

AN ENVIRONMENTAL NOISE STUDY IN THE INDUSTRIAL, COMMERCIAL, RESIDENTIAL AREAS AND ARTERIAL ROADS IN WESTERN BOGOTA, COLOMBIA

UN ESTUDIO DE RUIDO AMBIENTAL EN EL SECTOR INDUSTRIAL, ÁREAS COMERCIALES, RESIDENCIALES Y ARTERIALES EN EL OESTE DE BOGOTÁ, COLOMBIA

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Abstract

Noise pollution as byproduct of development and urban activity is related with a great amount of economical, social and cultural variables, whose importance as stressing, and possible even dangerous agent in human life has come to be recognized in the last decades. In this case the megacity of Bogotá is the capital of Colombia, located in the center of the country. Bogotá is a very variable city in terms of economical and social level location, and even use of soils in the city planning. The factors mentioned above makes Bogotá a very complex analysis system for sound and noise pollution studies. Due to the size of the city, in this study the western area of the capital district was analyzed through sound measurements in 7 sites selected by types of areas, involving commercial, transportation, industrial,

residential and arterial roads. The main objective of this study was to identify the most important noise sources in the western area of the city. This study allowed to identify the arterial roads as one important source of noise in the city, possibly due to the traffic or heavy vehicles inside the city. The maximum harmful levels of sound reach values of about 85 dB in the mentioned locations (Ciudad de Cali avenue, ClI 13 avenue arterial roads and Salitre – El Greco Transmilenio Station), exceeding the permitted limits of 75 dB(A) according to the local environmental standards.

Keywords: Noise pollution, environmental noise, public health, sound measuring, environmental policies.

Resumen

La contaminación acústica como subproducto del desarrollo y la actividad urbana está relacionada con una gran cantidad de variables económicas, sociales y culturales, cuya importancia como agente estresante, e incluso peligroso, en la vida humana ha llegado a ser reconocida en las últimas décadas. En este caso, la megaciudad de Bogotá es la ciudad capital de Colombia, ubicada en el centro del país. Bogotá es una ciudad muy variable en términos de ubicación de nivel económico y social, y uso de suelos en la planificación de la ciudad. Los factores mencionados anteriormente hacen de Bogotá un sistema de análisis muy complejo para estudios de contaminación acústica y sonora. Debido al tamaño de la ciudad, en este estudio se analiza el área occidental del distrito capital a través de mediciones sonoras en 7 diferentes tipos de áreas seleccionadas, que incluyen carreteras comerciales, de

transporte, industriales, residenciales y arteriales. El objetivo principal de este estudio es identificar las fuentes de ruido más importantes en el área occidental de la ciudad. Este estudio permitió identificar las carreteras principales como una importante fuente de ruido en la ciudad, posiblemente debido principalmente al tráfico de vehículos pesados en el interior. Los niveles máximos y dañinos de sonido alcanzan valores de aproximadamente 85 dB en los lugares mencionados (Av. Ciudad de Cali, Av. Cll 13 vías arteriales y Salitre - Estación El Greco Transmilenio), excediendo los límites permitidos de 75 dB (A) de acuerdo con las normas de regulación de las autoridades ambientales locales.

Palabras Clave: Contaminación acústica, ruido ambiental, salud pública, medición sana, políticas ambientales.

Introduction

New advances in sciences and technology have large impacts in the society. Those impacts go through economic, cultural, health and social issues. However, progress also entails some significant drawbacks that would be preferably avoided, or at least minimized. One such case is noise pollution, whose importance as stressing, and possible even dangerous, agent in human life has come to be recognized in the last decades (Barrigón Morillas, Gómez Escobar, Méndez Sierra, Vílchez Gómez, & Trujillo Carmona, 2002; de Noronha Castro Pinto & Moreno Mardones, 2009; Hunashal & Patil, 2012; Silva & Mendes, 2012; USEPA – US Environmental Protection Agency, 1978; Zannin, Diniz, & Barbosa, 2002). Regarding noise pollution in large cities several impacts in human health, and finally public health, have been clearly identified and studied. Also impacts

of noise levels over animals and local species such as birds have been identified before (Francis, Kleist, Ortega, & Cruz, 2012; Istrate, Oprea, Rada, & Torretta, 2014; Ortega, 2012).

