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Soundscape engineering of a promenade on Namsan Mountain Park by noise, sound, and preference maps

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ABSTRACT

Namsan Mountain is a 262m-high mountain located in the center of Seoul. It functions as a park rather than a mountain and has a 7.5km-long promenade around it with a moderate slope. Some sections of the promenade are accompanied by trees and rills, which provide a good sonic environment, but the other sections are influenced acoustically by shuttle buses, road-traffic and various noise sources. Noise map for the road-traffic was generated to find the spatial distribution of the noise over the mountain including the promenade. It shows that the promenade of Namsan Mountain is exposed to the noise levels ranging from 55dB(A) to 75dB(A). The natural sound which was identified most frequently by visitors was rill sound and rill-sound map was generated. Individual responses from 4 acousticians and 6 non-acoustic people were collected from on-site questionnaire about sonic environment along the promenade at 37 evaluating spots. The results of questionnaire were used to generate preference map. Separate and combined analyses of the three maps were performed and the addition of the rill sound was proposed to improve the sonic environment. To determine the levels of the rill sound a listening experiment was conducted and the adjusted levels of rill sound were incorporated into the noise map.

Keywords: Soundscape, Noise Map, Sound Map, Preference Map, Soundwalk, Psycho-acoustic Experiment

1. INTRODUCTION

Namsan Mountain is a 262m high mountain located in the center of Seoul. Its easy accessibility and tourist attractions such as a cable car and a tall tower on the top allure native and foreign people. It functions as a park rather than a mountain and has a 7.5 km promenade around it with a moderate slope where even the old and weak enjoy walking. Some parts of the promenade. Some sections of the promenade are surrounded by trees and flowing waters but the other sections are influenced by various un-wanted sound sources such as shuttle buses, roundabout road-traffic and several machines to provide inadequate soundscape on the promenade Therefore, appropriate measures are needed to improve the soundscape that can provide positive effects such as stress relief for Namsan Mountain's visitors.

In this study, noise maps for the sources were generated to find the spatial distribution of the noise over the mountain including the promenade and also sound maps were generated using the natural sound including mainly water streaming sound were identified by along the promenade. Individual responses collected during Soundwalk and these results used to generate the preference map.
Separate and combined analyses of the three acoustic maps were performed to propose some locations to need to improve the soundscape. Through the listening experiment, the levels and types of water sound determined to improve the soundscape to make Namsan Mountain' visitors satisfy.

2. STUDY AREA

Namsan Mountain is a 262m-high mountain located in the center of Seoul. It functions as a park rather than a mountain and has a 7.5km- long promenade around it with a moderate slope. Some sections of the promenade are accompanied by trees and rills, which provide a good sonic environment, but the other sections are influenced acoustically by shuttle buses, road-traffic and various noise sources. Figure 2.1 shows the satellite map of Namsan Mountain and its promenade.

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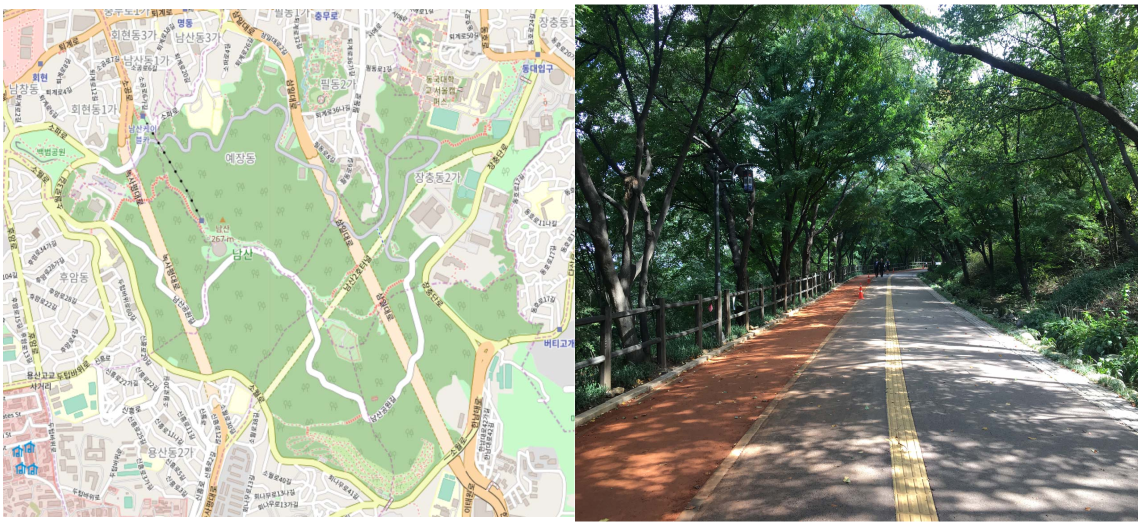
Figure 2.1 – The satellite map of Namsan Mountain (OpenStreetMap) and its promenade



3. NOISE MAP, SOUND MAP AND PREFERENCE MAP

3.1 NOISE MAP

Noise maps were calculated using the noise-mapping software SoundPLAN(ver.7.4), according to the RLS-90 road-traffic estimation model(1). Some sections of the promenade are influenced acoustically by shuttle buses, road-traffic and various noise sources. In order to calculate the noise map, the internal and external noise sources that can affect the promenade on Namsan Mountain' soundscape have examined.

