NOISEMONITOR : A PYTHON PACKAGE FOR SOUND LEVEL MONITOR ANALYSIS

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1 Introduction

Noise pollution represents a significant environmental threat that grows with increasing urbanization. In 2011, in the western part of Europe only, at least one million healthy life years were estimated to be lost each year from noise exposure [1]. To evaluate appropriate noise abatement strategies and/or soundscape interventions, the analysis and measurement of acoustic and psychoacoustic indicators through short-term and long-term noise monitoring is required. A large variety of noise indicators have been proposed in an attempt to encompass the complexity of human hearing and subjective assessment of noise (see [2] for a review). In this paper, we present `noisemonitor` (`https://pypi.org/project/noisemonitor/`), an easy-to-use Python package for short and long-term sound level monitor data analysis. In a few lines of code, the package allows to compute standard noise indicators such as proposed in the ISO 1996-1 :2016 standard [3] from short-term or long-term sound level meter data.

2 Noise Indicators

We present in this section a brief description of the noise indicators provided in the package. For a detailed description, please refer to [4].

2.1 Equivalent Sound Pressure Level

The equivalent sound pressure level is probably the most common type of noise indicator. It is an energy-based indicator and represents the total amount of acoustic energy over a specified time period. It is defined as :

$$L_{Eq,T} = 10\log_{10}\frac{1}{T}\int_0^T \left(\frac{p}{p_0}\right)^2 [dB],$$

where T is the time period over which measurements occur, $p(t)$ the instantaneous acoustic pressure and p_0 the reference sound pressure level ($20\mu Pa$).

2.2 Statistical Indicators

Statistical indicators can be used to report on the level of noise exceeded for a certain percentage of the measurement time. The most common are L_{10} (high noise levels) and L_{90} (background noise), representing the noise levels exceeded for respectively 10% and 90% of the time [4]. For instance, an $L_{90,1h}$ of 52 dB means that for 54 minutes in that hour (90% of the time), the sound pressure level exceeded 52 dB. The median sound level, L_{50}, is also known to have a good correlation with perceived sound intensity and pleasantness [2].

2.3 A-weightings

The human ear does not respond equally to sound at different frequencies and sounds at lower and higher frequencies are perceived to have a lower intensity [4]. To account for this a frequency-dependant weighting system (the A-weighting curve) is often applied on environmental noise measurements and provides an acceptable correlation to human response to different noise sources [4], though its relevance is still being questioned [2].

2.4 Day, evening, night sound level

Initially developed in the European Union Directive 2002/49/EC [5], the L_{DEN} (Day, Evening, Night equivalent sound level) is derived from the A-weighted equivalent level indicator and accounts for the fact that noise exposure during evening and night period are generally more problematic for public health than during daytime with the addition of penalties during these periods (+5 dBA for evening and +10 dBA for night, see [5]).

3 Description of the Package and Examples

In this section, we provide an overview of the package's main functionalities. To get more information on how to use the package, a tutorial is available in `https://pypi.org/project/noisemonitor/`. The package takes as input data sheets (`.csv`, `.txt`, `.xlsx` or `.xls` formats are accepted) directly extracted from sound level monitor stations such as the *NoiseSentry Mk4* or the *RION NL-52*. The package's output indicators may be A-weighted, depending on the type of data collected by the sound level meter. This section is illustrated with examples from analyses performed on week-long measurements with `noisemonitor` as part of a field study in Montreal, Canada [6]. The analyzed data consists of $L_{Aeq,5s}$ measurements taken every 5 seconds in seven outdoor positions in a mixed industrial/residential area during a week in August 2022 by engineering company *SNC-Lavalin*.

3.1 Discrete indicators

The `noisemonitor` package allows to get average, discrete indicators computed over long periods of time including L_{eq}, L_{10}, L_{90}, L_{50}, L_{DEN} as well as the individual day, evening, and night levels. These indicators can be computed at specific times of the day and days of the week as shown in Table 1.

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TABLE 1 – $L_{Aeq,24h}$ and L_{DEN} values computed with noisemonitor on weekdays and weekends at positions 1 to 5 [6].

