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Research on the Differences of Outdoor Sound Perception and Sound Preference between Urban and Rural Residential Areas

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Abstract:

In this study, it has investigated the residents' sound perceptions to outdoor sound sources in urban and rural residential areas by means of field measurements and questionnaire surveys, in which it analyzed the differences in sound perceptions and sound preferences of urban and rural residents, laying a sound foundation for subsequent soundscape designs for people of different socioeconomic status. The study demonstrated that the sound pressure levels (abbreviated as"SPL") of the third floor in the countryside was lowest. The SPL from the first floor to the second floor in cities declined gradually floor by floor. Whereas, the SPL from the second floor to the third-floor climbed layer by layer. The disparities in the sound sources in urban and rural residential areas contributed to the distinctions of the sound source recurrence rate between urban and rural residents. Rural residents' favorite was the sound of music, while urban residents' favorite was the sound of birds. There is a correlation at $p \leq 0.05$ or $p \leq 0.01$ between residents' gender, age, educational level, individual sound source and his/her sound preference evaluation. However, economic factors are not related to the resident's sound preference evaluation but affect it indirectly.

Keywords*:residential area, urban and rural residents, sound preference, sound source recurrence rate*

I. INTRODUCTION

At present, the sound plays an important role in identifying the environment of a place is comfortable to live in or not for us. Many architects and planners believe that it is a necessity to take the sound perception as a research project [1-3]. The sound perception is a human-centered term that attaches importance to the sounds that people could sense in daily life, understands the people's preference of sounds, then creates such sounds for people in their living environment [4, 5]. Therefore, people's preference is the core of sound perception research. Understanding what kinds of sound sources suit people's tastes and what factors affect their preferences contribute to the definition of a "high-quality" living environment. It has always been the focus of many studies of pursuing people's preferred sound sources and influencing factors and it has practical significance for planners and architects [6-8]. With the progress of society, the open space in urban and rural areas is becoming increasingly multifunctional and integrated, thus forming a complex acoustic environment and having an impact on the crowd [9, 10]. In the past studies on acoustics, most of them concentrated on the prevention and control of noise [11, 12], but the quality of the acoustic environment has not been effectively improved. At present, there is a trend to convert the research from only controlling the noise to the people's sound perception, which has brought about changes to the field of acoustic environment design. The sound perception is an important aspect of evaluating the acoustic environment, which has been widely used in the research of urban open space acoustic environment [13-17]. However, there are still relatively fewer researches on the disparities in sound perception for disadvantaged groups and common groups. It is necessary to understand the differences between the rural residents, the disadvantaged group with low economic income, and urban residents' sounds preferences, as well as the sound perception trends of groups with different incomes so as to provide references for soundscape design in the future.

In the urban and rural open space, the living space is an important place for people's daily leisure and living, where the acoustic environment experience has a direct impact on people's routine life. In-depth investigation and analysis of residents' ways of thinking as well as recognition of the acoustic environment are conducive to determine how to improve their quality of the living environment [18-20]. Myung-Ho Han et al. have confirmed the importance of the acoustic environment in residential areas and divided the sounds into 7 categories, indicating that there are differences in the sound perceptions regarding residents' personal characteristics (such as age and educational level) and residential characteristics (such as regional differences and utility) [21]. Guillermo Rey Gozalo et al. have suggested that the daytime noise is the most influential environmental feature on the urban acoustic environment perception [22]. Kin-Che Lam et al. have manifested that rural villagers' sound perception preferences are not related to the psychoacoustic indicators in statistics, but, related to whether people want sounds or not [23]. Jian Kang and other studies have demonstrated that Chinese villagers prefer nature sounds, animal sounds and sounds of music compared with British villagers, and they dislike traffic and industrial sounds. Nature sounds have a greater impact on the activities of British villagers than that of Chinese villagers [24, 25].

Over the past several decades, the decline trend of population in rural areas has become ever apparent, while the urban population has become more and more concentrated. Currently, 57% of the inhabitants live in agglomerations with a population of more than 300,000. It is estimated that 62% of the global population will live in cities by the year 2030 (UN, 2014). [26]. We chose Harbin City and Jianshan Farm in Nenjiang County of Heihe City as research sites and used objective sound level measurements and subjective questionnaires as data collection tools. Residential areas are important places for people's daily lives, and their acoustic environment experiences place direct influence on people's daily routine. Therefore, this study aims to investigate the differences in the sound perceptions to sound sources in outdoor environment between rural residents and urban residents. The main objectives of the research are: 1. Discuss the differences in the sound field distribution between rural and urban residences. 2. Investigate the differences in sound source recurrence rate of urban and rural residents to the outdoor acoustic environment in residential areas. 3. Investigate the differences in the sound preference of urban and rural residents towards the outdoor acoustic environment in residential areas. 4. Analyze the individual

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characteristics that influence the residents' acoustic environment evaluations. This study focused on whether there are some differences in the sound perceptions of urban and rural residents regarding the outdoor environment in residential areas, providing references for the construction and design of residences for people in different socioeconomic status.

II. METHOD

2.1 Site Selection

The study is conducted to look into the impact of socioeconomic status on sound perceptions. Due to the large income gap between urban and rural residents [27,28], urban and rural residential areas were selected as the main parts of the survey. In the winter of 2019, 124 villages in Heilongjiang Province were visited and surveyed. Finally, Jianshan Farm in Nenjiang County of Heihe City was selected as the representative village to conduct the investigation regarding the sound perceptions of residents in the residential area. The major reason for selecting this area as the research subject is that it is characterized by the specialties of the new village and the old village. The types of this residential area include both bungalow in the old village as well as two-story apartment houses and multi-story apartment buildings in the new village with different grades of roads and relatively developed traffic systems. It is convenient for the sample survey as there are a large number of residents in this area, and the sound sources are diverse and representative. Because we mainly investigate the differences in sound perceptions of rural and urban residents under different economic conditions, according to the economic situation and green area of the residential areas, excluding the apartment houses with the best rural economic conditions, and we finally selected an wing building, Wenxin Home Community and an area of bungalow as the survey targets (Figure 1).

Fig 1: Site selection in rural areas

With respect to urban area, Harbin City was selected as the representative to conduct the survey of

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people's sound perceptions, as it is the capital city of Heilongjiang Province with representative features of large flow of people and distinct levels. In the winter of 2019, we visited and investigated 131 communities in Harbin City. Firstly, the urban fringe areas and villas were excluded according to the economic situation and the green area of the residential areas; secondly, the top-grade communities were excluded based on the operability of the survey subjects; finally, the residential areas around tourist attractions were also excluded on account of their geographical locations. Among the remaining communities, Songshan Community and Liaohe New Area were characterized by the general features of urban residential areas. It is easy to sample as there are a large number of residents and an even distribution of ages with the representative different green area environment. (Figure 2)

Fig 2: site selection in urban areas

2.2 Field Measurement and Survey

We adopted the AWA5680 Sound Level Meter for testing in this survey. Since A-weighting sound level mainly simulates low-intensity noise frequencies less than 55dB in the three weighting networks of A, B and C, and the characteristic curve of the weighting sound level is similar to the auditory perception of the human's ears, the measurements of the ambient sound level and the sound level of a single sound source are based on the continuous equivalent A sound level measurement.The measuring sites in the countryside are located at No. 54 and No. 61 of the Sixth Committee of bungalow areas. No. 54 is on the street as shown in Figure 3, and No. 61 lies in the west of No. 54 and not on the street; among the multi-story apartment buildings, we chose Building B6 and B7 of Wenxin Home Community, of which Building B7 was a multi-story apartment building on the street, while Building B6 located behind Building B7, not on the street. There was an internal green belt between the two buildings and both were four-story; the rest separate multi-story apartment buildings were all on the street. The Wing Building No. 3 was used as a measuring site with six floors in total. The field measurement adopted the method of measuring layer-by-layer. Window closed, the probe detector was fixed to 1.2 meters away from the ground and 1.5

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meters away from the exterior window of the building. It counted once every one second, continuously measuring each site for 5 minutes, and recording 10 times for each measuring site in the sunny days in April and May of 2020. The specific periods of time for the measurement were 8:00 to 10:00, 14:00 to 16:00, and 20:30 to 22:30. The tests proceeded in working days.

