

Evolution of the Acoustic Contamination in the City of Leon (Spain)

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Abstract From year 1995, the Group of acoustics of the Physics Department of the University of Leon has made two projects of investigation to determine the space and temporary evolution of the acoustic contamination in a Spanish middle town: the city of Leon. In this paper we analyzed the results obtained in the study of the acoustic contamination present in the city of Leon in the nocturnal period. The studies were made on a network of 468 grids superposed on the urban plane. All the measures were done in situ, with the goal to obtain the maximum reliability in the most of the representative acoustic levels. To the light of the data we have reflected the zonal distributions based on the urban districts, on the one hand, and in the intervals of sonorous levels, on the other hand. At the same time we have come to make a comparative analysis of the evolution of the acoustic contamination in nocturnal period throughout these years.

1. INTRODUCTION

Directive 2002/49/EC of the European Parliament and of the European Council, of 25 June 2002, relating to the Assessment and Management of Environmental Noise [1], was transposed in November of year 2003 to the Spanish Noise Law [2]. This Law settles down the obligation of the Public Administrations to make before on 30 June 2012 acoustic maps of the "agglomerations" over 100,000 inhabitants, and before on 18 July 2013 the corresponding plans of action. In the Law also is indicated the objectives and the information that must contain. Later the regulations will make specific the acoustic types of maps, the minimum contents, the format and the form of presentation to the public.

Before the publication of the exigencies enunciated by the laws above indicated, from the Group of Investigation of the Acoustics Lab (University of Leon), through an agreement with the City Council of Leon, we began the elaboration of the first Acoustic Map of this city [3].

Six years later, we approached the update of that Acoustic Map, also with the collaboration of the City Council of Leon. The final conclusions were presented in December of year 2001. Through the Acoustic Map we have tried to cover several objectives:

- General diagnosis of the noise levels to which the people of this city are exposed in the streets.
- The evaluation of the sonorous levels variation as much in the space as in the time, establishing its distribution in the day and in the night, by means of the suitable acoustic indexes.
- The qualification of the urban areas, according to the existing levels of noise and the different sources, such as road traffic, railway traffic and cultural, recreational, commercial and industrial activities.
- To create a support and city-planning tools for future performances.
- To analyze the evolution of the acoustic contamination from the conditions reflected in the Acoustic Map from 1995 to the 2001.

In this paper we will talk about the nocturnal period, considering the measurements made in most of the urban surface and applying the methodology that we described continuation briefly.

2. EQUIPMENT AND METHODS

Starting off of the data of the first Acoustic Map of year 1995, first we fixed the differences appeared as a result of factors known: like the city-planning modifications, the changes in the traffic control, the development of new urban areas and the new pedestrian streets. Also it is necessary to consider that less well-known modifications could be produced like, for example, the application of asphalt layer in some streets or the renovation of the vehicles.

In the nocturnal period there are, in addition, three factors that can influence modifying the sonorous levels in this period. In the first place the change in the layouts to the traffic of vehicles in some important streets of the city, due to the adoption of restrictions to the circulation in monumental zones and historic district.

Secondly the degree of exigency and the performances developed for the Local Law over Noise and Vibrations of the City Council of Leon [4] approved in 1996, after the accomplishment of the first acoustic map, that established the maximum limits for noise emission in the four types of contemplated urban zones: sanitary areas (i), residential areas (ii), commercial (iii) and industrial areas (iv).

And in last term to the effect caused by the displacement of leisure activities to new urban areas for commercial reasons or tendencies.

The basic measurement instrumentation was the equipment Brüel & Kjaer 2231, CEL 393 and Rion NL-18, properly accredited and verified with the respective acoustic calibrators.

2.1 Methodology

One characteristic that had to reunite the acoustic map of the 2001 was the possibility of making an effective comparison with the 1995 map. For this reason it was decided to develop an identical method: a net of separated lines 100 m to each other. Thus the mesh arises from representative grids, of 100 x 100 m, on which later the different acoustic indexes were defined.

The study of the nocturnal period was made in the grids corresponding to the districts of greater population. The measurement points were located in the place, of public access, closest to the vertex of the grids.

Being based on the periods of activity of the city of Leon, the nocturnal period was considered from the 22:00 to the 8:00 of the following day, subdividing this period in three hour sections:

- **1st section:** from 10:00 pm to 12:00 pm
- **2nd section:** from 0:00 am to 06:00 am
- **3rd section:** from 06:00 am to 08:00 am

The duration of each measurement was of 5 minutes, repeated in each one of the 3 nocturnal hour sections. Therefore 15 minutes by point. These three measurements of 5 minutes were made in different days, in order to add randomness to the sample. For the same reason, never were measured two vertexes of the same grid in a same night.

