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Study of noise pollution in the area surrounding Delta Avenue through the application of Geographic Information Systems. (August 2022)

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***Abstract*— The present research work evaluated the level of noise pollution in the area surrounding the University of Guayaquil, prioritizing the activity on Delta Avenue. The study was placed in the hourly analysis of morning, afternoon, and night, where it is observed that among the possible causes is the agglomeration of vehicles responsible for the emission of noise due to the excessive use of horns. The methodology focuses on the qualitative and quantitative analysis of the problem using participant observation and noise capture through the application of a sound level meter (dB), exerting groups of influence in certain areas. According to the results, most points in the study area exceed the maximum permissible noise limits. In addition to monitoring, a noise map showing the sound pressure intensities at each point was made using ArcGIS software. It is concluded that noise emissions are in range from very annoying to very loud, for which strategies that prevent the direct passage of noise must be used to maintain the noise state to intrusive and unnoticed, which helps concentration and development. of study activities.**

Keywords: Noise pollution, monitoring, noise map, sound level meter

I. Introduction

THE ear is one of the main human sensory organs, and its function is to capture sound waves by transmitting them to the brain, where their identification is called sound. This procedure allows us to listen and determine to send signals to the brain and thus be able to carry out conversations between people.

If an individual is exposed to sound pressure levels below 70 dB it does not cause hearing damage, but if it is at levels above 85 dB it is potentially dangerous (85 dB is like the noise produced by heavy vehicles on a busy avenue) [1].

The main cause of noise pollution in the urban population is vehicular traffic, given this scope institutions such as the World Health Organization (WHO), specified that noise pollution is one of the three main environmental problems in the world. Ecuador is no exception, Guayaquil is one of the most developed and populated cities and therefore generates annoying noises, for example, on any road in Guayaquil, a set of noises is perceived: horns, engines, street vendors, etc.

The present research will be carried out in the surroundings of Av. Delta, located in the city of Guayaquil, the objective is to determine the level of noise pollution in the area and suggest solutions to this problem.

II Materials and Methods

In this project, the study of noise pollution on Delta Avenue is carried out. The measurements of the noise levels will be recorded at the established strategic points and the simulation will be implemented that allows us to see how the noise is distributed by this sector. Delta Avenue has a special situation of noise pollution since it is located in the vicinity of the University of Guayaquil [2]. When talking about its flow of traffic, this road is especially noisy since it circulates a large volume of traffic, and the intense flow of urban buses and cars is common. In addition, Delta Avenue connects with the busy Kennedy Avenue and Tungurahua and Alejo Lascano streets, it is for these reasons that the experimental and simulated measurement points have been strategically

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distributed to consider the effect that these roads produce in the area, in addition to taking other measurement points in secondary streets that represent the least noisy areas of the sector so that noise levels can be compared.

- **Location:** Area surrounding Delta Avenue.
- **Point of Reference:** University of Guayaquil Faculty of Architecture, Faculty of Administrative Sciences, Auditorium of Medical Sciences.
- **Types of Land Use:** Multiple Residential, Commercial, Educational
- **Traffic level:** The traffic level at this point is moderately high.
- Pavement Conditions: The pavement in this sector is in good condition, there is no major structural damage that contributes to the increase in noise levels.
- **Noise Emission Spotlights:** The main source of noise is at the intersection of Delta Avenue and Kennedy Avenue, this is because on Delta Avenue there is a large influx of traffic, both light vehicles, and heavy vehicles.

About 5,000 students from the University of Guayaquil needed spaces with shadows, whereabouts, vegetation, and furniture, so experts from the Faculty of Architecture of the University of Guayaquil designed alternative scenarios for the area. A railing was installed in the middle of the central parterre to regulate the passage of students and passers-by and to keep the road tidy and prevent accidents, as an urban planning and pedestrian protection strategy [3]. The bike path extends for 700 meters from the faculty of dentistry, at the height of Av. Kennedy, to the Malecón del Salado, along Quisuis street [4].

