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CONTROL AND STATISTICAL EVALUATION OF THE HIGH LEVELS OF NOISE IN THE MARKETS "LA UNIÓN" AND "CENTRAL" OF THE CITY OF MACAS

José Hernán Negrete Costales
https://orcid.org/0000-0002-2678-761X
Escuela Superior Politécnica de Chimborazo
jose.negrete@espoch.edu.ec
jhernan_2008@hotmail.com

Eder Lenin Cruz Siguenza
https://orcid.org/0000-0003-4982-9947
Escuela Superior Politécnica de Chimborazo (ESPOCH)
eder.cruz@espoch.edu.ec

Nelson Santiago Chuquin Vasco
Escuela Superior Politécnica de Chimborazo (ESPOCH)
nelson.chuquin@espoch.edu.ec
https://orcid.org/0000-0001-8998-1156

Victor Miguel Toalombo Vargas
https://orcid.org/0000-0002-9479-6307
Escuela Superior Politécnica de Chimborazo (ESPOCH)
victor.toalombo@espoch.edu.ec

Madison Yumey Castillo villizañay
Independient investigator
madi.villi-99@outlook.cl

Abstract: This work work consisted of the evaluation of noise pollution in the "Central" and "La Unión" market of the Macas city, having as one of the objectives the design of a mitigation plan in which measures were proposed to reduce and control high noise levels. Documented and explanatory methodologies were used, which allowed to identify the problem of the study area and thus propose new alternatives to reduce levels.

To begin the analysis, the strategic sampling points were located, which were obtained with the mesh method and georeferenced with the Garmin GPS where 10 points with the greatest noise influence in each market were chosen, then we proceeded to the data collection with the type 1 level meter Delta OHM brand these served for the statistical analysis and design of noise maps,

therefore, It was concluded that in the "Central" market 8 out of 10 points were found between 65 -70 dB, on the other hand the market "La Unión" the 10 points were found above 60 dB being above the maximum permissible limits in this way a mitigation plan was proposed for the reduction of noise pollution and ensure the welfare of merchants and people who transit through the place.
Keywords: Environmental noise, Georeferencing, Maps, Pollution, Statistics, Mitigation Plan

1. Introduction

Noise is an unpleasant auditory sensation, in general terms it is known as a nuisance to the human ear, depending on the sensitivity of each person, since in some cases the sounds that can be considered pleasant for some is unpleasant for others [26] Everyone knows that the current problem of noise has become a disturbing agent of daily life and not only in large cities but also in small towns, according to [27]. Noise is a manifestation of released acoustic energies, which can damage the human ear and affect the psychological and emotional state, when transmitted in sufficiently harmful quantities and can be instantaneous and uncontrolled such as an explosion or a low but constant noise such as music, affecting individuals who are exposed [28].

Noise pollution is grouped into four categories, including that which directly affects hearing, second, which causes physiological alterations, third, which causes psychological disorders and the last, which influences work performance. Recent studies have shown the adverse effects of noise pollution on people especially in urban areas, Among them is the alteration in their behavior, irritability, stress, high blood pressure, among others, taking into account that these elements act with subtlety and are complex [29].

Therefore, in 2011 the World Health Organization (WHO) places the nuisance generated by noise as the greatest unfavorable effect on the public health of the inhabitants of modern cities, mainly those that have large concentrated populations and lack large spaces [30]. Cataloging noise as one of the four most important types of environmental pollutants today [31].

Worldwide, for example, in France one of the main causes of environmental pollution is due to noise, another case we have Japan which is the first country to lead this problem, due to its high levels of noise. One of the causes is the little interest that today's society has paid to this serious environmental complication [28]. On the other hand, other countries, regions and cities have already taken lukewarm measures to mitigate these nuisances [32]. If we do not become aware of this global problem, in a very short time the entire population will suffer the terrible consequences of uncontrolled exposure to noise, with its consequent risks [33].

Ecuador has not been left behind in the concern to control noise and its consequences, measures have been taken in the corresponding legislation to impose sanctions or fines for those who go against the law, while the Ecuadorian Comprehensive Criminal Code provides in Article 607: "Anyone who causes noise due to lack of silencer of their vehicle or amplification equipment that alters the tranquility of citizens will be sanctioned"(Constitución del Ecuador, 2008, pág. 161). Like Book V of [34] establishes the maximum levels of noise emission in certain places, which has allowed to propose mitigation projects to control environmental noise, mainly in commercial and busy areas of cities, the corresponding legislation suggests that in these areas noise levels

should not exceed 65 dBA in the day at times from 06H00 to 20H00 and 55 dBA at night at times from 20H00 to 06H00.

