Buenos Aires – 5 to 9 September, 2016
Acoustics for the 21st Century…

PROCEEDINGS of the 22nd International Congress on Acoustics

Soundscape, Psychoacoustics and Urban Environment: Paper ICA2016-75

Fountains as sound elements in the design of urban public walks soundscapes

Fernando J. Elizondo Garza[(a)], Adrian Garcia Mederez[(a)], Cesar Guerra Torres[(a)], Diego F. Ledezma-Ramirez[(a)]

(a) Acoustics Laboratory of the Mechanical & Electrical Engineering School of the Autonomous Nuevo León State University. México
fjelizon@hotmail.com, adriangarcia69@gmail.com, cguerratorres@gmail.com, diego.ledezma@gmail.com

Abstract

One of the most common types of soundscape design are urban public walks, these are normally surrounded by buildings and avenues with common city sound and noise sources which must be minimized in order to reduce their negative effects, so that people can achieve an isolated space and time that permit relaxation and recreation during the walk. This work analyses the case of the Santa Lucia Riverwalk (Paseo Santa Lucía), in Monterrey, Mexico, an artificial riverwalk of approximately 2.5 Km, opened in 2007 in the context of the "Universal Forum of Cultures Monterrey 2007", which connects down town of Monterrey city with Fundidora Park. This walk is one of the major tourist attractions of the city and through various strategies a proper and pleasant soundscape is obtained. The strategies used in the soundscape design of the riverwalk are described, the acoustics of fountains are briefly discussed, and the uses of fountains to help masking of urban noise are analyzed. Moreover, the results of sound levels measurements produced by the fountains along the riverwalk are presented. Lastly, the aspects that must be considered in the use of fountains to mask noise in urban walks are discussed.

Keywords: Fountains, soundscape, design, riverwalk

Fountains as sound elements in the design of urban public walks soundscapes

1 From the river to the fountain

In addition to its basic function as drinking water, humans use water for different purposes, for example: to prepare food and various beverages, for cleaning, in agriculture and gardening, for heat exchange, as solvent, as part of chemical reactions in numerous industrial processes, in fire extinguishers, for sports, and in recreational activities among others. [1,2,3]

Also, from the religious, philosophical and literary point of view, the water receives great attention: it is considered by philosophers as one of the basic elements, along with fire, earth and air; It is used in religious rituals such as baptism, blessing, purification of the dead, etc.; and in literature: seas, rivers and lakes, as theme or scenario, commonly appear. Therefore, the water generates a strong positive psychological effect of safety in people, recognizing that one of the key elements for their survival is available and close. In this sense, fountains have a great importance in the modern design of spaces and landscapes.

Water is one of the factors that led to the sedentary communities, and the creation of cities in modern terms is related to access to drinking water. First were the lakes and rivers that generated the conditions for the establishment of the cities, which for its sustenance and growth required water engineering works, such as the construction of dams, aqueducts and fountains, the latter as drinking water suppliers for the towns and districts of the cities.

In the middle ages, Islamic culture produced fine fountains in private and public buildings, combining the utility with beauty, serving also to cool down spaces. Renaissance architects and artists created beautiful fountains, culminating in the lush and complex sculptures of the Baroque era fountains.

A drinking fountain is a supply of water that as architectural element used to be located in an urban space for utility, environmental comfort, or decorative purposes, see Figure 1. These fountains were located in courtyards, gardens, squares, or central locations in a city, embellishing them, improving them and highlighting its importance. [4]

Figure 1. The primitive drinking fountains were in squares or down town locations of the villages to supply water to the inhabitants and quench the thirst of their animals. They used to be meeting places that promotes the social relations of the community. (a). Fountain of the "Salto de Agua", in Mexico city. ([5]. b). Postcard of the "Caja de Agua" (water box), with its fountain in San Luis Potosí, Mexico. [6]

With the development of modernity and public health, water enters the houses through distribution networks. Drinking fountains mainly take recreational and aesthetic purposes, as it can see in Figure 2.

