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Advanced monitoring and analysis on recreational noise in urban area

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ABSTRACT

The paper describes the results obtained from a continuous noise monitoring campaign in an area affected, most of all, by *nightlife* activities during the summertime. More in details the campaign took place in the central part of a big city, in six parallel positions, over a three-months long period. A statistical analysis has been carried out on the large dataset to determine average noise levels exposure. Together with this, a new technique, able to separate the contribution of the recreational noise (music and anthropic) from the other sources in the area, has been implemented. The achieved results are presented in several formats.

Keywords: Recreational noise, Urban noise monitoring, Noise source discrimination
I-INCE Classification of Subjects Number(s): 52.7

1. INTRODUCTION

The Environment and Territory Science Department of Milano-Bicocca University led a medium-term acoustic monitoring campaing to investigate the noise levels generated during the summer in the central part of a big city, where many pubs are located [1]. The investigated area has also many shops, several tram lines as well as some local traffic. During the summer the anthropic component of the total noise becomes consistent because of the vehicular traffic of contiguous areas and because of the presence of pubs' terraces. This phenomenon, known as *nightlife (movida)*, finds its peak in the evening and early night, especially during the weekend. The implemented monitoring network consisted of 6 measuring stations placed close to some pubs, which collected data continuosly for about 11 weeks during summertime. Microphones were placed in front of the buildings at a height of 4 meters above the ground, and the distance between each microphone and the closest reflective object was the same for all the microphones, so direct comparison between acquired data was possible. In addition to the above, other two monitoring stations were placed in two positions far away from the pubs, collecting data continuosly for 6 days in order to have some information about background noise. For all the measuring points, the acquired data consisted in one 1/3 octave spectrum per second.

2. NOISE MONITORING RESULTS

Figure 1 shows L_{Aeq} for each monitoring station (P01 to P06, background noise) vs day of the week, both during daytime (06 am - 10 pm) and during nighttime (10 pm - 06 am). The red curve represents the average level of the six monitoring stations. The picture clearly shows that the most critical situation take place on Friday and Saturday nights, where also background noise increases. Daytime levels are almost homogeneous throughout the week.

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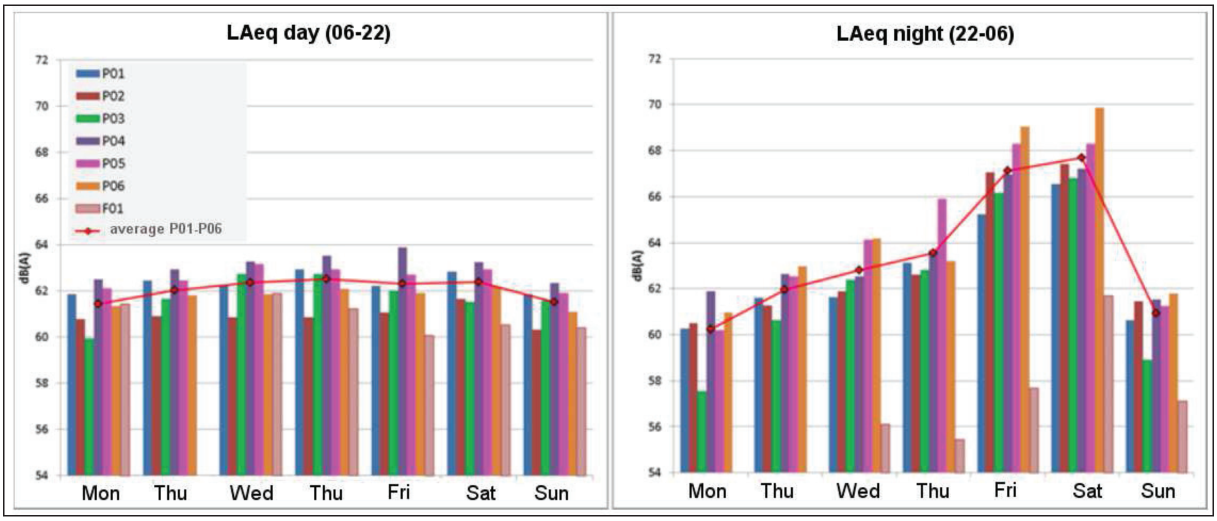

Figure 1- Levels during the day (left) and during the night (right)

The analysis of hourly trends for each single day allows to highlight the more critical time intervals. Characterization, based on the average data, includes in the analysis also the two cumulative statistical indicators L_{A10} and L_{A90} computed on hourly basis. Following, the results related to Saturday, Sunday and Monday are presented and, in order to clearly show the entire night period which is the most intresting if we consider the purpose of this study, each day is represented from 6 am to 6am of the following day.

