URBAN NOISE ASSESSMENT BASED ON NOISE MAPPING AND MEASUREMENTS

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Abstract

Noise pollution from road traffic was evaluated in a large city in Latin America based on *in situ* measurements taken at 174 points and on noise maps. The noise maps were calculated using Predictor 7810 version 8.11 software, based on the prediction model of the international standard ISO 9613. Three distinct areas in the city of Campo Grande (Brazil) were evaluated: 1) Commercial sector, 2) Mixed sector (commercial and residential), and 3) Residential sector. The noise maps indicate the presence of noise pollution in the Commercial and Mixed sectors, as well as the fact that parts of the Residential sector are noise polluted but that it still has large areas where the noise limit of 55dB(A) is respected.

Keywords: noise pollution, noise mapping, noise assessment, noise limits

Résumé

La pollution sonore de la circulacion routière a été analysée dans une grande ville en Amérique Latine basée sur des mesures *in situ* prise à 174 points et sur les cartes de bruit. Les cartes de bruit ont été calculés en utilisant Predictor 7810 version 8.11 software, grâce à un modèle de prédiction de la norme internationale ISO 9613. Trois zones distinctes dans la ville de Campo Grande (Brésil) ont été évalués: 1) Le secteur commercial, 2) Le secteur mixte (commercial et résidentiel), et 3) Le secteur résidentiel. Les cartes de bruit indiquent la présence de la pollution sonore dans les secteurs commerciaux et mixtes, ainsi que le fait que certaines parties du secteur résidentiel sont polluées par le bruit mais qu'il a encore de grandes zones où la limite de bruit de 55 dB (A) est respectée.

Mots clefs: la pollution sonore, la carte de bruit, l'évaluation du bruit, les limites de bruit

1 Introduction

The expanding urbanization around the world shares a common factor, which is the aggravation of environmental pollution, i.e., gas emissions, water pollution and noise pollution.

Noise pollution in urban environments comes from numerous sources, e.g., sirens, loud music, neighbors, car and home alarms, religious buildings, horns, motorcycles, trucks, passenger cars, buses, planes, trains, etc. [1-14].

The study reported here was conducted in the city of Campo Grande, located in Brazil's Central West region, with a population of approximately 800,000 and a vehicle fleet of about 436,000. The number of vehicles in Campo Grande has increased by about 42% over the last five years [15]. Hence, in view of this growth in the vehicle fleet, an assessment should be made to determine the presence or absence of noise pollution.

Noise pollution was evaluated by means of measurements and the calculation of noise maps. Three distinct areas of the city were evaluated: 1) Residential sector, 2) Commercial sector, and 3) Mixed sector, comprising both residential and commercial areas.

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2 Materials and Methods

Three types of areas were evaluated in the city of Campo Grande: 1) a commercial area, 2) a residential area, and 3) a mixed (commercial and residential) area. These three areas, which were chosen because they represent the main zoning types in the city of Campo Grande and are representative of large Brazilian cities, are identified in Figure 1 as Sector A (Commercial), Sector B (Mixed–business and residential) and Sector C (residential).

The equivalent sound pressure level, L_{Aeq}, was measured taken at 174 points in the three areas, as follows: 64 points in Sector A, 60 points in Sector B, and 52 points in Sector C. Data were collected following the procedures established by the city's legislation on the assessment of noise levels in the urban environment, as well as the procedures established by the Brazilian NBR 10151 standard for environmental noise assessments [16, 17]. The daytime measurements were taken at different times between 6:00 a.m. and 6:00 p.m., from Monday to Friday, between June and October 2011.The measuring time at each point, which was 10 minutes, was chosen to coincide with other studies found in the literature and published in a variety of international journals [5, 9, 18-26]. The measurements were taken using an Extech 407790 sound

level meter equipped with a with free-field microphone, which was placed on a tripod at a height of 1.5 m from the ground, as recommended by the Brazilian NBR 10151 standard [17]. The noise levels measured in Sectors A and C were compared with the legal levels established by Complementary Law No. 08 (Table 1), while the noise levels measured in Sector B were compared with those established by the Brazilian technical standard NBR 10151 (Table 2). The use of the Brazilian standard was necessary because Campo Grande's municipal law does not establish sound levels for mixed areas (commercial and residential) [16, 17].