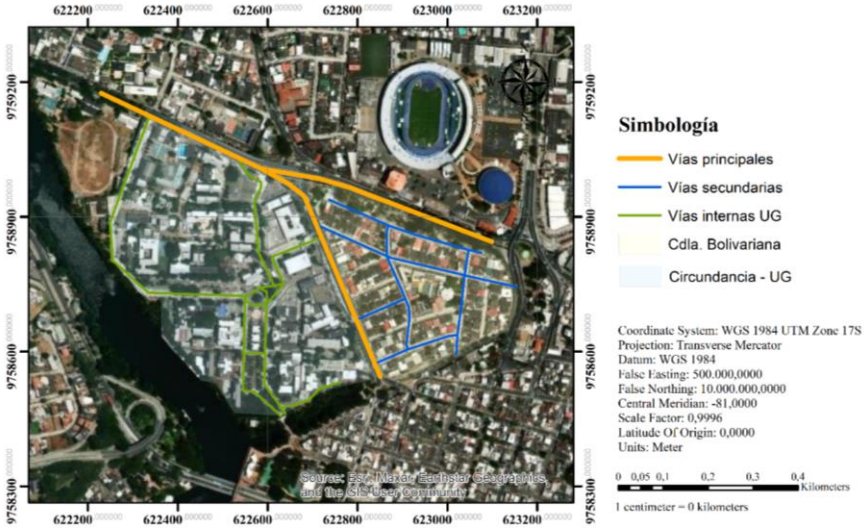

Fig. 1. Current plan study area. Note: Prepared by the authors

Theoretical foundation. -

Noise as a pollutant:

According to the World Health Organization, noise is generated when sound exceeds 65 decibels (dB). Therefore, noise becomes harmful when it exceeds 75 dB and when it is more than 120 dB it is already defined as painful. The WHO recommends that the population should not exceed 65 dB during the day and at night should not exceed 30 decibels [5]. One aspect that contributes to the noise problem is the age of the cities because their original design was not intended to withstand today's traffic. Buildings and narrow streets encase the noise and amplify it.

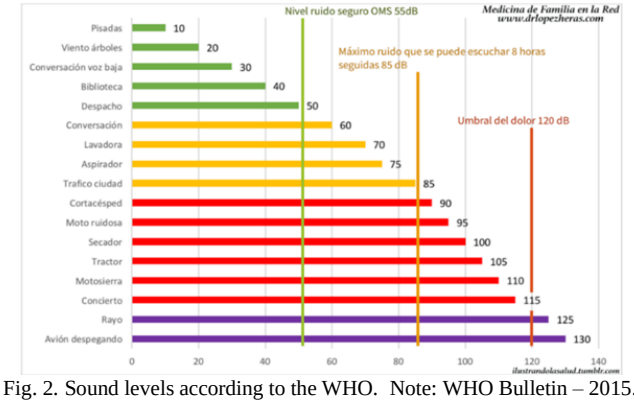

Fig. 2. Sound levels according to the WHO. Note: WHO Bulletin – 2015.

- **Problem Determination: Causes and Effects**

Causes: The main cause of environmental noise that is detected in Delta Avenue is vehicular traffic, in the early hours of the day a large number of vehicles are observed heading to their work activities [6], where it is frequently observed imprudence of buses that do not comply in receiving and leaving passengers at the whereabouts, so there is excessive use of the horns or horns of the automobiles; Other emitters of ambient noise are street vendors.

Effects: Nowadays most people are not aware of noise pollution, because the sound is not visible and therefore does not take importance, without knowing the effects that may lead in the future.

Below, the table with the noise levels and the effects produced by noise pollution on the population is presented.

TABLE 1
SOUND LEVELS AND HUMAN RESPONSE

Characteristic sounds	Sound pressure level (dB)	Effect
Rocket launch area (without hearing protection)	180	Irreversible hearing loss
Runway operationAnti-aircraft siren	140	Painfully strong
Airplane take-off	130	
Thunder	125	
Jet takeoff (60 m)Car horn (1 m)	120	Maximum vocal effort
Pneumatic hammerRock Concert	110	Extremely strong
Pickup truckFirecrackers	100	Very strong
Heavy truck (15 m)Urban transit	90	Very annoying Hearing damage (8 Hrs)
Alarm Clock (0.5 m)Hair dryer	80	Annoying
Noisy RestaurantHighway TrafficBusiness Office	70	Difficult phone use
Air conditioning normal conversation	60	Intrusive

Note: Permissible limits of ambient noise levels for stationary sources, moving sources, and vibrations. (MATTE, 2012)

According to this initial parameter *(See table 1)*, determinants are generated for each zone and its usual noise level, which leads to an acceptance that these noise levels will always exist as determinants of the zone, being framed in schedules as shown in Table 2:

