FORUM ACUSTICUM EURONOISE 2025

SOUNDSCAPE ANALYSIS ACCORDING TO ISO/TS 12913-2:2018: A CASE STUDY FOR AREAS OF HIGH HERITAGE VALUE IN COIMBRA

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ABSTRACT

Traditionally, most of the work done in assessing and controlling environmental noise has focused exclusively on measuring the physical parameters of the acoustic environment, as defined by standards. Recently, a new approach known as the "soundscape" method has emerged, which incorporates users' perception and contextual factors in this evaluation, as well. This innovative method marks a significant shift in environmental noise assessment by placing the user at the centre of the process.

In this study, the soundscape of two historical areas of high heritage value in Coimbra, Portugal, will be analysed by performing a soundwalk through these locations, using the methods provided in the ISO/TS 12913-2:2018 standard, for data collection (Methods A and B, as well as sound pressure level measurements). The collected data will then be analysed according to the guidelines specified in the third part of the same standard (ISO/TS 12913-3:2019). This approach allows for a comparative analysis of both objective physical noise measurements and subjective perceptual responses, resulting in a more comprehensive and holistic understanding of the acoustic environment.

Keywords: *environmental noise, soundscape, soundwalk.*

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1. INTRODUCTION

For a long time, the management of human exposure to noise has followed an approach that focuses only on physical parameters, usually consisting of measuring sound pressure levels, comparing the results obtained with the thresholds defined by regulations [1], and then designing solutions to lower the observed values, when needed. In more recent years, a new perspective on this problem has emerged, called the "soundscape" approach.

According to ISO 12913-1 [2] standard, soundscape can be defined as an "'acoustic environment as perceived or experienced and/or understood by a person or people, in context". This definition highlights the importance of subjective perception in evaluating a place's acoustic environment, considering sound not as a waste product, but as a resource to be used to improve people's well-being and health [3]. For this reason, in the soundscape analysis, the sound sources play a crucial role, as different types of sounds are often associated with different perceptions of the acoustic environment, affecting the acoustic comfort evaluation [4]. For instance, even under controlled loudness conditions, soundscapes dominated by technological sounds are typically perceived as unpleasant, whereas those dominated by natural sounds are considered pleasant and soundscapes dominated by human sounds to be eventful [5].

Essentially, this perspective shifts the focus away from mere quietness as the primary factor for acoustic preferences in outdoor environments. Instead, the consistency between the soundscape and the surrounding landscape is a key factor, as research shows that even places characterized by high sound pressure levels, can still have a good soundscape perception. [6].

According to the ISO/TS 12913-2 [7] standard, the process of assessing the soundscape of a place can be conducted

either in situ, by performing a soundwalk, or by reproducing the sound off-site, using headphones or loudspeakers instead. A soundwalk involves participants walking through a designated area while focusing on its acoustic environment and then answering a questionnaire. This standard recommends a group of at least 20 participants, with each listening silently to the sound environment for a minimum of three minutes at each stop, before completing the questionnaire. In addition to the human perception collected via the questionnaires, binaural acoustical measurements should also be performed to provide information on physical and psychoacoustic indicators [7]. The recording should also have a minimum duration of three minutes.

This study aims to evaluate the soundscape of two areas of high heritage value in the city of Coimbra, in Portugal, by collecting both perceptual and physical data, through the soundwalk method. The selected locations, recognized for their cultural and historical values, are currently under evaluation as part of an initiative to redesign and enhance public spaces. By analysing the acoustic environment of these areas and how it is perceived, the study seeks to understand the impact of existing sound conditions, contributing to more informed and sustainable urban planning decisions.

2. METHODOLOGY

2.1 Characterization of the sites and sample

As previously mentioned, this study evaluates the soundscape of two areas of high heritage value in Coimbra, namely the João das Regras Avenue, and the Polo I campus of the University of Coimbra (UC). As illustrated in Figure 1, at João das Regras Avenue the two sites evaluated were located close to one of the city's main roads, with a high traffic volume. In contrast, the Polo I campus of UC presents a different scenario, being classified in the UNESCO World Heritage List and with significantly lower traffic volumes and slower-moving vehicles, as most of the traffic consists of individuals studying or working at the University, rather than pass-through traffic.

