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Technical Note

Influence of State of Alarm Caused by COVID-19 on Noise in the City Centre of Huelva (Spain)

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At the beginning of the COVID-19 pandemic the government of Spain decreed the State of Alarm to confine the entire population at their homes, except for essential services. Therefore, the central objective of this study is to evaluate the implication of this situation for the environmental noise existing in the city of Huelva (Spain). This study demonstrates that during the state of alarm an average daily reduction of 3.4 dBA was noted, and in the central moments of the day these reductions reached up to 4.4 dBA, while from 10:00 to 12:00 pm the reduction was around 6.5 dBA. Nevertheless, there were two moments of day: 3:00 am (garbage collection, street cleaning and container disinfection), and 8:00 pm (daily applause for health professionals), when the noise during the pandemic was higher than before it. It is further shown that globally, the loudest events only decreased by about 3 dBA, while the global background noise decreased by 10 dBA during the alarm state. Regarding road traffic noise, it is verified that in addition to being reduced by about 4 dBA, traffic represents 6.7% of noisy events during the alarm state, while before it represented 13%.

Keywords: COVID-19; noise; States of Alarm; traffic.

1. Introduction

One of the most relevant environmental pollutants is noise (World Health Organization [WHO], 2011). It is estimated that around 20% of the European population bear noise levels that health experts and scientists consider unacceptable. This causes adverse effects on health and quality of life, which have already been widely demonstrated (Carrier *et al.*, 2016; Nissenbaum *et al.*, 2012; Bluhm *et al.*, 2007).

Road traffic is the most important source of urban noise (Phan *et al.*, 2009; Sánchez-Sánchez *et al.*, 2015; 2018; Ali, Tamura, 2003), and it includes three secondary sources such as:

a) engine noise (engine, transmission, fan, exhaust, etc.);
b) aerodynamic noise due to turbulent airflow around the vehicle body;
c) the noise of the tires on the pavement.

The latter has a significant dependence on the speed of the vehicle, the type of pavement, and especially its conservation (Sánchez-Sánchez *et al.*, 2018). Other factors, such as traffic density, and the number of heavy vehicles determine the generated sound pressure.

The states and the automobile industry try to reduce this source of pollution in various ways (electric vehicles, hybrids, "quieter" tires, improving the road surface, promoting public transport, etc.) (Pallas *et al.*, 2016; Campello-Vicente *et al.*, 2017; Taryma *et al.*, 2018; Chen *et al.*, 2018) but with still insufficient results. Suddenly, an unexpected event such as the pandemic of COVID-19, and the predictions about its spread (Kuniya, 2020), led governments to declare the States of Alarm (SA) in different countries. That forced most citizens to stay confined at home during the lockdown, without using any kind of transport, what caused a drastic reduction of the motor vehicles movement.

In this work, a comparative study is made of the noise level due to traffic in the city centre of Huelva (SW of Spain), before and during the SA, to check the variation in sound pressure levels during that period as it is the primary source of noise in this city since Huleva does not have airports or railways in its surroundings, along with activities related to the service sector.

2. Methodology and materials

2.1. Study area

Huelva is a city in SW of Spain with a population of about 150,000 inhabitants and its transport infrastructures are scarce since it does not have an airport, metro or tram, and its rail connections are almost nonexistent.

The Urbanism, Environment and Ecological Transition Area of the Huelva City Council has installed the Noise Monitoring Network (NMN) throughout the urban area. It has 12 fixed stations and 2 mobile stations in the most significant points of the city. These stations are basically made up of a sound level meter with IP45 environmental protection from the CESVA brand, and model TA 120, with a measurement range: 28–120 dBA; type 1 precision according to IEC 61672-1 (UNE-EN-61672-1); a degree of environmental protection IP45; with a sending of information every 83 records saved, via SMS through the GSM or GPRS network to the central server. A diagram of the NMN is shown in Fig. 1.

