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Original Research Article

A Reflection on the Role of Auditory Factors in the Soundscape of Educational Spaces in Qazvin City Based on Cognitive Maps (Case Study: Narges Shahed School in Qazvin)*

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Abstract

Problem statement: Sounds play a critical role in environmental perception and significantly influence human interaction with both the environment and other individuals. They directly affect the auditory senses as well as humans' understanding of their surroundings. The diversity of sounds within a given environment leads to the formation of various soundscapes. Both auditory and non-auditory factors play a notable role in shaping soundscapes. Auditory factors encompass anthrophony, biophony, and geophony which constitute the central focus of the present study.

Research objective: The present study was an attempt to investigate the auditory factors shaping the soundscape of educational spaces in the city of Qazvin, through cognitive maps. Narges Shahed School in Qazvin was selected as the case study and anthrophonic, biophonic, and geophonic sounds within the school premises and the surrounding off-campus areas were analyzed.

Research method: The research method of this study is descriptive-analytical and survey-based. Data collection was conducted through document analysis, recorded observations, field surveys, note-taking, and sketching using cognitive maps. To achieve the research objective, soundwalking and sensory survey techniques based on visual and auditory perception were employed.

Conclusion: In conclusion, the analysis of auditory factors in the study area revealed that all three auditory factors—anthrophony, biophony, and geophony—are present in the indoor spaces, courtyard, and surrounding off-campus areas of the school, both as direct sounds and indirect sounds (emerging from the echoes of dominant sounds in the environment). The biophony and geophony components are relatively desirable when they are not expressed in excessive amounts. In particular, the geophonic component, which is based on natural factors, but part of the anthropophonic component, due to its human-centered nature, appears undesirable in the form of noise, and in other cases is desirable. These soundscapes directly affect the auditory senses, perception, concentration, learning and cognition of students.

Keywords: *Soundscape, Auditory Factors, Cognitive Maps, Educational Spaces in Qazvin.*

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Introduction

Sounds are vital items in human life, constantly mediating the relationship between humans and their environment. They significantly contribute to the perception of non-physical elements in the environment. Diverse soundscapes emerge in different locations and times. What influences the perception of a soundscape from the perspective of the listener is their sensory perception. Pleasant and unpleasant sounds in the environment are closely linked to human perception, and depending on the extent they meet the criteria of pleasantness, they can create lasting impressions in the mind. Therefore, human perception of sounds from various sources and with different frequencies can affect their perceptual structure in various ways. Educational spaces are among the most significant environments in which most individuals have spent some time, perceiving various pleasant and unpleasant sounds. In educational spaces, sounds are one of the major elements that influence the audience, playing a critical role in shaping their perceptual functioning. The diversity of sound sources and the sounds produced within the physical structure of educational spaces are critical factors addressed in the present study. Educational spaces and schools are in constant interaction with their surrounding sounds, and knowledge of how these sounds influence the formation of their soundscapes and align with human perception plays a pivotal role. Therefore, examining sounds in the context of auditory factors within educational soundscapes highlights the significance of this research. Taking this into account, a question arises: how can criteria for evaluating the educational spaces in Qazvin be established using auditory factors such as biophony, geophony, and anthrophony, which influence sound perception? To address this question and fulfill the study's objective of exploring the influence of auditory factors of soundscape within Qazvin's educational spaces through cognitive maps, the key auditory factors of soundscape were investigated.

Literature Review

In recent years, a variety of studies in the field of sound and architecture have been conducted globally, focusing on the reciprocal relationship between architecture and sound and the formation of soundscapes in various spaces. Soundscape analysis emerged as a research field in the late 1960s and has garnered significant attention from researchers over the past two decades. Due to its multidisciplinary approach, soundscape studies emphasize how individuals experience their acoustic environments in both indoor and outdoor environments (Bartalucci & Luzzi, 2020). Soundscape generally refers to the sonic environment. The study of soundscape is significant to improve the quality of the environment, enhance the function of a place, and promote a healthy and quality life as well as for the understanding of cultures (Chieng & Chan, 2021). In the meantime, soundscapes represent the quality of sounds heard and perceived in urban spaces. Various factors influence the quality of urban soundscapes, and the acoustic behavior of a space depends significantly on its environmental characteristics (Ghaffari et al., 2021a). Soundscapes are considered one of the key elements shaping the non-physical perception of urban spaces, playing a vital role in the acoustic quality of the environment and the audience's experience (Esmaeili & Jahanbakhsh, 2024). Soundscapes have been likened to the acoustic expression of place, emphasizing the role of sounds in fostering a sense of place attachment (Schafer, 1993). On the one hand, the threshold of sound tolerance varies among individuals, and on the other hand, the perception of a pleasant soundscape can differ depending on the contextual setting where the sound is experienced (Personality and mental background factors, however, are typically disregarded in such evaluations) (Maleki Eshlaghi & Ghalambor Dezfuly, 2023). Moreover, high-quality soundscapes are not necessarily about low sound levels or about silence. What they are about is sounds that are appropriate to that

