

Analysis of sound environment in coastwise area of Haihe river and preliminary study on its soundscape design and soundscape expression method

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ABSTRACT

Haihe river, as the mother river of Tianjin city, China, not only plays a vital role in social culture and psychology, but also provides a good place for people's leisure and entertainment. With the advance of landscape transformation in Haihe coastwise area, creating a comfortable acoustic environment becomes an important part of the overall transformation. In this study, the sound situation of Haihe coastwise area including sound type, relationship among different sounds, sound expectation and so on, was analyzed through physical measurement and social surveys. By doing that, the method of improving the acoustical environment of Haihe coastwise area and its overall soundscape design were hoped to be explored. Furthermore, a suitable expression method of soundscape design in open area like Haihe coastwise area was tried to be found in order to build a communication platform for acoustic researchers, urban planners and the general public.

INTRODUCTION

With the increasing of people's requirement on environment comfort, it seems necessary to do soundscape design in public area such as urban park, plaza and so on because people feel the environment not only through eyes but also through ears. Soundscape design is interdisciplinary field and it needs the cooperation of architects, acoustic engineers, environmental health specialists, psychologists, social scientists and urban developers. Furthermore, the purpose of soundscape design is to create a good sound environment for certain people, therefore, the opinion from the public is also important in the process of soundscape design. Unfortunately, soundscape is too complicated to understand as a nonfigurative concept, and sometime it is difficult for common people, even experts in other research fields such as architect, urban planner and so on to give their opinion on the soundscape design. It seems necessary to find a suitable communication method among experts from different research fields and get more suggestions from different aspects on how to improve the sound quality of certain areas.

Haihe River plays a vital role in social culture and psychology in Tianjin, China, and it provides a good outdoor place for people's leisure and entertainment. In recent years, Tianjin government invest a lot of money to promote the landscape transformation in the coastwise area of Haihe River and it becomes a new important sightseeing spot in Tianjin. However, no soundscape plan was done in those coastwise areas though some of the coastwise areas were exposed to road traffic noise brought by a busy road along Haihe River. Also some of the squares along Haihe River were evaluated to be inanimate and undramatic though the buildings in those areas were built with outstanding characteristics. In

this case, soundscape design might be a good try to make those areas more attractive and lively.

In this study, the sound situation of Haihe coastwise area including sound type, relationship among different sounds, sound expectation given by visitors were analyzed through physical measurement and social survey held in four seasons. There are two purposes in this study: one is to analyze the sound environment in Haihe coastwise and put forward suggestions on sound scape design. The other one is to find out a rational expression method and design procedure so that more people including experts from different research fields and the common public could give their own opinions into the soundscape design.

STUDY METHOD

Measurement and Investigation Spots

Jinwan Square was selected as the main investigation area in this study. Along Haihe River, there are many squares, coastwise paths and coastwise platforms. In different area, it should have different acoustical characteristics. Jinwan Square is a very important and famous part in Haihe area and it is famous for the architecture style of its theatre. Furthermore, it includes different kinds of areas: square, coastwise platform, coastwise path far away from the road and coastwise path close to the road. Those areas could be the representative of Haihe coastwise area.

In the first stage of the study, in order to grasp basic acoustical information of Jinwan square, sound level and sound type were measured in 17 spots. Afterwards, investigation was held in several spots to get subjective evaluation on the

sound environment of Jinwan square. Figure 1 shows the measurement and investigation spots.

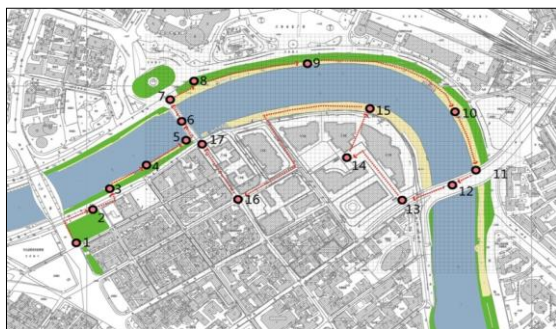


Figure 1. Measurement and investigation spots in Haihe coastwise area (1-17 are measurement spots. 2-4 and 13-17 are investigation spots.)

