Sounds as an expression of urban vitality: changes in the neighborhood's soundscape affected by technological disaster in Maceió - AL, Brazil

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ABSTRACT

Sounds are social markers, define territories and can be understood as a record of vitality within the cultural sphere, for bringing expressiveness and freedom. Urban dynamics reverberate directly in the soundscape. Places that suffer from environmental disasters can

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suffer losses in urban vitality and tend to become less noisy. The neighborhoods of Mutange, Bebedouro and Pinheiro located in Maceió-AL, Brazil, have been hit by a technological disaster due to the widespread destabilization of the soil, which caused cracks in buildings and craters in the soil, due to the extraction of rock salt by a chemical multinational. The area was evacuated and more than 600 families left the neighborhoods. This work aims to investigate, comparatively, the changes in the soundscape from the point of view of sound mapping, measurements of sound levels and perception of individuals. Methodological steps adopted: bibliographic/documental survey of the area studied; search of acoustic map collections of the region before 2019; sound measurements after emptying the area - 2020; questionnaire for sound perception analysis; soundscape analysis and diagnosis: comparison between scenarios. In addition to studying the soundscape of the neighborhoods before and after the event, the results will contribute to preserving the acoustic memory of the community.

1. INTRODUCTION

Sound is considered a determining aspect in the quality of the urban experience of inhabitants, through which it is possible to measure cultural, technological and economic changes in a society. The sound environment has meanings and allows one to understand the dynamics of a society. There is no denying that the intensities of noise interfere with the quality of life of the population, but on the other hand, noise can be understood as a record of vitality within the cultural sphere, it brings with it expressiveness and freedom, especially when it occurs in public spaces [1].

As sound is an indicator of urban dynamics, changes in the soundscape can portray social, cultural and spatial changes [2]. Environmental impacts, such as technological disasters, may directly, even temporarily, imply in the sound profile of the place, due to the loss of urban vitality, the environments tend to become less noisy. In 2017, three neighborhoods, Mutange, Bebedouro and Pinheiro, in the city of Maceió, the capital of Alagoas, located in northeastern Brazil, suffered a technological disaster that caused cracks in the buildings and craters in the soil. The cause of the disaster was due to the extraction of rock salt by a chemical industry, which generated widespread soil destabilization. Due to this disaster, the area had to be evacuated and more than 600 families left the neighborhoods [3]. This environmental catastrophe led to a state of calamity, negatively affected the local urban dynamics and modified the landscape.

With the prospecting for oil in the 1940s, drilling rigs drilled through the mangrove areas of the Mundaú lagoon, and found a "bed" of rock salt in the region in the neighborhoods. The company found "80m of high purity rock salt in the Maceió region, at a depth of 1,000 meters". The area of rock salt extraction was located in the neighborhoods of Mutange, Bebedouro and Pinheiro, affected by the disaster [4].

In early 2018, seismic tremors and structural collapse of streets and buildings occurred in the company's quarters of rock salt extraction. The city's civil defense was called in to gather the evidence and verify the veracity of the facts. From this episode, debates were fomented regarding the impacts generated in the urban space due to the extraction of rock salt [5].

The incident caused hundreds of families to be forced to leave their homes, this measure was taken in a protective manner in order to avoid greater structural damage and risk to life. The accident caused a rupture in social relations, among residents, traders and local workers. The result of the expropriation measures at the site brought with it a void in the urban environment. The soundscape was modified, some sounds ceased to exist and others were highlighted.

It is in this context that this work intends to investigate, from a comparative analysis, the changes in the soundscape of the area, from sound mapping, measurements of sound pressure levels and sound perception. The debates aim to contribute to the preservation of the acoustic memory of the community and to collaborate with the investigations on the impacts suffered by the technological disaster, given the gap on the sound aspect.

2. METHOD

In this paper, three methodological steps were performed for data collection and subsequent analysis. The steps were: 1. Documental Survey of the area; 2. Survey of the acoustic data of the area before and after emptying; 3. Seizures of sound perception. The steps will be described below.