place, achieving congruence between landscape and soundscape (Brown, 2010). However, the study of sounds in soundscapes depends on understanding how sounds from various biophonic, geophonic, and anthrophonic sources can be used to understand coupled natural-human dynamics across different spatial and temporal scales (Pijanowski et al., 2011). The concept of soundscape is an established theme in the acoustics environment and there is a need for soundscaping techniques that are specifically adapted to the outdoor environment (Rehan, 2016). With a proposed framework for designing soundscape in urban open public spaces, considering four key components, including characteristics of each sound source, acoustic effects of the space, social/demographic aspect of the users, and other physical conditions, design potentials are demonstrated (Kang, 2023). Soundscapes are assessed through human perception of the acoustic environment, with soundscape descriptors playing a crucial role in their evaluation (Aletta et al., 2016). To predict how individuals perceive the acoustic environment, it is essential to identify the underlying acoustic and non-acoustic characteristics of the soundscape (Mitchell et al., 2020). Kamal et al. (2022) investigated the association between objective and subjective measures and the growing interest in indoor soundscapes to improve the performance of learning spaces. Similarly, Quinn et al. (2024)'s article, has referred to the use of Ecoacoustic tools that quantify natural acoustic environments using a combination of biophony (animal sound) and geophony (wind, rain, and other natural phenomena) to represent the natural soundscape and, in comparison to anthrophony (technological human sound) can highlight valuable landscapes to both human and animal communities. Another study, Davies et al. (2013), based on qualitative survey work, explored the perception of soundscapes, which is influenced by cognitive factors such as the meaning of the soundscape, its elements, and how information is conveyed through it. Findings from auditory tests and soundwalks indicate that the two primary dimensions of emotional response to sound are calmness and vibrancy. On the other hand, addressing subjective and cognitive aspects through cognitive maps is a noteworthy approach. Cognitive mapping may serve as an essential component in the pre-design or post-design stages for public spaces (Chopra & Mahapatra, 2018). A review of literature highlights the significance of the acoustic environment and its impact on the audience's perception and cognition. The role of soundscapes has also been frequently addressed in the literature, with one of the shared focuses of the present study and the relevant literature being the examination of soundscapes. The present study aims to examine the soundscape of educational spaces and establish a connection between the formation of these soundscapes and cognitive maps, influenced by key auditory factors. In this light, Narges Shahed school recognized as one of the successful educational environments in Qazvin, was selected as the case study in this research.

Research Methodology

Considering the factors under investigation, the nature of the topic, and the research objectives, the study employs a qualitative research method with a descriptive-analytical and survey-based, classified under applied research. Data collection involved documentary research, recorded observation, field surveys, note-taking, and sketching, through cognitive maps. Cognitive mapping is regarded as a type of mental representation of the physical environment, specifically focusing on spatial relationships (Asadpour et al., 2015, 15). In the process of cognitive mapping, perceptual faculties were employed to identify auditory factors. The perception has been focused on relying on the visual and auditory senses in the soundwalk in the educational space under study, focusing on the components of anthrophony, biophony, and geophony. The reasoning behind this approach is the fact that auditory perception is considered an integral element in soundscape studies. In the next

step, both off-campus and on-campus soundscapes were subjected to investigations. To this end, the soundwalk technique was used to identify auditory factors at the selected study site. Soundwalk is an embodied method of personally connecting with the soundscape through focused listening. The main purpose of soundwalk is to listen to the environment (Polli, 2012, 258). During the soundwalk, a multisensory (auditory-visual) survey technique was employed. The core of this technique involves focusing on one specific human sense during the walk, allowing the study of pleasant or unpleasant perceptions of a place in relation to a particular sense (e.g., hearing, smell, taste, or even touch) (Yazdanpanah Shahabadi et al., 2023, 11). During the soundwalk phase, predetermined stop and movement points were set and anthrophony, biophony, and geophony were documented. The research process continued with the use of maps and guide-route marking. The population encompassed schools within Qazvin city, with the selected sample being one of the leading schools in the city. Therefore, the influential elements were analyzed, and the research question was addressed.

Theoretical Foundations

In the formulation of the theoretical framework of the study, the auditory factors contributing to the formation of soundscapes in educational spaces, as well as cognitive mapping based on audience perception and the influencing factors, were taken into account. A sensescape can be defined as a collection of five "scapes" namely visualscape (sight), tastescape (smell), smellscape (taste), soundscape (hearing), and hapticscape (touch) (Buzova et al., 2021, 2). Thus, engaging the audience's senses, particularly auditory perception, is a significant focus of this study. Architecture is an experiential journey through the built environment, with the potential to acknowledge emotions, desires, and pleasurable capacities in people. The multisensory architecture establishes its relevance within this context (Jirge et al., 2017, 179). Ultimately, the application of the theoretical foundations was incorporated into the research's conceptual model to gain insights into the analysis of the selected case study from among the educational spaces in Qazvin. This approach aimed to provide a method for extracting cognitive maps from these spaces.

- **Soundscape**

Sounds play a crucial role in understanding the environment and significantly contribute to establishing a connection with the surrounding world. Sound is a longitudinal mechanical wave that propagates through gases, liquids, and solids. The frequency range of audible sound waves lies between 20 and 20,000 Hz. Simply put, sound can be defined either as wave motion within an elastic medium or as a stimulus for the auditory sense (Ministry of Roads and Urban Development, Building Regulations Office, 2011, 2). During the past few decades' studies on the effect of noise on man have focused on physical and mental health, trying to relate it directly or indirectly to noise exposure level (Botteldooren et al., 2006, 105). One of the crucial elements of sound is its textural structure, which involves a simultaneous layering of multiple sounds that converge within an environment. Each sound possesses its own transient lifespan. These distinct sounds inherently harbor unique physical properties, yet their ultimate auditory manifestation is profoundly influenced by the specific acoustic characteristics of the space and the concurrent presence of other sounds. How these diverse sounds interact and impact one another gives rise to a masking effect (Schafer, 1993, 151). The concept of a soundscape was initially conceived to explore the intricate relationship between humans and their sonic surroundings. Since its inception, numerous definitions of soundscapes have emerged, drawing from both musical-acoustic and ecological perspectives. Consequently, the term 'soundscape' is often employed somewhat ambiguously, interchangeably referring to objective realities and subjective perceptions (Grinfeder et al., 2022, 1). A

