TRAFFIC NOISE LEVELS AT SELECTED POINTS IN METRO MANILA

Aileen U. MAPPALA   Rene Val R. TEODORO   Manuel T. APUAN
Ma. Carmen B. GERUNDIO   Merwyn Paul D. ROSTRATA   Teresita R. RONQUILLO
Seiya TAZAWA   Ma. Sheilah A. GAABUCAYAN   Hilario Sean O. PALMIANO

Training and Research Division
National Center for Transportation Studies
University of the Philippines
Diliman, Quezon City, 1101 Philippines
Phone/ Fax: (63-2) 929-0496 / (63-2) 929-0494

abstract: In line with the Metro Manila Urban Transportation Integration Study (MMUTIS) environmental surveys, sound level measurements were conducted at several points along selected major thoroughfares in Metro Manila. Monitored thoroughfares include EDSA, Taft Avenue, Roxas Boulevard, South Superhighway, Quezon Avenue and Quirino Highway, each representing unique physical, as well as traffic flow features. This paper basically presents an assessment of the sound level measurements based on current Philippine Noise Standards (PNS). It further conducts a site comparative analysis of the noise measurements to identify factors affecting noise generation and attenuation. This includes comparison of noise measurements along an intersection, road mid-block, typical urban arterial road, and expressway, under a light rail transit track, behind a wall and at varying distance away from the studied thoroughfare. Moreover, based on statistical results, this paper attempts to presents recommendations on how to abate the impact of noise in the context of traffic engineering and management.

1.0 INTRODUCTION

Noise, vibration, and air pollution are among the various environmental disbenefits attributed to road traffic particularly in urban areas. Their effects to human, property and the general environment are detrimental and must not be ignored. This paper tackles noise pollution being one of the growing concerns yet least dealt with among impacts of road traffic.

Noise, a nuisance, may be defined as any acoustical phenomenon producing a sensation perceived as disagreeable or disturbing by an individual or a group. In general, all sounds not meant to be emitted are considered noise. Noise not only disrupts activity, it also disturbs sleep, generates stress, and hamper one's ability to accomplish certain task. Apart from the permanent damage it can cause to hearing, it also has a very considerable impact on how the individual functions physiologically, psychologically and socially, both due to the required effort to adjust to noise and due to frustration resulting from the deterioration of the quality of life.

The sources of noise are varied. Many surveys, polls, and researches that had been done, apparently identify road traffic as the prime offending source of noise, particularly in terms of the number of people disturbed. Closely followed by neighborhood and aircraft noise, vehicle traffic is the main source of noise particularly in an urban area. Since the noise is very much a part of everyday life, the problem on noise has now moved to the forefront as an issue that must be resolved to the satisfaction of the public. Thus, it is necessary for highway engineers and planners to address the noise impacts by understanding the problem of noise, its generation, abatement and control. This paper is one of the pioneering studies focusing on the noise problem in Metro Manila.

2.0 THE STUDY

This study is one of the researches being conducted by the National Center for Transportation Studies in its thrust for excellence in the field of transportation and environmental research. Equipped with the state of the art traffic-attributed pollution monitoring facilities, the Center is currently conducting series of researches aimed to establish and evaluate the current environmental conditions of Metro Manila. Among others, long term goals include development of forecasting, planning and policy-making tools.

The scope of this study covers Metro Manila in general. Known as the National Capital Region (NCR), Metro Manila comprises a land area of 636 square kilometers with a growing population of approximately 9 million. Continuous urban migration, rapid population growth and expansion of urban areas that severely strain the urban infrastructure and ecology characterize the mètropolis. In particular, the supply and operation of various transport infrastructures can no longer cope with the increasing demand of efficient movement of goods and people. From 1986 to1996, the average annual increase of motor vehicle records at 8.66% outpacing the 2.3% increase of road through construction and improvement. This further contributed to the worsening road traffic congestion.

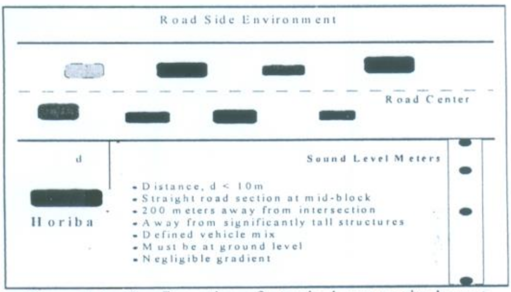


Figure 1.1 Configuration of a typical survey site layout.

The noise level survey was conducted in line with the Metro Manila Urban Transportation Integration Study (MMUTIS), simultaneous with a week-long air quality monitoring. Figure 1.1 shows a typical survey site layout showing the position of the monitoring equipment with respect to the road being studied. Though traffic volume and speed were also monitored, parameters such as vehicle age, vehicle weight and engine type were not directly considered in the conduct of the survey.

3.0 METHODOLOGY

The general objective of the study is to assess the present environmental condition of Metro Manila specifically in the aspect of noise pollution. Six representative stations located along the major thoroughfares were chosen as basis in establishing the current noise condition of the metropolis.

