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Data collection methodology evolution for Soundscape assessing: A case of study in Menorca Island (Spain)

Pavón, Ignacio[1], De Arcas, Guillermo[2], Sigcha, Luis[3]
Grupo I2A2. ETSI Industriales. Universidad Politécnica de Madrid.
C/ José Gutierrez Abascal, 2. 28006, Madrid – Spain.

San Millán-Castillo, Roberto[4]
ETSI Telecomunicación. Rey Juan Carlos University.
Camino del Molino s/n . 28943 - Fuenlabrada – Madrid

Suárez, Enrique[5]
Instituto de Acústica - Universidad Austral de Chile.
Edificio 6000, Campus Miraflores, Casilla 567, Valdivia, Chile

Hermida, Luis Fernando[6]
Universidad de San Buenaventura, sede Bogotá.
Carrera 8H # 172 -20, Bogotá, Colombia.

ABSTRACT

Soundscape is becoming a relevant topic in recent years in different areas as applied acoustics, health awareness, urban planning or cultural heritage. Scientific community have been discussing about them since late 60´s and an evolution from basic definitions to potential applications has been performed. Most of relevant changes in Soundscapes framework has been coming along with development in data collection methodologies. Technology plays a key role: progress, availability, ubiquity and democratisation of data acquisition systems provide nearly never-ending chances to address, enhance and enrich Soundscapes assessment. However, only some years ago available resources were completely different. This article presents a Soundscape study case carried out in Menorca Island in 2000 and the discussion of an upgraded study in 2019 regarding technological issues.

Keywords: Soundscapes, intangible cultural and environmental heritage.
I-INCE Classification of Subject Number: 52, 61, 66, 68

[1] ignacio.pavon@upm.es
[2] g.dearcas@upm.es
[3] luisfrancisco.sigcha@upm.es
[4] roberto.sanmillan@urjc.es
[5] enriquesuarez@uach.cl
[6] lhermida@usbbog.edu.co.

1. INTRODUCTION

Menorca is the easternmost and northernmost island of the Balearic Islands (Spain). It is the second in extension and third in population of the Balearic Islands. The capital of the island is Maó, on the east coast, while the most populated municipality is Ciutadella de Menorca in the west.

UNESCO declared Menorca a biosphere reserve on 8th October 1993, in view of the high degree of compatibility achieved between the development of economic activities, the consumption of resources and the conservation of a heritage and landscape that has maintained, and continues to maintain today, exceptional quality.

Menorca is a territory with a very rich traditional rural landscape. It hosts a notable diversity of Mediterranean habitats, in which species of animals and plants live exclusively on the island, some of them in danger of extinction [1].

As a biosphere reserve, Menorca has a several future challenges, some of which are directly related to the preservation of environmental acoustic quality:

- Favouring the conservation of rural activities that maintain the traditional landscape and avoiding those that could degrade it.
- Reinforce the conservation of natural ecosystems and of autochthonous fauna and flora, if they are threatened.
- To deepen the knowledge of the natural and cultural heritage.
- Define sustainability strategies on a local scale.
- Minimize the environmental impact of daily human activities.
- To become an outdoor sustainability laboratory. [1]

Although the island of Menorca has unquestionable environmental values, it also presents pressing problems due fundamentally to the tourist pressure and the seasonality of visitors.

The daily human pressure from 1996 to 2015 is presented in *Fig.1*. On certain dates in August, there is a simultaneous presence of more than 200,000 people on the island, while its resident population is around 80,000 [2].

