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ACOUSTIC DIAGNOSIS OF THE NOISE OF NIGHTTIME RECREATIONAL ACTIVITIES IN PARIS

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ABSTRACT

Nighttime recreational activities are part of the sources of noise pollution in the city, in the same way as transport. The regulation of the noise level produced by these activities is however particularly difficult to grasp, insofar as it is mainly a question of noise made up of human voices. It is therefore not a question of imposing a regulatory threshold not to be exceeded, as we can impose on noise-generating machines, but rather of questioning our way of occupying the urban space as a diverse public that share the same space-time. Indeed, how to reconcile on the one hand the right to enjoy a drink on a terrace during long summer evenings, and on the other hand the right to rest for the locals of a lively city centre?

The objective of a local acoustic diagnosis centred on nighttime leisure noise is to contribute to this reflection, by proposing an analysis of the sound level data measured on site, a noise map based on the distribution of the terraces in the perimeter and consequently an estimate of the population's exposure to noise. This aims to provide authorities with tools for regulation and decision support in urban management.

Keywords: *Leisure noise, recreational noise, environmental noise, modelling, health impact.*

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1. INTRODUCTION

Existing studies on nighttime recreational noise mainly focus on the effects of amplified music played at high volume levels on hearing [1], and especially in young audiences [2]. However, this problem is not limited to the very enclosure of festive places and their costumers: the noise observed outside during the evening, particularly downtown or in the busiest districts, can be made of music escaping from establishments but also, and mostly, the conversations of passers-by and customers of bars, restaurants, clubs or other festive places. The development of nighttime economic activities, particularly in large cities, seems to lead to an increase of complaints of noise pollution. In Paris, there is a 4.5% increase between 2017 and 2020 in the number of cafes, bars and restaurants according to a report from the Parisian urban planning workshop (APUR) published in 2021 [3]. Terraces have multiplied and spread in the streets, particularly following the health crisis due to COVID-19 and the continuation of the "summer terraces" system in the municipal decree of June 18, 2021, providing for additional authorizations for operators to extend their terraces from April to October. In this context, the concern to know more precisely the health impacts of exposure to this type of noise is only increasing. This constitutes a request from local residents who form associations to make their voices heard: their daily life is directly impacted by noise pollution, and particularly by nighttime recreational noise, sometimes seriously degrading the quality of their sleep. It therefore seems essential to advance research in this largely unexplored field.

It is in this context that this study [4] was carried out in 2022, the aim of which is to develop a first draft of a methodology for modelling recreational noise, making it possible to map this type of noise at a local scale, then to propose an estimate of population exposure. The studied sector is a very lively district with nightlife located in the centre of Paris, with an area of 0.83 km² and a population of around 21,000 inhabitants (2019 census). We focus here on the issue of Parisian terraces, often decried by groups of local residents for the place they occupy both spatially and acoustically. The proposal for a nighttime recreational noise-modelling tool in the streets of Paris is aimed at residents, for the purpose of information and knowledge sharing, but also at public authorities, who could use it for regulation and urban management.

2. ACOUSTIC MEASUREMENTS CAMPAIGN

The first stage of the study consists in collecting sound level data on the study perimeter, in order to characterize the sound environment of the district in terms of frequency composition, intensity, and temporality.

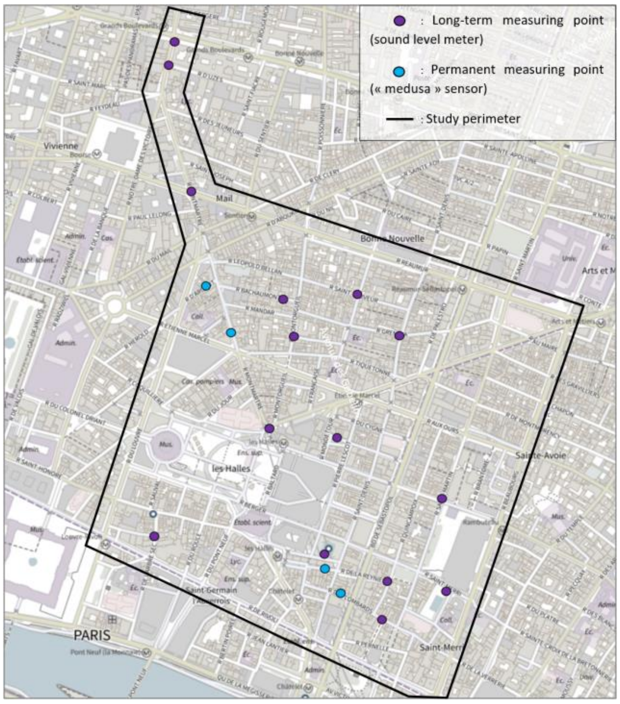

Figure 1 : Location map of measuring points.

