Urban Noise Pollution in Residential Areas of the City of Curitiba, Brazil

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ABSTRACT

This paper presents a study on noise pollution in residential areas of a large Brazilian city, Curitiba. The equivalent sound level values - L_{eq} - were measured and tabulated for 350 locations spread over residential areas. The results showed that 80.6% of the measured points exceeded 65 dB(A). Only 9.4% of the measured points satisfy the 55 dB(A) limit for residential areas during daytime (7:00am – 7:00pm), according to the environmental legislation in effect in the city.

1 – INTRODUCTION

This paper presents data on noise emission levels carried out in residential areas of the city of Curitiba, capital of Paraná state, located in the Southern Brazil. The city has 1,619,348 inhabitants and is one of the oldest and one of the most populated cities in Brazil. The economy of Paraná State was until recently agriculture-based. The industrialization is somewhat recent. Along with the economical growth of the State and especially of the capital Curitiba, significant structural changes in the city have been observed. Some examples can be cited:

a) Migration of country people to urban areas in search of more lucrative jobs in automobile construction and other industries;
b) Increasing number of circulating vehicles in urban streets;
c) Increasing activities in civil construction in order to build new homes for the new inhabitants.

The population of Curitiba has been continuously increasing since 1970, as shown in table 1 [1].

Year	1970	1980	1991	1996	2000
Inhabitants	609 026	1 024 975	1 315 032	1 476 253	1 619 348

Table 1: Populational growth in Curitiba

Together with the increasing number of inhabitants it has been observed an increasing number of circulating vehicles. In 1995 the total number of registered vehicles was 536,641, from which 5,395 were buses and 391,461 were cars; in 1999, the last available information on vehicle number, the total number of vehicles was 684,212, from which 6,983 were buses and 489,420 were cars. The motorcycles and utilitarian vehicles are not included in above numbers. The increasing number of living people and vehicles normally lead to increase in urban noise.

However, in countries with severe economical and social problems such as Brazil, urban noise has not received enough attention. Still, as a general rule for the whole world, the necessity for studies on noise pollution and its influences over the surrounding environment is increasing, especially by the increasing number of noise sources such as machines, markets, factories and the already cited motor vehicles. Many recent noise surveys treating the problem of noise pollution and the noise propagation have been conducted [2, 3, 4, 5, 6].

The objective of the present research was to show noise level measurements carried out during the day in residential areas of the city of Curitiba, and to compare these levels measured in 2000 with levels measured at the same locations and periods of the day in 1992 [7], the only noise survey ever conducted in Curitiba. The results were confronted with the sound emission limits for residential areas according to the municipal law number 8583 of 1995, which legislates about urban noise and public comfort [8]. The measured sites were also classified according to the criterium established by the U.S. Department of Housing and Urban Development – HUD [9].

2. EXPERIMENTAL APPARATUS

Noise levels were measured by using: Brüel and Kjäer Mediator 2238 type 1 to integrate and logg sound level meters, and Brüel and Kjäer Investigator 2260 type 1 to integrate sound level meters [10].

3. EXPERIMENTAL METHOD

The city of Curitiba, according to the municipal law number 8583 of 1995, which legislates about urban noise and public comfort, has limits for residential areas, according Table 2.

Zone	**Day – Limit 7:00am – 7:00pm**	**Rest – Limit 7:00pm – 10:00pm**	**Night – Limit 10:00pm – 07:00am**
Residential	55	50	45

Table 2: Noise emission limits for the residential area – L_{eq} – dB(A)

The current total population in residential areas is 700,000 inhabitants. In the present survey the measurements were carried out during the afternoon in 350 locations spread throughout those areas. This means that the residential areas have been broadly divided at the proportion of one location per 2,000 inhabitants. Similar surveys carried out in two cities in Palestine, similar proportion have been used: one location for each 3,000 inhabitants in the city of Nablus [5], and one location for each 750 inhabitants in the city of Arraba [6].