The analysis of the hourly L_{Aeq} trends and of the statistical indicators L_{A10} and L_{A90} shows that the increment of the noise levels during evening and night (approximately from 8 pm to 2 am) is related to an increment of background noise. This observation is confirmed by the distribution vs time graphs[2]; these charts, which represent with a colour scale the trend of distributive curve vs time, show a narrow distribution of levels between 8 pm and 2 am, and a wider level distribution during the rest of the day. The daytime is, in fact, acoustically related to tram passages, which significantly determine the energy of L_{Aeq}, despite they have a total duration range between 8% and 10% of the time. For this reason, the statistical indicator L_{A90} is not related to tram passages and has daytime levels well below the L_{Aeq}.
The above situation is completely reversed during evening / night time, when sources almost stationary, as anthropogenic noise and music propagation, become predominant in determining L_{Aeq}.

Comparing the Saturdays, Sundays and Mondays, there are some differences in the characteristics of the *nightlife* phenomenon within the area:

- On Saturdays (similar to Fridays) the increment of the levels has its peak between midnight and 1 am; hourly L_{Aeq} remain above 65 dBA from 9 pm until 2 am (Figure 2);
- Sundays show hourly levels lower than Saturdays levels; highest levels take place between 10 pm and 11pm whereas hourly L_{Aeq} are always above 62 dBA from 7pm until 1am; i.e. there is an anticipation of this phenomenon (Figure 3);
- Mondays evenings show a trend similar to Sundays evenings, although hourly values are two dB lower; the sound phenomenon is nonetheless visible by examining the hourly trend L_{A90} (Figure 4).