Fig 3: Measuring sites in rural area

The measuring sites in urban area were selected as Building 17, Building 35 and Building 7 in Songshan Community. As shown in Figure 4(A), Building 17 is adjacent to Xianfeng Road, and Building 35 is obliquely behind Building 17, not on the street. There was an internal green belt between the two buildings; Building 7 was located behind Building 17 on the Songshan Road. The three buildings were all multi-story apartment buildings, of which there were 6 floors in Building 17, 7 floors in Building 35 and 4 floors in Building 7; we selected Building 3 and Building 4 from Liaohe New Area, as shown in Figure 4(B). Building 3 is neighboring Liaohe Road and Building 4 is located behind Building 3, not on the street. There was an internal green belt between the two buildings. Both were multi-story apartment buildings, of which there were 7 floors in Building 3 and 6 floors in Building 4. The measuring method and time are the same as those measured in the rural area.

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A B

Fig 4: Measuring sites in urban areas
(A: measuring sites in Songshan Community, B: measuring sites in Liaohe New Area)

2.3 Questionnaire

2.3.1 Participants

In this study, the urban locals and people making their residences in the city for studying or working were chosen as urban residents, and the rural residents involved in the rural locals and the inhabitants for permanent living in village. The reasons are as follows: (1) Residents who live in urban areas and rural areas for a long period of time understand the city or the countryside better and are clearer about their needs for sounds and what noise they are troubled by; (2) Inhabitants are more familiar with the local culture and climate than tourists, which can exclude other factors that have an impact on individual sound perceptions. (3) Urban residents generally have higher income than rural residents do, and the income of permanent residents tends to be stable, which is feasible for research on.

2.3.2 Questionnaire Design

In order to investigate the subjective evaluations of urban and rural residents to sound perceptions and the influencing factors of their evaluation contents, this study has conducted cautious designs to the questions of the questionnaires and on-spot questionnaires to the inhabitants within the sample areas.

The questionnaires were surveyed quarterly, and each survey was distributed in three times. The questionnaire 1 for the first time is a preliminary one to determine the types of sounds in the residential areas and divided into two parts. The first part is for the residents to write down the outdoor sounds firstly heard and other sounds that can still be heard at home and in the community. The second part is designed for individual characteristics, including social factors such as gender, age and floor of living, for which some studies have shown that residents' social characteristics and behaviors may also affect their sound preferences and sound comfort [29]. In order to maintain the validity of the questionnaire, individual characteristics also include time period of living, excluding short-term residents in the community. With

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the purpose of effective collection of basic personal information, the questionnaire divides age and income, etc. into groups at the end and allows the interviewees to choose; the questionnaire 2 for the second time is distributed as the survey of the indoor sound perceptions of urban and rural residents. The questionnaire is divided into three parts: first part for the sound setting. According to the collected questionnaires 1, the types of sound sources that urban and rural residents can hear are sorted out. Due to the diversities of the sound sources and the similarities in the contents of the sound sources that studied by Kang J., referring to Kang J et al. [30], the sound sources are classified into six types: nature sounds, animal sounds, man-made sounds, musical sounds, mechanical sounds and traffic sounds. In order to obtain complete survey information and make it easier for the interviewees to fulfill the questionnaires, questions about the acoustic environment evaluations and sound preference evaluations are refined to a single-choice grading scale. The Likert Scale Method is used to divide the interviewee's responses to each sound and their degrees of preference into 5 grades, which are "1-Extremely Dislike", "2-Dislike", "3-Neutral", "4-Like" and "5- Extremely Like ". The second part is about the urban and rural residents' satisfactions with the indoor acoustic environment and their disturbance degree of noise. The Likert Scale is still used to divide the interviewee's satisfactions to each sound into 5 grades from "1- Extremely Dissatisfied" to "5- Extremely Satisfied ", and "1-Often", "2-Occasionally", "3-Didn't notice", "4-Occasionally but Acceptable" and "5-Never". The third part is designed for the individual characteristics; the questionnaire 3 for the third time is distributed to carry out the survey of outdoor sound perceptions of urban and rural residents and divided into three parts. Except for individual sounds, the remaining parts are the same as questionnaire 2 (see appendix). To obtain an objective and effective evaluation, the questionnaires for three times are distributed on the basis of random selection of residents in residential areas as the survey subjects. Secret ballot was adopted to complete the questionnaires. SPSS software was used for data input and correlation analysis.

2.3.3 Reliability Analysis

Each of the 3 questionnaires for the urban and rural areas was sent out for 150 copies, including 148 valid questionnaire 1 returned from rural area, 145 valid questionnaires from urban area; 144 valid questionnaires 2 were received from rural area and 147 valid questionnaires from urban area; 149 valid questionnaires 3 were returned from the rural area and 146 valid questionnaires from the urban area. In order to investigate whether the sound preferences of rural and urban residents are the same, they share a set of questionnaires with the same sound sources.

In this study, the KMO Test and Bartlett's Test of Sphericity were employed to test the internal validity of the data results [31]. The KMO Test results measured on questionnaires 2 and 3 reached $0.861>0.6$, which met the factor analysis requirements; the significant level in Bartlett's Test of Sphericity was $p=0.000<0.01$, which proved that the questionnaire survey results passed the validity test; the reliability test adopted the Cronbach coefficient test [32], and the Cronbach's alpha was $\alpha=0.856>0.7$ for the questionnaires 2 and 3. The inherent high consistency of subjects indicated the reliability of the results in the survey.

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III. RESULTS AND ANALYSIS

3.1 Characteristics of Sound Field Distribution

As shown in Figure 5, the SPL of Wing Building No. 3, which is a multi-story apartment building on a busy street, was highest, peaked at 62.7db during a day. A possible explanation for this result is that this busy street has heavy traffic and a large flow of people throughout the day. The places with the second highest, SPL were No.54, Six Community of the bungalow area, No.61 of the bungalow area and Building B7 of Wenxin Home Community, and the maximum values were 55.9db, 55.7db and 55.6db respectively. This result could be explained by the fact that Building B7 of Wenxin Home Community is located on a street and the result is affected by the traffic. While people living in bungalow area may raise poultries such as chickens, ducks, geese and dogs, and the sound of animals could affect the result. This can also explain the result that whether bungalow area is located on a street or not has a little effect on the SPL.

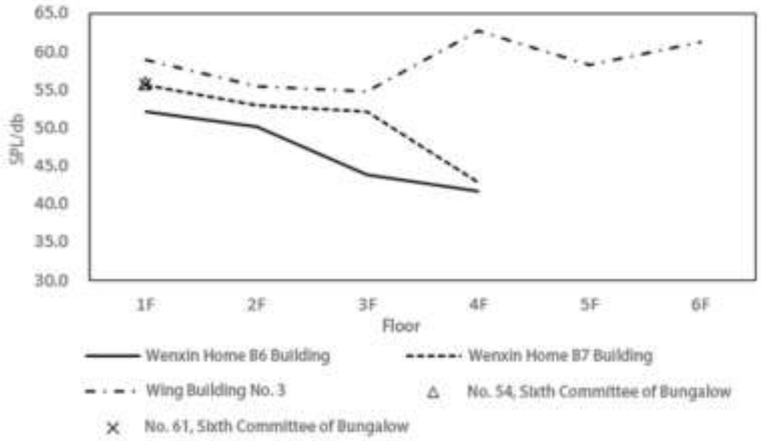

Fig 5: Sound pressure levels at each measuring sites in rural area

Figure 6 shows the SPL of each measuring sites at each time period and each floor in the rural area. In terms of time, the SPL was highest during the period from 14:00 to 16:00, as a result that residents returning from farm work and social activities. The second highest SPL was in the period from 8:00 to 10:00, during which residents were doing morning exercises, going out for farm work and shopping, etc. The lowest SPL happened from 20:30 to 22:30. For rural residents, there was neither outdoor nor indoor activities in this period of time. Regarding floors, the SPL in unit public space from 1F to 3F of Wing Building No. 3 decreased with the growth of the floors, and the SPL increased with the growth of floors from 3F to 4F, and the SPL went down with the growth of floors from 4F to 6F. The SPL dropped to the bottom when we were on the third floor, and the second lowest SPL was on 2F and 5F. The SPL reached its peak on the fourth floor. The SPL in the public space of a unit of B6 and B7 of Wenxin Home Community went down with the growth of floors from 1F to 4F.

