Sound environments and citizen action: what place for the participatory tool? The case of the city of Rezé using NoiseCapture

Arnaud Can[1]
UMRAE,Univ Gustave Eiffel, IFSTTAR, CEREMA, F-44344 Bouguenais, France

Philippe Audubert[2]
Ville de Rezé, Hôtel de ville, Place, J-.B Daviais – BP159, 44403 Rezé Cedex Full address

Pierre Aumond
UMRAE,Univ Gustave Eiffel, IFSTTAR, CEREMA, F-44344 Bouguenais, France

Claire Guiu
Ville de Rezé, Hôtel de ville, Place, J-.B Daviais – BP159, 44403 Rezé Cedex Full address

Tristan Lorino
UMRAE,Univ Gustave Eiffel, IFSTTAR, CEREMA, F-44344 Bouguenais, France

Emilie Rossa
Ville de Rezé, Hôtel de ville, Place, J-.B Daviais – BP159, 44403 Rezé Cedex Full address

ABSTRACT

Local authorities are increasingly interested in implementing participatory processes, associating inhabitants in decision-making. The Sonorezé project, involving researchers from the Gustave Eiffel University and the City of Rezé, evaluates the interest of a smartphone application for participatory noise measurement, namely NoiseCapture, as a vehicle for this citizen participation in the noise context. The project includes the recruitment of participants, the creation of participatory noise maps integrating different indicators, and the constitution of discussion groups that aim to elaborate concerted proposals regarding noise mitigation. In parallel, one will evaluate how access to this tool modifies the perception that inhabitants have of their soundscape, and facilitates their empowerment and the valorization of their inhabitant knowledge. This communication will present the whole workflow, highlighting how this framework helps to raise awareness of urban noise environments among inhabitants. Then, one will present in detail the dynamics of the recruitment, which amounts to more than 100 participants that performed almost 1000 measurements, at the stage of the first 4 months. The diversity of the participants' profiles, the temporal and spatial heterogeneity in the measurements, are however possibly an obstacle to the production of representative noise maps, which will be discussed in the communication.

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[1] Arnaud.can@univ-eiffel.fr

[2] Philippe.audubert@mairie-reze.fr

1. INTRODUCTION

The regulation of noise environments is a major issue in the urban fabric, in a context of urban densification, increased mobility and a strong social demand for calm. However, its analysis comes up against a gap between, on the one hand, quantitative, objective and normative approaches to noise, which are sometimes far removed from perceptions, and, on the other hand, sensitive and qualitative approaches that do not allow for generalisations. In particular, the method used to map noise levels, based on modelling, takes into account the main noise sources: road, rail and air traffic, as well as the main industries. This excludes many of the noise sources that make up the urban sound mixture (birds, voices, etc.), and does not account for temporal variations in noise levels. In parallel with efforts to mitigate high noise levels, research on soundscapes has been developed [1,2], which often highlights a distinction between mechanical, natural and human sounds [3]. It also highlights the importance of preserving quiet urban neighbourhoods [4, 5], which have been shown to have a positive effect on well-being and therefore require special attention [6]. Finally, the soundscape approach recommends the involvement of different stakeholders (policy makers, residents, experts) when making decisions that impact on noise environments [7,8].

In this context, the Gustave Eiffel University participated in the development of the free and open-source Android application NoiseCapture [9,10], which allows each inhabitant that installs the application to make noise level measurements from their mobile phone. Each noise measurement is combined with its GPS track. The data is then processed on a server to create an interactive noise map that can be viewed online: https://noise-planet.org/map_noisecapture. A "tag" mode also allows participants to enter the sound sources they hear. This method, in addition to being sensitive to all sound sources, has the advantage of involving citizens in the process of characterising sound environments. The application has more than 90,000 contributors worldwide, and nearly 3 years of data collected. Noise mapping methodologies based on the NoiseCapture application have been proposed, including a calibration and interpolation phase [11]. A dense collection protocol has been proposed, called NoiseCapture Party, which has been widely tested (cities of Bastia, La Coruña, Salerno, etc.): https://noise-planet.org/noisecapture_party.html. A NoiseCapture Party is an event that brings together a large number of participants, which makes it possible to cover a large area at a given time. The interest of the application for educational purposes has also been demonstrated [12].