Friday, Saturday and Sunday nights were not measured in this part of the study. The Acoustic Map obtained is referred to 1.5 m on the level of the ground.

In summary, the data corresponding to the measurements in this period of the grids Map are:

- Number of points: 544
- Number of grids: 468
- Surface: 4.650.000 m²
- Time per point: 15 min.
- Time per grid: 60 min.

Table 1.- Urban districts of Leon and grids number in nocturnal period

District	Streets/Areas	Grids
1	San Claudio, Lancia, Pícara Justina	62
2	Condesa, Colón, La Inmaculada	79
3	Eras de Renueva, Avda de Asturias, La Asunción	65
4	San Mamés	50
5	Alcalde Miguel Castaño, Sta Ana	40
6	Chantría, Pza Toros, Fernández Ladreda	45
7	Pº Salamanca, Crucero, La Sal	76
8	Poligono X, El Ejido	51
	Total Amount....	468

The measures were done following the described methodology, in agreement with the Leonese Noise and Vibration Law [4], similar to all laws adopted for Acoustic Maps of urban nuclei.

The city was divided in 8 Districts to organize better the work and by city-planning reasons. Each district is characterized by the number of grids that contains. Table 1 shows to the districts and their main streets.

The considered acoustic indices, for every period were L_{eq} , L_{max} , L_{10} , L_{50} and L_{90} ; all of them with frequency weighting A.

Also our group determined in each point of measurement the classification according to the following categories:

- Urban classification: Commercial, Industrial, Residential, Hospitals, Gardens, Vacated, Others.
- Volume of traffic in vehicles/hour, with three categories of vehicles: Heavy vehicles, Light vehicles, Motorcycles.
- Traffic Direction: Unique, Double or Pedestrian street.
- Vehicles Speed: Fast, Slow, Very Slow, Traffic Light.
- Main Noise: Traffic, People, Works, Others.
- Morphology of the street: U, L, Square, Others.
- Width of the street (m)
- Height of the buildings (m)
- Ground type: Concrete, Vegetal, Asphalt, Stone...

2.2 Treatment and Presentation of Data

In the elaboration and data processing it was used the commercial software Microsoft Access and Excel and for the space representation and the later access to the values, the following software: AutoCAD, Arc View and Arc Explorer, that allow in addition an interactive and customized visualization to the sonorous levels obtained in each point or grid. Also they offer the possibility of direct consultation about sonorous intervals or other restrictions introduced by the user. All it allows to the system a power and flexibility that justify their use.

The preparation and representation of the maps has followed the norm DIN 18005, adapting the scale and intensity of colors to obtain a greater clarity and better differentiation.

3. RESULTS

3.1 Analysis of the Results by Districts

The criteria of the WHO were followed. The emission levels that can cause severe irritation: L_{eq} of 45 dBA in nocturnal period [5]. In addition the suggestions of the European Commission in their Green Book over the Noise were considered [6]. It is verified that in all of the urban districts average values are higher the recommendation.

Although the times of measurement correspond only at intervals of 5 minutes, the repeated obtaining of the measures, the ample space distribution of the same ones, as well as the analysis of the different studied indices gives sufficient information us, necessary for the interpretation of the situation of sonorous contamination.

In table 2 we observed that the LAeq value of 52 dBA is always surpassed, as would be possible to hope in situations in that the predominant noise is of continuous traffic. In the districts located in the downtown of the city (Districts 1 and 2), are reached values near 58 dBA. In addition, not even the L90 index (that indicates the background noise), low of the 45 dBA, which reflects the maintenance in the time of the polluting agent.

Table 2. - Obtained values of the average indexes of the districts (dBA)

Districts	Lmax	Leq	L10	L50	L90
1	72,7	57,6	59,5	51,5	46,9
2	74,3	57,8	60,7	52,1	46,9
3	71,1	54,8	57,3	48,7	43,6
4	71,3	54,4	56,3	46,4	40,9
5	71,3	55,9	58,6	49,9	44,9
6	73,2	56,5	59,4	50,5	45,3
7	73,8	57,1	58,2	48,6	42,8
8	68,5	52,7	54,3	46,7	42,5
All	72,7	56,0	58,2	49,4	44,3

The measured LAeq have a average value of 56 dBA, and around these levels are the most of the urban grids. Only In District 8, corresponding to the Polígono X and El Ejido (located in peripheral areas of the city) are of 53 dBA (Figure 1). On the other hand, Districts 1 and 2 have the highest levels, over 57 dBA.

