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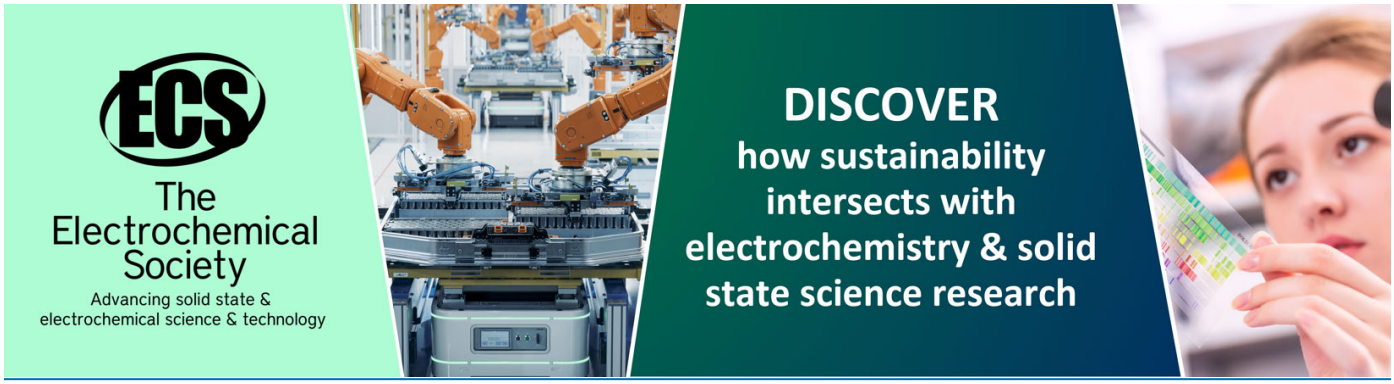

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Comparison between Sound Pressure Levels and Perception: a Soundscape Application in a University Campus

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Abstract. The assessment and control of acoustic noise in every place in which humans live is usually performed measuring the sound pressure levels and comparing these results with the thresholds defined by regulations. The latest approaches include the possibility to consider the subjective perception of sounds, using the so-called "soundscape" approach. In this paper the authors present a practical application of this approach performed in the Campus of Fisciano, University of Salerno (Italy), with the aim to compare the physical parameters, obtained by measuring the sound level, and the psychoacoustics one, acquired by administering questionnaires to a group of students during a soundwalk. Results will show that the higher sound pressure levels will not always correspond to the more annoying places. In particular, the main park of the University campus will present a positive soundscape, even though noise from the nearby highway will be highly present. Similar conditions will occur in vibrant areas of the campus, in which the interviews will highlight a good perception of the soundscape, even with quite high sound pressure levels.

1. Introduction

Soundscape is one of the most innovative approach for the study of noise pollution. It is common to find soundscape studies beside standard or innovative noise assessment methods, such as, for instance, the noise source and propagation modelling (e.g. [1-3]). The main innovation in soundscape is that the sound is not considered a waste product to be controlled and managed, but a real resource, acting on the enhancement of the desired sounds as, for example, the reproduction of natural sounds as water or birds chirping, to mask the unwanted ones. The first pioneering work on soundscapes was carried out in the '70s by the musician R.M. Schafer [4]. Several other studies have been performed in the last years, producing a large literature on the topic (see for instance [5-10]). The definition and the use of different data collection methods related to human perception, acoustic environment and context is defined into the ISO12913 series. The first part [11] introduces the key components in soundscape: people, acoustic environment and context, as well as the procedures of data collection and requirements for application. The second part [12] is a sort of "Technical Specification", introducing and discussing techniques of interviews and guidelines, as well as exploration of areas through soundwalks and other tools. As soundwalk and questionnaires represent tools to describe the perceived or experienced acoustic environment, the measurements of physical parameters describe quantitatively and objectively the sound pressure levels produced by noise sources present in the environment [13].
In this paper, an application of the soundscape approach is presented. A soundwalk in the Campus of Fisciano of the University of Salerno, Italy, was performed in order to compare the physical parameters,

