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ACOUSTIC QUALITY LAYERS: A SCOPING REVIEW TO UNDERSTAND ACOUSTIC QUALITY SPACES

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ABSTRACT

Acoustic quality spaces do not only focus on the quantitative values of sound in a space. It also considers the functions of the spaces. This is why it is different from quiet/calm areas. This difference is related to the sounds in the space, environmental conditions, sound experiences of the users, soundscape etc. Therefore, everything that affects the soundscape also affects acoustic quality spaces. Acoustic quality spaces are an urban need with positive effects on physical and mental health and quality of life. In order to manage this need, it needs to be defined. Considering the relationship between acoustic quality spaces and soundscape, the factors affecting acoustic quality spaces can be determined from studies investigating topics such as soundscape quality, quality of space, perceived affective quality etc. However, since these studies contain a lot of different information, a scoping review is needed. This study presents the literature review section of a comprehensive project that also includes expert interviews and field studies. The factors that create/influence acoustic quality spaces are referred to as "acoustic quality layers." These layers, derived from the analysis of the literature on soundscapes, quiet/calm areas, and acoustic quality spaces, are categorized into acoustic and non-acoustic quality layers.

Keywords: *Acoustic quality spaces, soundscape, acoustic quality layers*

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1. INTRODUCTION

Environmental sounds are one of the basic components of human life and the physical environment. Various activities, objects and events have their own sounds. Sounds are a source of information about the size, identity, culture of an area in the physical environment. Environmental sounds have positive effects such as enabling various desired activities, having a soothing effect on people in general and contributing to their well-being [1]. However, in general environmental assessment, sounds are negatively associated with the concept of noise. With the publication of the EU Directive on the assessment and management of environmental noise (END), the main focus has been on reducing noise levels [2]. However, in such a view, it may not always or everywhere be possible to reduce noise levels. Furthermore, a noise reduction strategy does not always meet the desired results in terms of improving quality of life. This is often because the pursuit of silence is not necessarily sufficient in all situations to define spaces of high acoustic quality [3,4]. A common and widespread but incorrect view is that the absence of noise is complete silence. This idea and perspective is in line with the idea that creating an air gap is a solution to air pollution. Research on acoustic quality is still ongoing. This is seen in the European Environmental Noise Directive as “the protection of places with good noise quality” [2]. This well-intentioned perspective creates confusion in the literature as it leads to an understanding that noise, known as “unwanted sound”, can be good, qualified and of good quality [5]. Sound is a valuable resource for understanding people's appreciation of a place. Looking at environmental sounds as only noise means ignoring the rich data that can be extracted from this source [6]. The auditory expectations of urban users in terms of urban quality of life are not only silence or calmness in cities. It is to understand the functions of the spaces in cities together with the sounds, to utilize these spaces to create an acoustic quality space without disturbing the listeners, and to benefit from these

spaces physically and psychologically. Therefore, with the rapid increase in urbanization, there is a need for alternative approaches that support better quality of life and overall health. High acoustic quality spaces, soundscape indices, acoustic comfort, studies supporting these approaches are being conducted. However, it is not known what makes acoustic quality spaces that support quality of life and acoustic comfort. However, research on auditory landscapes and acoustic comfort provides a great deal of supportive information for evaluating and creating acoustic quality spaces. Therefore, the primary aim of this review is to examine what factors are investigated in field studies when conducting soundscape and acoustic comfort research. By doing this study, it will be determined which factors are needed when studying/creating/evaluating acoustic quality spaces (all factors will be referred to as acoustic quality layers in this review). It is thought that such a determination will contribute to improving the acoustic potential of spaces that will contribute to the quality of life of urban users.
The questions addressed by this review are:
Which factors are investigated in the soundscape and acoustic comfort literature in field studies?
What are the acoustic and non-acoustic factors investigated in the soundscape and acoustic comfort literature and how can these factors be classified?

