Pollution Study (2020) Volume 1 Issue 1, *pp.*1–10.
doi:10.24294/ps.v1i1.2010

Noise pollution and vehicular traffic on the Mexican border

Abstract: Objective -to determine the relationship between the noise level of major road intersections and the number of vehicles traveling over them.

Method - a non-invasive electronic vehicle sound level meter was used for one-week periods; noise level assessment at daily intervals during the entire week, using type I integrating sound level meters.

Results - the annual average daily traffic of 2739 units was identified; estimated noise level of 77.6 dB for 12-hour periods; maximum levels of 98.5 dB and 58.3 dB as minimum noise level.

Limitations - the development of the field work in a period of less than one year.

Main findings - the noise level in the city exceeds the reference of 65 decibels, mentioned by the World Health Organization, which leads to the conclusion that the city has noise pollution due to vehicular traffic.

Keywords: pollution, noise, traffic, sound.

Introduction

The quality of the environment can be altered by different risk factors; for example, biological, chemical and/or physical. Noise is an agent that ranks among the physical risk factors, along with vibrations and temperature. Noise pollution is one of the least valued, however, it generates a negative impact on the quality of life of exposed people (Kim et al., 2012). According to reports from the World Health Organization (WHO), this phenomenon should be considered a public health problem in the modern world, particularly in cities with large populations and limited or confined spaces (Hunashal and Patil, 2012; Mehdi et al., 2011; World Health Organization [who], 2011). The noise produced by traffic is an aggressor agent of human health, it is considered that internationally about 40% of the population is exposed to levels above 55 dB and this percentage increases in underdeveloped countries (Chang et al., 2012; Zhang, Kang and Jiao, 2012).

The production of noise can be attributed to the rapid increase in industry, infrastructure of transportation systems whether railroads, airports and roads (Hunashal and Patil, 2012; Iglesias- Merchant and Diaz-Balteiro, 2013; Paviotti and Vogiatzis, 2012). In addition, it should not be overlooked that noise is easily produced, which potentiates its penetration capacity, this means that it can be detected in different areas, such as residential, recreational and leisure areas, commercial and industrial areas, i.e., as the population concentrates in a certain area, depending on the type of activities performed, the presence of noise also increases (Zamorano et al., 2014).

The degradation of the environment in urban environments due to noise can have different sources, but most of the time vehicular traffic is considered as the main cause (Fyhri and Aasvang, 2010; Mehdi, et al., 2011). The findings of some authors such as Gündogdu, Gokdag and Yüksel (2005), as well as Li et al. (2002) have pointed out that it is not a phenomenon exclusive to developed countries, but also to developing countries, it is a danger to environmental health and should be addressed in the cities that suffer from it. Especially in those countries and cities where urban spaces are concentrated and the authorities lack management systems that facilitate the implementation of planning processes in the face of development. Such statements make it possible to define that the situation of noise pollution caused by vehicular traffic represents a complexity for the authorities responsible for environmental and urban management (Li et al., 2002).

There is some research that associates the presence of noise produced by vehicular traffic and the damage it causes to health, mainly in urban areas, showing that the effects can be grouped into four categories: auditory, physiological, psychological and finally, those that affect people's performance (Hunashal and Patil, 2012). In particular, the most frequent symptoms include: alterations in people's behavior such as nervousness, irritability, lack of concentration, interruption of sleep, and even the appearance of high blood pressure (Chang et al., 2012). It is important to emphasize that exposure to noise does not only imply hearing loss, but also other pathologies of which individuals are not aware of their cause, which implies the need to explore new lines of study around noise exposure.

The way to address the issue of noise exposure involves a very particular approach and analysis, for example, in a punctual way in the generating sources, through the use of predictive simulators which take into account the shape of the street, green areas, density of constructions, position and shape of buildings; and by means of surveys that evaluate human response (Guedes, Bertoli, and Zannin, 2011; Laszlo et al., 2012; Szeremeta and Zannin, 2009). To obtain an assessment of noise pollution in cities, it is necessary to perform a measurement of the noise generated by vehicle traffic, this includes engine noise and the friction generated by tires on the surface (Vlachokostas et al., 2012). The measurement can also include some additional characteristics such as the number of vehicles and their type, as well as the average speed at which they circulate (Paunovic, Jakovljevic and Belojevic, 2009). The determination of the noise level can have different scenarios and it will depend on the researcher the choice of the evaluation method to be used.