With distance zero (D_0) established at the boundary of the sidewalk and carriageway, noise measurements were taken simultaneous with three other sound level meters at points of different distances away from road. A 24-hour classified traffic volume count was concurrently conducted. Likewise, a continuous 5-day video footage of the influencing traffic was taken with the aid of a mango-picker-mounted camera for in-door spot speed analysis. Though this initial output will be limited to the presentation of the monitoring results, future research direction of the study envisions empirical modeling on relationships between noise levels and traffic flow parameters.

3.1 Equipment

Noise pressure levels at the selected survey stations were recorded using the Sound Level Meter (SLM) NL-04. The instrument allows conventional sound pressure level measurements and incorporation of processing functions that make it possible to determine Leq, Lx, and Lmax. SLM NL-04 is equipped with a filter unit that allows frequency analysis with 1/1 or 1/3 octave bands. It also has a windscreen that reduces wind noise by 25 dB. The acoustical influence of the windscreen on the microphone response is within ± 1.0 dB up to 12.5 kHz.

The portable instrument often mounted on a tripod is capable of storing 999 data sets, each set consisting of L_{eq}, L_{max}, L_5, L_{10}, L_{50}, L_{90}, and L_{95}. A working tripod height of 1.5 meters is consistently used all through out the surveys.

3.2 Site Selection

Looking for an ideal survey site for this particular study was not an easy job. Ideally, target road sections should be a mid-block of at least 200 meters away from a nearby intersection. Meeting such requirement will simplify the influencing road configuration since road of more than 200 meters from the monitoring site technically have negligible noise contribution. Constraint on the availability of space however led to the selection of two (2) sites near an intersection namely Taft Avenue and Quirino Highway wherein sound level meters were positioned parallel to the minor roads Gen. Malvar St. and Tandang Sora Extension, respectively. Vehicles cruising mid-block are running in a uniform mode unlike that of nearby intersections where idling is very common.

Six (6) survey sites located along different major thoroughfares in Metro Manila where chosen as monitoring stations. Atop basic requirements such as the availability of power supply, an adequate space to accommodate the equipment and relative security, other requirements in the site selection includes a heavy traffic volume and proximity to the cordon line as defined in the MMUTIS study. The following is a list of the studied thoroughfares together with a brief locational description of the monitoring site.

1. **Quirino Highway** *(Figure 3.1)*
   Survey site is located proximate to Quirino Highway corner Tandang Sora. It is in the northern part of Metro Manila. It has an annual average daily traffic of 37,762 in 1995.

2. **Taft Avenue (R-2)** *(Figure 3.2)*
   Survey site located near the Taft Avenue - Gen. Malvar St. intersection and beneath the Light Railway Transit 1 (LRT) route. Taft Avenue is also in the western side of Metro Manila. It has an annual average daily traffic of 92,826 in 1995.

3. **Quezon Avenue (R-7)** *(Figure 3.3)*
   Survey site proximate to a bridge in between Sct. Chuatoco St. and Araneta Ave. Quezon Avenue road has an annual average daily traffic of 84,771 in 1995.

4. **South Superhighway (R-3)** *(Figure 3.4)*
   Survey site is a considerable distance away from the Bicutan Interchange. South Super Highway is a major entry point through the south of Metro Manila. The annual average daily traffic of SSH is 150,034 in 1995.

5. **Roxas Boulevard (R-1)** *(Figure 3.5)*
   Located near the Cuneta Astrodome, equipment is situated at a distance parallel to Libertad Street. Roxas is in the western part of the metropolis alongside Manila Bay with an annual average daily traffic of 92,827 in 1995.

6. **Epifanio de los Santos Avenue/EDSA (C-4)** *(Figure 3.6)*
   Survey site alongside Camp Crame with equipment located inside the Camp fronting EDSA. The thoroughfare is Metro Manila's major artery with an annual average daily traffic of 158,226 in 1995.

3.3 Sound Pressure Level Measurement

The sound level meters are set at a distance of 0, 5, 15, and 35 meters from the carriageway with the microphone at right angle with the roadside. A distance of about one-meter from existing walls or buildings is maintained for each level meter. For this study, samples were taken every 10 minutes for a period of 24 hours. This coincides with the traffic volume survey conducted for future noise level modeling. However, since only hourly average is required, Equation 3.1 below was used to convert the raw data into hourly values.

$$L_{eq} = 10 \log (1/T \int 1/n \; 10^{L_i/10} \, dt) \qquad \text{Eq. (3.1)}$$

where L_i = L_{eq} value every 10 minutes
T = interval of time

The tripod height of 1.5 meters consistently used in mounting the noise level meter was based on an average ear level of Filipinos.

