Evolution of the soundscape following the traffic closure on the right bank of the Seine in Paris

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Summary

Since September 2016, by decision of the City of Paris, the right bank of the Seine river is closed to traffic along 3.3 km. Bruitparif has put in place a system for assessment of the modifications on the sound environment brought by this closure. This system was based on the implementation of noise measurements at 90 sites in and around Paris as well as modeling. At the end of a year of follow-up, it was possible to establish the following observations:

1. Partial traffic shifts to the lanes located above the banks have generated an increase in traffic noise for residents. This is more pronounced at night (up to 4 dB (A) in some areas) than during the day (less than 2 dB (A) increase). However, during daytime there is an increase of noise peaks (horns, sirens of emergency vehicles ...) related to rising congestion.

2. Other axes in Paris have also undergone a slight increase in noise likely related to the traffic reports, but in a more limited manner (of the order of 1 dB (A)).

3. Outside Paris, especially on the ring road and major roads, no significant change has been noted.

4. At the end of a year of observation, there does not seem to have been an adaptation of the behavior of drivers.

5. On the other hand, traffic noise has clearly decreased on the bank which is now pedestrianized, as well as on the façades of the first buildings located opposite the right banks of the Seine river. However, with the beautiful days and the developments made on the banks (restaurants, terraces, leisure games ...), new sounds have appeared in connection with the recreational activities that have taken place, thus partially offsetting the decline in traffic noise.

1. Introduction1

In September 2016, by decision of the City of Paris, the Georges Pompidou lane is closed to traffic along 3.3 km, from the entrance of the tunnel under the « Jardin des Tuileries » to the exit of the Henri IV tunnel, in order to pedestrianise the right banks of the Seine.

This decision to close a road that had previously been used by 43,000 motorists a day to traffic has prompted heated debates and questions from motorists, local residents and elected representatives about its relevance in terms of mobility and fight against atmospheric and noise pollutions. This has led the Île-de-France Region, the Greater Paris Metropolitan Area and the local authority of police to set up various committees to monitor the impact of the measure on traffic conditions, air quality and noise.

In this context, Bruitparif proposed the installation of a specific system to analyse the evolution of the noise environment over a large area covering the direct surrounding of the Georges Pompidou lane closed to traffic as well as the roads potentially impacted by traffic transfers or changes in traffic conditions in Paris and the inner suburbs. The monitoring took place over a full year between the beginning of November 2016 and the end of October 2017 in order to take into account the cycles of traffic variations, the diversity of weather conditions and possible changes in driver behaviour.

2. Methodology2

The study conducted by Bruitparif was based on the exploitation of different data sources:

- the results of two measurement campaigns implemented by Bruitparif, one in November/December 2016 and the other in May/June 2017, at 64 sites (30 in Paris and 34 in the inner suburbs);

- the short-term measurement data carried out on certain sites before the closure of the Georges Pompidou lane, in particular the measurements carried out over a few days in November 2015 by a consultancy company on six sites on the upper tracks as part of the impact study for the pedestrianisation of the right bank project submitted by the Paris City Hall;

- data provided by 12 permanent monitoring stations of the Bruitparif measurement network located near road traffic (9 in Paris and 3 in the inner suburbs) as well as by 14 semi-permanent stations specifically set up for the needs of the study (all in Paris);

- fine modelling of the area most affected by the traffic modifications induced by the closure to traffic of the right bank.

The noise data collected at the 90 measurement sites were also analyzed in conjunction with the available road traffic data, taking into account variations in weather conditions in order to highlight the only influence of traffic changes induced by the closure of the right bank on the observed noise levels.

The exploitation of all the data enabled Bruitparif to draw up an analysis of the state of the noise environment after the pedestrianisation of the Georges Pompidou lane and to provide an assessment of the acoustic consequences of the closure of this axis to traffic.