2.1. Documental Survey of the área

At this step, a systematic review was carried out in order to underpin the theoretical framework and identify possible research gaps that could contribute to the discussions on the problems surrounding the technological disaster that occurred in the neighborhoods of Mutange, Bebedouro and Pinheiro. In this way, historical and urban data from the neighborhoods and information related to the disaster were collected, such as news, publications of articles and periodicals. The acoustic data survey was carried out by the GEAS research group (Grupo de Estudos do Ambiente Sonoro), of the Federal University of Alagoas. In addition to a photographic survey of the area, conducted during the visits.

2.2. Survey of the acoustic data of the area

The acoustic data survey occurred in two moments, in 2016, before the technological disaster and the emptying of the area, and in 2020, after the event and the emptying of the neighborhoods. The measurements of sound pressure levels (SPL) were performed on site according to the procedures suggested by NBR 10151 - Acoustics - Measurement and assessment of sound pressure levels in inhabited areas - General purpose application [6]. The equipment adopted was the sound pressure meter of 01dB- Metravib Solo, which already provides the LAeq in several frequency bands. The equipment measures sound in dB(A), filter A is considered the most representative of the auditory sensitivity curve.

To perform the measurements, the equipment was calibrated, as required by the Brazilian standard NBR 10151 [6]. Still according to the standard, the equipment was positioned on a tripod 1.20m from the floor and at least 2m from the building limit.

The software used to produce the sound maps by means of computer simulations was Cadna-A version 4.4. It is worth mentioning that the license to use the program belongs to the Grupo de Estudos do Ambiente Sonoro (GEAS) of the Federal University of Alagoas.

To make the simulations, a three-dimensional model was elaborated, as close as possible to reality regarding the topography and volumetry of the buildings. For this, the Cartographic Base of Maceió was used and exported from the AutoCad program to Cadna-A in dxf model. To perform the calculations in the model, it was necessary to segment the study area, due to the amount of volumes higher than allowed by the software package, which limits the calculation of up to 1000 objects.

2.2.1 Survey of the acoustic data of the area (before emptying)

The acoustic data collected before the emptying are from 2016, when GEAS made a survey of measurements of the sound pressure levels of the three neighborhoods for the production of acoustic maps. The project aimed to build the acoustic map of the city of Maceió. The acoustic data collected before emptying the area are extremely important for the construction of the comparative analysis between scenarios.

2.2.2 Survey of the acoustic data of the area (after emptying)

In 2020, visits were made to the three neighbourhoods to survey sound pressure levels after the area was emptied. The surveyed data were tabulated and entered into the CADNA-A software to simulate the current sound map of the area.

2.3. Seizures of sound perception

Researchers visited the area to survey sound perception, identifying sound events and conducting an experimental perceptual analysis of the pre-disaster soundscape, seized during the surveys conducted in 2016 and the current soundscape, experienced in 2020.

3. ANALYSIS AND DISCUSSION

3.1. The place and the problem: Mutange, Bebedouro and Pinheiro

The Mutange, Bebedouro and Pinheiro neighborhoods are located in the city of Maceió, in the state of Alagoas, in the northeast region of Brazil (Figure 1). The neighborhoods are located on the banks of the Mundaú lagoon, one of the two main lagoons in the state. The three neighborhoods had areas affected by the technological disaster that occurred due to the exploitation of rock salt. The disparity between the Mutange (2,632 inhabitants) and Bebedouro (10,103 inhabitants) neighborhoods is striking, with a population with low purchasing power, neighboring services and commerce geared to basic local needs, and Pinheiro (19,062 inhabitants) a predominantly residential neighborhood, with a tendency for higher income and diversified services [7].

Figure 1: Situating object of study, neighborhoods Mutange, Bebedouro e Pinheiro in Maceió, Alagoas, Brazil.

In all three neighborhoods the rock salt mines were located. The establishment of the company in the city of Maceió in the 1970s did not give rise to obvious conflicts until the year 2018, when the first tremors occurred. Before the first signs of earthquakes in 2018, the company's relationship with the city did not present obvious conflicts, the presence of the industry had social and economic importance for the development of the region.