However, no experimentation of constitution of an expert group of inhabitants around noise, based on an experimentation around the diffusion of a smartphone application of noise measurement, has been made to date. This is the objective of the Sonorezé project, which was the result of a rapprochement between the city of Rezé and the Gustave Eiffel University. The general objective of the project is to test a protocol for diagnosing noise environments involving inhabitants on a city scale. In parallel, the project evaluates the interest of a smartphone application for participatory noise measurement, namely NoiseCapture, as a vector of this citizen participation in the context of noise. The project includes the recruitment of participants, the creation of participatory noise maps integrating different indicators, and the constitution of discussion groups aiming to develop concerted proposals for noise mitigation. The idea is for the city to be able to draw on inhabitant knowledge when designing new urban developments. At the same time, an assessment will be made of how access to this tool modifies the inhabitants' perception of their soundscape, and facilitates their empowerment and the enhancement of their know-how.

This communication will present the whole framework, highlighting how it helps to raise awareness of urban sound environments. Then, the dynamics of recruitment will be presented in detail. The diversity of the participants' profiles, the temporal and spatial heterogeneity of the measurements, are however likely to be an obstacle to the production of representative noise maps, which will be discussed in the paper.

2. METHODS

2.1. Case Study

Rezé is a town in the Nantes conurbation with a population of around 43,000, structured by various road and rail routes, close to Nantes-Atlantique airport, and crossed by significant commuting traffic. However, the town also has remarkable environmental amenities: the edges of the Loire and Sevres rivers, the Jaguère stream, the Ilette valley, the urban forest and numerous green spaces. A qualitative description of the sound environment of Rezé is shown in Figure 1.

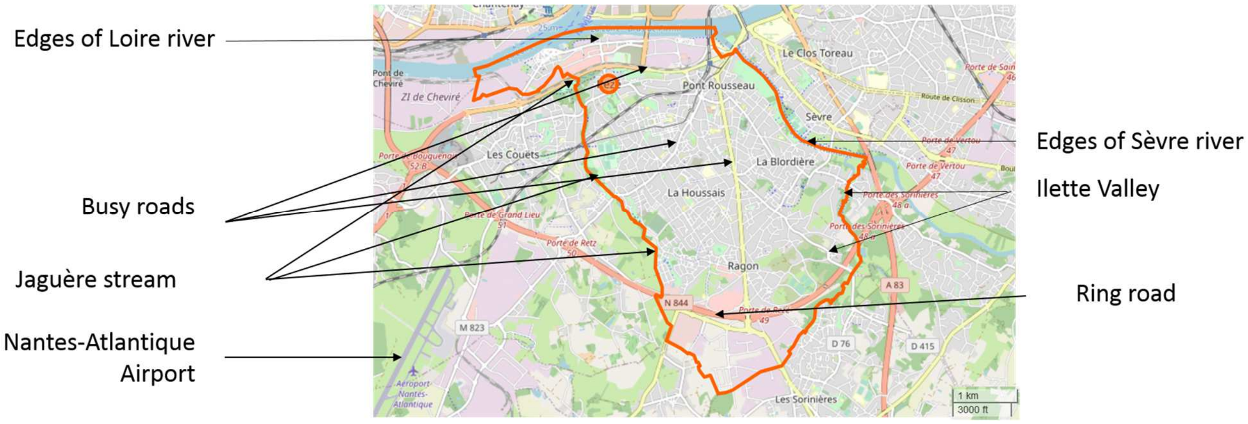

Figure 1: The city of Rezé

2.2 Framework

The duration of the part of the project involving the inhabitants is 7 months. The framework consists of three stages, namely participant recruitment, data collection, and focus groups. The events relating to the project are shown in Figure 2.