While it is true that the noise levels generated by a vehicle have not presented great changes since a few decades ago, it is preponderant to point out that, what has changed is the amount of vehicles that are circulating in the city (Ogren, Molnár and Barregard, 2018).

To take into consideration vehicular traffic as a determinant in the presence of noise, it is important to know the level of vehicular traffic in an area. This activity implies making a decision regarding the type of observation to be carried out. The first option is permanent gauging, i.e. when the measurement is carried out every day of the year. In the second type, the measurement is carried out only during some days of the year, usually during one week; this methodology is known as weekly base weekly gauging. The result of the observations, in either case, is used to make estimates: annual average daily traffic, maximum or minimum, passing through a given point on a highway (Secretaría de Comunicaciones y Transportes, 2006). Based on the traffic estimates and according to the classification of roads established by the Mexican Secretariat of Communications and Transportation (Mendoza et al., 2004), the type of roadway can be determined. Table 1 describes the six categories classified according to speed and Annual Average Daily Traffic (tpda).

Table 1.

Classification of roads

Type of kettle	Speed km/h	TPDA
Highways	80 a 110	>5000
Fast lanes	80 a 110	3000-5000
Secondary	70a110	1500-3000
Collector	60a 100	500-1500
Premises	50a 80	100-500
Gaps	30a70	<100

Source: Recommendations for updating some elements of the geometric design of roads (Mendoza et al., 2004).

In Mexico, environmental authorities at different levels of government have proposed and established laws to curb noise pollution. However, the effort has not been sufficient, since the regulatory framework lacks methodological and technical aspects that involve the community in general and not only institutions or businesses. The particular case of the Mexican Official Norm 081, which establishes the maximum permissible limits of noise emission from fixed sources and its measurement method, published in 1995, which presents a modification in the maximum permissible limits (Secretaría del Medio Ambiente y Recursos Naturales, 2013), but still considers only noise emitted by fixed sources leaving aside other activities that take place in public places, open spaces or roads. Likewise, such regulations are used by state and local authorities to address citizen complaints and grievances, due to the absence of other types of regulations with greater specificity. This forces governmental and private environmental managers to be subject to a method and values that probably do not correspond to their activity.

Another aspect to take into account are the regulations that address the noise produced by the exhaust ducts of means of transportation: motorcycles, motorized tricycles and automobiles; which describe certain procedures for their evaluation, but present a methodological weakness, since the measurement is carried out in specialized verification centers, in situations and conditions different from the daily use of the vehicles or the conditions of the roads.

This study has its origin in the research project: "Urban noise and its effects on the population of Matamoros, Tamaulipas". The objective is to establish a relationship between the noise level generated in the main road corridors and the number of vehicles traveling in the city of Matamoros, Tamaulipas, Mexico.

Methodology

The study was developed in the city of Matamoros, Tamaulipas, in the Northeast region of Mexico. The city has a geographical extension of 4 632 km^2 and the population is made up of a total of 520 367 people, according to the report presented in 2015 by the National Institute of Statistics and Geography. While it is true that the figure barely exceeds half a million inhabitants, it is necessary to emphasize that such information reflects only and exclusively people who have a fixed address, and, therefore, live permanently in the city. This figure does not include all those people who arrive for migratory reasons and who represent a floating population of around one million people, of whom there is no precise census. The vehicle fleet is in a similar situation, since records indicate a total of 144,113 motor vehicles; however, the number may at least double due to the large number of vehicles coming from the United States. These vehicles have U.S. owners who constantly cross the border for leisure, work and/or business. Another large number of foreign vehicles are part of the informal economy in the city and the number may far exceed official records due to the lack of controls over these (Inegi, 2016).

Data collection, as part of the field work, was carried out in the period from April to September 2016. For the selection of the evaluation zones, the inclusion of those places with houses within a diameter of one kilometer was considered. Data collection required two activities: the first consisted of a vehicular gauging, and the second, in the evaluation of daytime noise levels.

