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Regulation of nightlife noise in Paris: the contribution of innovative monitoring and perspectives

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ABSTRACT

Recreational noise generated by nightlife in urban areas is a particularly delicate issue, as the complex nature of the noise sources involved (music, human voices, traffic…) makes it complicated to grasp from a technical point of view. It is also difficult to regulate since there is a highly subjective aspect to the perception of such noise.

Bruitparif has been involved in the observation of this type of noise in the most attractive areas of Paris since 2016. More than 40 « Medusa » sensors making it possible to identify the dominant source of the noise have been deployed in areas where nightlife noise is reported to be problematic by the local residents. This outdoor acoustic monitoring allows an analysis of the sound levels generated by customers of festive establishments or gatherings of people in public spaces, and provides objective data support that can then serve as a reference for discussions between the various stakeholders.

Measurement data coupled with modeling development is essential for the proper consideration of this problem, which is more than a simple nuisance. Indeed, it probably has important consequences for the health of inhabitants given that noise occurs during periods that are particularly critical for sleep quality.

1. INTRODUCTION

When we discuss the subject of noise pollution in urban areas, we often think first of transport noise: cars, motorcycles, trains, airplanes... It is true that the urban soundscape is very dependent on traffic, especially road traffic, in an environment where the on-going flow of people is a constant phenomenon, especially during the day. However, there are times when people also occupy set places: as the day ends, a turmoil of another kind awakens in the streets when bars, restaurants, festive and cultural places start to open their doors. In a big city like Paris, nightlife is a very important social and economic activity throughout the year, in addition to being an attractive criterion for tourism. But in a "city that never sleeps", are we not forgetting a whole section of Parisians who would just like to get the sleep they need?

The World Health Organization (WHO) has documented the deleterious effects of noise pollution on human health for many years, and has been warning since 1980 about the deterioration of hearing, but also of the deterioration of sleep quality, stress generation, or psychological discomfort [1]. Knowledge on the subject is improving year after year, and is more and more targeted by official recommendations ([2], [3], [4], [5]). Moreover, one can also quantify the financial cost of noise for society. In France, the Environment and Energy Management Agency (*Agence de l'environnement et de la maîtrise de l'énergie, ADEME*) and the National Noise Council (*Conseil National du Bruit*) give an estimation of the social cost of noise of 147.1 billion euros per year [6]. This study takes into

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account health and non-health costs such as loss of productivity at work and the devaluation of real estate.

Although the problem of noise pollution is more and more considered as a major public health issue, local authorities' action programs to fight this problem have focused mainly on transport noise. The Environmental Noise Directive 2002/49/EC focuses particularly on these noise sources, which are the top noise annoyances expressed by the inhabitants of Île-de-France, in competition with neighbourhood noise [7]. One may therefore wonder how political actors can also address the specific problem of what we will call *recreational noise*, which emerges especially during the night and which may combine different sources (neighbours, costumers of festive establishments, noisy behaviours in the public space, amplified music).

The nightlife noise is indeed unique in that it is made up of multiple and diverse sources, that can vary in time and space in an unpredictable way. It is therefore difficult to characterize it precisely or to establish generalities about its nature and composition. We can however, at first sight, distinguish two main types of sound sources: music (especially if it is amplified), and the voices of the users (especially if they are cheerful, or intoxicated). We will see how we can be able to address this issue with observation and acoustic modelling tools, in an attempt to contribute to the more global process of conflict calming in the city.

2. THE FRENCH REGULATION

We will focus here on the noise directly or indirectly generated by festive places (bars, restaurants, nightclubs, etc.) and the appropriation of public space, perceived outside or in the neighbourhood. For the protection of local residents, we have regulations, relating on the one hand to the sound level generated within establishments broadcasting amplified music in the usual way, and on the other hand to neighbourhood noise.