soundscape is essentially defined as the ensemble of sounds present within a given environment. In Schafer's seminal work, "The Tuning of the World," published in 1977, both natural and artificial soundscapes, as well as their geographical underpinnings, were comprehensively delineated (Polli, 2012, 257). Soundscapes play a pivotal role in assessing the quality of an environment, as they constitute the spatial experience that individuals engage with through listening (Rehan, 2016, 338). The term "soundscape" has been adopted across various disciplines to describe the correlation between a visual landscape and its accompanying auditory composition (Pijanowski et al., 2011, 203). A soundscape serves as an emotional stimulus that significantly influences the perceived quality of different spaces (Habibi et al., 2021, 283). Within the context of soundscapes, it is imperative to delve into the nature of sounds, such as whether they are desired or undesired, and to pay meticulous attention to how all existing sound sources interact and are perceived by individuals within a specific setting (Aletta et al., 2016, 368). Any unwanted sound within a space is categorized as background noise (Ministry of Roads and Urban Development, Building Regulations Office, 2011, 2). The perception of a soundscape is initially grounded in human perception and subsequently subjected to physical analysis (Bartalucci & Luzzi, 2020, 1). A soundscape can be characterized as the ensemble of biophony, geophony, and anthropophony originating from a specific landscape, each contributing uniquely to various aspects of sound utilization across different spatial and temporal scales (Pijanowski et al., 2011, 204). Different spatial contexts yield distinct soundscapes, with variations in perceived sound stemming from their unique acoustic properties. Visual cues and spatial qualities significantly influence how individuals perceive a soundscape. Biophony encompasses the natural sounds emanating from terrestrial or marine habitats and aerial sources (Ghaffari et al., 2021b, 83). Geophony, on the other hand, pertains to the natural, non-biological sounds of a landscape, while anthropophony refers to the myriad sounds produced by human activities and their surroundings, including human speech, aircraft, trains, mobile phones, vehicles, industrial machinery, and more. The amalgamation of biophony, geophony, and anthropophony within a soundscape is termed "cacophony." This cacophony can be a distinctive feature of a specific soundscape or, when excessive, can evolve into noise pollution (Jirge et al., 2017, 181). Biophony is often used to describe the collective sounds generated by organisms, while geophony refers to non-biological environmental sounds such as wind, rain, and thunder. Anthrophony, as mentioned earlier, is produced by human activities (Pijanowski et al., 2011, 204). Natural sounds have the potential to enhance perceptions and restorative experiences by fostering a sense of realism and immersion in nature (Ratcliffe, 2021, 3). However, it is crucial to encourage individuals to identify the sound sources within soundscapes to better understand how biophony, geophony, and anthrophony contribute to the composition, patterns, and processes of sound (Farina et al., 2023, 11). In general, it can be stated that individuals experience a lower level of auditory satisfaction in urban spaces where they are present for essential activities compared to when they are present for elective and social activities (Ghaffari et al., 2021c, 64). Fig. 1 illustrates the structural model of sound and its connection with the mind.

- **Educational spaces**

A school is an institution established based on the official criteria set by the Ministry of Education, aimed at fulfilling individual, social, and environmental needs. It provides an ethical, scientific, safe, healthy, vibrant, and compassionate environment with a collective identity, while also implementing the programs approved by the Ministry of Education at designated academic levels (Planning and Budget Organization, 2016, 5). Educational spaces, as part of public spaces, bring

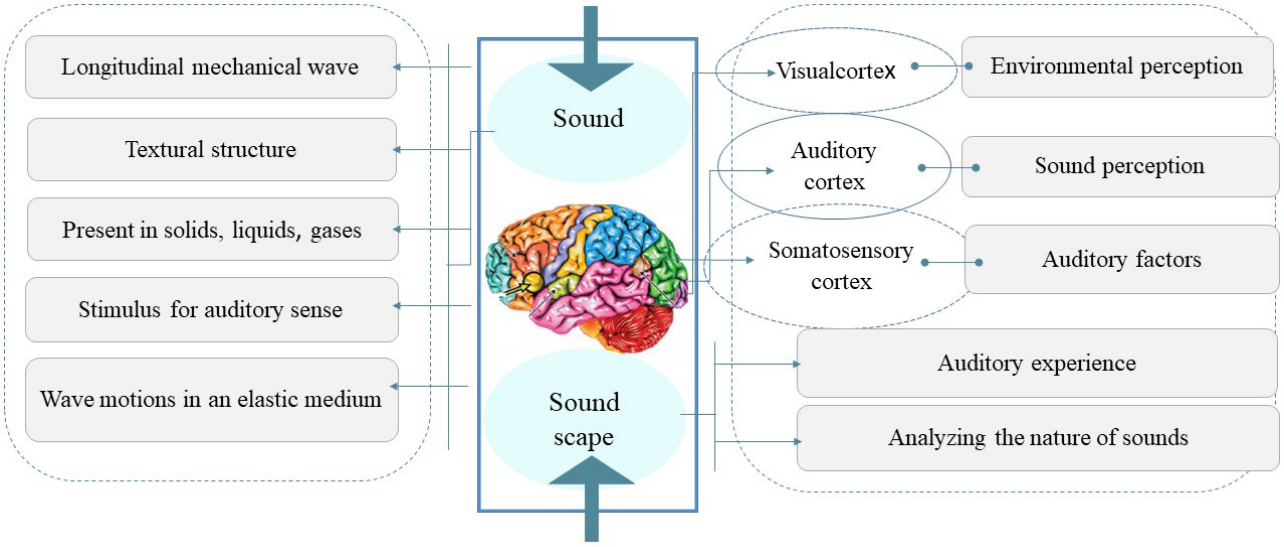

Fig. 1. Structural Model of sound and its connection to the mind. Source: Authors.

individuals together within various spatial organizations, voluntarily, to engage in cultural and social activities. These spaces are considered ideal environments for establishing social interactions (Mansouryar & Jalalian, 2017, 67). The educational environment is defined as everything that happens within a classroom, department, faculty, or university. Perception of the educational environment is directly related to individuals' motivation, satisfaction, and effective learning (Patil & Chaudhari, 2016, 281). Educational spaces encompass all indoor and outdoor spaces, as well as all other areas and elements associated with the school (Lotfata, 2008, 82). Additionally, the spatial conditions of the physical environment significantly impact the teaching and learning process (Widiastuti et al., 2021, 503). Meanwhile, Educational space designers must take into account a variety of factors such as the creation of acoustic rhythms influenced by building materials, architectural and spatial elements, the potential for generating unique underlying and environmental sounds, the diversity of activities and functions within schools, around-the-clock activities of adjacent facilities, the enhancement of social, religious, and national functions in the vicinity of the school, and the design and placement of various types of furniture in different spaces (Tabibzadeh et al., 2020, 12). As growing evidence corroborates the link between physical characteristics in schools, it must be acknowledged that while some impacts are evidently physiological, some others are related to social aspects (Uline & TschannenMoran, 2008, 56 & 57). The elements that constitute the quality of the educational environment include spatial dimensions, lighting, color, sound, diversity, acoustic comfort, thermal comfort, nature, and the presence of open spaces (Torkaman et al., 2016, 10). In the present study, attempts are made to investigate sound and the auditory factors of the soundscape in educational spaces.