The first soundwalk took place at João das Regras Avenue on Friday, November 22nd, 2024. The selected participants were a group of 30 students (12 women, 18 men) with ages between 18-24 years old, no particular knowledge in acoustics and no particular association with the place (all had been there at least once, but most were not frequent visitors).

The second walk took place at Polo I of the University of Coimbra, on a Friday, January 16th, 2025, with a group of 19 foreign students, and one Professor (7 women, 13 men) from a master's program in acoustics, with ages between 20-50 years old and no particular association with the place (all had been there at least once, but most were not frequent visitors).

Personal data and questionnaire responses were collected anonymously, ensuring full compliance with privacy regulations.

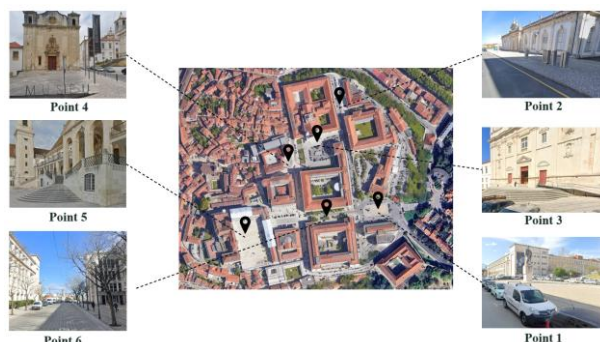**Figure 1**. Soundwalk path for João das Regras Avenue (Source: Google Maps).

Figure 2. Soundwalk path for Polo I campus of UC (Source: Google Maps).

2.2 Methods

As mentioned above, the study was conducted by applying the soundwalk methodology in compliance with the requirements specified in the ISO/TS 12913-2 [7] standard. Therefore, during the walk, at each point, after listening to the acoustic environment in silence for 4 minutes, the participants were asked to fill-in an online questionnaire. This survey, whose questions are presented in Table 1, was based on Methods A and B provided in the referred standard [7]. Although the questionnaires were made to be mutually exclusive, some literature suggests that the choice of one protocol over the other can lead to some differences in the soundscape data collected and that a combined

version of the two methods would constitute a more reliable option [8].

Since, in the first case, all students were Portuguese, the questionnaires were translated for easier interpretation. Although efforts are being made to develop official translations of the standard [9], one is not yet available. Therefore, the authors carefully have selected the most appropriate adjectives to keep the original meaning and ensure clarity. In both cases, a briefing session prior to the soundwalk was promoted, in order to introduce the participants to the concept of soundscape and the study's objectives and methodology. In this session, the meaning of the soundscape's descriptors was clarified.

As previously mentioned, in addition to the subjective perception data collected via the questionnaires, data on physical indicators should also be collected. Therefore, in parallel to the 4-minute listening evaluation, sound level measurements of L_{Aeq}, L_{90}, L_{50}, and L_{10} parameters were

also performed using a certified sound level meter (Rion – NL-42).

By applying the soundwalk methodology that combines questionnaires with sound level measurements, a more complete and comprehensive representation of the acoustic environment is obtained, which constitutes a fundamental factor for its effective management.

3. RESULTS AND DISCUSSION

Once the soundwalks were completed, the data collected was analysed following the guidelines outlined in the third part of the ISO 12913 standard [10]. The measurement results for the four parameters considered (L_{Aeq}, L_{10}, L_{50} and L_{90}) are presented in Tables 2 and 3, for each recorded point in both locations. On the other hand, the questionnaire responses are summarized in Figs. 3 to 10.