2. METHODOLOGY

In order to obtain sufficient and contemporary information in this review, articles published between 2020-2025 were analyzed in the Scopus database using AND, OR, AND NOT Boolean operators in the title-abstract-keywords. In the review {soundscape} AND {acoustic comfort} combination was used. The keywords {high quality}, {sound quality}, {quiet/calm areas}, {acoustic quality}, {acoustic quality spaces}, {field survey} were used with the OR operator in order to see the studies that have research on quality and have conducted field surveys. The use of 'OR' ensures that at least one of the terms in these keywords is included. The keywords {indoor} and {interior} were excluded with the AND NOT operator, as the review was focused on studies conducted in urban open spaces. The review was conducted in accordance with the PRISMA-ScR (Preferred Reporting Items for Scoping Reviews) guideline.

2.1 Search strategy and selection process

Fifty articles were obtained through title, keyword and abstract searches. Rigorous abstract and full-text searches were performed for each of these articles. Articles related to the Covid-19 pandemic were excluded as they contained extreme case comparisons. With the elimination of indoor and out-of-scope studies, twenty studies were finally obtained. The inclusion criteria were as follows: (1) It includes the concepts of soundscape and acoustic comfort, (2) It has an approach related to the concept of quality, (3) It is a qualitative or quantitative field study, (4) It is a quiet/calm field study depending on the quality of the space. Articles were excluded if (1) it was indoor research, (2) it was a study conducted at an extreme time related to the Covid-19 pandemic, (3) it was not available in English, (4) it was not relevant to the topic. The inclusion and exclusion criteria are shown in Table 1.

Table 1. Inclusion and exclusion criteria for included studies.

Inclusion criteria	Exclusion criteria
It includes the concepts of soundscape and acoustic comfort	It was indoor research
It has an approach related to the concept of quality	It was a study conducted at an extreme time related to the Covid-19 pandemic
It is a qualitative or quantitative field study	It was not available in English
It is a quiet/calm field study depending on the quality of the space	It was not relevant to the topic

Figure 1. shows the screening process of the current review. The number of included and excluded studies is given in the figure.

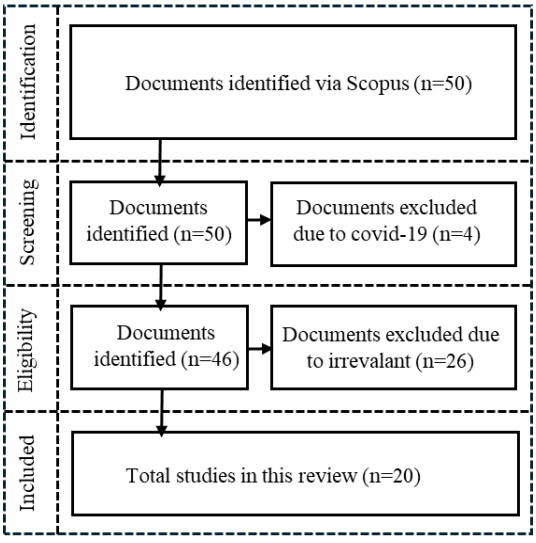

Figure 1. The search method and screening process.

As seen in Figure 1, 50 articles were obtained in the first screening phase. According to the title, abstract and full text, 4 Covid-19 articles were excluded. In the second stage, abstracts and full texts were reviewed and articles related to indoor spaces, which were still available despite the concepts such as interior, indoor, which were excluded in the keywords, and 26 out-of-scope articles were excluded. The remaining 20 articles were reviewed once more to ensure that all met the inclusion criteria and required data.

2.2 Search strategy and selection process

The data of the 20 included articles were categorized into article information (publication year, authors, title, abstract), factors investigated in the study (sound level, gender, visit frequency, duration of staying, aim of the visit, loudness, roughness, sharpness, etc.), research area (park, square, bus stop, etc.), personal notes of the reviewing authors. All extracted data were stored in an Excel worksheet. When the full text searches were completed, the factors investigated by the studies were categorized by the authors. Groups of words indicating the same factors were considered as the same concept (such as Income per month - monthly income status etc.).