Figure 2. Currently the drinking fountains meet aesthetic and historic character functions. Fountain "Salto de Agua", as seen today in Mexico City. [7]

Later on, fountains took other functions and became independent of the natural water flows thanks to the technological changes, as the use of closed circuit of water, driven by pressure pumps. They also were lit to make them more eye-catching in the night and become to be used in conjunction with audio in public shows.

2 The Santa Lucia Riverwalk

In order to analyze the use of water resources in the design of a successful soundscape, measurements were made in the Santa Lucia Riverwalk (Figure 4), a channel (artificial river) and pedestrian thoroughfare located in the downtown of the city of Monterrey, Nuevo León, in the northeast of Mexico, being one of the more attractive and more visited site in the city. [8]

Figure 4. View of Google Earth [9] of the Santa Lucia Riverwalk in Monterrey, Mexico, where is indicated the position of fountains considered in this paper

The construction of this project began in 1996, but was limited to a first part of small dimensions. After being stopped for more than 9 years, in 2005 the work was continued to its

end. The walk opened on September 15, 2007 by the President of the Republic of Mexico in the context of the international event “The Universal Forum of Cultures Monterrey 2007”.

The main attraction of this walk, designed by Arq. Enrique Abaroa Castellanos,[10] is a navigable channel, which has a distance of 2.5 km, with a depth of 1.20 m., in which visitors, either walking or sailing in small tourist boats, can enjoy a beautiful landscape with water fountains whith artificial lighting, bridges, walkways, artistic murals and sculptures, a large expanse of green areas, terraces and esplanades which create landscapes and scenes where different cultural, sports and leisure events are organized. There are also museums, theatres and restaurants in the zone.

From the acoustic point of view, can be mentioned as sound sources, in addition to the fountains of our interest: a public addressing and music audio system, people passing through the walk, the sound of the tourist boats engines, water pumping and purifying systems and sporadically the sounds produced by events held at or near the riverwalk. Externally, the main sources are the traffic on the avenues and streets that surround or cross the walk.

Along the way are 24 fountains some of which, in addition to its aesthetic function, have an acoustic intention either for soundscape character or for masking.

3 Measurement of sound emitted by the fountains in the Santa Lucia Riverwalk.

In order to obtain an idea of the range of sound levels that the fountains generated, on January 2016, eleven fountains of the Santa Lucia Riverwalk, with different characteristics, were measured, which range from the purely ornamental type, which do not produce significant levels of sound, up to the waterfall types that produce sounds able to mask other nearby sources.

The measurements were performed by scholarship assistant students of the Mechanical and Electrical Engineering School of the Autonomous Nuevo León State University.

The following equipment was used for the sound measurement of the fountains:

- Sound Spectrum Analyzer, CESVA, model SC 310.
- 4 Precision Sound Level Meters, Brüel & Kjær, type 2232.
- Sound Calibrator, Bruel & Kjaer, type 4230.

Two types of measurements were performed:

- Sound level in dB (A) slow response.
- Spectrum by octave bands.