Questionnaires

In this study, visitors were chosen randomly and asked to finish a questionnaire. The social survey was and will be held in last winter, spring and in the coming summer and autumn in order to get probably different subjective impression of the sound environment and different sound expectation in the same area in the different season. The questionnaire used in four seasons were almost same though few questions would be changed according to the investigation time. It includes the following questions: 1) visiting purpose, 2) general evaluation of the environment and the sound environment, 3) the type of the sounds can be heard, 5) evaluation of comfort extent and harmony extent of each sound and 6) sound expectation when staying in the area.

Research steps

All the study could be divided into three steps: 1) Preliminary sound measurement including sound level, sound type and relationship among different sounds was carried out in Jinwan square in order to get a basic knowledge on the sound situation of this area. Considering of the different situation in weekday and weekend, three times measurement in the morning, afternoon and evening of weekday and three times measurement in the corresponding time of weekend were held. Both L_{Aeq} and L_{max} were measured and the time period of measurement was 1 minute. 2) Social surveys were and would held in different seasons to compare subjects' evaluation of sound environment and their sound expectation in different time of one year. By doing that, the characteristic of the visitors, their evaluation of the acoustical environment, their sound expectation could be explored and the useful information might be scientific guide for soundscape design of this area. Until now, the winter and spring investigation has been finished. 3) The expression method of soundscape situation and soundscape plan were discussed. As it was referred before, soundscape design is a complicated process and needs more suggestive opinion from other research fields such as urban planning, psychology, architect and so on. Also, it is vital to obtain real receipt of the people in the environment. Therefore, it is important to find a suitable communication method among those people so that every person related to soundscape design can understand soundscape thoroughly and communicate with each other freely. Otherwise, soundscape design would be an idle theory created by alleged acoustical method. Also, in this step more accurate analysis on the sound signal is necessary to get enough signal information of the sound environment.

RESULTS

Though the social survey on the sound environment of Haihe coastwise area was only finished partly, some results could still show the study skeleton.

Basic analysis of sound situation in Jinwan square

In the first step, the sound level of 17 selected spots was measured using indicators of L_{Aeq} and L_{max} in one minute. Considering the number of the visitor could be different in weekday and weekend, three times measurement in each spot was done in both weekday and weekend. Except the measurement of sound level, the relationship among each sounds and comfort extent of the sound environment were evaluated

Table 1. Measurement of sound situation in Jinwan square

Spot	L_{Aeq}	L_{max}	Sound Relation	Comfort Evaluation
1	68.1	80.3	unclear	uncomfortable
2	57.4	65.3	clear	comfortable
3	61.9	71.6	clear	comfortable
4	55.6	63.8	clear	comfortable
5	56.9	76.0	clear	comfortable
6	64.6	80.6	clear	uncomfortable
7	64.3	76.2	unclear	uncomfortable
8	56.4	65.9	clear	uncomfortable
9	55.7	68.0	clear	comfortable
10	54.5	62.9	clear	comfortable
11	71.2	77.1	unclear	uncomfortable
12	71.2	77.1	unclear	uncomfortable
13	54.6	71.5	unclear	uncomfortable
14	60.7	74.7	unclear	uncomfortable
15	67.4	88.9	clear	comfortable
16	60.9	71.2	clear	uncomfortable
17	61.6	84.9	clear	uncomfortable

Table 2. The type of the sounds heard in different spots

Spot	I	II	III	IV	V	VI	VII	VIII
1	●	●	●			●	○	
2	●	●	●			○	○	
3	●	●				○	○	○
4	○					○	●	○
5	●					●	○	
6	●	●				●	○	○
7	●					●	○	
8	○		●			●	●	○
9	○				●	○	●	
10	●	●			●	○	●	○
11	●	●				●		
12	●	●					○	
13	●			○			○	○
14	○			●		●	○	○
15				○	●	●	○	
16	●	●				●		
17	●	●				○	○	○

(I: road traffic noise; II: horn sound; III: construction noise; IV: sound from the pub; V: sound from a big clock; VI: talks from the people; VII: sound from the leaves; and VIII: birdsong. ● means the sound could be heard clearly; ○ means the sound could be heard vaguely.)

by the researchers who have knowledge background of urban planning and have little knowledge of acoustics. If the researchers could hear each of the sound clearly, they gave a

“clear” evaluation of the sound relation. On the contrast, they gave an “unclear” evaluation to the sound relation when they could not identify each sound from other sounds clearly. From Table 1 it is can be seen that except for the coastwise pathes far from road (spot 4, 5, 8-10, 13), the sound level of the other coastwise areas was higher than 60dB. Some of them close to the road had a sound level higher than 70dB. From the researchers’ point of view, if they could not identify each sound from other sounds, they thought the sound environment was not comfortable. However, if the researchers thought the sound relation was clear, they still could not give a comfort evaluation to the sound environment.