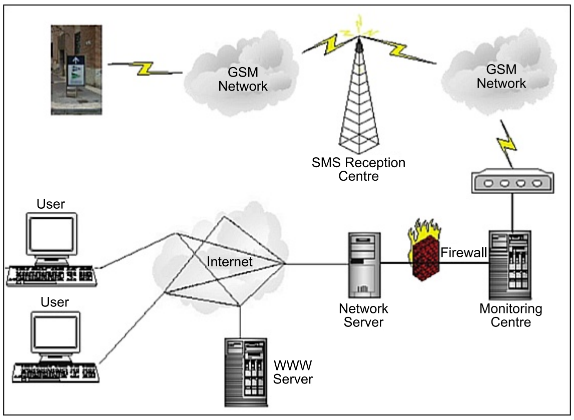

Fig. 1. Noise Monitoring Network (NMN) diagram.

Thanks to the access to the monitored network, the previous research carried out in the same city (Sánchez-Sánchez *et al.*, 2018), and the analysis of the data achieved, it was possible to simplify the number of points to one as representative of what happens in the whole city. It should be borne in mind that the state of alarm has practically unified noise in all areas due to the absence of people on the streets, vehicles, and commercial and community activities.

The chosen sampling point of the NMN of Huelva is located in the Dynasty of the Litri Square (Pablo Rada avenue, confluence with Cabezo de la Joya Avenue), see Fig. 2. It is one of the main arteries of the capital, in the city centre, and the speed limit there is 50 km/h.

Fig. 2. Sonometer of NMN (framed in red) located in the Dynasty of the Litri Square.

2.2. Methodology

The noise levels of two full months, from February 15 to April 15, 2020, are the data that we used for this work in order to analyse the influence of the SA in Spain declared on March 14, 2020 (Royal Decree 463/2020). For this, the different noise parameters ($L_{\text{Aeq,1h}}$, the $L_{\text{Aeq,1d}}$, L_{A10}, L_{A50}, L_{A90}) were studied by comparing the data from February 15 to March 13 (before the state of alarm) and from March 14 to April 15 (with the declaration of the state of alarm already in force). Royal Decree 1367/2007 (2007) was also applied for the noise indexes of the day (L_{d}), evening (L_{e}), and night (L_{n}) periods and the Directive 2002/49/CE (2002) that establishes the day-evening-night L_{den} noise index, obviously, adjusted only to the period of the study, and not to a full year as it is defined in the previous directive.

A total of 87,886 1-minute measurements were used, taken seven days a week. Besides, during the state of alarm, between March 30 and April 9, inclusive, the cessation of nonessential activities was approved, which further increased departures and trips on those dates. The daily meteorologically variations in the city of Huelva was obtained from the database of the Spanish Meteorological Agency (Agencia Estatal de Meteorología [AEMET], 2020): average temperatures, maximum wind speed, and rainfall. The graphs illustrating the meteorological conditions are shown in Figs 3, 4, and 5.

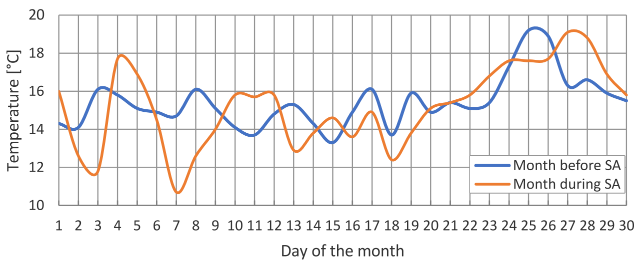

Fig. 3. Variations of the average daily temperatures in Huelva city, in the months before and during confinement for SA.