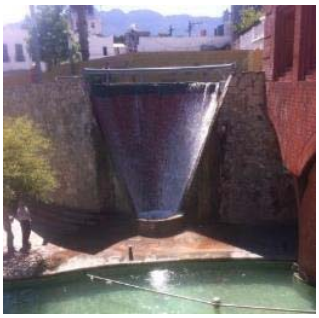
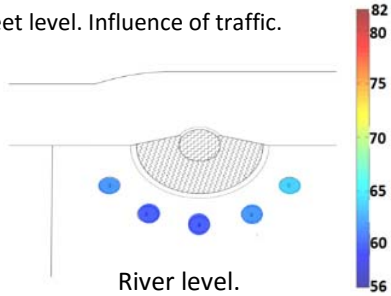
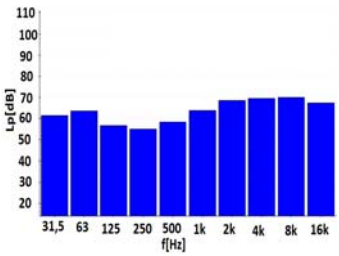
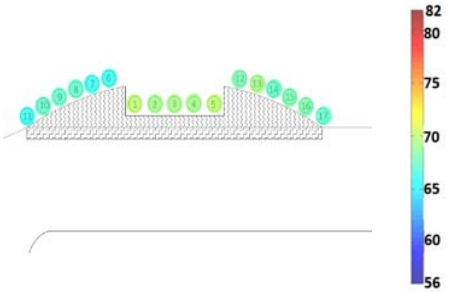
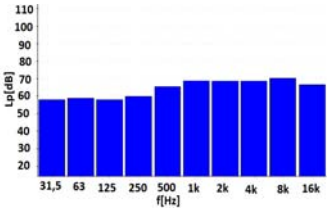
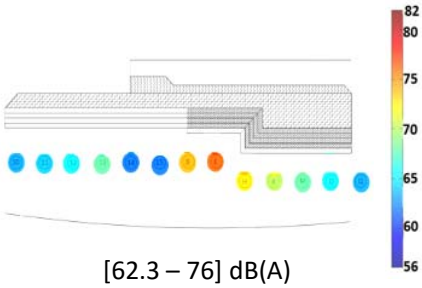
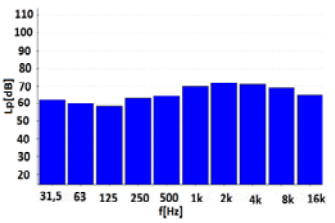
The measuring points were selected in the first instance at 1 meter from the edge of the source or channel, depending on the case, as the more frequent path of the walking people. In the case of the spectral measurements, a representative point was selected centered with respect to the source, also in the path of step of passers-by. The microphone was set 1.50 m in height and windscreens and incidence correctors were used.

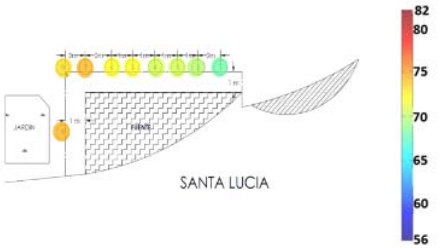
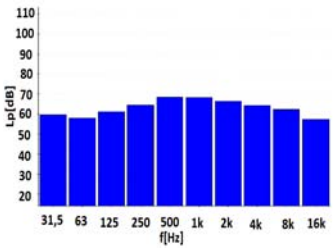
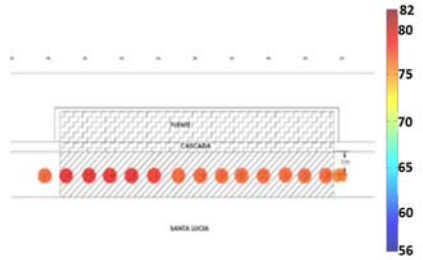
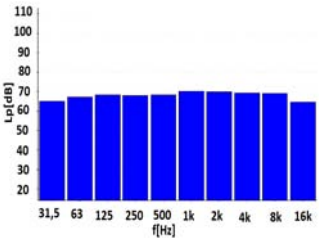
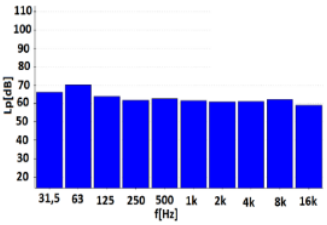
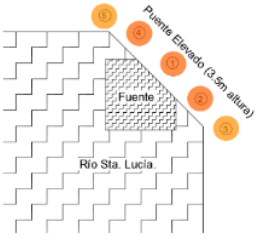
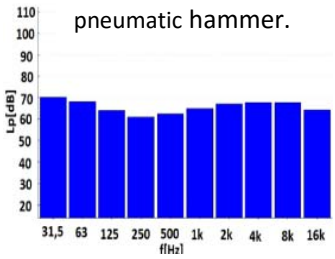
The measurements were taken on a normal day during the week. Since the sound of the fountains could be considered constant, it was measured as the background noise. When there were sounds that interfered, as people, vehicles or other sound sources, the measurements were made after it stopped. In the cases where it was not possible to eliminate the interfering noise, it will be specified that the combined effect was measured.