	Weekday		Weekend	
Position	$L_{Aeq,24h}$	L_{DEN}	$L_{Aeq,24h}$	L_{DEN}
1	55.42	59.73	52.51	57.4
2	52.53	56.12	51.0	55.12
3	55.01	59.67	52.81	57.91
4	55.82	59.18	54.38	57.31
5	50.59	55.39	47.95	52.54

3.2 Rolling averages

In addition to discrete indicators, the `noisemonitor` package can perform overall and daily rolling averages on either L_{eq}, L_{10}, L_{90}, or L_{50} values, with the option of choosing window and step sizes. The result can be plotted with a dedicated function, as shown in the next figures. The analysis can be performed on all data (see Figure 1), but also at specific days of the week and times of the day (see Figures 2 and 3).

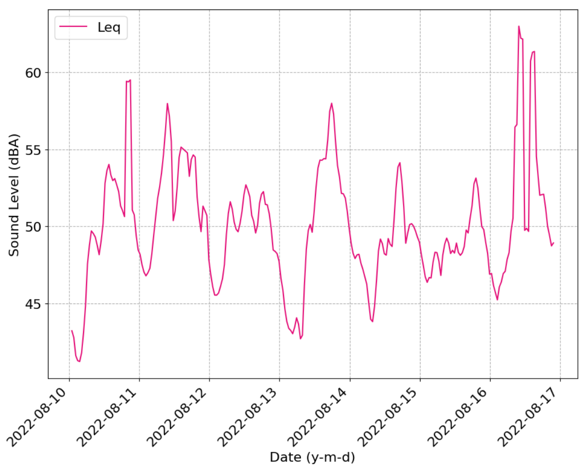

FIGURE 1 – $LAeq, 2h$: rolling average on all data (window size : 2h; step size : 40min). Output from the noisemonitor package at position two [6].

4 Conclusion

We believe this package can be useful for Professionals of the Built Environment as well as Public Professionals that do not necessarily have the expertise to compute noise indicators from sound level meter data. In addition, the rolling averages provided by this package including daily and weekly profiles allow for the identification of recurrent patterns of noisy activities and/or space use and should help to address them in a tailored way. The package is currently in its early stage of development and will be further updated to include more indicators such as personalized statistical indicators, and to allow for a more versatile use. Any feedback on the package would be highly appreciated, and users are welcome to contact the main author or to create an issue in the GitHub repository (`https://github.com/valerianF/noisemonitor/issues`).

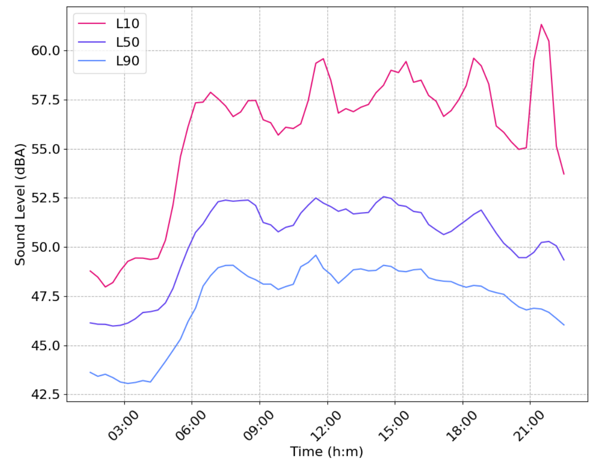

FIGURE 2 – Statistical indicators : daily rolling averages weekdays from 2am to 10pm (window size : 1h; step size : 20min). Output from the noisemonitor package at position one [6].

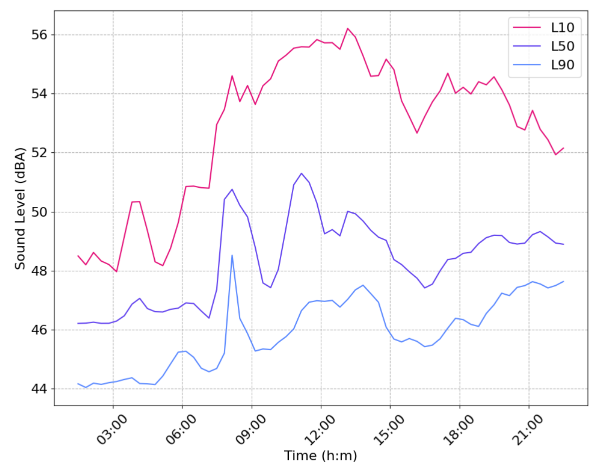

FIGURE 3 – Statistical indicators : daily rolling averages on weekends from 2am to 10pm (window size : 1h; step size : 20min). Output from the noisemonitor package at position one [6].

References

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