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# RECREATION NOISE IN ACOUSTIC MAPPING

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**Abstract**

As far as most of citizens complains are about noise coming from recreational activities, usually related with the presence of people in the street around bars, pubs, parties and other activities carried out in public spaces, it seems reasonable to include this kind of noise source in the strategic noise maps, especially if the main objective of the noise mapping is to draw action plans. A methodology is proposed to analyze that kind of noise environments including short-term and long-term measurements, obtaining the acoustic indicators $L_n$ and $L_{den}$ as well as number of people exposed to those indicators. The results obtained in six different cities show that similar trends can be found for commercial streets in different cities, showing an increase of 5 dBA in $L_{eq}$ between 5 p.m and 8 p.m compared to the average value of $L_{eq}$ during the rest of day time. Night recreational noise seems more variable and an in field study must be carried out. It has also been found that around 10% of population is exposed to noise coming from commercial streets.

**Keywords:** Noise, environmental, recreation, mapping

## 1 Introduction

One of the objectives of the strategic noise maps for agglomerations, as it is established in the EU Directive 49/2002 [1] about environmental noise, is to draw action plans. In order to obtain the acoustic information, the Directive also establishes that maps have to be carried out for different sound sources, which are road traffic, rail traffic, aircraft flights and industrial activities. However, noise of recreational activities, as bars, pubs, parties and other activities carried out in public spaces as beaches or gardens have its share of people's disturbance [2], especially in tourist cities [3].

Thus, if the main objective of noise mapping is to draw action plans, noise from recreational activities should be included as a different noise source in every strategic noise map,

specially because the main goal of a noise map is to draw action plans to protect people from noise pollution. Moreover, it is not appropriate to publish noise exposure levels neglecting one of the most annoying noise sources. As a consequence, the Environmental and Home Department of the Catalan Government decided that recreation noise has to be included as a noise source like traffic noise, rail noise, aircraft noise and industrial noise in the strategic noise maps. Simultaneously, and stressing the need of noise management, a strategic noise map includes by definition [4]:

- Noise map depicting the existing acoustical situation in accordance with a noise index
- Capacity map showing the maximum level achievable in a road as a function of $L_d$, $L_e$ or $L_n$ and also regarding the kind of noise source
- Difference map between the current levels and the limit levels according to the capacity map (deviations map)
- Estimated number of people exposed to different noise levels in an area

Combining the deviations map and the exposed population data, useful information can be extracted in order to establish the priority of the noise abatement actions.

The present work explains the methodology used to asses the recreational noise levels in recreational areas and pedestrian streets since both kinds of streets can be grouped as services streets and the same method can be used. It also shows some partial results extracted from the realization campaign of strategic maps in Catalonia.

# 2 Methodology

On one hand, it is evident that recreational noise is very difficult to calculate by simulation since it is generated by people passing by or musical activities of variable and unforeseeable acoustic power. On the other hand, an accurate acoustic study requires a reconnaissance of the area in order to infer which activities are the main acoustic sources. This two reasons lead to direct noise measurement as the best evaluation option.

The evaluation of ambient noise in pedestrian and recreational areas is done by combining short and long-term measurements. Short-term measurements are carried out within a time window when recreational noise is representative. Not just the noise level is observed, but also which activities are predominant in terms of noise, also the area is acoustically characterized, and the limits of the area affected by recreational noise and its homogeneity is established. Long-term measurements are used to know the time evolution of the noise level and to determine when the different sources (if more than one) predominate. In general, when an homogeneous area of study is determined, a long-term and some short-term measurements are performed, the number of short-term measurements is a function of the extent of the area and the number of noise sources. The specific placement of the

measurement points in the street is chosen so they are representative of the street characteristics. In cases where the same street has several features that may affect the resulting sound level, more than one measurement point is planned.

Provided that EU Directive requires data on noise levels incident on the facades of buildings, the measurements are generally performed with the microphone located as close to the facade as possible, and it is applied a correction of - 3 dB to the measured noise level. Whereas the long-term measurements have been carried out normally at 4 meters of height, the short ones have been made at street level, taking care to avoid shielding.