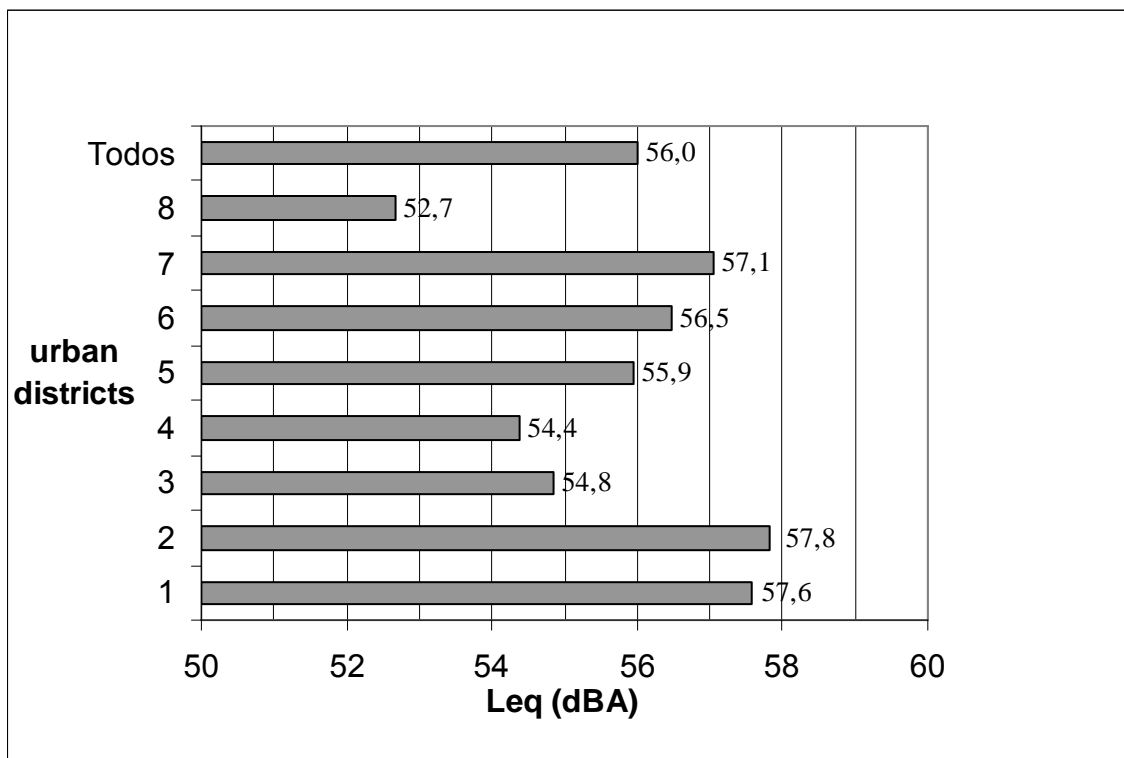


Figure 1. - Representation of nocturnal Leq of the urban districts

3.2 Analysis of the Results by Intervals

After describing the results in the different urban districts, we analyze now what happens globally in the grids. In Figure 2 the representation in the Acoustic Map of LAeq of the studied grids can be seen. Splashed in the city are areas with values between 65-70 dBA, corresponding to squares and cross zones of intense traffic: Guzmán, El Crucero, Carlos Pinilla, Independecia, Estación de Feve, Espolón. On the other hand, the grids of low levels appear in peri-urban areas or streets closed to the traffic: Polígono X, El Ejido, Cathedral and Barrio Húmedo, La Sal and Eras de Renueva.

If we analyzed the distribution of the LAeq by intervals of 5 dBA (Figure 3), we can see that only 1.5 % of them (7) the level is below 45 dBA; the majority is in 50-55 (29,3 %), 55-60 (38.7 %) and 60-65 (19 %), surpassing the 65 dBA in 2.6 % of the grids.

Figure 3 represents the variation that has had the sonorous levels from 1995 acoustic map to the map of year 2001. The reader can observe that a displacement of some zones has taken place towards more elevated intervals. Whereas the grids with levels smaller than 55 dBA have been reduced in the map of the 2001 with respect to the map of 1995, the grids with levels higher than 55 dBA have increased in a global amount of 7.5%.