All measurements were carried out during working days and under ideal meteorological conditions: no wind and no rain. The duration of each measurement in each site was one hour, each site was measured in duplicate. The first measurement was carried out while people were returning home from work between 12:00 and 01:00 pm. Having lunch home is still a characteristic present in many Brazilian cities. The second measurement was carried out when people were returning home after a working day, between 06:00 pm and 07:00 pm. The average values of the measured equivalent sound levels are presented in Table 3.

In order to compare the current data with 1992 data on noise levels in Curitiba [7], the same measurements points had to be used as in [7]. A non-regular grid was used by Barbosa in

1992, with 350 measurements points spread over the main residential area of the city of Curitiba, as shown in Figure 1. Figure 1 shows the measurement points distributed through the residential areas of Curitiba.

L_{eq} - dB(A)	Residential areas			
	1992		2000	
	Locations	Percentage (%)	Locations	Percentage (%)
$L_{eq} \leq 50$	0	0	7	2
$50 < L_{eq} \leq 55$	2	0.6	26	7.4
$55 < L_{eq} \leq 60$	7	2	15	4.3
$60 < L_{eq} \leq 65$	14	4	20	5.7
$65 < L_{eq} \leq 70$	33	9.4	45	13
$70 < L_{eq} \leq 75$	32	9.1	131	37.4
$75 < L_{eq} \leq 80$	133	38	102	29.1
$80 < L_{eq} \leq 85$	129	36.9	4	1.1
$L_{eq} > 85$	0	0	0	0
Total	350	100	350	100

Table 3: Equivalent sound level for residential areas – measured in 1992 by Barbosa [7] and in 2000, in the present study.

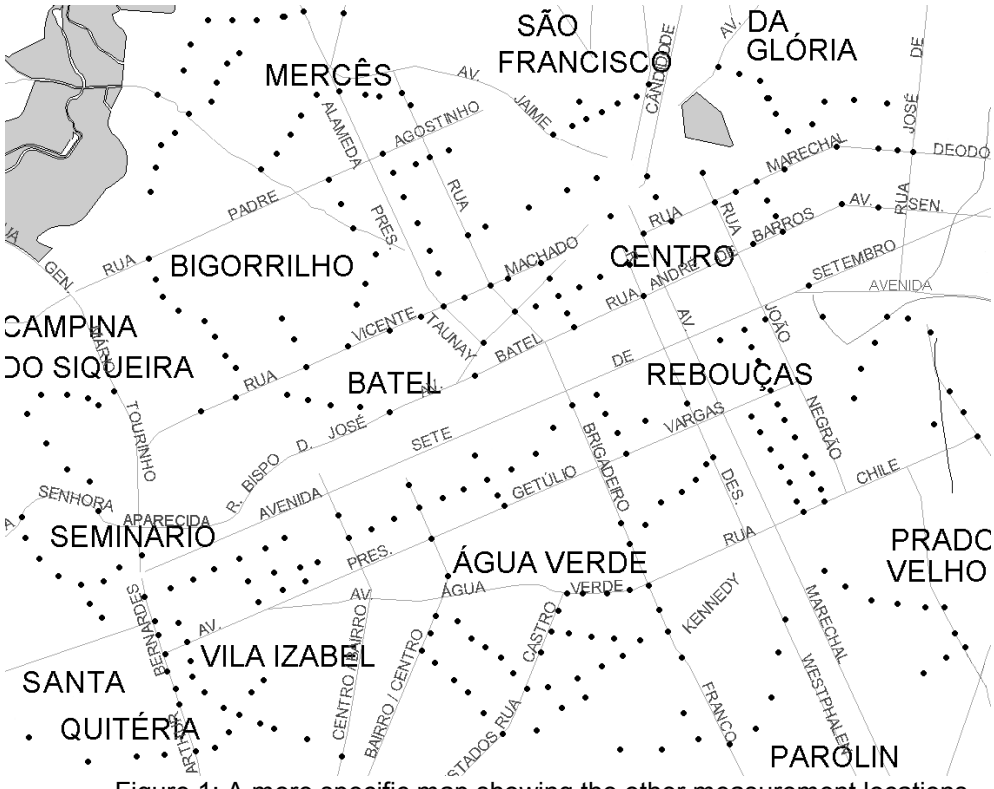

Figure 1: A more specific map showing the other measurement locations.