An acoustic measurement campaign of fixed points was carried out between May 16 and July 2, 2022, over a period of 6 weeks. It included 15 measurement points within the study perimeter between the Renard/Beaubourg axis to the east and rue du Louvre to the west, and between rue Montmartre and boulevard Réaumur to the north, and rue de Rivoli to the south. In addition, 4 permanent "medusa" type sensors [5] are deployed in the perimeter. We consulted the district council to determine the locations of these measurement points, to take into account the feedback of the local inhabitants. If it is indeed interesting to document the places subject to many complaints, it is however also relevant to carry out measurements in quieter soundscapes to be able to compare the different situations and identify the contrasts.

In parallel with this campaign, we also performed short itinerant measurements on three evenings during the same period: it was then a question of marking a stop in front of different establishments along a defined route, and to measure the sound level for a period of about one minute.

2.1 Frequency composition of noise

The acoustic measurements made it possible to highlight various characteristics of the sound environment of the district, starting with the composition of the noise, which we can try to identify by a frequency analysis. We can first note that the points positioned near streets with heavy road traffic show, as expected, typical road noise spectra. The dominant frequencies are then in the range [31 – 125 Hz] (**Figure 2**). Conversely, for the points located in mainly pedestrian streets, the spectra recorded are consistent with a noise whose dominant component is a set of human voices. In this case, the dominant frequencies are rather in the range [200 – 2000 Hz] (**Figure 3**). It is also possible to identify the presence of music, when there is a rhythmic solicitation of low frequencies over time. However, music rarely remains dominant in the soundscape of the streets, except during special events such as the Music Day, which takes place every year on June 21 and where the broadcast of amplified music in the street is exceptionally tolerated.

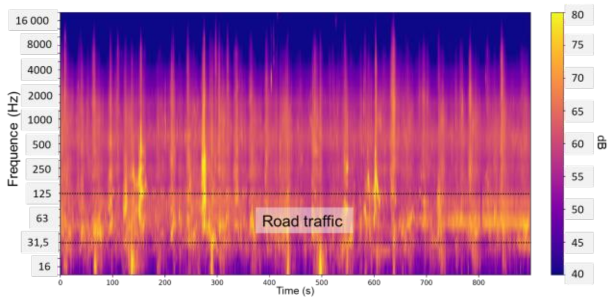

Figure 2 : Spectrogram at the rue Réaumur measurement point in Paris, Friday June 17, 2022, [10:15 p.m.-10:30 p.m.].

The sound level readings for which the road noise component was identified as being dominant for a majority of the time were discarded from the rest of the study (4 measurement points out of 15), which consists in proposing an acoustic emission model of the nighttime recreational noise and therefore focuses on measured data allowing a characterization of this type of noise.

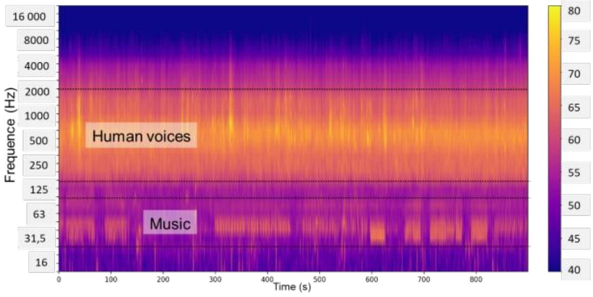

Figure 3 : Spectrogram at the measurement point rue de la Grande Truanderie in Paris, Friday June 17, 2022, [10:15 p.m.-10:30 p.m.].

Finally, it can be noted that among the four measurement points mainly influenced by traffic, two show a mixed spectral profile: if we do note a significant traffic noise component, we also detect a component of human voices, that is lower but testifies nonetheless to the presence of terraces nearby.

These results therefore show a set of sound situations varying according to the location in the neighborhood, representative of the different atmospheres that can be found there, and mainly reporting sound profiles corresponding to a strong human presence in the public space.