Decree No. 2007-1244 of August 7, 2017, relating to the prevention of risks related to amplified noise and sound, imposes thresholds not to be exceeded: "*Do not exceed, at any time and in any place accessible to the public, the levels continuous sound pressure equivalent 102 dB(A) over 15 minutes and 118 dB(C) over 15 minutes.* [Translation]" The level of the music played in the establishments is therefore clearly regulated, and controlled by sound level limiters directly connected to the sound systems.

The Environment Code (Art. R571-26, Art. R571-27) also requires establishment managers to carry out a noise pollution impact study in order to prevent the risk of annoyance in the vicinity, by verifying the regulatory criteria for noise emergence in the neighbouring dwellings. However, the noise generated directly by people on the public highway is not subject to precise restrictive regulations: in the event of a complaint to the competent police authorities, the solicited officer will establish the illegal nature of the noise by ear. It seems difficult, both technically and morally, to limit by law the sound level emitted by the human voice, as opposed to the noise generated by machines (amplified music, vehicles, industrial sites, building ventilation equipment, etc.). The specific case of portable loudspeakers, more and more popular in the past years and used by groups of people occupying public spaces, is considered a source of noise pollution as a "behavioural noise" and can therefore be the subject of a complaint to the local police.

For all noise nuisances, and especially when it comes to those that come from the behaviour of other people, the subjective nature of everyone's perception is a crucial point: the person who issues the complaint is the one who defines the annoyance. We can therefore see that the problem of noise pollution does not have an obvious solution to it, since it very often involves different points of view and legitimate interests that conflict with each other: inhabitants pleading for their right to rest, against

establishments that live from a festive activity, for example. So in addition to the existing regulations, it is the way in which the discussion can take place between the various stakeholders that brings another vector of reconcilement, in particular through the city's policy on the treatment of noise pollution.

3. BRUITPARIF'S ACTION IN PARIS

In a context where the issue of nocturnal noise pollution is precisely becoming an increasingly important political concern, thanks in particular to the growing mobilization of local residents' associations, Bruitparif, in collaboration with the City of Paris, has carried out a first experiment with acoustic measurements in the 11th arrondissement of Paris in 2012. The Paris Night Council (*Conseil de la Nuit*), created in 2014 following the General States of the Night (*États Généraux de la Nuit*) held in 2010, is part of the development of a participatory policy for the City by bringing together the Parisian nightlife actors around consultations. In this context, we have deployed sensors in various strategic locations in the capital since 2016, to be able to provide all stakeholders (residents, festive establishments, municipal services and political personnel) with objective data on the sound levels resulting from nightlife activity.

3.1. The "Medusa" sensor

The Medusa is a sensor developed and patented by Bruitparif, originally for the purposes of a first experiment in the festive districts of Paris. Building on its success, this measurement system has gradually been extended (from 25 sensors deployed in 2018 to 42 in 2022), with a presence today in around ten neighbourhoods where the problem of noise pollution due to nightlife is particularly denounced by residents' associations.

The Medusa sensor operates on the principle of a simplified acoustic antenna: it has four microphones arranged in a tetrahedron shape, making it possible to measure not only the sound level but also the direction of origin of the dominant noise, at each instant. A 360° camera integrated into the device takes a photograph of the environment every 15 minutes, allowing, after computer processing of the data, a visualization of the noise by its projection in the image in the form of coloured hexagons. So we have access to two pieces of information at one glance: both the location of the main sound source in the image, and the associated sound level thanks to a colour scale varying according to the measured intensity.

