

## ASSESSMENT OF ENVIRONMENTAL NOISE IN CITIES, A THEORETICAL APPROACH



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### Abstract

Environmental noise is a major problem with increasing presence in cities; its effects are not only assimilated into the environment, but also impact on human health. Noise sources are part of the city's daily life and it has not yet been given due attention, although prolonged exposure causes often irreversible physiological and psychosomatic damage.

This paper presents a theoretical approach from several authors that expose the different tools that can be used the measurement and evaluation of environmental noise. These authors, to explain the causes and effect of environmental noise in cities consider various variables such as: sound pressure levels, weather conditions and urban structure.

## 1. Introduction

Cities are strategic spaces for societies to move towards sustainable development. According to the World Bank today (2020), about 55% of the world's population, or 4.2 billion people, live in cities.

The quality of life of the inhabitants of a city is closely linked to its environment, however, all cities face a worrying environmental degradation, with high levels of pollution (ECLAC and UN-Habitat, 2017). A report issued by the World Health Organization (WHO) indicates that environmental noise is the second leading cause of disease due to environmental reasons, behind air pollution and not only as an environmental nuisance, but also a public health problem of the modern world (Fritschi, Brown, Kim, Schwela, & Kephelopoulos, 2011), as it generates cardiovascular disease and contributes to harmful effects on the health and well-being of the population (Podor & Borsfoldi-Nagy, 2018). WHO (2011) recognizes that the acoustic quality of the city's sound environment is not simply an aspect of the urban environment, but a public health problem. Exposure to environmental noise, meanwhile, causes physiological and

psychosomatic damage often irreversible to more than 120 million people worldwide and 13 million in the member countries of the Organization for Economic Cooperation, OECD (Birgitta, Lindval, & Schwela, 1999).

In 2002, the European Parliament defined the concept of environmental noise as that unwanted or harmful external sound generated by human activities, including noise emitted by means of transport, by road, rail and air traffic and by industrial activity sites ("DIRECTIVE 2002/49/EC", 2002). Noise-generating sources are part of the daily life of the city, however, due attention has not been paid to environmental noise pollution because its effect is not immediate (García Rodríguez, 2006).

The World Health Organization (WHO, 2011), in the Burden of disease from environmental noise report warns that the civilization of noise is in the face of health, and although the excess sound that alters normal environmental conditions in a given area is not cumulative or transferred, it has a serious impact on people's quality of life if not adequately controlled.

Faced with this challenge, several countries have made efforts to regulate the allowable maximum noise emission limits in the environment through regulatory frameworks on noise pollution. That is why it is necessary to quantify the level of noise emissions in cities.

The aim of this paper is to highlight common methods of environmental noise assessment. By studying the level of environmental noise pollution in cities through the sound pressure level, updated information on the existing noise situation would be generated based on a noise indicator, indicating places where there is excess of any relevant limit value in force, the number of people affected or the number of dwellings exposed to certain values of a noise indicator, for decision-making.

## **2. Addressing the Problem of Noise Pollution Related to Environmental Noise**

In the world, different studies have been carried out to approach the problem represented by noise, where the affected or exposed population has been characterized, works with empirical or simplified approaches, identifying sources and making maps.

An assessment of urban environmental noise was carried out in the La Candelaria neighborhood, located in the interior of the municipality of Medellín, Colombia. The information was processed in the SPSS 11.0 program and information was obtained through surveys on the degree of noise disturbance, noise sources and days and times of increased noise presence. Sound pressure levels were measured in this neighbourhood and compared to the permissible limits set out in Resolution 8321 of 1983. A 200 meter by 200 metre rettier mesh was used for the selection of measuring points, superimposed on the Prado neighbourhood, and the center of each grid was determined as a measuring point; measurements were made at each point on Wednesdays, Fridays and Sundays for 12 continuous hours, from 7 am to 7 pm. These points were located near the facades of the houses, not less than one meter from any reflective surface, with the microphone in the direction of the public roads and between 3 and 4 meters high above ground level; In addition, the weather conditions and other standards in this regard provided for in Colombian regulations and the International Organization for Standardization (ISO 1996) were taken into account. Measurements were made with a Quest Q-100 dosimeter. The data obtained by the dosimeter was processed in Excel, then in a geographic information system by interpolating three points noise maps of the Prado neighborhood were obtained. (Ortega & Cardona, 2005).

