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MOVING TOWARDS THE VISUALISATION OF THE URBAN SONIC SPACE THROUGH SOUNDSCAPE MAPPING

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Currently noise maps only show sound levels and their areas of influence in a given urban space. These sound levels result from mechanical sound sources such as transportation and industry. Although noise levels are discriminated by statistical data -on which the construction of the noise maps are based, in reality, it is difficult to distinguish each sound through auditory perception. Sound environments are made up by different types of sounds. This range goes from the natural such as the human voice and sounds of nature to the artificial like musical, mechanical and technological sounds. The urban space has soundscapes that combine all kinds of sounds where some can stand out from others and change over time, which alters their perception. Since noise maps have the ability of making noise levels visible in an urban area; therefore it should be possible as well to make visible the soundscapes that incorporate specific sound distinctions to create a unique sound expression in different urban spaces. This document presents a proposal of soundscape mapping that considers the various aspects of sound beyond merely noise. The results which were obtained using this new criteria show the possibilities in the mapping and visualisation of soundscapes.

1. Introduction

It is well known that environmental noise is an issue already considered as an environmental pollution and public health problem (WHO, 2011). Due to the effects of noise on people a need for diagnosing the problem in the cities has emerged, especially in Europe based on the Directive 2002/49 (EC, 2002). Therefore methods including measurements, population surveys and mapping of noise to attend this problem have been developed.

Environmental noise is however a component of the acoustic environment, consequently the environmental noise is only a partial element of this whole; it is only a way to appreciate the sound environment of a place.

Another approach that emerges from the late 60s is known as soundscape, which focuses on recognising all acoustic fields of study (Schafer, 1977), including environmental noise, however the central point of view of this movement is to consider both, sound environment and environmental noise from a "positive" belief through the concept of soundscape, taking out the "negative" charge which usually implies the noise term.

The essence of soundscape focuses on the perception of space from the sonic point of view. How individuals or groups of people in urban space perceive the soundscape is one of the objects of study and source of information of the urban soundscape, besides being able to study the urban space as the container of the sound sources that emit sound at a particular moment or period of time.

This difference between the environmental noise and the soundscape, where the latter regards the overall sound environment is very important because it is much more inclusive for citizens or residents of a region, and not limited to a single aspect of the sound environment.

Certainly noise, as a phenomenon that causes discomfort or harm to people, cannot be ignored, but this should be framed more precisely within the context of the problems of environmental pollution and public health.

Assessment tools for both environmental noise and soundscape are very similar, somehow they apply to both concepts, as follows: acoustical measurements, surveys applied to population and the noise maps as key tools, in addition to sound recordings, video recordings and the use of applications on mobile devices. Each of these tools have value in themselves and as part of a whole, as well as being excellent information providers. From all of these tools the one that is of interest for this study is the noise mapping and more precisely the soundscape mapping, in order to find the most suitable for architects, urban planners and landscape architects to understand sound in the urban space.

2. Mapping sound

The need to know to what extent sound affects the urban space and people, as well as how it creates a sound environment, it is necessary to visually understand (through sound mapping) what happens from the acoustics point of view in the urban space..

Architects, urban planners and urban landscapers are used to the visual evaluation of their design proposals as well as for the assessment of the urban space because they are, in essence, visual. Therefore it is important to develop tools that allow us to display graphically the generated sound environment in an urban space. The existence of noise maps is a reference to such conditions, but in positive terms there is a need to develop soundscape maps: i.e. maps of the sound environment that characterise the urban sonic space as graphical information.

2.1 Noise maps

Noise maps currently have strengthened their presence in the urban planning field following the issuance of DIRECTIVE 2002/49 (EC, 2002), which requires, (at Article 7) strategic noise maps of the main cities of all Member States. Thus in Europe its existence and use is really useful especially for achieving the objectives set out in the Directive.

A noise map is a fundamental tool in order to know the impact of noise levels in specific urban areas. Its construction is possible by the generation of databases with geographical and statistical information as well as acoustic properties data and measurements that will result in areas affected by noise levels in a given area, which can range from a small urban area to a city or region.

The information provided by noise maps is usually expressed only in noise levels through equal loudness contours in different visual projections such as plans, sections, three-dimensional views and even animations (Fig. 1).

Noise maps have been characterised by taking into account major roads, railways, airways and industrial complexes, considering the regional level and major cities, focusing on characterising the noise by road traffic, aviation noise, railway noise and industrial noise as the main sound sources. This denotes the use of large urban scales, leaving aside the scale at which the average citizen moves: the neighbourhood scale.