Vehicular traffic

In order to understand the way in which a particular phenomenon is presented and developed, it is necessary to describe it from its universe as a whole. Based on this premise, the behavior of vehicular traffic requires obtaining information with the instrumentation of continuous gauging throughout the year, however, this represents a difficulty in the development of urban studies due to the high cost involved in the installation of monitoring points for prolonged periods. One way of resolving this type of conflict is to obtain traffic samples that allow the elaboration of calculations to generalize the behavior of the population (Reyes and Cárdenas, 2007).

In order to determine the existing traffic on each of the roads, a vehicle gauging was performed by installing a non-invasive Traffic Logix gauging device. With the information obtained, we proceeded to estimate the Average Daily Weekly Traffic (TPDS), which represents the average daily traffic value and is obtained based on a week's traffic. The calculation is based on that established by the Ministry of Communications and Transportation (2006) and the mathematical expression is defined by equation 1.

$$TPDS = \frac{TS}{7}$$

(Equation 1)

Where:

TPDS= Weekly Average Daily Traffic.

TS=Sumulative weekly traffic (Secretaría de Comunicaciones y Transportes, 2006).

Subsequently, TPDA was estimated using the procedure proposed by Reyes and Cárdenas (2007), using equation 2

$$TPDA = TPDS \pm KE \quad \text{(Equation 2)}$$

Where:

TPDS= Average daily weekly traffic.

K= Product of the number of standard deviations (s) by the confidence level (1.96).

E= Standard error of the mean.

The standard deviation was determined by equation 3.

$$S = \sqrt{\frac{\sum_{1}^{n} (TD_i - TPDS)^2}{n-1}}$$

(Equation 3)

Where:

TDi= Transit volume of the day.

The standard error of the mean was obtained using equation 4.

$$E = \frac{S}{\sqrt{n}} \left(\sqrt{\frac{N-n}{N-1}} \right)$$

(Equation 4)

Where:

S= Standard deviation of traffic volume distribution.

n= Sample size in number of days of the gauging.

N= Population size in number of days of the year (Reyes and Cárdenas, 2007).

Daytime noise

The evaluation of the noise level was carried out during the seven days of the week, the data collection considered three different periods throughout the day, with a duration of one hour. The noise recording was carried out during four intervals of 15 minutes each, which allowed the equipment to be located at the four cardinal points of the intersection, thus completing each one-hour period. Class I integrating sound level meters were used in this process, with their respective field calibrators; both the sound level meters and the acoustic calibrators were verified by an environmental testing laboratory.

During the location of the measuring equipment, it was ensured that they were placed at a minimum distance of at least two meters from any facade or surface that could reflect sound. In addition, the installation height of the tripods supporting the sound level meters was four meters. The evaluation parameters obtained by programming the sound level meters were: daytime equivalent continuous sound pressure level in the 12-hour time interval (L_{day12}), the maximum sound level (L_{Max}), as well as the minimum sound level (L_{min}) (International Standards Organization, 2016); the retrieval of the measurements stored in the instruments was by connecting to a computer, through the Quest Suit Pro II software.

Additionally, field personnel ensured compliance with ISO Standard 1996-1 2016, description, measurement and evaluation of environmental noise, where the weather conditions at the time of measurement are established: absence of rain and thunder; as well as anemometers were used to determine that the wind speed was less than three meters per second (International Standards Organization, 2016), in cases where different situations were present, the measurement was omitted.

Results

Table 2 shows the results of the vehicle counts performed, the weekly traffic volume and the TPDA estimators; it is worth mentioning that, during the field work, three road intersections (15 %) were discarded because maintenance work was being carried out on the storm drainage system, as well as road reconstruction activities. Through this activity it was possible to identify that, at least among the selected areas, 11 intersections were found (55%) with a TPDS higher than 1,500 vehicles.

Table 2.