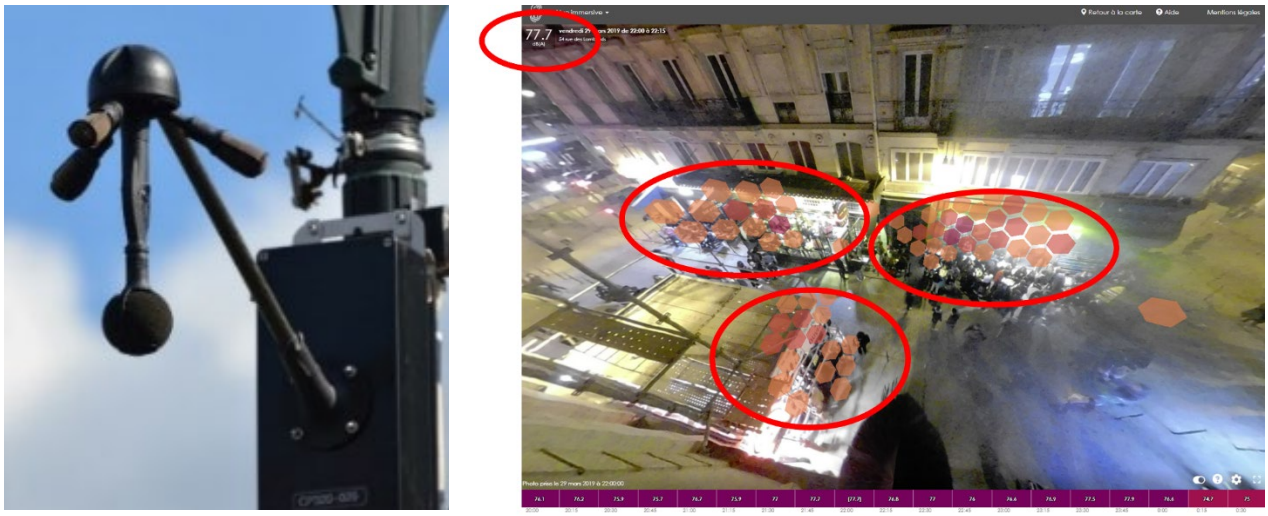

Figure 1: Medusa sensor (on the left) and example of immersive view (on the right)

3.2. Data exploitation for the study of lively neighborhoods

Real-time access to sensor data is made possible through a public Internet platform (http://monquartier.bruitparif.fr). This allows total transparency on the information recorded by the Medusa, which anyone can consult. It is for this reason that the interface is to be as intelligible as possible, summarizing the information in a simple and explicit visual, accessible for all because it does not require any specific acoustic knowledge in first approach.

In practice, we are able to use the data measured by the Medusa sensors installed in the city of Paris in different ways. Through real-time visualization, the Internet platform allows everyone to check for themselves whether the quantified sound level readings corroborate their personal feelings of a given situation. In particular, the immersive view of the sensor can make it possible to identify the exact place of origin of the noise, and thus confirm or invalidate a suspicion based solely on perception. For example, if a local resident is disturbed by the noise coming from a nearby festive establishment that cannot be identified with total certainty based on perception alone, the immersive view can be of some help. In the same way, an establishment manager can check in real time the sound level emitted by his activity, and take the initiative to lower the volume of the music he plays or even carry out prevention within his costumers in the case of too loud voices, for example.

To provide a more detailed overview, the web platform offers a visualization of different information for a selected time interval (with a length of 15 minutes by default):

- a graph of the evolution of the sound level in dB(A) or in dB(C) as a function of time,
- an immersive view as described above, using the 360° photograph of the optical sensor and representing the noise by patches of variable colour,
- a graph presenting the detailed angles (azimuth and elevation) calculated at each instant and defining the direction of origin of the dominant source of noise.

Moreover, the subsequent processing of the data from the sensors makes it possible to establish a statistical analysis over longer periods, on the scale of the week, the month or the season, of the sound levels recorded. We can then highlight more global and long-term trends in the different activities observed: the noisiest establishments, the noisiest days of the week, the noisiest time slots, etc.