2.2.1 Recruitment of participants

A series of events were organised, supported by the city's communication services (special section on the city's website, press release), to communicate about the project and the search for participants:

- A public kick-off meeting brought together more than thirty inhabitants to launch the project on the 01/12/2021;
- The project was then publicised in the regional and national press during December;
- A special event was organised as part of the "Unesco Week of Sound", which is an international event that promotes noise awareness;
- One article was published in the city local journal in February;
- 4 events were organised on the city's markets, during which the project members had a stand and went to meet the inhabitants.

2.2.2 Data collection

Acoustic data collection has been continuous since the start of the project. Each event was subject to telephone calibration for participants who wished to do so, in order to improve the quality of the collected data. The calibration followed the procedure described in detail in Guillaume *et al.* 2021, according to the calibration mode of the NoiseCapture application [12]. It consists in correcting the sound level given by the smartphone according to the value given simultaneously by a reference smartphone, and based on a controlled sound emission. This way, a set up to ten smartphones can be calibrated simultaneously. A mailing list and a social network discussion group were created, in order to maintain the momentum around the project. However, since for reasons of anonymity it is not possible to know the telephone number of the people who have downloaded the application, it was not possible during the project to send messages to people who are taking measurements and have not left their e-mail address. As a result, some of the data collected comes from not calibrated phones, which the application keeps track of.

The inhabitants were free to take measurements whenever they wished, with the instruction either to take measurements in spots of at least one minute, or to take mobile measurements, taking care not to pollute the measurements with their own steps, and to pay attention to the weather conditions (rain or gusts of wind). In addition, a page dedicated to perception, present in the NoiseCapture application, allows participants to fill in perceptual variables: tag the sound sources heard (on/off), and give a sound pleasantness rating.
Finally, NoiseCapture parties were organised from the 5th month onwards, to focus on areas poorly covered by the measurement, with internal communication. The idea was to bring together residents to carry out measurements over a period of about 30 minutes, and then followed by an informal discussion on the sound environments heard.

Perceptual data were collected in parallel, to investigate the perception of the city's noise environments (quality of the noise environment, annoyance felt, outstanding noise environments), as well as noise behaviour and sensitivity regarding noise. These data were collected via questionnaires, distributed during meetings with the inhabitants, or via an online version of the questionnaire.

2.2.3 Focus groups

Discussion groups were organised, involving residents, local authorities and researchers. The aim was to get the inhabitants to express themselves freely on the city's noise environments, their negative or positive elements. A transcript of the exchanges was made to analyse a posteriori the content of the discussions.

3. RESULTS

3.1 Temporal and spatial dynamics of measurements

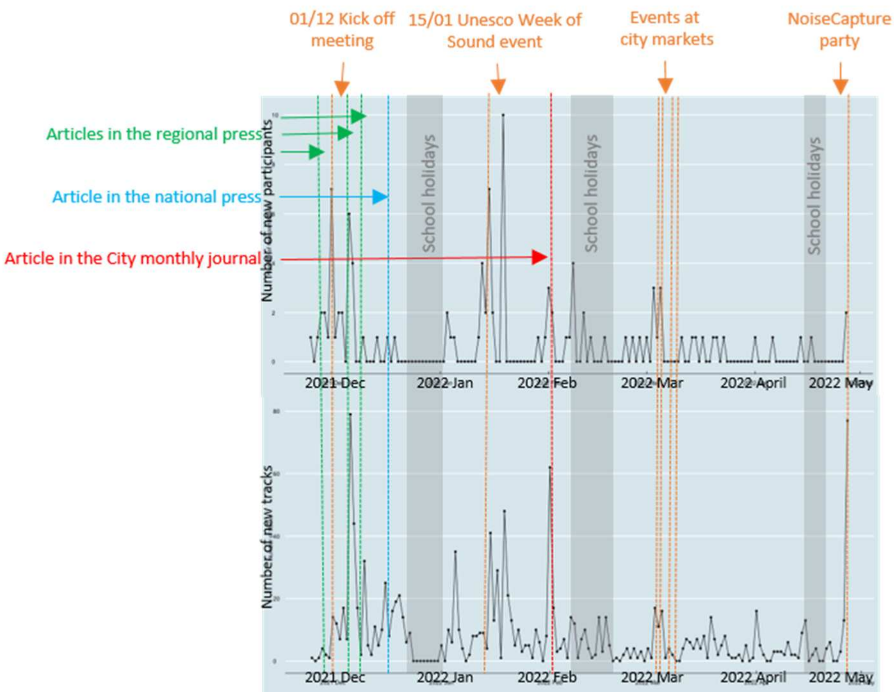

Figure 2: Temporal evolution of the number of participants and the number of daily measurements