Therefore, the study of noise in cities is considered relevant, mainly because of the complications that its presence has on the quality of life and well-being of citizens [35]. Therefore, we proceed to carry out an evaluation of the noise levels in the city of Macas focusing on the commercial areas especially in the Market "La Unión" and the market "Central" the same ones that possibly have noise pollution since there are many anthropogenic activities that could be altering the tranquility of citizens, mainly to: the users of the markets, the same merchants and inhabitants of the areas of influence. The interest of carrying out this study and if there is such noise pollution, will seek to generate strategies or solution proposals that help mitigate, prevent and control this environmental problem through the development of mitigation plans and noise maps.

2. Materials and Methods

The Materials and Methods should be described with sufficient details to allow others to replicate and build on the published results. Please note that the publication of your manuscript implicates that you must make all materials, data, computer code, and protocols associated with the publication available to readers. Please disclose at the submission stage any restrictions on the availability of materials or information. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited.

The study was carried out in the province of Morona Santiago, this province in turn is located in the south center of the Amazon region, between the geographical coordinates 79° 05' longitude W; 01° 26' latitude S and 76° 35' long. W; 03° 36' Lat. S, according to the figure 1 y 2. Specifically it was focused on the parishes Macas where the markets are located. In these spaces, the noise study was carried out both within and in the surrounding areas of the institutions. According to the map described below:

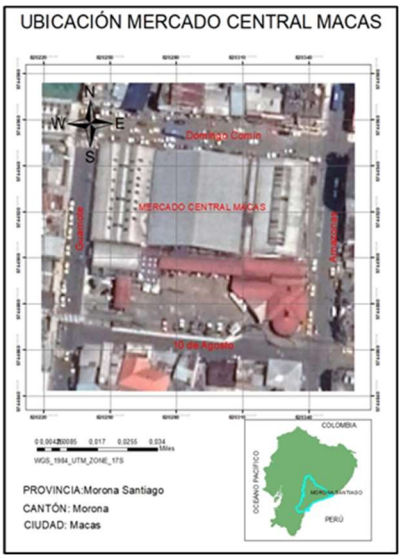

Fig. 1 Location of "Central Macas" Market

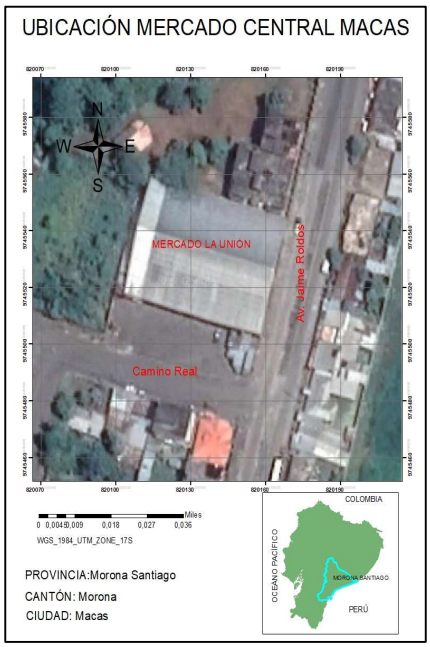

Fig. 2 Location of "La Unión" Market

Within the methodologies used in this study, those of scientific research as well as a technical study are highly efficient, within those of scientific research based on the deductive scientific analysis to the practical:

2.1 Quasi-Experimental, Experimental Research: The purpose of experimental research is to establish a link between cause and effect, and on the hierarchy of evidence, experimental studies (such as an RCT) provide a higher level of evidence than a QE (Quasi– Experimental) study. To establish causality, a researcher needs to look, the other conditions of causality. These include establishing a relationship between the IV (independent variable) and DV (dependent variable), ensuring temporal antecedence, and determining that there are no alternative explanations. It is easier to meet RCT (these causality requirements), in an than in a QE study because of the amount of control afforded by an RCT design. [16].