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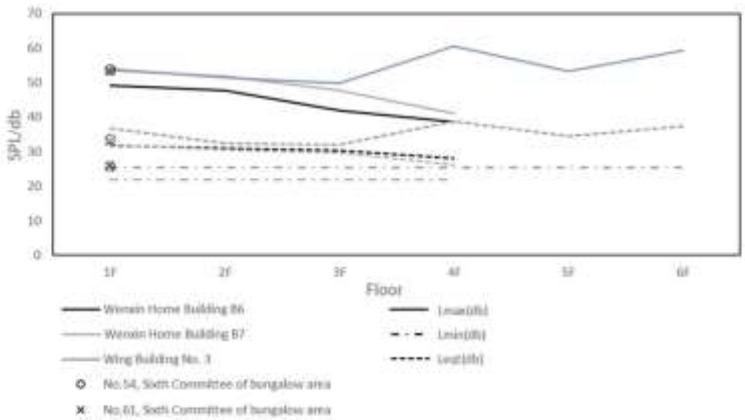

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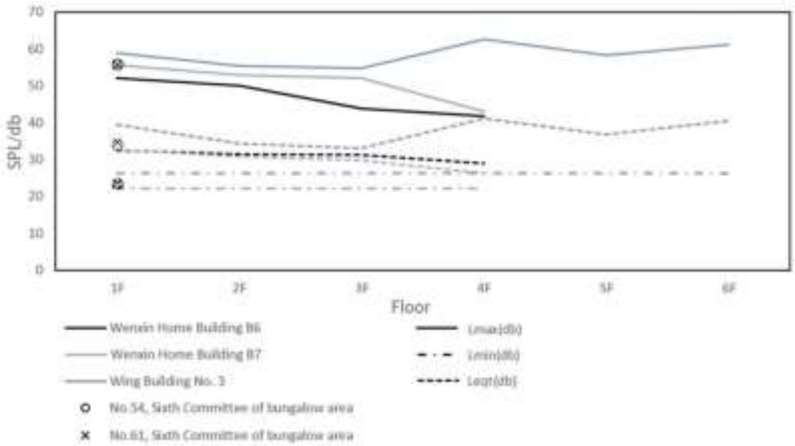

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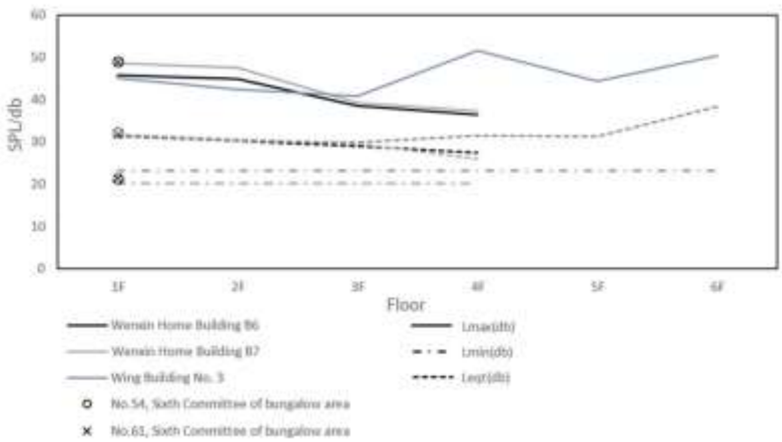

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Fig 6: Sound pressure levels of each measuring sites at each time period and each floor in the rural area (A: 8:00 am-10:00 am; B: 14:00 pm-16:00 pm; 20:30 pm-22:30 pm)

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Displayed in Figure 7, the SPL of Songshan Community Building 17 was highest and the maximum value peaked at 76.2db in a day. This is because Xianfeng Road next to Songshan Community Building 17 and it is a main street with extreme heave traffic throughout the day. The second highest SPL was in Songshan Community Building 7, which could reach 64.2db and in Liaohe New Area Building 3, which could reach 59.7db. Songshan Community Building 7 is located in Songshan Road and Liaohe New Area Building 3 is located on Liaohe Road. They are both affected by the passing traffic. While Songshan Community Building 35 and Liaohe New Area Building 4 are not near any streets, the noise is relatively low. The SPL of Songshan Community Building 35 was the lowest. Songshan Community has a larger green area than Liaohe Community. It can be seen that traffic noise is the main source of noise in urban residential area, and green area can effectively reduce the noise.

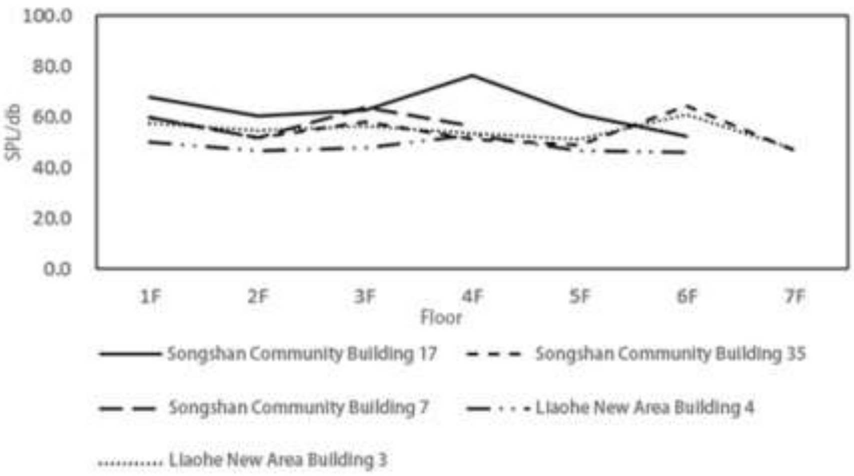

Fig 7: Sound pressure levels of measuring sites in urban area

As can be seen in Figure 8 that the SPL reached its maximum during the period from 8:00 to 10:00, during which residents mainly went to work or did morning exercises. The second highest SPL was in the period from 14:00 to 16:00 since it was the major period for residents to participate in social activities. The SPL was minimum from 20:30 to 22:30. Generally, residents did not go out for any activities, and only a few might go out for walks or shopping. It was found that the SPL varied with floors. The SPL measured in Liaohe New Area Building 4 (not on the street) and Songshan Community Building 17 (on the street) reached its lowest point on 6F, while it reached its highest point on 4F; The SPL measured in Liaohe New Area Building 3 (on the street) and in Songshan Community Building 35 (not on the street) both reached its bottom on 7F and peaked on 6F; The SPL measured in Songshan Community Building 7 (on the street) reached the bottom on 2F and the summit on 3F.