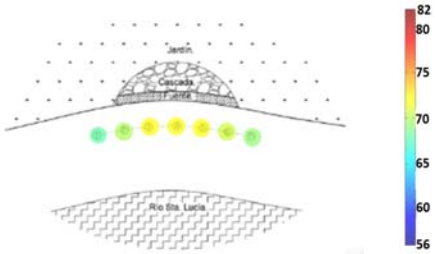
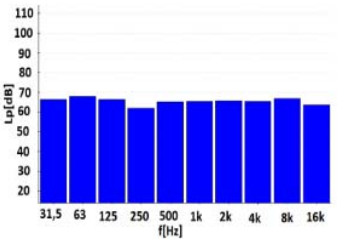
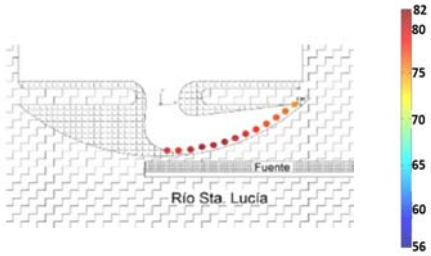
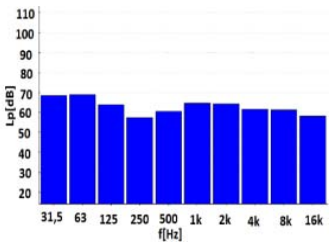
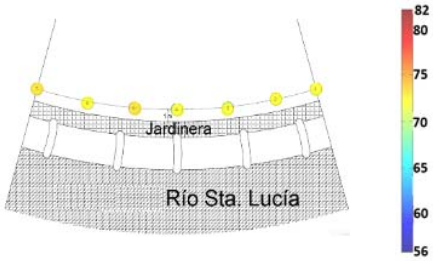
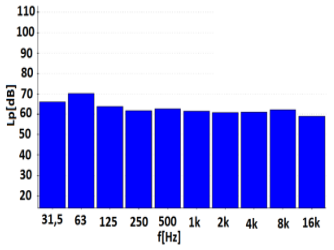
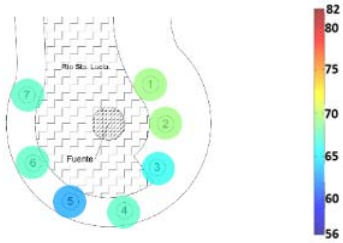
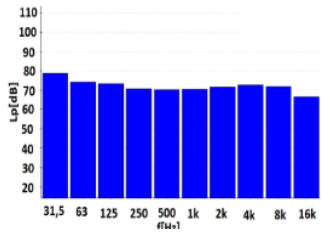
4 Results of measurements

Below, in Table I, the results from measurements made in some of the fountains of Santa Lucia Riverwalk were shown. The first column shows a picture of the fountain. In the second column a plant diagram of the fountains showing measured points and the range of the sound pressure level in dB(a) in format [SPLlower – SPLhigher] at points located on the main line of traffic of people passing in front of the fountain. It is indicated when the measurement were influenced by other sound sources. The third column shows a linear octave band spectrum representative of the fountain, and also an evaluation of the SPL in dB(A) for each spectrum.

Table I. Summary of results of measurements of sound pressure level in dB(a) and sound spectrum per octave, representative of the levels received by the pedestrians, walking in front of the fountains, in the Santa Lucia Riverwalk in Monterrey, Mexico.

FOUNTAIN	SOUND LEVEL, dB(A)	OCTAVE BAND SOUND SPECTRA
	Street level. Influence of traffic.  River level. [60.4 – 64.1] dB(A)	 SPL=62.3 dB(A)
	 [66.1 – 70.3] dB(A)	 Measured in the other side of the river SPL=75.566.3 dB(A)
	 [62.3 – 76] dB(A)	 SPL=75 dB(A)

	 [68.4 – 74.3] dB(A)	 SPL=72.8 dB(A)
	 [76 – 79.7]dB(A)	 SPL=76.3 dB(A)
	 [67.2 – 71.6]dB(A)	 SPL=71.5 dB(A)
	Influence of traffic and pneumatic hammer.  [75.2 – 76.8]dB(A)	Influence of traffic and pneumatic hammer.  SPL=78.4 dB(A)

	 [68 – 72.8]dB(A)	 SPL=72 dB(A)
	 [75 – 81.7]dB(A)	 SPL=80.5 dB(A)
	 [72.2 – 73.7]dB(A)	 SPL=72.6 dB(A)
	 [66.3 – 69.5]dB(A)	 SPL=68.3 dB(A)

In terms of noise level, results shown that the range of the sound levels produced by fountains on the line of pass of the people, are between 60.4 and 81.7 dB (A). During a walking tour along the promenade, it was clear that as higher the noise level of the fountains their masking effect and its zone of influence was greater, allowing an adequate psychological isolation from the environment.

