Outdoor Elements Providing Urban Comfort:
The role of fountains in the soundscape

CATHERINE SEMIDOR[1], FLORA VENOT-GBEDJI[1]

[1]GRECAU-Bx, ENSAPBx, Talence, France

ABSTRACT: Urban planners and other town designers need information to improve the environmental quality of cities. It is well known that water constitutes an important element for mitigating outdoor thermal comfort, especially in hot climates. The use of water takes different forms: the evapotranspiration effect from vegetation, river currents or the water jets from a fountain. It also concerns the urban acoustic comfort. As the matter of fact knowing how to provide pleasant and quiet outside areas in order to ensure pleasant and quiet inside areas is one of the challenges for a better urban environment. So, it is necessary to know what type of urban design enables such areas to exist and how to characterise their sound quality. This paper deals with the data analysis from different case studies (Barcelona, Bristol and Genoa) depending on the type, the place, and the surroundings of the fountains. In each case, some soundwalks were carried out in order to highlight the quality of the urban soundscape.
Keywords: urban comfort, environmental quality, urban soundscape

INTRODUCTION

At different scales, a lot of elements contribute to the environmental quality of cities. The shape of the streets, the building height, the material of the facades and so on, depend on the urban and architectural design. Some of those elements are of natural origin. They often play a role in global urban comfort.

As a part of the urban environment concerns acoustic comfort it is particularly important to know how to create quiet outside areas. Therefore it is necessary to know what type of urban design and natural components produce such areas and how to characterise their sound effect on the urban environmental quality.

From previous research results, the natural sound sources are perceived as very pleasant. Water in different forms (from vegetation, river currents, basins and so on) is one of those components: besides the importance of its hygrothermal effect when the climate is hot, its impact on the sound environment is also important. Our research question concerns the fountain as natural soundscape element: what role do fountains play in the soundscape, particularly in noisy areas?

URBAN SOUNDSCAPE ASSESSMENT

Nowadays, noise mapping is the only way to assess external acoustic characteristics. Thanks to some in situ measurements and computed simulation data, this tool gives Sound Equivalent Level values around streets, but does not inform about global urban sound quality. Its goal is to determine the most annoying areas due to traffic noise in order to control the normalised sound insulation of façades. Nevertheless, as it is obvious that quiet outside areas ensure peaceful inside places, it is necessary to have a methodology to characterise them. That is why GRECAU-Bordeaux recommends using the soundscape concept proposed by the Canadian composer Murray Schafer [1].

The soundscape analysis enables us to list all types of sound sources. Most of them concern the noise annoyance of motor vehicles: cars, city buses, small trucks,…traffic in general, but there are also many varied and pleasant sound signals in the urban environment like bird-song, the wind in the leaves, fountains, children playing, chatting on café terraces or footsteps on the gravel…. Therefore, urban practices (residential, office, industrial or commercial areas…) have to be analysed in order to qualify the soundscape. The "sonoscenes" or “soundscenes” (significant sound events) are characteristics of urban activities. All have a clear meaning for each city-dweller. Thus, the results of a subjective survey of their opinion on the quality of the urban soundscape have to be taken into account. Due to the essential role of urban morphology in sound propagation, all architectural characteristics (street-shape, used façade materials, etc.) must also be investigated.

For a very noisy area (e.g. highway surroundings), the approach used by the soundwalk (GRECAU's assessment method) brings no added value when

compared with traditional sound measurements. The soundwalk is suitable for a medium sound environment where different activities are taking place. The sound level of the area needs to be varied. It should be an area where transport encounters other types of activities. This type of study enables us to reflect and think about different options for places with too much traffic.

PRINCIPLE OF THE SOUNDWALK METHOD

The urban soundscape is the product of a large variety of sound sources. Only phonography keeps a track of them. The sounds are recorded with all their acoustic characteristics (intensity, frequencies, duration). To establish the role of the urban morphology on the soundscape, soundwalks of approximately half an hour are performed following a route which crosses sites with very different urban forms. This method was inspired by the approach proposed by K. Lynch [2]. It is obvious that the urban noises fluctuate constantly with time and the observation time of approximately half an hour is too short to have a complete picture of the site. So soundwalks have to be conducted several times per day and several days per week.

