



Agglomeration Noise Strategic maps in Catalonia

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Abstract

The Directive 2002/49 on evaluation and management of the environmental noise demands in case of agglomerations, a series of information that one must communicate to the Commission, between which there is the number of people whose housings are exposed to every range of values of L_{den} and L_{night} in dBA. In this work they present the criteria contemplated in the delimiting of the agglomerations inside Catalonia's territory, as well as the methodologies used in the estimation of the audible levels and the population exposed to the different indicators of noise with the results obtained.

Keywords: agglomerations, indicators of noise, population exposed.

1 Introduction

The main purpose of the law 176/2009, which approves the Law Regulation 16/2002 on protection against noise pollution, [1] is the development of the law itself and also to achieve the adequacy of those precepts of basic nature of the European and state regulations that directly affects the Catalanian legislation [2] [3]. It considers that both local authorities, which constitute a agglomeration, and holders of the major roads which have more than three million vehicle a year, railways which have more than 30,000 train passages a year, major airports which have more than 50,000 movements a year and major ports, have to develop and approve strategic noise maps, according to common criteria set for the European Union.

2 Definition of agglomeration

Agglomeration has been 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 km². It can also constitute agglomeration 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 [4] 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 agglomerations including 3,343,779 inhabitants in the region of Catalonia. [5] [6]

Table 1. Municipalities and supramunicipalities agglomerations in Catalonia

| <i>Supramunicipality agglomeration</i> | <i>Inhabitants</i> |
|---|---------------------------|
| <i>Barcelonès I</i> | 1,649,131 |
| Barcelona | 1,615,908 |
| Sant Adrià del Besós | 33,223 |
| <i>Barcelonès II</i> | 338,397 |
| Badalona | 215,329 |
| Sta. Coloma de Gramenet | 117,336 |
| <i>Baix Llobregat I</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 |
| <i>Baix Llobregat II</i> | 107,763 |
| Viladecans | 62,563 |
| Gavà | 45,190 |
| Sant Boi | 82,428 |
| <i>Vallès Occidental I</i> | 248,069 |
| Sabadell | 203,969 |
| Barberà del Vallès | 30,271 |
| Badia del Vallès | 13,829 |
| <i>Vallès Occidental II</i> | 209,042 |
| Terrassa | 206,245 |
| Viladecavalls (Can Trias) | 2,797 |
| <i>Gironès</i> | 123,247 |
| Girona | 94,484 |
| Salt | 28,763 |
| <i>Lleida</i> | 131,731 |
| <i>Mataró</i> | 119,780 |
| <i>Reus</i> | 107,770 |

3 Definition and content of strategic noise maps for agglomerations

According to Directive 2002/49/EC [3] a strategic noise map is a map designed for the global assessment of noise exposure in a given area due to the existence of different sources of noise, or to make overall predictions for the area.

Decree 176/2009 considers the capability maps and the strategic noise maps as tools for environmental management of noise and it defines the strategic noise map as the representation of the data relative to any of the following:

- Existing acoustical situation, expressed in accordance with a noise index, Noise map.
- Exceeding a limit value according to the map of acoustic capacity.
- Estimated number of people located in an area exposed to noise.
- Estimated number of homes, schools and hospitals in a given area that are exposed to specific values of a noise index.

Strategy maps of agglomerations have to take special account of road traffic noise, rail traffic, airports and industrial areas, including ports.

The exceed of limit values are determined from the comparison between the existing noise situation and the acoustic quality objectives set out in the map of acoustic capacity for a given area, [5] [6]

3.1 Noise map

The noise map is made according to criteria indicated at the law 16/2002 on protection against noise pollution as well as the general criteria that are outlined in ISO-1996, in addition to the council indications so that results are representative of the acoustic environment throughout the municipality. More than a set of data indicating the acoustic state of an agglomeration, the map is a tool that leads to policy coherence and management of urban noise, [7]. The map made fulfill the following basic requirements:

- *Regional Representation: Measuring points are selected related to land use, adapting the measures to noise sources.*
- *Temporal Representation: long-term measures are made. Those measures establish the sound development along 24 hours a day, depending on the types of street and land use.*
- *Discriminatory source of noise: In the measures dominant noise sources are defined, which are reflected in separate maps, the combination of which gives the total map. Knowledge of noise sources make possible actions aimed at reducing noise.*