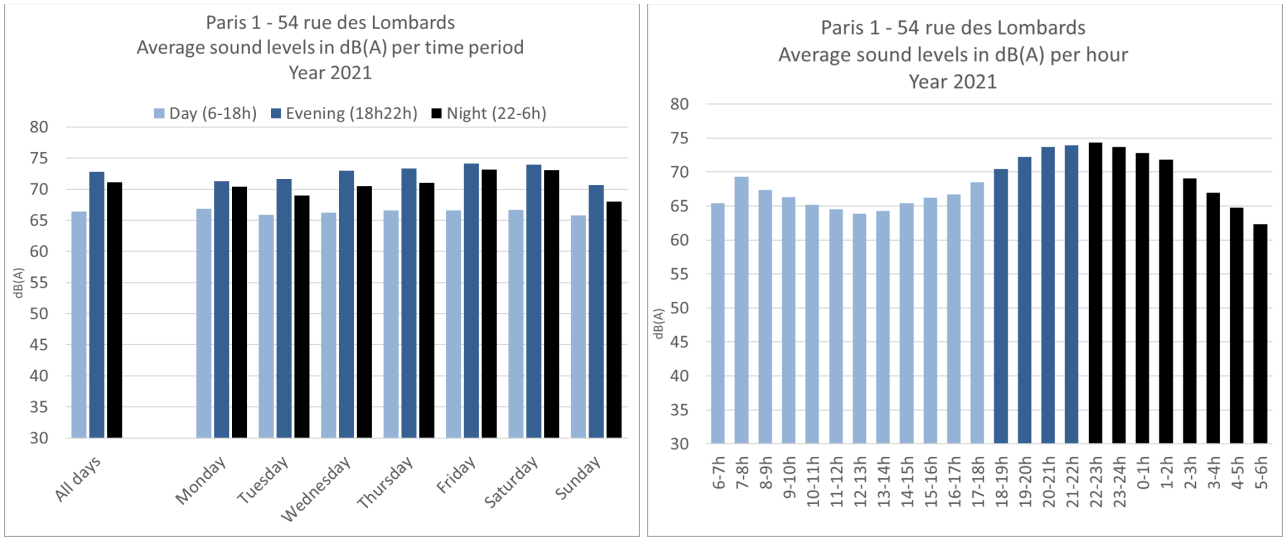

Figure 2: Graphs showing the 2021 annual trends in average sound levels: weekly profile (variations by day of the week, on the left) and daily profile (variation by time of day, on the right).

In the analysis of the 2021 summer season, we propose comparative elements to put the data recorded to into perspective.

On the one hand, in comparison with the WHO recommendations in terms of levels of exposure to transport noise. We observe that these recommended levels are quite largely exceeded on all the observation points within the lively districts, including on the sites where road traffic contributes little or nothing to the noise environment.

On the other hand, we also propose a direct comparison with measurements taken by sensors intended for the observation of road traffic noise on Parisian streets, making it possible for us to compare the two types of noise in terms of measured sound level on site. This comparison highlights the places and periods where the noise level from nightlife is equivalent to that produced by major roads, or even higher for some very lively districts.

A comparison of data from different sensors may prove to be relevant, in particular to compare the sound contributions of different establishments, or even between the different neighbourhoods observed. If the approach is not necessarily to highlight a hierarchy of neighbourhoods according to their associated average noise level recorded, it remains interesting however to cross-reference this information with the involvement of local residents' associations, or the number of complaints reported about noise nuisance. Any data comparison must however be made with caution, since each sensor reports a unique sound situation.

We thus establish summary reports based on data recorded over long periods, on the scale of the summer season, and we are now able to provide comparative data between the documented past years. These reports are often used as a support for discussion during the consultations organized by the City, which regularly oppose associations of residents and festive establishment's representatives on the issue of noise, by providing objective elements for a better-informed debate.

3.3. Current developments

A new technique for analyzing Medusa data is currently being studied, further exploiting the ability of the sensor to discriminate sound sources according to their location in space. This type of data processing, already tested on specific scenarios, makes it possible to distinguish, over a given period, the contributions in terms of acoustic energy from different predefined areas of the image depending on the environment of the sensor. In the case of festive districts, this method makes it possible, for example, to compare the sound contributions of terraces belonging to different establishments. This tool thus provides better accuracy in reading a given sound environment.