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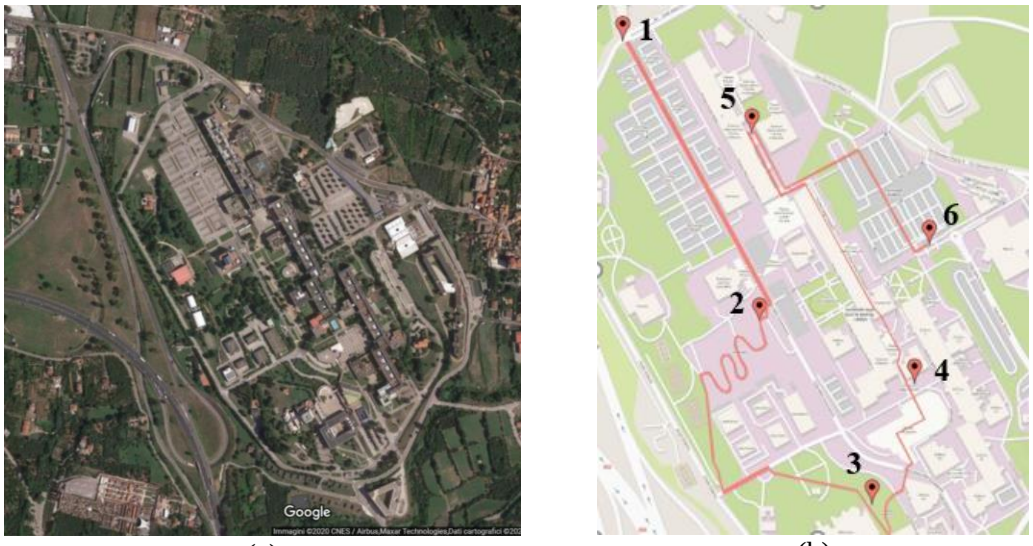
measured by means of a sound level meter, and the psychoacoustic ones, acquired administering a questionnaire to the participant group, during the soundwalk. This comparison will highlight the potentialities of the soundwalk technique, which is able to detect the subjective perception of the sound field, beside the sound pressure level.

2. Methodology

Main purpose of the soundscape approach is the description of an acoustic environment in its entirety, including its physical characterization, the interaction with people who use it and the surroundings. For these reasons, the methodology adopted in this application is the combination of a soundwalk, with questionnaire interviews, and sound level meter measurements.

2.1. Soundwalk and questionnaire

Soundwalk is a qualitative method to explore an area with the aim to focus the attention on the perceived sounds of the surrounding environment. The soundwalk moderator guides the participants along the chosen itinerary, proposing questions, collecting feedbacks and helping in filling the questionnaires.
Regarding the participant group, ISO 12913-2 suggests a group of at least five participants walking together along a certain path. As regard the participants social/demographical features, some literature studies suggest that age and education level are two features influencing the sound preference significantly [14-15]. In this application, a group of 22 participants were chosen from a list of volunteered students. Even though students are not effectively inhabitants of the area, they could be considered as "local experts", because they factually join, every day, the campus life. In order to have quite heterogeneous information, the process selection has been made so that the number of male and female participants was equal, as well as their ages (in the 19-26 years old range). Personal data and questionnaire responses were collected anonymously respecting all privacy rules. The soundwalk was performed in the campus of the University of Salerno (Italy), in March 8, 2019. The university campus is located in Fisciano, a little town, few kilometres away from the city of Salerno. The campus area is just in the nearby of two important highways of the region (Fig.1a). The chosen path (Fig. 1b) covered a total length of about 2.6 km, from one of the vehicles entrances of the university campus to one of the most crowded areas (nearby the canteen and the terminal bus), passing through the central road axes.



(a) (b)

Figure 1. Site of the soundwalk: (a) map of the area, with the university campus area and the principal highways on the left (Google Maps©); b) Soundwalk path with evidence on the stopovers (from 1 to 6). The starting point and the direction are displayed according the progressive numbers.

Table 1. Descriptions of the points selected for survey and L_{eq} measurements.