When representing the cumulative distribution of levels (Figure 4) is contemplated like the curve that represents the percentage of surface of map 2001 goes ahead slightly, which, although does not constitute an upset of the situation with respect to the 1995 map, indicates a progressive distance of the criteria of acoustic quality previously referred.

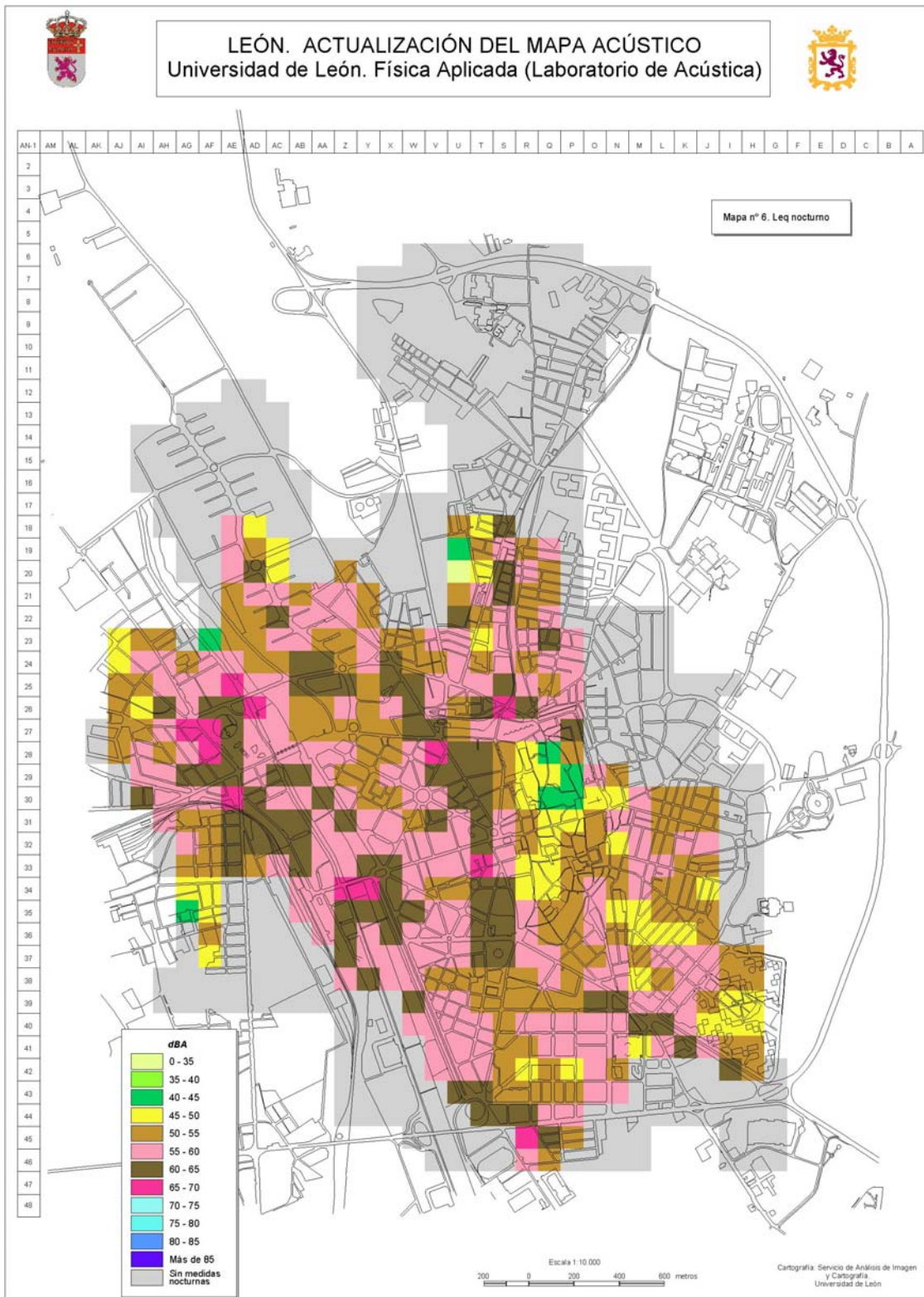