After 5 months of the planned 7 months of data collection, the number of participants is 104. The total number of measurement tracks made is 1,238, for a total duration of 66.3 hours. Thus, the mean measurement duration of each track is about 3 mn. Figure 2 shows the detailed temporal evolution of the number of participants, and the number of data collected. This dynamic is very dependent on the events organised to maintain activity around the community, as seen in Figure 2. For example, the number of participants increased after the events of 1 December and 15 January, as well as during the four meetings organised at the markets in early March. However, the number of measurements constantly slowed down, showing the difficulty in getting people involved in the measurement on the long term. This is countered by one-off events such as the NoiseCapture Party organised on 27 April. The drop in the number of measurements during the school holidays is also notable. The impact of the weather on the number of measurements is harder to analyse, although the difficulty of motivating oneself when the weather conditions are unfavourable has been the subject of comments from inhabitants.

In addition, the number of measurements per participant is heterogeneous. Among the 104 participants, 35 participants took 5 or more measurements, 13 participants took 20 or more measurements, and 3 participants took between 100 and 150 measurements. This combined with the fact that the population density in the city is higher in the north than in the south, which is a suburban residential area, results in a heterogeneous density of measurements in the city, with many more measurements taken in the north of the city; see Figure 3. This is what the measurement sessions organised in the form of NoiseCapture Party is aimed to counter. The result is the difficulty of producing a participatory noise map of equivalent quality over the whole territory, which is discussed in the following section.

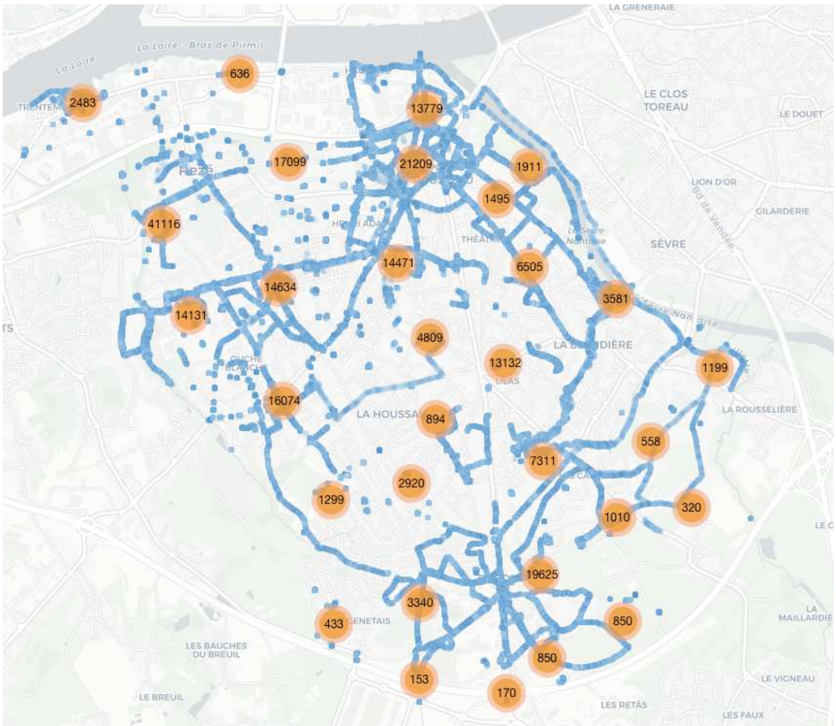

Figure 3: Spatial distribution of the measurement density

3.2 Participatory noise maps produced

The noise map produced is based on the 228,000 raw $L_{Aeq,1s}$ collected (approximately 63.3 h of measurements in total). Each raw $L_{Aeq,1s}$ value is associated with a position, a time value, and meta data such as a participant Id number, and possibly a calibration value. Each of the raw $L_{Aeq,1s}$ value is then processed in two steps:

- 1) Correction with the calibration value. Raw data are kept when no calibration value is known;
- 2) Correction with the hour of the day value. The correction for the time of the day is based on previous works, described in [13]. The objective is to account for the fact that a measure taken at a given time of the day can serve to estimate the average daily sound level, once the difference between the average sound levels at this time of the day and the average of the daily sound levels is known. Correction values from [13] are used.