This study shows that the acoustic consequences of the closure of the Georges Pompidou road to traffic are mainly located in Paris, particularly along the upper tracks, and that these consequences are more pronounced at night than during the day.

3. Implementation

Temporary measurements were made using Rion NL52 class 1 sound level meters. These materials are subject to Cofrac calibrations performed every 24 months at the Laboratoire National d'Essais as well as regular additional self-checks performed by the Bruitparif laboratory in accordance with standard XPS31-117[1]. The measurements were conducted during 10 days. The systems were installed on public lighting poles at a height of 4 metres above the ground, with the exception of the points deployed on the 2015 impact study sites for which installation was carried out on building façades in accordance with NFS 31-185[2].

Permanent sites include two types of stations. Class 1 Opera 01dB stations and Class 2 Azimut Monitoring Ladybird stations. These stations are installed on public lighting poles 4 meters above the ground. The permanent stations are equipped with a telecommunication device allowing real-time or periodic remote transmission of data.

The semi-permanent stations deployed for a few months as part of the specific monitoring system include Azimut Ladybird stations and Azimut Greenbee stations. The latter also have an air quality module and have been deployed in partnership with Airparif.

4. Data processing

4.1. Data validation

The autumn/winter measurement campaign took place between 31 October and 20 December 2016 and the spring/summer campaign between 11 May and 4 July 2017. Additional measurements were made on the façades of buildings on the upper tracks between 23 October and 7 November 2017.
Most of the semi-permanent stations were installed between late October and mid-December 2016, some of which could only be installed in early 2017 for logistical reasons.

Initially, periods that were not representative of the situation studied were excluded. These may include periods of material handling and calibration of sound level meters at the beginning and end of the measurement, as well as exceptional

disturbances such as work. Periods of restricted circulation (alternating or differentiated circulation) due to air pollution episodes occurring during the months of December 2016 and January 2017, as well as periods of school holidays were also excluded from the calculations.

Periods with bad weather conditions (rain and/or strong wind periods) were also excluded, in particular to avoid the effect of rain making pavements wet and thereby modifying tyre/road contact noise.

The acoustic indicators were produced after excluding these invalid, unrepresentative or significantly disturbed periods.

4.2. Noise indicators

The elementary quantity that has been measured and stored is the LAeq.1s. This is the noise level, expressed in dB(A), measured every second.

From this elementary level, it is possible to calculate energy averages over defined periods. Thus, it is possible to calculate energy averages by steps of one hour (LAeq,1h), over 24 hours (LAeq,24h) or over any other periods like LAeq(6-22h) and LAeq(22-6h) calculated for day and night periods respectively. Specific analyses were also conducted for the morning LAeq(8-10h) and evening LAeq(18-20h) peak traffic hours.

These noise indicators have been produced:

- For the ambient noise including the various sources of noise in presence: rolling noise of vehicles, noise of engines but also noise associated with specific sound events such as horns, sirens of emergency vehicles and motorcycles particularly noisy.

- Only for noise that can be directly associated with the road contribution (vehicle rolling noise and engine noise) as defined in NFS 31-085[2]. For this reason, the most significant noise peaks were not taken into account when calculating the energy indicators. This is intended not to take into account the noisiest events such as horns, emergency vehicle sirens and particularly noisy motorized two-wheelers, which can be quite random from one day to the next.

Road traffic conditions are likely to vary significantly between weekdays and weekends. To highlight the impact of these variations on noise levels, the indicators were calculated by dissociating weekdays from weekend days.

The measurements include noise peaks, e.g. noisy emergency vehicle sirens, horns or motorized two-wheelers. Although most of these noise events are linked to road traffic, they are not taken into account when calculating regulatory noise indicators.

A treatment was therefore implemented to isolate the most significant noise peaks in order, on the one hand, to calculate their contribution to overall noise energy and, on the other hand, to be able to exclude them from the calculation of regulatory noise indicators (non-peak levels).