Figure 3.1: Vicinity Map of the Quirino Highway - Tandang Sora Survey Site

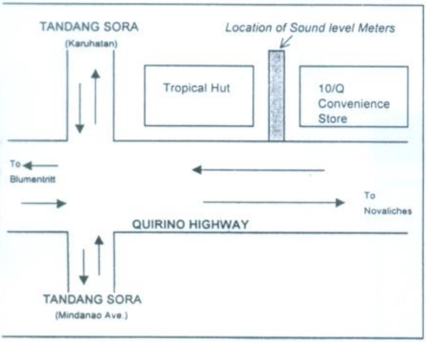


Figure 3.2: Vicinity Map of the Taft Ave. - Gen Malvar St. Survey Site

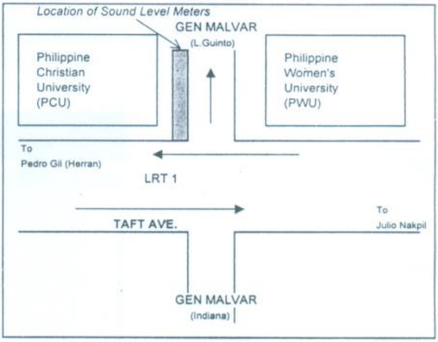


Figure 3.3: Vicinity Map of the Quezon Ave. Survey Site

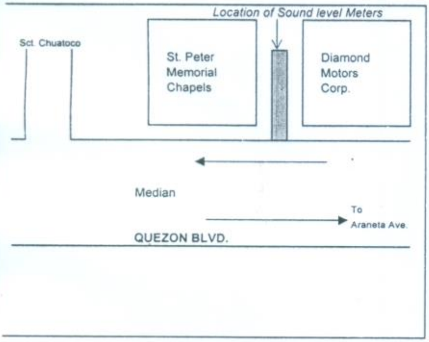


Figure 3.4: Vicinity Map of the South Superhighway (SSH) Survey Site

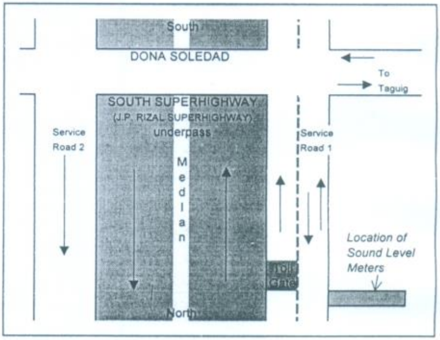


Figure 3.5: Vicinity Map of the Roxas Blvd. - Libertad Survey Site

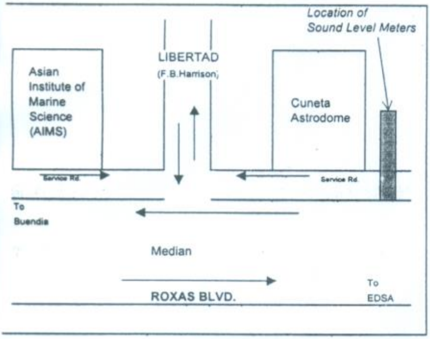
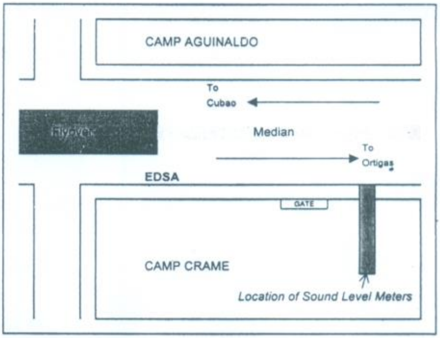


Figure 3.6: Vicinity Map of the EDSA Survey Site



3.4 Classified Volume Count

Traffic volume is the main parameter in the roadside environment noise pollution study. Defined as the number of vehicles passing a given point during a specified period of time, traffic volume gives an accurate information on the total traffic from each direction that contributes to the pollution level in the study area (TTC, 1983). The number of vehicles is expected to be directly proportional to pollution concentration.

Five vehicle classes were used in the survey, namely: cars, jeepneys, bus, trucks and others. *Car* includes both the sedan and the utility vehicles while the *bus* category covers both regular and mini-buses. Included under *trucks* are the rigid and articulated types while *others* include tricycles and motorcycles. For each site, simultaneous noise and traffic survey was conducted for 24-hours from 6:00 a.m. on Wednesday to 6:00 a.m. on the following day. Wednesday was chosen as the survey day being generally characterized by a normal working day traffic.

3.5 Method of Analysis

Analysis of the results of the survey will primarily include the comparison of field measurements to the existing standards. The Philippine Noise Standards (PNS) establishes four standard noise levels corresponding to four time intervals namely: (a) Morning; (b) Daytime; (c) Evening and (d) Nighttime. Different set of noise standards is being applied for different land use classifications. The study areas, being generally commercial, have the following applicable PNS values shown in Table 4.1.

Table 3.1 Philippine Noise Standard for commercial area.

Period	Time Span	Standard
Daytime	9:00 a.m. – 6:00 p.m.	75 dB
Morning	5:00 a.m. – 9:00 a.m.	70 dB
Evening	6:00 p.m. – 10:00 p.m.	70 dB
Nighttime	10:00 p.m. – 5:00 a.m.	65 dB

Correlation among noise measurements for different distances away from the road will be examined to check for potential factors affecting normal noise attenuation. Weak correlation between readings at different distances might hint the possible existence of another noise source other than the subjected thoroughfare. Correlation between noise pollution level and observed traffic volume in consideration of the locational characteristics of the survey sites will also be examined.

4.0 SURVEY RESULTS AND ANALYSIS

A 24-hour noise level monitoring survey was conducted for each of the sites. The proposed distances of the sound level meters with respect to the roadside were 0, 5, 15, and 35 meters. However, for reasons like inadequacy of space, the farthest monitors for Quezon Avenue, South Superhighway and EDSA Stations were only 19.8 m, 30 m and 30 m respectively.