The effect of noise pollution in different location all over the globe deeply depends of several variables: level of development, total population and population density, kind of activities involved, culture, local habits, geographic location, soil usage, etc. the factor described above make necessary to characterize carefully the site and the situation under the study (Barrigón Morillas et al., 2002; Fiedler & Zannin, 2015; Silva & Mendes, 2012).

Bogotá is the capital of Colombia, located in the center of the country. It is one of the densest cities in Colombia with 10,700,000 inhabitants

in the metropolitan area, in a surface extension of 1,580 km²(DANE, 2006). Bogotá is a very variable city in terms of economical and social level location, and land use of in the city planning (Ramírez et al., 2018). Even when Bogotá has regulations and public administration entities in charged of monitoring the noise pollution emissions (Secretaria Distrital de Ambiente, 2006, 2010a, 2010b), there is concern about the actual situation of the city in noise levels aspects and other contamination forms of the environment (Ramírez, Mura, & Franco, 2017).

Factors mentioned above makes Bogotá a very complex system to be taken as object of study in any technical field, in this case sound and noise pollution. Due the size of the city, in this study the western area of the city was analyzed through sound measurements in 7 different selected types of areas, involving commercial, transportation, industrial, residential and arterial roads.

The main goal of this study was to define the noise levels in the western region of the Bogotá capital city for 3 types of locations: commercial (Gran estación and Diverplaza), transportation (Salitre- El Greco Transmilenio station), industrial areas, residential and arterial roads (Av. ciudad de Cali and Av. Cll 13). Other important target of this research was to identify the most important noise sources in the locations established for the study founding the base for further researches and stimulating actions by the local public regulation institutions.

This research was performed using measurements for the 7 selected locations of the city region during 30 minutes, according to the established procedures by the local authorities standards, for selected dates (Secretaria Distrital de Ambiente, 2006). Sonometer CIRRUS 162-B CLASS 2 was used.

This first study allowed to identify the arterial roads as one important source of noise in the city, possibly mainly due to the traffic or heavy vehicles inside the city. The maximum harmful levels of sound reached values of about 85 dB in the mentioned locations (Av. Ciudad de Cali, Av. Cll 13 arterial roads and Salitre – El Greco Transmilenio Station) exceeding the permitted limits of 75 dB(A) according to the environmental local authorities regulation standards (Francis et al., 2012; ISO, 2003, 2007, Secretaria Distrital de Ambiente, 2006, 2010a, 2010b; USEPA – US Environmental Protection Agency, 1978).

Methods

There are extensive studies regarding methods to study the sound levels in cities with different characteristics. In this case the size of the City makes necessary the use of an specific approach suggested by Brown and Lam (Brown, 1991; Brown & Lam, 1987). This strategy was described based on the selection of sampling points using a suitable classification of the urban noise and the location where it will be measured.

Approach mentioned has been implemented successfully in previous researches (de Noronha Castro Pinto & Moreno Mardones, 2009; Hunashal & Patil, 2012).

Based on this principle of sampling for the development of the study, the western area of the city was selected and inside this area 7 places were chosen as sampling points for the measurements during 30 minutes, according to the established procedures by the local authorities standards, for selected dates (Secretaria Distrital de Ambiente, 2006). These standards establish a maximum noise level allowed according to the local soil usage, for the areas under study the maximum value is 75 dB(A), and the minimum measuring time is 15 minutes.

Data processing was performed using Python® version 3.6 (Anaconda Python, n.d.). The Spyder IDE was the graphical user environment for the code development.

Places

Based on the method described before for the noise study, the 7 sampling sites are shown in

(Figure 1) and their coordinates are tabulated in (Table 1). The selected sampling points were located in zones of normal exposure of people. Also, all locations are in exterior-public sites with a great people traffic and concurrency in normal hours during the day, and particularly in the sampling hour.