The identification of noise peaks is based on the detection of a threshold overrun. The rule applied is as follows:

Sound event (or noise peak) if LAeq,1s > max (80 dB(A), LA95eq,1h + 10)

With : LA95eq = equivalent background noise level during the hour considered, the background noise being evaluated every second from the level exceeded for 95% of the time during the previous 10 minutes.

Once these noise peaks have been identified, it is possible to calculate their contribution to overall noise energy and to exclude them from the calculation of regulatory noise indicators.

The identification of sound events is not completely exhaustive, sound events of small amplitude may not be identified, this method nevertheless makes it possible to isolate the most important and significant noise peaks.

4.3. Road traffic conditions

In order to provide elements for interpreting noise indicators and to give trends in noise evolution between before and after the closure of the Georges Pompidou lane to traffic, the road traffic data available near the measurement points were used specifically.

For speeds, most permanent traffic monitoring stations only provide flow rates. To complete these data, speed data coming via the FCD-Coyotte system from motorists' GPS operations have been used. These speeds have been made available on average hourly for Tuesdays and Thursdays from 6am to 10pm. Since speed data were not available for the night periods, it was assumed that speeds during these periods had not changed significantly between before and after the closure of the Georges Pompidou lane, as night-time traffic conditions were relatively fluid.

The available traffic data were cross-analyzed with noise data for the months of November 2015 and over the periods corresponding to the two measurement campaigns carried out in November/December 2016 and May/June 2017.

This made it possible to provide both a quantitative and qualitative interpretation of the variations in noise between the two situations "before" and "after" the closure of the Georges Pompidou lane.

It should be remembered that the theoretical analysis of the consequences, on the noise level, of changes in traffic conditions is complex because several aspects have to be considered, the effects on rolling noise, engine noise and untimely events (horns, emergency vehicle sirens, noisy motorised two-wheelers, etc.) being linked to the combined changes in flow rates and speeds. These effects may be cumulative in some cases or compete with each other. For example, an increase in flow generally increases traffic noise. However, if this increase is such that one approaches the congestion point, the speed of traffic drops, which then translates into a reduction in rolling noise but sometimes also an increase in engine noise (because the engine speed becomes more pulsed) or even noise peaks (in the case of increased congestion).

Interpretation must therefore be carried out by considering, on the one hand, the effects of flow and speed variations on vehicle traffic noise (rolling noise and engine noise) and, on the other hand, the effects on probable traffic congestion and the associated increase in noise peaks.

4.4. Temperature corrections

Finally, to avoid the effects of temperature variations on rolling noise and to highlight the only impact of changes in traffic conditions, road noise data (excluding noise peaks) were corrected and adjusted on the basis of average temperatures observed during the 2016 winter season (from November to mid-December 2016).

The correction method is derived from XPS 31-145-1[3]. This standard proposes the following temperature correction (1) of the data:

Temperature correction = 0.1 x (T measured - T reference) (1)

Where: T measured = temperature during measurements and T reference = 20°C

5. Results

5.1. On the right bank

The closure of the Georges Pompidou lane to traffic led to significant traffic transfers on the upper tracks at night, which generated a significant increase in night (22-6h) noise levels (Figure 1), often greater than 2 dB(A) and up to 4 dB(A) (i.e. increases of +60% to +150% in sound energy) on a large part of the right bank of the upper tracks between the Louvre and Place du Châtelet, between the Pont Louis Philippe and the Pont Marie and between boulevard Henri IV and boulevard Bourdon. Increases of the same order of magnitude, in a more localized manner, on the façades of certain buildings located on other sections of the upper tracks (between the Place du Châtelet and the Louis Philippe Bridge for example) cannot also be excluded.

For residents living near these areas, this is an increase considered significant within the French regulations (> 2 dB(A)) and corresponds to a real deterioration in noise exposure. As a reminder, an increase of +3 dB(A) is equivalent to a doubling of the sound energy (+100%).