For noise level at the roadside, all measurements are found to be over the standard values through out the day. EDSA, having the second highest traffic volume on the survey date, has the highest sound level at all time intervals peaking at daytime with 83.9 dBA. This is closely followed by measurements along Taft Avenue except on its *nighttime* noise level where in a drop of about 4 dBA compared to that of the other time interval was noticeable. Most measurements have minimal variation throughout the day except at Taft and Quirino stations which were characterized by a drop and an increase in *nighttime* noise level respectively. Further, it was observed that except for Quirino, the highest noise level occurs at either *morning* or *daytime* as respective time intervals covering the morning and afternoon peak hours.

The decrease in *nighttime* noise level for Taft, as well as the high *morning*, *daytime* and *evening* levels, despite of its relatively low traffic volume, can be attributed to the non-operation at nighttime and the operation of the light rail transit (LRT) during the rest of the day. This is further aggravated by high pedestrian activity in the area coinciding with the time intervals of high noise level measurements. The unusual low daytime noise at Quirino Highway station can be attributed to lean tricycle operation at this time of the day, the station being proximate to a tricycle terminal. The high *nighttime* noise level on the other hand can be attributed to an active nighttime population in the area, the site being located near a parking space of a 24-hour fast food chain and a tavern.

A summary of the survey measurements for distance equal to zero, together with the standard values adapted by the Department of Environment and Natural Resources (DENR) are shown in Table 4.1. Noise measurements are expressed in dBA together with the standards and are presented by the Time of Day classifications. The pavement type classifies the road material as either concrete or asphalt.

Table 4.1 Noise measurements for all stations at Distance = 0 (D_0).

	Pavement	Morning	Day	Evening	Night
Quirino	Asphalt	80.6	77.2	80.2	81.4
Taft	Concrete	82.6	82.7	81.8	78.0
QA	Asphalt	78.7	79.8	78.9	75.2
SSH	Concrete	76.9	76.5	75.4	74.8
Roxas	Concrete	77.4	76.9	76.8	76.7
EDSA	Concrete	83.6	83.9	83.2	81.7
Standard	-----	70.0	75.0	70.0	65.0

Except at *daytime*, with the most lenient noise standard at 75 dBA, noise measurements at 5 meters away from road generally exceeded the PNS criterion for the other time intervals. The highest noise level occurred at daytime in Taft Ave. station with 80.5 dBA. Surprisingly, EDSA noise level dropped by more than 10 dB as compared to the roadside measurement, thus, becoming the survey's lowest noise measurement all throughout the day at about 69 dBA. Examining the survey site however shows that the 5-meter distanced SLM at EDSA station is inside the camp's compound located behind a wall. An almost 10 dB drop at EDSA station due to the wall is within the normal noise reduction range of a simple noise barrier. EDSA however still exceeded the nighttime standard with 68.2 dBA.

A summary of the site measurements at 5 meters away from road is presented in Table 4.2. Values in bold text indicate an exceedance of the noise standards.

Table 4.2 Noise measurements for all stations at Distance = 5m (D_5).

Time Interval	Mean Average (dBA)					
	QRINO	TAFT	Q.AVE	SSH	ROXAS	EDSA
Morning	72.6	79.4	74.5	74.2	74.3	69.2
Daytime	74.8	80.5	75.3	74.3	73.8	69.2
Evening	77.9	79.1	75.0	72.9	74.2	68.9
Night	78.3	74.7	72.6	72.7	74.1	68.2

At 15 meters away from thoroughfare, noise levels for all time intervals in Taft Avenue exceed the PNS criterion. The highest noise measurement likewise occurred at daytime at 78.8 dBA. Closely following Taft Avenue are thoroughfares Quezon Avenue and Roxas Boulevard, both barely exceed all the time-interval noise standards. Moreover, Table 4.3 as well as the other noise measurement tables indicate that Taft Avenue consistently generates the biggest drop between evening and nighttime noise measurements. An evening-nighttime drop is normally attributed to reduction of noise sources such as road traffic and pedestrian activity. A notable noise reduction observed at the Taft Avenue station reinforces the significant contribution of the LRT which does not operate at nighttime. The LRT has a combined frequency of 48 passes per hour on a normal operation.

At 15 meters away from the road, EDSA, which characterizes a thoroughfare protected by a noise barrier, was able to meet even the most stringent nighttime standard. This hints the potential efficiency of the use of noise barriers in Metro-Manila.

Table 4.3 Noise measurements for all stations at Distance = 15m (D_{15}).

Time Interval	Mean Average (dBA)					
	QRINO	TAFT	Q.AVE	SSH	ROXAS	EDSA
Morning	70.0	77.5	74.4	69.7	72.2	64.6
Daytime	72.2	78.8	72.6	70.4	72.1	64.9
Evening	74.9	77.0	73.3	68.4	72.3	64.3
Night	73.8	71.6	70.8	68.2	72.0	64.5

South Superhighway, on the other hand, despite having the highest traffic volume being an expressway, records the lowest set of noise measurements next to EDSA. It should be noted however, that such portion of the expressway is approaching an interchange. The total width, thus, comprises directions leading to and coming from the interchange, through directions going under the interchange, and service road lanes serving the local traffic. In effect, traffic volume on other lanes of the expressway become a considerable distance away from the SLM resulting to a relatively low detection of noise in the study area.