Regarding the octave bands Spectra, it was found that for the eighth bands from the 31.5 Hz to 16 KHz the fountains present a flat type spectrum. As the measurement was carried out on a normal weekday, the influence of low frequency noise produced by the traffic in the surrounding avenues may appears in the spectrum.

From field sensory observations, it was evident that some fountains produce local soundscapes, hiding the sounds of the surroundings. In other cases their effect was more visual that acoustic, and in cases where traffic noise was high, the fountains generate a dynamic sense that avoids the preponderance of traffic noise, that added to a design of the walk that prevents people to see vehicles, allows people to focus on the combined visual and acoustic effect of the fountains.

The fountains located along the promenade generate a set of soundscapes which on one hand produce areas to satisfy different types of listeners, who may choose to stay a while in the place of their choice, and on the other hand make that strollers have a non-monotonous journey

5 Strategies for the use of water sources in the design of soundscapes [11]

The use of fountains must be based on the functions expected of them. It is important to be clear that they have several uses, as already discussed, from drinking, to pure aesthetics.

What kind of soundscape will be offered? It should be asked to potential users (tourists, employees in their rest, young people from schools, mothers with children, etc.) as it will be necessary to establish zones for each stratum, that's mean: different soundscapes.

A soundscape design is not just a matter of acoustics, and should be dealt as a combination of different designs that create the perception of a whole in the receiver.

For the purpose of landscaping the design is based on visual-acoustical integration, either imitating an environment or isolating the surrounding to create a space/environment that represents an option for being or transit of persons in the place.

One of the main function of the soundscape design is the creation of options to the listener, i.e.: Spaces to talk; Spaces for reading; Spaces for activities without audio; Spaces for events with audio; Spaces for relax; Spaces for individual exercise (usually with earphones); Spaces for team sports; Spaces for children; Etc.

To achieve this, specific sounds must be generated and unwanted sounds must be isolate, for which the main acoustic design tools are: Distance source-receptor. Sound isolation of unwanted sources; Sound-visual barriers; Masking; Audio system with background music; Audio with ambient sounds: birds, rain, etc.; Inclusion of iconic sound sources; Fountains; Etc.

In terms of our topic of interest: fountains, it must be clear that in the case of silent places they do not require to produce a high sound level and therefore other features will be priority. In other cases we require the sound of the fountain to promote relaxation and concentration, in such case the level and the spectral structure of the sound are important. On the other hand in noisy environments as in the case of urban spaces where you want to have places to isolate people from urban life, fountain can be useful if they generate a sound sufficiently strong so that it can mask, or remove the preponderance, of unwanted noise sources.

The main factors that influence the noise level produced by a fountain are: Available water flow; The pressure of the water; The height of the waterfall; The type of nozzle used, whether for spraying, generates drops or produce jets of water; The number of areas of water contact surfaces; The type of surface where the water comes in contact; If this is the case, the sound system of the fountain; etc.

On spectral shaping of sound, should be added, among other aspects: the type of surface materials and the way in which is used, i.e.: its damping properties (is not the same rubber than tin plate), its thickness (it's not equal a concrete floor than a glass) and the formation of cavities in the structure or surface that can act as Helmholtz resonators).

Because sound decay with distance from the source, in terms of the effect of masking, it should be considered in the first instance (excluding cases of Spectra with pure tones) the sound level of the fountain and of the noise source that you want to mask, as these will determine the areas of acoustic interaction around the fountain. This implies that the following areas for each source must be determined: a). acoustic area around the fountain in which it sound will prevail, b). the area of interaction between both sources and c). The distance from which the sound of the source of unwanted noise prevails. In this regard the work of Calarco, F. M. A., & Galbrun, L. "Soundscape design and mapping of water features used over road traffic noise"[12] it can be consulted. Based on the concept of zones of influence is that it is designed the walk travel path as well as the location of benches, tables and playgrounds areas with respect to the fountains.