In the city of Cartagena, Colombia, the determination of noise levels was made in the second section of TransCaribe. Measurements were made at four different times (10:00 am,

11:00 am, 12:00 am and 1:00 pm) for a period of six days with the help of a Cel sonometer, model 573; which was used in the environmental measurement mode by octave bands, performing measurement episodes of at least 15 minutes per hour, and recording the values obtained for further processing. Measurements were made by installing the equipment on a tripod at 1.5 m high and the equipment was calibrated before and after each measurement day. The continuous sound level of decibels per hour (LAeq) and the maximum recorded per hour was recorded. The results were compared to the benchmarks raised by the Ministry of Environment, Housing and Territorial Development (Castro, Tirado, & Manjarrez, 2007).

In the city of Lima, a study of noise pollution from vehicle noise was carried out on Javier Prado Avenue, the main road and of greater vehicle congestion. To learn about the impact of the noise, both passers-by and drivers were found along the avenue at 07:00-09:00 and 15:00-19:00 hours. Information on noise and noise sources was obtained (Santos de la Cruz, 2007).

Environmental noise assessment was carried out in the city of Puerto Montt, Chile, carrying out an empirical study, with noise measurements at different points in the city, and a subjective study on community noise, using a survey.

Finally, an average annual noise map was developed for the evaluated area of the city, and the perception and degree of discomfort of the environmental noise that the inhabitants have was obtained (Lobos Vega, 2008).

In the city of Medellín, Colombia, a methodology was developed with the support of geographic information systems to model environmental noise, through a spatial database, called SIGCARES, a multi-crime spatial analysis model was subsequently designed for the location of the most vulnerable areas and, finally, a noise map was developed in a vulnerable area with LeqA values, through a spatial analysis model called SIGNAS, developed with the Model Builder tool of ESRI's ArcGis program (Tafur Jiménez and Castro Castro, 2008).

The noise produced by motor transport on Aguilera Street in the historic center of Santiago de Cuba, Cuba, was evaluated. First, the peak time was considered in the day and monitoring was carried out on weekdays. The method consisted of obtaining the noise level with a Model CR: 272 Cirrus brandEd Integrator Sonometer made by British. Measurements were made as close to the source; 1.0 m from the street and 1.20 m above the level of the street. Wind speed was deemed not to exceed 3 m/s. For the implementation of this method, the dependencies between traffic density (number of vehicles per hour) and statistical levels of

acoustic pressure (Fajardo-Segarra, 2012) were taken into account.

A study was conducted on environmental pollution from noise and emissions of particulate matter associated with mobile sources in the Pereira - Dosquebradas conurbation, Manizales, Colombia, with the aim of analyzing the health relationship with these pollutants. Measurements of vehicle flow and environmental noise were performed at three sites of interest for vehicle congestion. From this data, models were developed to estimate environmental noise from vehicle flow conditions and two simulation models are proposed bringing out characteristics of population growth dynamics, vehicle flow and possible emissions of particulate matter, to estimate the potential effect on health and induced costs associated with pollution. (Morales Pinzón & Arias Mendoza, 2013).

Acoustic pollution from fixed and mobile sources was determined on the road to Samborondón in Ecuador. The Extech 407730 – Sound Level Meter sonometer and Garmin 60 CSx brand GPS were used to measure the sound pressure levels of the avenue, while for data collection the automatic scale of the sonometer was programmed, with a "slow" time weighting of one second. The sonometer was located at point 0, at a height of 1.5 m from the ground at each site, three periods were selected based on the high vehicular concurrence of the city; these are: 08:00-12:00 h, 13:00-17:00 h and 17:01- 21:00 h. The results are expressed based on compliance with the regulations permissible according to the Tulas and the percentage increase between the day and night period (Guijarro Peralta, Terán Narváez, & Valdez González, 2015).