2.2 Evolution of noise level over time

The second dimension of noise that we can analyse is the evolution of the sound level over time for the different measurement points. As shown in **Figure 4**, we can see, for the points directly affected by recreational noise (10 measurement points out of 15-see previous paragraph), that the evolution of the noise level during the evening and night follows a common overall trend. We can explain this general trend, in whole or in part, by easily identifiable contextual elements.

The noise level increases between 6 p.m. and 8 p.m., as the clientele fills the establishments and their terraces. In the following hours – between 8 p.m. and midnight – the noise levels continue to increase due to the growing crowds and the increase in the volume of the discussions, caused in particular by the alcohol consumption and more generally by the Lombard effect [6]. We observe a drop in the sound level from midnight on, in connection with the gradual departure of customers from the establishments. There is a pronounced drop in the sound level between 1 and 2 a.m., which can be linked to the last metros and the closing of most Parisian bars at 2 a.m. The clientele of the terraces is thus led to travel during this time slot, either to return home or to migrate to establishments that are open later at night, such as nightclubs.

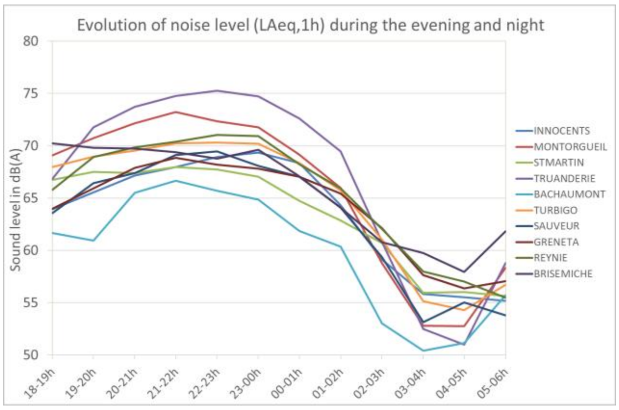

Figure 4 : Evolution of noise level ($L_{Aeq,1h}$) during the evening and night.

Based on these findings, the rest of the study focuses on the time slot [6 p.m. – 2 a.m.], identified as the most critical in terms of observed noise levels.

3. ACOUSTIC MODELLING AND MAPPING

Based on the analysis of measured data, we propose a first empirical model of noise emission from nighttime recreational activities in the neighbourhood.

3.1 Input data

The noise maps are produced with the CadnaA software (Datakustik) version 2022. This tool takes into account the topography of the land via the altimetry data provided by the French National Institute of Geographic Information, as well as the location of the Parisian buildings, provided by the City of Paris. We also take into account the location of all authorized terraces in the district, as extracted from the Paris open data platform, whether these are permanent (open all year round) or summer terraces (open from April 1 to October 31, with in this case a mandatory closure at 10 p.m.). Among the identified terraces, we only retained those of establishments such as restaurants, bars and clubs. In all, 701 permanent terraces and 67 summer terraces were included in the model.

To determine the acoustic power spectra (L_w) to be associated with recreational activity according to the time slot chosen, we proceeded by inverse modelling by adjusting the power levels at the input of the model to find at the output sound levels corresponding to the data measured on site. For each measurement point mainly influenced by recreational activity, we have thus deduced, from the levels measured by the device, the sound power levels associated with nearby recreational activity, i.e. the terraces located in a radius of 30 meters around the sound level meter. Using the acoustic modelling software allows to take into account the phenomena of propagation, reflection and absorption that occur between the emission of noise at the source (terraces, represented by surface sources in the software) and the measurement of the ambient sound level at the sensor (represented by a receiver in the software). The acoustic power spectrum of the source is thus determined for each of the following four time slots: [6 p.m.-8 p.m.], [8 p.m.-10 p.m.], [10 p.m.-0 a.m.] and [0 a.m.-2 a.m.].

Figure 5 presents the results obtained for each point, in sound power level per square meter and per frequency band, for the slot [10 p.m.-12 a.m.]. If we note that the shape of the frequency spectrum is very similar for all the points, we observe that the power level varies according to the location, in an interval of approximately 10 dB(A) in global level. The information we have on the establishments and their terraces does not allow us to explain this difference precisely. It is likely however that parameters such as the type of establishment, the average age of the clientele, the male/female ratio, alcohol consumption practices according to the type of establishment, or even the significant presence of people on the public highway, outside the terraces, play an important role in this dispersion.

In order to feed the calculation model, it was decided to retain an average sound power level spectrum (in red in the graphs of **Figure 5**) for each two-hour period, which was then used for all recreational activity areas identified within the study perimeter. This methodological choice leads to local overestimates or underestimates that can reach up to approximately 5 dB(A) compared to reality.