The modus operandi is based on the use of a system of sound recordings associated with photos. On the one hand the accompanying photos keep a track of a part of the urban forms that the walk follows and on the other hand, of the "soundscenes" (significant sound events) which may occur in relation to specific activities on the taken route. For the sound equipment GRECAU [3] chose a DAT tape recorder equipped with two microphone capsules, equivalent to a "dummy head". This recording equipment is very user-friendly, and gives access to stereophonic recordings which are similar to the natural binaural hearing of the walker. The calibration of the tapes (coupled with the location of the position of the attenuator) enables us afterwards to sift through each of the tracks in the laboratory, thanks to the Symphony card and the dBEnv software.

This method gives us relevant, real and significant information which can be added to the data obtained from classical acoustic measurements. The information can be used while performing the interviews during which people listen to recorded sounds in order to enable us to know their opinion on their sound environment.

The resulting data can be analyzed either in the form of a 3D spectrum or in the form of an "acoustic image". This 2D representation corresponds to the evolution of the Equivalent Sound Level versus frequency during the soundwalk time, and as such gives a visual translation of the auditory impression.

Every image, with key (Figure 1), which attributes a colour (or a grey shade) to every range of Sound Pressure Level (SPL) according to a scale, which goes from 10 dB to 10 dB, is related to its evolution versus time.

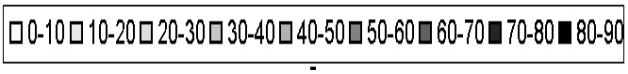

Figure 1: Greyscale key corresponding to SPL range in dB

Knowing that each time point is associated to a point on the route, we thus have an immediate evaluation of the soundscape of a site. Indeed, the soundwalk methodology is accessible to users, urban-planners, and city decision-makers. It also keeps track of the soundscapes in relation to the heritage of the city.

URBAN ANALYSIS GRID

To assess urban morphology and urban activities, GRECAU proposes the use of a grid in order to structure the thinking methodology. The tool has already been tested in a former study [4]. It enables us to integrate and organize varied and very different data (qualitative, quantitative, intuitive…) without necessarily ranking them. We are interested in the data which highlight the relationship between a site's soundscape and its morphology, because this is regarded as being the first element the urban-planner will modify. The soundscape will be identified using soundwalk methodology and morphology, and using traditional space representation techniques (plans, façades, elevations, side views). By modifying the site's morphology, the urban-planner will also change the locations of different activities; as a consequence the sound sources also will be changed. The specific characteristics of these activities must also be integrated in the grid.

Firstly we defined two categories, the site's morphology and the site's sound source layout. Actually, it is the combination of these two categories which enables us to define the soundscape as such:

- Morphology of the hollow volume constituting the site's space.
- Use of noise sources.

Secondly, we decided to add a topic which includes elements which do not involve 'use' but which belong to the soundscape. Each topic is then detailed into criteria defined by measurable parameters:

- The morphology of the studied public space (ground, buildings, plants and trees, urban furniture).
- The activities present (noise sources: means of transport, human activities and mechanical activities).
- Natural elements (noise sources: water, air flows and movements, animals).

Regarding the category "Means of transport.", even though it could be a part of either "human activities" or

"mechanical activities", we chose to create a separate classification, as transport constitutes an essential element of the Silence Project where some data come from. The other two classifications are "human activities" and "mechanical activities" and not "human sources" and "mechanical sources" because in this study, not only acoustic parameters, but also spatial and temporal parameters have been taken into account.

CASE STUDIES

For the Silence research project [5], four European cities belonging to the Polis network partnership: Barcelona, Bristol, Brussels and Genoa. Thanks to the surveys in three of them, we had the opportunity to carry out some soundwalks in areas where the fountains are placed close to the main streets: Plaza Catalunya in Barcelona (Figure 2), "The Centre" in Bristol (Figure 3) and Piazza Ferrari in Genoa (Figure 4). All squares are large with a lot of traffic all around and surrounded by high buildings.

Figure 2: Plaza Catalunya

Figure 3: The Centre

Figure 4: Piazza Ferrari

In order to compare different parts of the same site at the same time, several soundwalks were carried out:

- 2 soundwalks (route A and B) per site and at the same moment,
- 3 soundwalks per day (morning, noon and afternoon) for the same route,
- 3 days (Thursday, Friday and Saturday) per week.

SOME RESULTS

In each case study, the examination of the acoustic images enables us to split the site in several areas depending on the auditive perception of the fountains. Because of the data quantity, not all the acoustic images about the three cities can be presented in the paper. Concerning Barcelona and Genoa we can find more results in [6]. The only detailed data given here are those from Bristol.