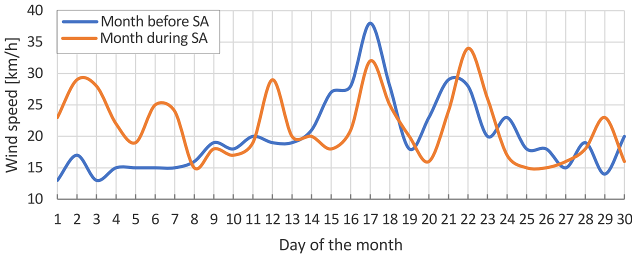

Fig. 4. Variations of maximum daily wind speed in Huelva city, in the months before and during confinement for SA.

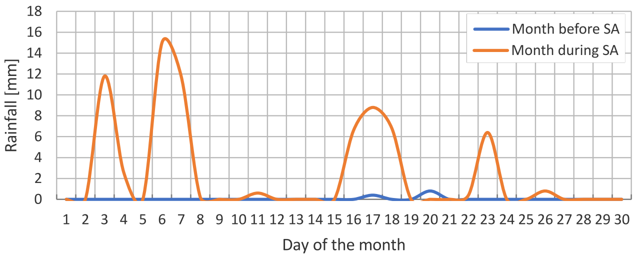

Fig. 5. Variations of daily rainfall in Huelva city, in the months before and during confinement for SA.

From the statistical analysis based on the average daily temperature in the city of Huelva, during the month before and after the declaration of the SA, it was obtained that no significant differences at 5% of a significant level between both periods occured:

$$|t_{\text{exp}}| = 0.6173 \leq t_{0.95}$$

(test two tails and 29 degrees of freedom) = 2.0.

Consequently, with the Student's t-test, with a significance level of 0.05, there is the evidence that these two samples are not different. Therefore, the variations of the temperature do not influence the noise measurements before and during the SA.

Figure 4 shows that before the SA, between days 10 and 24, the maximum daily wind speed exceeded the limit value of 20 km/h (5.5 m/s), and that during the SA there were also many days when this limit value recommended by ISO 1996-2 (2007) was exceeded. But, from the statistical analysis based on the data samples of the daily maximum wind variations in the city of Huelva, during the month before and after the declaration of the SA, it was obtained that:

$$|t_{\text{exp}}| = 1.33 \leq t_{0.95}$$

(test two tails and 29 degrees of freedom) = 2.0.

Consequently, with the Student's t-test, with a significance level of 0.05, there is the evidence that these two samples are not different. Therefore, the daily variations of the maximum wind do not influence in a different way the noise measurements before and during the SA.

From the statistical analysis based on the data samples of the daily rainy variations in the city of Huelva, during the month before and after the declaration of the SA, it was obtained that:

$$|t_{\text{exp}}| = 3.0 \geq t_{0.95}$$

(test two tails and 29 degrees of freedom) = 2.0.

Therefore, in this case, taking into account the Student's t-test, with a significance level of 0.05, does not allow us to conclude that there is the evidence that these two samples are the same, and therefore a small influence of the rainfall could affect the noise measurements before and after SA, but this effect will reduce the difference between both periods (Cai *et al.*, 2017).

3. Results and discussion

For each hour of the day the parameters $L_{\text{Aeq,1h}}$, L_{A10}, L_{A50}, and L_{A90} were calculated, and according to ISO standards (ISO 1996-1, 2016; ISO 1996-2, 2017), they were calculated using $L_{\text{Aeq,1min}}$ with the objective to study the daily evolution of noise.

The $L_{\text{Aeq,24h}}$ was also calculated. Figure 6 shows how the noise started to decrease from March 14 and decreased even more between March 30 and April 9, when the restrictions were strict. Then a slight rebound is seen.

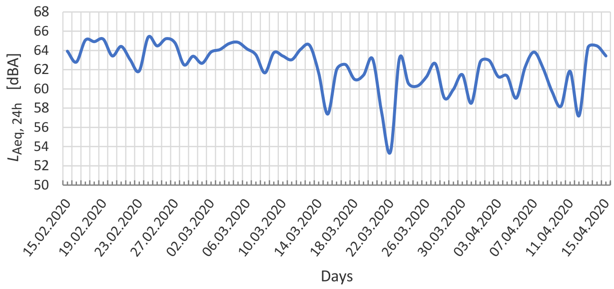

Fig. 6. Variations of the $L_{\text{Aeq,24h}}$ at the sampling point of the Dynasty of the Litri Square.