- **Cognitive Maps**

Cognitive mapping is a general mechanism for creating an internal representation of sensory information (Gornet & Thomson, 2024, 829). Cognitive maps are based on human perception, mind, and the senses. The experience of lower senses (touch, smell, taste) does not fulfill human cognitive purposes to the same extent as the experience of higher senses (vision and hearing). Therefore, vision and hearing play a more significant role in the perception of aesthetic values (Lang, 2008, 209). As early as 1913, the idea of cognitive maps captivated scientists. Research in this area intensified in the mid-20th century, with psychologists and geographers alike recognizing the connection

between cognitive maps and spatial cognition (Freundschuh, 2009, 336). The formation of mental images is a result of direct and indirect spatial experiences. These experiences involve acquiring, processing, and interpreting information within the human mind, manifesting as internal representations known as cognitive maps. These maps guide individuals' actions and relationships within a given space (Mijani et al., 2023, 381). Generally, three distinct functions can be attributed to cognitive maps: spatial recognition and identification, spatial location and memory, and planning of spatial actions (Poucet, 1993, 164). Cognitive maps encapsulate mental knowledge of the environment. On one hand, they provide individuals with insights into their orientation within a space and its utilization; on the other, they can be employed for planning purposes (Polic & Repovs, 2004, 66). Given that cognitive maps represent an individual's perception of their environment, differences in perceptions and expectations among various age groups lead to cognitive maps with distinct structures (Hanaee, 2022, 183). Cognitive maps can be defined as mental images and concepts constructed for visualizing and absorbing information. They are also referred to as mental maps, schemas, and frames of reference (Sammut-Bonnici & McGee, 2015, 1). The reason people engage in cognitive mapping is that it offers an opportunity to represent their experiences of their environment (Chopra & Mahapatra, 2018, 138). Cognitive mapping is a process comprising a series of psychological transformations through which an individual acquires, stores, recalls, and decodes information about the locations and relative characteristics of phenomena in their everyday spatial environment (Downs & Stea, 1973, 7). Cognitive maps are crucial for facilitating a more comprehensive understanding of how individuals perceive and represent physical spaces mentally. When utilizing them as a tool, it is essential to consider the distinction between real and perceived environments (Triponescu et al., 2023, 1). The process of mapping and the map itself serve as research tools for investigating how individuals understand and perceive built environments and how they function within them (Kim & Penn, 2004, 485). In essence, clear and accurate mental images and cognitive maps of the environment have historically been instrumental in achieving internal representations of the environment and have influenced the shaping of the physical identity of cities (Balali Oskoui et al., 2021, 25) Finally, in some cases, the term "cognitive map" has been used descriptively to denote a conceptual depiction of an individual's cognitive processes, and the result of the cognitive mapping process (Kitchin & Freundschuh, 2000, 2). Based on a review of the literature and the key factors influencing sound, and in alignment with the central focus of this study on auditory factors, the conceptual model of the research is illustrated in Fig. 2.

- **Introduction of the case of study**

In line with the research procedure, the case study is introduced below. Narges Shahed School in District 1 of Qazvin city, recognized as one of the exemplary schools, was chosen as the subject of the study. The school is situated in the northern part of the city, on Shahid Dastgheib Street, between Madani Street and Shahid Beheshti Boulevard. This street hosts five schools, one of which was chosen as the subject of this research. This particular school in this area was selected to investigate the auditory factors that could contribute to the formation of diverse soundscapes. The auditory factors namely anthrophony, biophony, geophony, and ambient noise were surveyed. The Dastgheib Street, which hosts schools along its main (western) boundary, holds significant relevance in the context of educational space and the presence of diverse land uses such as residential, recreational, educational, administrative, park and green spaces, religious, and commercial functions—within a limited geographical scope—has further enriched the diversity of sound sources in the region. Among the mentioned land uses, the Velayat Mosque (religious land use) is located closest to Narges Shahed School, while the green space (service and

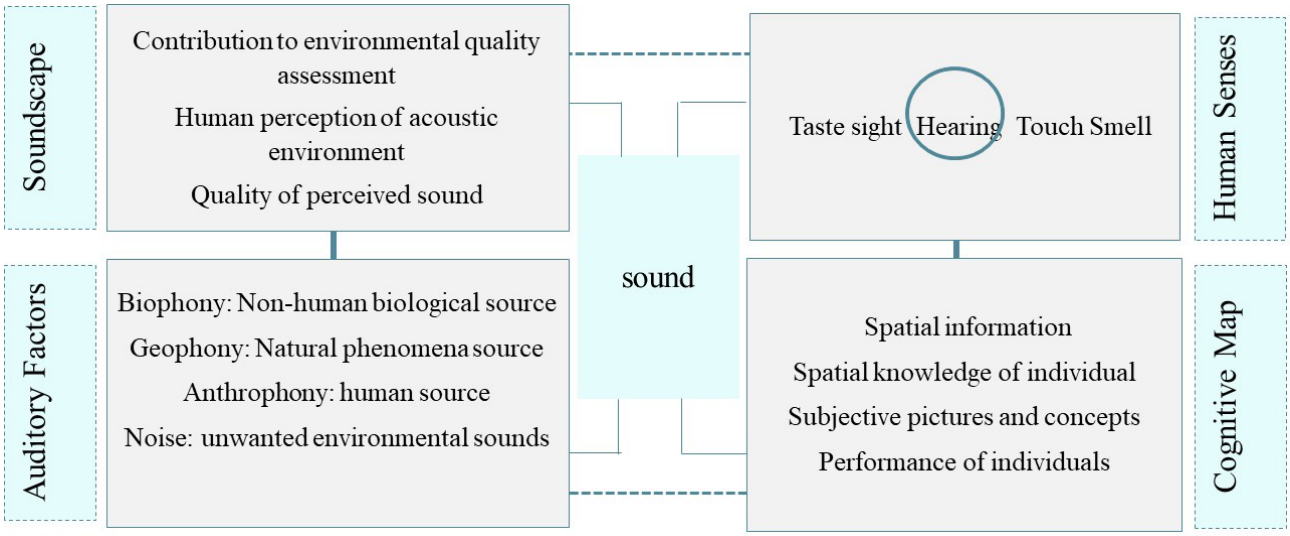

Fig. 2. Conceptual Model of the research. Source: Authors.