2.2 Measurement and data recording: Noise level data was recorded at georeferenced points in in the Market "La Unión" and the market "Central" with the use of a professional sound level meter PCE-428. The sonometer parameters were set to[16]: range 25 ... 136 dB(A) precision Class 2 Frequency range 20 Hz ... 12.5 kHz Standard: GB/T3785.1-2010 GB/T3785.2-2010 IEC60651:1979 IEC60804:2000 IEC61672-1:2013 ANSI S1.4-1983 ANSI S1.43-1997 Frequency analysis: Octave band filter: 20 Hz ... 8 kHz 1/3 octave band filter: 20Hz ... 12.5kHz microphone: microphone 1/2, taking as reference of the Unified Text of the secondary Legislation of the Ministry of Environment (TULSMA, for its acronym in Spanish)[17].

Fig. 3 Taking samples of noise levels in the “Mercados Central y la Unión”

2.3 Noise mapping. – The construction of noise maps by calculation methods requires the collection of geographic data to form the geographic databases, involving specialized technical staff and equipment. Currently, there are collaborative initiatives in information and communication technologies that allow sharing. Environmental noise maps were prepared in the two markets in Macas city using QGIS (Geographic Information Systems) software, that is open access software, QGIS is made for inexperienced users who want to create their first digital geological map. Nevertheless, it includes basic information on coordinate reference systems is given., implementation of different base map layers (e.g. raster data, web map services and scanned maps) as background maps. The georeferencing tool for the implementation of scanned maps is also presented[18].

2.4. Monitoring Points. - In the "Central" market, the mesh method was applied to determine the points within the area and take them as a reference in the sampling, giving a total of 56 points of which only 10 were considered that are divided around the market the same ones that we consider as the areas with the greatest influence of noise where there is more pedestrian and vehicular traffic.

In the marking the Union determined 39 points of which only 10 were chosen to be monitored and evaluated each one being in a different area and depending on the influence of noise. Table 8-3 shows the coordinates of each point chosen for sampling.

2.5 Georeferenced Monitoring Points. - With the planimetry of the markets, the maps were georeferenced with the GPS (Global Positioning System), also taking internal and external points. The coordinates of each monitoring point were extracted and an excel table was generated, both from CENTRAL and UNIÓN markets. This can be seen in the figure 4 y 5.

MERCADO CENTRAL MACAS			
N° DE PUNTOS	PUNTO DE REFERENCIA	COORDENADAS	
		X (Este)	Y(Norte)
1	44	820328,566	9744940,999
2	30	820298,566	9744940,999
3	16	820268,566	9744940,999
4	2	820238,566	9744940,999
5	4	820238,566	9744910,999
6	6	820238,566	9744880,999
7	49	820328,566	9744865,999
8	47	820328,566	9744910,999
9	39	820313,566	9744910,999
10	25	820283,566	9744910,999

Fig. 4 Coordinates of sampling points in the Central market

MERCADO LA UNIÓN MACAS			
N° DE PUNTOS	PUNTO DE REFERENCIA	COORDENADAS	
		X (Este)	Y(Norte)
1	7	820102,307	9745516,109
2	19	820132,307	9745516,109
3	32	820162,307	9745501,109
4	31	820162,307	9745516,109
5	29	820162,307	9745546,109
6	23	820147,307	9745546,109
7	10	820117,307	9745561,109
8	6	820102,307	9745531,109
9	18	820132,307	9745531,109
10	21	820132,307	9745486,109

Fig. 5 Coordinates of sampling points on the Unión market

2.6 Noise point measurement. - To take samples at each point, a type I sound level meter was used, calibrated, with a weighting and acceptable response for this type of investigation, “The sound level meters directly record the sound pressure level of an acoustic phenomenon, and expresses the result in dB, with a reference sound pressure of 20 x 106. According to the TULSMA book, was performed by obtaining data with the help of the type I sound level meter, the technique of direct observation of the facts was applied, taking the data at peak hours of high vehicular traffic from 7:00 a.m. to 9:00 a.m. from 12:00 to 14:00 p.m. from 16:00 to 18:00 P.M. on Mondays, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday taking into account the indications according to Official Register No. 096 Annex V (Official, 2015, pg. 64) in which the method of 15 seconds (leq 15s) was chosen in which data is obtained and will report a minimum of 25 samples, 15 seconds in a time of seven minutes at each point where two weeks of June and two weeks of July were taken.