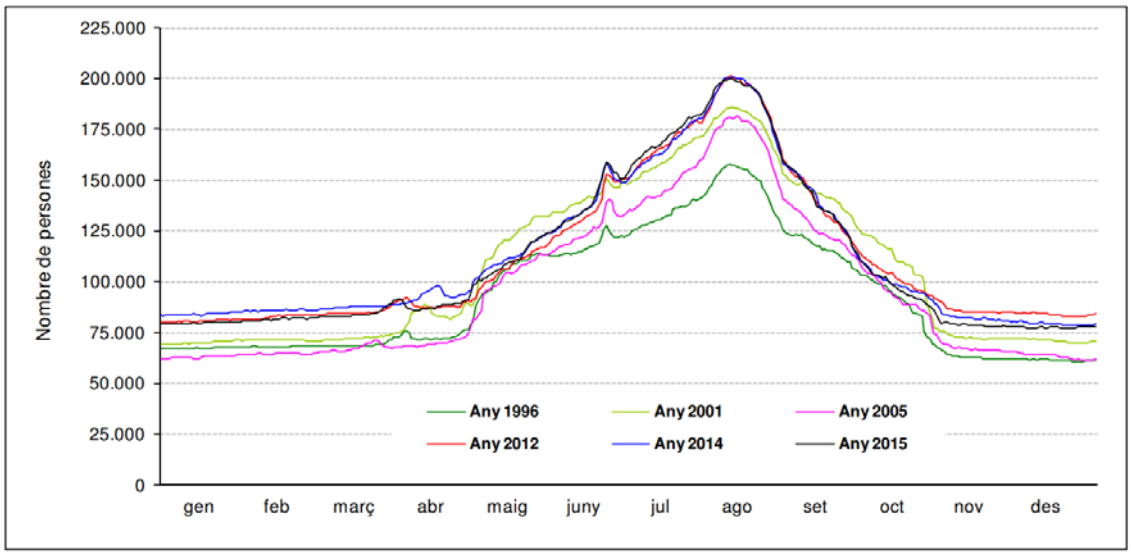

Fig. 1. Daily human pressure in Menorca from 1996 to 2015 [2]

According to the 5th Ecobarometer of the Balearic Islands, 56% of citizens of the Balearic Islands consider the arrival of tourists to the Islands in summer to be excessive, comparing costs and benefits. In relation to the main problems that affect the environment, first appears the massification of cars (39%) and the massification of people occupies the second place (30%) [3].

Menorca is not an exception to the situation in other places with regard to noise pollution. Sound sources such as road and air traffic, commercial activities, as well as cultural practices product of the increase of urban conglomerates, can generate acoustic emissions that are presented as a potential danger to people's health, to the detriment of life quality [4–8]. Likewise, the specialization of spaces and the need to generate coherence between the different stimuli offered by urban environments have meant that traditional approaches to environmental acoustic management (mainly focused on the control of sound pressure levels) must be extended in order to consider cognitive, contextual and semiotic aspects, depending on the use and meaning of places [9,10]. This leads to the need to extend the traditional approach of environmental noise control so that people are at the centre of urban acoustic management models [11–18].

Derived from the English term landscape, the concept of soundscape has been developed in various ways. Currently, the consensus is that soundscape refers to the perception and/or understanding that human beings have of an acoustic environment, according to its context [4,19]. This definition underlines a difference between acoustic environment and soundscape: whereas the first term refers to the sound of all sources that have been modified by the environment, the second refers to perceptive and cognitive processes that people carry out regarding such environments [4,20]. Likewise, analysing the conceptual framework of soundscapes presented by the International Standard Organization (ISO) in the ISO 12913-1 standard, it states that contextual aspects impact on sound sources, auditory sensation, the cognitive process, short-term responses, and people's outcomes. In this order, it is considered that acoustics environments can be studied as a communication system, where the relationship between the individual and the environment is analysed [21,22].

Due to the multidisciplinary character of the soundscapes, the works developed in this field are diverse. Some researchers have focused on processes of analysis and characterization of acoustic environments from taxonomic aspects (related to the classification of sound sources [9,23–25]). Other researches have remarked acoustic aspects focused on the study of the energetic behaviour of the sound field, using energetic time-average, statistical descriptors such as percentiles and maximums and minimums, and in some cases psychoacoustic and binaural descriptors [26–31]. Another important line of research has been related to soundscape assessment processes, where in addition to the traditional aspects of comfort and noise annoyance, perceptual attributes such as activity, pleasure and eventful have been introduced. Works have also been developed on the influence of other stimuli (mainly visual) on the perception of the acoustic environment [32–39].