Figure 1: Location of the sectors

Table 1: Permissible noise levels – Complementary Law Nº. 08 [16]

Zones of use	Daytime (6:00 a.m. - 6:00 p.m.)
Residential areas	55 dB(A)
Commercial areas	60 dB(A)

Table 2: Permissible noise levels according to the use of the area NBR 10151 [17]

Types of areas	Daytime (7:00 a.m. - 7:00 p.m.)
Mixed area, predominantly residential	**55 dB(A)**

2.1 Noise Mapping

Noise mapping was carried out using the Predictor 7810 version 8.11 software package, based on the prediction model of the international standard ISO 9613 [27], which requires the following data: Total vehicle flow; Composition of vehicle traffic; Average speed of the flow; Characteristics of the streets/roads; Topographic data; and Geometry of the buildings.

The traffic flow was determined by counting vehicles manually, while simultaneously measuring the noise levels, considering motorcycles, light vehicles (cars and small trucks) and heavy vehicles (trucks and buses) separately. The vehicles at each measurement point were counted for 10 minutes. Since the traffic flow input data into the software are represented in vehicles/hour, the counts were extrapolated, i.e., the vehicle count in 10 minutes was multiplied by six. The other data required for the simulation were obtained from field surveys (average vehicle speed and pavement characteristics). The topographic information and orthophotos of the areas were obtained from the Campo Grande city hall. Table 3 describes the average vehicle flow measured in the daytime in the three areas, which is characterized mainly by light vehicles, followed by motorcycles and heavy vehicles. Table 3 also shows the total flow measured per hour in each analyzed sector. Table 4 describes the type and quality of pavement and average speed of the traffic flow in the three areas.

Table 3: Average vehicle flow – Daytime.

		Motorcycles	Cars	Heavy vehicles		Total Flow
				Trucks	Buses	
Sec A	Veh/h	2766	10579	70	253	13668
	Total (%)	20.24	77.40	0.51	1.85	100
Sec B	Veh/h	1558	9148	72	105	10883
	Total (%)	14.32	84.06	0.66	0.96	100
Sec C	Veh/h	280	1127	22	15	1444
	Total (%)	19.39	78.05	1.52	1.04	100

Table 4: Average speed, pavement type and quality

	Sector A	Sector B	Sector C
Pavement type and quality	Asphalt in fair condition	Asphalt in fair condition	Asphalt and dirt in fair conditions
Average speed (km/h)	30 – 50	20 – 50	10 – 50

The calculated noise maps were calibrated as recommended by the EU Working Group on the Assessment of Environmental Noise (WG-AEN) and by Licitra & Memoli [29], who suggest that the difference between measured and calculated noise levels should not exceed 4.6 dB(A) [28, 29].

3. Results and Discussion

Figure 2 compares measured and simulated noise levels for the three sectors (see Figure 1). As Figure 2 indicates, only 2 points (one in Sector A and the other in Sector B) show differences that exceed the limit set by the WG-AEN and the 4.6dB(A) recommended by Licitra & Memoli [28, 29].