The first signs of soil subsidence occurred in February 2018, after a rainy period in the city. Seismic tremors caused structural collapse of streets and buildings, and quakes of 2.4 on the Richter scale were recorded, causing craters in the roads and cracks in the walls of buildings (Figures 2, 3 and 4). In December 2018, an emergency situation recognized by the Brazilian Federal Government was decreed, from which families had to leave their homes and received a social rent aid paid by the federal government. The damage caused to the soil was aggravated by the installation of extraction wells in places with pre-existing geological faults in the region, which caused loss in the structural integrity of the rock salt exploration caves and consequent collapse.

Figure 2, 3 and 4: Craters in the streets and cracks in buildings caused by earth moving. in the Pinheiro district. Source: Freitas (2019) [5].

The Municipal Government did a mapping of the damage caused to the region. Initially, only the neighborhood of Pinheiro was in the critical zone, after deepening the studies, the area expanded contemplating the neighborhood of Mutange and part of the neighborhood of Bebedouro. Areas with more severe fractures and erosion were classified, areas with erosion processes, land movement areas (steeper areas), and flooding areas (areas bordering the Mundaú Lagoon) (Figure 5).

Figure 5: Demarcation of the area affected by the technological disaster. Source: Google Earth, 2020. Adapted by the authors, 2020.

The technological disaster brought serious consequences to the three neighborhoods, the fact generated rupture in social relations and local urban dynamics. The neighborhoods had high demographic density and were connectors from the upper to lower part of the city. The current scenario is one of destruction, abandonment and neglect with the residents' sense of belonging (Figures 6, 7, 8, 9, 10 and 11).

Figures 6, 7 and 8: Aerial view and urban forms of the neighborhoods Mutange, Bebedouro and Pinheiro, respectively. Source: PJM Drone, 2019. Available at: <https://www.youtube.com/channel/UC5XypoND3jHZbpD0e-OUd7g> .

Figures 9, 10 and 11: Photos of the Mutange, Bebedouro and Pinheiro neighborhoods after the area was emptied. Source: Maceió former officer. Available at: https://www.instagram.com/p/B-8JD25J0rY/.

The abandonment is evident, most of the buildings in the neighborhoods are unoccupied and deteriorated, with no elements of fence such as roofing, frames (Figures 12, 13 and 14). The inhabitants of the area are signaled by means of signs about their permanence in the neighborhoods. (Figures 15, 16 and 17).

Figures 12, 13 and 14: Abandoned and dilapidated buildings in the affected neighbourhoods.

Figures 15, 16 and 17: Notice signalling the existence of local residents.

The Mutange and Bebedouro neighborhoods have representative historical buildings for the city of Maceió, which are currently abandoned and exposed to deterioration. Figures 18, 19 and 20 present, respectively, a historical building, where the Dr. José Lopes health care home, the headquarters of Sinteal (Union of Workers of Alagoas) and the cultural space Professora Jarede Viana, besides the headquarters of the Environment Institute (IMA), all closed.

Figures 18, 19 and 20: Abandoned historical buildings of cultural importance.

3.2. Soundscape of the place: changes after emptying the area

After the discussions on the problem and approximation with the object of study, the analyses of the sound environment of the area affected by the technological disaster will now be presented. The data analyzed are results of measurements of sound pressure levels (SPL) collected in the affected neighborhoods, in two moments. The first moment of collection was in the year 2016, before the technological disaster, when measurements were made to collect acoustic data for the noise map of the city of Maceió. Thus, the data for the neighborhoods Mutange, Bebedouro and Pinheiro were collected. The second moment was in 2020, after the disaster caused by the extraction of rock salt, with a significant portion of the area emptied.

The data were organized in Table 1, by neighborhood, with the location of the measurement points the sound pressure level values collected in both moments, year 2016 and 2020 and the reference values presented in NBR 10151 - Acoustics - Measurement and assessment of sound pressure levels in inhabited areas - General purpose application [6]. The number of vehicles passing through the measurement points were also computed.