This procedure results in 228,000 $L_{Aeq,1s}$ values each of which is a very short term estimate of the average L_{Aeq} at one location. Follows a spatial processing, which consists of a Kriging described in [13, 14]. The variogram and Kriging algorithms presented in this study are computed using the functions vgm (computation of the variogram), fit,variogram (best fit of the variogram) and kriege (Kriging function) of the package gstat [15].

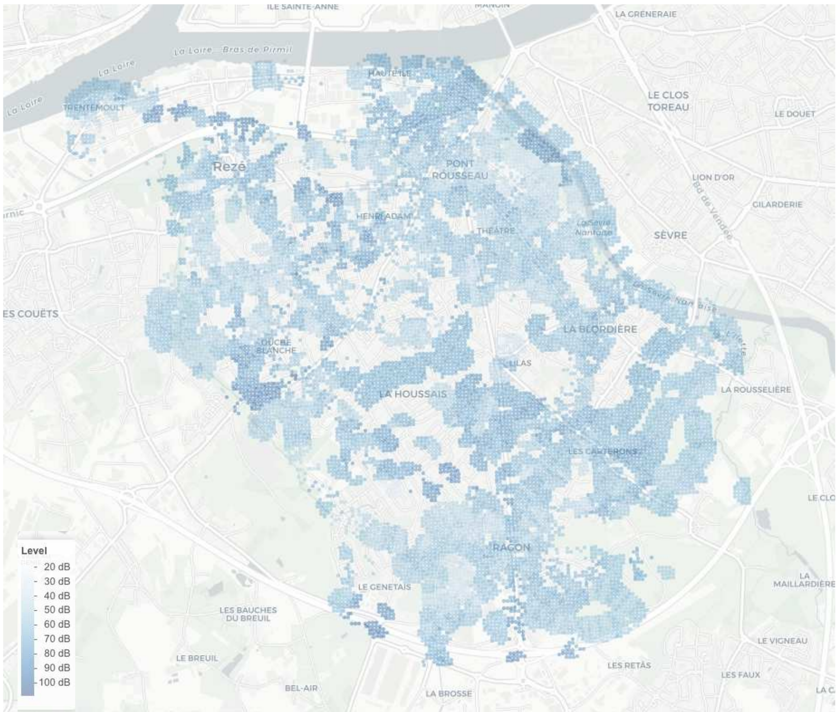

Figure 4: L_{Aeq} sound map produced through the Sonorezé participatory measurement campaign

4. DISCUSSION

A framework was set up, in collaboration between the Gustave Eiffel University and the city of Rezé, to involve the inhabitants in the process of characterising the city's noise environments, and to set up a community of inhabitants aware of the noise issues and able to carry out discussions and proposals in liaison with the local authorities. However, the overall success of this initiative depends greatly on the quality of the noise maps produced, and how well they correspond to people's perceptions of the noise environment. This article has detailed the process of data collection and production of the noise maps, focusing here on the L_{Aeq} indicator.

The main difficulties lie in the difficulty of keeping the community active, as this is the first experience of long-term participatory noise mapping. Events have been created to maintain this dynamic, through meetings and exchanges, and organised collective measurement sessions. The spatial and temporal heterogeneity of the data collected is also a handicap in this type of open participatory process. The article presents a noise mapping process that partly succeeds in overcoming the parsimony of the data collected. The next challenges will be:

- To achieve greater homogeneity in the data collected;
- To study in detail the statistical tools allowing to optimize the process of creation of the participative noise maps;
- To work on the production of noise maps on a whole set of indicators, closer to the perception of the inhabitants (L_{A90}, L_{A10}, number of noise events, etc.).