Description of traffic in circulation

Location	TPDS	±Kϑ	TPDA $_{max}$	TPDA$_{min}$
Ave. Cavazos Lerma and Calixto Ayala	1733		1848	1617
Ave. Cavazos Lerma and Virgilio Garza	2091		2247	1935
Virgilio Garzay Mexicali	1170	99	1269	1071
Ave. Constituyentes and 12 de marzo	1652		1737	1568
Ave. Constituyentes and Sendero Nacional	1830		1956	1704
March 12 and Sendero Nacional	1723		1832	1614
Rigo Tovary Ave Rigo Tovary National Trail	ND	ND	ND	ND
Ave. Cavazos Lerma and Cuauhtémoc			2112	1805
Sixth and Cuauhtémoc	2484		2739	2228
Sixth and Gonzalez	1288		1401	1175
Ave. Avaro Obregón and Sexta	ND	ND	ND	ND
Ave. Cavazos Lerma and Sexta	2422	212	2634	2210
Ave. Cavazos Lermay Ave. Del Nino	ND	ND	ND	ND
Ave. Cavazos Lerma and Roberto Guerra	1455		1565	1344
Ave. Lauro Villar and Acción civica.	2318	292	2610	2025
Ave. Lauro Villar and Francisco Villa	1933		2073	1793
Ave. Lauro Villary Roberto F. Garcia	1486	92	1577	1394
Ave. Lauro Villar and Primera	1344	132	1477	1212
Marte R Gomez Ave. and 12 de marzo	933		1062	805
Marte R Gómez Ave. and Pedro Cárdenas Ave.	2193		2326	2059

Source: vehicle gauges, own elaboration.

As part of the field work activities, those streets and avenues were selected with TPDA min estimates of between 1500 to 3000 vehicles, considered as arteries or secondary roads, with a small route and although the Secretary of Communications and Transportation mentions that they could have a speed limit in a range of 60 to 110 km/h, the speeds ranged between 20 to 60 km/h as maximum. Noise measurements were obtained at each of the selected locations. Table 3 shows the results.

Table 3.

Daytime noise level

Location	TPDAmin	dBLday	dBLmin	dBLmax
Ave. Cavazos Lerma and Calixto Ayala	1617	77.4	72.3	87.34
Ave. Cavazos Lerma and V urgil io Garz a	1683	74.5	58.7	98.5
Ave. Constituyentes and 12 de marzo	1568	73.5	65.5	84.1
Ave. Constituyentes and Sendero Nacional	1502	72.3	59.1	97.8
12 de mano and Sendero Nacional	1614	71.5	62.3	89.3
Ave. Cavazos Leima and Cuauhtemoc	1558	77.6	58.9	95.8
Sec ta and Cuauhtemoc	1813	75.6	61.3	96.8
Ave. (Lavazas Lerma and Sexta	1866	75.6	58.3	97.9
Ave. Lauro Villar and A ction Ovica.	1550	72.1	59.7	
Ave. Lauro Villar and Francisco Villa	1568	71.7	58.6	86.7
Marte R Gómez Ave. and Pedro Cárdenas Ave.	1845	74.8	60.4	95.2

Source: Type I integrating sound level meter, own elaboration.

The results generally show that in all zones the Lday12 parameter exceeds 65 dB. The minimum value reaches 58.3 dB and the maximum value 98.5 dB. It is important to note that, according to WHO recommendations, environmental noise during the day should not exceed 65 dB, to avoid damage or disorders that people could suffer, especially those who are constantly exposed (WHO, 2011). In Mexico, the agreement to modify the Mexican Official Standard 081, published in 2013 establishes that, for spaces dedicated to the residential sector, there will be a maximum permissible limit of 55 dB, while industrial and commercial areas, may reach 68 dB, and finally, in school areas may reach 55 dB, during recreational activities. The results of the field work for the assessment of noise levels in the previously selected areas show that in all cases the recommended values are exceeded.

Discussion

The existing studies that address the problem of noise present the perspective of interest of those who develop them, in some cases, address the problem in the workplace; others are oriented to the design and formulation of environmental policies on noise pollution; some, through the design of urban maps and others, seek to confirm and discover the effects that noise produces on the exposed population.

The review of different authors allows the development of a frame of reference in relation to the strategies for measuring noise, some use methodologies established by law, but many others propose a method that helps to redefine the established levels. Such is the case of the study carried out in the city of Medellin, Colombia, where they identified that in 15 of the 16 points evaluated (94%) 65 dB are exceeded (Ortega and Cardona, 2005). In a similar way, it was observed in the present study that in all the measurement points this value is exceeded. This means that at least in the aforementioned areas there is an environmental health problem, but other roads with traffic of close to 1,500 vehicles per day cannot be ignored. A similar situation occurs in Cochabamba, Bolivia, where they recorded, evaluated and presented the noise levels to which the population is exposed, prepared noise maps and defined that at least 75% of the city has noise pollution levels (Medrano and Antezana, 2006). In this type of case, it is important to consider the characteristics of invasion and depth of the noise.