Table 2 shows the type of the sounds which could be heard in each measurement spot. It seems in Jinwan square more man-made sounds such as road traffic noise, construction noise and people’s talking were clearly heard rather than natural sounds such as the leave sound and birdsong. Also, most of the sounds that were reported to be heard clearly were negative sounds and they potentially would bring adverse effects to the sound environment in this area.

Analysis of the visitors in Jinwan square

It is widely accepted that soundscape design should satisfy the requirment of the people who stay in the area. Therefore, the analysis of the visitors is necessary for the further soundscape design. In the present study, visitors were chosen randomly and they were the people who were glad to finish the investigation questionnaire. Table 3 is the basic demographic information of the visitors attending the investigation in last winter. All together 121 visitors received the social survey face to face and the ratio of male and female is 1.42:1. Young people were more interested in the social survey.

Table 3 Demographic information of the visitors

Age	Male	Femal	Total
10-19	5	0	5
20-29	39	26	65
30-39	14	8	22
40-49	3	9	12
50-59	5	2	7
60’s and above	5	5	10
Total	71	50	121

Figure 2 shows visitors’ purpose to come to Jinwan square. Form the figure it can be seen that except two fifth person came to this area for work or passing by, most of the people came here for entertainment. Therefore, the soundscape design should be accord with this purpose. Say it in other words, soundscape design in this area should be helpful to people’s relaxation.

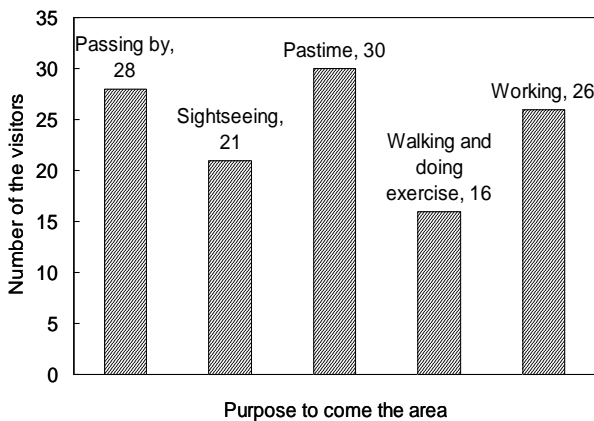


Figure 2. The purpose of people to come the area

Analysis of social survey conducted in winter

Firstly, in the questionnaire, subjective evaluation focusing on the comfort of enviroment, comfort of sound enviroment and definition extent of the sound were obtained. Through the statistic analysis, the Pearson correlation coefficient between evaluation of enviroment comfort and sound enviroment comfort was 0.439. This correlation was significant at 0.01 level. However, it had no relationship between the evaluation of sound enviroment comfort and the definition of the sounds (it means every sound could be heard clearly and could be identified from other sounds easily.). The correlation coefficient was -0.012 and it was not significant at all. Those data show that a good sound environment can promote the comfort extent of the whole environment. A good sound enviroment has no relationship with the sound idefinition. This result seems was quite different from the result obtained from researchers’ description related above.

Secondly, sound type was explored by questionnaire. In this part, sounds were divided into good ones and bad ones. The “good sound” means people thought the sound was harmonious with the enviroment and they liked the sound. The “bad sound” means people thought the sound was disharmonious with the enviroment and they disliked the sound. Figure 3 shows how many people thought one sound could be heard in this area. Twelve kinds of sounds, which are ship siren, walker rumpus, children frolic, peddling, pet calling, music broadcasting, construction noise, horn and road traffic noise, birdsong, wind sound, leave sound and other sounds were listed as the options. From the figure it can be seen that more people could notice the sounds such as construction noise, horn and road traffic noise, wind sound and walker rumpus than other sounds. Fewer people could notice the natural sounds such as leave sound and birdsong. This result shows in Jinwan square, more man-made sounds appeared in this area. Whether the man-made sounds should be controlled or be taken advantage of depends on people’s attitude to them.