About soundscape assessment tests, these are divided into laboratory tests and in situ tests. The laboratory tests seek greater control of the different variables to which the evaluator is exposed, in such a way that, as far as possible, only the stimuli of interest for the research are presented to the evaluator. In addition to the semantic differential type or response scale tests, it is possible to apply tests as pairs compared to those that can be obtained from Thurstone or Likert scales [27,32,33,38,40–43]. One of the main advantages of this type of test is that it allows the listener to be presented with simulated acoustic environments, a key aspect in the design of soundscapes, although it is limited in the realism and total immersion offered by the tests in situ [44]. Concerning the in-situ tests, these can be developed from sound walks or fixed listening points, where the evaluators present their opinion regarding different attributes of the acoustic environment in which they find themselves. Semantic differential or response scale tests are generally used, although it is also common to conduct interviews and open-ended questions in order not to limit the evaluators' ability to respond. Being an in-situ test, the environment offers visual, olfactory and tactile stimuli, allowing total immersion to the evaluators with respect to their environment, so that the results obtained reflect not only sound aspects but also the complexity of the real world [45–50].

Considering the need to obtain detailed information of the acoustic environments, as well as the diversity of data required for the analysis, planning, and design of soundscapes, technological aspects play a fundamental role in data collection. This project focuses on the case study developed on the island of Menorca in the years 2000 and 2019, discussing technical and technological aspects of these processes according to the technologies available in these years.

2. PREVIOUS STUDY OF SOUNDSCAPE IN MENORCA ISLAND (2000)

In the year 2000, a survey of the environmental acoustic quality of the island of Menorca was carried out. The research included noise mapping in urban areas, noise nuisance surveys, analysis of traffic noise prediction equations and sound landscape studies [51].

In the island the population multiplied three times in the summer season (tourists), acoustic measurements were made in winter and summer. The noise maps of the two main cities (Maó and Ciutadella de Menorca) and of three tourist developments were performed for both seasons. In both cities a total of 320 measurements of 10 minutes and 96 measurements of 20 minutes were carried out at seven different times of each day, and

on four days of the week. More than 168 hours of acoustic measurements were analysed with stations at different points in each city, and more than 413 hours of acoustic measurements.

A subjective study was carried out on the perception of environmental noise and sound ambiences. In Maó and Ciutadella de Menorca, surveys were applied during winter and summer. The survey incorporated questions about sound environments. The total number of surveys was 886: 324 surveys of Maó neighbours (winter), 299 surveys of Ciutadella de Menorca neighbours (winter), 65 surveys of school teachers, 142 surveys of young people, and 56 surveys of tourists.

Four questions about sound environments were included in the surveys. Some questions recorded low response rates, possibly because respondents did not know the meaning of "soundscape". Other questions provided valuable information in the selection of soundscapes, places and activities of interest. The soundscapes of interest were traditional celebrations (especially the *Festes de Sant Joan* de Ciutadella), natural sites (sea, beach, forest, countryside), noisy environments (motorcycles, bars, streets) and tourist areas (urbanizations and coves).

In activities with children, the sound environments were represented with great detail of elements, see *Fig. 2*. To children, pleasant sounds and sound environments were elements of nature: sea, beach, birds, forest. The negative or noisy environments were related to sounds generated by human activity: machines, traffic, motorcycles, etc. The use of children's drawings about the acoustic environment was an alternative way of collecting data regarding children's opinions and preferences.

Fig. 2. Drawings of children (4 to 11 years old): Noise and Sounds.

The first study was an initial and exploratory investigation, including interviews and questionnaires to a panel of experts with people with knowledge of the island, its history, architecture, nature, and cultural facts. They identified the importance of traditional celebrations and their symbols as something typical and representative (especially San Juan in Ciutadella de Menorca, and the last celebration of the season, in Maó), the presence of the sea and the wind (Tramuntana) in memories and insular character of daily life in Menorca, the silence as an element of intimacy and nostalgia that the cities shelter in winter (solitary streets, without tourists) and an important value is also appreciated for natural areas and autochthonous fauna (such as wetlands, pine forests, birds, etc.). They provided descriptions of the identified sounds, their significance and cultural and historical context, the value of Menorca's traditions, the presence of the sea and the wind in the immediate everyday environment.