At distance 30 or 35 meters (19.8 for Quezon Ave.), South Superhighway and EDSA exhibited sound levels below the PNS criteria all throughout the day. Similarly, Roxas Boulevard barely satisfied all the standard noise levels except for an exceedance of 3.5 dB from the nighttime criterion. What is common among the three thoroughfares is their being adjacent to a vast open space that is free from pedestrian as well as domestic activities. Likewise, the three stations are situated at mid-block, hence, relatively free from other mobile noise sources plying along the nearby roads.

Taft Avenue station continually exceeds all noise standards despite the 35-meter distance from the observed thoroughfare. In addition to the LRT and pedestrian activities, the high noise levels can be partly attributed to the nearby structures as well as the dense daytime population of the vicinity. The lightly trafficked, yet adjacent Malvar Street, likewise, contributes to the high noise level. The high noise levels observed in Quezon Avenue, on the other hand, is primarily attributed to the distance of only 19.8 meters away from the road. It can be noticed that such set of measurements in Quezon Avenue is just slightly lower to that of the SLM located 15 meters away from the same thoroughfare.

Table 4.4 Noise measurements for all stations at Distance = 30/35 m.

Time Interval	Mean Average (dBA)					
	QRINO	TAFT	Q.AVE	SSH	ROXAS	EDSA
Morning	65.2	73.7	74.2	66.5	68.2	64.6
Daytime	67.3	75.8	72.6	68.1	67.5	63.9
Evening	70.3	73.0	73.6	64.4	68.4	63.4
Night	69.0	67.2	71.0	64.5	68.5	63.6

5.0 FURTHER OBSERVATIONS PER STUDY SITE

Further discussion on the observed overall sound level condition of each survey site is presented below. With traffic volume monitored hourly, a descriptive analysis of the traffic volume in relation to the hourly noise measurements recorded at the roadside is also included together with discussions on the correlation of set of measurements with respect to the roadside noise level. Figure 5.1 shows a summary of the observed maximum and minimum traffic volume for each survey site together with their corresponding time of occurrence.

Table 5.1 Summary of traffic volume survey results.

TRAFFIC SURVEY	Min. Traffic Volume		Max. Traffic Volume	
	(veh/hr)	Time	(veh/hr)	Time
Quirino	572	2:00 a.m.	3,003	7:00 a.m.
Taft	797	3:00 a.m	3,766	10:00 a.m.
QA	1,005	3:00 a.m.	7,083	7:00 a.m.
SSH	1,723	3:00 a.m.	11,522	6:00 p.m.
Roxas	1,593	2:00 a.m.	8,098	6:00 p.m.
EDSA	1,880	2:00 a.m.	10,017	10:00 a.m.

5.1 Quirino Highway

Quirino Highway survey site is observed to be at critical noise level within 35 meters from the thoroughfare at evening and nighttime. Among the survey sites, it closely represents a typical light density commercial area often located at major intersections outside the city center. Though vehicle traffic is a major contributor to the ambient noise level indicated by high measurements along the side of the road, it is evident that noise is further aggravated by other sources located off the road. This is evident from the poor correlation among sets of noise measurements with respect to that of distance 0, particularly at daytime, evening and nighttime.

Maximum noise level is measured at 82.41 dBA, ironically occurring at 2:00 a.m. where vehicle traffic is at its lowest. Minimum noise level on the other hand was detected at 12:00

Figure 5.1: Comparison of Equivalent Sound Level (L_{eq}) at Quirino Hi-way at 0,5,15 & 35 meters away from the carriageway

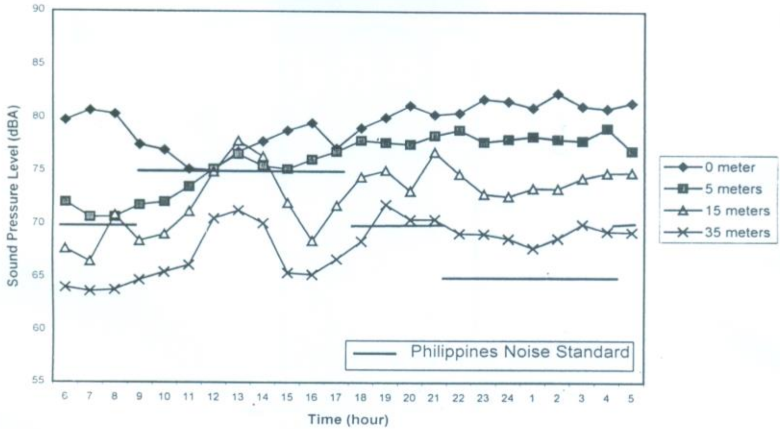
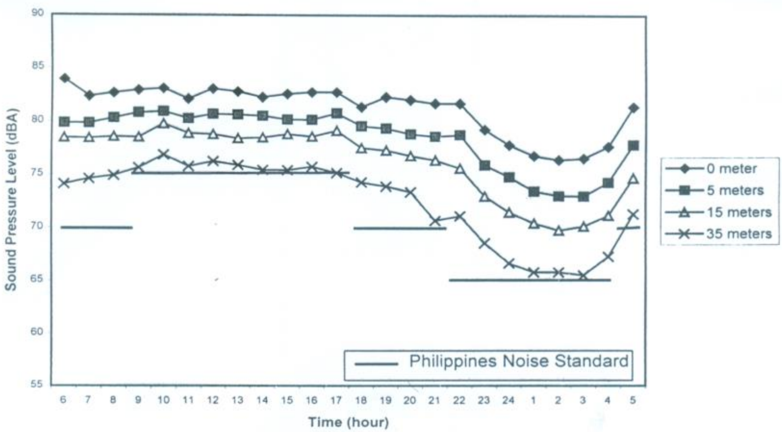