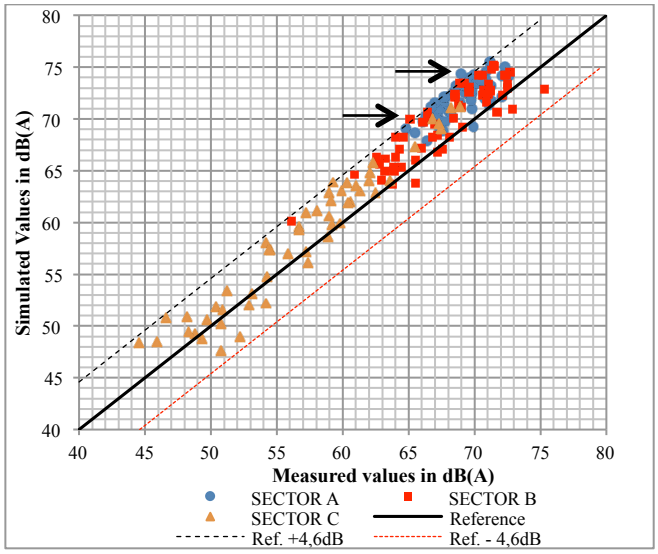

Figure 2: Comparison of the measured and simulated noise levels

The noise maps in Figures 3, 4 and 5 show the current situation of the three sectors. Considering the noise levels indicated in Tables 1 and 2, note that the noise limit in Sector A is exceeded by 0 to 20dB(A), while in most of Sector B it is exceeded by 0 to 15dB(A), reaching up to 20dB(A) in some areas, and in Sector C the limit is exceeded by 0 to 15dB(A). Among the three analyzed areas, Sector C (residential) generally presented the lowest noise levels, mainly due to the lower vehicle traffic and speed in this sector. Moreover, this sector also contains green areas. However, it should be noted that this sector is also becoming increasingly urbanized.