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Description of the location	Vehicles entrance	Main park	Rectorate square	Central square	External area, building F	Way to bus station and canteen

Along the path, six points have been chosen (Fig. 1b) in order to identify different acoustic environments, visual characteristics and dominant sound sources (Tab.1).
In the context of this work, specific questionnaires were drawn up according to ISO 12913-2, focusing on the investigation of elements as the perceived loudness, pleasantness, tranquillity and appropriateness of the sound sources identified by "listeners" of the participation group in that specific place ('point of investigation'). Thus, the first part of the questionnaire required the characterization of the acoustic environment by identifying which sound sources are audible and how dominant they are. Sound sources have been divided in four main groups: traffic noise (deriving from transportation, for instance cars, trains and planes, among the others); natural sounds (wind, water and birds, among the others) and sounds due to humans (for instance conversation, laughing, children playing and footsteps), other sounds deriving from sources not included in the other clusters (for instance sirens, constructions, and industry). The second part of the questionnaire is related to the perceived quality, i.e. to the investigation on the qualities of the sounds perceived by listeners in the environment. The selected features of the soundscape are pleasantness, annoyance, monotony, chaoticity, liveliness, quietness, and the respondents were asked to rank their agreement on each of them. In addition, four questions about loudness, unpleasantness, appropriateness and will to visit that place again, were asked, adopting an evaluation scale from 1 to 5.

2.2. Sound level meters
In order to correlate the perceived acoustic environment and the real physical one, the authors decided to perform, during the soundwalk, measurements of the sound continuous equivalent level L_{eq}, i.e. the hypothetical constant noise that, if substituted to the real noise, generates the same amount of sound energy in the same time interval. In particular, in this study, measurements were performed by using a certified sound level meter Fusion 01dB and data post processed with the data post processing software supplied by the manufacturer. Each measurement lasted 3 minutes. The calibration was performed before and after the measurement campaign.

3. Results and discussion
The soundwalk was organized according the methodologies described in the previous sections. In each point, questionnaires regarding participants' perception were filled and collected, as well as data measurements, performed by means of the sound level meter. The path was covered in about 80 minutes. Results of the sound level meter measurements are resumed in Table 2, for each point recorded.

Table 2. L_{eq} measurements in the 6 points selected.

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Measured L_{eq} [dBA]	55.2	53.3	48.3	57.0	68.2	55.4

As for the questionnaires results, the presentation here is limited to only part of the data, for the sake of brevity. A more detailed analysis will be presented in a forthcoming paper. In particular, Figures 2 and 3 present for each point respectively the score of each noise source and the scores related to the last four questions of the questionnaire.
As results suggest, volunteers' experience was in agreement with physical measurements. In point 1, traffic noise was expected to be the main perceived sound source, and questionnaires confirmed that. Other types of sound, as natural ones, were not enough strong to mask the unwanted ones. Point 5 was affected by HVAC plants noise and, as the pressure level here measured suggests, it was perceived as

highly unpleasant. In the authors' opinion, point 2 gives us evidence of the efficiency of the method. Even if the pressure level was high, and even if the nearby highway could cause annoyance, the soundscape was perceived as good and relaxing. Natural sounds, thanks also to the greenery, mask the traffic ones, making no operation necessary. Points 3, 4 and 6 present similar aspects. The soundscapes of these locations were perceived indeed as vibrant and pleasant, thanks to the high presence of anthropic sounds, such as, among the others, chatting, laughing and footsteps.