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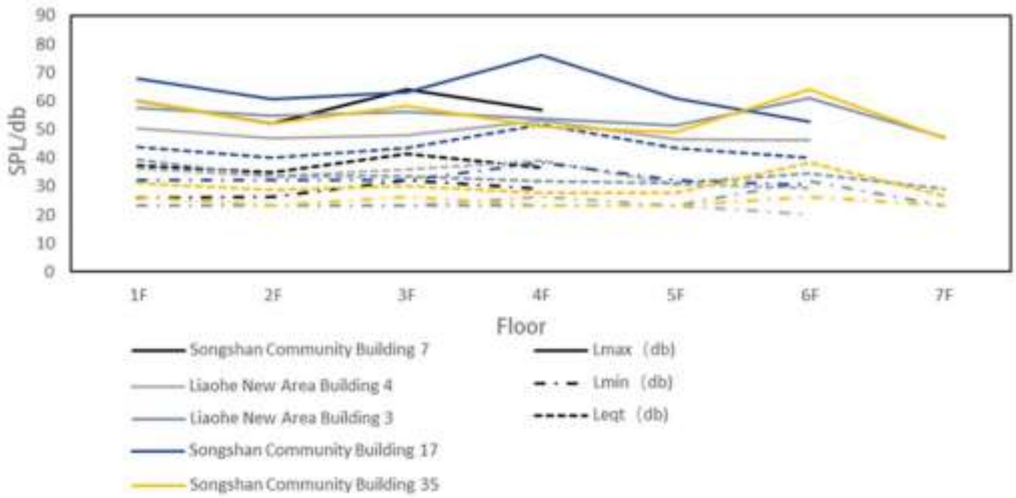

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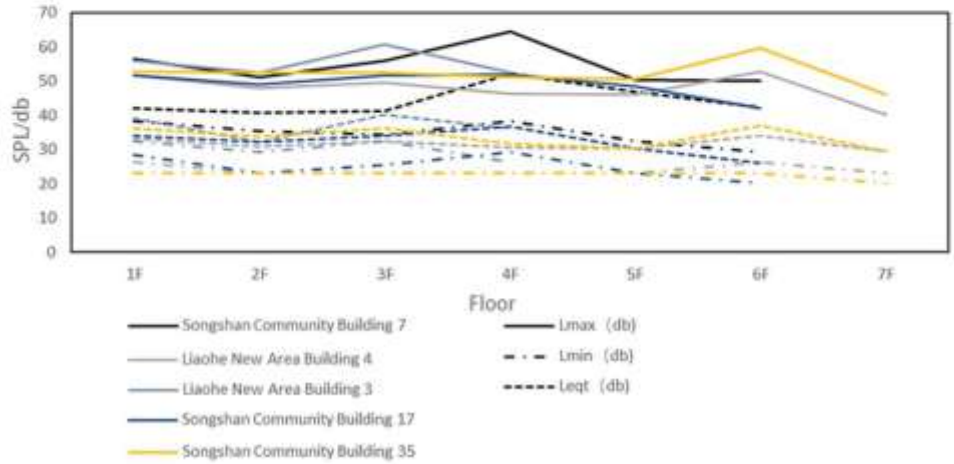

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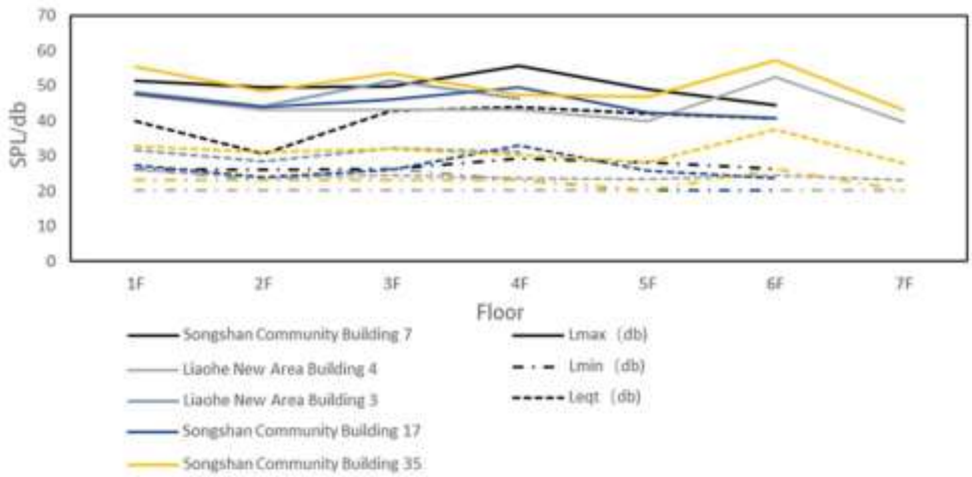

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Fig 8: Sound pressure levels of each measuring sites at each time period and each floor in the urban area (A: 8:00-10:00; B: 14:00-16:00; 20:30-22:30)

In summary, the traffic sounds and the flow of people both have effects on rural apartment buildings, no matter buildings are on the street or not. The SPL of the third floor in an apartment building near a street was lowest, followed by the second and fifth floor. The SPL of apartment buildings not near streets decreased with the growth of floors. It indicated that in a relatively quiet environment for a long time, the higher the floor is, the quieter it is. The apartment buildings on the street in urban area were affected by the sound of traffic most, whereas the buildings not near street were affected by its interior sounds. In apartment buildings on the street, the SPL on 2F, 6F and 7F were lowest, and it was the same for 6F and 7F in the buildings not on the street. Moreover, whether buildings were near street or not, the SPL from1F to 2F decreased gradually floor by floor and increased from 2F to 3F floor by floor. On the whole, the green area in cities is better than that in rural areas, and the environment in rural areas is quieter than that in cities.

3.2 Evaluation Results of Sound Source Recurrence Rate

After understanding the sound field distribution in residential areas, the analysis of the sound recurrence rate of sound source in rural and urban residential area was accomplished. The indoor and outdoor sound sources in urban and rural residential areas were studied through Questionnaire 1 as follows: man-made sounds in urban and rural areas included chatting sound, sound of children frolicking, footsteps, road sweeping sound as well as firecracker sound in rural areas in winter; traffic sounds include tire/road noise from vehicles, car horn, motorbike sound and agricultural vehicle sound in countryside; mechanical sounds included noise from remodeling, factory machinery sound and mechanical equipment sound; nature sounds included wind blowing leaves sound, rain sound and lightning sound; animal sounds include bark, sounds of birds, chirping of cicada, cockcrow/quack/honk of goose and bleat/moo in countryside; musical sounds include sound of music, sound of musical instruments and sound of square dancing.

Figure 9 illustrates the percentage of indoor sound recurrence rate in urban and rural residential areas. As shown in the figure, the most frequent sounds heard by rural residents in winter were the tire/road noise from vehicles, car horn and occasionally heard road sweeping sound, chatting sound, sound of children frolicking, cockcrow/quack/honk of goose, bleat/moo and bark, etc. Due to the frequent cleaning and transportation of coal for heating in winter, the sounds of mechanical equipment and factory machinery can also be heard. Owing to the loudness of firecracker sound, it was the first sound to be heard by residents in indoors and outdoors during the Spring Festival. Since the firecracker sound exists at a specific period and the mechanical equipment sound was not often heard, so the two sounds were not included in the indoor and outdoor sound recurrence rate statistics. The sound most frequently heard for indoor residents in the cities was the traffic sounds, and occasionally heard the road sweeping sound, the sound of music, chatting sound and the sound of children frolicking; the sound that indoor residents in the

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countryside firstly perceived was the sound of agricultural vehicles, the tires/roads noise from coming and going vehicles as well as car horn, followed by sounds of children frolicking, bark, sound of birds and sound of music, and sometimes heard chatting sounds, wind blowing leaves sounds and other nature sounds. The most frequent sound heard for indoor residents in cities was the traffic sound, followed by the sound of children frolicking, bark and sound of birds, and occasionally heard chatting sound, sound of music and wind blowing leaves sound and other nature sounds; the most recurrence rate of sounds heard for indoor residents in rural spring and autumn were the sounds of agricultural vehicles, tires/road noises from vehicles and car horn, followed by chatting sound, sound of children play, bark and sound of birds, occasionally sound of music, sound of musical instruments, sound of square dancing, wind blowing leaves sound and rain sound; The most frequent sounds that the indoor residents heard in the cities were still the traffic sounds. In addition, the Songshan Community was being renovated at that time, thus, there were noises from remodeling, and followed by the sound of birds from indoors. Occasionally they could hear chatting sound, sound of children frolicking, sound of music, wind blowing leaves sound and rain sound.