# 3 Agglomerations in Catalonia

According to 2002/49 Directive, an agglomeration is defined as the sector of territory containing a population equal or greater than 100,000 inhabitants, with a minimum density population of 3,000 inhabitants per $km^2$. An agglomeration can also be constituted by different municipalities or parts of municipalities that satisfy the density criterion and are spaced a maximum of 500 m between them.

From this definition and using 1:5000 scale aerial photographs available in the Cartographic Institute of Catalonia, and data from the last census of municipalities, urban areas have been identified in Table 1. This results in a total of 10 agglomerations formed by 23 different municipalities, which means that there are agglomerations containing 3,343,779 inhabitants in the region of Catalonia.

So far data is available on noise or pedestrian recreational activities for the 6 towns that are agglomerations itself. These cities are Gava, Esplugues, Viladecans, Sabadell, St Adrià and L'Hospitalet. All but Sabadell are located very close to Barcelona and perhaps for this reason Sabadell is the only one that has an area of urban leisure. It is possible that the major leisure offer for towns near Barcelona is located within the city of Barcelona while Sabadell is a local leisure center, attracting people from nearby towns that are part of the same agglomeration, or part of the agglomeration of Terrassa.

Table 1. Agglomerations in Catalunya. The entries in boldface are the agglomeration's name, and below each one there are the cities included in it.

| ***Agglomeration*** | ***Population*** |
|---|---|
| ***Barcelonès I*** | **1.649.131** |
| Barcelona | 1.615.908 |
| Sant Adrià del Besós | 33.223 |
| ***Barcelones II*** | **338.397** |
| Badalona | 215.329 |
| Sta. Coloma de Gramenet | 117.336 |
| ***Baix Llobregat I*** | **446.629** |
| Hospitalet de Llobregat | 253.782 |
| Cornellà de Llobregat | 85.180 |
| Esplugues de Llobregat | 46.586 |
| Sant Feliu de Llobregat | 42.628 |
| Sant Joan Despí | 31.647 |
| Sant Just Desvern | 15.365 |
| ***Baix Llobregat II*** | **107.763** |
| Viladecans | 62.563 |
| Gavà | 45.190 |
| Sant Boi | 82.428 |
| ***Vallès Occidental I*** | **248.069** |
| Sabadell | 203.969 |
| Barberà del Vallès | 30.271 |
| Badia del Vallès | 13.829 |
| ***Vallès Occidental II*** | **209.042** |
| Terrassa | 206.245 |
| Viladecavalls (Can Trias) | 2.797 |
| ***Gironès*** | **123.247** |
| Girona | 94.484 |
| Salt | 28.763 |
| ***Lleida*** | **131.731** |
| ***Mataró*** | **119.780** |
| ***Reus*** | **107.770** |

# 4 Noise level results

The figures 1-3 show the size of the zones affected by pedestrian or leisure activities of each of the cities considered. The percentage of streets of this type is really small but the truth is that it tends to grow

In most of the cities it can be found two main types of pedestrian streets (see captions): those contained in residential areas, with little or no presence of activities, which are often

more or less isolated from the downtown, and those with a significant presence of commercial activities that lie at the heart of the city. The noise levels in the first case are usually low, about 55 dBA $L_d$, with a few fluctuation, and 45dB or less $L_n$, being the background noise of the city predominant over the noise of the street itself. In the case of shopping streets, the noise levels vary significantly throughout the day and also vary depending on the type of city. Figs 4-6 shows the noise levels $L_{eq,\ 1h}$ recorded in several commercial pedestrian streets in some of the cities analyzed. The trend is the same in every street: the $L_{eq,\ 1h}$ remains basically constant throughout the morning and afternoon until 5 p.m. Between 5 p.m and 8 p.m there is an increase of about 5 dBA, then it starts a decline that continue until a minimum value after 3 a.m in the morning. These results together with the observation and realization of short-term measurements in situ suggest that in the interval between 7 a.m and 5 p.m the background noise of the city dominates, with negligible contribution of the commercial activity noise. From 5 p.m (when primary schools finish their activity) to 8 p.m (when people goes home for dinner) the main source is the commercial activity. From 8 p.m on, the activity level drops (leaving only the food and beverage activities) and the background noise predominates up to 3 a.m in the morning.