Figure 5.2: Comparison of Equivalent Sound Level (L_{eq}) at Taft Ave. at 0,5,15 & 35 meters away from the carriageway



noon measuring 75.06 dBA where vehicle traffic is 2,342 veh/hr. A sound level of 80.73 dBA was observed corresponding with the maximum traffic volume of 3,003 veh/hr.

5.2 Taft Avenue

Taft Avenue is the most critical among the selected survey sites exceeding all the time of day noise standards at different measuring points. Situated between two universities, the station typically represents a noise environment just outside an institution located in the dense city center. Taft Avenue though is further worsened by a plying light rail transit, which will be the case for most major thoroughfares upon the operation of five (5) other proposed and under construction rail transit lines.

Sets of noise measurements taken at different points indicate highly significant correlation throughout the day to that at distance 0. This indicates that the primary noise generators in the area are located along Taft Avenue, particularly the vehicles and the LRT. Maximum sound level measures 83.93 dBA coinciding with the 6:00 a.m. morning rush hour with a traffic volume of 2,646 veh/hr. Lowest recorded sound level is 76.35 dBA at 2:00 a.m. with a corresponding traffic volume of 881 veh/hr. This almost coincides with the 3:00 a.m. minimum traffic volume that generated a corresponding sound level of 76.49 dBA. Maximum traffic volume yields an 83.05 dBA noise level. An hourly fluctuation of sound level at different distances from Taft Avenue is presented in Figure 5.2.

5.3 Quezon Avenue

During morning, evening, and nighttime, the average sound pressure levels at all distances from Quezon Avenue exceed the Philippine standard noise levels. For daytime, only average sound pressure levels at distance 15 and 19.8 meters are not above the PNS. The maximum sound level at distance 0, 15 and 19.8 meters for the 24-hour duration occurs during daytime and morning where the volume of the vehicles is at its peak. Similarly, the minimum sound level at all distances falls during nighttime where the volume of vehicles is at its lowest. This indicates that the volume of the vehicles is likely to primarily influence the sound level.

For the whole 24-hour duration, sound levels at different distances are significantly correlated with that of the roadside noise except during evening at the 5 meter-distance (D5). This further establishes that although road traffic is the main influence to the ambient noise level in the area, there are still local noise sources that become relatively significant particularly in the evening. A minimum sound level of 73.70 dBA occurred at 2:00 a.m. with 1,385 veh/hr traffic volume. Maximum sound level was measured at 81.12 dBA occurring at 2:00 p.m. when traffic volume is at 5,581 veh/hr.

5.4 South Superhighway

South Superhighway has the highest through traffic yet the lowest sound level among the studied thoroughfares. This is due to an extraordinarily wide road width, being an

Figure 5.3: Comparison of Equivalent Sound Level (L_{eq}) at Quezon Ave. at 0,5,15 & 19.8 meters away from the carriageway

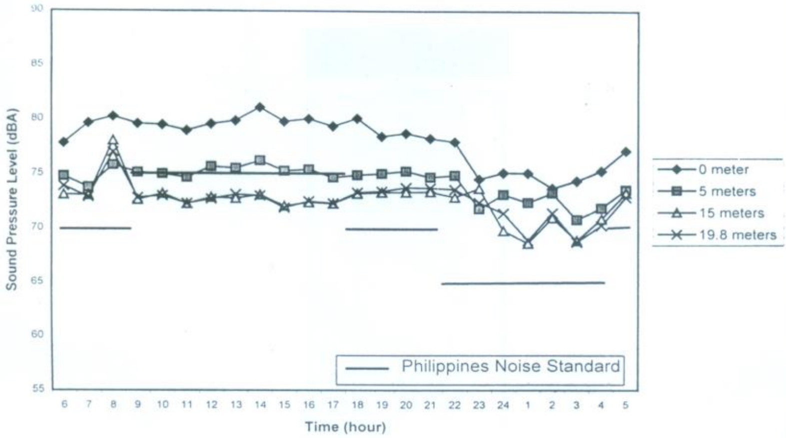
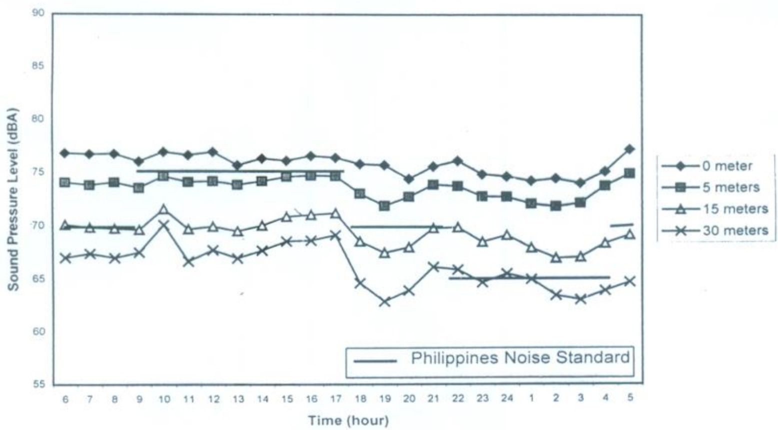