TABLE 2
MAXIMUM PERMISSIBLE NOISE LEVELS ACCORDING TO LAND USE

Type of zone according to its land use	Equivalent sound pressure level NPS eq (dBA)	
	From 06H00 to 20H00	From 20H00 to 06H00
Hospital area Educational zone	45	35
Residential area	50	40
Mixed residential area	55	45
Shopping area	60	50
Mixed commercial zone	65	55
Industrial zone	70	65

Source: Permissible limits of ambient noise levels for stationary sources, mobile sources, and vibrations. (MATTE, 2012)

The study area is framed as a mixed commercial zone, mixed residential and educational since it borders housing areas such as the Bolivarian Citadel, commercial areas such as Delta Avenue, and an educational zone comprised by the University of Guayaquil. Therefore, an additional determinant must be considered, such as the level of vehicles generated on Delta Avenue *(See table 3).*

TABLE 3
MAXIMUM PRESSURE LEVELS FOR MOTOR VEHICLES

Vehicle category	Description	Maximum NPS (dBA)
Motorcycles	Up to 200 cm^3 Between 200 and 500 cm^3 Over 500 cm^3	80 85 86
Light vehicles	Light with a gross weight of less than 2,500kg, except those with 3 or fewer wheels.	88
Passenger vehicles	Van with a capacity for 8 to 16 passengers. Bus, with a capacity for 17 to 28 passengers. Bus, with a capacity for 29 to 55 passengers.	88 90 90
Cargo vehicles	Net weight of more than 3,500 kg	90

Source: Technical Standard establishing permissible ambient noise limits for stationary and mobile sources. (MATTE, 2012)

I. METHODOLOGY

The research was conducted on environmental noise measurement procedures, as well as studies that provided information on health problems caused by noise.

To check whether or not the noise in the study area exceeds the level allowed by Ecuadorian legislation [7], an application of a sound level meter was used, which allows the sound pressure level to be measured. Using the built-in microphone to measure the sound volume in decibels (dB) and presents the samples on the graph. In our project, the application that was used is SOUND LEVEL METER.

Determination of measuring points

To evaluate noise in the area, it was decided to specify different points in the area studied, to obtain data on sound pressure levels of each evidence in different sites of the university citadel of the University of Guayaquil and along Delta Avenue.

TABLE 4
DETERMINATION OF POINTS SOUND MEASUREMENT BY COORDINATES

Coordenadas UTM WGS 84 ZONA 17S		
Puntos	**X**	**Y**
Punto 1	622848,58108	9758548,30002
Punto 2	622799,66680	9758619,44767
Punto 3	622766,00702	9758706,25342
Punto 4	622716,44777	9758790,56516
Punto 5	622706,71207	9758882,48955
Punto 6	622656,92046	9758978,76704
Punto 7	622532,64394	9759022,56138
Punto 8	622405,83426	9759081,70764
Punto 9	622323,98692	9759049,66795
Punto 10	622273,54628	9758926,27408
Punto 11	622291,41262	9758767,37105
Punto 12	622373,00066	9758635,93551
Punto 13	622459,52859	9758545,79005
Punto 14	622441,43152	9758743,05928
Punto 15	622567,70805	9758873,44094
Punto 16	622616,87826	9758801,27816
Punto 17	622576,92856	9758712,58599
Punto 18	622570,32392	9758619,58243
Punto 19	622569,66295	9758507,01789
Punto 20	622627,90296	9758462,72031
Punto 21	622728,91010	9758513,41907

Data collection

Monitoring in the study area was carried out from August 16 to August 27 of this year. Spot measurements of 3 minutes were made at each of the measurement points. To comply with the noise analysis, each of the points was analyzed at the following

times: from 08h00 to 09h00, from 13h00 to 14h00, and from 19h00 to 20h00, which are considered the hours of greatest vehicular circulation.

The construction of tables was carried out in which to summarize the collected data, recording the UTM coordinates and the time of measurement of each of the points. After extracting the data from the sound level meter, the data was recorded in the Excel program, to link this data to the attributes of the points in the ArcGis program and to obtain the noise maps of each day, using the Buffer geoprocessing tool. The graphic results obtained are presented below.

II. RESULTS

It was possible to measure and evaluate the noise levels at different points of the surrounding AV. Delta, which was used for the elaboration of the maps, you can observe the sites with the greatest noise pollution, whose sounds exceed the optimal limits for study centers such as the campus of the University of Guayaquil.