"The Centre" is the name of a public area near the waterfront of Bristol's Floating Harbour. In the year 2000, as part of the celebrations for the Millennium, the area was remodelled from a 4-lane roundabout to be a more pedestrian-friendly public area, with pools and flowerbeds. The Centre is used equally well on weekends and weekdays, as well as throughout the day. Traffic levels were reduced quite significantly at the time, but have since increased as people become more familiar with the layout. As part of the aesthetic improvements to the pedestrian environment, the area was cobbled, which could have led to an increase in vibratory noise, and the area also serves as a major bus interchange.

The Centre, with shops on both sides, facing onto the bars and restaurants of the waterfront is busy throughout the day even after midnight. The Centre has a very wide avenue, rather like a promenade, with two sidewalks lining a dual-carriage-way and a large central promenade with fountains. The fountain area is composed of many small water jets of small capacity but regularly distributed over three large basins. In the study, route B

follows the right side pavement along the facades and route A passes between the road and the fountains (Figure 5).

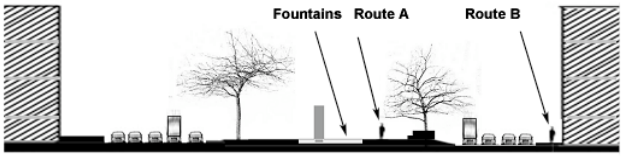

Figure 5: Situation of the two routes

Concerning the elements of the urban analysis grid, we can note that the gentle slope has no impact on the soundscape, but that the high buildings along "The Centre" (ground floor, 3 floors or more + attic) have. The bushes, plane trees planted in the central area, and the urban furniture all along the routes constitute no sound source but have an impact on the soundscape. The role of the bus shelters as a noise barrier between the pedestrian and the street is obvious on route B. Figure 6 shows a comparison between the soundscapes of route A and B recorded at the same moment.

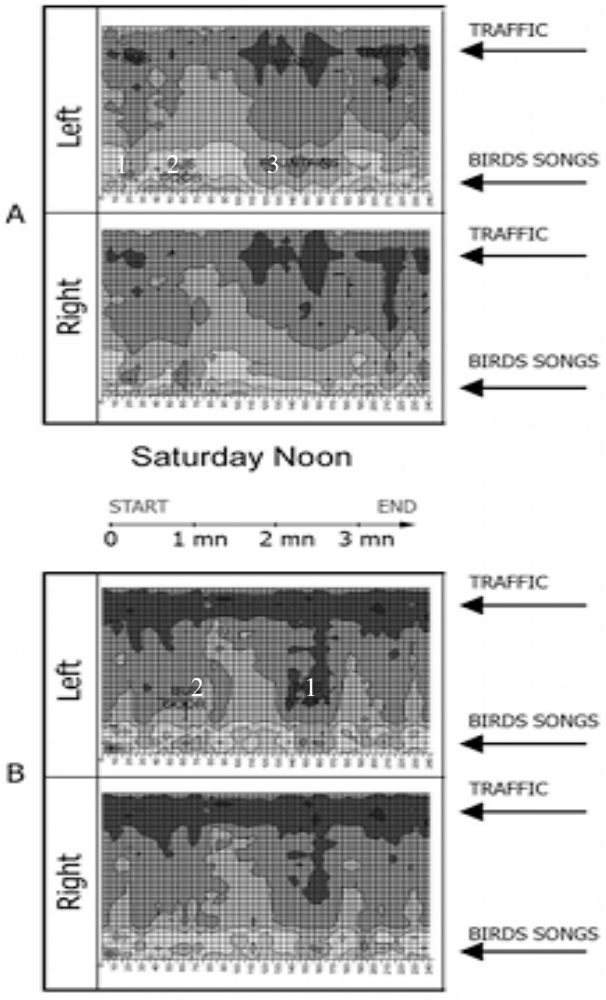

Figure 6: Soundscapes along route A and route B

Some sound events which occurred during the soundwalks can be highlighted:

- Passing buses (1).
- Shutting bus doors.(2)
- Fountains.(3)

The traffic is far important in The Centre as we can see in the low frequencies bands. The buses are the noisiest vehicles. There are also private cars, taxis, motorbikes and some bicycles. The Centre is rather crowded because there are a lot of shops and bars on the ground floor of the buildings. Seagulls are audible in several parts of the routes (high frequencies bands).

The sound of the fountains is preponderant in the central area of the esplanade, but is not audible from the lateral sidewalks. Figure 7 shows a photo of one of the basins and a zoom of the acoustic images.