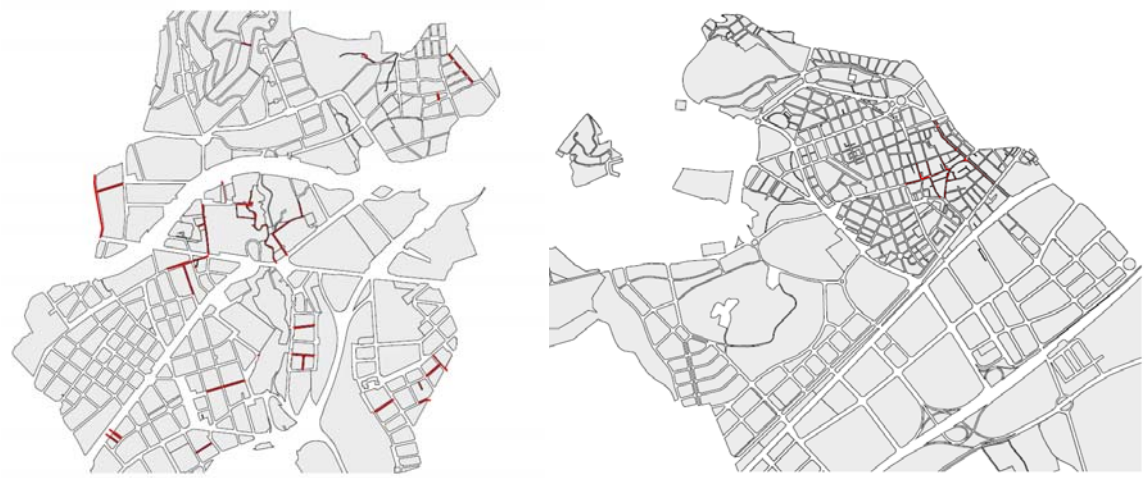

Fig. 1. Esplugues (left) and Gavà. Pedestrian streets are indicated in red. The ones placed in the center of Esplugues are basically commercial, being the rest residential, with small shops. Pedestrian streets in Gavà are basically commercial.

Fig.2. L'Hospitalet and St. Adrià. Pedestrian streets are indicated in red. Most of them are located in residential areas

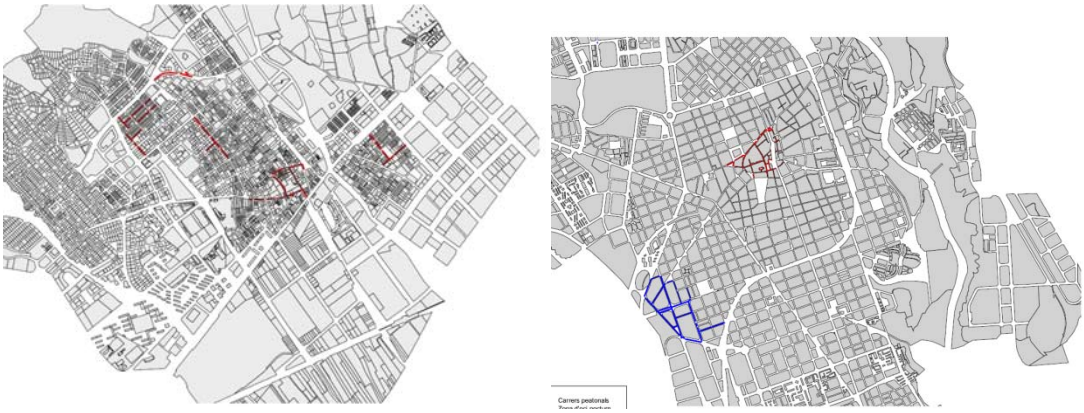

Fig. 3. Viladecans and Sabadell. Pedestrian streets with basically commercial use in red, in blue streets with recreational activities