TABLE 5
DATA OBTAINED – SCHEDULE 08H00 TO 09H00

Points	UTM coordinates		Start Time	End Time	Measurement time	Lmax (dBa)	Lmin (dBa)	NPS (dBa)
	X	And						
P01	622848	9758548	08:39	08:42	3 min	69.70	68.40	69.20
P02	622799	9758619	08:45	08:48	3 min	85.00	63.00	74.00
Q03	622766	9758706	08:51	08:54	3 min	75.60	65.60	68.20
P04	622716	9758790	08:54	08:57	3 min	73.10	62.60	65.60
P05	622706	9758882	08:52	08:55	3 min	88.00	61.00	77.00
Q06	622656	9758978	08:41	08:44	3 min	86.00	67.00	77.00
Q07	622405	9759022	08:20	08:23	3 min	86.00	71.00	80.00
P08	622405	9759081	08:11	08:14	3 min	86.00	64.00	78.00
P09	622323	9759049	08:32	08:35	3 min	85.00	62.00	82.00
Q10	622273	9758926	08:06	08:09	3min	80.00	43.00	60.00
Q11	622291	9758767	08:10	08:13	3 min	53.78	52.17	52.25
Q12	622373	9758635	08:16	08:19	3 min	53.20	51.50	52.60
Q13	622459	9758545	08:21	08:23	3 min	63.80	58.90	63.50
Q14	622441	9758743	08:13	08:16	3 min	57.50	54.10	55.40
Q15	622567	9758873	08:32	08:35	3 min	54.46	48.56	51.05
Q16	622616	9758801	08:27	08:30	3 min	61.70	57.9	60.20
Q17	622576	9758712	08:22	08:25	3 min	58.70	54.30	56.50
Q18	622570	9758619	08:18	08:21	3 min	58.50	55.50	58.00
Q19	622569	9758507	08:25	08:28	3 min	59.40	56.70	58.10
Q20	622627	9758462	08:29	08:32	3 min	53.50	51.00	51.50
Q21	622728	9758513	08:34	08:37	3 min	56.80	53.50	54.30

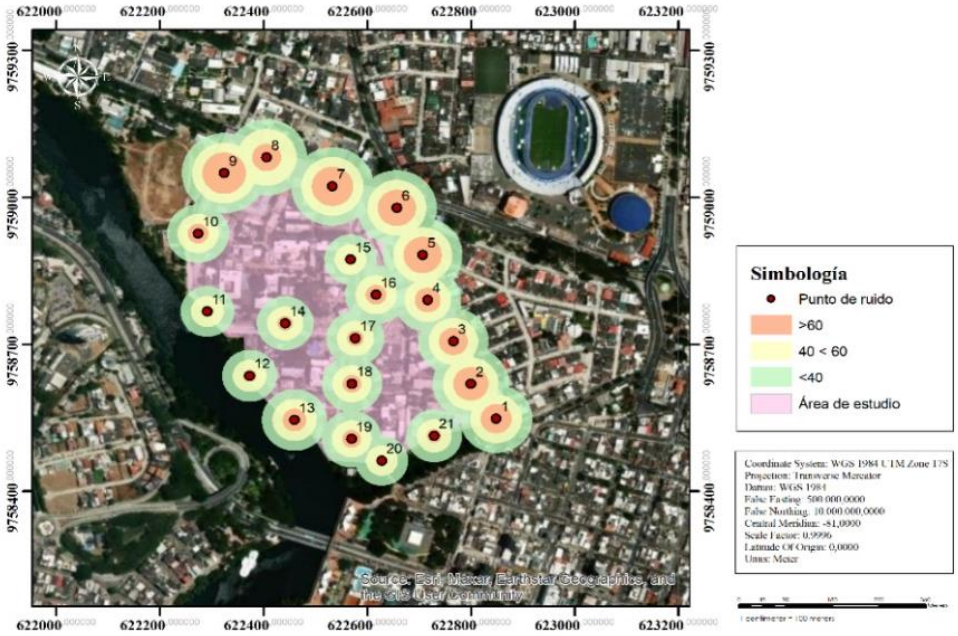

Fig. 3 Diagram of results. Prepared by: Authors.

The methodology used for data collection allowed us to obtain specific values for each measurement point, when taken for periods of 3 minutes, high noise levels were captured in areas where there is greater vehicular circulation.

- It can be observed in the morning from 8h00 to 09h00, that points 01 to point 09 present a higher noise level, especially in points 02 and 05 to 10 that exceeds 80 dB, exceeding the maximum permissible levels. since there is an accumulation of noise generation factors: traffic, bus stop, the concentration of students and workers, and also because the streets are narrow.