The factors investigated in the studies were grouped into acoustic layers and non-acoustic layers. Acoustic layers were subdivided into Sound, Source characteristics, soundscape. Non-acoustic layers were subdivided into user, space, environment and sensory factors. Thus, the review was carried out in seven categories in total. This approach enables the factors obtained from soundscape and acoustic comfort studies to be used efficiently in acoustic quality space research.

3. FINDINGS

Regardless of the purpose, method and field of study, the information to be obtained from the studies examined is only the factor(s) evaluated in the field studies. For this reason, every material used and questioned in research methods such as questionnaires, sound recordings, soundwalks and interviews is important for this study. Table 2. shows the included studies and the data extracted from these studies.

Table 2. Included studies and extracted information

No	Source	Research factors
1	Tibone, et al, 2020 [7]	LAeq, LA95 percentile levels, background level (BGN), event-based component (EVT) related to the sound peaks, fluctuation strength, loudness, sharpness, seasons, day time
2	Liu, et al, 2020 [8]	SPL, sharpness, fluctuation, loudness, roughness, effect of elevation, effect of visitor density (person/ m^2), effect of human behavior patterns, sound sources
3	Meng, et al, 2020 [9]	distance to nature, inclination to communication, preference for crowd, comfort, loudness, eventfulness, vibrancy, pleasantness, calmness
4	Hong, et al, 2020 [10]	signal-to-noise ratio (SNR), perceived loudness of noise (PLN), loudness, sharpness, roughness, fluctuation strength,
5	Miterska and Kompała, 2021 [11]	LAeq
6	Ma, et al, 2021 [12]	gender, visit frequency, duration of staying, aim of the visit, LZ=unweighted sound pressure level, LA=A-weighted sound pressure level, N=total loudness, S=sharpness, 10/50/90=percentiles of 10/50/90%.
7	Herranz-Pascual, et al, 2022 [13]	LAeq, 10 min, LAmin, 1 s, LAmax, 1 s, LA10, LA50, LA90 and number of total events, gender, educational level, employment, resident, landscape, thermal comfort, safety, cleanliness, maintenance and accessibility, average time spent, vegetation and natural elements, capacity of greenery
8	Xie, et al, 2022 [14]	LAeq, the degree of natural soundscape, soundscape/landscape diversity, audio–visual harmonies, and soundscape/landscape comfort
9	Yu, et al, 2022[15]	LAeq, sound sources
10	Di Loreto, et al, 2022[16]	SPL (dBA), Loudness, Sharpness, Fluctuation Strength, Roughness, gender, visit frequency, duration of staying, aim of the visit
11	Cui, et al, 2022 [17]	SPL (A), Gender, Age, Education level, Occupation, Income (per month), Residential location, Residential floor, Length of residence, sound sources,
12	Nwankwo, et al, 2022 [18]	Gender, Age, Educational level, weather conditions of the visit, perceived affective quality
13	Guo, et al, 2022 [19]	Gender, Age, Educational level, Monthly income status, Distance between residence and the park, natural landscape elements (creeks, lakes, lawns, boulevards, bushes) and artificial landscape elements (sculptures, bridges, children's play facilities, adult fitness facilities, and trash drop-off points), Sound Source
14	Bonet-Solà, et al, 2023[20]	Annoyance by type of noise source
15	Benocci, et al, 2023 [21]	sound sources
16	Yang and Kang, 2023 [22]	Crowd density, Sound Preference, sound sources, sound types, visual comfort
17	Xiang, et al, 2023 [23]	L Aeq, L Amax, L Amin, L A10, L A90, Loudness, Roughness, Sharpness, Fluctuation, Impulsiveness
18	Wang, et al, 2024[24]	L eq, quietness (SPL), naturalness, population distribution, Location, Proportion of cultivated land, grassland, forest, and shrub land, Proportion of water bodies, Proportion of artificial surface, Proportion of industrial and mining areas, Entropy value of land use, indicating degree of land use disorder, Road density, Street coverage ratio, Building coverage ratio, Nighttime light value, Vegetation characteristics, time
19	Zarei, et al, 2024 [25]	Convenience Level, Expectation Level, Appropriateness, Being Temporary/Permanent, Being Pleasant, Loudness, Noise sources, Age group, Education Category,
20	Yang, et al, 2024 [26]	Sound type saliency, Soundscape appropriateness, Sound pressure level, SPL (LAeq, 30s)