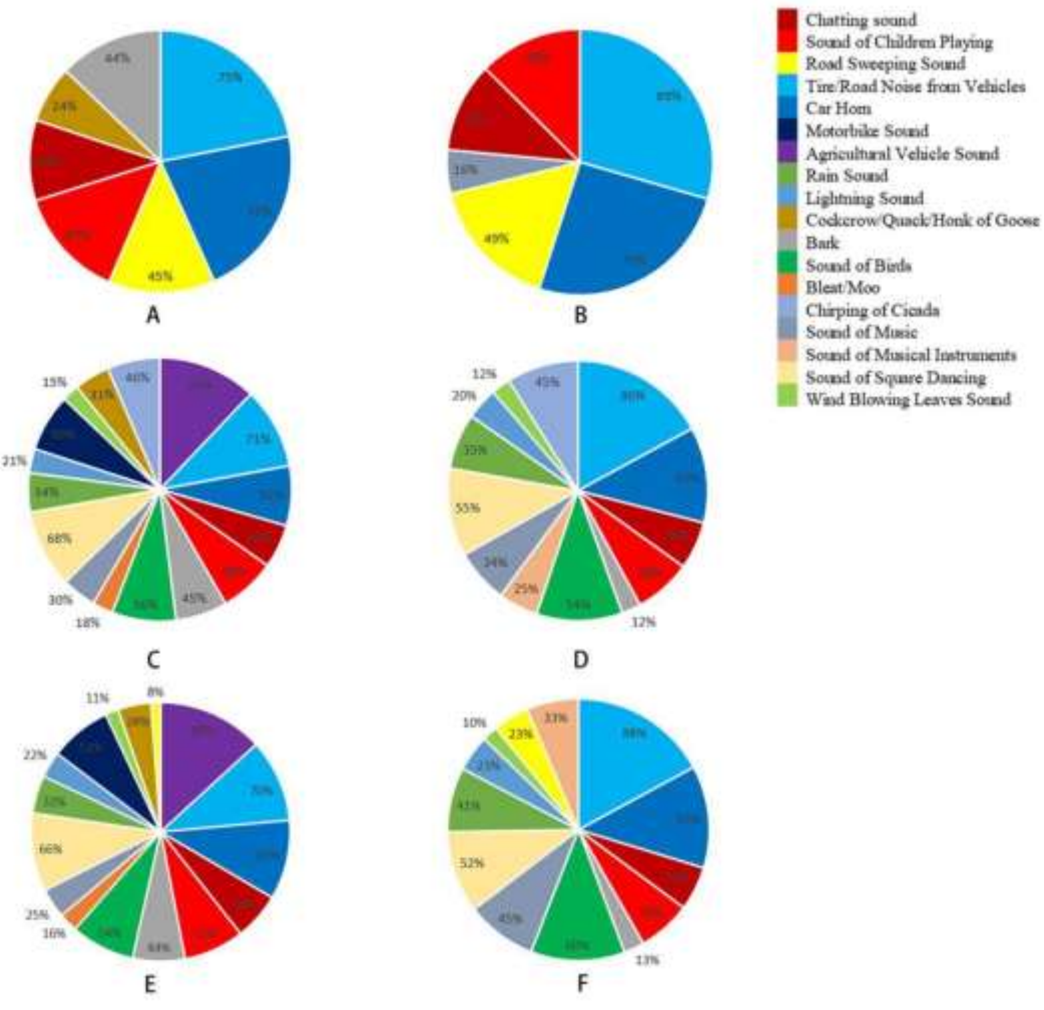

Fig 9: Indoor sound recurrence rate in rural and urban areas

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(A winter in rural areas; B winter in urban areas; C summer in rural areas; D summer in urban areas; E spring and autumn in rural areas; F spring and autumn in urban areas)

Figure 10 indicates the percentage of outdoor sound recurrence rate in urban and rural residential areas. As shown in the figure, the most frequent sounds that outdoor residents heard in winter of rural area were tire/road noise from vehicle and car horn, followed by sounds from animals, footsteps, road sweeping sound, chatting sound and sound of children frolicking. For outdoor residents in cities, they heard the sound of traffic most frequently, and followed by footsteps, road sweeping sound, chatting sound and sound of children frolicking, and occasionally sound of music and bark; the sound most frequently heard for outdoor residents in summer as well as spring and autumn in the countryside were sounds of agricultural vehicles, the tires/road noise from vehicles and car horn. The most frequently heard sound for outdoor residents in cities was traffic sounds, followed by man-made sounds, animal sounds and musical sounds in urban and rural areas with occasional natural sounds.

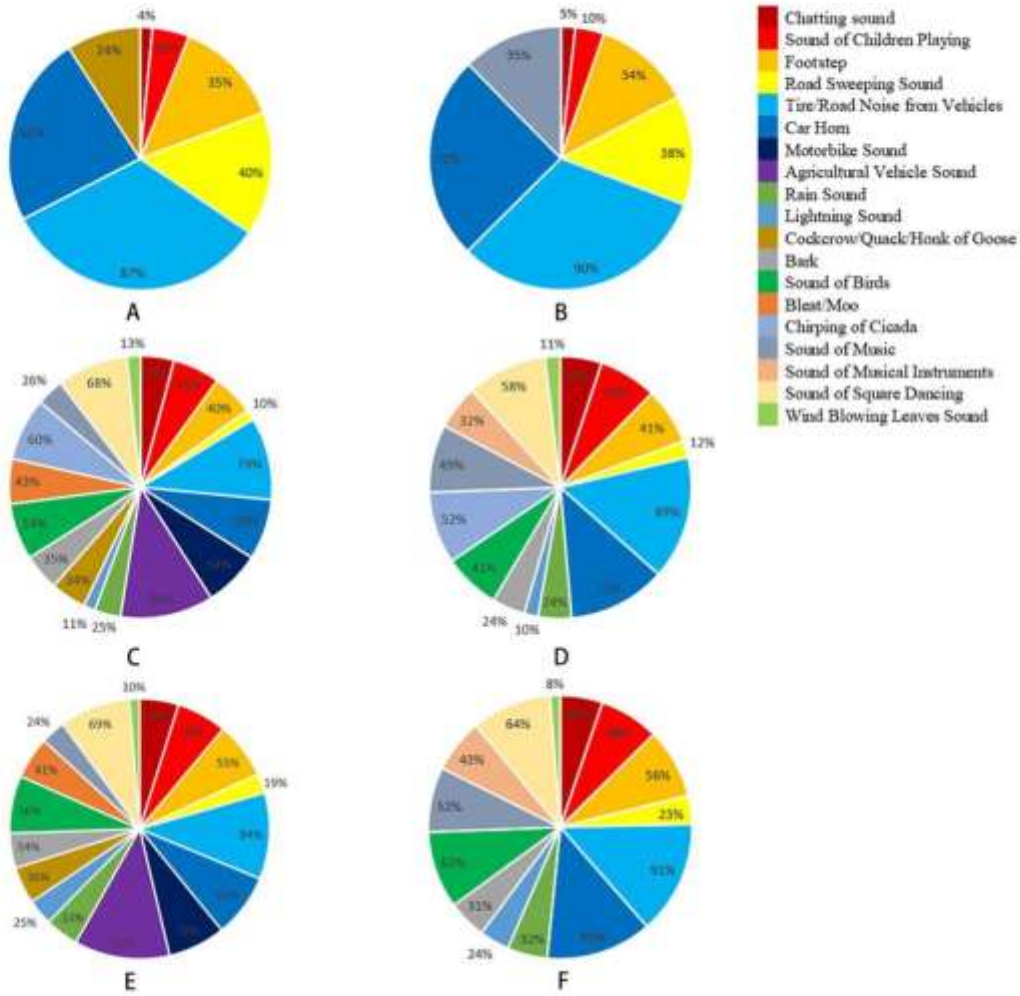

Fig10: Indoor sound recurrence rate in rural and urban areas
(A winter in rural area; B winter in urban area; C summer in rural area; D summer in urban area; E spring and autumn in rural area; F spring and autumn in urban area)