In Cuba, a simulation model was developed in the city of Havana, which made it possible to determine the noise level of vehicular traffic. Based on this model, values higher than 68 dB were determined during the day, which reflects an alteration of environmental quality due to noise pollution (Guzmán and Barceló, 2008). A similar study was conducted in the city of Bogota, Colombia, in which it was concluded that environmental noise is mainly caused by road corridors, where it can be observed that they exceed 70 dB, also determining that it is not only produced by the number of vehicles but also by the type and characteristics of the vehicles that travel there (Pacheco, Franco and Behrentz, 2009).

In the city of Chihuahua, Mexico during 2013, a study was conducted in road accesses finding that in 100 % of the 64 measurement points 65 decibels were exceeded (Olague-Caballero, Wenglas-Lara and Duarte-Rodríguez, 2016), results almost identical to those found in the present study. This shows that the noise level is related to the vehicles traveling on a given road, and that the noise levels exceed the parameters established by the World Health Organization.

The work presented mainly presents the limitations of the assessment of vehicular traffic in a partial manner, subject to a period of five months, as well as the noise was evaluated only during the daytime period. Other variables that could influence the results and that were not considered are: soil characteristics and vehicle speed. However, the results do not contradict the existing evidence which demonstrates that the evaluations in short periods allow associating the noise level with the amount of vehicular traffic circulating on a given road without finding differences in the results of long-term evaluations (Morelli etal., 2015).

Conclusions

It cannot be ignored that means of transportation are of great utility, even becoming a reference of the modernity of today's societies, what is transcendental implies that these means of transportation have the best scenarios to achieve their best performance.

The noise levels reached are directly related to vehicular traffic, so it is necessary to promote and inform the exposed population about this risk factor. In this sense, the intervention of health and environmental authorities becomes necessary, since the establishment of actions that favor the reduction of noise levels depends on them. One of these actions could be the establishment of regulations, accompanied by mechanisms to monitor compliance, mainly because in Mexico there is a lack of laws regulating the noise generated in cities.

Developing and implementing appropriate policies would allow the city to improve its urban growth strategies. Of great help in reducing noise would be the development of new road corridors to free certain areas from traffic, reorient traffic, improve the structure of street surfaces, verify vehicle conditions to ensure optimal operation, promote with experts the development of studies, as well as methodologies that allow establishing the actual noise conditions in certain spaces.

The population also plays an important role, as they need to be aware of this risk factor and the consequences of exposure to noise, how to protect themselves, but mainly, how to avoid generating loud noises, which is why information and awareness programs are required.

Finally, the results only present the pollution generated by vehicular traffic noise; therefore, the studies should be expanded to other parameters, such as community noise, noise in plazas and shopping centers; noise maps should be drawn up and the nuisance caused by noise on the population in general should be assessed. This will provide a more in-depth understanding of noise pollution and its effects.

Acknowledgments

The researchers are grateful for the support and guidance of the Department of Support Programs of the Universidad Autónoma de Tamaulipas for the successful development of the project.

References

Chang, T.-Y., Lin, H.-C., Yang, W.-T., Bao, B.-Y., and Chan, C.-C. (2012). A modified Nordic prediction model of road tra ffic noise in a Taiwanese city with significant motorcycle traffic. Science of the Total Environment, 432, 375-381. DOI: https://doi.org/10.1016Zj.scitotenv.2012.06.016

Fyhri, A., & Aasvang, G. M. (2010). Noise, sleep and poor health: Modeling the relationship between road tra ffic noise and cardiovascular problems. Science of Be Total Environment, 408(21), 4935-4942. DOI: https://do i.org/10.1016/j.scitotenv.2010.06.057.

Guedes, I. C. M., Bertoli, S. R., and Zannin, P. H. T. (2011). Influence of urban shapes on environmental noise: A case study in Aracaju - Brazil. Science of Be Total Environment, 412-413, 66-76. DOI: https://doi.org/10.1016/j.scitotenv.2011.10.018

Gündogdu, O., G6kdag, M., and Yüksel, F. (2005). A traffic noise prediction method based on vehicle composition using genetic algorithms. Applied Acoustics, 66(7), 799-809. DOI: https://doi.org/10.1016Zj.apacoust.2004.11.003.