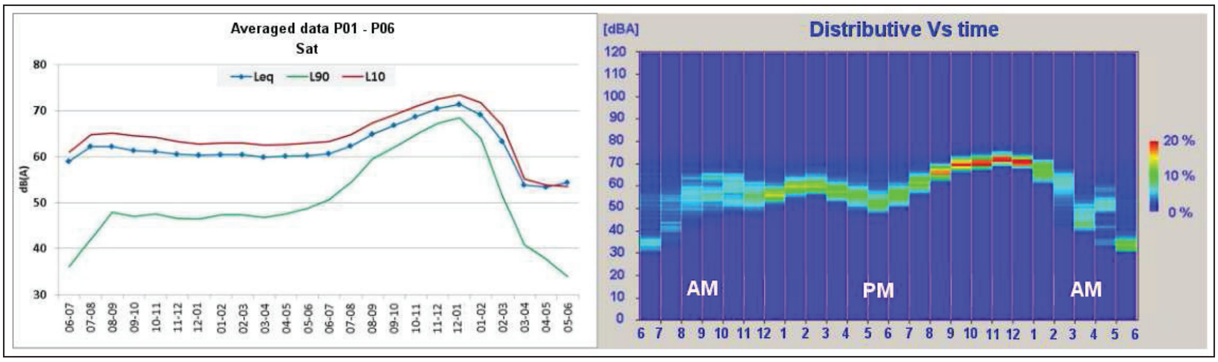

Figure 2 - Saturday: hourly level trends and distributive Vs time

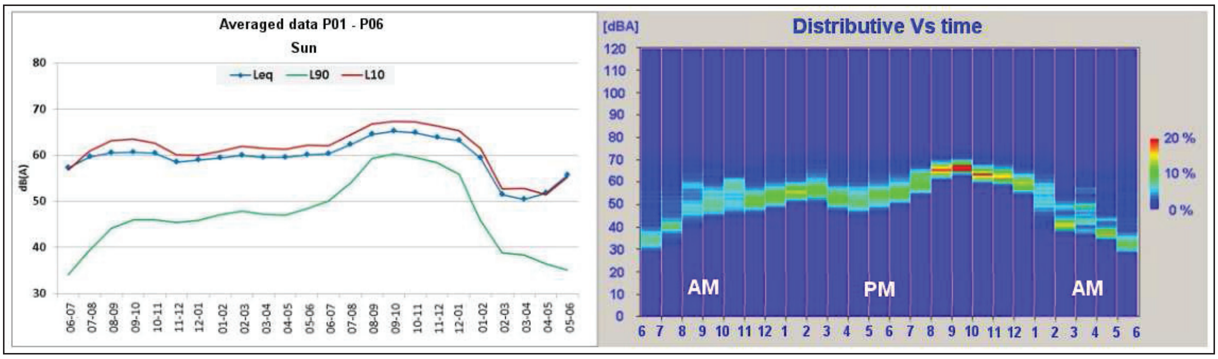

Figure 3 - Sunday: hourly level trends and distributive Vs time

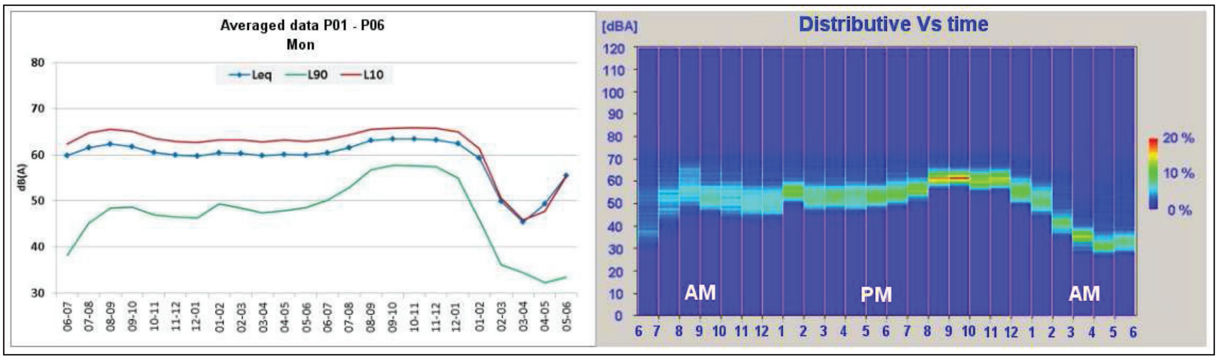

Figure 4 - Monday: hourly level trends and distributive Vs time

3. DISCRIMINATION OF SOUND CONTRIBUTION

The characterization of the noise contributions, directly related to the types of sources in the area, was carried out through the usage of the spectral information contained in sonograms, and by the implementation of some specific functions implemented in the calculation program *Noise Data Analyzer*, which has been used to process acquired data.

More in details, the availability of such detailed data over a long period allowed to:

- Identification of main sources (tram passages, spreading music, speaking people);
- Masking function configuration and filter identification for specific sources;
- Evaluation of sound contribution in terms of averaged hourly L_{Aeq}.

The first type of source that had to be characterized and excluded from measurements, as unrelated to the *nightlife* phenomenon, was represented by tram passages. After some assisted measurements, it was possible to identify frequency threeshold and duration for tram event masking taking into account the followings:

a). Broadband threeshold in terms of L_{Aeq};
b). Sum of energy in two typical bands: from 80 Hz to 125 Hz and from 400 to 1250 Hz;
c). period of existence of a) and b) conditions.

The selection of the 'event search conditions' was obtained by a parameter optimization procedure (modulating threshold and duration), followed by a calibration procedure applied to the number of identified events with respect to the number of real scheduled events.

The conditions were applied to some specific time intervals, corresponding to timetable printouts of tram service, and involve masking event, including pre-trigger and post-trigger intervals.

Figure 5 shows the Saturdays average spectrogram on the entire monitoring period for station P3. The spectrogram in Figure 6 represents the obtained result after the removal of tram passages.