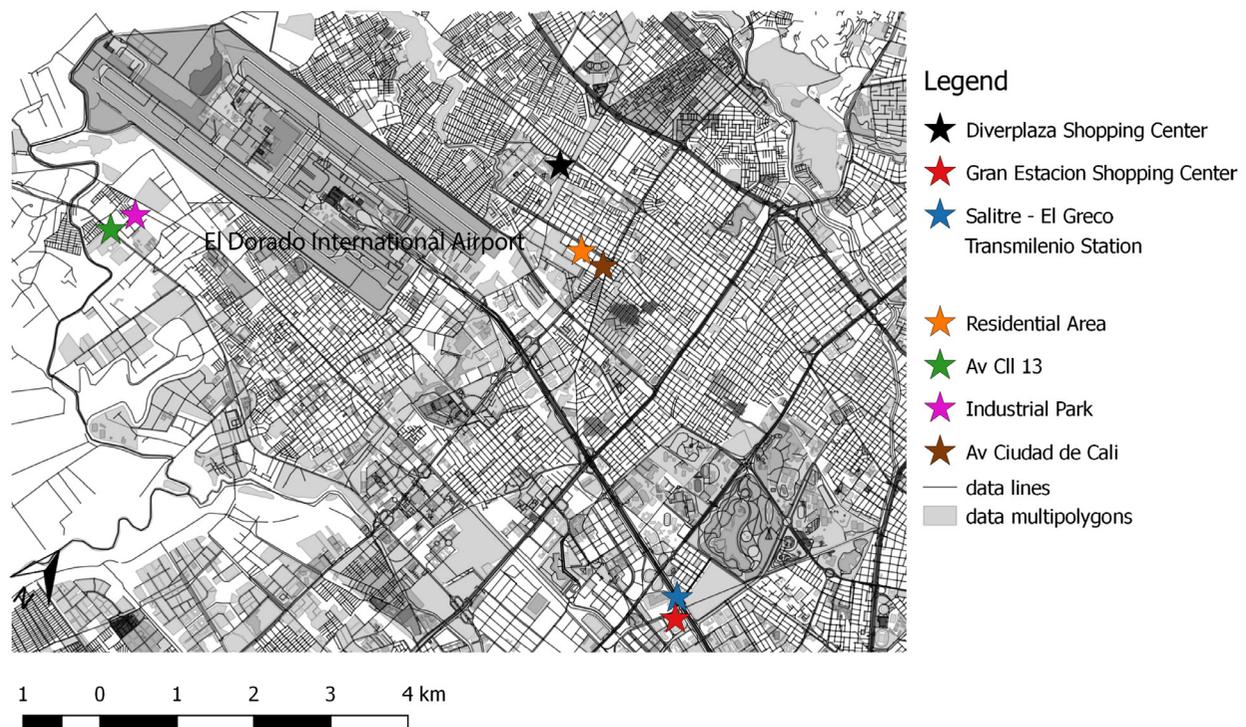


Figure 1. Measuring points location for this study according to the analysis strategy defined (This Research).

Measuring instrument

The sonometer used for this study was the CIRRUS 162-B CLASS 2 (CIRRUS Research plc, 2017). Universidad Nacional de Colombia supplied the measuring equipment. Technical personal from the institution performed the calibration of the equipment in January 2017, using the kit provided by CIRRUS.

Measuring procedure

The instrument was put on the tripod for data collection (Figure 2). All measurements were made on Monday at 11:00 am per 1800 seconds (30 minutes). Description about the sites is summarized in Table 1.



Figure 2. Measuring instrument in Ciudad de Cali Avenue (CIRRUS Research plc, 2017)

Table 1. Measured sound data summary, and geographical locations.

Location	Coordinates		Date	LAeq dB(A)			
	Lat	Long		mean	Max	Min	Std. Deviation
Av. Ciudad de Cali arterial road	4.68906	-74.11007	16/01/2017	72.465	85.140	56.340	5.582
Industrial area	4.69494	-74.16471	23/01/2017	52.224	61.930	47.350	2.455
Av. Calle 13 arterial road	4.69327	-74.16759	30/01/2017	75.124	83.100	66.220	3.496
Residential Area	4.69080	-74.11261	6/02/2017	52.640	71.630	45.160	5.392
Salitre – El Greco Transmilenio Station	4.65060	-74.10145	13/02/2017	76.823	87.130	65.930	4.160
Commercial area Gran Estación Shopping Center	4.64816	-74.10165	20/02/2017	62.300	73.000	56.320	3.385
Commercial area Diverplaza Shopping Center	4.70073	-74.11513	27/02/2017	69.952	81.260	58.450	3.675

Results and discussion

The data collected in the 7 different sites along the western region of Bogotá is summarized in (Table 1). The data considered corresponds to the LAeq levels measured by the instrument. Data saved by the memory log of the measurement instrument have a temporal resolution of 1 s.