Guzmán, R, and Barceló, C. (2008). Estimation of traffic noise pollution in Havana City, 2006. Cuban Journal of Hygiene and Epidemiology, 46(2). Retrieved from http://scielo.sld.cu/scielo.phpPscript=sci_arttext&pid=S1561-30032008000200004&lng=en&tlng=en

Hunashal, R. B., and Patil, Y. B. (2012). Assessment of noise pollution indices in the city Kolhapur, India. International Conference on Emerging Economies - Prospects and Challenges (ICEE-2012). Procedia-Social and Behavioral Sciences, 37, (pp. 448-457).

Iglesias-Merchant, C., and Diaz-Balteiro, L. (2013). Noise pollution mapping approach and accuracy on landscape scales. Science of total, environment, 449, 115-125. DOI: https://doi.org/10.1016/j.scitotenv,2013.01.063

National Institute of Statistics and Geography [Inegi] (2016). Intercensal Survey 2015: Bank of indicators. Retrieved from http://www.beta.i negi.org.mx/app/indicadores/#

International Standards Organization. [ISO]. (2016). Acoustics-Description, measurement and assessment ofenvironmental noise. Part 1: Basic quantities and assessment procedures, ISO 1996-1:2016. Retrieved from https://ww w.iso.org/standard/59765.html.

Kim, K. H., Ho, D. X., Brown, R. J., Oh, J. M., Park, C. G., & Ryu, I. C. (2012). Some insights into the relationship between urban air pollution and noise levels. Science of Total, environment, 424, 271-279. DOI: https://doi.org/10.1016/j.scitotenv.2012.02.066.

Laszlo, H. E., McRobie, E. S., Stansfeld, S. A., & Hansell, A. L. (2012). Annoyance and other reaction measures to changes in noise exposure - A review. Science of He Total Environment, 435-436, 551-562. DOI: https://doi.org/10.1016/j.scitotenv.2012.06.112.

Li, B., Tao, S., Dawson, R. W., Cao, J., and Lam, K. (2002). A GIS based road tra ffic noise prediction model. Applied Acoustics, 63(6), 679-691. DOI: https:// doi.org/10.1016/S0003-682X(01)00066-4.

Medrano, H., and Antezana, J. (2006). Noise map of districts 10, 11 and 12 of the city of Cochabamba. Acta Nova, 3(3), 458-474.

Mehdi, M. R., Kim, M., Seong, J. C., and Arsalan, M. H. (2011). Spatio-temporal patterns of road traffic noise pollution in Karachi, Pakistan. Environment International, 37(1), 97-104. DOI: https://doi.org/10.1016/j.envint.201 0.08.003.

Mendoza, A., Abarca, E., Mayoral, E. F., and Quintero, F. L. (2004). Recommendations for updating some elements of the geometric design of highways. Querétaro: IMT-SCT . Retrieved from http://www.imt.mx/archivos/Publicaciones/PublicacionTecnica/pt244.pdf.

Morelli, X., Foraster, M., Aguilera, I., Basagana, X., Corradi, E., Deltell, A., Ducret-Stich, R., Phuleria, H., Ragettli, M.S., Rivera, M., nomasson, A., Künzli, N., and Slama, R. (2015). Short-term associations between traffic-related noise, particle number and tra ffic flow in three European cities. Atmospheric Environment, 103, 25-33. DOI: https://doi.org/10.1016/j.a tmosenv.2014.12.012.

Olague-Caballero, C. O., Wenglas-Lara, G., and Duarte-Rodríguez, J. G. (2016). Noise pollution on access roads to the city of Chihuahua. Ciencia UAT, 11(1), 101-115. DOI: https://doi.org/10.290 59/cienciauat.v11i1.551.

Ortega, M., and Cardona, J. M. (2005). Methodology for the evaluation of urban environmental noise in the city of Medellín. Revista facultad nacional de salud pública, 23(2), 70-77.

Ögren, M., Molnár, P., and Barregard, L. (2018). Road tra□c noise abatement scenarios in Gothenburg 2015 - 2035. Environmental Research, 164, 516-521. DOI: https://doi.org/10.1016/j.envres.2018.03.011

Pacheco, J., Franco, J. F., and Behrentz, E. (2009). Characterization of noise pollution levels in Bogotá: Pilot study. Revista de ingeniería, 30, 72-80. DOI: http://dx.doi.org/10.16924%2Friua.v0i30.230

Paunović, K., Jakovljević, B., and Belojević, G. (2009). Predictors of noise annoyance in noisy and quiet urban streets. Science of e Total Environment, 407(12), 3707-3711. DOI: https://doi.org/10.1016/j.scit otenv.2009.02.033.