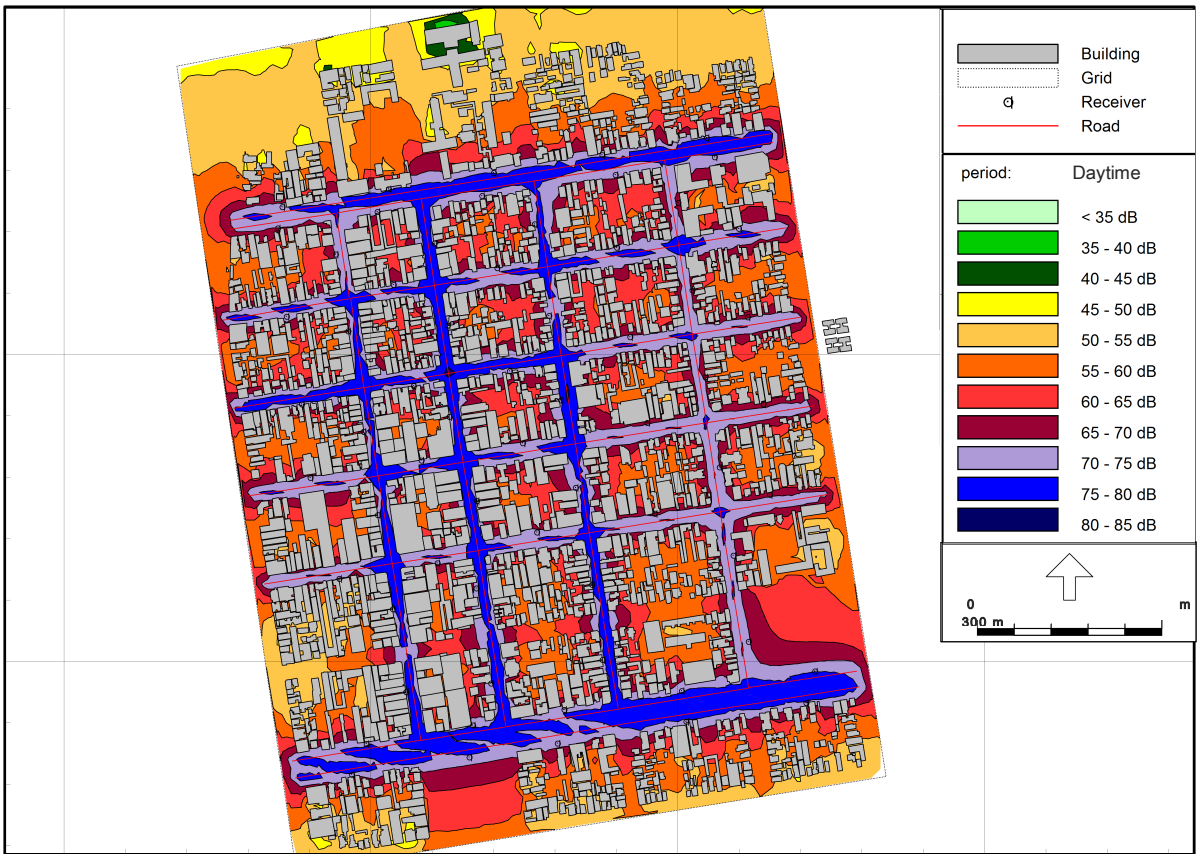

Figure 3: Noise map of Sector A – (Commercial).

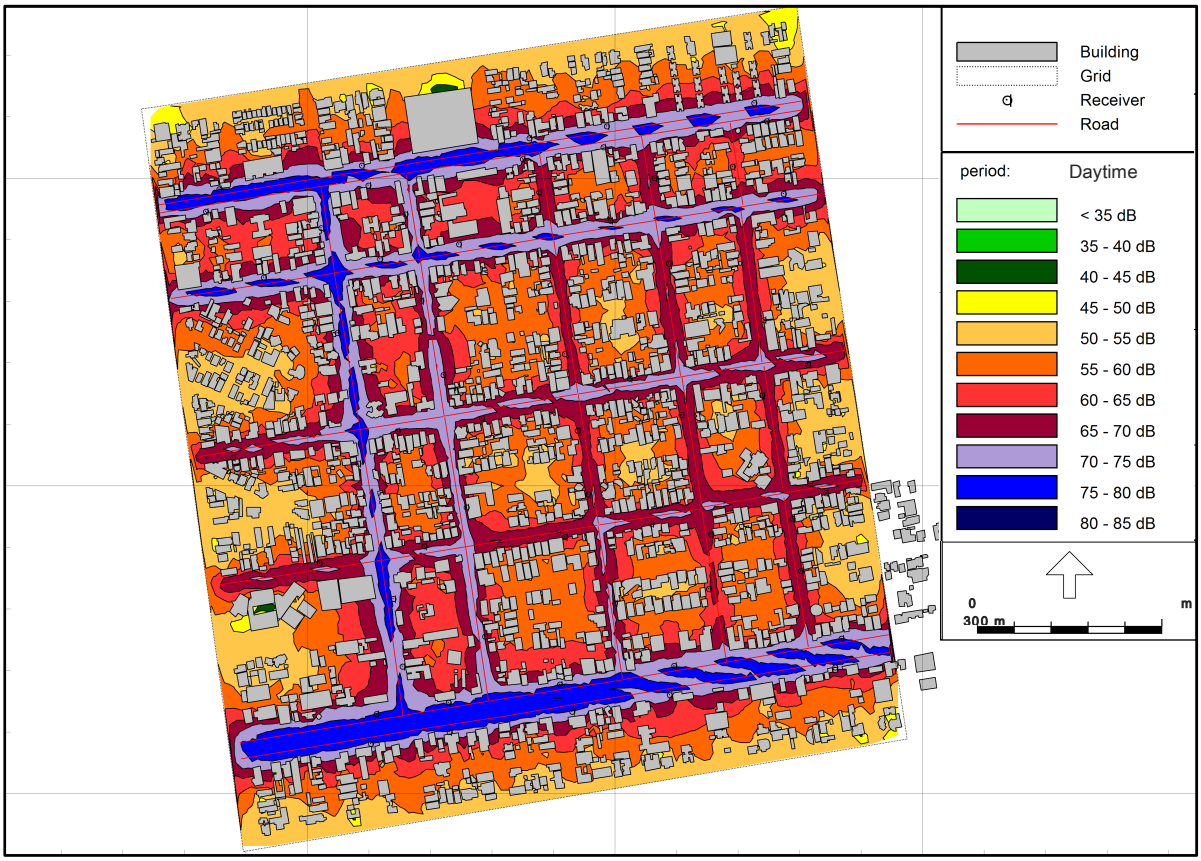

Figure 4: Noise map of Sector B (Mixed residential and commercial)