TABLE 6
DATA OBTAINED - TIMETABLE 13H00 TO 14H00

Points	UTM coordinates		Start Time	End Time	Measurement time	Lmax (dBa)	Lmin (dBa)	NPS (dBa)
	X	And						
P01	622848	9758548	13:00	13:03	3 min	68.40	69.90	67.90
P02	622799	9758619	13:05	13:08	3 min	85.00	55.00	79.00
Q03	622766	9758706	13:45	13:48	3 min	57.00	81.00	67.00
P04	622716	9758790	13:50	13:53	3 min	74.80	70.60	73.10
P05	622706	9758882	13:05	13:08	3 min	88.00	70.00	80.00
Q06	622656	9758978	13:16	13:19	3 min	86.00	61.00	80.00
Q07	622405	9759022	13:23	13:26	3 min	84.00	73.00	78.00
P08	622405	9759081	13:30	13:33	3 min	83.00	71.00	78.00
P09	622323	9759049	13:40	13:43	3 min	85.00	61.00	76.00
Q10	622273	9758926	13:48	13:51	3 min	84.00	72.00	77.00
Q11	622291	9758767	13:12	13:15	3 min	53.10	48.61	50.32
Q12	622373	9758635	13:18	13:21	3 min	68.00	61.20	66.10
Q13	622459	9758545	13:22	13:25	3 min	61.70	58.20	58.30
Q14	622441	9758743	13:13	13:16	3 min	57.20	54.30	55.40
Q15	622567	9758873	13:32	13:35	3 min	46.02	52.25	48.91
Q16	622616	9758801	13:27	13:30	3 min	61.30	56.30	58.00
Q17	622576	9758712	13:22	13:25	3 min	60.80	53.80	56.00
Q18	622570	9758619	13:18	13:21	3 min	63.90	54.70	58.80
Q19	622569	9758507	13:27	13:30	3 min	60.90	56.70	58.00
Q20	622627	9758462	13:31	13:34	3 min	55.30	53.10	54.10
Q21	622728	9758513	13:36	13:39	3 min	55.80	53.40	54.00

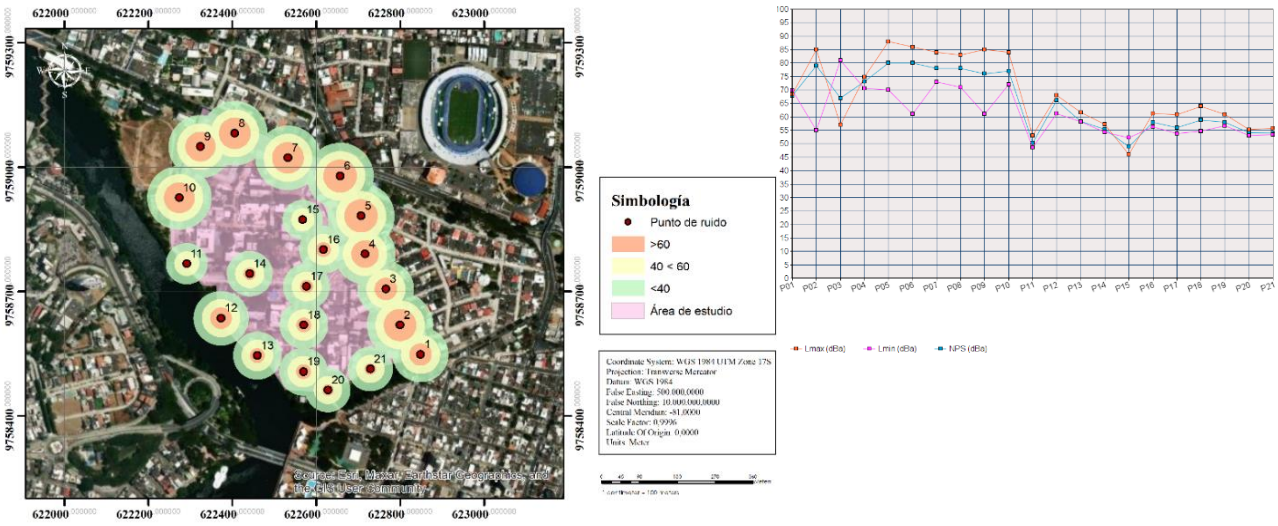

Fig. 4 Diagram of results. Prepared by: Authors.