Figure 2. - Space representation of the Leq values in the measured grids

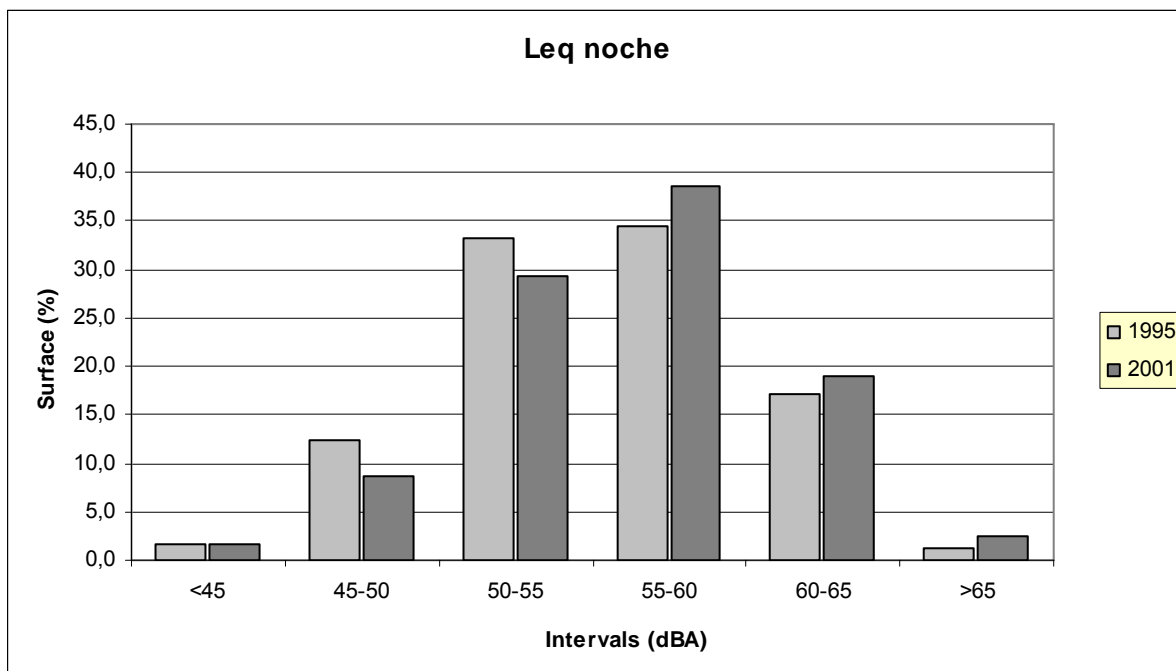


Figure 3. - Distribution of the grids by Leq intervals of 5 dBA

If we considered the L90 index, it is appreciated clearly the acoustic action of the input and exit axes, that constitute the streets Facultad de Veterinaria , Condesa de Sagasta, Paseo de Salamanca and Sáenz de Miera.