Table 3. Acoustic quality layers extracted from the studies

Acoustic Quality Layers				
Acoustic Layers			**Non-acoustic Layers**	
Sound	**Acoustic Parameters**	LAeq [7,11, 13,14,15,23,24]	**User**	Gender [12,13,16,17,18,19]
		SPL(A) [7,12,13,16,17,23,26]		Age [17,18,19,25]
		Signal-to-noise ratio (SNR) [10]		Educational level [13,17,18,19,25]
		LA10, LA50, LA90 percentile levels [7,12,13,23]		Occupation [13,17]
	Psychoacoustic parameters	Fluctuation strength [7,8,10,16,23]		Visit frequency [12,16]
		Loudness [7,8,9,10,12,16,23,25]		Aim of the visit [12,16]
		Sharpness [6,8,10,12, 16,23]		Human behavior patterns [8]
		Roughness [8,10,16,23]		Average time spent [12,13,16]
Sound Sources		Sound Source Type [8,15,17,19,21,22]		Monthly income status [17,19]
		Annoyance by type of noise source [20]	**Space**	Visitor density [8,16,22]
Soundscape		Perceived affective quality [9,18]		Landscape elements [13,14,19,24]
		Degree of natural soundscape [14]		Urban space quality parameters [13,14,19,24]
		Soundscape/landscape diversity [14]	**Environment**	Day time [7,24]
		Soundscape/landscape comfort [14]		Season [6]
		Sound Preference [22]		Distance to nature [9,19]
		Soundscape appropriateness [26]		Weather conditions of the visit [18]
			Sensory	Thermal comfort [13]
				Audio–visual harmonies [14]
				Visual comfort [22]
				Nighttime light value [24]

According to Table 3, the information extracted from the reviewed studies has been simplified so that it can be used in acoustic quality space studies. In the data extracted in Table 2, the parameters specific to each study are categorized in Table 3. for general use. It does not matter how many times the concepts are used or researched. The important thing is to take the first step in a general approach to investigate the factors that can determine the acoustic quality spaces. Table 3. constitutes the first step of the acoustic quality space researches created with literature information.

4. DISCUSSION

In this study, acoustic quality layers are summarized in a multidimensional framework that includes both objective and subjective criteria of acoustic layers, as well as non-acoustic layers that encompass individual characteristics, behaviors, spatial and environmental features, and sensory perceptions. This holistic and inclusive approach demonstrates that the relationship established with sounds in spaces is not solely related to the physical properties of sound, but can also be shaped by the users' connection with the space, the environment in which the space is located, and the sensory bonds formed.

The acoustic layers are classified into three groups: sound, sound sources, and soundscape.

The sound layer, which pertains to the physical properties of sound, includes **acoustic parameters** related to environmental sound levels. These parameters are objective and assist in the evaluation of an environment in an impartial manner. **Psychoacoustic parameters**, on the other hand, are employed in cases where the information provided solely by sound levels is insufficient. These parameters play a complementary role in understanding the auditory experience and highlight that sound is not only a physical phenomenon but also has experiential and perceptual dimensions.

Within the **sound sources layer**, the types of sound sources and the annoyance caused by noise sources are addressed. This demonstrates that the presence of wanted or unwanted sounds can positively or negatively influence the acoustic quality of a space and users' auditory experiences. Regardless of sound level, the presence of preferred sounds and the absence of annoyance from noise sources can contribute to the improvement of a space's acoustic quality.