Paviotti, M., and Vogiatzis, K. (2012). On the outdoor annoyance from scooter and motorcycle noise in the urban environment. Science of total environment, 430, 223-230. DOI: https://doi.org/10.1016/j.scitotenv,2012.05.010

Reyes, R. C., and M. and Cárdenas, J. (2007). Ingeniería del tránsito: fundamentos y aplicaciones (8ª edition). Mexico: Alfaomega.

Secretaría de Comunicaciones y Transportes [SCT] (2006). Demand modeling for toll roads (Manual No. SCT-NIS-0420). Steer Davies and TransDirección General de Desarrollo Carretero. Retrieved from http://www.sct.gob.mx/normatecaNew/manual-de-modelacion-para -carreteras-de-cuota/

Ministry of Environment and Natural Resources [Semarnat] (2013). Acuerdo por el que se modifica el numeral 5.4 de la Norma Oficial Mexicana NOM-081-SEMARNAT-1994, Que establece los límites máximos permisibles de emisión de ruido de las fuentes fijas y su método de medición. Mexico: Diario Oficial de la Federación. Retrieved from http:// www.doEgob.mx/nota_detalle_popup.php?codigo=5324105

Szeremeta, B., & Zannin, P. H. T. (2009). Analysis and evaluation of soundscapes in public parks through interviews and measurement of noise. Science of He Total Environment, 407(24), 6143-6149. DOI: https://doi.org/10.1016/j.scitotenv.2009.08.039

Vlachokostas, C., Achillas, C., Michailidou, A. V., & Moussiopoulos, V. (2012). Measuring combined exposure to environmental pressures in urban areas: An air quality and noise pollution assessment approach. Environment International, 39(1), 8-18. DOI: https://doi.org/10.1016/j.envint.2011. 09.007

World Health Organization [WHO] (2011). Burden of disease from environmental noise. Bonn Office. Quantification of healthy life years lost in Europe. JRC European Commission. World Health Organization: Regional Office for Europe. Retrieved from http://www.euro.who.int/_ data/assets/pdf_file/0008/136466/e94888.pdf

Zamorano, B., Peña, F., Parra, V., & Vargas, J. I. (2014). Social perception of urban noise. Ojeando la Agenda, 32,2-21.

Zhang, M., Kang, J. and Jiao, F. (2012). A social survey on the noise impact in open-plan working environments in China. Science of He Total Environment, 438, 517-526. DOI: https://doi.org/10.1016Zj.scitotenv.2012.08.082

Asia Pacific
Academy of Science Pte. Ltd.

Author's notes

a. Master of Science with a major in Occupational Health from the Universidad Autónoma de Tamaulipas. He is a full time professor at the Unidad Académica Multidisciplinaria Matamoros, in the degree program in Safety, Health and Environment, and a member of the Academic Body of Psychology and Risk Prevention.

b. D. in Learning and Cognition from the University of Seville. She is a full time professor at the Multidisciplinary Academic Unit Matamoros, in the degree in Psychology. She is a member of the National System of Researchers and leader of the Academic Body of Psychology, Cognition and Culture.

c. D. in Education from the University of Baja California. She is a full time professor at the Unidad Académica Multidisciplinaria Matamoros, in the degree program in Safety, Health and Environment. She is a member of the National System of Researchers and a member of the Academic Body of Psychology, Cognition and Culture.

d. D. in Nursing Sciences from the Universidad Autónoma de Nuevo León. He is a Full Time Professor at the Unidad Académica Multidisciplinaria Matamoros, in the Bachelor's Degree in Nursing. He is a member of the National System of Researchers and leader of the Academic Body of Psychology and Risk Prevention.

e. Master's Degree in Academic Communication from the Universidad Autónoma de Tamaulipas. He is a full time professor at the Unidad Académica Multidisciplinaria Matamoros, in the degree program in Safety, Health and Environment, and a member of the Academic Body Psychology and Risk Prevention.