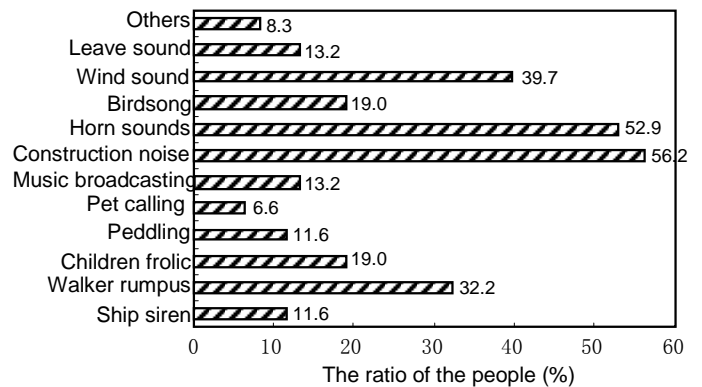


Figure 3. The ratio of the people who noticed the sounds

In order to explore people’s attitude to each sounds, the visitors were asked to select their favourable and unfavourable sounds from the twelve listed sounds. Figure 4 and Figure 5 show how the people divide the sounds into bad ones and good ones according to their favour extent. According to the figures it can be drawn that comparing with man-made sounds people preferred birdsong, music broadcasting and leave sound though construction noise and road traffic noise appeared in this area more frequently. As for the man-made sounds, more active sounds such as children frolic and ship siren were liked by the investigation population. Nobody liked construction noise and road traffic noise, therefore the

sound component in this area should be changed and more works needed to be done in the soundscape design.

noises and also created a dramatic scene for the square. In point of 5, it was thought that a corridor with wind bells should be built to add natural music to the area. Furthermore, main fountain in point 7 and small fountain in point 9 were recommended to be built to attract people's attention from noise to fountain sound. Also the fountains could be active elements in the square considering the relationship between architecture and environment in this area.

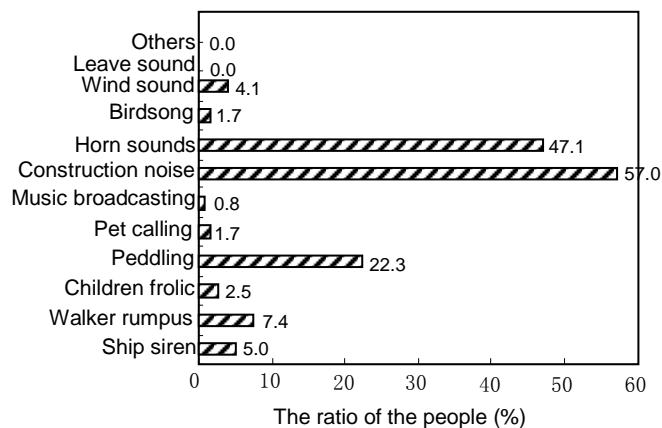


Figure 4. The ratio of the people who disliked the sounds

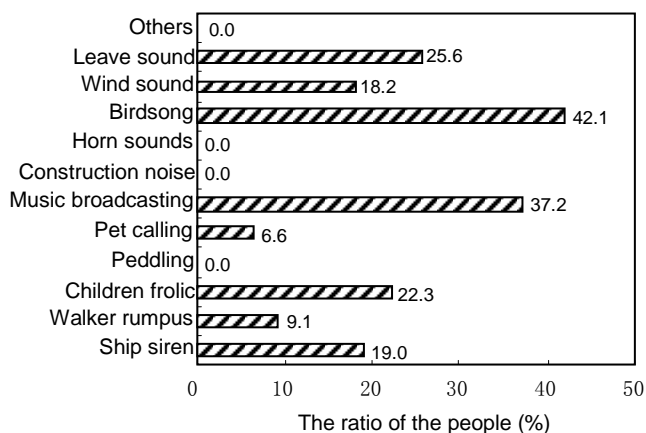


Figure 5. The ratio of the people who liked the sounds

Thirdly, the investigation results obtained in different seasons would be compared with each other. As it is known, soundscape design should adapt to not only area but also time period. People have different requirements on sounds with the changing of the time. More systematic analysis on the investigation results got in different seasons would be done after all the investigation finished.

Proposal of expression method of soundscape design

In order to make it possible that more and more people such as experts in other research fields and the public could attend the process of soundscape design, the expression method of soundscape was discussed and brought forward preliminarily. Urban planning method was used for reference in order to add the visual impression into soundscape design. By doing that people could understand the sound sources, sound diffusion, and interaction among sound sources clearly. On the basis of the knowledge on sound environment, people could attend the process of soundscape design more possibly and professionally. Otherwise, soundscape is a quite vague concept for people and they can not understand it very well.

