	variance	
	1,01455365	0,935526448	1,046617318	0,955083493	1,05830977	st. deviation	
	Mon vs Sun	Tue vs Sun	Wed vs Sun	Thu vs Sun	Fri vs Sun	Sat vs Sun	
	4,97108999	4,489030282	5,035171924	4,645193321	5,167390381	2,202726845	variance
	2,22959413	2,118733179	2,243918876	2,155271055	2,273189473	1,484158632	st. deviation

Table 2 - Analyses of variance and standard deviation between the seven days of the week data (LAeq)- day period - analysis

Analysis of variance and standard deviation between the seven days of the week data (LAeq) - night period -							
22:00h to 07:00h	Mon vs Tue						
	2,7982259	variance					
	1,672789855	st. deviation					
	Mon vs Wed	Tue vs Wed					
	7,101654806	6,880340653	variance				
	2,66489302	2,623040345	st. deviation				
	Mon vs Thu	Tue vs Thu	Wed vs Thu				
	6,950424948	6,729313717	0,216447722	variance			
	2,63636586	2,59409208	0,465239424	st. deviation			
	Mon vs Fri	Tue vs Fri	Wed vs Fri	Thu vs Fri			
	7,819982452	7,597716307	0,233537849	0,241674294	variance		
	2,796423153	2,756395528	0,483257539	0,491603798	st. deviation		
	Mon vs Sat	Tue vs Sat	Wed vs Sat	Thu vs Sat	Fri vs Sat		
	1,843280985	1,636021623	5,33367317	5,190717544	5,190717544	Variance	
	1,357674845	1,279070609	2,309474652	2,278314628	2,278314628	st. Deviation	
	Mon vs Sun	Tue vs Sun	Wed vs Sun	Thu vs Sun	Fri vs Sun	Sat vs Sun	
	2,570101359	2,364430815	7,23323557	7,074283317	7,074283317	1,439993789	variance
	1,603153567	1,537670581	2,689467525	2,659752492	2,659752492	1,199997412	st. deviation

Table 3 - Analysis of variance and standard deviation between the seven days of the week data (LAeq) – night period -

The above figures conducted us to the dissection of the weekly day period in two:

- Work days and Saturday that includes Monday to Saturday data
- Sunday that includes only Sunday data

DATA ANALYSIS

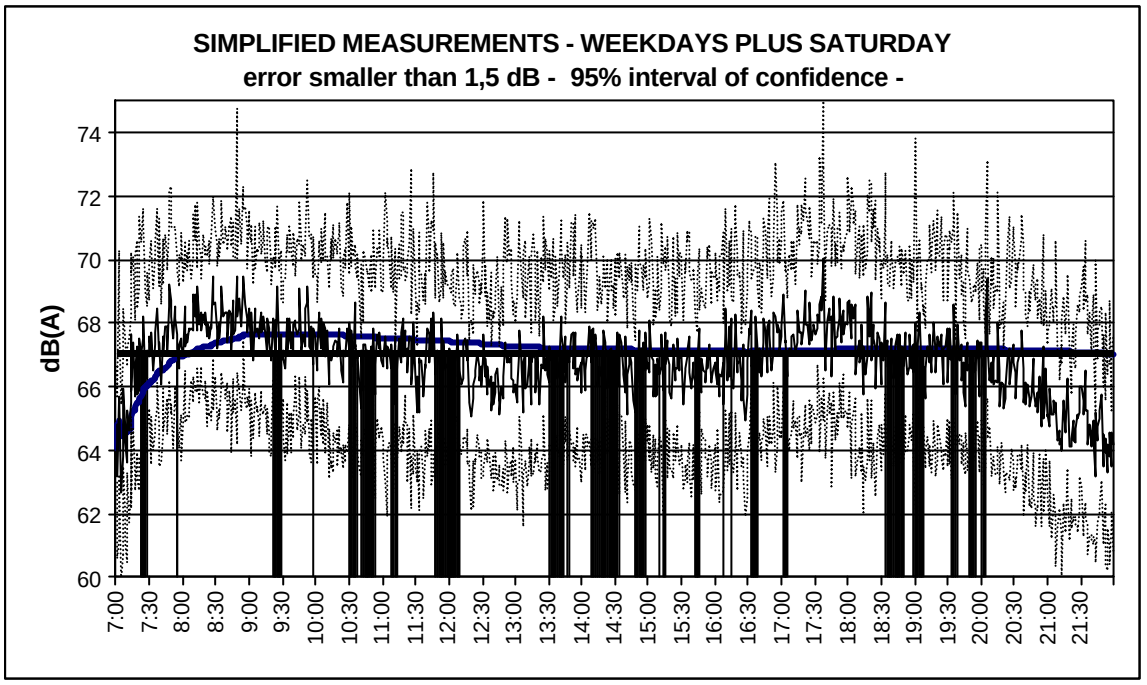
Analysis of Results

"Working" days (Mondays to Fridays plus Saturday)