Analysis of Table 2, related with the sound pressure levels registered at João das Regras Avenue, evidences that the

Table 1. Soundwalk questions and possible answers

Method	Category	Questions	Responses' Scale/Type
Method A	Sound Source Identification	To what extent do you presently hear the four following types of sounds? • Traffic noise (e.g., cars, buses, trains, airplanes) • Other noise (e.g., sirens, construction, industry, loading of goods) • Sounds from human beings (e.g., conversation, laughter, children at play, footsteps) • Natural sounds (e.g., singing birds, flowing water, wind in vegetation)	1 - Not at all 2 - A little 3 - Moderately 4 - A lot 5 - Dominates completely
	Perceived affective quality	For each of the 8 scales below, to what extent do you agree or disagree that the present surrounding sound environment is… • Pleasant • Chaotic • Vibrant • Uneventful • Calm • Annoying • Eventful • Monotonous	5 - Strongly agree 4 - Agree 3 - Neither agree, nor disagree 2 - Disagree 1 - Strongly disagree
	Assessment of surrounding sound environment	Overall, how would you describe the present surrounding sound environment?	5- Very good; 4- Good; 3- Neither good, nor bad; 2 - Bad; 1 - Very bad
	Appropriateness of the surrounding sound environment	Overall, to what extent is the present surrounding sound environment appropriate to the present place?	1- Not at all; 2- Slightly; 3- Moderately; 4 - Very; 5 - Perfectly
Method B adapted	Assessment of the sound environment	• How loud is it here? • How unpleasant is it here? • How tranquil is it here?	Continuous scale from 1 - Not at all to 5 - Extremely
		• How often would you like to visit this place again?	Continuous scale from 1 - Never and 5 - Very often
	Sound source recognition and ranking	Please list sound sources you noticed in descending order starting with the most noticeable sound source.	[Open answer, limited to 8 items]
	Subsequent comments	What is going through your mind?	[Open answer]

sound pressure level at Point 1 is higher than at Point 2. The questionnaire responses allow to identify that, at Point 1, traffic was perceived as the dominant sound source (Fig. 3), while at Point 2, one dominant sound source was not identified, being the sound of nature together with traffic noise more noticed than other sounds. Regarding the sound environment, participants describe it as good at Point 2, while at Point 1 it was found to be fair (Fig 4). Results, for the soundwalk performed, also suggest that there is a relation between loudness and unpleasantness as the louder environment (Point 1) was identified as the less pleasant (Fig.5). As for the perceived affective quality, Point 1 falls in the chaotic quarter, while Point 2 falls in the calm one (Fig. 6). The results provided by the volunteers' experience are therefore aligned with physical measurements.

Table 2. Results of the sound level measurements at João das Regras Avenue.

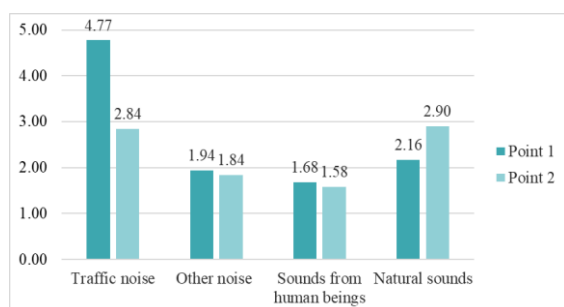|	Indicators			
	L_{Aeq} (dB(A))	L_{90} (dB(A))	L_{50} (dB(A))	L_{10} (dB(A))
Point 1	58.2	53.7	57.5	60.4
Point 2	49.7	46.5	49.6	51.8

Figure 3. Ratings for the different sound sources at each point for João das Regras Avenue.
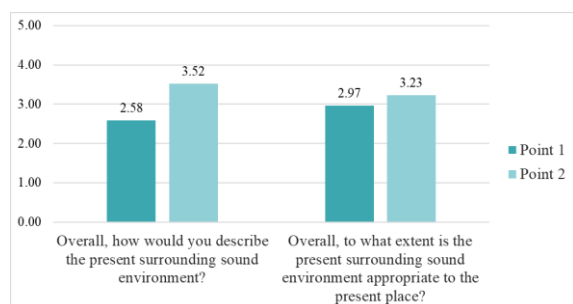

Figure 4. Ratings for overall assessment and appropriateness of the sound environment at each point for João das Regras Avenue.
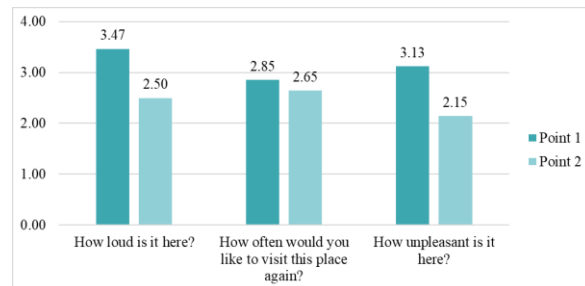