Remember that not all people are looking for silence and there are even people who cannot tolerate the silence. Try to completely isolate a sound space of its urban environment is not a matter of seeking silence, the idea is to create zones where people can comfortably: walk, socialize or relax. For this, to place some barriers to reduce the external sound in some cases could be suffice, in others circumstances a background music system will be useful and in other cases a fountain can help significantly to the visual and soundscape.

In the case of the design of a riverwalk, settle the layout of the walk (river) in a level under the surrounding land (city ground) will be of great help and reduces the design requirements of masking sound sources or other types of barriers.

There are urban noise sources, as fly sources, sirens and alarms, which cannot be adequate or economically controlled with current technology.

6 Final comments

With the current systems of pumping and cleaning of water, coupled with the large number of types of fountain nozzles available in the market, the design and construction of fountains has become easier.

Carefully selecting acoustic aspects of fountains is possible to achieve different sounds, both in sound level as in spectral characteristics, in such a way that people can differentiate the sources not only in the visual but also acoustically.

Santa Lucia Riverwalk represents a good example of landscape design, in which different strategies were used to generate areas for different activities. It is important to emphasize the use of a water channel as axis, the use of a gradient as acoustic and visual barriers and the use of fountains like the cherry on the cake.

For urban parks and walks the use of fountains could be a useful element in the design of the soundscape, as it allows, in addition to create a background sound that promotes relaxation, to generate specific areas differentiated acoustically with respect to the sounds from city and create the possibility of generate areas for the various uses of public spaces.

Acknowledgments

We thanks the authorities of the Mechanical and Electrical Engineering School of the UANL, in particular to its Director, Dr. Jaime Castillo Elizondo, for their support of this project, as well as to students: Sandra Eunice Alfaro Estrada, Daniel Aarón Gutiérrez Montesinos, Mario Andrés Hernández Crespo, Roció Guerra Lomelí, Luis Ángel Carranza Rodríguez who made the sound measurements.

References

[1] Hidratation for Helth. H4H Initiative Agua en el cuerpo. http://www.h4hinitiative.com/es/ academia-h4h/laboratorio-de-hidratacion/hidratacion-para-los-adultos/agua-en-el-cuerpo

[2] Wikipedia. Agua. https://es.wikipedia.org/wiki/Agua

[3] INEGI. Usos - Agua. Cuéntame de México. http://cuentame.inegi.org.mx/territorio/agua/usos.aspx?tema=T

[4] Bryan R. Hirst. Fountains. http://www.gardening-uk.com/waterlands/fountains/index.html

[5] Máspormás. ParaElRecuerdo | Fuente Salto del Agua. http://www.maspormas.com/2015/08/28/paraelrecuerdo-fuente-salto-del-agua/

[6] Archivo F. J. Elizondo G. de Tarjetas Postales. Monterrey, México.

[7] Leyendas Coloniales, Fuente de Salto del Agua. 22 de febrero de 2015.

[8] Paseo Santa Lucía. https://es.wikipedia.org/wiki/Paseo_Santa_Luc%C3%ADa

[9] Google map / google earth. Paseo Santa Lucias. https://www.google.com.mx/maps/@25.6757378,100.2928383,2769m/data=!3m1!1e3?hl=en. Consultado 10 mayo 2016.

[10] Arq. Enrique Abaroa Castellanos. http://urbanlandscape.com.mx/enrique-abaroa.html

[11] Fernando J. Elizondo Garza. Fuentes, cascadas y otros elementos acuáticos en el diseño de paisajes sonoros. Capítulo del libro “Ruido ambiental y paisaje sonoro en la ciudad”. Publicación en proceso por la Universidad Autónoma Metropolitana – Unidad Azcapotzalco, México.

[12] Calarco, F. M. A., & Galbrun, L. (2015). Soundscape design and mapping of water features used over road traffic noise. In Inter-Noise 2015: 44th International Congress and Exposition on Noise Control Engineering. [158]