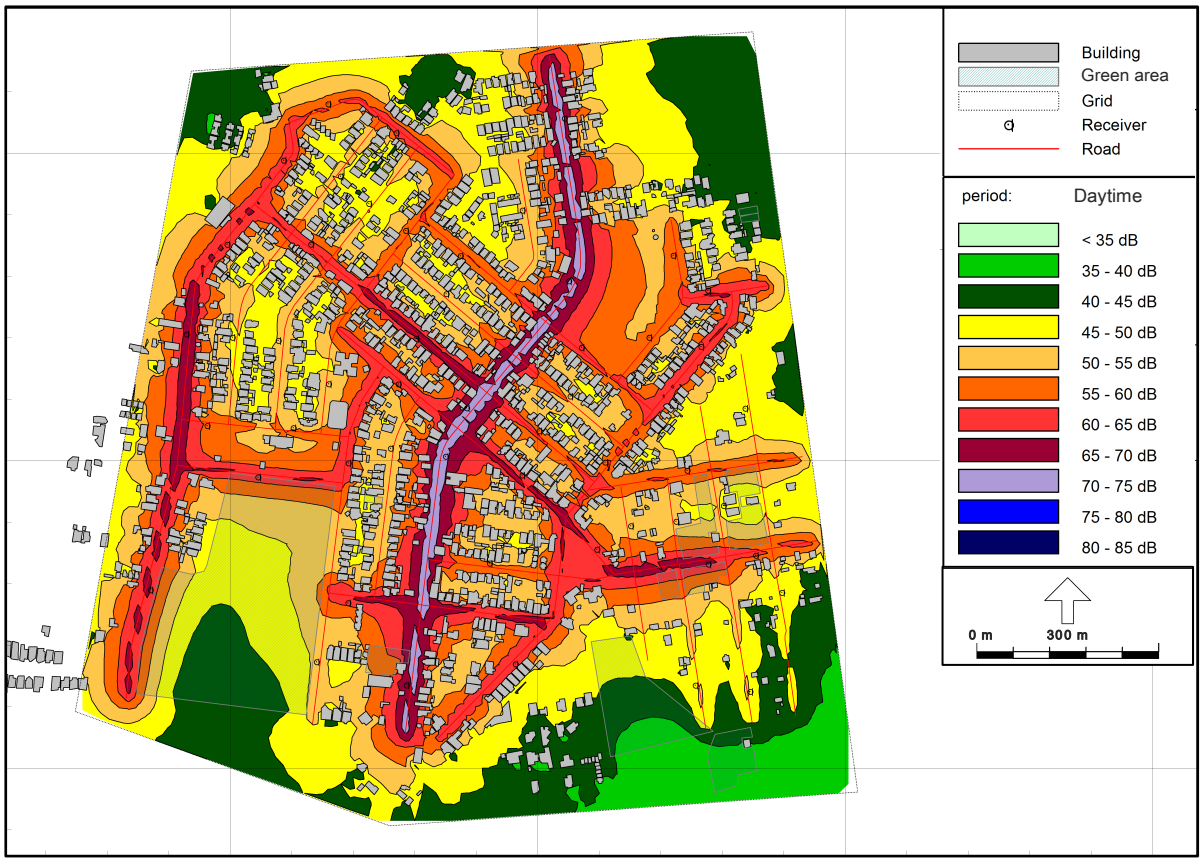

Figure 5: Noise map of Sector C (residential)

In addition to indicating the existing noise levels in a given area, noise maps also serve to identify the portions of each area where the noise levels are lower or higher than the legal limits. This facilitates a possible intervention in noise polluted areas, as well as the maintenance of sound levels in areas where noise levels are within the legally established limits. In this regard, noise maps for the three sectors were created in only two colors, one illustrating the areas where the limits are exceeded and the other showing where they are lower than stipulated, according to Tables 1 and 2. Figures 6, 7 and 8 show that large portions of Sector A (commercial), Sector B (mixed) and Sector C (residential) are acoustically polluted.