- In the afternoon, a high noise level can also be observed on Av. Delta and Kennedy Avenue, all this is due to the large number of vehicles that pass through the avenue, which also affects the traffic of aircraft in that area and at this time.

- **TABLE 7**
- **DATA OBTAINED – TIMETABLE 19** H00 to **20H00**

Points	UTM coordinates		Start Time	End Time	Measurement time	Lmax (dBa)	Lmin (dBa)	NPS (dBa)
	X	And						
P01	622848	9758548	19:30	19:33	3 min	86.00	77.00	82.00
P02	622799	9758619	19:38	19:41	3 min	85.00	62.00	82.00
Q03	622766	9758706	19:43	19:44	1 min	84.00	64.00	77.00
P04	622716	9758790	19:00	19:03	3 min	83.00	67.00	74.00
P05	622706	9758882	19:05	19:08	3 min	83.00	56.00	71.00
Q06	622656	9758978	19:12	19:15	3 min	87.00	66.00	82.00
Q07	622405	9759022	19:18	19:21	3 min	84.00	67.00	75.00
P08	622405	9759081	19:25	19:28	3 min	87.00	65.00	78.00
P09	622323	9759049	19:33	19:36	3 min	86.00	67.00	76.00
Q10	622273	9758926	19:42	19:45	3 min	87.00	65.00	75.00
Q11	622291	9758767	19:12	19:15	3 min	70.80	60.30	65.40
Q12	622373	9758635	19:18	19:21	3 min	59.90	53.10	57.00
Q13	622459	9758545	19:22	19:25	3 min	66.80	60.10	60.90
Q14	622441	9758743	19:13	19:16	3 min	74.70	59.80	65.70
Q15	622567	9758873	19:32	19:35	3 min	66.70	62.60	64.40
Q16	622616	9758801	19:27	19:30	3 min	67.70	65.30	66.10
Q17	622576	9758712	19:22	19:25	3 min	67.50	54.10	61.40
Q18	622570	9758619	19:18	19:21	3 min	61.00	53.90	57.70
Q19	622569	9758507	19:27	19:30	3 min	66.20	62.40	64.50
Q20	622627	9758462	19:09	19:12	3 min	84.00	74.00	77.90
Q21	622728	9758513	19:15	19:18	3 min	88.00	77.00	82.00

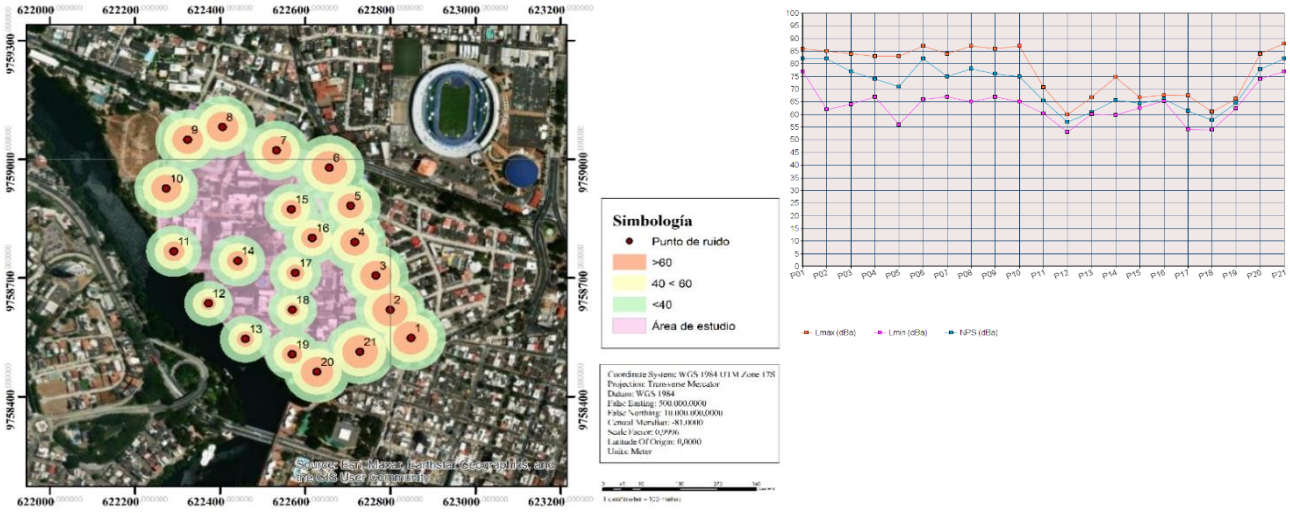

Fig. 4 Diagram of results. Prepared by: Authors.