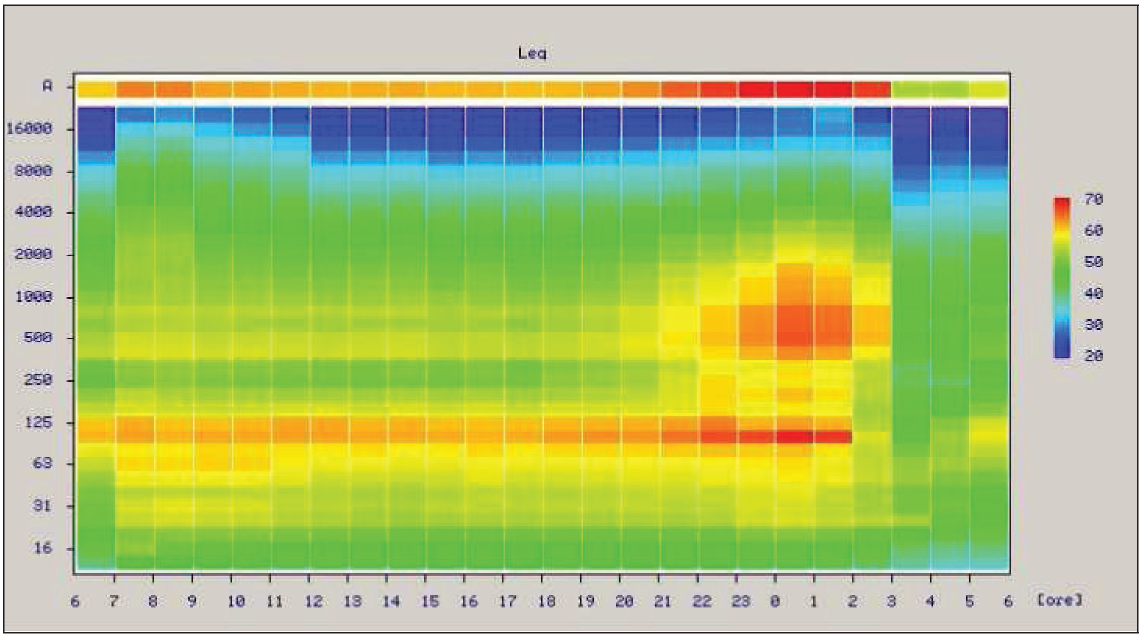

Figure 5 - Saturday hourly L_{eq} spectrogram averaged over the entire monitoring period

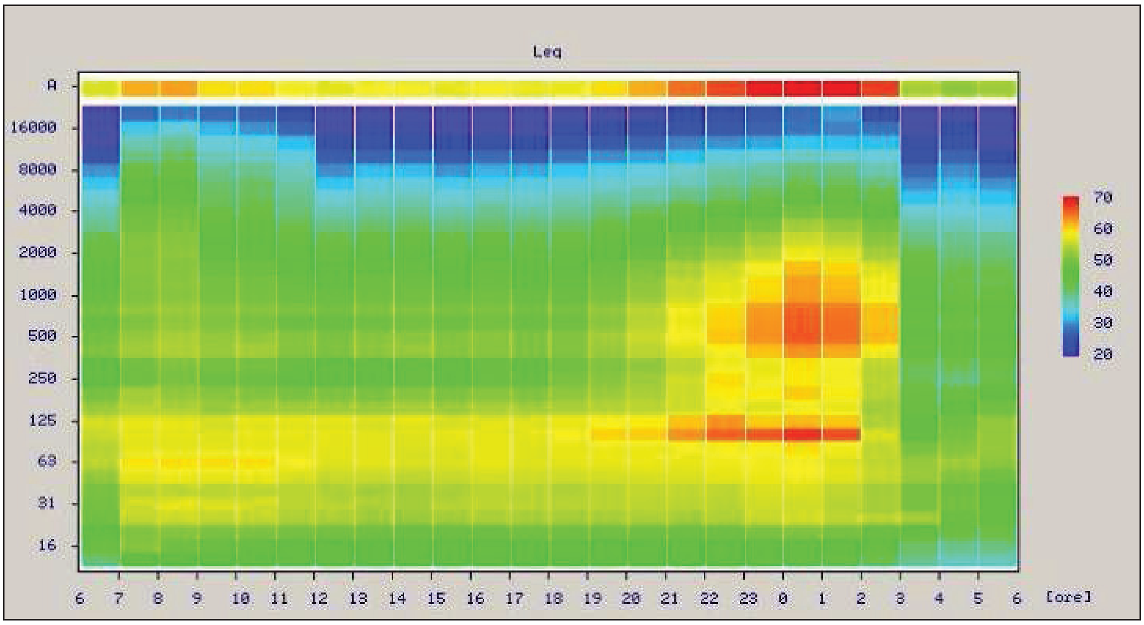

Figure 6 - Saturday hourly spectrogram after trams removal

A second function (*Filter function*) was implemented for the automatic identification of the noise contribution related to the music spread outside pubs. This *Filter function* allowed, when an user-definable threeshold is exceded, to replace the levels of one or more bands related to each 1-second spectrum, with a statistical user-selectable parameter calculated for that band over a specific number of seconds.