As for the sound level meter used for data collection, it was with the appropriate calibration and its certification, "Sound level meters directly record the sound pressure level of an acoustic phenomenon and express the result in dB" (Cepeda et al. 2020, p. 4). According to the TULSMA it is stipulated that the sound level meter must be placed on a tripod at a height ≥ 1.5 m from the ground, directing the microphone towards the source with an inclination of 45 to 90 degrees, on its horizontal plane.

2.7 Data tabulation and statistical analysis. - the data in the different points and their measurements with the specialized equipment, which were obtained in the study areas such as the "La Unión" market and the "Central" market, data was tabulated in Excel software and for statistical analysis the MINITAB statistical software programs for various multivariate analyzes[20] was used where the samples of each day of the week and their different schedules were analyzed which were obtained in the unit of measurement of noise known as decibel in which the maximum noise and minimum noise were considered.

2.8 Noise mitigation plan. - The noise mitigation plan [3, 21]. To avoid and reduce noise in the study areas, a mitigation plan was created that provides knowledge to the population of the problem they are exposed to in their jobs considering that negative effects on human health can be obtained, so this alternative was presented as a possible solution in the areas affected by the different activities that take place on the site.

3. Results

The present research work was carried out in order to know the levels of noise pollution that exists in the two main markets of the city of Macas, remember that noise comes from different sources: public transport, private vehicles, relief vehicles (ambulances, firefighters, police), motorcycles without the appropriate silencer, speakers with loud music.

As is known, noise pollution can cause serious effects of different types to people, therefore, a situational diagnosis of noise levels was made in the two main markets of the Macas city such as Central and La Unión. [22, 23].

3.1 Planimetry Central Market

In the central market the mesh method was applied the same that indicates the points that can be considered for sampling, therefore, only the points that presented greater influence of noise around the market as in the internal part were taken into account. What helped to have a reference to be able to draw the maps in the QGis software with the data obtained with the sound level meter. Figure 6 shows the market area using the mesh method.

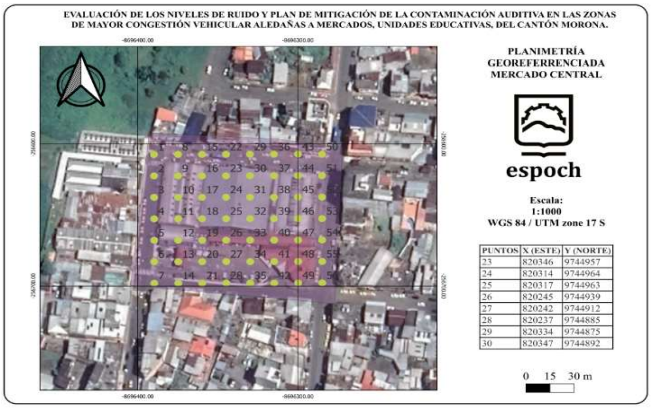

Fig. 6 Mesh method market "Central Macas"

3.2 Planimetry La Unión Market

In the market "La Unión" proceeded to apply the mesh method in which it yielded 39 points in total which was considered only 10 points in the internal part and around it. Figure 7 shows the application of the mesh method on the Union market.

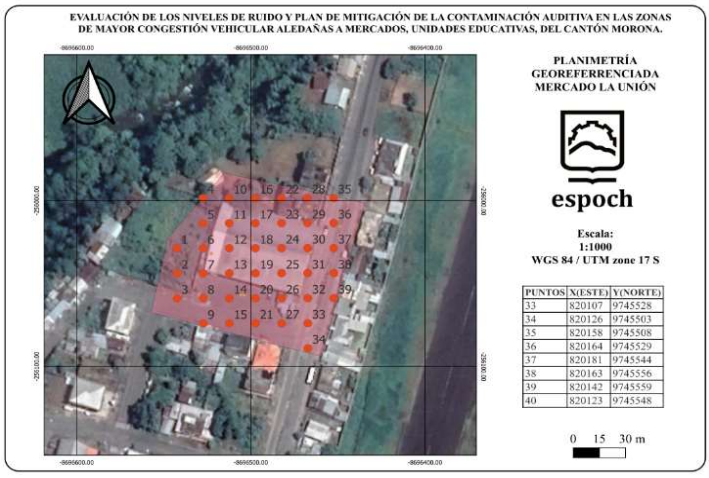

Fig. 7 Mesh method market "The Union"