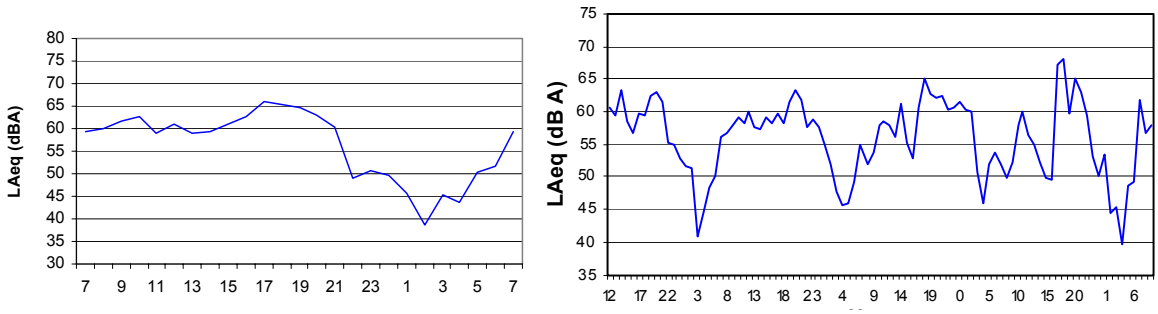


Fig 4. 24 hours noise history (left) and from Thursday to Sunday (right) in the commercial streets of Gavà.

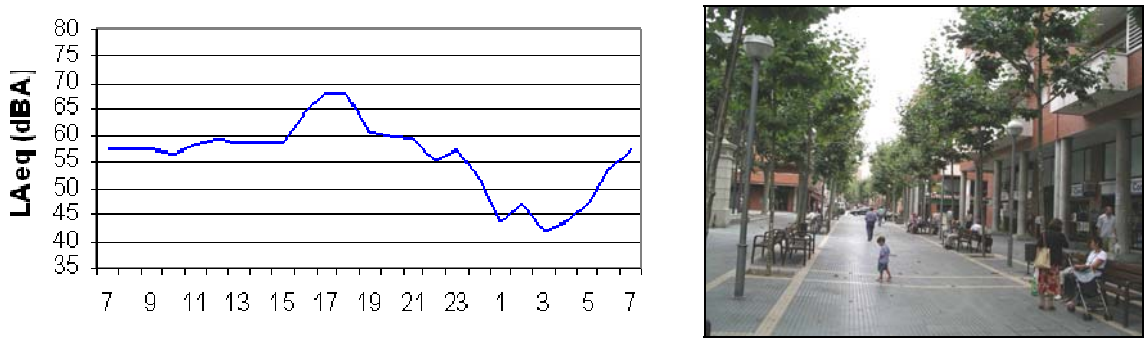


Fig 5. 24 hours noise history in the commercial streets of Esplugues.

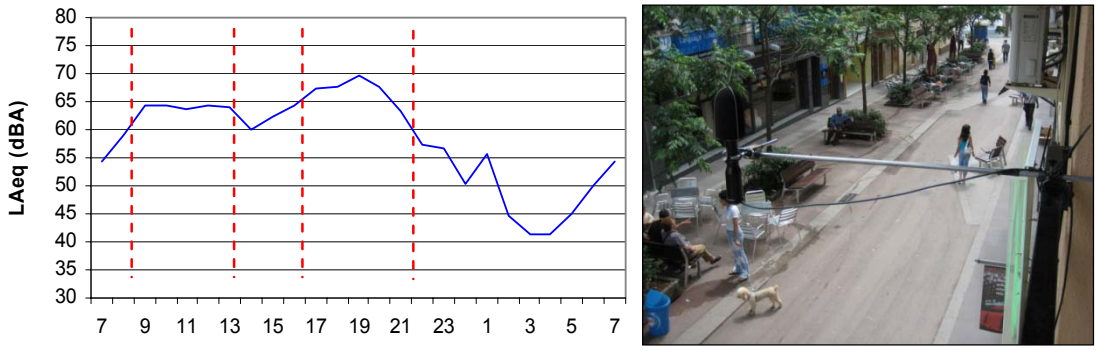


Fig 6. 24 hours noise history in the commercial streets of Viladecans.