Figure 5. Ratings regarding overall perception of the sound environment at each point for João das Regras Avenue.
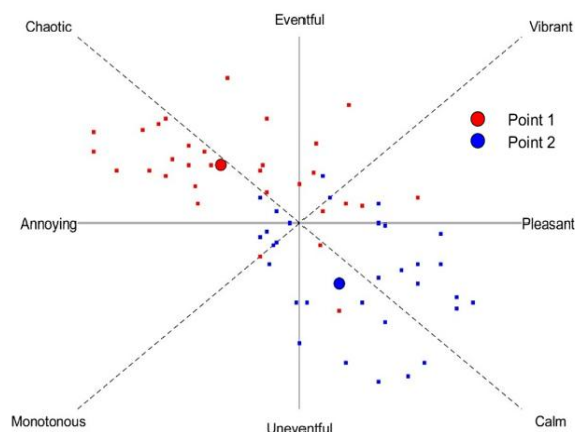

Figure 6. Plot of perceived affective quality of the sound environment at each point for João das Regras Avenue (according to ISO/TS 12913:3).

On the other hand, the results obtained for Polo I campus of UC reveal a different scenario, as the pleasantness scores (Figs. 7 to 10) cannot be fully justified by the different sound pressure levels alone (Table 3). As illustrated in Fig. 10, even though Points 4 and 6 exhibit very similar sound pressure levels (Table 3), one is perceived as uneventful and annoying, while the other is considered as pleasant and eventful, respectively. These findings suggest that the type of sound source plays a crucial role in evaluating the pleasantness of a place, since at Point 6 human sounds, such as people talking and laughing, and footsteps, were predominant, whereas, at Point 4, traffic was the most identified sound source (Fig. 6). Furthermore, an analysis of the sound pressure levels indicates that Point 4 had the second lowest sound level for L_{90}. This value, which is considerably lower than the one for Point 6, highlights the importance of both background and peak sound pressure

levels and their sound sources in shaping the auditory perception.

A comparison of the remaining points further supports these findings. As Fig. 10 illustrates, even though these points (except for Point 3 which provides a lower overall sound level) have similar overall sound levels, Point 2 is perceived as significantly less pleasant. This can be justified by the fact that, although human beings were the main sound source, at this point, the sound from traffic and other noises (in this case, construction work) was also very present, increasing sound in a calm background environment, as evidenced by the low L_{90} value. In contrast, at Point 1, while traffic noise was still present, sounds from human beings were also noticeable and no other noise sources were significant, making it more pleasant than Point 2. At Point 3, despite traffic being the dominant sound source, it was mostly distant, resulting in significantly lower sound pressure levels. Meanwhile, at Point 5, sounds from human beings were dominant, with no other significant noise sources, which contributes to its perceived pleasantness.

Table 3. Results of the sound level measurements at Polo I campus of UC.

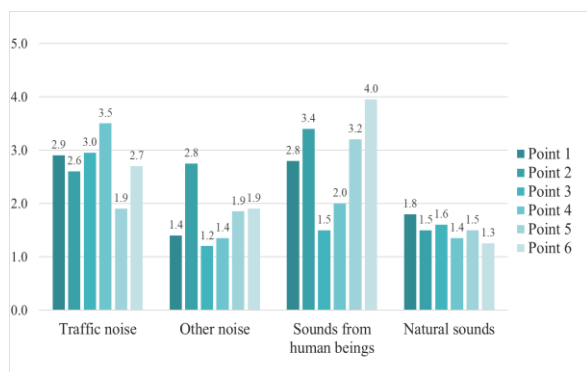|	Indicators			
	L_{Aeq} (dB(A))	L_{90} (dB(A))	L_{50} (dB(A))	L_{10} (dB(A))
Point 1	53.4	46.2	48.5	52.9
Point 2	52.0	43.2	50.4	54.7
Point 3	47.8	40.5	45.6	51.6
Point 4	56.5	41.3	46.0	62.9
Point 5	51.3	48.0	50.4	53.3
Point 6	56.2	53.5	55.8	57.9