Once the results have been obtained with the integrative sound level meter type 1 which were taken according to Ministerial Agreement 97, we proceed to tabulate the data in the Excel software locating them according to the schedules and points and then validate them with the MINITAB program which allows to calculate the mean, maximum, minimum, standard deviation, hypothesis testing and time series plot of LAeq values

The data was tabulated according to the points chosen in the Central Macas market and the Union market, each point is organized with the three schedules that were considered above, the first schedule is from 07H00 to 09H00 A.M, second schedule of noon from 12H00 to 14H00 and the last in the afternoon from 16H00 to 18H00 which are considered according to the opening and closing hours in the market, in this way the sound levels were evaluated. At each point, 25 samples were taken with a duration of 15 seconds giving a total of 5250 data in all the monitoring of the week by market.

3.5 Noise mapping Central market

In Figure 8 it was shown that, in P1, P2, P3, P4, P5, P6, P7 and P8 the sound levels that are between 65 – 70 dB, that is, over pass the permissible limits of AM 096 annex 5, compared to the internal points that are P9 and P10 are between 60

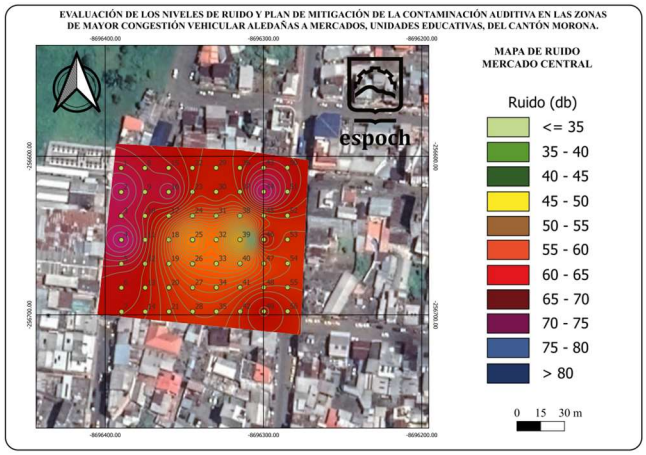

Fig. 8 Central market noise map

3.5 Noise mapping La Unión

Figure 9 showed that in P1, P2, P3, P4, P5, P6, P7, P8, P9 and P10 the sound levels are between 60 – 65 dB, i.e. they were above the permissible limits of AM 096

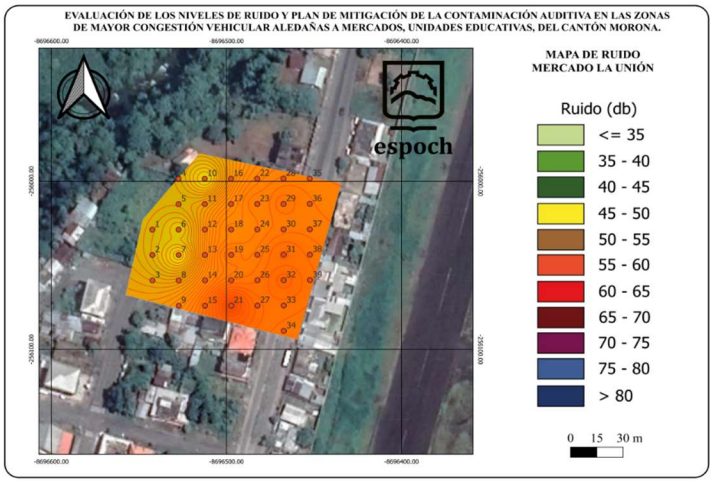

Fig. 9 La Unión noise map

3,6 Recording noise data with the sound meter and dosimeter / Monitoring Points

Similarly, we proceeded to design the noise maps in the QGis software, where the data can be evidenced according to the UNE ISO 1996-2: 1997 standard. A noise map was prepared for each market where in the La Unión market no samples greater than 70 decibels were found, on the other hand, the Central market showed sound levels greater than 70 decibels.