During the night period, noise levels on the façades of residents are now between 65 and 70 dB(A), i.e. 5 to 10 dB(A) above the maximum level allowed for the night period, which is 60 dB(A), in the case of a modification considered significant in the noise contribution of the infrastructure

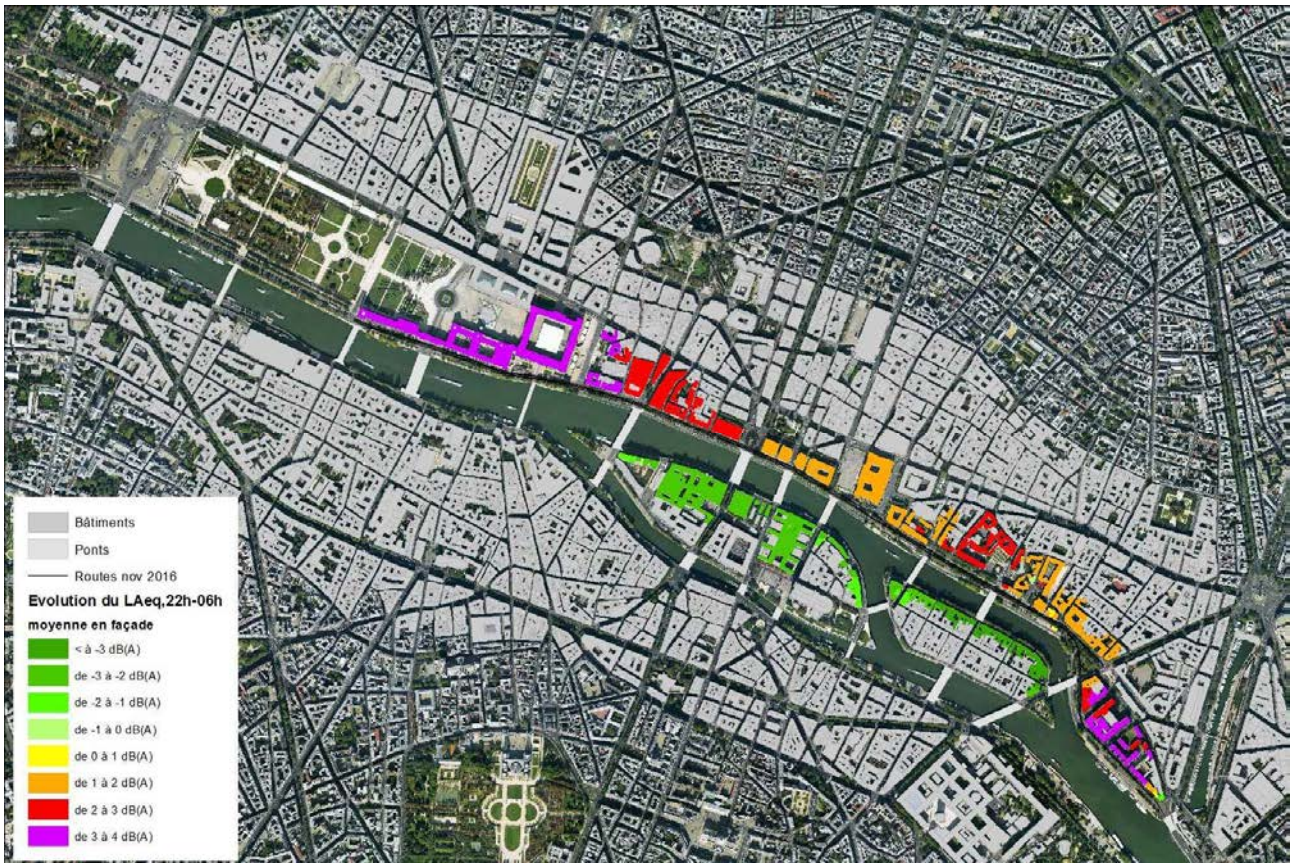

Figure 1. Evolution of the noise levels LAeq,22h-6h on the façades of the residents of the tracks before/after closure of the Georges Pompidou lane.