When the government notifies the measures days in advance, even before those measures were mandatory, the citizens had already assumed their compliance. Thus, in the most restrictive moment of movements, which was due to start on March 16, it can be seen that since March 14, movements begin to decrease and, consequently, the sound pressure. The abrupt drop on March 22, can have two explanations: a temporary one since it corresponds to the first consolidated Sunday after declaring the state of alarm; and a psychological one as the awareness of citizens that the problem of the pandemic was serious increased. It should be borne in mind that during this period the first outbreak of COVID-19 in Huelva took place, passing in five days from 8 to 50 infected patients, as can be seen in Fig. 7. In addition to the infected at a national level, being already 40,000 infected and 2700 deceased, as can be seen in Fig. 8.

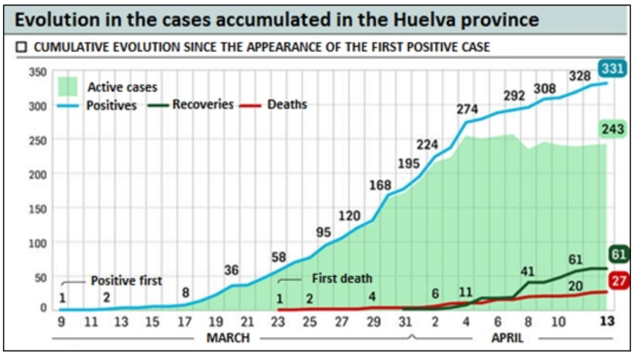

Fig. 7. Evolution of the pandemic in Huelva (source: Ministry of Health and Family of the Junta de Andalucía).

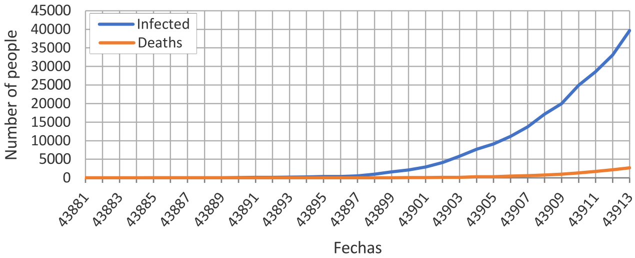

Fig. 8. Evolution of COVID-19 data nationwide.

In Figs 9a and 9b the global daily evolution of the $L_{\mathrm{Aeq,1m}}$ and $L_{\mathrm{Aeq,1h}}$ levels can be observed comparatively, respectively, before and during the state of alarm. As can be seen in both figures, but especially in Fig. 9b, a parallelism between them is clear, but the one below corresponds to the period after the implementation of the state of alarm. During this period, however, a punctual rise to 60 dBA is observed at 3:00 am, probably due to the performance of the municipal garbage collection and cleaning and disinfection services that increased during the SA. It is also observed how from 8:00 pm and on, there is an increase in noise up to 68 dBA, which could be related to the fact that at that time citizens came out onto the balconies to applaud in gratitude to the health professionals and other workers who, by obligation, made possible the confinement of the rest. These two specific increases were also observed in the results obtained in studies carried out in other world cities suffering from the lockdown caused by the COVID-19 pandemic (Mishra *et al.*, 2021; Steele, Guastavino, 2021), justifying in some cases also, by emergency vehicles.