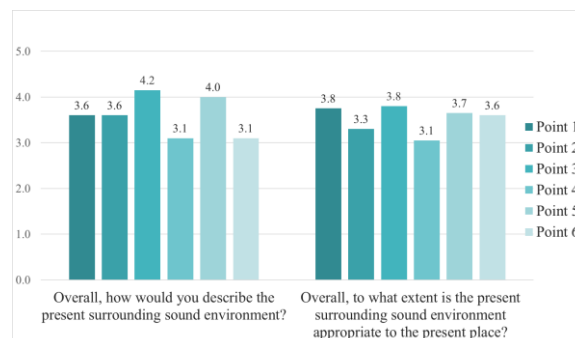**Figure 7.** Ratings for the different sound sources at each point for Polo I campus of UC.

Figure 8. Ratings for overall assessment and appropriateness of the sound environment at each point for Polo I campus of UC.
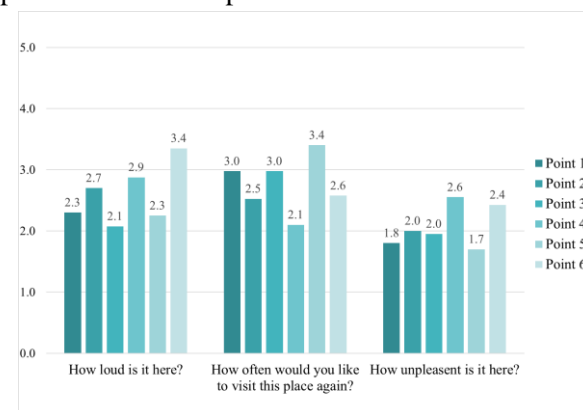

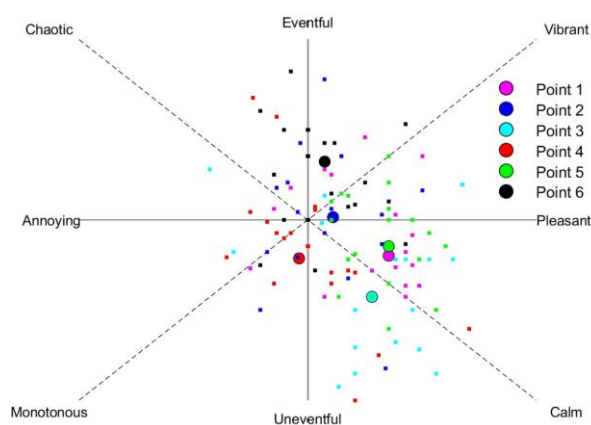**Figure 9.** Ratings regarding overall perception of the sound environment at each point for Polo I campus of UC.

Figure 10. Plot of perceived affective quality of the sound environment at each point for Polo I campus of UC (according to ISO/TS 12913:3).

4. CONCLUSIONS

The aim of the present study was to analyse the soundscape of two historical areas of high heritage value in the city of Coimbra, in Portugal, according to the soundwalk methodology outlined in the ISO 12913 series. This approach, which combined subjective questionnaire responses and objective sound pressure level measurements, would allow for a more complete evaluation of the sound environment of these places, by considering the three key components of soundscapes: acoustic environment, people and context.

Among all the results obtained, the most interesting ones show that places with similar sound pressure levels can still be perceived differently and that areas with relatively high sound pressure levels can still be experienced as pleasant and vibrant, rather than annoying and chaotic. These results highlight the importance of sound source types in shaping auditory perception.

In conclusion, this research emphasizes the need of considering not only physical indicators, but also contextual factors and sound sources characterization when assessing the acoustic environment of a place. Adopting this holistic approach is essential for a thorough understanding of the soundscape and for enabling more effective urban planning. Moreover, this study highlights soundwalks, and complementary sound pressure level measurements, as a valuable methodology for exploring and evaluating the soundscape of a given area.

5. ACKNOWLEDGMENTS

6. REFERENCES

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