The increases observed on the uppertracks are less over the daytime period, the increases in traffic noise there being less than 2 dB(A) for this period. However, an increase in noise peaks (emergency vehicle sirens, horns, excessively noisy motorised two-wheelers) is manifesting itself as a result of increased congestion, particularly during peak morning or evening traffic hours. This can generat higher noise increases. Thus, taking into account the noise peaks, increases of 2.2 dB(A) on average during the day and 3 dB(A) at peak hours were noted at Henri IV site. The contribution of noise peaks now represents 20 to 60% of the noise energy measured on the upper tracks, the record having been observed at the quai du Louvre.

During the day period, the noise levels (excluding noise peaks) on the façades of residents of the upper tracks are now between 68 and 73 dB(A), i.e. 3 to 8 dB(A) above the maximum noise level authorised during the day period, which is 65 dB(A) in the case of a significant modification.

5.2 Roads with transfered traffic

Some roads within Paris have experienced an increase in noise, probably due to traffic reports and/or increased congestion associated with the closure of the Georges Pompidou lane. These include boulevard St Germain, boulevard Bourdon, boulevard des Capucines, rue La Fayette and boulevard du Montparnasse. However, the estimated increases (between 0.5 and 1.5 dB(A) at night and between 0 and 1 dB(A) during the day) are lower than on upper tracks.

5.3 Outside Paris

At the level of major traffic roads such as the ring road, the A13 or A86 motorways, the N118 national road, as well as outside Paris, there is no clear trend in relation to the closure of the right bank lane.

The only changes noted that can possibly be linked to a consequence of the closure of the right bank lane are observed to the east near the A4

motorway at Charenton-le-Pont and Saint-Maurice, where an increase in noise is observed (probably linked to an increase in congestion, particularly at peak evening hours). However, these changes remain limited (around 1 dB(A) on average).

5.4. Georges Pompidou lane

The closure of the right bank lane to traffic was accompanied overall by a marked improvement in the quality of the sound environment on the banks and also by a reduction in noise on the façades of the first buildings on « Île Saint Louis » and « Île de la Cité » islands opposite, as shown in Figure 2.

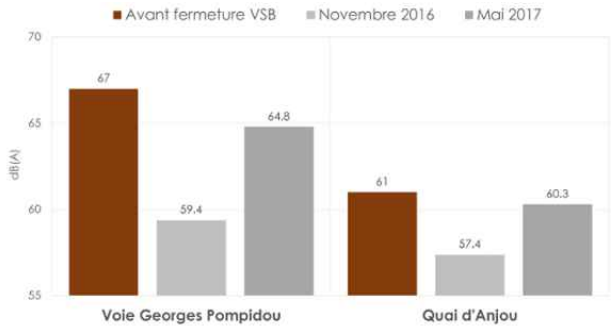

Figure 2. LAeq,22h-6h on the banks of the Seine, before and after the closure to traffic.

This improvement in the noise environment can of course be explained by the sharp reduction in road traffic noise, which has disappeared on the now pedestrianised bank lane (a reduction of around 8 dB(A)).

The improvement of the sound environment varies also greatly according to the periods of the day (day or night), the types of days and the seasons. Indeed, since the closure to traffic on the banks, restaurants and bars have set up and the uses of the banks have evolved with a greater presence of pedestrians and cyclists on the banks. These new festive and recreational activities have led to the appearance of new sounds (human voices, children's cries, music) that depend on the period when the banks are used and that have partially replaced the road traffic noise that reigned on the banks before they were closed to traffic.

The gradual increase in noise levels on the banks with the arrival of good weather, as well as the weekly cycle of bank use, are clearly shown in Figure 3 below. This upward trend is more pronounced at night than during the day. The noisiest months are June and July. The night noise level then becomes 3 dB(A) higher than the daytime noise level.