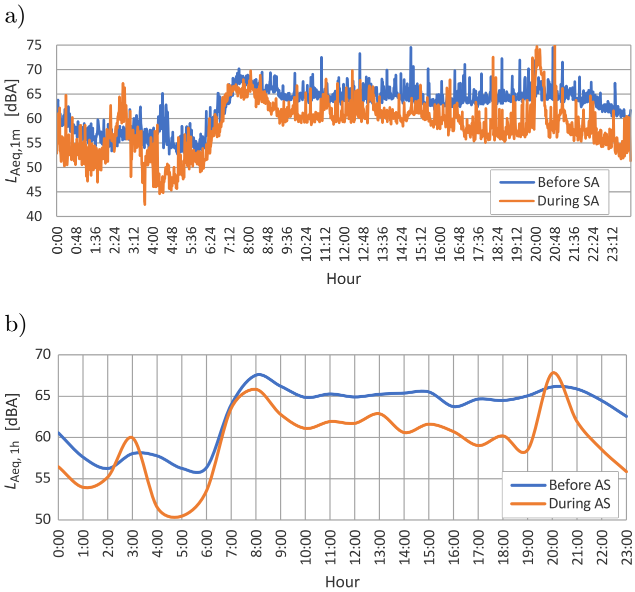

Fig. 9. Global daily evolution of $L_{\mathrm{Aeq,1m}}$: before/during the state of alarm (a) and global daily evolution of $L_{\mathrm{Aeq,1h}}$: before/during the state of alarm (b).

To quantify the difference in the $L_{\mathrm{Aeq,1h}}$ index between the period before and after the state of alarm, the linear fit was made, which is shown in Fig. 10; whose fit have by equation:

$$L_{\mathrm{Aeq,1h(during)}} = (0.99 \pm 0.13) \cdot L_{\mathrm{Aeq,1h(before)}} - (2.74 \pm 8.40), \quad [R^2 = 0.714],$$

with average differences of $\overline{x} = (3.4 \pm 0.5)$ dBA and standard deviation $\sigma = 2.36$, calculating σ as:

$$\sigma = \sqrt{(x_i - \overline{x})^2/(n-1)}.$$

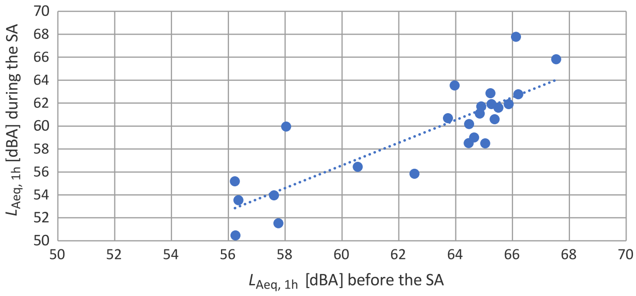

Fig. 10. Comparison before-during SA of $L_{\mathrm{Aeq,1h}}$ levels.

In general, this bad fit between before and during the state of alarm, is due to the rises that occur in this index (during the SA) at 3:00 am, between 6:30 and 7:30 am, and 8:00 pm as a consequence of the referred events of cleaning and disinfection of streets, the start of the activities declared as essential, and applause for health workers, etc. These events made the indexes during the SA even exceed those of the same hours before the SA, distorting the parallelism that these daily evolutions generally maintain. This is corroborated if a new adjustment is made by eliminating the L_{Aeq} levels, 1h of those events. Getting for the new fit, the following equation, and parameters:

$$L_{\mathrm{Aeq,1h(during)}} = (1.06 \pm 0.09) \cdot L_{\mathrm{Aeq,1h(before)}} - (8.05 \pm 5.96), \quad [R^2 = 0.881].$$

As can be seen, the slope of the regression line is compatible with unity, therefore, only the ordinate at the origin remains as the difference between the indices.

Furthermore, the coefficient of determination R^2 is much closer to unity, clearly indicating the correctness of this fit.

The average difference in this case is $\overline{x}$ = (4.4 ± 0.3) dBA, and standard deviation σ = 1.35 which is clearly inferior, indicating that the dispersion of these differences is much smaller.