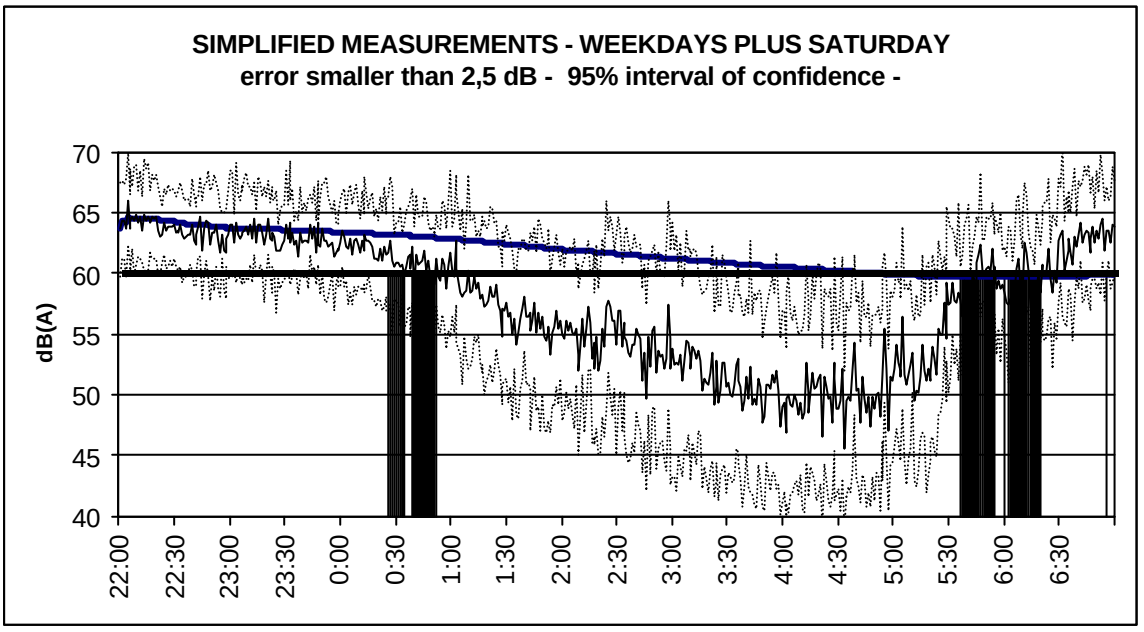
As all the working days of the week including Saturday present similar variation of sound pressure levels, the relative data to all Mondays, Tuesdays, Wednesdays, Thursdays, Fridays and Saturdays were grouped with the objective to construct a database representative of the "typical weekly profile". In this database, small dispersions are found (standard deviation approximately 1 dBA). The noise profile evidences well the difference between the daytime and the nighttime periods. However, it must be pointed out also the clear difference found on the 22 to 24 h period, where the values of the describing parameter decrease about 2 to 3 dB(A) for the remaining period. That values marks already typical night levels with values of early morning to reach, from the 05 h, values above the 60 dB(A). It is then possible to have the measurements done in shorter time intervals than the totality of the reference period with comparable results to the real full measurement. The Table 2 shows how it is possible to have these simplified measurements.

SIMPLIFIED MEASUREMENTS - SCENE 03 – Weekdays plus Saturday		
Period	Sampling measuring duration (min.)	Simplified measurements time (h)
DAYTIME See Graphic 1	10	10:30-10:50; 11:40-12:10; 14:10-15:00; 18:30-19:10; 19:40-20:10
NIGHTTIME See Graphic 2	10	12:20-12:50; 05:30-06:20

Table 4. - Simplified measuring periods to characterize the weekdays plus Saturday



Graphic 1 - Simplified measurements for Daytime



Graphic 2 - Simplified measurements for Nighttime

Sundays

The analysis of the Sundays' data allows concluding that Sunday is less noisy day. Between the 07:00 and 10:00 h the values of the sound pressure level oscillate between 60 and 65 dB(A) (while during the remaining days of the week these are presented, for this interval of time, above 65 dBA). During all daytime period never the 70 dB(A) are reached. The nighttime period presents however a similar variation of the sound pressure levels as the nighttime periods for Mondays, Tuesdays, Wednesdays and Thursdays, but not of the Fridays and Saturdays.

Sundays are not represented by graphics as weekdays, but table 4 shows how it is possible to have these simplified measurements.

SIMPLIFIED MEASUREMENTS - SCENE 03 - Sundays		
Period	Sampling measuring duration (min.)	Simplified measurements time (h)
DAYTIME	10	10.15-11.45; 14.30-16.00; 18.30-20.00
NIGHTTIME	10	00.30-01.00 or 06.00-06.15

Table 5. – Simplified measuring periods to characterize the Sunday's regimen

CONCLUSION

The integral analysis of urban noise is precious help in noise monitoring. This because from an integral noise analysis in one determined typical urban place (a crossroad, a road with intense traffic, a rotunda, etc.) it is possible to determine the best time for simplified measurements.

In the present case measurements were done in what is was stipulated to call "Scene 03" having evidenced the useful measurement periods and the characterization of the weekly noise profile.

The days from Monday to Saturday present much significance and can be used to describe a "Weekday Regimen". Sundays are deeply different and without correlation with the weekdays.

The periods of "daytime" and "nighttime" nuisance are not good describers of the reality observed in this study. They contain noise-generating situations of urban noise deeply different whose description needs to be better developed. The nighttime period is particularly evident in which the energy describer cannot translate peaks of transit or significant variations in the totality of the period. The “evening time” period is well came.

Simple time oriented measurements are a good way to achieve noise evaluation of large periods.

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