4. RESULTS AND DISCUSSION

The measured equivalent sound level (L_{eq}) values of all measurement locations from the Barbosa´s survey in 1992 [7] and the results obtained in the present survey, are directly comparable in Table 3. As already mentioned, the sites and periods of the day the measurements were carried out in the present survey coincide with the ones in Barbosa´s survey [7].

The equivalent sound levels in Table 3 are the mean values of the two measurements carried out for each measurement point as mentioned in the Methods section. In 1992, only two locations, representing 0.6 % out of the total number of locations investigated, the equivalent sound levels - L_{eq} - were at or below 55 dB(A) (Table 3), that is in agreement with the city urban legislation (Table 2). On the other hand, the measurements carried out in 2000 showed 33 locations, representing 9.4% out of the total number of locations, with equivalent sound levels at or below 55 dB(A) (Table 3).

The U.S. Department of Housing and Urban Development (HUD) [9], recommends the following noise levels for residential areas, measured outdoors:

$L_{eq} \leq 49$ dB(A) – clearly acceptable
$49 < L_{eq} \leq 62$ dB(A) – normally acceptable
$62 < L_{eq} \leq 76$ dB(A) – normally unacceptable
$L_{eq} > 76$ dB(A) – clearly unacceptable

Considering the criteria from HUD, only 9 locations in 1992 but 48 locations in 2000, representing respectively 2.6% and 13.7% out of the total 350 locations surveyed, can be classified as *normally acceptable.* But it is important to notice that not all of these locations are in accordance with the local municipal law of the city of Curitiba as stated above.

At this point we can question whether the municipal legislation is not setting a limit for noise emission level that is difficult to be met – 55 dB(A) during the day – facing the local conditions:

1) The bad conditions, in general, of the urban streets;
2) The poor maintenance of the circulating vehicles: cars, buses, motorcycles. It is not rare to find circulating vehicles with damaged exhaust system or even without it.
3) Generally the circulating vehicles are old. The average age of the Brazilian vehicles is 14 years.
4) The bad habits, in general, of the Brazilian drivers:
    a) Using the horn for any purpose, with or without apparent reason to do so.
    b) Accelerating the vehicle during traffic jams or while waiting for green traffic light.
    c) High speed driving inside urban regions. It is not rare to find people driving over 80 km/h.

The present research does not have the objective of analyzing the applicability of the municipal legislation – Law 8583 of 1995. It is clearly noticeable that maybe before the setting of an environmental legislation establishing realistic limit sound emission levels, it would be desirable to conduct an awareness campaign for everybody in general and specifically for drivers to control their bad habits previously discussed, so that maybe this 55 dB(A) limit could be met more often.

A widely accepted scientific fact is that living in black acoustic zones, where the equivalent sound level is higher than 65 dB(A) [11, 12] put an urban population in a high risk status for numerous subjective effects of noise, including psychological, sleep, and behavioral disorders. Out of the measured locations in the survey conducted in 2000, 80.6% of the locations display measured L_{eq} over 65 dB(A). On the other hand, in the survey carried out by Barbosa in 1992 [7], 93.4% out of the total locations presented L_{eq} values over 65 dB(A) (Table 3).