Other sources of information included interviews with other experts (biologists, urban planners), analysis of studies on the visual landscape of the island (landscape map), and field visits. Other soundscapes of interest were incorporated: the markets of Ciutadella de Menorca and Maó on Saturday morning, some bars, also on Saturday morning, a shoemaker and his hammering, a craftsman of sandals and their characteristic sounds, manufacture of gin and cheese, the reverberant sound inside the quarries (Ciutadella de Menorca), among others.

The equipment used was a Sony DAT (TCD-D10 PRO II), and two identical AKG microphones (CK 91), with AKG power supply (SE300B). The two cardioid microphones were used at an angle of 110º, spaced horizontally at 17 cm (ORTF configuration). This methodology allows a proper recording of the environment, with good accuracy of location of the sounds. The 17 cm spacing produces good image stability for head movements, assuming an angle of about 30º between loudspeakers.

The equipment was used in different visits to the Island, recording more than 8 hours of sound material, coordinated with the measurements made for the other parts of the study (noise maps).

One of the most relevant topics is "*Festes de Sant Joan*" in 2001. On this occasion 4 hours of sound recordings were completed. 27 audio tracks were selected, including recordings in some of Menorca's most characteristic landscapes and situations: traditional markets, Festivals of Sant Joan (Ciutadella de Menorca), beachside sounds, countryside sounds, etc. All these sounds were recorded, processed and stored in a sort of audiobook, with the purpose of preservation and archiving, however, no acoustic processing or psychoacoustic study was performed in 2000.

3. CURRENT RESEARCH ON THE SOUNDSCAPE OF THE MENORCA ISLAND (2019)

In 2018 a research grant was awarded to study the soundscapes on the island of Menorca as intangible cultural and environmental heritage.

In this research project, it is proposed to characterize the most characteristic soundscapes of the Island of Menorca by means of psychoacoustic parameters and descriptors of sound quality defined in the ISO/TS 12913-2 standard [52]. To this end,

the catalogue of soundscapes recordings obtained on the island in 2000 as a result of a previous UPM research project will be updated, with new complementary recordings obtained in 2019. . The main goals are to suggest actions for soundscapes conservation, as well as disseminating the results in open format in order to make the population aware of the fragility of this heritage.

In contrast to what was done in 2000, where only classical acoustic indicators defined in the 1996-1 standard such as LAeqT, LCeqT, percentiles, etc. were obtained, the new study proposes, in accordance with what is defined in the ISO/TS 12913-2 standard, to characterise soundscapes using classical acoustic indicators along with psychoacoustic indicators (sharpness, tonality, roughness, and fluctuation strength) and other types of acoustic parameters that are being proposed for the evaluation of soundscapes such as Normalized IACF and Running IACF, see Table 1 [29, 53-56].

Table 1. Objective acoustic parameters used for spatial analysis.

General Function	*Analysis Parameters*	*Descriptive Statistic*
Normalized IACF: $\phi_{lr}(\tau) = \frac{\Phi_{lr}(\tau)}{\sqrt{\Phi_{ll}(0)\Phi_{rr}(0)}}$ (Eq. 1) **Running IACF:** $\phi_{lr}(\tau) = \phi_{lr}(\tau; t, T)$ $\phi_{lr}(\tau) = \frac{\Phi_{lr}(\tau;t,T)}{[\Phi_{lr}(0;t,T)\Phi_{lr}(0;\tau+1,T)]^{1/2}}$ (Eq. 2) where $\phi_{lr}(\tau)$ is given by Eq. 1	**$IACC_{running}$:** Using the temporal stepsize of the IACF in the running IACF, multiple IACC of the different segments of the signal are obtained.	Can be considering the difference between the 90th and 10th percentiles.
	τ_{IACC}: The τ_{IACC} is the delay at which the IACF attains its maximum value of IACC [53]. The values of the τ_{IACC} should be between 1 and -1. τ_{IACC} is related to the location of the sound in a horizontal plane [29,54].	For the running IACF multiple values of τ_{IACC} are obtained. The range and the difference between the 90th and 10th percentiles of τ_{IACC} were considered.
	w_{IACC}: The width of the maximal IACF peak [53]. This parameter is defined by the size of the delay range under which the peak of the IACF is below 90% of the maximum value (δ=0.1*IACC) [55]. The w_{IACC} offers information related to spatial perceptions such as location and spatial clarity in the horizontal plane [56].	For the running IACF, multiple values of the w_{IACC} were obtained, where the range w_{IACC} and the difference between the 90th and 10th percentiles show the variation of this parameter over time.