In the longer term, the aim will be to link this experience of participatory measurement by the inhabitants, with the potential modification of their perception of the sound environment, or their empowerment to discuss issues relating to the improvement of the sound environment with the local authorities.

5. ACKNOWLEDGEMENTS

The Sonorezé project is funded by the I-Site Future under the programme "Chercheur.e.s / Citoyen.ne.s".

6. REFERENCES

1. ISO 12913-1:2014. Acoustics – Soundscape – Part 1: Definition and conceptual framework.
2. Kang, J., Aletta, F., Gjestland, T.T., Brown, L.A., Botteldooren, D., Schulte-Fortkamp, B., et al. Ten questions on the soundscapes of the built environment, *Building and Environment*, **108**(Suppl. 455C), 284–94 (2016).
3. Aumond, P., Can, A., Lavandier, C., De Coensel, B., Botteldooren, D., Ribeiro, C. Modeling soundscape pleasantness using perceptive assessments and acoustic measurements along paths in urban context, *Acta Acustica united with Acustica*, **103**(3), 430-443 (2017).
4. EEA. Good practice guide on quiet areas. European Environment Agency. EEA Technical report n_4; 2014. ISSN 1725-2237. 58p.
5. Payne, S. The production of a perceived restorativeness soundscape scale, Applied Acoustics, **74(2)**, 255–63 (2013).
6. Van Kamp, I., van Kempen, E., Klæboe, R., Kruize, H., Brown, A.L., Lercher, P. Proceedings of Internoise. Hambourg, Germany (2016).
7. Can, A., L'Hostis, A., Aumond, P., Botteldooren, D., Coelho, M.C., Guarnaccia, C., Kang, J. The future of urban sound environments: Impacting mobility trends and insights for noise assessment and mitigation, *Applied Acoustics*, **170**, 107518 (2020).
8. Haouès-Jouve, S., Lemonsu, A., Gauvreau, B., Amossé, A., Can, A., et al. Cross-analysis for the assessment of urban environmental quality: An interdisciplinary and participative approach. *Environment and Planning B: Urban Analytics and City Science*, Mike Batty University College London, UK, **48** (2021).
9. Picaut, J., Fortin, N., Bocher, E., Petit, G., Aumond, P. & Guillaume, G. An open-science crowdsourcing approach for producing community noise maps using smartphones. *Building and Environment*, **148**, 20-33 (2019).
10. Guillaume, G., Can, A., Petit, G., Fortin, N., Palominos, S., Gauvreau, B., Bocher, E., Picaut, J. Noise mapping based on participative Measurements. *Noise Mapping*, De Gruyter open journal, 3, 140-156 (2016).
11. Aumond, P., Can, A., Rey Gozalo, G., Suarez, E. Method for in situ acoustic calibration of mobile measuring devices, *Applied Acoustics*, 166, 107337 (2020).
12. Guillaume, G., Aumond, P., Bocher, E., Can, A., Ecotière, D., Fortin, N., Foy, C., Gauvreau, B., Petit, G., Picaut, J. NoiseCapture smartphone application as pedagogical support for education and public awareness. *The Journal of the Acoustical Society of America*, 151(5):3255 (2022).
13. Aumond, P., Can, A., Mallet, V., De Coensel, B., Ribeiro, C., Botteldooren, D., Lavandier, C. Acoustic mapping based on measurements: space and time interpolation, Proceedings of Internoise 2017, Hong-Kong, 27-30 August (2017).

14. Aumond, P., Can, A., Mallet, V., De Coensel, B., Ribeiro, C., Botteldooren, D., Lavandier, C. Kriging-based spatial interpolation of mobile measurements for sound level mapping. *Journal of Acoustical Society of America*, **143 (5)**, 2847-2857 (2018).
15. geoR: Analysis of Geostatistical Data version 1.7-5.2 from CRAN [Internet]. [cited 2022 April 29]. Available from: https://rdrr.io/cran/geoR/.