The level of noise pollution of vehicular origin was evaluated in the town of Chapinero, Bogota, Colombia, performing measurements of vehicular noise on the intersections with the highest vehicle flow 36 x 2 samples of 10 minutes were taken, time that was defined, from a presampling, as sufficient to stabilize the continuous equivalent level (LAeq). Measurements were carried out during peak hours during working days, without rain and with dry pavement. An integrative type ii sonometer equipped with a windproof display, with A and slow weights, located on a tripod at 1.2 m high, 1 m from the track and more than 2 meters from the facades, pointing to the center of the intersection. The descriptors evaluated included the continuous (LAeq), maximum (LMáx), minimum (LMín) and 10th (L10) and 90 (L90) percentiles equivalent levels. On the information gathered, descriptive statistics were carried out that were confronted with national regulations (Resolution No. 627 of 2006; mavdt 2006) contemplating land use in each station. Additionally, two averages comparison tests were conducted

through Student's t-statistic to compare the sound pressure level (noise) with the presence and absence of buses, and between morning and afternoon measurements. The indicators of intensity LAeq/LNorma, variability L10 / L90 and risk (fuzzy conjunction of the previous two) were also calculated, proposed by Ramírez (2011; cited by González, Antonio, & Calle, 2015) using the programs SPSS v.15, Kyplot v.2.0, Matlab and past v. 1.89.

Noise pollution was assessed in the historic center of matamoros city, Tamaulipas, Mexico, in two stages; the first was to assess noise levels and the second stage collected information on people's perception of environmental noise. All fieldwork was carried out from Monday to Friday. For the assessment of noise levels, a 50 m long reticular mesh by 50 m wide was drawn on a plane, covering a total of 139 km<sup>2</sup>. The screen in the plane determined a total of 75 points for the development of the measurements. For data collection in relation to noise levels, five different periods were determined at one-hour intervals at each point, within a 8:00 a.m. to 6:00 p.m. For the measurement of noise levels, the sonometers were located 3 m from any facade that could reflect the sound; at the height of 1.5 m. The equipment used were integrator sonometers type I, brand Quest Technologies, model Sound Pro SE/DL. Acoustic calibrators of the same brand, model QC-10/QC-20 were used each start and end of each measurement day. These equipment were programmed to provide measurements in A-weight and low rapid response (F), obtaining the following units of measurement: LAeqT, maximum sound level (Lmax), minimum sound level (Lmin) and data recovery was through QuestSuit Professional II software. With the LAeqT value calculated in each hour the daytime sound level (Ld) was determined for a period of 10 h, which is obtained by integrating the five samples obtained from each interval (Zamorano González, Peña Cárdenas, Parra Sierra, Velázquez Narváez, & Vargas Martínez, 2015).. The second part of the study was to assess people's perception of environmental noise pollution. An adaptation of the questionnaire "Assessment of urban noise" (Barrigón, et al., 2002b) was used for this purpose.

A noise map was developed in the urban area of the city of Cuenca, Ecuador, using the ordinary Kriging geostatistical interpolation technique. The study proceeded with the determination of sampling sites based on traffic density, then recorded environmental noise measurements and subsequently systematized and evaluated the information raised through the statistical method "ordinary kriging" (Delgado & Martinez, 2015).

A simplified method was evaluated and applied to generate a traffic noise map of the city of Valdivia, Chile. Experimental design involved simplifying cartographic information in

buildings by grouping houses into a block, and classifying vehicle traffic flows into categories to generate a low-cost noise map. The streets were classified according to the official road classification of the country. The segregation of light, heavy and motorbike vehicles was done to account for the flow of traffic. In addition, a number of traffic noise models were compared with many measurements, and therefore the RLS-90 road traffic model was chosen to generate the city noise map using computer-aided noise reduction (CadnaA) software. The methodology developed in this study seems to be desirable in developing countries to obtain accurate approximations to develop low-cost traffic noise maps (Bastián-Monarch, Suarez, & Arenas, 2016).