The common citizen who moves through public space has a much more local level than the big city perception. The information of strategic noise maps as conceived now goes beyond the citi-

zen's range of motion so that strategic noise maps are useful for a macro level, i.e. to the level of urban planning and decision making by the governments.

The neighbourhood level, or any local level, is the way by which citizens are more identified with their sound perceptions.

2.2 Soundscape maps

The soundscape is conceived as a set of sounds, it considers the group of sounds that are not traditionally characterised by statistical data of their performance, such as road traffic densities, airways routes, etc., this implies the absence of information to generate maps as it is made with noise mapping, which could mean the need to have objective soundscape measurement data as acoustic parameters of a space.

But for architects and urban planners the use of sound levels is not significant, since sound levels are linked with the concept of noise, something considered bad, harmful and even hazardous. They prefer a symbolic language, where the symbolic elements used have a more qualitative rather than a quantitative value.

Graphically there are many ways to symbolise sounds in urban space; the first is of course the use of equal loudness contours, which, as discussed previously, have a noise level implication. Other elements are based on the location of sound sources in a map, even identifying them with symbols related to direct sound sources such as the sound of birds with birds, the sound of cars with a car, the sound of music from the radio or from speakers with a radio player or musical notation. (Fig. 2)

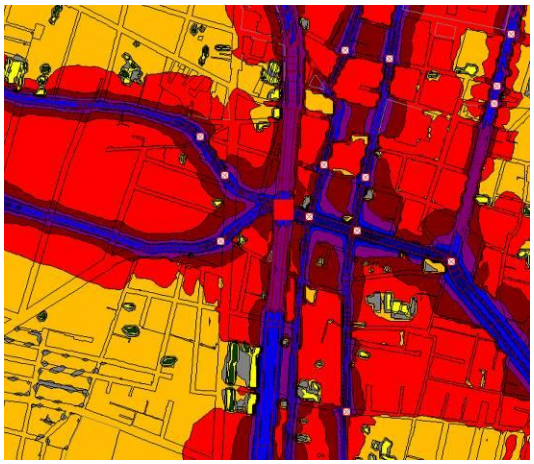

Figure 1. Noise map section of road traffic noise in Mexico City (UAMA-LADAc-SMA,2011)

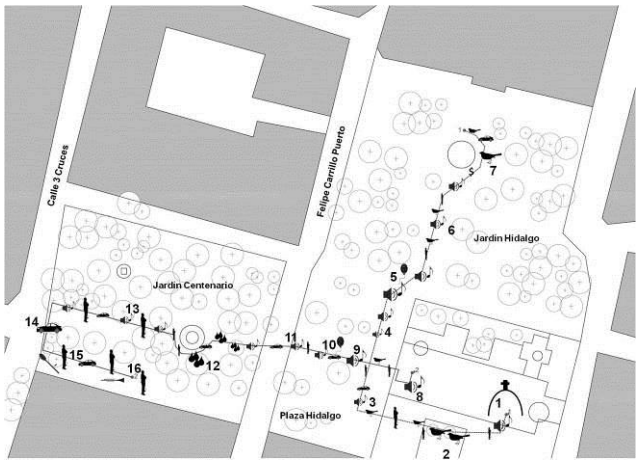

Figure 2. Soundscape map of a traditional Plaza in Coyoacán neighbourhood in Mexico City (Rodríguez-Manzo & Garay-Vargas, 2013)

Considering that the most important aspect of a soundscape is the perception of the human being, noise levels are not particularly useful for representing the entire sound environment nor are the graphic symbols that evoke sound sources. An analysis of the components that characterise the perceived soundscape is then required.

3. Soundscape characterisation

The knowledge of the soundscape of a place takes into account the understanding of:

- The sound environment features of the urban space
- The citizen's subjective preferences of the soundscape

For a graphical representation of the soundscape it is desirable to develop maps that explain these aspects separately. This paper addresses the first aspect that is the most objective for architects, urban planners and landscapers.

The soundscape components according to Schafer (1977) are grounded on the significant features of it, like "their individuality, their numerousness or their domination", and it can be distinguished by three categories: *keynote sounds*, *signals* and *soundmarks*, where keynote sounds can be referred to the background sounds of a community, signals are those sounds "visible" on the background, and soundmarks are quality significant sounds in a given community, something unique.