The data collected showed notable mean and maximum high levels for arterial vehicular

roads and the transportation station (Ciudad de Cali Avenue, Cll 13 Avenue arterial roads and Salitre – El Greco Transmilenio Station). The mean levels were above 70 dB for LAeq, which are normal levels of noise in public sites. Even so, for these locations mentioned the maximum sound levels reached values of 85.140, 83.100 and 87.130 dB(A) respectively, that means these places are reaching harmful levels of noise with possible sensible effects in the public health of the population of this part of the city.

The peaks of the sound levels during the data sampling can be better observed graphically, the (Figure 3) (Anexo) shows the time series of the LAeq sound levels for the 7 sampling sites. There are notable peaks observed in all sites, but the scale of the arterial vehicular roads and the transportation station mentioned have considerable higher values of maximum levels. These observations permit to correlate the presence of vehicular activity with high noise levels, even with greater impact than the industrial area in this case.

The qualitative comparison of the noise levels in the sampling points is shown in the contour maps of noise levels (Figure 4). Again, the levels of noise for the locations mentioned before were higher in comparison as expected. The commercial and residential areas had normal sound levels, even when the noisy locations are close in spatial terms.

In this case, the industrial area had relatively low noise levels possibly due to low working intensity in the plants the day of the measurement. It is natural to expect higher sound levels in this type of area, further studies and measuring campaigns can bring additional data and results to take better planning decisions about the location of this kind of areas and its impacts. In addition, studies indoor in the commercial areas are necessary to analyze the particular situations inside shopping centers in Bogotá.

The arterial road in this study have the particular feature of high proportion of heavy vehicles in traffic. This aspect makes important the roads in terms of noise and atmospheric pollutants to the areas inside the city, and the effects in the population (Fiedler & Zannin, 2015; Pathak, Tripathi, & Mishra, 2008; Ramirez & Dominguez, 2013)



Figure 4. Sound Maps (LAeq units in dB(A)): a) Ciudad de Cali Avenue road and Residential area, b) Industrial area and Cll 13 Avenue road, c) Transmilenio Salitre - El Greco station and Commercial Area Gran Estacion shopping center, d) Commercial area Diverplaza shopping center.

Conclusions

The sound levels of 7 different places were measured and summarized in this study. The sound levels measured were compared between them and with the harmful levels standard regulation values as 75 dB(A) (Secretaría Distrital de Ambiente, 2006), and its implications in human health. The arterial vehicular roads and the transportation station (Ciudad de Cali Avenue, Cll 13 Avenue arterial roads and Salitre – El Greco Transmilenio Station) were the location with higher levels of noise, in terms of peaks for the maximum and mean measurements. For these locations, the maximum sound levels reached values of 85.140, 83.100 and 87.130 dB respectively, the mean values are about 70 dB lightly under the maximum allowed level.

For data collected, standard deviations between 3.385 and 5.582 dB(A) were obtained. These variability means that the sound levels trend to be stable at the mean values for each dataset. The location with the higher variability is the residential area, and the location with the lower variability is the commercial area.

The maximum values measured of about 85 dB are high enough to be harmful and affect negatively people health, and therefore affect the public health aspects of the city. These high levels can be related with the strong presence of heavy vehicles in the traffic roads inside the city. The regulations of heavy vehicles traffic inside the city must be regulated to mitigate problems of noise pollution taking this study as part of the technical evidence, and other issues regarding atmospheric contamination can be improved as well. In addition, negative impact of high noise levels in public health will generate economic losses to public budget of the city.

Further studies in another city places are required to observe and understand the

complete phenomena in relation with noise pollution. This study was developed in outdoor environments, will be also important to investigate about noise pollution indoor for many common environments of the city, such as: shopping centers, schools, hospitals, offices, and bus terminal stations. The results obtained can be useful for public administration entities in the future to make a suitable planning of the use of different areas inside the city and in its surroundings.

El Dorado International Airport was not considered in this case, but it will be interesting to consider the contribution of aircraft traffic in the situation of the city noise pollution nowadays and in the future.

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Conflicto de Intereses

Los autores declaran no tener ningún conflicto de intereses