Following this principle, three attendance scenarios were considered for each time slot: an "average attendance" scenario, based on averaged sound level readings over the total measurement period; a "lower attendance" scenario, based on evenings with below-average noise levels; and finally a “high attendance” scenario, based on evenings with above-average noise levels. Noise maps were produced for each of these scenarios.

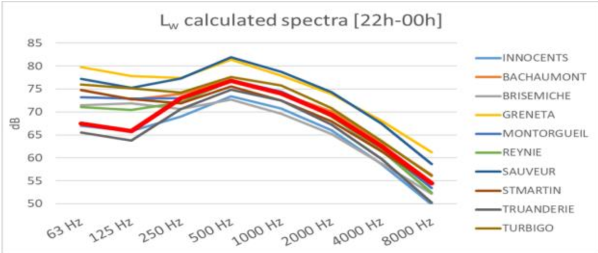

Figure 5 : Acoustic power level spectra (L_w/m²) determined to characterize the recreational activity surrounding each measurement point for the time slot [10 p.m.-12 a.m.]. In red, the average spectrum chosen for application in the model.

3.2 Recreational noise map

The mapping result is presented in **Figure 6**, in a summary map of nighttime recreational noise showing the total time slot [6 p.m. to 2 a.m.], in the average attendance scenario. This highlights the main places with high noise pollution issues, which are the pedestrian streets and squares that concentrate a large number of terraces.

Figure 6 : Summary map of noise induced by recreational activities, period [6 p.m. to 2 a.m.].

3.3 Vertical propagation

Three-dimensional acoustic modelling also makes it possible to visualize the propagation of sound in the vertical plane, and to observe in particular the influence of different street configurations on the sound level perceived in the upper floors of apartment buildings. In fact, narrow canyon-type streets amplify the sound level through reflections on the facades of buildings facing each other (**Figure 7**). On the contrary, a building facing a square will mainly experience direct sound.

This phenomenon is all the more important to underline that we find numerous narrow streets in Paris. We can also mention that most buildings are old in these Parisian districts, in which sound insulation is not optimal. Local residents can therefore suffer from a combination of factors that aggravate acoustic discomfort in their homes.

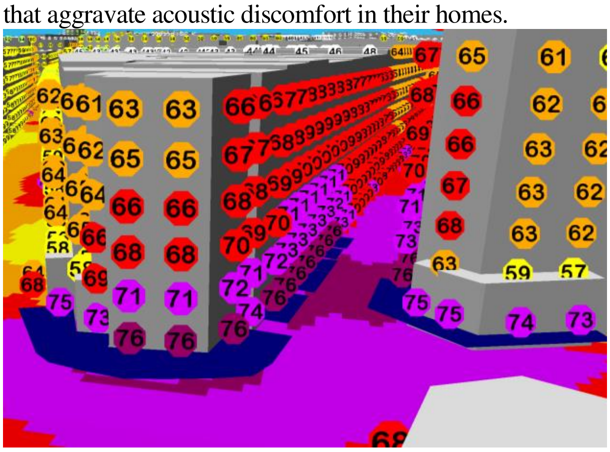

Figure 7 : 3D view of the acoustic simulation, rue Montorgueil, time slot [8 p.m.-10 p.m.], high attendance.

3.4 Maps of cumulative noise from recreational activities and road traffic

Strategic noise maps in application of the 4th deadline of European Directive 2002/49/EC, provide modelling of traffic noise for the periods of day [6 a.m.-6 p.m.], evening [6 p.m.-10 p.m.], night [10 p.m.-6 a.m.], and for the Lden indicator. We therefore carried out the exercise of producing noise maps taking into account both the roads and the terraces included in the study perimeter.

Figure 8 shows the result for the night period, on which the estimates of the health impact of noise on populations are mainly based, since it is the period devoted to sleep.

Figure 8 : Mapping of noise from recreational activities and road traffic, night period [10 p.m. to 6 a.m.].

Figure 9 shows a map of the sound level difference between recreational and traffic noise on the night period. This brings out the areas where recreational noise is higher than traffic noise: in streets where the terraces are numerous and where the night activity increases the influx of passers-by, human voices are the main source of noise and cover up traffic noise.