In order to raise awareness and possibly allow self-regulation within the terraces, an indicator light device is also being tested. Connected to data recorded by a Medusa sensor, it displays a colour that varies according to the sound level recorded from a targeted terrace. The processing includes the Medusa zoning analysis technique mentioned above, allowing to only take into account the sound contribution of the observed establishment. One can configure the colour changing of the indicator according to the exceeding of certain sound level thresholds, which are adaptable according to their relevance in the given situation. We propose this device to establishments willing to equip themselves with it. They can install it at their will, either in full view of all, or solely for their own information. Customers could then become aware of their excessively noisy sound environment by seeing the colour of the light, or be directly encouraged by the staff of the establishment to lower the level of their voice to avoid excessive shouting emerging in the late hours of the evening.

4. A TERRITORIAL ACOUSTIC DIAGNOSIS OF NIGHT-TIME RECREATIONAL NOISE IN PARIS IN 2022

The Halles-Beaubourg-Montorgueil district, in the heart of Paris, is renowned for its high concentration of festive places. It is therefore an ideal laboratory for carrying out a study on noise

pollution resulting from nightlife. The Neighborhood Council asked Bruitparif to establish a territorial acoustic diagnosis with the aim of better documenting the problem of local nightlife noise, and in particular to establish a first recreational noise mapping. This could make it possible to estimate the population's exposure to this type of noise, and thus provide tangible data justifying the integration of nightlife noise in the assessment of the health impacts attributable to noise. This diagnosis, intended to offer a macroscopic look at the phenomenon, contributes to a more general reflection on urban planning in Paris.

4.1. The stakes of the study

The still too partial, or even sometimes missing, consideration of recreational noise in strategies to fight noise pollution is a real gap to we have to fill. As highlighted by an Italian study on the city of Pisa [8], as strategic noise maps do not represent nightlife, one can find big local differences between the mapping and the reality of sound environments. This is even more true as nocturnal human activity generally occurs during time slots where road traffic is usually reduced (evening, night), or in areas where transportation is simply not an issue (pedestrian streets, squares). It therefore seems essential to develop tools to map recreational noise in order to integrate it, in the long term, into the strategic noise maps, which must better account for all the sources of noise pollution.

Our work will follow the existing contributions of studies dealing with recreational noise in urban areas, particularly in Mediterranean countries, which are subject to the phenomenon of *movida* in large agglomerations. One can note for example the Italian studies on the cities of Turin or Milan, which propose on the one hand acoustic instrumentation methodologies for the festive districts and a reflection on the acoustic indicators to be used [9], and on the other hand, surveys on the audiences that are essential to understanding the annoyance caused by noise ([10], [11]). The city of Barcelona, which is particularly affected by nocturnal party noise, has been equipped with a noise measurement network that has been in development since 2006 [12], which makes possible a partial mapping of recreational noise in lively neighbourhoods [13]. The subject is also studied in France, and we can cite in particular a contribution from 2002 on the city of Bordeaux [14], which offers a geographical approach to the problem and already addresses the question of nightlife noise mapping. In addition, the literature also mentions the socio-economic aspects and the political stakes around the problem of recreational noise; we can cite in particular the articles by Elsa Lafaye de Micheaux [15] and Philippe Le Guern [16]. On the city of Angers, or the contributions of Étienne Walker on the cities of Caen and Rennes ([17], [18]), which offer us very relevant perspectives for the difficult analysis of such a complex phenomenon that is the inconvenience due to noise in town. In the light of these studies, we will try in our turn to bring a proposal in the development of the techniques implemented for the observation and the modelling of recreational noise, through the study of the liveliest districts of Paris.

4.2. Methodology

To achieve such a macroscopic visualization of the neighbourhood's recreational noise, it is first necessary to inventory the information available about the elements that contribute to the nocturnal noise environment. First of all, of course, it is essential to make a detailed identification of all the festive establishments (bars, restaurants, clubs, any drinking establishment), and to gather as much information as possible concerning their activities, their opening hours, or their habits in terms of music streaming. A precise map of all permanent terraces, but also summer terraces (only authorized between April 1st and October 31st), can also be established based on data made available by the City of Paris.