recreational land use) is the farthest. Other land uses are scattered throughout the Dastgheib Street area. Notably, all non-educational land uses are located along the eastern side of the street and the point taken into account in the selection of the sample is the presence of schools along a single street, as the soundscape in these educational spaces is directly associated with the surrounding environment. While the environmental settings are similar, individuals' perceptions of the soundscape will vary. Narges Shahed School is characterized by a diverse soundscape both in on-campus and off-campus spaces. Given the school's location, the impact of soundscape is also a noteworthy consideration. Therefore, the reciprocal impact of on-campus and off-campus school spaces on each other and the soundscape of the Dastgheib Street area can be analyzed through various auditory factors including biophony, geophony, and anthrophony. Fig. 3 illustrates the location of the selected case study along with the adjacent land uses.

Findings

To investigate the selected subject, the soundwalk technique was employed during various timeframes (considering visitation hours) and on different days (the beginning, middle, and end of the week) within the educational space. As Narges Shahed School is situated along the educational border of Dastgheib Street, the sound sources in this area varied and both acoustic comfort and noise pollution were significantly affected by the sound sources which also impacted the pleasantness or unpleasantness of the perceived sounds. Field surveys were conducted at the case study site to investigate the soundscape within this educational environment. The soundscape analysis considered acoustic factors, including the sound sources and interactions between sounds. The auditory factors included biophony, geophony, and anthrophony. The sound sources from both on-campus spaces (indoor spaces and schoolyard) and the surrounding off-campus area of the school are compiled in Table 1. To ensure alignment with the research procedure, the sensory navigation technique was utilized during the soundwalk phases. In the present study, both visual and auditory senses were employed and the findings were presented in the form of cognitive maps. In this process, three general sources of sound were identified: Source 1 pertains to the interior spaces (indoor school areas), Source 2 pertains to the schoolyard, and Source 3 pertains to the surroundings of off-campus areas (the area outside the school). Sound points were marked on the maps using dot mapping and marking. In the sensory navigation technique, the movement and stop points, which were determined through the

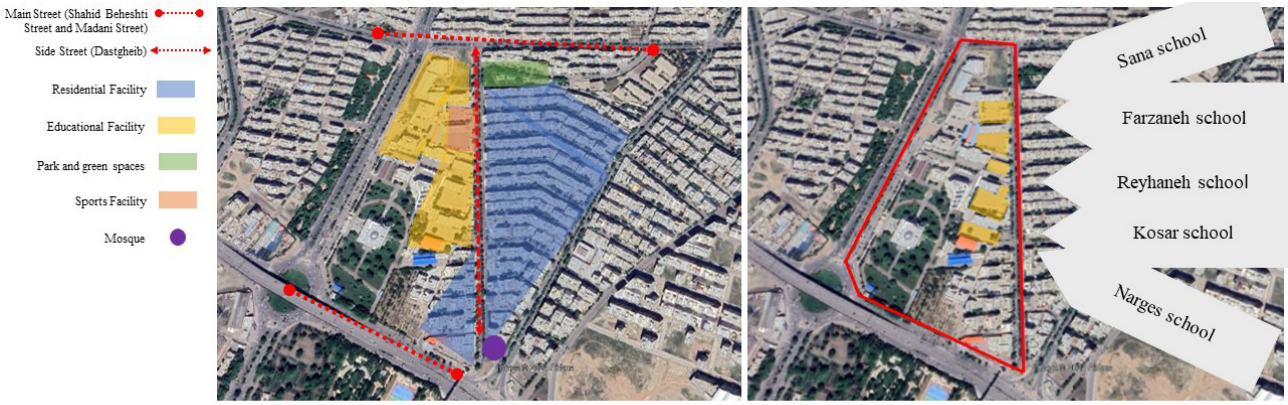

Fig. 3. 1) The location of land uses surrounding the Dastgheib Street area, illustrating the distance between Madani Street and Beheshti Street, 2) The location of the studied educational spaces. Source: Authors based on archive of Qazvin municipality, 2024.

soundwalk method, were analyzed. The study on the mentioned school was conducted during two distinct timeframes within the year: One month in winter and another one month in spring. The auditory factors under investigation during the one-month winter period (February 4 to March 5, 2024) and the one-month spring period (April 9 to May 10, 2024) were identified through field survey and cognitive mapping. The on-site visits to the school were conducted from Saturday to Thursday during three-time slots: 7:30–9:00, 10:00–12:00, and 13:00–14:30, when the soundscape exhibited the greatest sound diversity.

Discussion and Analysis

The present study was an attempt to investigate the formation process of auditory factors in the soundscape of educational spaces in Qazvin city through cognitive maps. Since the research is grounded in the soundwalk method (emphasizing attentive listening during walking and stationary phases) and involves field surveys (data collection and analysis by researchers) through cognitive maps, and taking into account that the emitted sounds originate from various sources, the perceived pleasantness or unpleasantness of sounds affects their positive or negative perception. This perceptual factor constitutes the primary basis for categorizing auditory factors into biophony, geophony, and anthrophony. Dastgheib Street, as a side road, experiences peak traffic during school opening and closing hours (7:30–8: 00 AM on School class days, 2: 30 PM on Saturday through Wednesday, and noon on Thursdays). Positioned between Madani and Beheshti streets, it is constantly exposed to traffic noise and vehicle horns, with a notable increase in both noise levels and sound source diversity during peak hours. Thus, to analyze the soundscape components, it is essential to examine auditory factors and their related elements in parallel, as they significantly influence soundscape quality. Fig. 4 presents the movement and pause points along the soundwalk route in the study area.