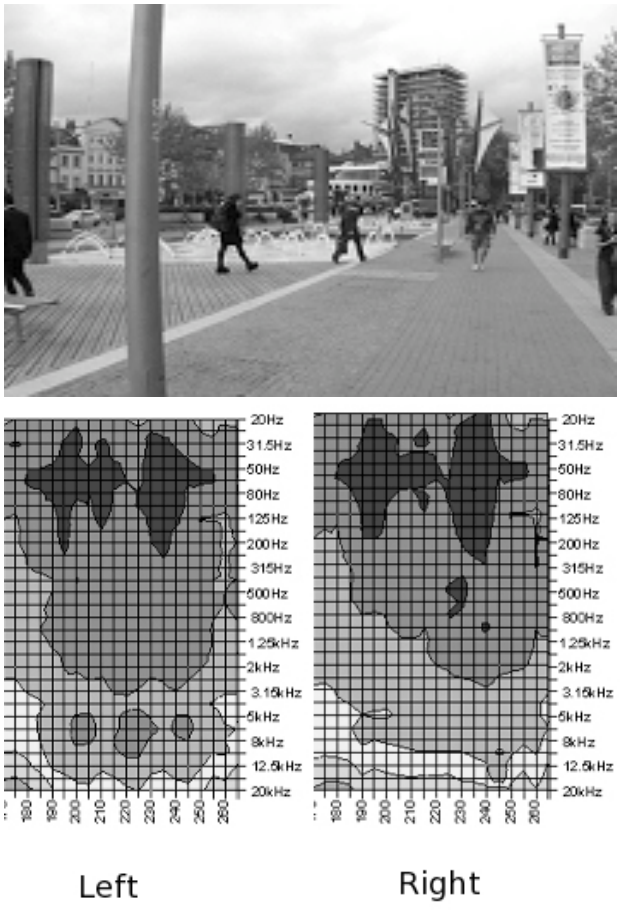

Figure 7: Soundscapes on route A with the fountains.

What characterises the sound is the spectral sound energy distribution: the sound of the waterfalls is a white noise source (an equal distribution of energy on the whole frequency range). So, the sound mark of the

fountains on the acoustic image is particularly visible in high frequency bands because the SPL exceeds the level of the background noise. We also can note that the walker has the fountain on the left side which is clear on all the acoustic images because the sound level is higher on this side. The sound mark of the three basins is very clear. Because the power of the water jets varies in time the middle one (M) is larger than the right (R) and left one (L).

Because, during the survey, the fountains stopped half a day, it was possible to record a soundwalk on route A without the noise of the fountains (Figure 8).

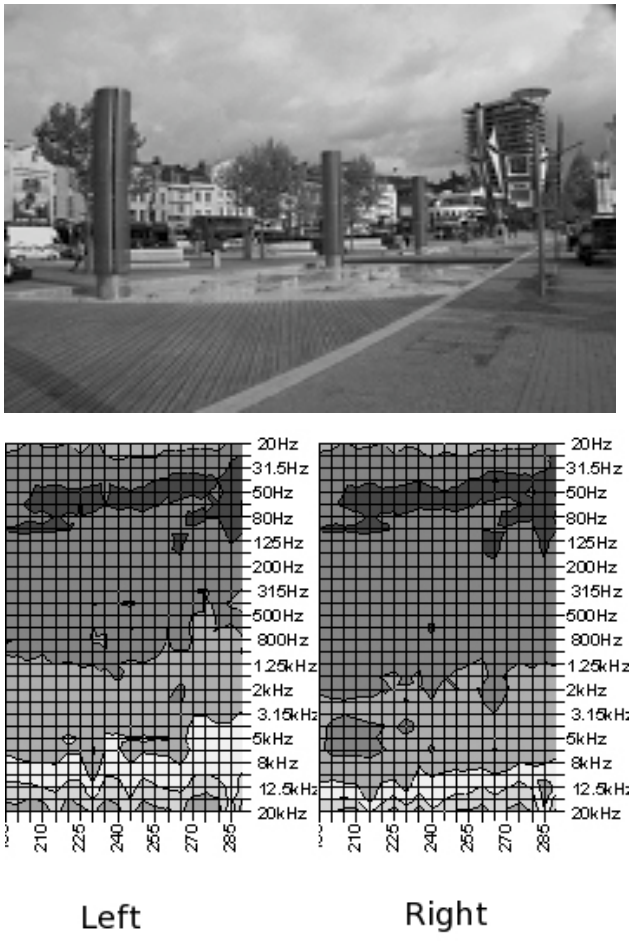

Figure 8: Soundscape on route A without the fountains.