This highlights the predominance of road traffic noise near high traffic axes, and, conversely, the predominance of recreational noise in pedestrian zones and areas with a high concentration of terraces. It can be noted that locally, recreational noise could significantly exceed road noise in intensity.

Figure 9 : Map of the emergence of recreational noise in relation to road traffic noise, night period [10 p.m. to 6 a.m.].

4. POPULATION EXPOSURE

Based on the established noise maps, we were able to estimate the exposure of populations to recreational noise and road noise. We evaluated these statistics according to the CNOSSOS-EU 2020 method, which assigns a number of inhabitants of a building to the noise levels calculated at 4 meters from the ground and 2 meters in front of the facades. The allocation method consists of retaining only the half of the linear facade of the building most exposed to noise, then distributing the inhabitants proportionally to the values of the receptors considered on these facades.

The comparison of exposure to road traffic noise alone with exposure to traffic noise combined with recreational noise shows that the latter has a major impact on local life. Indeed, taking into account recreational noise in addition to road noise brings the proportion of the population exposed to a level higher than 45 dB(A) during the night, target value for night-time noise level proposed by the WHO in 1999 [7] to avoid any sleep disturbance, from 51% for traffic noise alone to 75% for the accumulation with recreational noise. If we refer to the intermediate target value of 55 dB(A) proposed in a 2009 WHO report [8] allowing the operational management of nighttime noise by authorities, this proportion goes from 21 % to 52 %.

These estimates show the strong impact of recreational noise, not only on the sound environment of the neighbourhood, but also potentially on the health of inhabitants.

5. CONCLUSIONS

This work is part of an experimental approach around the methodology of acoustic studies on the noise of nighttime recreational activities. The rise of this issue is linked to the development of nighttime activities in the city and the associated urban space management policies. In Paris, we can note the multiplication of terraces for a large part of the year following a measure to compensate for economic losses due to the COVID-19 health crisis for the catering and nightlife sector. In general, the issue of nighttime noise pollution highlights the conflicts of use of public space.

This study has provided a first procedure for objectivizing noise pollution related to nighttime recreational life. At a local scale, we built a recreational noise estimation map with acoustic modelling tools. As a result, we also estimated the nighttime recreational noise exposure of the local population. These calculations highlight a significant impact of recreational noise on the lives of residents and therefore potentially on their health.

To make a reliable estimate of this health impact, it is necessary to conduct epidemiological studies specific to this type of noise, which to date remains a gap to fill in this field of research. More generally, a longer-term study would allow to perfect the noise modelling methodology by analyzing in more detail all the influential parameters, and to provide a more precise estimate of both the proportions of the population exposed and the corresponding health impacts.

Such a modelling tool should make it possible, as it is for transport noise, to highlight the impact of nighttime recreational noise on human life and the environment. It is therefore a vehicle for raising awareness and a support for reflection on the improvement of community life in the city, for the inhabitants, the economic players and the public authorities.

6. REFERENCES

[1] Neitzel, Richard L., Brian J. Fligor. « Risk of noise-induced hearing loss due to recreational sound Review and recommendations » in *The Journal of the Acoustical Society of America* 146, nº 5, 2019.

[2] Sofie Degeest, Hannah Keppler, Bart Vinck. « Leisure noise exposure and associated health-risk behavior in adolescents an explanatory study among two different educational programs in flanders » in *International Journal of Environmental Research and Public Health* 18, nº 15, 2021.

[3] Bruno Bouvier, François Mohrt. « L'évolution des commerces à Paris - Inventaire des commerces 2020 et évolution 2017-2020 » (April 2021).

[4] Cécile Revol, Fanny Mietlicki. « Diagnostic acoustique territorial du quartier Halles-Beaubourg-Montorgueil et de la rue Montmartre, tenant compte des activités nocturnes récréatives ». Study report, 2022.

[5] Laetitia Nave, Fanny Mietlicki. « Medusa, a new approach for noise management and control in urban environment » in *Proceeding of Inter-Noise 2019*, 259:2411-19. Madrid, ES, 2019.

[6] Étienne Lombard. « Le signe de l'élévation de la voix » in *Annales des Maladies de l'Oreille, du Larynx, du Nez et du Pharynx*, 37, 101-119, 1911.

[7] Berglund, Birgitta, Lindvall, Thomas, Schwela, Dietrich H & World Health Organization. Occupational and Environmental Health Team. « Guidelines for community noise ». World Health Organization, 1999.

[8] Night noise guidelines for Europe, WHO regional office for Europe, 2009.