In Fig. 11, a comparison between the Sunday before and during the period of confinement can be clearly seen, specifically the Sundays before (March 8, 2020) and during (March 22, 2020) the declaration of the SA. It can be also seen that the two graphs are almost parallel for most of the day, that there is a general decrease in the noise level after the SA and that it is more noticeable at night. But at 8:00 pm a rise begins, caused by the applause, already mentioned, on the balconies and curiously, an increase is still higher than at 9:00 pm that could be justified by Sunday "pan-banging" protest against the government's management of the pandemic.

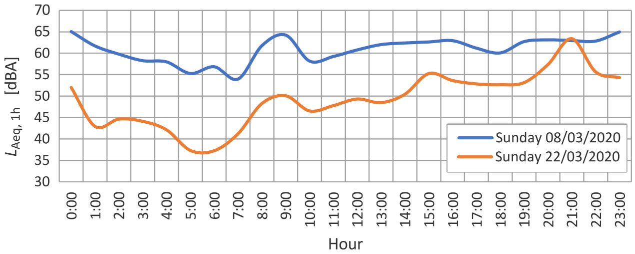

Fig. 11. Comparison of two Sundays, before and during the state of alarm.

It should be noted that according to (Payne, 2004), as the uncertainty associated with the linearity in the reference range, for a sound level meter type 1 it is ±0.1 dBA, as the most unfavourable situation. Uncertainty that is much lower than the difference that exists between the levels of March 8, 2020 (before the SA) and March 22, 2020 (during the SA).

Figure 12 shows the graphs of the indexes of day (L_d), evening (L_e), night (L_n), and the noise index (L_{den}), calculated during the study period. It can be seen how before March 14 L_d day index is close to 70 dBA, and how later it is between 65 and 55 dBA, that is, with a decrease of between 5 and 15 dBA.

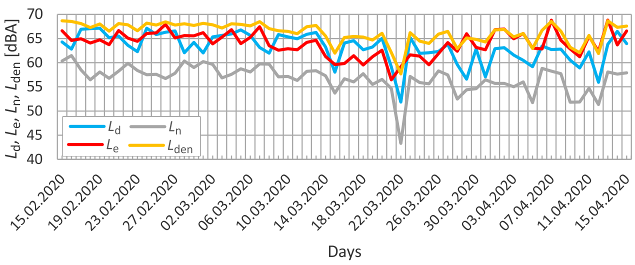

Fig. 12. Variations of the indexes: L_d, L_e, L_n, and L_{den}, adjusted to the study period.

The graph of the evolution of the L_e index is similar to the previous one, from around 65 dBA on average to 60 dBA in the first 15 days after the SA declaration, but at the end of March it begins to rise and in April it has similar values to the previous days of the SA.

The graph of the evolution of the L_n is observed to be around 60 dBA in the days prior to March 14, to subsequently drop to an average of around 55 dBA.

The L_{den} index graph, which determines the nuisance associated with noise exposure, goes from 68 dBA before SA to 66 dBA during SA.

In summary, there is a drop in all indices between the period before and after March 14, when the state of alarm was decreed. Also, between March 22 and 23 there is a considerable reduction in noise. It should be noted that it is the first weekend of confinement, where the population was very sensitized.

Figure 13 shows the graphs of the evolution of the L_{10}, L_{50}, and L_{90} percentiles during the period studied. Although the three graphs have a certain parallelism, a decrease can be observed from March 14, but it is a small decrease (about 3 dBA) in L_{10}, which represents the noisiest events. It is observed that this decrease is somewhat greater on the L_{50} graph (about 7 dBA), which corresponds to the median. While the decrease is more pronounced (around 10 dBA) in the L_{90}, it represents the background noise. Reductions of the same order of magnitude in similar studies carried out in other cities of the world have been observed (Aletta *et al.*, 2020).