Table 1: medições acústicas dos níveis de pressão sonoro nos bairros de Mutange, Bebedouro e Pinheiro.

	Point	Data from 2020 SPL in dB (A)			Number of vehicles	
		2016 dB (A)	2020 dB (A)	NBR 10151	2016	2020
Bebedouro	01. St. Bela Vista do Conrado	59,5	x		0	6
	02. St. Empresário Jorge Montenegro	75,2	x		0	90
	03. St. Faustino Silveira	63,1	62,4		14	6
	04. St. Cônego José Belarmino Barbosa	56,5	57,7		0	9
	05. Ave. Major Cícero de Góes Monteiro and square Cel. Lucena Maranhão	71,4	66,3	60	145	180
	06. Ave. Major Cícero de Góes Monteiro	77,1	61,3		15	107
	07. Hospital Miguel Couto	x	61,5		14	x
	08. Ave. Major Cícero de Góes Monteiro (Condominium Bosque do Mundaú)	x	61,3		15	x
Mutange	09. St. Gruta Prade Cícero Romão Batista	59,5	56,6		10	10
	10. Ave. Cícero de Goés Monteiro, opposite the IMA	62,1	60,3		43	11
	11. Ave. Dr. Muniz Falcão	57,3	47,5	55	14	0
	12. Ave. Cícero de Goés Monteiro, opposite the post Total Giro	65,9	65,9		131	14
	13. Ave. Major Cícero de Góis Monteiro	x	53		x	1
Pinheiro	14. St. Tereza de Azevedo	71,3	68,3		103	74
	15. St. Doutor Passos de Miranda – Calmon Slope	71,1	70,1	60	91	133
	16. St. Professor José da Silveira Camerino	73,2	66,8		81	87
	17. St. Jornalista Augusto Vaz Filho	56,7	53,4	50	4	1
	18. Rua Santa Júlia	60,4	56,3	55	6	4
	19. Ave. Fernandes Lima - 59º Motorized Infantry Battalion	78,6	69,9	60	570	194
	20. St. São Jorge and St. São Benedito	59	52,6	50	7	2

A decrease in the SPL values measured after emptying the area is noticed, which confirms the hypothesis that the lack of urban vitality directly interferes with the sound environment. This is even more evidenced, with the observation of the decrease of vehicles circulating in the area. Parts of the affected region are interdicted, some roads were deactivated. Recovery services of the damages caused in the area generate noise from mechanical equipment resulting from these activities. For example, the well monitoring study, conducted in compliance with the requirement of the National Mining Agency (Figures 21, 22 and 23).

Figures 21, 22 and 23: Existing barrier in front of Braskem, there is no car passage.

Even with the emptying of the area, represented by the sequence of images depicting abandonment and consequent silence (Figures 24, 25, 26 and 27), sound pressure levels did not drop significantly, with a decrease of up to 5dB(A). One of the reasons for not having a greater drop in SPL values is the presence of noise from mechanical equipment for restoring the area and motorcycles. The current local soundscape has a predominance of mechanical sounds, human sounds were silenced. The sounds of nature such as birds and leaves swaying in the wind were evidenced in areas near the lagoon.

Figures 24, 25, 26 and 27: Empty and dilapidated buildings.

Next, the sound maps of the neighborhoods will be presented with the data obtained before and after the emptying of the area. In this way, the differences in the sound environment at the two different moments are visually clearer.

The Mutange neighborhood suffered a great impact from the disaster, as it had the entire territory affected, the SPL values had an average drop of 3 dB(A), which brought it closer to the value of 55dB(A) stipulated by NBR 10151 [6] (Figure 28). Because it is a neighborhood located on the banks of the Mundaú lagoon, the natural sounds of water, animals and leaves were evident, possibly due to the decrease in the flow of vehicles and people in the region.