From this perspective the assessment of soundscape can be performed through the characterisation of these issues with the following parameters, which could be translated into graphic information, in order to show graphically the perceptible soundscape sound elements.

- Sonority: (keynote) what sounds (intensity); background sounds, presence and scope.
- Predominant sounds (signals) (distinguishing sounds from background noise) sounds that stand in relation to the whole. Sounds that have more presence than others.
- Sound marks (sound marks) significant sounds and sources for the individual or the community.

In the case of sound marks, they are not always present, in addition they generally refer to scales of an entire community or even a city, and its mapping is possible when they are continuously present.

4. Mapping the soundscape: A proposal of sound and colour

Sound and colour have affinities according to various authors, including Newton (Caivano, 1994), the proposal presented here considers the colour as a graphic element of higher presence for soundscape mapping purposes. Although colour is present in noise mapping, they only indicate noise level contours. The objective in this study is to relate the tonality of present sounds to colour scales.

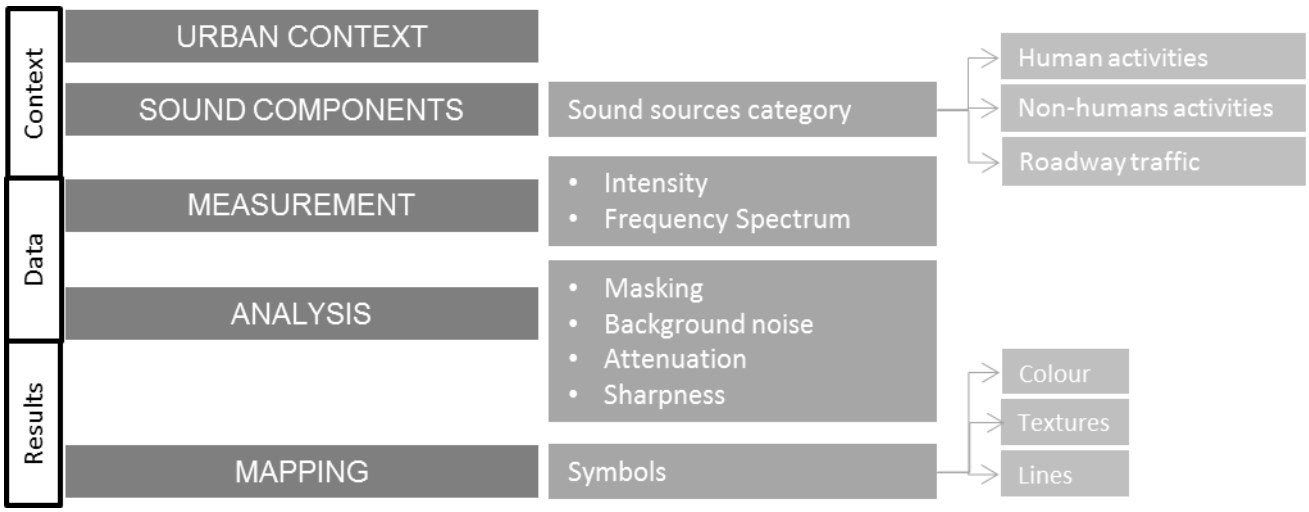

Figure 3. Conceptual model for a soundscape mapping process

In order to integrate a soundscape map based on sound and colour it is necessary to develop a process leading to it. Considering this as an urban problem, a conceptual model is proposed (Fig. 3).

The model above considers three levels:

- Urban and sonic context analysis
- Acoustic measurement and data analysis,
- Graphical representation (mapping).

Urban and sonic context analysis. After making walkscapes, a visual analysis and registering the urban and architectural features of the place, a selection of sampling points is needed in order to locate and differentiate significant areas showing greater relevance of urban and sonic behaviour.

Identifying sound components (signals). In order to identify and classify the predominant sources, the classification of sound sources according to Brown, et al. (2011) should be taken into account:

1. Sounds generated by human activity: Motorised transportation, human mobility (non-motorised), electromechanical sources (stationary and /or mobile), voice and instruments (amplified and non-amplified) and social/community and cultural sources.
2. Sounds not generated by human activity: Nature and animals.

Acoustic measurements. Field measurements at one metre from the source, applied to a sample of sound sources and environmental sound as well as audio recordings taken simultaneously both for 5 to 10 minutes.