For a better understanding of this function [3], its application in a different but more complex and interesting context is shown in Figure 7 and Figure 8. The first picture shows a measurement (one third-octave spectrum per second) affected by some birds' chirping that should be removed, whereas the second picture shows the same measurement after a proper *Filter* application (starting from 05:43 am); the implemented filter replaced each band between 1600 Hz and 16000 kHz with the L_{95} computed over a 12 second long period. After the filter application, only phenomena that satisfy *Filter* conditions are removed; it is interesting to see that the phenomenon between 05:48 and 05:49 remained in the measurement although it was mixed together with the birds' chirping. Of course this function can be applied only in some situations, where the noise to be excluded is not a continuous noise. Filter parameters should be defined case by case according the specific situation.

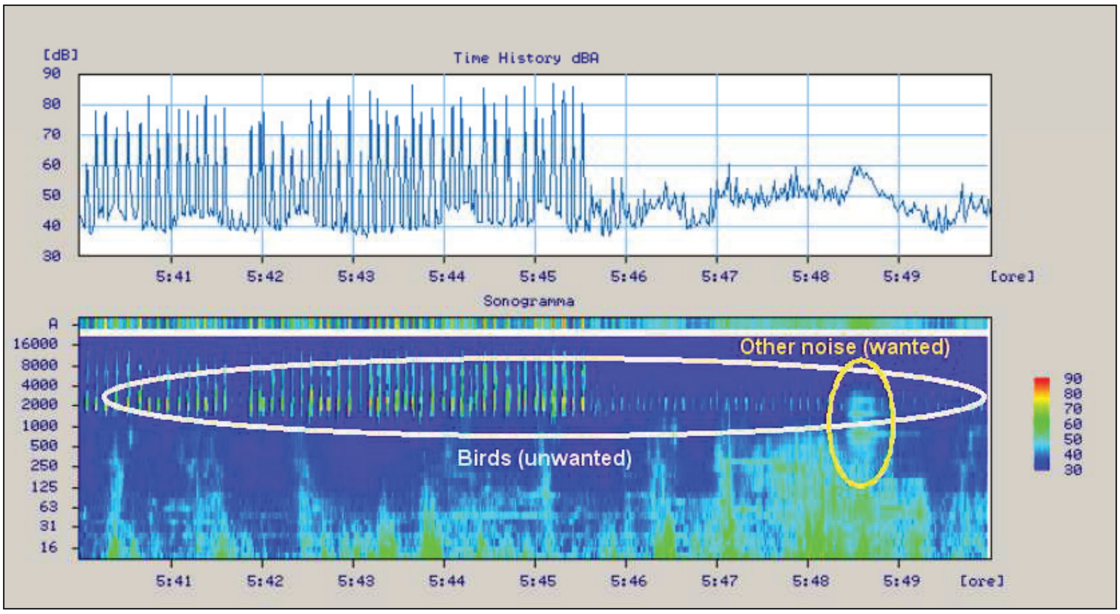

Figure 7 - measurement affected by unwanted spurious noise

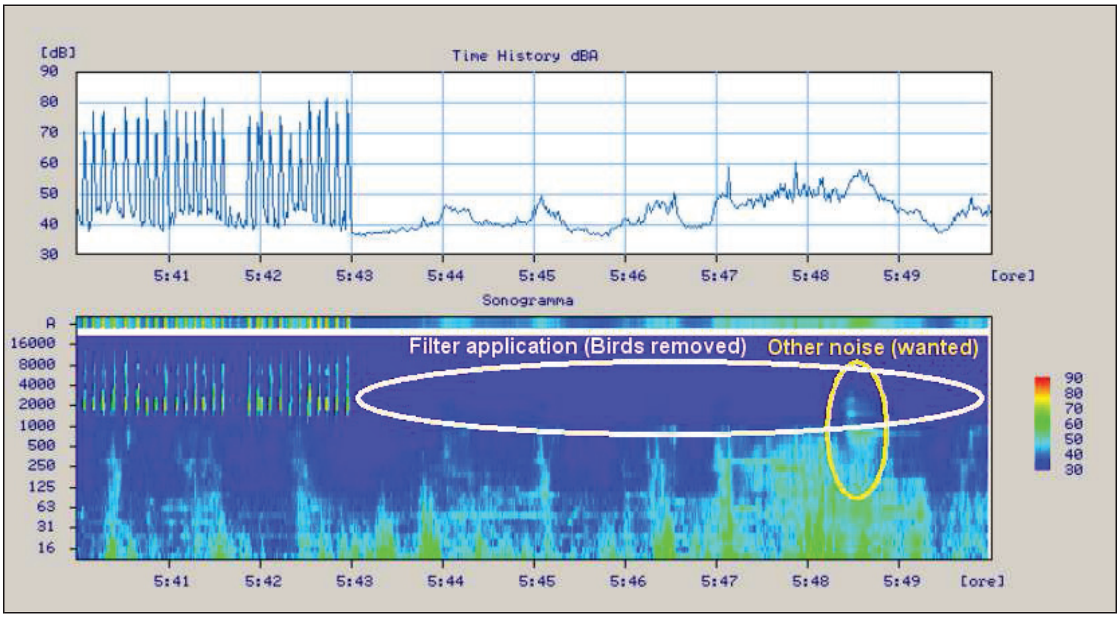