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In conclusion, the traffic sounds were heard most frequently in the four seasons of urban and rural areas, followed by animal sounds and musical sounds, and finally nature sounds and man-made sounds. Because traffic sounds and mechanical equipment sounds are troublesome to residents, they hear those sounds most frequently. Nature sounds and man-made sounds are the background sounds for residents' activities and residents have become accustomed to them; thus, their frequencies are lower than animal sounds and musical sounds. In addition, urban and rural residents have basically the same auditory frequency of the same sound source. It is speculated that the main reason for the differences in sound source recurrence rate is the disparities between urban and rural sound sources.

3.3 Sound Preference Evaluation Result

The evaluation of outdoor sound preferences of urban and rural residents is shown in Table 1. The most favourite sounds of rural residents outdoor were the sound of music (4.12) and musical instrument performance (4.05), followed by the sound of wind blowing leaves (3.67) and the sound of birds (3.45). And then the sound of square dancing (3.32) was last. The most popular outdoor sounds of urban residents were the sound of birds (4.10) and the sound of wind blowing leaves (3.94), then the sound of musical instruments (3.58) and music (3.55), and following that was the sound of square dancing (3.23). It appeared that although urban and rural residents have different tastes for favourite sounds and preferred sounds, they all preferred the musical sounds and nature sounds. In the survey results of rural and urban areas, the sound of firecrackers and children's frolicking did not behave as we expected. The evaluation value of rural residents about firecrackers was only 2.7, but during the Spring Festival, there were 53% of people said they like the sound of firecrackers as the sound during the Spring Festival could liven up festive atmosphere. That is why the sound of firecrackers was loved by some residents, whereas others did not like it on account of its extreme loudness. Though firecrackers have been banned in cities, most urban residents still like the sound of firecrackers during the Spring Festival. Rural and urban residents were not fond of the sound of firecrackers when it's not the Spring Festival. The evaluation value of the sound children's frolicking in rural area was 3.03 and 3.15 in cities respectively, which were both outstripped our expectations. Most families have children, thus out of the love of their own children, and they were more likely to accept the sound of children frolicking. Meanwhile, 10% of people did not like this sound and they reckoned the sounds were too noisy. Most of them subconsciously believed that children would bring troubles with their frolicking. The most disliked sounds of urban and rural residents were the sounds of factory machinery (1.69) (1.61) and building remodeling (1.79) (1.69), followed by the sound of the mechanical equipment (2.01) (1.82) and lightning sound (2.03), then tire/road noise from vehicles (2.11) (2.05) and car horn (2.27) (2.14). The urban residents disliked the sound of agricultural vehicles (1.97) more than the sound of thunder and lightning.

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TABLE I. Outdoor Sound Preference Evaluation of Urban and Rural Resident

			Countryside	**City**
Location	Sound Source Classification	Sound	Evaluation Value	Evaluation Value
Outdoors	Man-made Sounds	Chatting Sound	2.51	2.48
		Sound of Children Frolicking	3.03	3.15
		Footsteps	2.59	2.50
		Road Sweeping Sound	2.66	2.52
		Firecracker Sound	2.70	2.81
	Traffic Sounds	Tire/Road Noise from Vehicles	2.08	2.05
		Car Horn	2.11	2.14
		Motorbike Sound	2.44	2.09
		Agricultural Vehicle Sound	2.27	1.97
	Mechanical Sounds	Noise from Remodeling	1.79	1.69
		Factory Machinery Sound	1.69	1.61
		Mechanical Equipment Sound	2.01	1.82
	Nature Sounds	Wind Blowing Leaves Sound	3.67	3.94
		Rain Sound	3.25	3.01
		Lightning Sound	2.03	2.15
	Animal Sounds	Cockcrow/Quack/Honk of Goose	2.42	2.39
		Bark	2.48	2.56

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		Sound of Birds	3.45	4.10
		Bleat/Moo	2.72	2.74
		Chirping of Cicada	2.87	2.77
	Musical Sounds	Sound of Music	4.12	3.55
		Sound of Musical Instruments	4.05	3.58
		Sound of Square Dancing	3.32	3.23

Indoors, urban and rural residents generally have a low preference for sounds. As can be seen in Table 2, the most favourite sounds of rural residents indoors were still the sound of music (3.95) and musical instrument (3.83), followed by the sound of rain (3.25) and wind blowing leaves (3.24), then the sound of birds (3.00). The most favourite sounds of urban residents indoors were the sound of birds (3.97) and music (3.86), followed by the sound of wind blowing leaves (3.47) and the sound of musical instruments (3.42), and then the sound of rain (3.04). Even though on certain festivals occasions, more than 50% of people liked the sound of firecrackers outdoors. Still, 66% of people said they didn't like this kind of sound when they were indoor, and 36% of people even said they hated the sound of firecrackers, because it was too loud for them to rest. Indoors, the evaluation value of the sound of children frolicking was also reduced accordingly, owing to the fact that the sound of children's frolicking was too noisy, which affected residents' rest. The most disliked sounds of urban and rural residents were still the sound of factory machinery (1.69) (1.64) and building remodeling (1.71) (1.65), followed by the sound of machinery and equipment (1.77) (1.70) and agricultural vehicles (1.92) (1.83), then the car horn (1.96) (2.00) and the tire/road noise (2.06) (2.04) from vehicles.

TABLE Ⅱ. Indoor Sound Preference Evaluation of Urban and Rural Residents

		Countryside	**City**
Sound Source Classification	Sound	Evaluation Value	Evaluation Value
Man-made Sounds	Chatting Sound	2.82	2.51
	Sound of Children Frolicking	2.75	2.48
	Road Sweeping Sound	2.48	2.56
	Firecracker Sound	2.08	2.12
Traffic Sounds	Tire/Road Noise from Vehicles	2.06	2.04

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	Car Horn	1.96	2.00
	Motorbike Sound	2.07	2.05
	Agricultural Vehicle Sound	1.92	1.83
Mechanical Sounds	Noise from Remodeling	1.71	1.65
	Factory Machinery Sound	1.69	1.64
	Mechanical Equipment Sound	1.77	1.70
Nature Sounds	Wind Blowing Leaves Sound	3.24	3.47
	Rain Sound	3.25	3.04
	Lightning Sound	2.09	2.23
Animal Sounds	Cockcrow/Quack/Honk of Goose	2.15	2.20
	Bark	2.19	2.26
	Sound of Birds	3.00	3.97
	Bleat/Moo	2.44	2.14
	Chirping of Cicada	2.56	2.74
Musical Sounds	Sound of Music	3.95	3.86
	Sound of Musical Instruments	3.83	3.42
	Sound of Square Dancing	2.90	2.60

Overall, urban and rural residents differ in acoustic preferences. Rural residents liked music most, whether indoors or outdoors, while urban residents liked the sound of birds most. Moreover, no matter indoor or outdoor, urban and rural residents did not like the sound of machinery and traffic, and indoor residents liked the sound of rain but dislike the sound of square dancing (see Figure 11).