Sound levels, traffic volumes, vehicle speed and classifications were measured at the roads within 500 meter from the promenade and other data were provided from the report from Seoul website. GIS information about the ground surfaces, buildings and roads were obtained from government websites.

Noise map was calculated with A-weighted equivalent noise level(LAeq) and Figure 3 shows the noise map of the Namsan Mountain. As expected, most of the study area results to be exposed to more than 65 dB with a few spots falling in the 55 – 60 dB range(2).

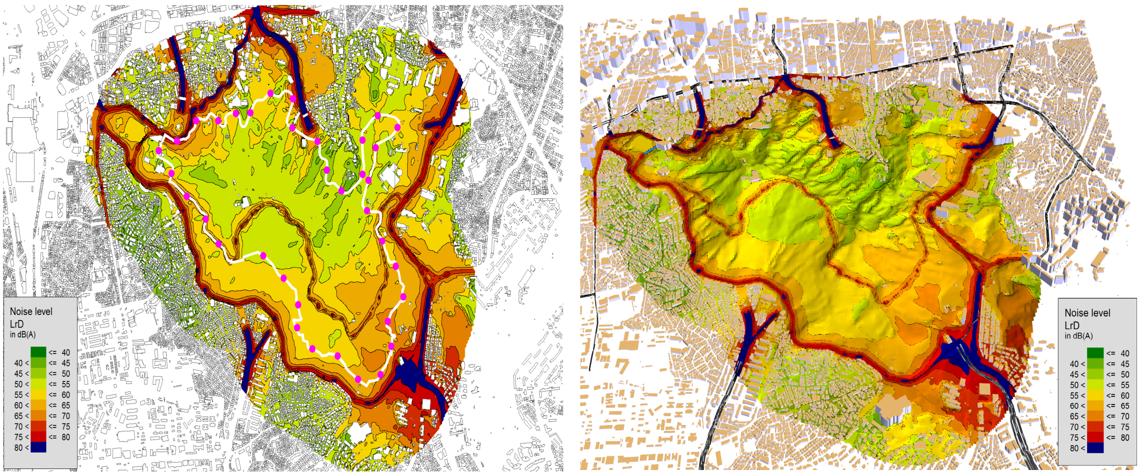


Figure 3.1 - Noise map of Namsan Mountain (2D (left) and 3D (right))

3.2 SOUND MAP

Noise map are largely used to assess exposures to un-wanted sounds (i.e. road traffic noise)(3).

In order to evaluate the overall soundscape of the promenade, sound map using water sounds also needed to assess the soundscape.

The rill was selected as water sound source to make a sound map Only the northern part of the promenade has the water sound and it has 1.0~1.5m wide and flows along the promenade. Rill is classified into two types: Rill with no step and steps. Figure 4 shows the image of the two types of the rill on the promenade on Namsan Mountain. The rill sound sources were measured at 1m from the center of the source for a minute and it was analyzed using ArtemiS, an acoustic and vibration analysis program.

The sound map was again calculated in SoundPLAN(ver.7.4) and the rill sound sources were treated as a surface source with a continuous operating time and 1/3-octave band spectra (125~4000Hz, dB(A)) were considered to be representative(7).

Figure 3.2 – Two types of the rill with no step(left) and steps(right) on the promenade

3.3 SOUNDWALK AND FIELD SURVEY

Field surveys were performed in total of 37 spots on the promenade. These spots were chosen by dividing the total length of Namsan by 200m intervals.

The field survey continued for 2 hours, with 10 subjects (one female and nine males) aged 20-30. All the participants conducted the soundwalk at the same time and they were led by an experimenter who walked the promenade and stopped at 37 evaluating spots. For each spot, participants were required to listen to the sonic environment for one minute and to fill in a structured questionnaire. At the same time, a non-participant operator carried out the sound-pressure level measurements for one minute by means of a calibrated sound level meter.

3.3.1 Questionnaire

The questionnaire included questions about: demographic information of the participant (age, gender, etc.), suitability of the spots for promenade (preference related to the sound environment and appropriateness of the sound environment), noticeability of different sound sources' types and their preference(4).

Two questions were selected for the purpose of this study: [Q1] "Overall, how would you rate sound environment of the present spot using given adjectives such as bad/good, noisy/calm, etc.?" and [Q2] "Overall, "What types of sound can you perceive here?"