Both the data acquisition methodology and the equipment have changed significantly from 2000 to the present. Binaural measurement techniques, by means of a binaural midrophones headset are currently being used in combination with soundwalks.

A comparison of block diagrams of the procurement systems used in 2000 and 2019 are shown in *Fig.3* and *Fig.4*.

Fig. 3. Equipment used in 2000.

Fig. 4. Equipment used in 2019.

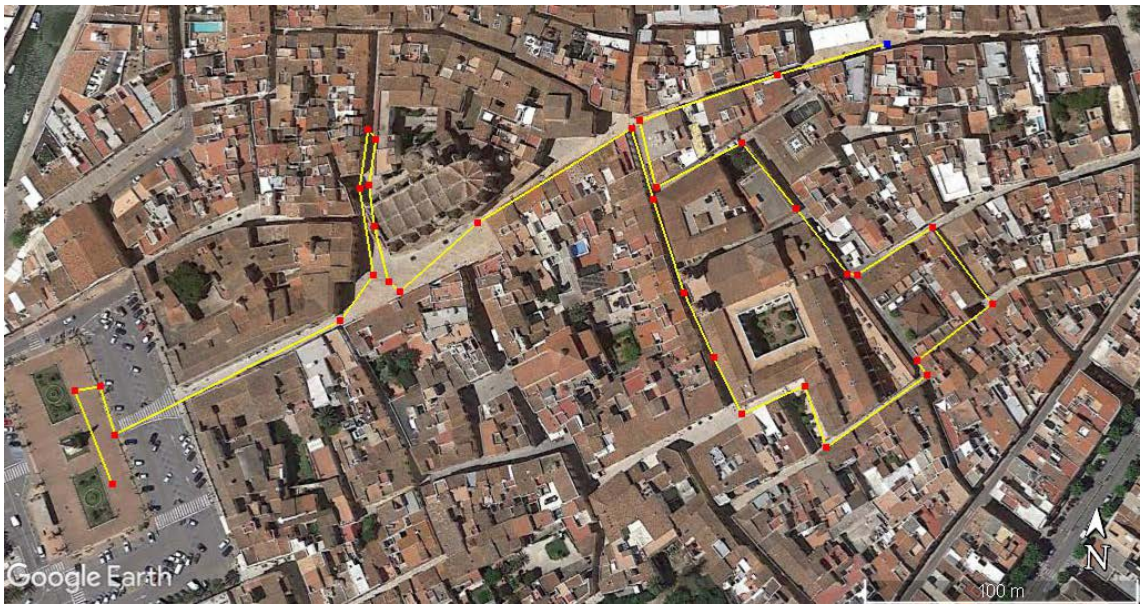

Fig. 5. Example of the itinerary of one of the sound recordings made in Ciutadella.

In addition to binaural registers, audio recordings were performed with the SLM channel and the traditional acoustic parameters were recorded, at every test.

The objective of these records is to obtain metrologically validated acoustic parameter values and, in addition, values of other additional acoustic parameters.

The winter campaign for the measurement and recording of soundscapes in Menorca took place at the end of February 2019. For this reason, at the time of writing of this article, there are still no publishable results.

The future campaigns to measure and record soundscapes are planned in June and September 2019.

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