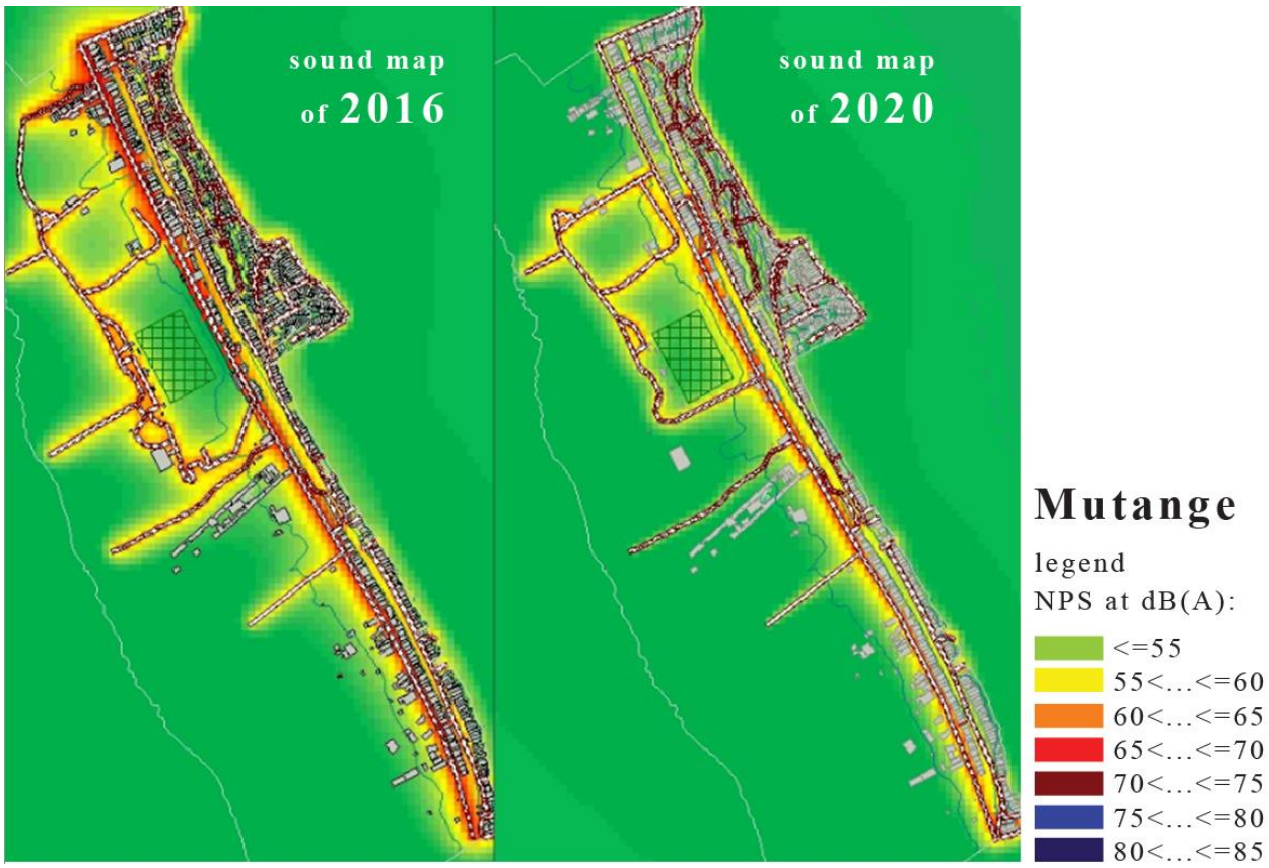

Figure 28: Sound map of Mutange neighborhood in the years 2016 and 2020.

In the sound map of the Bebedouro neighborhood, one can notice greater changes in sound pressure levels in the area that was affected by the disaster (indicated by white arrow), as the neighborhood had buildings deactivated and a ban on stretches of road (Figure 29). In these affected areas, there was a significant drop in sound pressure levels. Natural and human sounds were masked by noises from machines working in the restoration services of the affected area.