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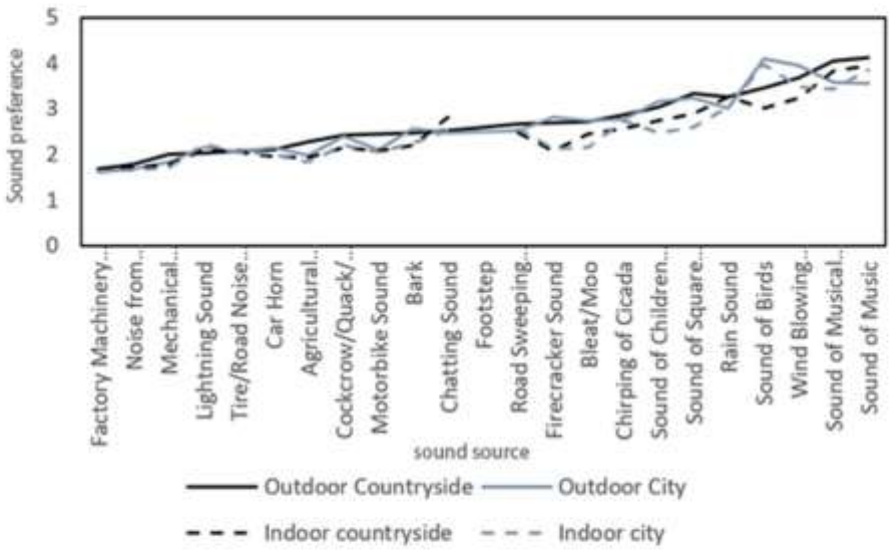

Fig 11: Sound Preference Comparison

Ⅳ. DISCUSSION

For urban and rural residents, the acoustic environment of residential areas is of significance. Studies have shown that sound preferences and satisfaction were being affected dramatically by the social factors of residents [33]. The social factors of residents here include gender, age, educational level, occupation and location of house, etc., as well as the auditory experience of individuals in life and work. Nowadays, researches on the factors affecting acoustic perception in cities reflect that social factors such as age, educational level, and occupation of interviewees, have a certain influence on the evaluation of sound preferences [34,35]. For habitable spaces of rural areas, the living patterns, traffic conditions, and characteristics of people are different from those of cities. This time, with the help of SPSS data analysis software, we studied the influencing factors of acoustic perception of urban and rural habitable spaces in-depth with the intention of obtaining new discoveries.

This analysis of gender factor revealed that the gender of residents in urban and rural residential district was solely related to the preferences of individual sound source. According to Table 3, gender was positively correlated with the sound of firecrackers and bark at $p \leq 0.05$ outdoors; as can be seen from Table 4, gender and bark were positively correlated at $p \leq 0.01$, what is more, gender and factory machinery sound were negatively correlated at $p \leq 0.05$. Due to the fact that men prefer the sound of firecrackers than women, it was illustrated that in residential districts, men were more receptive to the sound of firecrackers and bark than women, while women were more receptive to the sound of factory machinery sound than men. Besides that, the gender of residents did not have significant correlation with other voice preference evaluation.

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TABLE Ⅲ. Gender and outdoor sound preference correlation coefficient

Social Factor	**Sound Source Classification**				
	Chatting Sound	Sound of Children Frolicking	Footsteps	Road Sweeping Sound	Firecracker Sound
Gender	-.178	.137	-.065	-.095	.307*
	Tire/Road Noise from Vehicles	Car Horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling
Gender	.102	.065	.117	.087	-.158
	Factory Machinery Sound	Mechanical Equipment Sound	Wind blowing Leaves Sound	Rain Sound	Lightning Sound
Gender	-.214	-.068	-.026	.029	.284
	Cockcrow/Quack/Honk of Goose	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada
Gender	.114	.332*	-.104	.000	.166
	Sound of Music	Sound of Musical Instruments	Sound of Square Dancing		
Gender	.152	.182	-.094		

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

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TABLE Ⅳ. Gender and indoor sound preference correlation coefficient

Social Factor	**Sound Source Classification**				
	Chatting Sound	Sound of Children Frolicking	Road Sweeping Sound	Firecracker Sound	Tire/Road Noise from Vehicles
Gender	-.115	-.108	.182	.019	-.203
	Car horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling	Factory Machinery Sound
Gender	-.079	-.129	-.073	-.087	-.380*
	Mechanical Equipment Sound	Wind Blowing Leaves Sound	Rain Sound	Lightning Sound	Cockcrow/Quack/Honk of Goose
Gender	-.134	.020	.039	.151	.301
	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada	Sound of Music
Gender	.398**	-.166	.162	.164	-.111
	Sound of Musical Instruments	Sound of Square Dancing			
Gender	.058	-.159			

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

The analysis indicated that age affects the preference of specific sound source. Outdoors, as detailed in Table 5, age was negatively correlated with footsteps, sound of rain and bark at p≤0.05, and was positively correlated with goat bleat and moo at p≤0. 05. Indoor, as listed in Table 6, age has a negative correlation with lightning sound and bark at p≤0. 05. Then it was concluded that the older the residents were, the less they liked footsteps, sound of rain and bark, and the more they could tolerate the bleating of sheep and cow outdoors. While indoors, the older the residents become, the less they enjoyed bark and lightning sound. Apart from that, the age of residents did not have significant correlation with other voice preference evaluation.

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TABLE Ⅴ. Age and outdoor sound preference correlation coefficient

Social Factor	**Sound Source Classification**				
	Chatting Sound	Sound of Children Frolicking	Footsteps	Road Sweeping Sound	Firecracker Sound
Age	-.173	.149	-.369*	.065	-.026
	Tire/Road Noise from Vehicles	Car Horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling
Age	-.239	.008	.116	.155	-.023
	Factory Machinery Sound	Mechanical Equipment Sound	Wind blowing Leaves Sound	Rain Sound	Lightning Sound
Age	-.124	-.182	-.174	-.347*	-.234
	Cockcrow/Quack/Honk of Goose	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada
Age	.157	-.369*	.243	.304*	.263
	Sound of Music	Sound of Musical Instruments	Sound of Square Dancing		
Age	-.058	-.252	.075		

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

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TABLE Ⅵ. Age and indoor sound preference correlation coefficient

Social Factor	**Sound Source Classification**				
	Chatting Sound	Sound of Children Frolicking	Road Sweeping Sound	Firecracker Sound	Tire/Road Noise from Vehicles
Age	-.141	.095	-.155	.119	-.007
	Car horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling	Factory Machinery Sound
Age	.083	.094	.163	.131	-.137
	Mechanical Equipment Sound	Wind Blowing Leaves Sound	Rain Sound	Lightning Sound	Cockcrow/Quack/Honk of Goose
Age	-.191	-.15	-.08	-.315*	.147
	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada	Sound of Music
Age	-.335*	-.016	.064	.214	-.009
	Sound of Musical Instruments	Sound of Square Dancing			
Age	.019	.116			

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

From the detailed analysis, it found that the educational level of the residents was related to the preference of individual sound source. Outdoors, displayed in Table 7, educational level was positively correlated with chatting sound at p≤0.01, and was also positively correlated with sound of rain and lightning at p≤0. 05. It displayed a negatively correlated with cicada chirping at p≤0. 05. From Table 8, it can be seen that indoors, there was a negative correlation between the educational level and cicada chirping at p≤0. 05. It was thought that in the outdoor, with the growth of educational level, the residents' tolerance to chatting and lightning sound would be higher, tolerance to the sound of cicadas would be lower, and the love for the sound of rain would be more; while indoors, with the higher the level of education, the lower the tolerance of the residents to the cicadas. In addition, the educational level of residents did not have significant correlation with other voice preference evaluation.