A noise map was produced for the metropolitan area of Mexico City (ZMVM), the noise maps in the Azcapotzalco delegation and the specific case study of the Hidalgo Garden. The process involved the collection of data in situ, equipped with a general sound level meter to obtain the Leq and LAeq parameters, in a minimum period of five minutes based on ISO 1996-1:2003 for Mexico; the construction of simulation models on noise maps, based on urban, geographic and statistical information; field data validation centre; simulation model with the use of the CadnaA specialist programme and the prediction of results (Rodríguez, Garay, Lancón, & Gerardo, 2016).

The spatial characteristics of road traffic noise were analyzed at morning, afternoon and evening weather intervals on different road networks in Dhanbad City, India. The basic instrument for recording noise levels was a Bruel & Kjaer 2238 integration sound meter and for noise contour maps the ArcGIS version 10.3 geographic information system (Debnath & Singh, 2018) was used.

Exposure to noise of vulnerable population groups in The city of Barcelona, Spain, was assessed. The assessment of noise levels was carried out using two methods of analysis, real measurements and simulation, long-term measures were made, with a minimum duration of 24 hours, and short-term measures, with a minimum duration of 15 minutes, highlighting the sources causing and giving a typology to the streets. A fourth Lden index was also calculated as recommended by Directive 2002/49/EC (Lagonigro, Martori, & Apparicio, 2018).

A method was developed to assess a population exposed to urban traffic in the main urban area of Guangzhou, China. The method was based on points of interest (POIs) and the execution of a cluster analysis for regions according to the properties of the POIs, with the functional regions of environmental noise (NFR) of the urban area presented. Then the surrounding POIs were used to infer the type of buildings, and according to the attraction of

the different types of buildings and the entire population of the region, the distribution of the population was calculated at the level of the building. (Wang, Chen, & Cai, 2018).

The level of exposure of the population to traffic noise was evaluated in the Pinheiros neighborhood, located in the municipality of Sao Paulo, Brazil. The study was conducted in two parts: 1) Noise Assessment, with the creation of neighborhood noise maps under study, and 2) the application of a questionnaire to determine the perception of neighborhood residents about the effects of this exhibition (Mary Paiva, Alves Cardoso, & Trombetta Zannin, 2019).

### 3. Conclusions

The regulation of asset confiscation sanctions in the KUP Law, based on the type that the tax crime is a white collar crime, so that in law enforcement there must be resistance against the perpetrators by adding sanctions of asset confiscation in the KUP Law in order to create a deterrent effect and benefit. Alternative assets confiscation in the KUP Act can be through the model of Criminal Base Forfeiture (CB) and Non-Criminal Base Forfeiture (NSB), as stated in Law Number 31 of 1999 Jo Law Number 20 of 2001 concerning Eradication of Corruption Crime by placing seizure assets as additional crimes, as well as the state can still make a civil suit against perpetrators of criminal acts of corruption. Considering the huge state loss caused by this tax crime, a strategy to save state losses is needed, both in the level of investigation, prosecution and execution stage. For example, a country can still conduct a civil suit if the suspect dies during an investigation, prosecution or execution. Methods like this have not been regulated in the KUP Law. Though this method is very important considering the state is very dependent on taxes in developing the country.

Asset saving model in the future KUP Act can be through CB and NSB, considering the state is very dependent on taxes, so efforts to save assets due to criminal acts must also be extraordinary. For example, in Law Number 31 of 1999 Jo Law Number 20 of 2001 concerning Eradication of Corruption Crimes includes articles to pursue and save state financial losses including by conducting a civil suit if the suspect/defendant dies before the case is decided by a judge. Even the state can still file a lawsuit against the property of a convicted person obtained from the results of a criminal act of corruption, if the assets are found later and have not been seized when the case has been decided by a judge.

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