For Q1 questions, a seven-point scale was used, ranging from "Very unfavorable" (-3) to "Very favorable" (+3) and various sound source options such as water sound, birdsong, etc. were provided and their preference was evaluated using 5-scale for Q2.

3.4 PREFERENCE MAP

In order to calculate the preference map, the mean individual assessments of two question (Bad/Good and Noisy/Calm) in Q1 were selected. The individual responses collected at 37 evaluating spots were averaged over the 10 soundwalk' participants. Those values were then uploaded to a GIS software (ArcGIS pro) and used to generate a prediction surface based on "IDW (Inverse Distance weighted)" method(5). Figure 3.3 shows the preference maps for the overall assessment of soundscape on the promenade. From the maps' observation, it emerges that some parts on the promenade are characterized by a poor individual assessment, for both "Bad/Good" and "Noisy/Calm". This is likely due to the spots are influenced by high roundabout road-traffic or non-existence of the water sound, leading to poor preference that result in contrast with the visual scenario (park or mountain).

3.5 COMBINE ANALYSIS OF NOISE MAP, SOUND MAP AND PREFRERNCE MAP

Separate and combined analyses of the three maps were performed and the results showed not only the presence or absence of the water sounds improve the preference of promenade but also seven evaluating spots need to improve the soundscape. Thus, the addition of the water sounds in the laboratory experiment was proposed to improve the sonic environment. To determine the levels and types of the water sound, a listening experiment was conducted and the adjusted levels and type of water sound were proposed.

4. LABORATORY EXPERIMENT: ENHANCEMENT OF SOUNDSCAPE USING WATER SOUNDS

In Sec 3.5, seven evaluating spots determined that need to improve the soundscape. Thus, a listening experiment was designed to determine which the levels and types of water sounds were able to improve the soundscape for each seven spots(6).

Water sounds selected from a commercial sound effects CD (Sony Pictures Sound Effects Series), which included sounds called "Small Stream"," Medium Stream", "Small Waterfall", "Medium Waterfall", "Steady Fountain" and "Rhythmic Fountain" and also two types of rill sound that measured from the promenade included. Spectral characteristics of water sounds were not modified, but their levels were adjusted for the experiments. During the Soundwalk, the background sound of each seven spots recorded was used into auditory experiments.

4.1. Preferred the types of water sound

In the first part, the preference to types of water sounds was evaluated. The sound levels of water sound were adjusted to be equal to the sound levels of the background of each seven spots, and adjusted water sounds were combined with each background sound. The duration of the combined sounds with adjusted water sound and background sound was 5s, and their LAeq varied from 50 to 65 dBA. Ten subjects aged 20-30 participated in this experiment, and the stimuli were presented through headphones in a hearing laboratory. Subjects rated their preference when the combined sounds were presented to them. They were informed about the purpose of the experiments and instructed about how to use 7-point scale. They were asked to respond to the following question: Which stimuli do you prefer if you were exposed to it on the promenade? The stimuli were presented to the subjects simultaneously. A visual image of each seven spots was shown to the subjects before the listening tests began.

Figure 4.1 – Participants in the listening experiment

4.1.1 Results and discussions

The results of this auditory experiment are shown in Figure 4.2, where a larger value indicates a higher preference. As shown in Figure 8.1, the small stream or medium stream were highly preferred with background sounds, which measured at the seven spots.

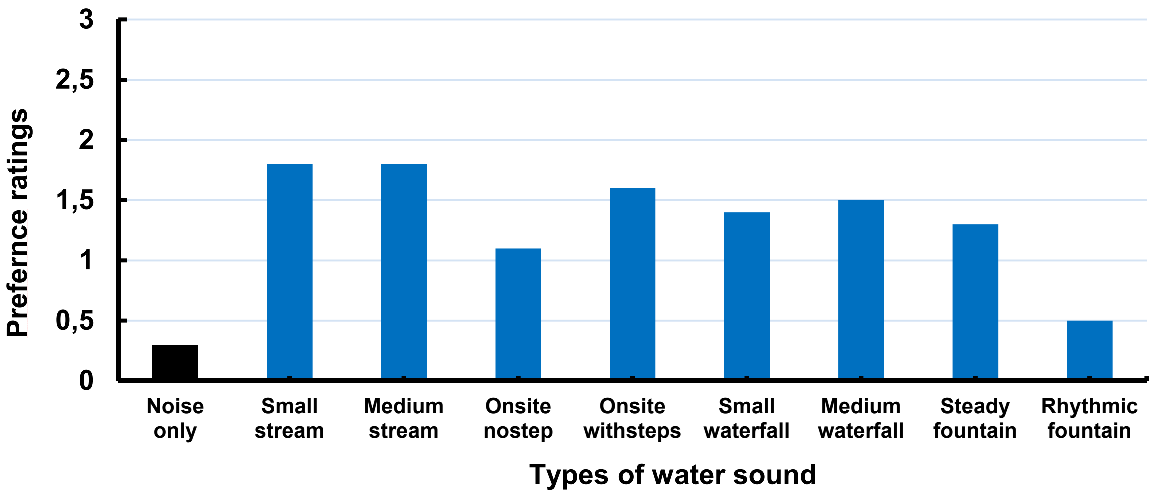


Figure 4.2 – Preferred water sounds at spots where sound environment are recommended to improve