The soundscape layer encompasses the subjective evaluation of the soundscape, natural soundscapes, the balance between soundscape and physical landscape, comfort, and sound preferences. This layer provides a basis for acoustically high-quality environments through general sound preferences and systematic subjective evaluations.

Non-acoustic layers are categorized into four groups: user, space, environment, and sensory. These layers encompass numerous factors that directly or indirectly influence how users perceive environmental sounds.

The user layer includes variables such as demographic characteristics, users' aims for using the space, and frequency of visits. These factors influence the subjective perception of a space, users' sensitivity, and their evaluation of acoustic quality.

The space layer involves concepts such as view and urban space quality parameters, which can either enrich or negatively affect the space experience. It facilitates the shaping and interpretation of behavioral indicators that explain users' interactions with the space.
The environment layer covers contextual effects such as time of day, season, and weather conditions. The physical environment can produce various impacts on the perception of sounds and individuals' evaluations of the sound environment.
The sensory layer emphasizes the necessity of evaluating sound perception holistically, especially within the context of comfort. It underlines the importance of identifying acoustic quality spaces not solely based on sound, but through multisensory harmony, considering the presence or absence of various comfort conditions such as thermal and visual comfort.
The findings reveal that the components defining acoustic quality spaces are multidimensional and that various interactions exist among these components. While acoustic layers facilitate the technical measurement and evaluation of the environmental soundscape according to specific standards, non-acoustic layers serve as tools to understand how individuals experience and assess these environments. Establishing the interrelations between acoustic and non-acoustic layers, understanding their influence on acoustic quality spaces, and learning how they contribute to the formation of such spaces necessitate a holistic, cross-layer approach.
In this context, it is considered that relying solely on physical measurements in the planning and management of acoustic environments may be insufficient. Concepts such as user-centered approaches, sensory integration, and comprehensive and systematic investigations constitute fundamental strategies for the evaluation of sound environments.

5. LIMITATIONS

Studies using the concept of acoustic quality space are limited. Current research includes studies with comments and research on quality of life, acoustic quality, soundscape quality. First of all, Scopus database was used in this review to limit the scope. Although Scopus is a widely used database, it may not include all the literature on soundscapes, acoustic comfort and acoustic quality spaces. Not using other databases may lead to the exclusion of some sources. Research in English may have led to the exclusion of studies in other languages. In addition, having only reviewed articles, it is necessary to accept that the rich information in the conference paper, which include ideas and research that have not been published in peer-reviewed journals, cannot be accessed. Finally, it should be recognized that this review, which investigated the current period of five years, may not contain enough information in the studies that contributed to the development of the concepts and were the source of the studies examined.

6. CONCLUSION

The acoustic environments to which individuals and urban users are exposed in the physical environment are significant not only in terms of physical impacts but also in relation to psychological and cultural effects. These impacts influence users' experiences of their surroundings, shaping their satisfaction, discomfort, and aesthetic appreciation. While traditional urban acoustics research has predominantly focused on noise and noise control, studies on acoustic comfort and soundscape have become increasingly prominent in recent years. It can be argued that the parameters involved in soundscape and acoustic comfort research provide a conceptual framework for understanding general acoustic quality and acoustic quality spaces.
Although research factors tend to vary depending on the specific goals and contexts of field studies, common elements include users' demographic characteristics, sound level measurements, the application of psychoacoustic parameters, environmental and sensory factors, and documentation of soundscape characteristics. In the literature on soundscape and acoustic comfort, acoustic layers have been classified into sound, sound sources, and soundscape, while non-acoustic layers include user, space, environment, and sensory dimensions.
Based on the findings of existing studies, it is evident that the concept of acoustic quality and its constituent layers are inherently multidimensional, with numerous factors still requiring investigation. Although many studies examine similar variables, there is a need for further research into how these layers are derived, how they can be measured, and how they interact with one another. Understanding these interrelationships will contribute to the creation, evaluation, and preservation of acoustic quality environments, ultimately supporting more livable and perceptually enriched urban spaces.

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