Figure 8 - 'cleaned' measurement after *filter* application from 05:43 am

As regards our case study, thanks to this feature, it has been possible to exclude from the L_{Aeq} calculation the contribution of the music by the usage of L_{95} computed over a 240 second long period. The above-mentioned operation was automatycally applied to all measurement (previously cleaned from tram passages) in the interval between 7:30 pm and 2:00 am, in the frequency range between 63 Hz and 160 Hz.

Figure 9 shows the hourly spectrogram after tram and music effect removal, whereas Figure 10 shows hourly levels trends after noise event recognition and removal. From the picture it can be seen that the tram effect removal leads to a level reduction of about 4 dB during daytime; this reduction becomes smaller during the nighttime. Further measurement cleaning, using the described filter operation to remove music effect, does not lead to an appreciable effect on the hourly L_{Aeq} (its contribution never exceeds 0.2 dB because of the involved low frequencies).

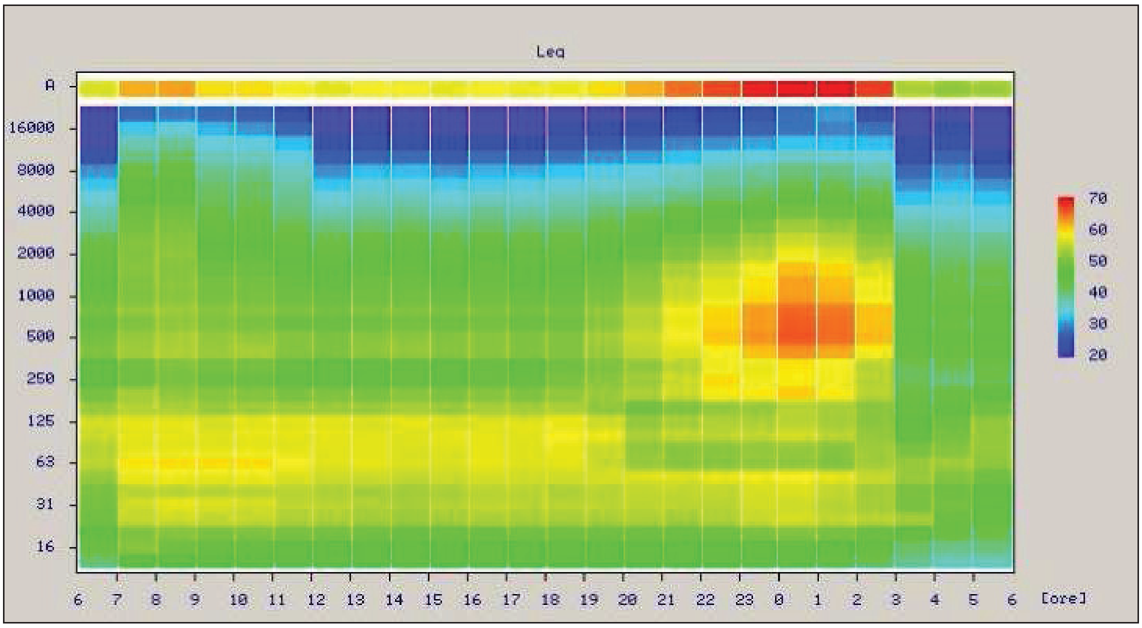

Figure 9 - Saturday hourly spectrogram after trams and music removal (*Filter* function)