3.7 Statistic Analysis

. The data was tabulated according to the points chosen in the Central Macas market and the Union market, each point is organized with the three schedules that were considered above, the first schedule is from 07H00 to 09H00 A.M, second schedule of noon from 12H00 to 14H00 and the last in the afternoon from 16H00 to 18H00 which are considered according to the opening and closing hours in the market, in this way the sound levels were evaluated. At each point, 25 samples were taken with a duration of 15 seconds giving a total of 5250 data in all the monitoring of the week by market.

3.7.1 Statistical analysis of the "Central Macas" market

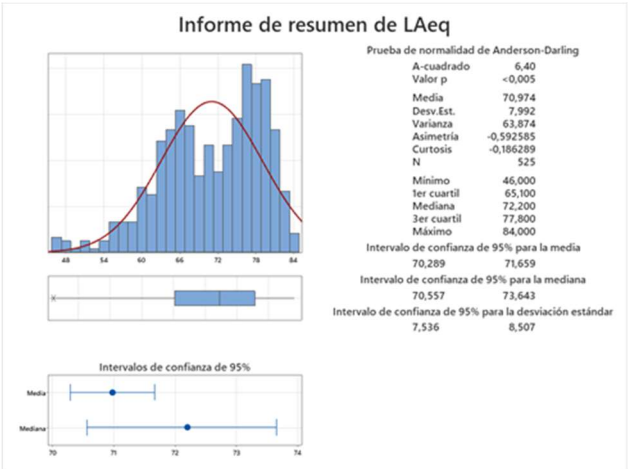

Fig. 10. LAeq Summary Report of the "Central Macas" market

In Figure 10 of point 1 show an average value of 70.9 dB, based on the data obtained by sampling from 07H00 to 18H00, where the values range from a minimum of 46 dB to a maximum of 84 dB.

With regard to the Gaus bell, a dispersed distribution of data can be seen, which allows us to conclude that if there are high levels of noise, which could affect the quality of life of people, which is why this study shows that it is feasible to carry out a mitigation plan to reduce the amount of noise pollution.

Estadísticas descriptivas

N	Media	Desv.Est.	Error estándar de la media	IC de 95% para μ
525	70,974	7,992	0,349	(70,289; 71,659)

μ: media de población de LAeq

Fig. 11. Standard deviation value

In Figure 11 it is observed that the standard deviation has a result of 7.99 which indicates that there is a dispersion of the data considered from the mean, taking into account that 0.2 is the acceptable average, it can be noted that the values are very far from the average.

Hipótesis nula	H_0: $\mu = 71$
Hipótesis alterna	H_1: $\mu \neq 71$
	Valor p
	0,000

Fig. 12. Hypothesis testing

Figure 12 shows the p-value is lower than the confidence level (5%) indicating that the hypothesis is accepted.

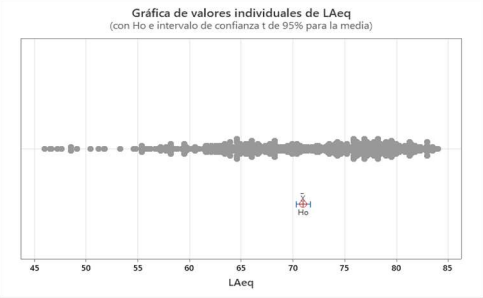

Fig. 13. Individual LAeq values

Figure 13 showed a greater repetition of values from 76 dB to 80 dB.

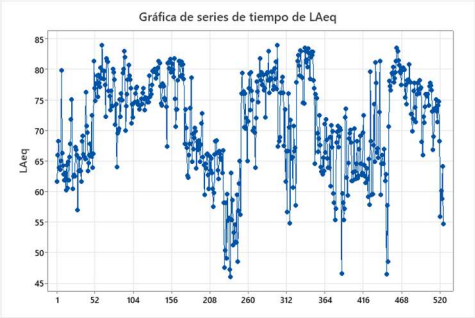

Fig. 14. LAeq time series plot

In illustration 16.4 of point 1 that is located on Amazonas Street, it is observed that it is the one with the greatest vehicular and pedestrian congestion, because it is a main artery of entry and exit of the city, mainly from Monday to Friday. Likewise, low noise levels are observed on Saturdays, Sundays and holidays