- *Versatility: The noise should not be treated as an independent agent of the other variables that make up the urban organization. The information on noise pollution should be able to connect easily with other data such as population, location of activities, traffic and so on. That is why the noise data are entered into the GIS of the City Council, so as to be usable by the staff of the City Council in later stages of the map.*
- *Thoroughness: measures will be sufficient to ensure the accuracy of the map to reality, with margins of error less than 5 dBA of range of representation that includes the Law on Protection against noise pollution and other regulations.*

In the development of noise mapping both short-term measures and long term are made. The location of measuring points in the street has been chosen so that the position will be representative of the characteristics of the street. In cases where the same street has several features that may affect the resulting sound level; there have been made more than one measurement.

The long-term measures (24 hours minimum) determine the time evolution of the immission of sound at a given point for a whole day. These measures are intended to obtain a model that estimate the night time sound levels depending on the type and use of each street, [8] On the other hand, enable to know the variability of the sound levels throughout the day so they are useful to establish the optimal schedule for making short-term measures.

3.2 Acoustic capability maps

The acoustic capability maps have been prepared in accordance with what is laid down by Decree 176/2009 which approves the Regulation that develops the Law 16/2002 on protection against noise pollution, which sets out the criteria for elaborating of such maps and also have to take into account the acoustic quality objectives of the territory and the immission limit values for the various types of acoustic radiator, [1]

The acoustic capability map is the grouping of the different areas of the territory where there are permitted the same limit immission levels. Delimiting the different zones depending on the acoustic dominant land use, where each zone is assigned a level of noise immission limit, set as a quality objective. In the acoustic zoning of the territory as well as considering the dominant land use, are also considered the existence of transport infrastructure or equipment, as well as the existing reality of sound. This map should be allowed to set conditions or limitations on land use in order to preserve the quality of the sound environment of the agglomeration, [9] [10]

All urban land or developable urban land has to be associated with a type of sound zone. Knowing the area is possible to know the corresponding immission level and therefore, it is also possible to determine the implications arising for use either as constraints for industrial use as conditions for the construction of new housing, as conditions for the introduction of new economic activities and so on.

The capability acoustic noise maps lay down the acoustic zoning of the territory and the immission limit values according to the noise sensitive areas and land use, depending on whether it is existing urbanized areas or undeveloped areas, according to the following table:

Table 2. Limit immission values according to Decree 176/2009 [1]

| Land uses | Limit immission values in dB(A) | | |
|---|---------------------------------|---------------------|--------------------|
| | L_d (7 h – 21 h) | L_e (21 h – 23 h) | L_n (23 h – 7 h) |
| ZONE OF HIGH ACOUSTIC SENSITIVE (A) | | | |
| (A1) Zones of natural interest and others | - | - | - |
| (A2) Predominance of sanitary, educational and cultural land use | 55 | 55 | 45 |
| (A3) Houses placed at rural environment | 57 | 57 | 47 |
| (A4) Predominance of residential land use | 60 | 60 | 50 |
| ZONE OF MODERATE ACOUSTIC SENSITIVE (B) | | | |
| (B1) Coexistence of residential land use with activities and/or transport infrastructures | | | |
| (B2) Predominance of tertiary land use different from (C1) | 65 | 65 | 55 |
| (B3) Built-up existent areas affected by industrial land use | | | |
| ZONE OF LOW ACOUSTIC SENSITIVE (C) | | | |
| (C1) Recreational uses and entertainment | 68 | 68 | 58 |
| (C2) Predominance of industrial land use | 70 | 70 | 60 |
| (C3) Territorial areas affected by general system of transport infrastructures of other public equipments | - | - | - |

Attention values: on the built-up existent areas, for land uses (A2), (A4), (B2), (C1) and (C2), and for the houses existent at rural environments (A3), the value for the immission is increased by 5 dB(A).