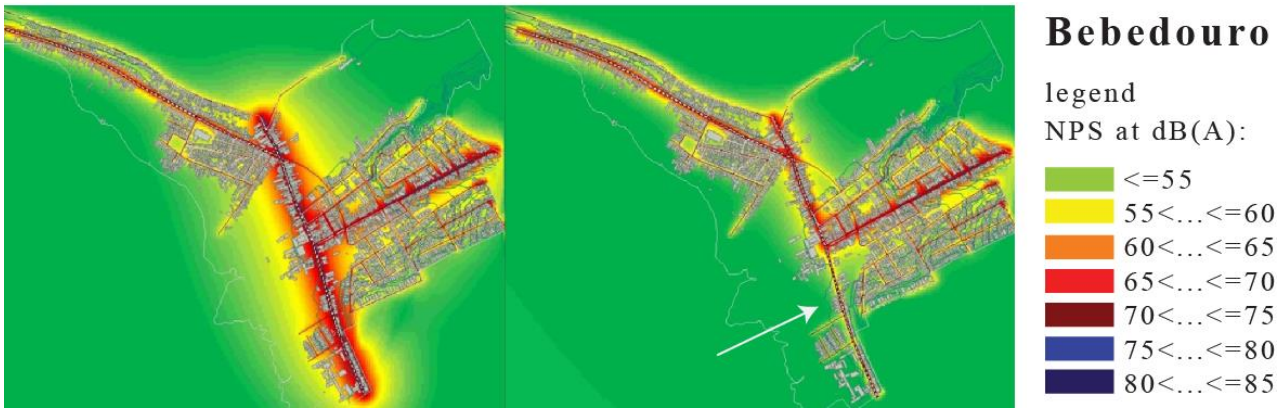

Figure 29: Sound map of Bebedouro neighborhood in the years 2016 and 2020.

The Pinheiro neighborhood also had a large part of its territory affected, which caused a loss of urban vitality due to emptying and, consequently, a decrease in sound pressure levels. Pinheiro is located in the part of the plain and close to one of the busiest avenues in the city of Maceió, highlighted as the noisiest area in Figure 30. Among the neighborhoods analyzed, Pinheiro is the one with the highest flow of vehicles, as it is an area with collecting roads that connect with other neighborhoods in the city.