3.7.2 Statistical analysis of the "La Unión" market

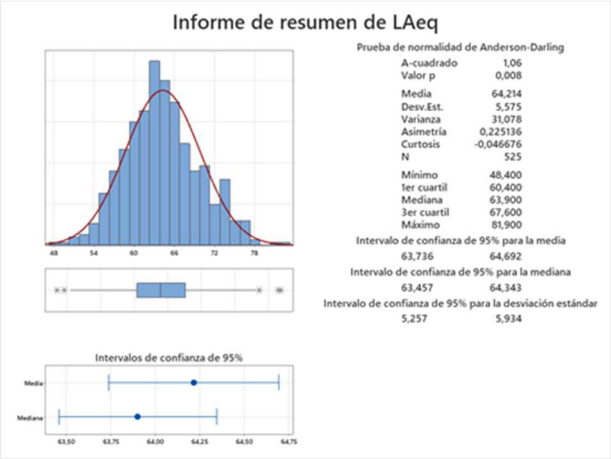

Fig. 15 LAeq Summary Report of the "La Unión" market

In Figure 15 of point 3 I can show an average value of 64.21 dB, based on the data obtained by sampling from 07H00 to 18H00, where the values range from a minimum of 48.40 dB to a maximum of 81.90 dB.

About the Gaus bell, a dispersed distribution of data can be seen, which allows us to conclude that if there are high levels of noise, which could affect the quality of life of people, which is why this study shows that it is feasible to carry out a mitigation plan to reduce the amount of noise pollution.

Estadísticas descriptivas

N	Media	Desv.Est.	Error estándar de la media	IC de 95% para μ
525	64,214	5,575	0,243	(63,736; 64,692)

μ: media de población de LAeq

Fig. 16. Standard deviation value

In Figure 16 it is observed that the standard deviation has a result of 5.57 which indicates that there is a dispersion of the data considered from the mean, taking into account that 0.2 is the acceptable average, it can be noted that the values are very far from the average.

Hipótesis nula	$H_0: \mu = 64$
Hipótesis alterna	$H_1: \mu \neq 64$
	Valor p
	0,0028

Fig. 17. Hypothesis testing

Figure 17 shows the p-value is lower than the confidence level (5%) indicating that the hypothesis is accepted.

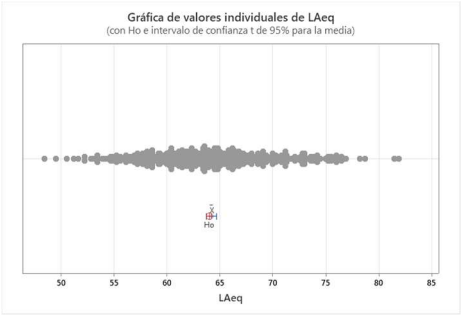

Fig. 18. Individual LAeq values

Figure 18 showed a greater repetition of values from 61 dB to 67 dB.

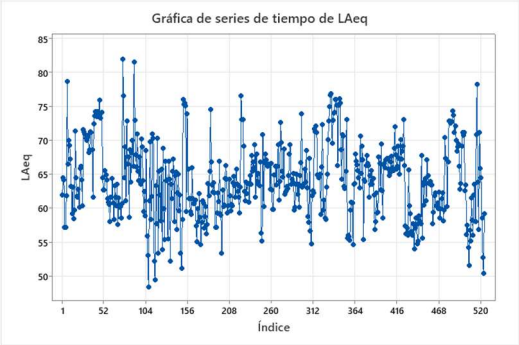

Fig. 19. LAeq time series plot

In illustration 19 the point 3 that is in the area of products of the area, was evidenced in illustration 76.4 that samples range from 61 dB to 67 dB with greater repetition considering that it is in front of the road of greater vehicular traffic.

3.8. Summary of the Statistic Analysis

MERCADO CENTRAL MACAS			
PUNTOS	LAeq (dB)	AM 097 ANEXO 5)	CUMPLE
1	70,97	60	NO
2	69,37	60	NO
3	70,79	60	NO
4	69,71	60	NO
5	69,30	60	NO
6	68,27	60	NO
7	70,06	60	NO
8	69,78	60	NO
9	60,38	60	NO
10	62,37	60	NO

Fig.20. Comparison of "Central Macas" market performance

It was evidenced that in the 10 points they presented higher values of the maximum permissible limits of the current environmental regulations, that is, they exceed the 60 dB that are considered for the schedule from 06H00 to 20H00. As noted in the figure 20

Fig.21. Comparison of "La Unión" market performance

MERCADO CENTRAL MACAS			
PUNTOS	LAeq (dB)	AM 097 ANEXO 5)	CUMPLE
1	62,17	60	NO
2	63,55	60	NO
3	64,21	60	NO
4	62,35	60	NO
5	61,81	60	NO
6	62,81	60	NO
7	61,53	60	NO
8	61,60	60	NO
9	62,41	60	NO
10	61,12	60	NO

It was evident that in the 10 points they presented values higher than the maximum permissible limits of the current environmental regulations, that is, they are outside the 60 dB that are considered for the schedule from 06H00 to 20H00.