Using the soundwalk approach, sound level was assessed during both timeframes (winter and spring). According to the results, the sound level was relatively pleasant in the early morning hours but gradually deteriorated to unpleasant levels as noon approached, mainly due to the proximity of other schools and the Velayat Mosque near the study area, as well as increased pedestrian and vehicular

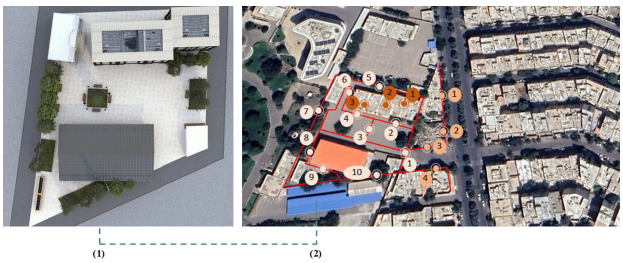

Fig. 4. 1) 3D image of the school, Source: Authors. 2) Movement- stop point along the study area. Source: Authors based on archive of Qazvin municipality, 2024.

Table 1. Analysis of Auditory Factors and Their Corresponding Sound Sources. Source: Authors.

Auditory Factors	On-campus sound sources		Off-campus sound sources
	Source 1 (indoor spaces)	Source 2 (schoolyard)	Source 3 (areas beyond the school perimeter)
Biophony	Insect buzz	Insect buzz	Insect buzz
	Bird chirping (indirect)	Bird chirping	Bird chirping
	-	Stray dog barks	Stray dog barks
	Cat meows (indirect)	Cat meows	Cat meows
Geophony	Wind howl (when windows are open)	Wind howl	Wind howl
	Thunderclap	Thunderclap	Thunderclap
	Storm roar	Storm roar	Storm roar
	Rain patter (audible through open windows during heavy rain)	Rain patter	Rain patter
	-	Water dripping (from the drinking fountain)	-
	-	-	Water flow in roadside streams
Anthrophony	Student-teacher conversations	Student chatter	Public conversations
	Door and window creaks	Door and window creaks	-
	school loudspeaker in the classrooms	School loudspeaker in the schoolyard	School loudspeaker in the schoolyard (echoing in the surrounding off-campus areas)
	Teacher discussions	-	-
	Police and ambulance sirens (audible when windows are open)	Police and ambulance sirens	Police and ambulance sirens
	Student activities	Student playing	Footsteps of people
	Students playing sports in the yard (when windows are open)	Students playing sports in the yard	Students playing sports in the yard (heard in the surrounding off-campus areas)
	Motorbikes, cars, and bicycles passing by (when windows are open)	Motorbikes, cars, and bicycles passing by	Motorbikes, cars, and bicycles passing by
	Car and motorbike horns (when windows are open)	Car and motorbike horns	Car and motorbike horns
	Air conditioners inside classrooms	-	-
	The loudspeaker inside classrooms	The loudspeaker inside classrooms	The loudspeakers of other schools
	The school bell	The school bell	The school bell
	The sound of flipping through book pages	-	-
	Teachers' mobile phone ringtones	-	Mobile phone ringtones
	The sound of the call to prayer (when windows are open)	The sound of the call to prayer	The sound of the call to prayer
	-	The sound of loud music from cars	The sound of loud music from cars
	Street vendors' loudspeakers	Street vendors' loudspeakers	Street vendors' loudspeakers
	Moving objects like desks and chairs	-	-
	-	-	Shopkeepers and vendors
	School transportation traffic (when windows are open)	School transportation traffic	School transportation traffic
	-	Opening and closing school transportation vehicle doors	Opening and closing school transportation vehicle doors
	Teachers talking in adjacent classrooms.	-	-
	Nearby residential homes heard through open windows	-	-

traffic. In the afternoon and evening, the sound level quality improved once again, reaching pleasant levels. The soundwalk method was employed to perform targeted field surveys over both short- and long-term intervals in a continuous manner. All movement and stop points were determined during the soundwalk, and the auditory factors listed in Table 1. were documented. Based on the soundwalk technique, cognitive maps were developed for both on-campus and off-campus school spaces. Fig. 6 provides an analysis of the auditory factors in the off-campus spaces. According to the findings, it was determined that pleasant auditory factors predominantly stem from biophonic and geophonic sources, while unpleasant auditory factors mostly stem from anthrophonic sources, which typically manifest as background noise. In Narges Shahed School, due to the simple and composite separators and partitioning elements used in the building's indoor and outdoor spaces, biophonic elements such as sounds of insects, cats, or birds are perceived limitedly and mostly indirectly only if the classroom windows are open. Additionally, the sound of stray dogs can be heard in the courtyard and surrounding off-campus areas. Geophonic elements, such as the wind howl, rain patter, storms, and thunderclaps, are more prevalent during the winter season, however, in spring, only the rain patter is audible indirectly. Both biophonic and geophonic elements are intermittently and clearly perceived in the courtyard and the areas outside the school. A noteworthy point regarding anthrophonic elements, which are human-made and centered around human activity, is that the intensity of anthrophonic sounds—whether strong or weak—depends on the auditory perception of individuals and is influenced by whether the classroom windows are open or closed. Anthrophonic sounds identified in this context include the students /teachers' conversations, the door and window creaks, the loudspeaker sound within classrooms, conversations between teachers, the sounds of student games, sports, and activities, as well as the sound of air conditioners and classroom loudspeakers, schoolyard loudspeakers and their echoes in the surrounding off-campus areas, the school bell, the sound of flipping through book pages, the ringing of teachers' mobile phones, the loudspeaker of street vendors, the movement of objects like desks and benches, the voice of teachers in adjacent classrooms, school transportation vehicles, the call to prayer, vehicle horns, and the sounds of motorcycles, bicycles, and cars. Further contributing to the soundscape are the sirens of police and ambulances, the footsteps of pedestrians, the voices of nearby shopkeepers, and even the audible sounds from adjacent residential homes through open windows. In Fig. 5, the auditory factors present in the study area are illustrated along the movement route.