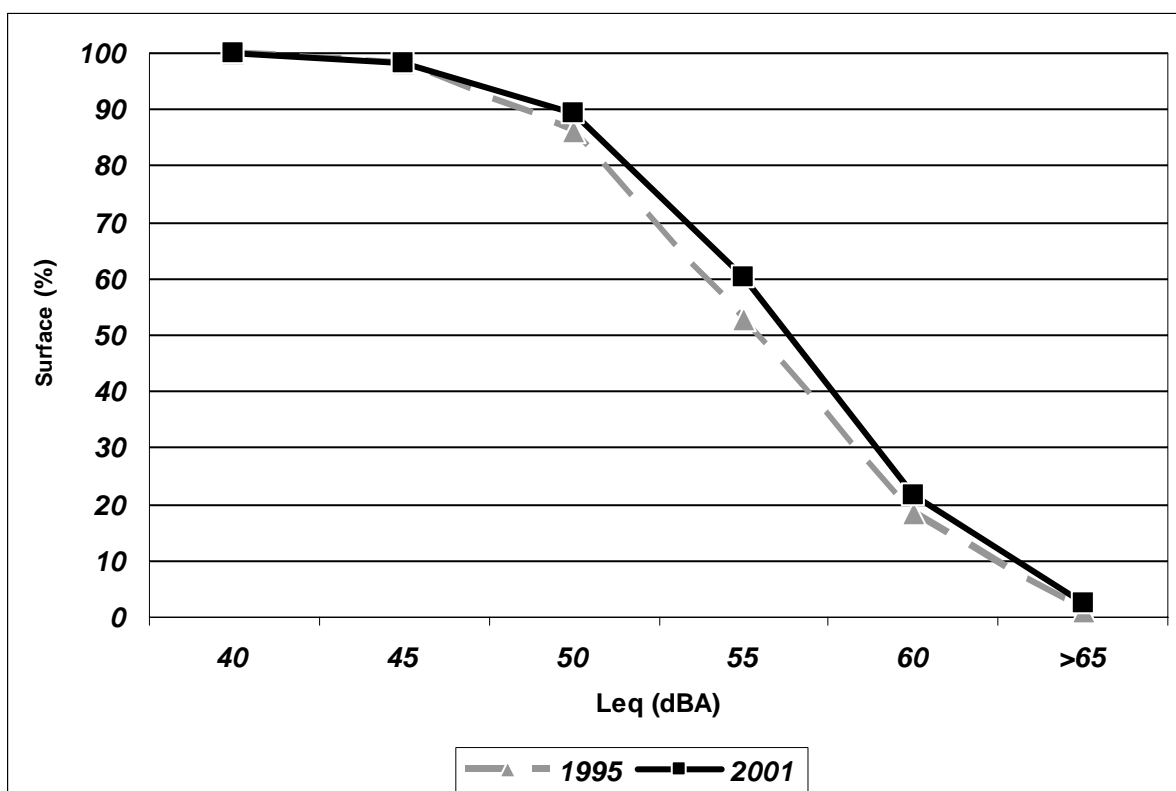


Figure 4. - Cumulative distribution by intervals of Leq

It is interesting to emphasize that in 40.4 % of the grids (189) the values of the L90 index surpassed 45 dBA, and in 8.8 % of same (41) the L10 index (that shows the tendency of the maximum levels) surpassed 65 dBA. This fact indicates the presence of sporadic events that, since we are speaking of a nocturnal period, can produce especially annoying effects.

As it could be expected, the hour section in which the grids reflect the higher levels of all indexes is the section from 10 pm to 24 pm, followed by the section from 6 am to 8 am.

4. CONCLUSIONS

Considering the data collected in our study, we can say that the global results of acoustic map 2001 of the city of Leon are similar to the corresponding ones to the acoustic map of year 1995. Nevertheless, analyzing with more detail the evolution of the different urban districts, significant differences in several grids and areas of the city are observed. Studying other urban variables it is observed that the population of the peripheral areas of the city has been increased, and therefore has entailed the urbanization and development of new residential areas. In addition the downtown has conserved many traditional commercial activities, as well as the most popular zones dedicated to leisure activities. All it has determined the increase of the displacements and the volume of traffic, which has contributed to cause a slight and progressive elevation of the observed acoustic levels in the affected zones.

The results show a great number of grids pertaining to downtown in that the indices Leq and L10 are considered limit for the nocturnal period; even in the period from 24 pm to 6 am, which has minor activity.

In summary, we can say that the inhabitants of the city of Leon are, in general, exposed at levels of noise similar to those of other cities of the European Union of similar characteristics.

However, it is necessary to indicate that in this city performances clearly oriented to reduce the acoustic contamination have been developed in the last year: concrete measures as the declaration of pedestrian zones, the inclusion of environmental considerations in the new plan of urbanism or the reform of the local law over noise and vibrations, as well as the greater exigency in the application of the same one. Nevertheless in our study it is reflected that such performances is not accompanied, at the moment, of a significant reduction of the noise levels. In general, the observed levels continue exceeding, as it already happened in the 1995 study, the values recommended by the international organisms.

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REFERENCES

- [1] *Directiva 2002/49/CE sobre Evaluación y Gestión del Ruido Ambiental*. Unión Europea. Diario Oficial de la U.E. 22 Agosto de 2003.
- [2] *Ley 37/2003, de 17 de Noviembre, del Ruido*. Boletín Oficial del Estado Nº 276 de 18 de Noviembre de 2003.

- [3] García, E.; Cepeda, J. Melcón, B. *Mapa Acústico de la Ciudad de León*. ULE-Ayuntamiento de León 1995
- [4] *Ordenanza Municipal sobre la Protección del Medio Ambiente contra la Emisión de Ruidos y Vibraciones*. Ayuntamiento de León. B.O.P. N° 139 de 19 de Junio de 1996.
- [5] *Guidelines for Community Noise*. World Health Organization, Geneva, April, 1999.
- [6] *Política futura de lucha contra el ruido*. Libro Verde de la Comisión Europea. Comisión Europea. Bruselas, 1996.