As can be seen, Sector A (Figure 6) has few areas that are below the established limit of 60 dB(A). The areas where the noise levels exceed the limit, represented by the blue color, cover almost the entire sector, clearly demonstrating the presence of noise pollution. Like Sector A, Sector B (Figure 7) is also clearly noise polluted. The residential sector, Sector C (Figure 8), shows large areas where the limit of 55dB(A) is not exceeded.

According to Maschke [30], the sound level of 65 dB(A) is considered the recommended exposure limit for populations in urban environments.

5. Conclusion

This study evaluated the problem of noise pollution in a large Brazilian city based on *in situ* measurements taken at 174 points scattered over three distinct commercial, mixed (commercial and residential) and residential areas, which were identified as Sectors A, B and C. Noise maps were also calculated showing the current situation of these sectors. The noise maps clearly indicated the presence of noise pollution in Sectors A (commercial) and B (mixed commercial and residential). The noise maps pinpointed the portions of the investigated areas where the noise levels exceed the limits established by law or by the Brazilian standard for environmental noise assessment. Although parts of Sector C (residential) have noise levels exceeding the limit of55dB(A), it also contains large areas where this limit is not exceeded. This is attributed to the fact that this is a residential neighborhood in Campo Grande, which still contains large green areas. However, the results presented here should serve as a warning for the public authorities, because Sector C is undergoing an increasingly intense process of urbanization. The data presented here may serve to help prevent noise pollution in expansion plans for this neighborhood.

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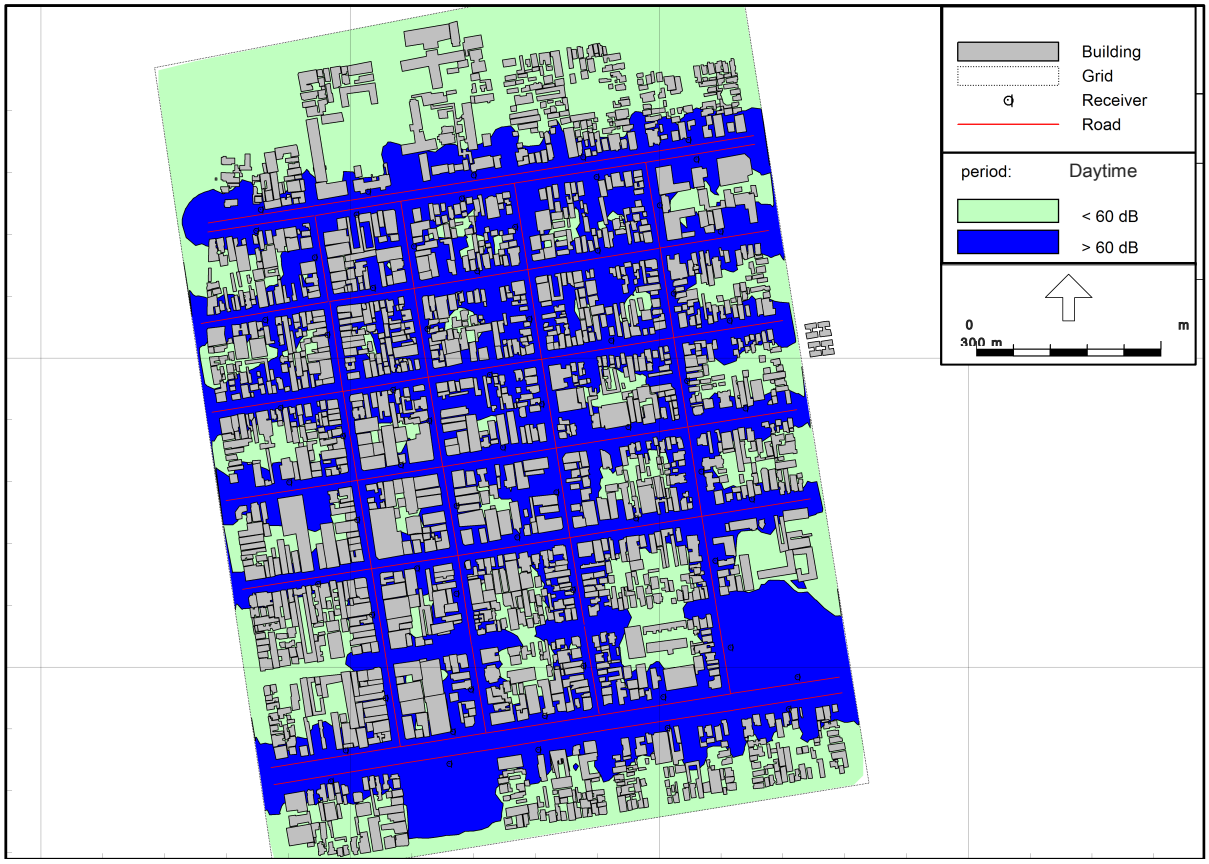