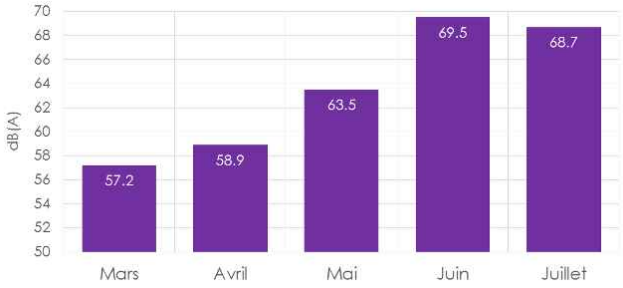

Figure 3. Change in noise levels between March and July 2017 during the night on the pedestrianised Georges Pompidou lane.

The noisiest days are weekends with night noise levels that then become 2 dB(A) above the daytime noise level.

At the level of the Georges Pompidou lane, the overall reductions in noise levels observed are thus around 8 dB(A) during the day and night in winter, whereas they are only 7 dB(A) during the day and 2 dB(A) at night during the summer period.

If we average the results obtained for the two seasons (winter and summer), the overall noise reductions measured at the level of the Georges Pompidou lane are about 7 dB(A) during the day and 4 dB(A) during the night. This is a clear improvement in the sound environment corresponding to decreases of 80% and 60% respectively in sound energy during the day and night periods. Noise levels are now between 60 and 67 dB(A) during the day and between 57 and 70 dB(A) at night depending on the month of the year.

It should be noted that such levels are still much higher than the values usually used to qualify a space as a "quiet zone" (desired sound level below 55 dB(A)).

6. Consequences and recommendations

The results obtained within the framework of this study showed that a good part of the buildings located on the upper tracks were affected by a significant change according to the French regulations (Decree No. 95-22 of January 9, 1995), an increase of more than 2 dB(A) in the noise contribution at night having been observed on the façades.

The result is an obligation for the Paris City Hall to take measures to limit the noise exposure of the populations and to respect the maximum permissible noise levels, i.e. levels of 65 dB(A) during the day and 60 dB(A) at night.

Direct treatment of the infrastructure must be sought as a priority but the regulations also provide for the possibility of directly treating the building (façade sound insulation) when actions at source are not sufficient.

Examples of actions that could be considered directly at the level of noise emission from the infrastructure include :

- the use of acoustic pavements
- lowering the speed limit on upper tracks, especially during the night
- the change of engine of the bus fleet using the high platforms for hybrid or electric buses;
- strengthening prevention and repression in the field of excessive use of the horn or driving excessively noisy motorised two-wheel vehicles
- encouraging the purchase of electric vehicles for passenger cars, commercial vehicles and motorcycles.

In view of the objectives to be achieved in order to comply with the admissible noise levels set by the French regulations, which correspond to a reduction of up to 10 dB(A) on the façade of certain buildings, the solutions will necessarily have to be combined and it will probably be necessary to carry out sound insulation on dwellings for the most critical exposure situations.

It would also be desirable to pay particular attention to the sound management of recreational areas created on the banks, and this specifically on weekend and weekend nights in summer, where the increased use of the banks is also likely to generate noise nuisances (diffusion of amplified music, particularly low frequencies, shouting, incivil behaviour, etc.) which could be added to the traffic noise for residents of the tracks.

All the results and documents relating to this study are available on the website: https://vsb.bruitparif.fr/

Acknowledgement

This project has been funded by the Regional Council of Île-de-France, the Paris City and the Greater Paris Metropolitan Area Authority.

References

[1] XPS31-117: Self-checking of sound level meters, Afnor, December 2015

[2] NFS31-085: Characterization and measurement of road traffic noise, Afnor, November 2002.

[3] XPS31-145-1: In-situ characterization of pavement acoustic performance - continuous pneumatic / pavement contact noise measurement, Afnor, 2007.