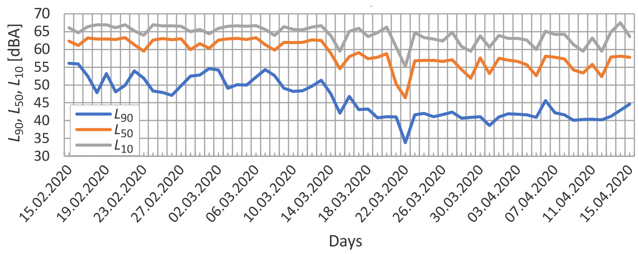

Fig. 13. Variations of the percentiles L_{90}, L_{50}, and L_{10}.

If the percentage frequency diagrams between the two periods (before/during) the SA are analysed, as can be seen in Fig. 14. Thus, before the alert, the graph presents a bulge, although slight, around 42 dBA, which could represent the source corresponding to the background noise.

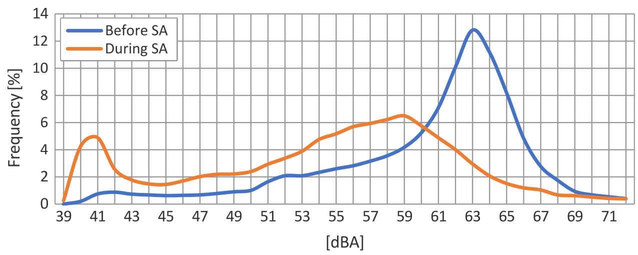

Fig. 14. Frequency percentage diagrams before/during SA.

A large peak is also displayed at high levels (approximately 63 dBA), which would correspond to the source of the road traffic noise, before the SA. Whereas, if the percentage frequency diagram is observed during the SA, a perfectly marked peak is observed in the 41 dBA area that would also correspond to the background noise, and a second peak (approximately 59 dBA) will correspond mainly to the traffic noise and some of the activities allowed during the alert.

During the SA the 41 dBA bell is very narrow, while the 59 dBA bell, with 7% of the events, widens a lot, due to greater dispersion. There is more variation of sound events, but without marked predominance of any of them, and the road traffic does not predominate as much over other sound events.

On the other hand, before SA there is only one peak, at 64 dBA, with 13% of the sound events. None of the values between 43 and 51 dBA exceeds 2% of the total.

4. Conclusions

This research demonstrates that in the city of Huelva there is a general decrease in noise during the state of alarm due to COVID-19, as expected. As of the day of the declaration, March 14, noise levels decreased from an average of (4.4 ± 0.3) dBA, representing an average acoustic pressure of 2.8 times lower. There are nights, like the one on March 22, when it dropped to 53 dB. This data indicates a citizen's awareness of the problem (around the 50 deceased in the city and news from the rest of the country) (see Figs 7 and 8).

Especially significant is the decrease between 3 and 6 o'clock where the values reach 50 dB, when before the SA they were around 57 dB, this shows that during SA, night-time acoustic pressure was 5 times lower. Which may be due to an almost total absence of activity as that period of the night does not coincide with the entry or exit of the work classified as essential by the authorities. At night, due to the absence of noise, a 60 dB peak appears that coincides with the performance of the municipal garbage collection, cleaning and disinfection services that increased during the SA. The rest of the day, the descent is slight from 8 am to 1 pm and the rest of the day is accentuated. There is a slight rise at 8:00 pm because citizens came out onto the balconies to applaud in gratitude to the health professionals and other workers who, by obligation, made possible the confinement of the rest. Later it could, in some cases, be prolonged by some playful demonstration from the balconies where music was played and on other occasions by protests.

This decrease is manifested both on working days and public holidays as reflected in the graphs with values that vary, depending on the period chosen between:

$$L_{\mathrm{d}} : 70\text{–}60\ \text{dBA}; L_{\mathrm{e}} : 65\text{–}60\ \text{dBA}; L_{\mathrm{n}} : 60\text{–}55\ \text{dBA};$$
$$L_{\mathrm{den}} : 68\text{–}66\ \text{dBA}.$$

Acknowledgments

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