Figure 3: Auditory Factors present in the study area. Source: Authors

According to Fig. 6, a multi-layer structured classification system was utilized for the analysis of auditory factors. In the first layer, the spatial layout of students was mapped based on the primary location of classrooms, and the spatial layout of teachers was mapped based on their seating positions in the staff room, as well as the sounds emitted from their respective locations.

In response to the research question: How can criteria for evaluating educational spaces in Qazvin be formulated through auditory factors (biophony, geophony, and anthrophony) affecting sound perception, it can be stated that, in the first layer

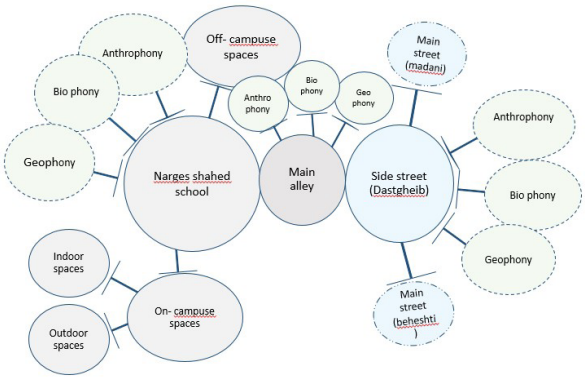

Fig. 5. Auditory Factors present in the study area. Source: Authors.

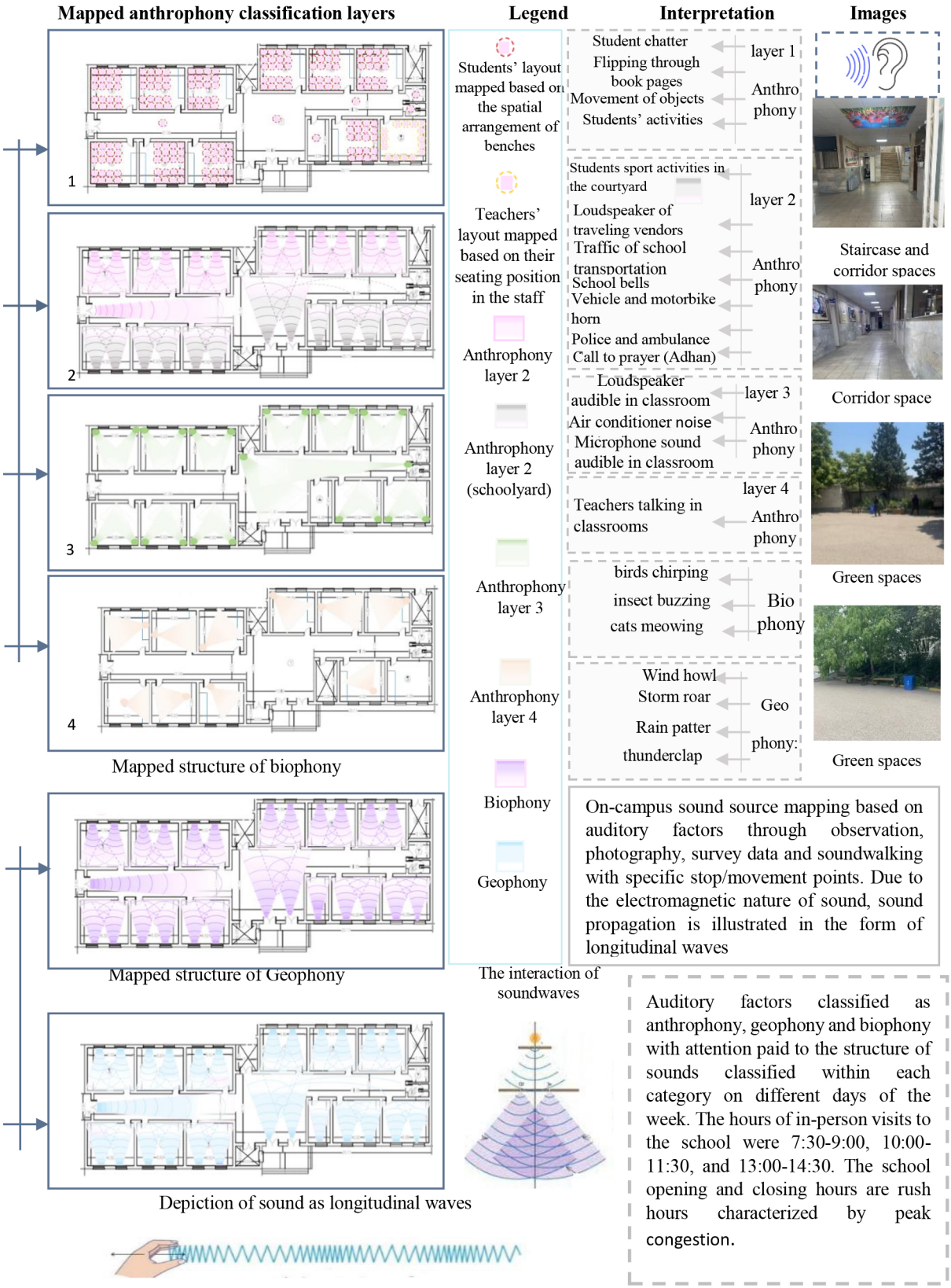

Fig. 6. Analysis of auditory factors in the indoor spaces of Narges Shahed school. Source: Authors.