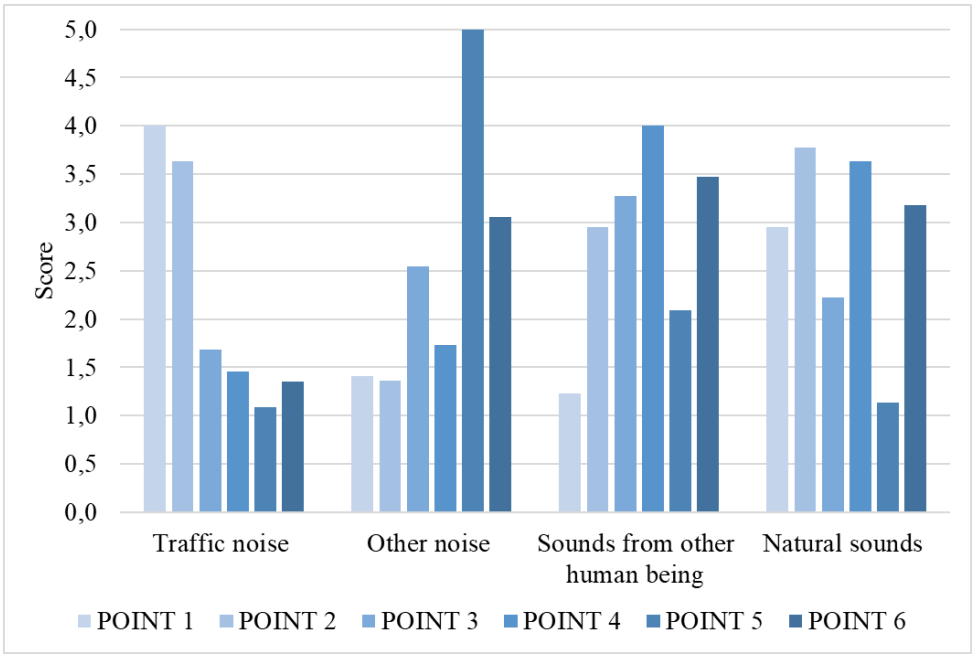


Figure 2. Subjective rating of each noise source for each point of investigation.

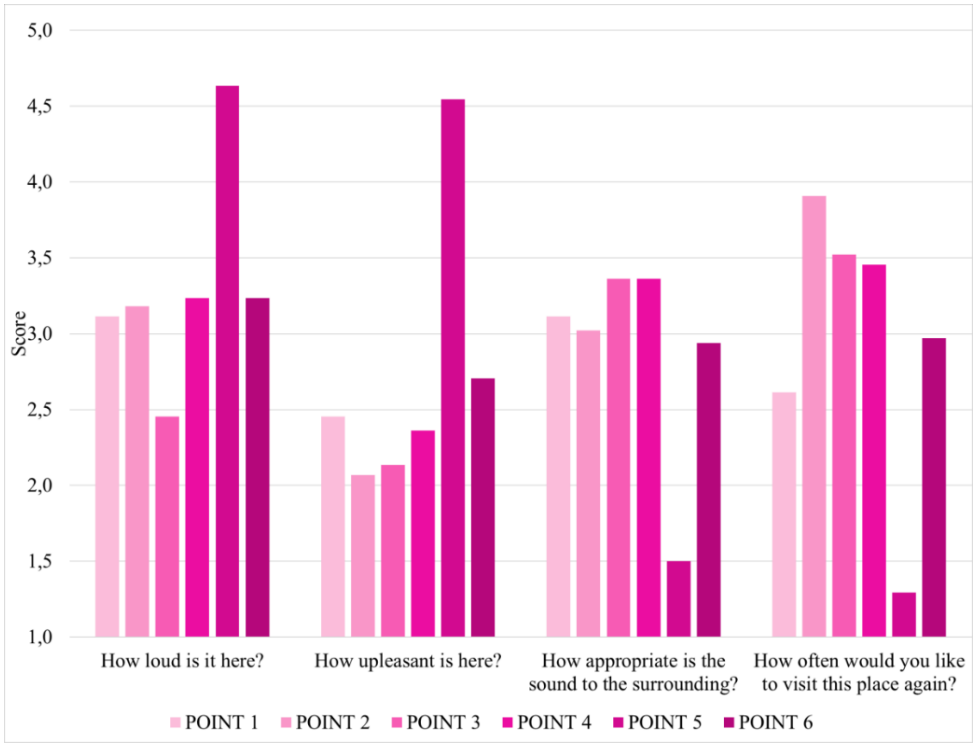


Figure 3. Soundscape's perception of each point of investigation, provided by loudness, unpleasantness, appropriateness, will to visit that place again.

4. Conclusions

In this paper, an application of the soundscape approach, performed in the Campus of the University of Salerno, was presented. The soundwalk was organized according to the reference ISO. The main scope of the application was to compare the qualitative results obtained using the soundscape approach with the quantities obtained measuring sound pressure levels. This analysis allows, from a practical point of view, the comprehension of how sound levels measured by a sound level meter correspond to different perceptions of users. This kind of correlation study has been demonstrated, in literature, to be very useful to assist the urban planner, especially in the understanding of necessary mitigation interventions.
All data obtained from questionnaire and sound level meter were elaborated and results were compared. Among the most relevant results, it is interesting to underline that the main green park of the University campus presented a perceived positive soundscape, even though noise from the nearby highway was present. Similar conditions occurred in vibrant areas of the campus, in which the interviews highlighted a good perception of the soundscape, even with quite high sound pressure levels.
These results demonstrate how the approach to base the design of a place taking into account the perception of people, as well as physical parameters, can ensure many positive effects, in economic terms, quality of life, spatial identity, as well as a better feedback from the population.

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