This fluctuation in the level $L_{eq,\ 1h}$ causes a significant variation in the evaluation of the parameters that quantify the noise pollution. Particularly the $L_e$ (between 7 p.m and 9 p.m) increases by about 3.5 to 4 dBA compared to the same parameter without the increase due to the presence of people in the street. The contribution on the day level is lower, because the interval (7 a.m -7 p.m) is 12 hours, but even so it increases by 1.5 dBA.

Sabadell is the only city that has an area where leisure activity is the main activity. However, this activity predominates only during night hours where bars and discos are open, while during the day the light industrial activity predominates. During daytime, the sound level is caused mainly by traffic in the area, although in some streets industrial noise sources are noticeable in some specific moments. Consequently, the time history of the sound level throughout the day remains basically flat (Fig. 7), as expected for this type of environment. The noise level tends to decline after 9 p.m, as in most streets, but from 11 p.m on the level increases up to daytime levels between midnight and 2 a.m. Between 2 a.m and 5 a.m, the noise level tends to decline slowly (5 dBA in 3 hours) to, again, between 5 a.m and 7 a.m, recover up to daytime values.

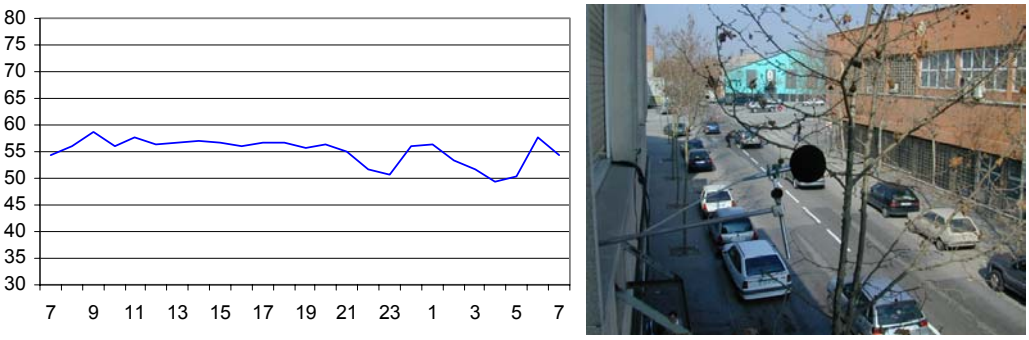


Fig 7. Tipical 24 hours noise history in the streets of Sabadell with recreational activities at night. At day time, light industrial activity predominates.

The increase in noise level between 11 p.m and 1 a.m may be because it is the time window when most of the clients of bars and discos arrive, while the increase between 5 a.m and 7 a.m corresponds to their closing time. Within these intervals, the noise level stays, at least 5 dBA above the usual level in a street where traffic noise predominates. This is due to the persistent traffic access to the area, and to the presence of clients in the street. As a result, the difference between day and at night the level is only 2 dB.

## 4.1 A particular case: tourist city

The emergence of the legal framework as a result of Directive 2002/49 and the elaboration of strategic maps have boosted noise mapping in municipalities that can't be considered as an agglomeration, undoubtedly it is because of the need to manage urban noise. An example of this is the coastal and touristic city of Sitges. The local population is around 20,000 inhabitants but it has a seasonal population increase during the summer reaching 80,000 inhabitants. The pedestrian zone is shown in Figure 8, and it is composed entirely of commercial streets. Some of these streets, however, have a strong nocturnal activity due to the presence music bars and terraces, resulting in a significant increase of nocturnal levels (Fig. 9). However, it is not possible to establish a relation with the dynamics obtained for the recreational area of Sabadell.


Fig 8. Pedestrian streets in Sitges (left) and, among these, the ones with recreational activities (in purple, right).