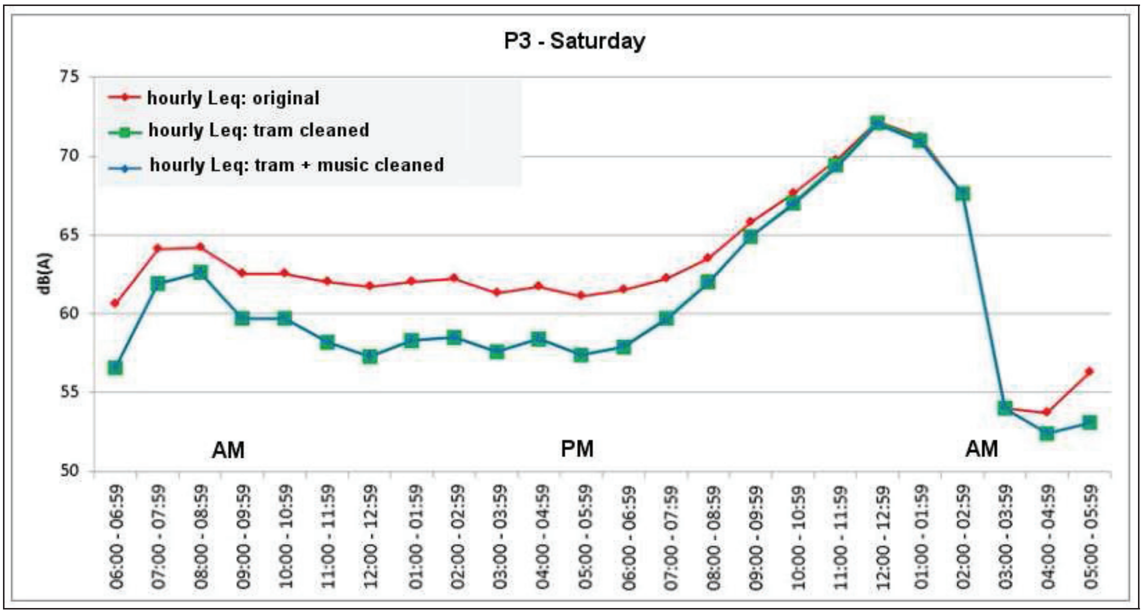

Figure 10 - Saturday hourly spectrogram after tram and music removal (*Filter* function)

The pictures clearly show how the main contribution between 8 pm and 2 am, expecially during the weekend, is located between 200 Hz and 3150 Hz. This frequency range, which has a great contribution to L_{Aeq} because of its position in the audio spectrum, can be ascribed to human voice and is thus correlated to the stationing of people at the open area in front of pubs. From an acoustic point of view, such sound source has a more random characterization respect to the other analyzed noise sources, depending on the number of persons, gender composition and speech volume; however, its short-term time trend permitted to define a statistical indicator, computed over short intervals of time, able to quantify it.

Thanks to the above mentioned *Filter function*, it was also possible to replace each 1 second L_{eq} in the frequency range between 200 Hz and 3150 Hz above a defined threeshold, with L_{05} and L_{95} computed over a 300 second long period.

After these new calculations, it was thus possible to compute two new hourly L_{Aeq} values named L_{Aeqf_L05} and L_{Aeqf_L95}. Since the two statistical parameters L_{05} and L_{95} tend to assume closer values as much as the sound phenomenon is of stationary type (as happens in the presence of a high number of speaking people), the reciprocal of the difference between L_{05} and L_{95} can be considered as a kind of index, proportional to the sound contribution of the speaking people (or, by extension, of the *nightlife*).

At the end an indicator, which takes into account this observation only for the frequencies of interest, was introduced by operating with the data obtained after the application of the *Filter function*.