Fig. 7. Noise levels in external spaces and noise levels in internal spaces of Narges Shahed School. Source: Authors.

of anthrophony, sounds produced by students in the classroom, including chatter, flipping through books, and moving objects have been mentioned. In the second layer, two different colors used to represent anthrophonic elements, correspond to sounds produced by individuals other than students, which are either directly perceived by students or heard as echoes. Off-campus sound sources include the call to prayer (Adhan), police and ambulance sirens, traveling vendors' loudspeakers, and bells from nearby schools. On-campus sound sources consist of students playing sports in the schoolyard and the traffic of school transport vehicles within the premises. Sounds emanating from the schoolyard, such as the students playing sports and the traffic of school transport vehicles, significantly affect most classrooms facing the schoolyard by exposing them to various types of noise. On the other hand, due to the presence of vegetation and trees in the schoolyard, the way sounds propagate differs. Sound waves first interact with the vegetation and then strike the window glasses before reaching the auditory perception of individuals. In the third layer, sounds from loudspeakers, microphones, and air conditioners inside the classrooms are depicted. In the fourth layer, the positioning of the teacher within the classroom in various sides and orientations was taken into account to analyze the above auditory factors. Since anthrophonic sounds generally influence the pleasantness or unpleasantness of the soundscape, background noise, and unwanted sounds often originate from these sources. On-campus and off-campus noise sources within the Narges Shahed School are summarized in Fig. 7. Owing to the acoustic variability and the diverse range of sound sources within the anthrophonic category, background noise is perceptible across all directions throughout the school premises. Based on the conducted analyses and the corresponding results presented in Fig. 7. Focusing on noise within indoor spaces, the schoolyard, and the surrounding off-campus areas—the various noise sources within the indoor spaces of the school, particularly during class hours, have been identified as unpleasant due to their direct impact on students' reception and concentration. Although many of these noises originate from off-campus sources, their echoes still find their way into classrooms through the windows.

Conclusion

The present study was an attempt to investigate the role of auditory factors in the soundscape of educational spaces through cognitive maps, focusing on the Narges Shahed School in Qazvin. In addressing the research question aimed at explaining auditory factors influencing sound perception and criteria for assessing educational environments in Qazvin, survey-based data were collected through soundwalks and cognitive mapping at Narges Shahed School. Attention to ambient sounds in various spaces, particularly educational environments, is a critical aspect when conducting acoustic studies. In the present study, attempts were made to explore auditory factors in educational spaces through investigations conducted at different timeframes and time slots and to analyze their impact on the Narges Shahed School in Qazvin, as a school affecting the soundscape of Dastgheib Street. The auditory factors identified in the case study were categorized into three groups: biophony, geophony, and anthrophony, and the unwanted sounds, identified as background noise from the anthropophonic sources, were collected. Biophony and geophony, as elements with natural and biological sources, are identified as relatively pleasant. In the category of anthrophony, which pertains to human-generated sounds, the types of sounds vary, often adopting unpleasant characteristics represented as noise. In the present study, the method of graphical representation was utilized to create cognitive maps. Given the direct relationship between these maps and individuals' perceptions, cognitive maps were drawn based on the sound conducted in the study area by the researchers. Considering that various sound sources contribute to the formation of the soundscape, the noise resulting from them directly

impacts auditory senses and students' concentration. Based on the three acoustic components—biophony, geophony, and anthrophony—outlined in the present study, the focus of the evaluative criteria used in the study is mostly on off-campus noise from the beginning of the school day until mid-school hours, while on-campus noises, primarily generated by the students themselves, play a less notable role. Since the school is bordered by neighbors on three sides and only connected to Dashtgheib Street from the eastern side, most of its noise originates from these directions. However, in the late hours of the school day, due to the presence of school transportation vehicles in the yard and the departure of students, on-campus noise plays a more significant role in shaping the soundscape. Additionally, thanks to the classroom windows and the situation of some classes along the yard's perimeter, sounds from both the yard and outside the school area interact with the window glasses. According to the soundwalk surveys conducted across multiple timeframes and slots on different weekdays, the soundscape quality diminishes during the school's opening and closing times, which could be attributed to the high volume of students, school transportation vehicles, and other individuals present both inside and outside the school premises. Among the three auditory factors subjected to investigations, anthrophony has a stronger impact on the environment. According to the findings, students and passersby, or individuals temporarily present in the area, report less dissatisfaction compared to those who are permanent residents of the area. However, since most of the sounds are repetitive and continuously audible, the soundscape of the area is less pleasant for the residents. This is because the propagation of sound in an open space, such as the areas beyond the school premises, depends on the geometric structure of the sound's source. Among indoor spaces, the classroom holds greater significance because, according to the standards, the optimal reverberation time for an unoccupied classroom with a volume of 175 cubic meters ranges from 1.2 to 1. 5 seconds and decreases to 0. 9 to 1. 0 seconds when the classroom is occupied by students (Forer & Lauber, 1990). This is partly true for the classes in the aforementioned school. The vegetation in front of classroom windows can act as an acoustic barrier. According to the findings, the following suggestions can be made:

- Considering the background noise levels within a space and mitigating them through appropriate acoustic control measures.
- Utilizing effective partitioning elements (Robust walls, floors, ceilings, and doors) to protect against noise in educational environments.
- Identifying the soundscape and diverse sound sources and their propagation pathways to separate micro spaces within an educational setting, such as a school, through acoustic interventions.
- Considering the number of users in a space before using sound-absorbing layers and appropriate partitioning elements.
- Separating sensitive areas, such as high-noise and low-noise zones.
- Using sound-absorbing materials to ensure the reflection of unwanted sounds.

Proper site selection for the construction of educational spaces and avoiding excessive mixed-use areas within the educational settings.

Based on the analysis of auditory factors at Narges Shahed School, it can be inferred that biophony, anthrophony, and geophony are directly and indirectly perceived in indoor spaces, the schoolyard, and the extramural areas, through the reflection of dominant environmental sounds. Considering that the components of biophony and geophony, whose origin is non-human and natural biological factors, were relatively desirable except when they appear with indescribable intensity, and the anthrophony component with its human-centered and man-made characteristics is undesirable when it appears as noise and desirable in other cases. These soundscapes directly affect the auditory senses, perception, concentration, learning and cognition of students.

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