- The night day presents a greater record of data exceeding the permissible limits, in the areas near the streets and the sector near the Malecón del Salado, as it is a very active area at night, with music and many vehicles traveling around.

The evaluation carried out in the study area allowed for the formulation of different observations on the sound pressure levels identified in the monitored points, being able to identify the spaces that register to exceed the maximum permissible levels of the standard. For this reason, there is a need to generate a control proposal to reduce the impact of sound effects on the activities of the sector. Initially, it could be decided to impart through the media the existing concerns about noise pollution to students and other citizens who develop activities in the area studied, to sensitize and raise awareness among people, especially drivers, who can contribute to reducing noise levels.

Because one of the main factors of noise pollution in the study area is caused by traffic produced on Delta Avenue, different proposals can be presented to reduce the existing problem. A viable option is to contact the Municipal Transit Authorities, and propose the placement of noise reduction signs along Delta Avenue considering the statutes that sanction the use of elements that cause noise pollution, so that, in case of drivers violate the signal or resort to the uncontrolled use of the horn, sanctions may be

presented. In addition, it is important to comply with the maximum speed limits, since regularly vehicles that exceed 40 km / h speed reach the noise of the tires is greater than the noise of the engine.
The construction of barriers or absorbent acoustic panels contributes to reducing the harmful effects of noise on the population. These can be placed on the bridge that passes through av. Kennedy, as it would help reduce the high levels of noise generated in that area. You can choose to place acoustic panels replacing the metal railings that divide
the double track of Delta Avenue and increase vegetation in areas near the street to dissipate sound waves.