Figure 5.4: Comparison of Equivalent Sound Level (L_{eq}) at SSH at 0,5,15 & 30 meters away from the carriageway



expressway, resulting to a farther distance between the vehicle and the SLM. Though noise measurement exceeds all standard sound levels at the roadside, noise significantly decreases at points away from the road. At 15 meters (D_{15}), only nighttime standard was exceeded while all measurements were below PNS at a distance of 30 meters (D_{30}). This implies that the vehicles on the road are primarily influencing the sound level measurements.

Correlation of equivalent sound level at different distances indicates significant correlation to that of distance 0 (D_0) during morning and nighttime. This is fairly consistent with most of the survey sites, particularly those with a relatively low pedestrian activity and an inactive nightlife. With SSH station situated in an area less frequented by people, sound generated by vehicles tend to stand out from other noise sources in the morning where traffic is at its peak and at nighttime when noise other than generated by road traffic is very minimal.

The maximum roadside sound level of 77.25 dBA was measured at 5:00 a.m. when morning peak is building up with 5,341 veh/hr. The minimum sound level of 74.03 dBA coincides with the occurrence of the minimum traffic volume.

5.5 Roxas Boulevard

Sound level measurements along Roxas Boulevard, except during daytime at monitoring points D_5 and D_{15}, exceed all noise standards within the 15-meter distance from the side of the road. Meanwhile, at D_{30}, only the stricter nighttime noise standard was exceeded. Maximum hourly sound level at D_0 is 78.33 dBA occurring at 9:00 a.m. with an observed traffic volume of 4,914 veh/hr. The minimum sound level of 75.86 dBA coincides with the daytime minimum traffic volume of 6,130 veh/hr occurring at 10:00 a.m.

Correlation of equivalent sound level at different distances shows highly significant correlation of evening and nighttime sound level to measurements at D_0. On the other hand, the lowest correlation coefficient to D_0 was that of daytime measurements at D_{15} and D_{30}. It is observed though, that like all of the other stations, measurements at D_0 are significantly higher than measurements at farther points. These indicate the presence of other noise sources, particularly at daytime, located away from the road, though not as high as the noise generated by the immediate road traffic.

5.6 EDSA (Camp Crame)

EDSA has the highest sound level measurements throughout the day at D_0. Being the busiest intercity thoroughfare, it services a considerable percentage of the total person trips. Among the sites, it ranks second in terms of vehicle traffic to the intracity expressway, the South Superhighway. EDSA though has the highest number of buses comprising about 10% of its total traffic. Other measuring points were situated behind a wall thus simulating the existence of a concrete noise barrier.

The minimum sound level of 80.35 dBA coincides with the minimum hourly traffic volume, thus, consistently showing the influence of traffic volume to the ambient sound level. The

Figure 5.5: Comparison of Equivalent Sound Level (L_{eq}) at Roxas Blvd. at 0,5,15 & 30 meters away from the carriageway

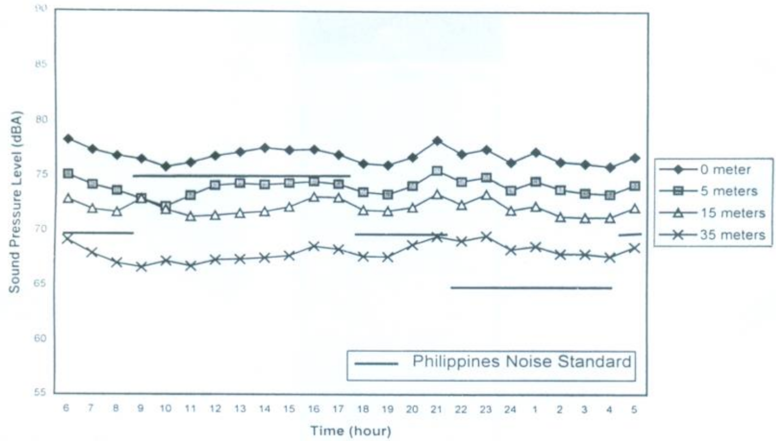
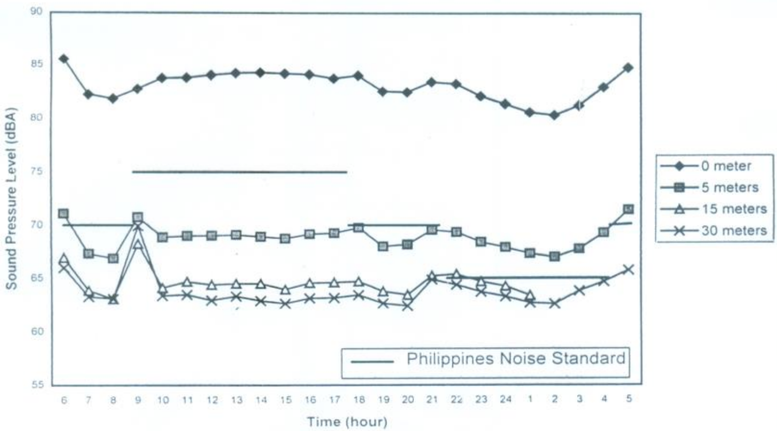