Data Analysis. Selection and classification of significant sound sources (signals) and background sound (keynote) taken from field measurements and recordings, where each sound component is characterised on the basis of their dominant frequency in relation to their sound level. Because sound levels do not show the sonority perceived by the human ear, since two different sounds (different frequency spectrum) of the same sound level will not be perceived as equal sounds (Shiffman, 2010). Being that different sources could not be compared by their sound level, loudness according to Zwicker (ISO, 1975) is proposed, taking it in this study as sonority to cover all the different sounds through an ascending scale (from lowest to highest loudness).

The level of presence of the predominant sound sources (signals) compared to the background sound is given by the percentile difference (dBA) where 10 means presence of signals and 90 means background sound (Nillson, 2007), the greater the difference the predominant sources will be clearer with respect to the background sound, a smaller difference means a saturated sound environment where the predominant sources will not be easily identified.

Graphical representation (mapping). The proposal is based on three basic graphic criteria, use of color, texture / transparencies and lines. In which each symbol shows visual information of different sound components, as follows:

- Colour, type of sound source (sound component).
  - Warm tones, human activities
  - Cool tones, not human activities
  - Grayscale, motorised transport activities.
- Texture, attenuation of the perceived intensity (loudness)
  - Solid Texture, higher sonority
  - Faded Texture, lower sonority
- Lines, sharpness
  - Solid line, sharp sound environment
  - Dotted line:, saturated sound environment

5. Soundscape map of a pedestrian street in Mexico City

To illustrate the way this proposal is applicable a case study is here presented, based on criteria of similarities in the configuration of the urban-architectural space, so that the acoustic behaviour is has similar characteristics along different segments of the street. A pedestrian street in downtown México City was chosen, with several ways of appropriation of the public space that allow different perspectives of soundscape analysis.

It is a street canyon for pedestrian use in which commercial activities (shops and restaurants), leisure and entertainment, as well as services (offices, banks) are located.

The soundscape character reflects the use of space, commercial activities and the flow of people representing the sonic character of the place, the background sound sources are accompanied with the presence of natural sounds of birds and the road traffic noise (from the surrounding streets).

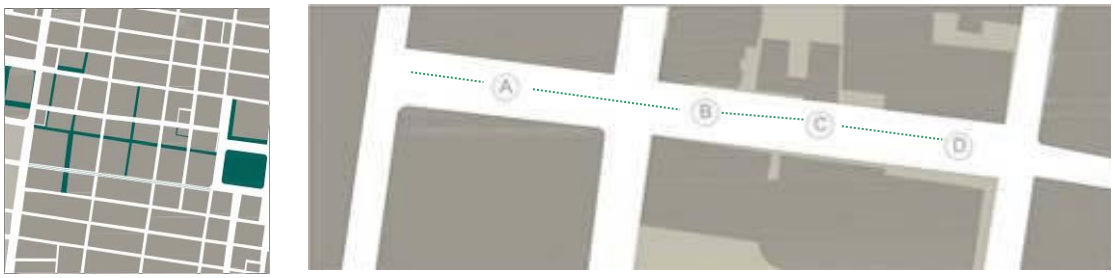

Figure 4. Downtown Mexico City: location map of space mapped.

5.1 Analysis

A classification of sound sources was done. Table 1 shows predominant sources (signals): Human (amplified voice from trade established informal and entertainment using street speakers and radios) and unamplified voice (from the transient and temporary visitors); Non-human: Natural (birds) and vehicular traffic and noise characteristics, fundamental frequency and loudness (sones).

Table 1. Sound source characterization

Sound source	Sound sources category	Sound pressure level (dBA)	Sonority (sones)	Louder frequency
People	Voice non amplified	65.7	21.738	500 Hz-600Hz
Shops & Restaurant	Voice & instrument	67.5	28.2047	500 Hz
Street trading a	Voice & instruments amplified	68	30.497	125Hz-160Hz
Street trading b	Voice & instruments amplified	64.1	22.035	315Hz-630 Hz
Street artist	Voice & instruments amplified	76.9	38.124	400Hz-630Hz
Birds	wildlife	61.6	15.378	315 Hz

Tabla 2. Samples of soundscapes measurements and recordings

Sample	Sound sources category	Sound pressure level (dBA)	Loudness (Sones)	Louder frecuency
A	Sound generated by human activity and sounds no generated by human activity	61.6	17.713	500 Hz
B	Sound generated by human activity	63.7	19.9	500 Hz
C	Sound generated by human activity and sounds no generated by human activity	63.7	35.646	250 Hz
D	Sound generated by human activity and sounds no generated by human activity	75.4	44.172	500 Hz

The analysis of data identified that the background noise is caused by the human voice and that natural sounds are masked in most of the space by predominant sound sources creating saturated sound environment.