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TABLE Ⅶ. Educational level and outdoor sound preference correlation coefficient

Social Factor	**Sound Source Classification**				
	Chatting Sound	Sound of Children Frolicking	Footsteps	Road Sweeping Sound	Firecracker Sound
Level of Education	.475**	.185	.244	-.169	.008
	Tire/Road Noise from Vehicles	Car Horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling
Level of Education	.244	-.121	-.031	-.275	-.048
	Factory Machinery Sound	Mechanical Equipment Sound	Wind Blowing Leaves Sound	Rain Sound	Lightning Sound
Level of Education	-.07	.116	.099	.355*	.361*
	Cockcrow/Quack/Honk of Goose	Bark	Sound of Birds	Cockcrow/Quack/Honk of Goose	Chirping of Cicada
Level of Education	.045	.134	.024	-.07	-.380*
	Sound of Music	Sound of Musical Instruments	Sound of Square Dancing		
Level of Education	-.181	-.162	-.168		

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

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TABLE Ⅷ. Educational level and indoor sound preference correlation coefficient

Social Factor	Sound Source Classification				
	Chatting Sound	Sound of Children Frolicking	Road Sweeping Sound	Firecracker Sound	Tire/Road Noise from Vehicles
Level of Education	.118	-.058	.002	-.182	.193
	Car horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling	Factory Machinery Sound
Level of Education	.13	.039	-.045	-.001	.239
	Mechanical Equipment Sound	Wind blowing Leaves Sound	Rain Sound	Lightning Sound	Cockcrow/Quack/Honk of Goose
Level of Education	.284	-.11	.036	.222	-.194
	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada	Sound of Music
Level of Education	-.138	-.235	-.181	-.325*	-.064
	Sound of Musical Instruments	Sound of Square Dancing			
Level of Education	.079	-.167			

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

The analysis revealed that there was no significant correlation between residents' economic conditions and their preferences for sound sources. But Table 9 says that the floor that residents live in is positively correlated with the noise from remodeling at p≤0.05. That is to say, the higher the living floor is, the higher the tolerance for noise from remodeling. Results in Table 10 represent that outdoors, the location of house had a negative correlation with road sweeping sound at p≤0.01 and had negative correlation with the sound

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of firecrackers indoors at p≤0.05 (shown in Table 11), which means that in outdoor, residents who were living next to the street were more tolerant of the sound of sweeping road than those who were not directly facing the street. However, the lower floors in the residential districts were cheaper than the higher floors, and the street-facing houses were also cheaper than the non-street-facing houses. Therefore, this suggested that economic conditions have some indirect effects on sound preferences.

TABLE Ⅸ. Floor of apartment and sound preference correlation coefficient

Social Factor	**Sound Source Classification**				
	Chatting Sound	Sound of Children Frolicking	Road Sweeping Sound	Firecracker Sound	Tire/Road Noise from Vehicles
Residential floor	.230	-.147	.234	.116	.027
	Car Horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling	Factory Machinery Sound
Residential floor	.042	-.047	-.063	.328*	.233
	Mechanical Equipment Sound	Wind Blowing Leaves Sound	Rain Sound	Lightning Sound	Cockcrow/Quack/Honk of Goose
Residential floor	.054	.235	.142	.103	.286
	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada	Sound of Music
Residential floor	.135	.131	-.010	.066	-.125
	Sound of Musical Instruments	Sound of Square Dancing			
Residential floor	-.159	.175			

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

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TABLE Ⅹ. Apartment location and outdoor sound preference correlation coefficient

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

Social Factor	Sound Source Classification				
	Chatting Sound	Sound of Children Frolicking	Footsteps	Road Sweeping Sound	Firecracker Sound
Residential location	-.151	.118	.126	-.475**	-.189
	Tire/Road Noise from Vehicles	Car Horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling
Residential location	-.079	-.018	-.037	-.253	.143
	Factory Machinery Sound	Mechanical Equipment Sound	Wind Blowing Leaves Sound	Rain Sound	Lightning Sound
Residential location	.145	.164	.083	.026	.041
	Cockcrow/Quack/Honk of Goose	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada
Residential location	-.045	-.277	-.148	-.034	-.196
	Sound of Music	Sound of Musical Instruments	Sound of Square Dancing		
Residential location	-.272	-.239	-.230		

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TABLE ⅩⅠ. Apartment location and indoor sound preference correlation coefficient

Social Factor	Sound Source Classification				
	Chatting Sound	Sound of Children Frolicking	Road Sweeping Sound	Firecracker Sound	Tire/Road Noise from Vehicles
Residential location	.110	.189	-.129	-.390*	.031
	Car Horn	Motorbike Sound	Agricultural Vehicle Sound	Noise from Remodeling	Factory Machinery Sound
Residential location	-.066	-.049	-.189	.097	.254
	Mechanical Equipment Sound	Wind Blowing Leaves Sound	Rain Sound	Lightning Sound	Cockcrow/Quack/Honk of Goose
Residential location	.221	-.047	.010	-.073	-.218
	Bark	Sound of Birds	Bleat/Moo	Chirping of Cicada	Sound of Music
Residential location	-.303	-.260	-.142	-.166	-.023
	Sound of Musical Instruments	Sound of Square Dancing			
Residential location	-.010	-.123			

Note: * and ** refer to significant. * refers to $p \leq 0.05$ and ** refers to $p \leq 0.01$

We conducted the study of correlation analysis of individual social factors, indoor and outdoor acoustic environment satisfaction and indoor noise disturbance and found that individual social factors have no correlation with both indoor and outdoor acoustic environment satisfaction and indoor noise disturbance. Most urban and rural residents considered that they were disturbed occasionally. Only a small number of people thought that they were occasionally disturbed in an acceptable or satisfied with their

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accommodations Then the indoor acoustic environment satisfaction degree, outdoor acoustic environment satisfaction degree and indoor noise disturbance were analysed and the results found that the outdoor acoustic environment satisfaction degree and the indoor sound satisfaction degree were positively correlated at the level of $p \leq 0.01$ (Table 12). It can be seen that in order to improve residents' satisfaction with the acoustic environment, the management of outdoor sound sources is also crucial.

TABLE Ⅻ. Indoor and outdoor acoustic environment satisfaction degree and indoor noise disturbance correlation coefficient

	Satisfaction Degree of Indoor Acoustic Environment	**Indoor Noise Disturbance**
Satisfaction with Outdoor Acoustic Environment	.520**	.188

Note: * and ** refer to significant. * refers to p≤0.05 and ** refers to p≤0.01

Field measurement and questionnaire were used to figure out that gender, age, economic condition, and living environment can all have different effects on residents' sound preferences. This research aims to provide a reference for the construction and design of residential districts for people in different socioeconomic status in the future. However, due to factors such as material resources, financial resources and energy, etc., we did not conduct surveys and comparisons of multiple villages and cities. Future work should focus on more comparison of villages and cities.

Ⅴ. CONCLUSION

Through the analysis of the sound field and soundscape evaluation in urban and rural residential districts, the following conclusions were drawn: 1) the SPL of urban and rural residential areas varied as floor changed. The SPL on the third floor in the rural areas was the lowest, followed by the second floor and fifth floor. In the quiet environment, the SPL decreased with the growth of floors; the SPL on the sixth and seventh floors of the city was the lowest. The SPL from the first floor to the second floor decreased gradually, and it increased layer by layer from the second floor to the third floor accordingly. 2) There were no differences in the sound source recurrence rate of the same sound source between urban and rural residents, and the differences in sound source recurrence rate of urban and rural residents were attributable to the differences in sound source. 3) The sound preferences of urban and rural residents differed. Compared with urban residents, rural residents preferred the sound of music. Compared with rural residents, urban residents preferred the sound of birds. 4) The gender of residents had correlation with the sound of firecrackers, bark and factory machinery sound, and age had correlation with footsteps, sound of rain, bark, bleating of sheep and cow and lightning sound. The level of education was correlated with sound of chatting, rain, lightning and cicada. Economic condition had no correlation with sound preferences, but indirectly affected the evaluation of residents' sound preferences. The outdoor acoustic environment satisfaction directly had an effect on the residents' satisfaction with the indoor acoustic environment.

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