Figure 5.6: Comparison of Equivalent Sound Level (L_{eq}) at EDSA at 0,5,15 & 30 meters away from the carriageway



84.84 dBA maximum hourly sound level however, occurred at 5:00 a.m. with only 4,013 veh/hr. This is far lower than the maximum traffic volume of 10,017 veh/hr which occurred at 10:00 in the morning. Comparing the traffic volume with respect to the observed sound level hints the significant influence of another explanatory variable, traffic speed, to the measured noise level.

Morning and nighttime measurements at D_5, D_{15} and D_{30} were observed to generate a near-perfect correlation to that of the roadside sound level. Such were the highest resulting correlation as compared to that of the other sites. The relatively higher correlation can be attributed to the location of the site, being inside a military camp, hence, more isolated from other sources, particularly on the above-mentioned time of the day.

However, result shows that daytime sound levels at D_5, D_{15} and D_{30} have negative correlation to sound levels at D_0. Negative correlation implies an inverse relationship, which means that whatever the fluctuation trend at D_0, the fluctuation of the sound level at the other points shows the opposite. Such observation was considered an isolated case rather than a trend and can be attributed to the random location of other noise sources with respect to the wall, as noise generated on one side, will not generate the same degree of contribution to the other side.

The reduction of high noise measurements to an acceptable sound level due to the presence of a concrete wall shows the potentials of using a noise barrier. With appropriate noise barrier technology, the 10 dB reduction exhibited in the case of Camp Crame can be easilly exceeded.

6.0 CONCLUSION AND RECOMMENDATIONS

Roadside noise level based on measurements from different stations along selected major thoroughfares in Metro Manila indicates a worsening level of noise pollution. EDSA for instance registers the highest roadside daytime sound level of 83.9 dBA, exceeding the PNS by about 8.9 dB. Among the survey sites, Taft Avenue exhibits the generally worst scenario of a noise-polluted roadside environment. Plied by an elevated light rail line, measurements at various points along Taft Avenue exceeded all the time-of-day noise standards throughout the duration of the survey. The heavily trafficked South Superhighway, on the other hand, is the study's least noise-polluted thoroughfare. Its width significantly contributed to the local noise attenuation.

About five other proposed and under construction railway lines will soon traverse the length of Metro-Manila's major thoroughfares. Hence, sound level measurements such as that of Taft Avenue must trigger consciousness and concern among the transportation engineers and planners to carefully consider the impacts of transportation facilities into its immediate environment.

The low sound level measurement inside Camp Crame is attributed to the wall acting as a noise barrier, reducing the noise level by around 10 dB. Such observation deemed the potential efficiency of noise barriers in reducing roadside noise. The use of noise barriers however carries with it some disadvantages. One is the inaccessibility it creates to road facilities as it acts like a wall that physically separates the road from the other side of the barrier. Likewise, it must be recognized that solutions to traffic noise problem on highways may be approached in three (3) different ways. The first approach involves direct control of the noise emission by the individual vehicles; the second, involves noise control at the community level through either careful zoning practices or acoustical upgrading of existing or proposed structures, and; the third, utilizes highway location and design as the main medium to achieve proper noise environment in the community. These efforts to reduce highway noise impacts have focused on protecting the public from present and future traffic noise.

Vehicle traffic is identified as the primary factor affecting the ambient noise level. Among other factors include pedestrian movement, as well as, commercial, light industrial and domestic activities in general. Depending on the predominant landuse, such other factors tend to vary in significance, often times more apparent in evening and daytime, while negligible at early morning and nighttime. Noise generated by an active commercial area at nighttime however can be more noticeable due to a relatively insignificant contribution of light vehicle traffic.

Traffic parameters though should not be limited to traffic volume. As in the case of EDSA, a faster traffic flow of a particular volume can generate higher noise level than that of higher volume yet of slower speed. Besides, traffic volume alone is not enough to fully describe the degree of congestion the thoroughfare is experiencing. This further recognizes the role of traffic speed. Another traffic flow parameter that must be considered particularly in sound level forecasting is the vehicle composition. Trucks and buses tend to generate a higher unit noise than that of smaller vehicles.

Despite the potential efficiency demonstrated by the wall in EDSA, a policy which deals with noise at the source level is highly favored over the structural solutions. A standard subjecting various potential sources to a reasonable noise generation limit is a good take off point towards a meaningful crusade in battling noise pollution. It is unfortunate however, that as of this point, the government is not conducting any program pertaining to the noise problem.

By establishing the fact that Metro Manila is already suffering from the hazards of vehicle attributed noise pollution, further researches gearing towards abatement strategy building and control development is highly encouraged. Among the immediate research directions include the development of sound level forecasting models in relation to the identified traffic parameters.

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