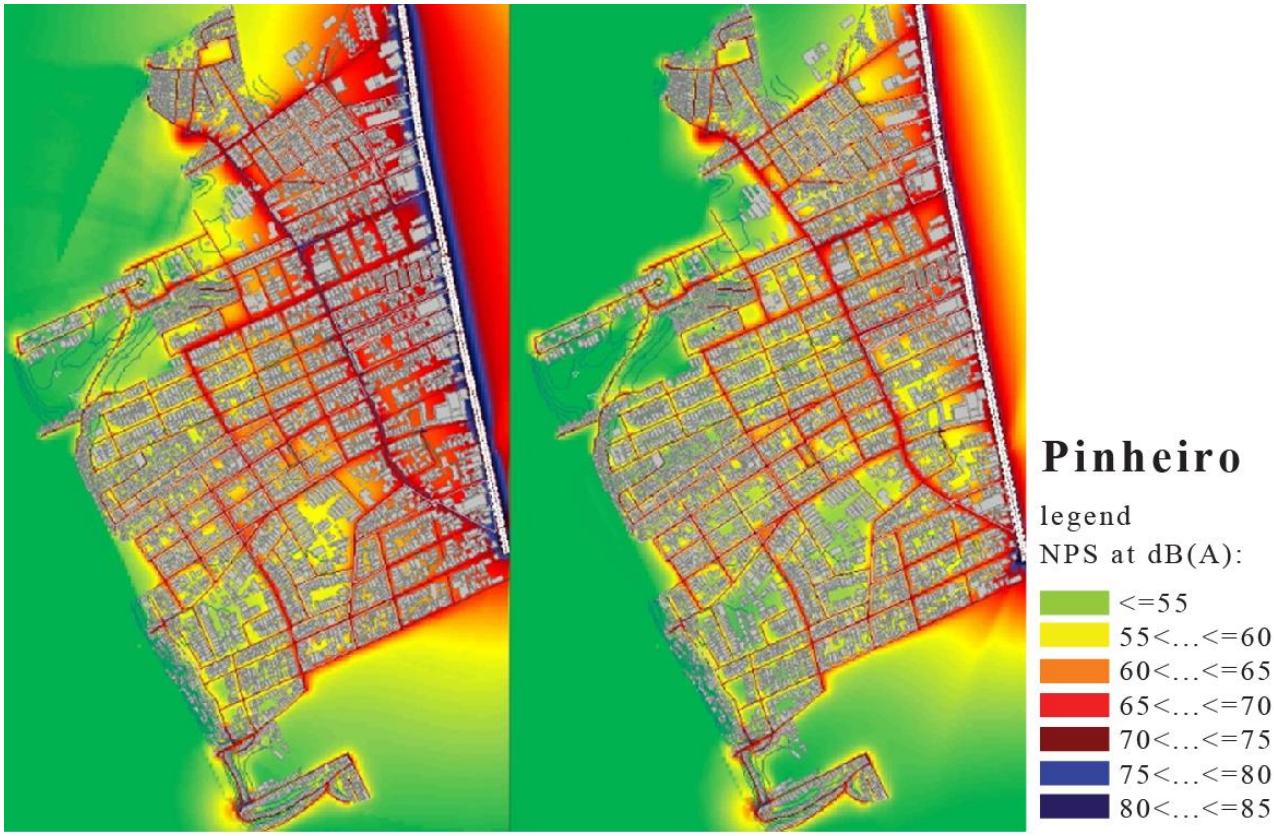

Figure 30: Sound map of Pinheiro neighborhood in the years 2016 and 2020.

By analyzing the sound map simulations of the three neighborhoods, the sound impact of the disaster in the area was verified, there were changes in the SPL values, consequently the noise map. In addition, changes in the profile of the soundscape were found, with the predominance of sounds previously masked, such as natural sounds, and the presence of intrusive sounds, such as mechanical sounds resulting from restoration services in the area.

3.3. Sound perception

The researchers observed the sound environment of the neighborhoods during the two moments of visits to collect the acoustic data. The first in 2016, before the disaster and the second 2020 after the emptying of the area. It is remarkable and change in the sound profile of the place, in Mutange, a neighborhood on the shores of Lagoa Mundaú, the natural sounds were evident, in all three neighborhoods, it is perceived as background noise mechanical sounds of machines working to restore the area. The noises from motor vehicles are most evident in the Pinheiro neighborhood, with motorcycle sounds predominating. The sound perception of the current scenario is opposed to the soundscape of an urbanized area, as there are no sounds that express social relations and urban vitality.

3.4. Limitations and future work

This is paper resulting from research that is still under development, which is already a limiting factor in the analysis of data and conclusions. Still more SPL measurements will be used to capture and portray more reliably the sound environment of the region. Since, many noises captured are originated from occasional and ephemeral works, such as the restoration works of the damaged area, carried out by the company, which would be characterized as a study of neighborhood impact, since it generates a harmful noise that is not characteristic of the area. Another limitation is the

apprehension of the sound perception having been restricted to the experience of the researchers, since the expansion of this question to society will still occur in the stages after this publication. For future works, it is intended to carry out a mapping of the sound events identified in the area, expand the sound perception to the former residents, by means of questionnaires, simulate future scenarios with the respective sound maps and create guidelines for the soundscape of the area.

4. CONCLUSIONS

Soon, it is realized that the technological disaster, which hit the neighborhoods of Mutange, Bebedouro and Pinheiro, located in the city of Maceió, capital of the State of Alagoas, Brazil, seriously affected the urban dynamics of the place. The sound environment also underwent great changes, although the difference in sound pressure levels was not so high, reaching 5dB (A) of difference. In addition, it was noted that there was a loss in the quality of the soundscape, with the predominance of mechanical sounds and the lack of human sounds, which represent vitality and express the dynamics in social, economic and cultural parameters.

The changes in the visual landscape of the place are evident, the photographic records portray a scenario of destruction. The visual landscape was modified and damaged, as well as the soundscape, which silenced the sounds of a society. In this way, a community is damaged in its relations with the built environment, whether in the sense of belonging to the place, in consolidated affective relations and in memory.

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