4.2 Preferred the sound levels of water sound

Even though specific water sounds were determined as preferable sounds in urban spaces, a detailed difference in sound level between the water sound and the urban noise was needed to improve the soundscape for promenade. Therefore, the preference to sound levels of water sound was evaluated in the second part. The SPLs of each water sounds were adjusted. For example, The SPLs of water sound varied from 44.4 to 56.4 dBA in a step of 3 dB in the case of the background sound of.50.4 dBA. Thus, a total of 280 combined sound sources with water sound and background sound was used for the listening test to evaluate. These stimuli were presented randomly through headphones and subjects were asked to respond to the following sentence: Please rate the sounds on your preference according to the 7-point scale. A visual image of each seven spots was shown to the subjects during the listening tests began.

4.2.1 Results and discussions

The scale value of preference is shown in Figure 4.3. As shown in Figure 4.3, the mean scale value was the highest when the relative SPL of Small stream and Medium stream was 0 dB compared to the background sound. In other words, the results suggest that the water sounds are most effective to enhance the promenade soundscape when the water sound is with the same level or 3 dB lower than the background sound. It is interesting to note that the preference decreased when the sound level of the water sound increased, perhaps due to the increase in the total sound level.

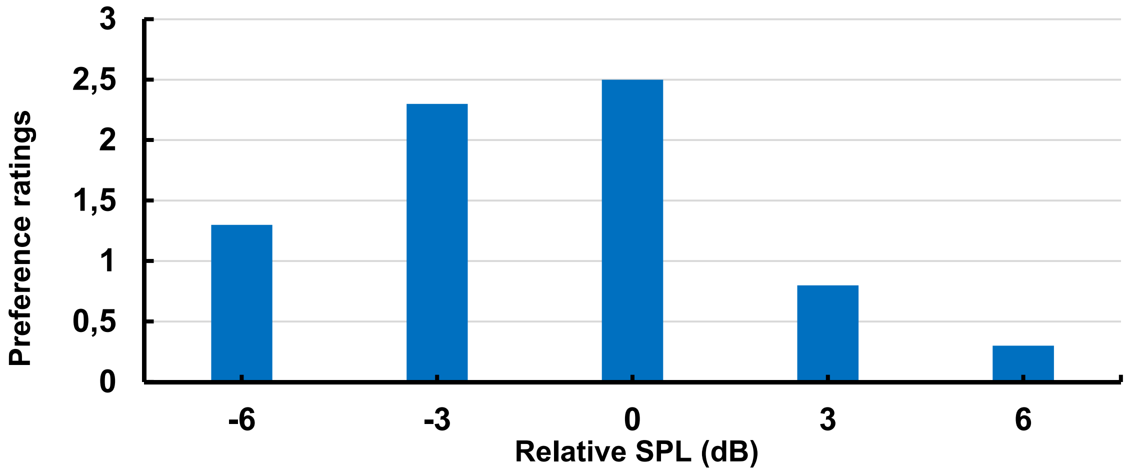


Figure 4.3 – Preference rating according to relative presentation level of sounds of waters and background sound.

5. CONCLUSIONS

Separate and combined analysis of the three acoustic maps were performed to propose some measures to improve the soundscape of the promenade through listening experiment. The main conclusions are as follows:

1. The noise map of surrounding road-traffic and crossing shuttle buses shows that the noise can affect visitors and ecology and most of the study area results to be exposed to more than 65 dB with a few spots falling in the 55 – 60 dB range.
2. The sound map was calculated with the rill sound sources which were treated as a surface source with continuous operating time and is shown for the rill sound sources' spatial distribution.
3. Preference map calculated by individual responses during Soundwalk. The results presented the spots are influenced by high roundabout road-traffic or non-existence of the water sound, leading to poor preference.
4. Separate and combined analyses of the three maps were performed and the results proposed that seven evaluation spots need to improve the soundscape.
5. From the results of listening experiment, the water sounds such as "Small Stream" and "Medium Stream" sounds were selected as preferred natural sound to improve soundscape. The appropriate level of the water sounds should be similar to or not less than 3 dB below the level of the background sounds on the promenade of Namsan Mountain.

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