The soundscape map (Fig. 5 f) is composed by the sound sources maps that were identified as shown below (Fig. 5 a-e).

a. b. c. d. e. f.

Figure 5. Sound sources map: a) Natural; b-c) Voice & instruments amplified; d) Voice not amplified; e) Road traffic noise; f) Soundscape map (with signs of sharpness and saturation).

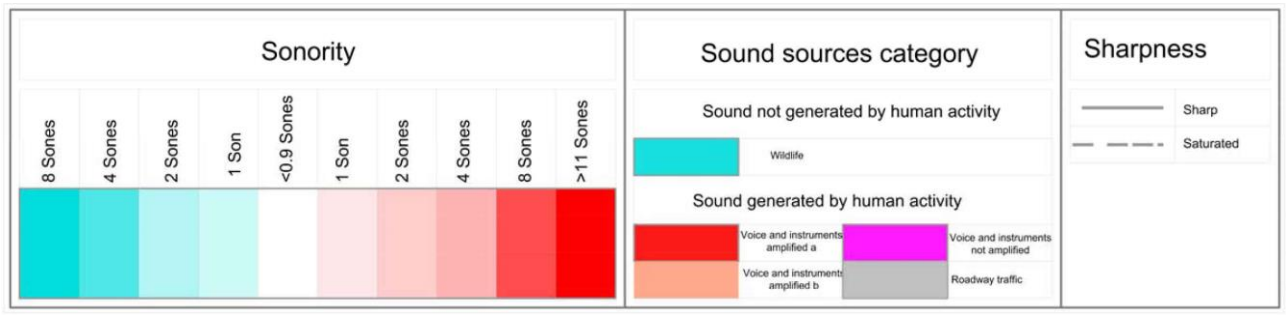

Figure 6. Soundscape colour charts.

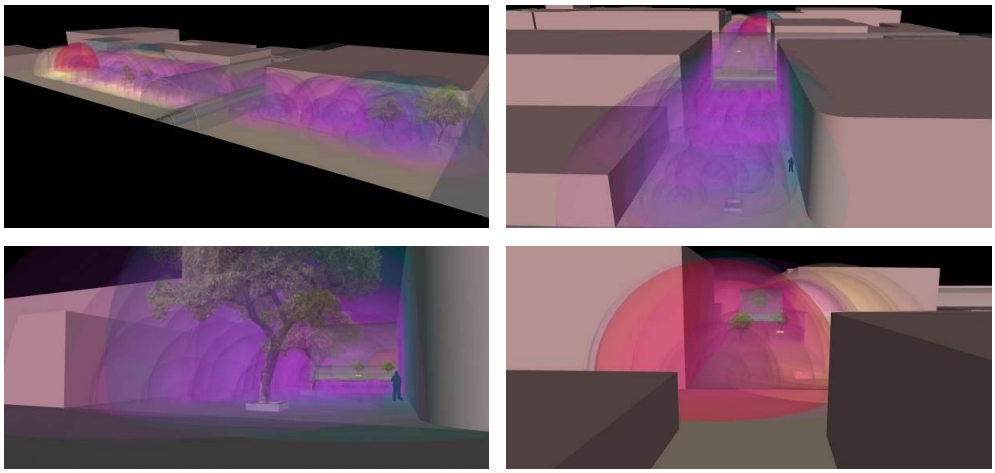

Figure 7. Soundscape: sonority 3D views (sonic space)

6. End notes

A proposal for soundscape mapping has been developed in order to show new ways for graphically representing the sound environment and its interaction with the urban space. Current noise mapping techniques are almost the only one method for representing the sound and its impact in cities. However, noise mapping regards to an approach more linked with environmental and health problems than to the daily sound environment, to which the soundscape mapping is intended.

The authors seek through this tool to find a clear graphic language which in combination with the concept of soundscape can be an expression of the possibilities that sound has to interact with the urban space or in turn to be expression of the urban space. It is important for architects, urban planners and landscape architects understand the sound as part of the space created and considered in their design concepts, and in this way of thinking this proposal is also developed.

The work here shown is just the beginning of a research program about noise and urban space in Mexico City that intends to define the sound and noise behaviour in the urban space of this complex city and among other objectives to continue with the integration of as many concepts involved with the soundscape as possible.

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