Figure 2 shows the equivalent sound levels - L_{eq}, and the statistical levels - L_{10} and L_{90} - measured in the main avenues of the city of Curitiba. The reduction in noise pollution between 1992 and 2000 are obvious. Some thoughts can be drawn about what caused the reduction in noise emission in the city along these 8 years, despite population increase and also increase in the number of vehicles circulating in the city. No specific measure was undertaken by the public administration in the sense of seeking for a reduction in environmental noise emissions. However, some measures were taken by the public administration after 1992

seeking for traffic speed control and reduction in the number of car accidents and traffic deaths. As an example, Com. Franco Avenue (see Figure 2) can be cited where after the installation of speed control radars, the number of tramplings has decreased by 85% [13], and L_{eq} was of 85 dB(A) in 1992 and 78 dB(A) in 2000. The goal of the municipal public administration was to improve the traffic safety conditions but it ended up contributing, without any direct intention, to the reduction in environmental noise emissions. The measures taken to improve the traffic safety conditions were as follows:

1) Installation of vehicle speed control radars. The installation of these radars has also contributed to the reduction of the number of people hit by cars. Installation of electronic speed controllers;
2) Establishment of speed limits for some urban streets and avenues. Nowadays the speed limits are:
    a) 30 km/h – near hospitals,
    b) 40 km/h – residential areas and areas close to schools;
    c) 60 km/h – connecting streets between districts and downtown;
    d) 70 km/h – marginal streets which guides the traffic out of the urban peripheral limit.

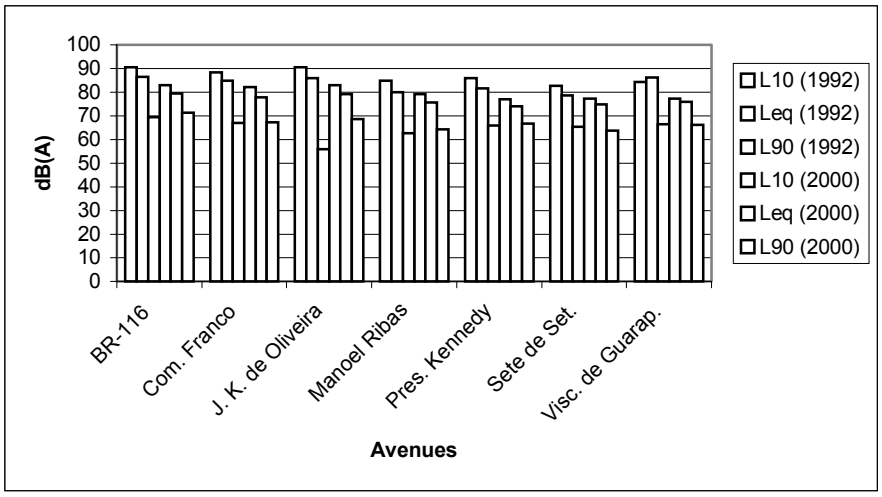

Figure 2: Comparison between emission levels in 1992 and 2000 for the main avenues in the city of Curitiba.

Another possible reason for the reduction in sound emission observed in Table 3 are the better conditions of the new road vehicles circulating in the Brazilian cities and in Curitiba, stimulated by the opening of the Brazilian market to the importation of vehicles, which occurred in the early 1990´s. This fact made the market more competitive, forcing the assemblers established in Brazil to improve their products. The construction of acoustically improved vehicles was certainly one of the improvements.

5 – CONCLUSIONS

We can thus conclude that the residential areas of the city of Curitiba are, during the day, environmentally noise polluted. About 80.6% out of the total locations measured in this study have shown equivalent sound levels over 65 dB(A). The good news for the inhabitants of Curitiba is that in 1992, 93.4% out of the measured locations had equivalent sound levels above 65 dB(A). The explanations for these findings are that the adoption of the law number 8583 of 1995, the installation of radars and electronic speed controllers and the adoption of speed limits for the urban zones of the city have considerably contributed for the reduction of urban noise pollution levels in the city.

There is still much room for improvement. The measures that can be done to relieve even more the environmental noise pollution are:

- Promote awareness of the population about the risks of daily exposure to high noise levels;
- Promote awareness of the population about the existence of a environmental legislation about noise emission;
- Tighter police action toward punishing those who emit sound over the allowable limit or drive over set speed limits.
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