Figure 6 is a soundscape design of Jinwan square. In the point of 1, 2 and 8, green plants were suggested to be used to decrease the adverse influence of construction noise and road traffic noise. In the point of 3, 4, 6, water walls were suggested to be built. The water walls could be a sound barrier of



Figure 6. Soundscape design in Jinwan square (1,2: green plants; 3,4: water wall; 5: corridor with wind bells; 6: water corridor; 7: central fountain; 8: green plants; 9: fountain)

DISCUSSION

Through the measurement of sound situation in Jinwan square, it could be seen that except the coastwise paths far from the road and construction spot, most part of this area had a high sound level of more than 60dB. Some spots were reported to be noisy and the main noise sources were road traffic noise (with horn sounds) and construction noise nearby.

At the present time, Jinwan square was full of man-made noises such as construction noise, road traffic noise and walker rumpus. Also wind sound was an important component in this area because of the climate of Tianjin. Among those sounds, more people liked wind sound instead of disliking it. Construction noise and road traffic noise were obtained a universal negative evaluation. Considering of the situation of Jinwan square, construction noise would be temporary though it would exist for a long time and road traffic noise would exist for ever. Therefore, how to decrease the adverse effect of construction noise and road traffic noise should be the first work in the soundscape design of this area.

Though natural sound of birdsong and active man-made sounds such as children frolic and ship siren were visitors' favourable sounds, they were reported to seldom appear in Jinwan square. According to the investigation face to face, visitors said Jinwan square was too boring though it was not too noisy sometime. It seems this area needs some dramatic sound elements to make it lively and actively. Therefore, how to add some sounds into area should be the other one important work.

Definition of the sounds that means each sound can be heard clearly is popularly regarded as a good soundscape. However, in the present study, definition of the sounds had no relationship with the comfort of sound environment. A good sound environment had a significant effect on people's comfort evaluation of the whole environment though the correlation coefficient was not so high. Say it in other words, a good sound environment has a promotion effect on the quality of whole environment, but the effect is limited.

Expression in urban planning was creatively used to soundscape design in order that more people including the public and experts in other fields could give suggestions on the soundscape design of certain areas. On the basis of concluding the opinion of visitors, fountain sound was suggested to add into the soundscape of Jinwan square to mask some of the construction and road traffic noises. Furthermore, water was an important environment component in Jinwan square and fountain could combine the architecture and the river around this area naturally from both visual and audio aspect.

In the process of soundscape design, it is necessary to analyze the situation of the people such as the demographic information and purpose of staying in the area. In the present study the definition of sound was an important factor for researchers' (They have little knowledge of acoustics) evaluation of the sound environment. However, it had no effect on visitor's evaluation. Whether definition is an important factor to soundscape or not needs further study.

CONCLUSIONS

From the general speaking, Haihe coastwise area particularly Jinwan square does not have a good sound environment. Construction noise and road traffic noise are main noise sources in this area.

More active and dramatic sounds are needed to be added into the sound environment of Jinwan square so that this area can become more lively and attractive. Considering of the relationship between architecture and environment, fountain is thought a suitable landscape and soundscape element that should be added in this area.

Expression method of soundscape is put forward under the reference of the expression method of urban planning. By doing that, it is hoped more people can attend the process of soundscape design.

In order to do scientific soundscape design of Jinwan square, more analysis on sound signal and compare on investigation result of different season are necessary.

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REFERENCES

- 1 B. Schulte-Fortkamp, K. Genuit and A. Fiebig, "Developing a public space in Berlin based on the knowledge of new experts" Proceedings of 37th International Congress and Exposition on Noise Control Engineering (2008)
- 2 K. Genuit, B. Schulte-Fortkamp and A. Fiebig, "Psychoacoustic mapping within the soundscape approach" Proceedings of 37th International Congress and Exposition on Noise Control Engineering (2008)
- 3 W. Yang and J. Kang, "Acoustic comfort evaluation in urban open public spaces" Applied Acoustics, 66, pp.211-229 (2005)
- 4 J. Ge et al, "Researches on the acoustic environment of urbanpark and its design" Architectural Journal, 9, pp.58-60 (2003)