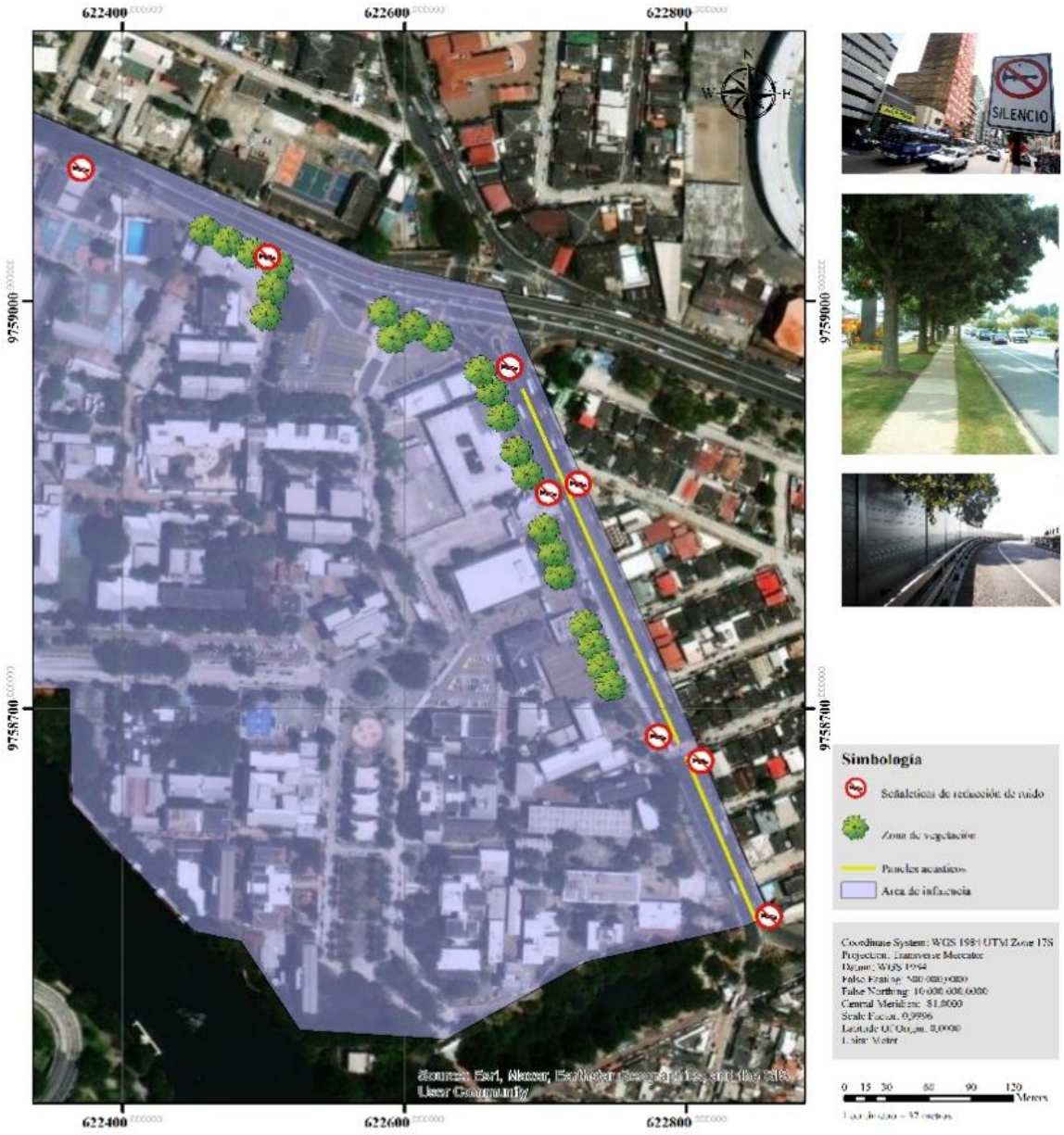

Fig. 3. *Proposed plan resulting from field measurements*

III. DISCUSSION

The evaluation carried out in the study area allowed for the formulation of different observations on the sound pressure levels identified in the monitored points, being able to identify the spaces that register to exceed the maximum permissible levels of the standard. From this analysis the following discussions are obtained:
The high levels of sound pressure are mainly the product of the high vehicular traffic in the sector, caused by the excessive use of the horn, the continuous passage of light, heavy vehicles, buses, and motorcycles, and their increase in peak hours.

From the data obtained it can be determined that the points near Delta Avenue exceed the maximum permissible limit, that is, they exceed 60 decibels, which can cause the inhabitants of the sector, students, and staff of the University of Guayaquil consequences in their state of health, increased stress, and lack of concentration in their daily activities.

IV. CONCLUSION

In the results obtained through the measurements with the Sonometer application, it was confirmed that most of the points exceed the established levels, especially the monitoring that represents the direct area, point 05 at the intersection of Delta Avenue of UTM coordinates, 622706 X, 9758882 Y, is the most critical where the sound pressure level registered a value of 88 dB in the morning and afternoon.

During the field measurements, it was possible to observe the main activities that affect the increase of noise pollution in the studied area, among these, the main factor was vehicular traffic, especially in the peak hours since the arrival and departure of students to the university citadel and workers of the sector increases traffic in the area; consequently, the use of the horn due to the traffic jam.

Another factor is the commercial activities of the sector, especially in the afternoon. In addition, it was evident that during the afternoon and night the traffic of airplanes in this area increases, which causes a great increase in noise in the university citadel.

The development of research was carried out through the monitoring of the points located in the vicinity of Delta Avenue, observing high levels at certain points of the road, as shown in the tables, noise pollution is present in the daily activities of people and due to this proximity, people are not aware of the damage to their health until they exceed their comfort level. To improve or provide possible solutions to noise pollution, some proposals have been made to mitigate this pollution problem and improve the quality of life of those who travel along this avenue.

This study aims to formulate future lines of research in which citizens can be made aware of the problems of noise pollution, where they can guide on measures to avoid the proliferation of noise sources. Mainly due to the lack of information on the subject to be discussed and very little interest on the part of the authorities.

As a second axis maintain vehicles for proper operation and maintain respective checks by the authorities so that technically defective vehicles do not circulate. This type of research can support future architecture-related research to develop design strategies that help mitigate the impact of sound pressure levels in the area.

THANKS

Special thanks to the group of researchers that make up this team, where it has been possible to obtain concise, coherent research with a level of experimentation effectively analyzing the territory that, thanks to the opening of the University of Guayaquil and the participants of the study, have come to obtain the results.

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Our research group is a multidisciplinary group interested in developing new technologies within the field of architecture and territorial planning to provide an optimal solution to problems within urban planning, construction, city development and people's ways of living. Our group is made up of three academics and we have extensive experience in executing research projects published in high-impact journals and books, laboratory, experimental, longitudinal studies, and qualitative approaches. And how many. These approaches have allowed us to develop a linear knowledge model that improves the ability to understand and manage new technologies to improve the quality of life and sustainability in the territory.