Figure 6: Noise map of Sector A – Limit of 60 dB(A) [16]

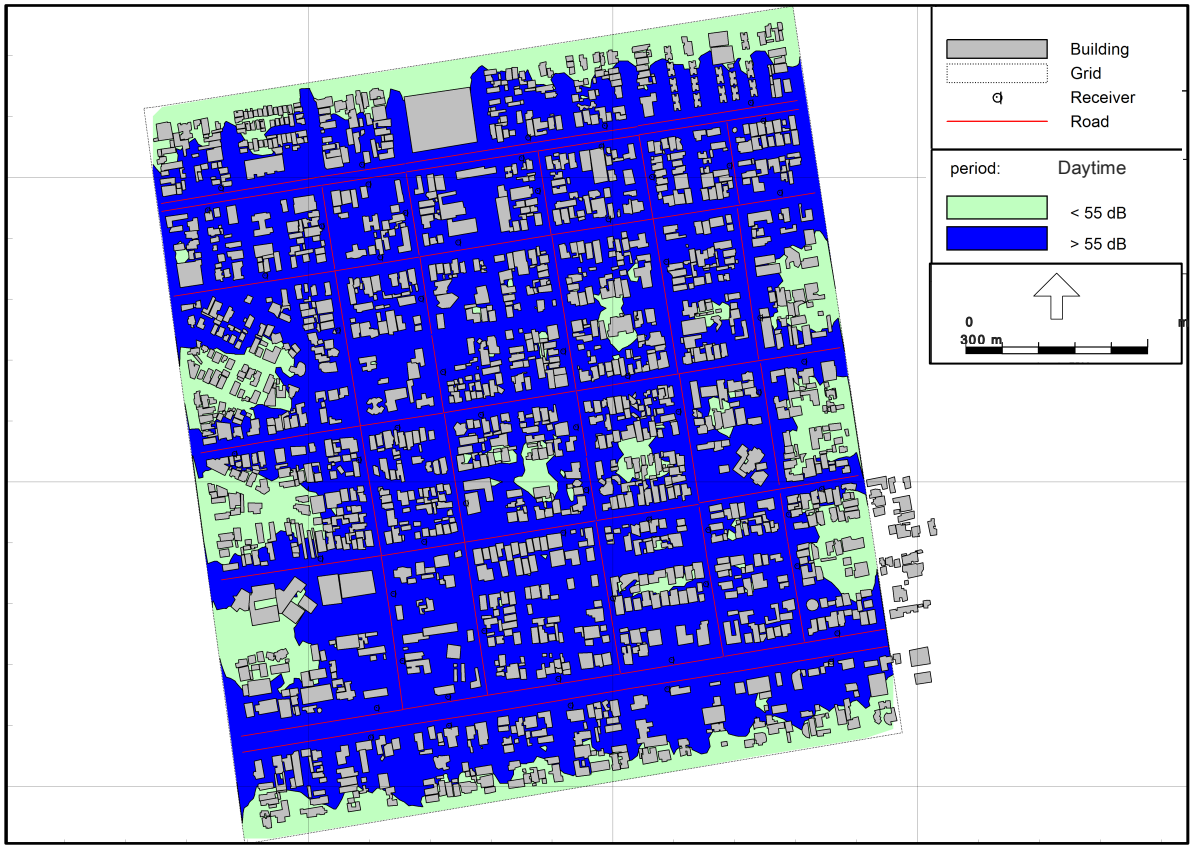

Figure 7: Noise map of Sector B – Limit of 55 dB(A) [17]