3.3 Exceeding noise level limits map

Made the proposed acoustic capability map, it can be represented on a map the differences between the sound levels measured or assigned to each street on the acoustic map and the limit level of acoustic immission corresponding to the same street, depending on the area of sensitivity which has been allocated. Thus, the maps are drawn for overcoming limit immission levels, regarding the proposed capability map.

- Map of exceeding daytime immission levels.
- Map of exceeding immission levels during the night.

To represent the exceeding of the immission levels, it has been chosen a graphic scale, so to facilitate the identification of the streets where limits are exceeded for the immission levels indicated in Decree 176/2009, which would be necessary to develop action plans.

3.4 Exposed population exposed to different noise levels

Directive 2002/49 on the evaluation and management of environmental noise [3] requires a set of data to be sent to the committee, among which is the number of people whose homes are exposed to each range of values of L_{den} in dBA at a height of 4 meters above ground level.

Although the facade noise level can vary with height, the calculation of population exposed to each of the ranges, is made from the measured or calculated values to 4 meters in height according to the established of Directive 2002/49 on the assessment and management of environmental noise.

Population data referred to in the last municipal census provided by the city council, are introduced into the same GIS were where introduced on the acoustic noise map, with the aim of making the evaluation of the exposed population to each sound level range, [11] [12] [13] [14][15]

Population data were introduced in the GIS in address order, so that each address corresponds to the amount of people registered in that direction. The calculation of the exposed population was made by assigning the noise level of the stretch of street to the addresses (and previously assigned population) corresponding to the stretch of street, and so for all sections of street in the municipality.

To assess in detail the exposed population to different noise levels, it has been considered that a certain percentage of homes do not directly communicate with the outside of the public road, but give to the internal zones with noise levels below those limiting the street block. [16]

The calculation of the exposed population to the interior and exterior of the blocks can be determined by the following method:

Firstly, it is determined which blocks meet the condition set forth in the preceding paragraph, from the information provided by the distribution of holdings and aerial photographs of the municipality. Then the calculations of the total perimeter of each block (outer perimeter + interior).

Then, the perimeter of the façade exposed to noise levels of public roads is determined and also the perimeter of the facade exposed to the sound level from inside the block.

From the data obtained for a representative sample of households that make up these inner blocks, the percentage of the population exposed to indoor and outdoor is calculated as follows:

$$\% \text{ exposed population to the interior level} = \frac{\text{Perimeter of indoor facade}}{\text{Total perimeter of facade}} \quad (1)$$

$$\% \text{ exposed population at the level of the street} = \frac{\text{Perimeter of outdoor facade}}{\text{Total perimeter of facade}} \quad (2)$$

Those percentages, applied to the population attributed to the addresses of the blocks under consideration, it gives the population exposed to the street and population exposed to the interior of block. The population exposed to the street has been assigned noise levels for the stretch of the street, while the people inside, it has been assigned the estimated level of the internal patio of the block (quiet façade), [3] which is the higher noise level of the streets surrounding the residential block minus 15 to 20 dBA. The estimation is based on a set of measurements performed in blocks of houses that form the internal patio of several municipalities.

Thus, the total number of blocks that have interior patio, the 30% of the population is exposed to noise levels corresponding to the interior of the block, while the remaining 70% of population is exposed to noise level corresponding to the streets.



Figure 1. Example of blocks of houses with affected population to different noise levels

The results for all agglomerations show that between 3% and 6% of the population is exposed to certain noise levels inside the patio of the blocks, ie, have a quiet façade.

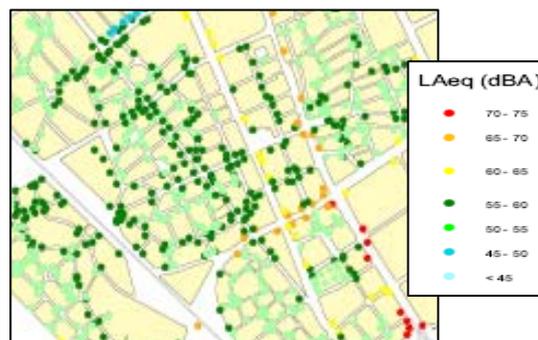


Figure 2. Distribution of the exposed population at L_{den} , Each point show the address and population assigned according to the noise level for the stretch

4 Results

Tables 3 and 4 shows the estimated number of people (in hundreds) exposed to each of the ranges of values for day-evening-night level L_{den} and L_{night} for the agglomerations of the supramunicipalities and municipalities scope of Catalonia of which data is at ones disposal.