The soundscape is more characterised by traffic noise and city rumour. As such it looks like a normal urban circulation area with disagreeing pedestrians.

It is obvious that the perception of the traffic noise is completely different in the central part of the Centre when the fountains are working or switched off.

To compare the effects of the fountains in the two other cities, the results from Barcelona and Genoa are resumed as follows.

Plaza Catalunya is a very large space with two big fountains on the upper side of the square. From the Rambla, two soundwalks were carried out in order to compare different parts of the same site at the same time. From the analysis of the acoustic images, several zones (Figure 9) can be underlined:

Zone 1: the main source is the traffic characterised by high sound level in low and medium frequency bands from 20 Hz to 2 kHz. The route is very close to the façade, the sound field is quasi-diffuse as the similarity between the right track and the left one shows.

Zone 2: here the space is open which explains the difference between left and right tracks. It is marked by the progressive emergence in the spectrum of the sound of the fountains more on the right side when we are close the belvedere. The perceived sound level is due to the fountains which masked the traffic noise.

Zone 3: then the walker leaves the belvedere to reach the centre of the square. The space is completely open. In the high frequencies band we can recognise birdsongs and human voices/conversations in the medium frequency band from 200 Hz to 5 kHz. The global level is lower than in zone 1 and 2 because we are far from the traffic.

Figure 9: Different soundscape zones

Piazza Ferrari is less large than plaza Catalunya but the traffic is also important because of the presence of three big streets. A part of the square is only for pedestrians. There are several lines of small fountains around the central one. In Genoa, the two soundwalks (Route A and Route B) were performed in parallel all around the fountains (Figure 10).

The routes are split in two parts (A1, A2, B1 and B2) in order to be analysed. On the recorded acoustic images of route B2 the difference between the left and the right tracks is due to the uninterrupted perception of the central big fountain on the left side and the discontinuity in the perception of the lined small ones on the right side.

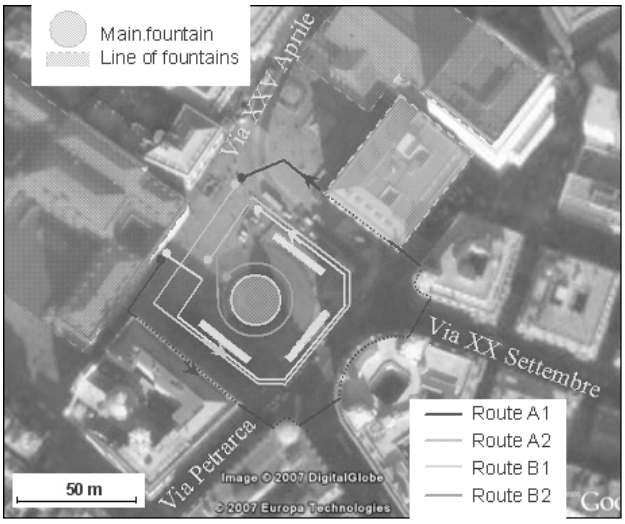

Figure 10: Routes A1, A2, B1 and B2 around the fountains

Although there is no shadow and the sound level quite high because of the fountains in the central part of the square, a lot of people stay around to read, to have lunch or just to be quite.

CONCLUSION

The sound of falling water is characterised by a very specific frequency response close to a white noise spectrum. So, depending on the urban tissue (open or closed) and the position of the walker in relation to the fountain(s), the frequency marks can be spotted on the left and/or right acoustic images.

The fountain's ability to mask traffic noise is demonstrated in each case study. The first results show that not only the power of the water jets, but also the number of fountains, their location on the site (mostly they on a square) and the way they are implemented ensure their efficiency: the proximity of a big fountain and the power of its water jets masks the level of urban noise quite efficiently, but when it concerns a large area a multitude of small fountains is more useful in reducing the auditive perception of traffic noise.

The location of the group of fountains in relation to the surrounding streets is also important: in order to mask the traffic noise considerably and to create a quieter area in the central part of a square, the best place for a group of fountains is at the periphery of the square.

Fountains are not only an important cultural symbol for the city, but they also have a crucial environmental function. The analysis of the soundscenes enables us to split the site into different areas depending on the auditive perception of the fountains. So, it is possible to give urban planners some information about the role of fountains on global comfort in urban spaces.

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