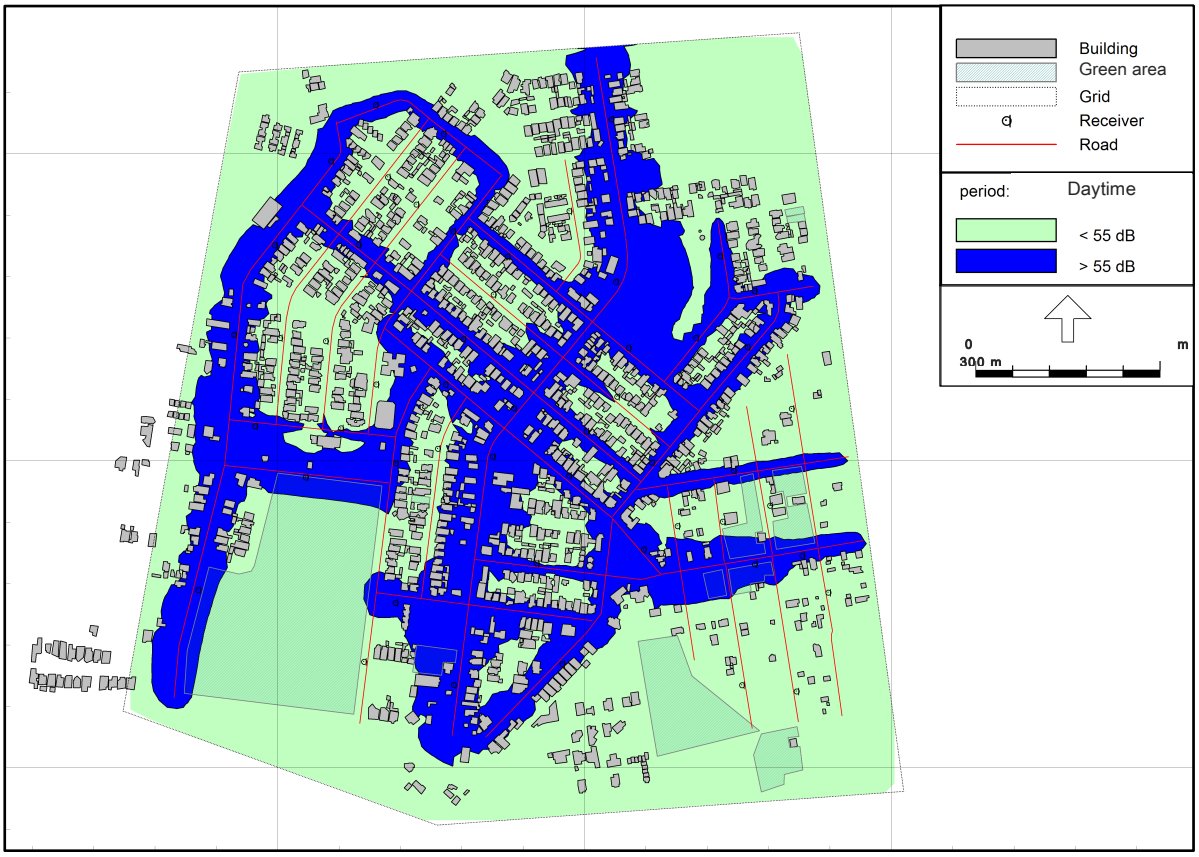

Figure 8: Noise map of Sector C – Limit of 55 dB(A) [16]

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