Table 3. Exposed population at each of the following ranges for the L_{den}

| Exposed Population | |
|----------------------|---------------------|
| L_{den} values dBA | Population hundreds |
| <55 | 3.635 |
| 55-60 | 4.952 |
| 60-65 | 8.666 |
| 65-70 | 7.230 |
| 70-75 | 4.429 |
| >75 | 975 |

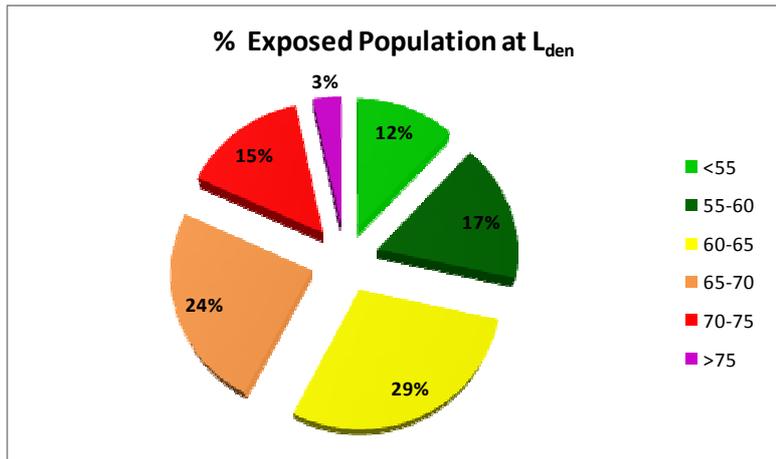
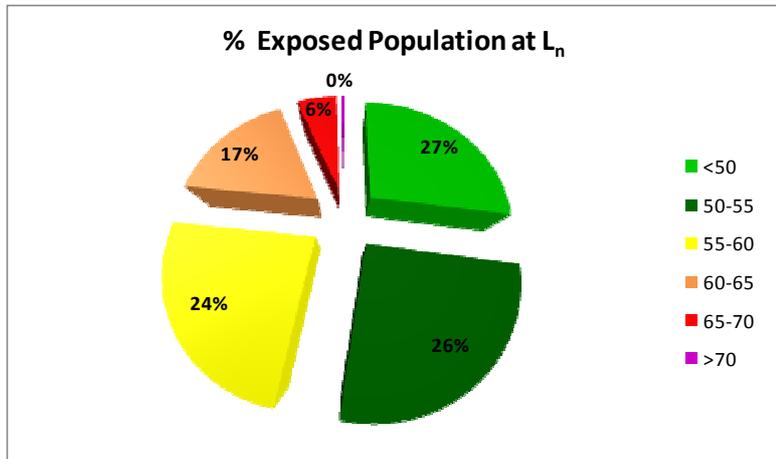


Table 4. Exposed population at each of the following ranges for the L_n

| Exposed Population | |
|--------------------|---------------------|
| L_n values dBA | Population hundreds |
| <50 | 8.095 |
| 50-55 | 7.569 |
| 55-60 | 7.121 |
| 60-65 | 5.116 |
| 65-70 | 1.674 |
| >70 | 113 |



5 Conclusions

The results obtained for the L_{den} indicator follows that the 29% of the population is exposed to levels under the 60 dBA, while another 29% are exposed to levels between 60 - 65 dBA, a 24% are exposed to levels between 65 - 70 dBA and a 5% of the population is exposed to levels of L_{den} between 70 - 75 dBA. Just a 3% of the population is exposed to levels of L_{den} greater than 75 dBA.

In reference to L_n indicator, it could be followed that the 27% of the population is exposed to levels up to 50 dBA, while a 26% is exposed at levels between 50 and 55 dBA, a 24% between 55 and 60 dBA and a 17% is exposed to levels for the L_n indicator between 60-65 dBA. Just 6% of the population is exposed at levels for the L_n between 65 and 70 dBA.

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