As mentioned in the introduction, the difficulty in studying recreational noise lies in the acoustic characterization of the sources, which are diverse, variable, and heterogeneously distributed in time and space. However, it seems reasonable to consider the terraces as the main sources: they are fixed in space and generate noise during periods that are long and regular enough to be described and analysed. It then remains to establish a typical profile of a terrace as an acoustic source, by defining a geometrical shape, a directivity, a frequency spectrum corresponding to a set of human voices, as well as a scale of intensities. To this end, an acoustic measurement campaign should make it possible to carry out sound readings at different strategic positions in the district, taking into account the various configurations encountered. The preparation of this measurement phase requires a good knowledge of the field and its tension areas, which is why it is carried out in close collaboration with the District Council.

By first using calculation methods already proven in the modelling of transport noise (CNOSSOS-EU, Directive (EU) 2015/996), the terraces will be represented by surface acoustic sources. To each source will be attached a sound power level, taking take into account the density of occupation, the spectrum of the human voice and a variable intensity (to represent spoken voices, forced voices, shouted voices, etc.), and the potential contribution of a music broadcast. A variation in these settings will allow us to test different scenarios.

The identification and characterization of areas with different sound environments make it possible to establish a sampling plan of measurement points that will be relevant to the study. These fixed sound level readings, supplemented by ambulatory measurements carried out with the innovative NoiseCapture application (developed by the National Center for Scientific Research (*CNRS*) and the Gustave Eiffel University) coupled with a class 1 sound level meter, will indeed provide essential data for the calibration of the 3D digital model of sound mapping.

5. CONCLUSIONS

Considering the worrying conclusions of studies concerning the health impact of noise on our societies, and in the light of the scientific contributions specific to recreational noise over the past twenty years, it seems essential to devote more efforts to the development of new studies on this subject. We tried here to remind how it has a highly influential position in the vast problem of urban noise pollution.

In Paris, the Bruitparif association has set up an important acoustic monitoring system in lively neighbourhoods, which, since 2016, has enabled detailed observation of this phenomenon. This set of sensors, deployed in around ten Parisian districts, provides objective sound level data for the various stakeholders (residents, managers of festive establishments, municipal services), contributing to their debate around the issue of noise pollution.

Through this observation device, data on sound levels mainly attributable to nocturnal recreational activities in Paris have been collected for several years and analysed over the summer seasons in particular, thus providing valuable information on the sound level variation trends on different time scales. On this basis, we are setting up the making of a territorial acoustic diagnosis focused on recreational noise within the Halles-Beaubourg-Montorgueil district in Paris for the summer season 2022, with the aim of developing a first mapping of this type of noise, in this area known for its strong nocturnal activity. Such a representation could be used to estimate exposed populations, thus presenting an overview of the impact of recreational noise on the life and health of city dwellers.

This local diagnosis will allow the development of a specific methodology for the study of recreational noise, and may propose a discussion on the acoustic indicators or the propagation calculation model used. In fact, it seems essential to open up a reflection on the tools best suited to

this type of noise, knowing that those that exist are primarily used to measure and model transport noise. Among the work already carried out in Europe, we can note the contribution of Ballesteros et al. [19] who proposes an empirical model specific to leisure noise, based on ambulatory acoustic measurements in some lively neighbourhoods of Spanish cities.

In order to replicate what is already in place for transport noise management, the mapping of recreational noise could eventually be an informative tool made available to everyone, and in particular, to the public authorities who will have to take up this issue. They will thus be able to rely on precise documentation of the current state of urban sound environments to initiate prevention or awareness-raising actions, or even to change the dedicated existing regulations. For a true consideration of the problem, it will also be essential to complete the sound levels studies with surveys of the affected public, which is an important key for a better understanding of the effects of noise pollution on health.

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