3.8.1 Activities to reduce noise from mobile sources

• Train the administrative staff of the "Central" and "La Unión" markets of Macas

• Train drivers of private vehicles, motorcycles, buses and taxis that transit outside the markets.

• Noise reduction and environmental education campaigns on noise pollution

• Perform vehicle inspection control.

3.8.2 Activities to reduce noise human training plan

• Train traders and administrative staff of the markets.

• Control the use of speakers, sound equipment and amplification.

• Train citizens on noise awareness.

4. Discussion

After having carried out the evaluation of the noise levels in the central market of Macas, it has been concluded that if there is noise pollution due mainly to vehicular traffic such as public service buses, taxis and private vehicles, the amplification systems of commercial premises that

seek to bring customers through advertising, and it also increases the noise levels of conversation and shouting of customers and merchants.

As for noise pollution by vehicles we can distinguish two peak hours in the morning from 07H00 to 09H00 and in the afternoon from 16H00 to 18H00 this is because most people are entering or leaving the city either for work, commercial or educational reasons.

The hypothesis that arises for the present investigation is: there is noise pollution in the Macas central market and the La Unión market caused by the increase in the size of the population and the vehicle fleet. While (Miranda 2016) does not pose a hypothesis for his research work.

5. Conclusions

For the study of noise pollution, 10 points were chosen in each market, taking into account the areas with the greatest influence of noise. In the "Central" market, eight points were considered around the market and two points in the internal part such as the clothing area and the food court. As far as the market "La Unión" is concerned, the nine points were in the internal part of the market and one point in the parking area.

With the data of the statistical analysis of each of the 10 points of each market, it was possible to compare with the maximum permissible limits of the noise belonging to the commercial area. In the "Central" market with the results of the whole week from Monday, July 4, 2022 to Sunday, July 10, 2022, it was concluded that in the 10 points there is noise pollution, that is, in P1 with 70.97; P2 with 69.37; P3 with 70.79; P4 with 69.30; P5 with 69.30; P6 68.27; P7 with 70.06; P8 with 69, 78; P9 with 60.38 and P10 with 62.37 over pass the 60 dB that are the permissible noise levels in the schedule from 06H00 to 20H00 because it is in the center of the city forming part of one of the most commercial places and with greater vehicular traffic.

In the market "La Unión" was also evaluated all week from Tuesday, June 2, 2022 to Monday, July 8, 2022, concluding that there is noise pollution, that is, in P1 with 62.17; P2 with 63.55; P3 with 64, 21; P4 with 62.35; P5 with 61.81; P6 with 62.81; P7 with 61.53; P8 with 61.60; P9 with 62.41; P10 with 61.12 being outside the 60 dB that are the maximum permissible limits belonging to the schedule from 06H00 to 20H00, since it is this area the days with the highest vehicular traffic as people are the weekends where all the products that are offered arrive.

By preparing noise maps for each of the study markets of the city of Macas, the sound levels are identified, resulting in a map that demonstrates according to the coloration the noise level of each point. In the "Central" market, points P1, P2, P3, P4, P5, P6, P7 and P8 are the ones with the highest noise pollution being between 65 – 70 dB and the lowest noise P8 and P9 are between 60 – 65 dB. In the Market "The Union" the 10 points were found above 60 dB being above the permissible limits being acceptable.

The mitigation plan was designed according to the results obtained from the monitoring and its respective statistical analysis of each of the points evaluated, in order to mitigate the surplus noise of the markets.

The hypothesis in the two markets studied gave results less and / or equal to 0.05 which is the acceptable range therefore it can be said that it was accepted, that is, noise pollution is caused by the circulation of vehicles and people.

Conflicts of Interest: The authors declare no conflict of interest. And The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Appendix A Not Apply

Appendix B Not Apply

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