Figure 11 shows the hourly trend of $L_{Aeq}/(L_{Aeq\,f\_L05} - L_{Aeq\,f\_L95})$ function for location P3, related to Saturdays, Sundays and Mondays (averaged levels over the entire monitoring period).

In the picture, the $L_{Aeq}/(L_{Aeq\,f\_L05} - L_{Aeq\,f\_L95})$ indicator shows very clearly the effect of the speaking people in the area.

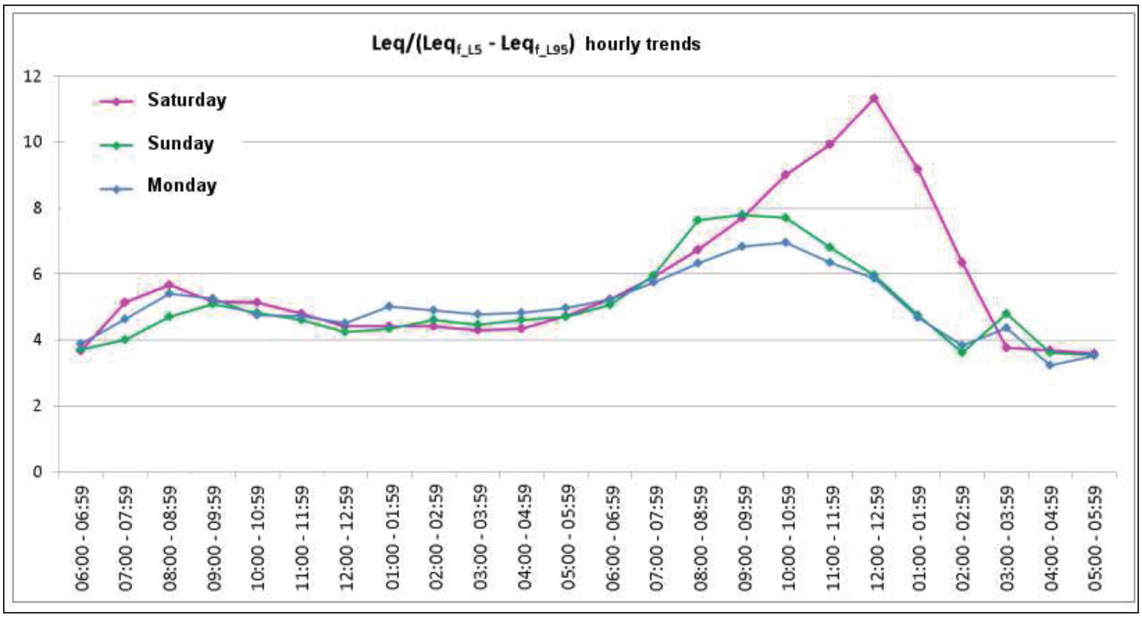

Figure 11 - P3 $L_{Aeq}/(L_{Aeq\,f\_L05} - L_{Aeq\,f\_L95})$ trend

4. CONCLUSIONS

The availability of such detailed acoustic data over a long period permitted to characterize the *nightlife* phenomenon during summertime with a significant statistical basis, allowing to distinguish the contributions of the different sources present in the area.

The contribution of the perceived music outside pubs was found to be negligible in terms of equivalent level, which only sporadically represents a low frequency annoyng noise source, whereas the main disturbing source was found to be the anthropogenic noise, or speaking people.

The indicator related to the difference L_{05}-L_{95}, computed as above described, proved to be well related to the anthropogenic noise caused by *nigthlife*. This indicator could be further developed to provide information not just in qualitative form, but applicable to different contexts, and capable of quantifying the degree of noise pollution from anthropogenic noise sources.

REFERENCES

1. G. Zambon, A. Bisceglie, A. Cerniglia. Monitoraggio e analisi del rumore prodotto da pubblici esercizi e implementazione di una tecnica per la discriminazione delle sorgenti. Proceeding of the 41st congress of the Associazione Italiana di Acustica, Pisa 2014.

2. S.Frosini, A. Cerniglia. Impiego del percentilogramma per l'individuazione di disturbi acustici da pubblico esercizio altrimenti difficilmente identificabili. Proceeding of the 38th congress of the Associazione Italiana di Acustica, Rimini 2011.

3. A. Cerniglia. Descrizione di una tecnica per la rimozione automatica di eventi sonori ripetitivi. Nota Applicativa ACCON, Pavia 2013