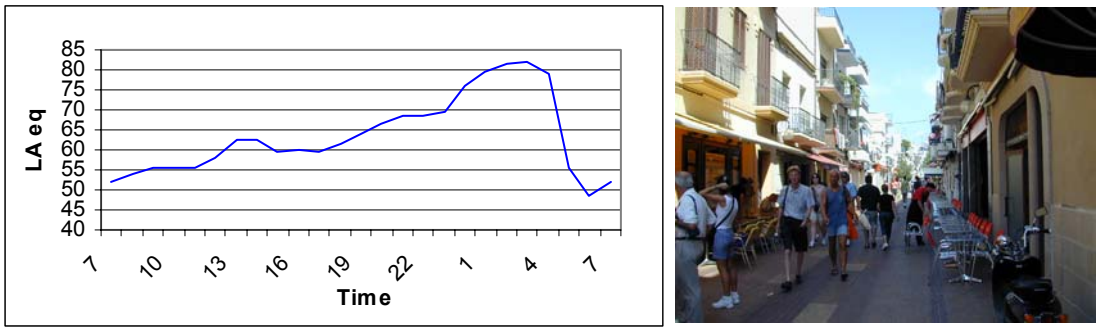


Fig 9. 24 hours noise time history in the streets of *Sitges with recreational activities* at night. At day time, commercial use predominates.

# 5 Population exposed results

Noise levels for different indicators were assigned to the streets, according to the results from short-term measurements and its extrapolation to long-term noise level indicators using the 24-hours trends obtained from long-term measurements showed previously. These values were introduced in the GIS of the local administration, if available or in a new GIS otherwise. Using the available GIS means that little effort must be made in order to obtain data from population exposed, because population data is usually already introduced and assigned to postal address. In that case, it is easy to assign a street noise level to population living in that street section and to calculate the total amount of people exposed to such noise indicator. When new GIS software was used, all that data regarding population was compiled, introduced, and assigned to a postal address, and then the same procedure was followed to obtain data on exposed population. However, it must be taken into account that a certain percentage of dwelling do not have outside walls facing the street, but facing to the internal zones such as courtyards with noise levels below those existing in the street. The calculation of the population exposed to the interior noise levels and to exterior noise levels can be determined applying the ratio of facade perimeter leading to the street per total facade perimeter to the population associated to a certain address. The buildings with internal quiet zones were located from the information provided by the distribution of holdings and aerial photographs of the municipality. Then, the perimeter of the facade leading to the street is determined and also the perimeter of the facade leading to interior areas. Table 2 show the results of population of the six cities included in the agglomerations referred previously. It can be seen that the total amount of population is between 50,000 inhabitans for $L_{den}$ and 70,000 for $L_n$. This means that night noise levels are higher than $L_d$-10 dB as it is expected or desired to be. The total population of the six cities considered here is about 64,5000 inhabitants, thus the population exposed to commercial/recreational noise is about 10% of the total population.

Table 2 – Population exposed to recreational/commercial activities

| dBA | Ln | Ld | Lden |
|---|---|---|---|
| **<55** | 55376 | 33793 | 25390 |
| **55-60** | 8836 | 10857 | 10161 |
| **60-65** | 6083 | 13305 | 13186 |
| **65-70** | 0 | 536 | 902 |
| **70-75** | 0 | 58 | 58 |
| **>75** | 0 | 0 | 0 |

# 6 Conclusions

Noise of recreational activities, which can include also commercial activities or simply activities in the street (as kids playing in the street, for example) cannot be simulated in an easy way because the sound sources are variable or are just people making noise. A methodology is proposed to evaluate that kind of noise environments composed by short and long-term measurements, in order to know the environment, the area affected by different sound sources, and the dynamics of noise levels. Using the trends showed by long-term measurements, values of $L_d$, $L_n$, $L_e$ and $L_{den}$ can be estimated. Once they are known, they can be related to the population living in those areas using the GIS from local administration. Results over six cities show that 10% of population is exposed to noise from, mainly, people attending commercial activities. Noise levels (of long-term parameters like $L_d$ or $L_n$) are not high in general, being most of people exposed to $L_d$ values about 55 dBA, but it has been found that during rush hours (between 5 p.m and 8 p.m, for commercial activities) $L_{eq}$ value rises 5 dBA compared to the average value of the rest of the day.

Noise level from recreational activities such as music bars and so increases at night, but in this case it is not possible to find general trends. However, if these activities are located inside industrial zones, there is no population exposed to such a noise, like in Sabadell city.

## References

[1] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, (2002)

[2] Night noise guidelines for Europe, *World Health Organization (2009)*.

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