

Proposition of an attenuating solution for noise pollution caused by telecommunications installations and systems in urban environments

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ABSTRACT

This study evaluates the noise generated by metallic cabinets of telecommunications transmission stations, before and after the implementation of a sound attenuator. The first step consisted of installing the attenuating system, which consisted of a glass wool plate on top of a metal cabinet. Then, we compared the results with a cabinet without the installation of the system. The speeds of the cooling system of the cabinets were the average and maximum. Noise measurements followed the guidelines of NBR 10151, and the acoustic descriptor used was the mean equivalent level (Leq). After verifying the effectiveness of the installation of the system in sound attenuation, several cabinets were adapted in installations located in two cities in southern Brazil. One installation was located in a residential area, with houses on its surroundings, and the other on top of a residential building. The study showed that the attenuating system was effective in reducing the noise generated by the cabinets, both at average and at maximum speed, in both locations. Although the final sound levels did not reach those recommended by the national standard NBR 10151, of acoustic comfort for communities, residents close to the facilities reported an improvement in the local acoustic environment.

KEYWORDS: Ambient noise. Acoustic comfort. Sound pressure level.

1 INTRODUCTION

Demographic growth and disordered urban expansion have caused several impacts to the environment and human health, including ambient noise. Among the problems associated with this type of pollution are sleep disorders (BASNER; McGUIRE, 2018), annoyance and stress (PAIVA; CARDOSO; ZANNIN, 2019), metabolic and cardiovascular changes (van KEMPEN et al., 2018; HUANG et al., 2020).

In urban agglomerations, the main sources of noise pollution are means of transport such as cars, motorcycles, trucks (FIEDLER; ZANNIN, 2015; MONTES-GONZÁLEZ et al., 2019; ANDRADE et al., 2021), trains (WOSNIACK; ZANNIN, 2021), and airplanes (SOUZA; ZANNIN, 2020). Among other types of sound sources that are important in urban environments are the telecommunications systems, for which there are no studies in the literature.

These systems, usually composed of towers and cabinets, are installed in different regions of the cities to meet the current and future demands of new mobile and fixed telephone service providers and internet services. According to the Brazilian National Telecommunications Agency (ANATEL), in 2019, around 91.2% of the population was covered by a mobile cellular network (ANATEL, 2021). Regarding internet use, in 2018, over 79% of Brazilians had access to this technology, with a greater concentration of households in urban areas of large regions of the country (IBGE, 2021).

The increased demand for access to mobile telephone networks requires more equipment to be installed in large demographic centers. The growth in the number of installed equipment increases the power dissipated internally in the cabinets, demanding better performance from the exhaust system. To meet the operating temperature specifications, the exhaust system increases the speed of fans. These, in turn, emit higher sound pressure levels, interfering in the daily lives of residents and in sound quality around these facilities.

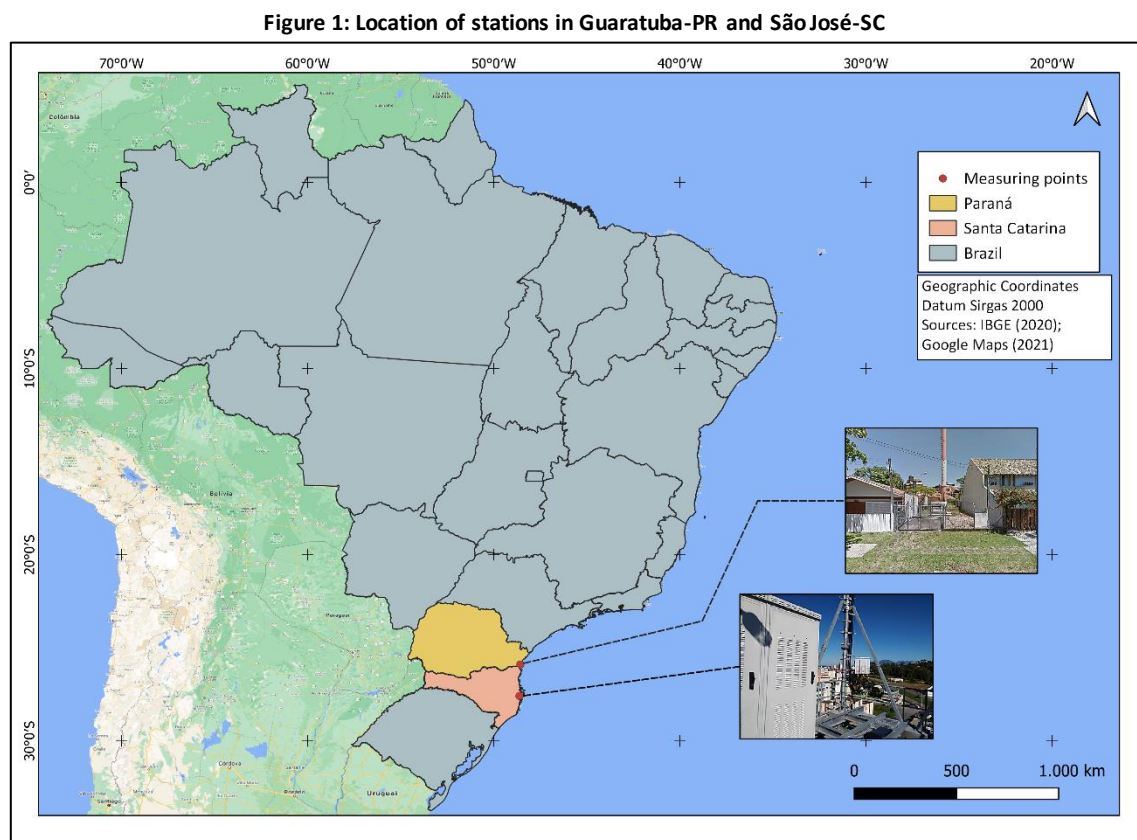
To eliminate or minimize noise impacts, control measures are necessary. Simulations in acoustic software (NASCIMENTO et al., 2021), implementation of barriers (ZANNIN et al., 2018), and asphalt exchange (MONTES-GONZÁLEZ et al., 2019) are some well-known measures used around the world for vehicle noise mitigation (FIEDLER; ZANNIN, 2015). Other important sound sources tend to be more complex, requiring studies with specific solutions.

Given this context, to fill this gap, this research proposes and evaluates a solution for telecommunications system noise by applying a case study in two locations in southern Brazil.

2 METHODOLOGY

2.1 STUDY SITE

Sound measurements were carried out in two transmission stations located in southern Brazil, one in Guaratuba city, Paraná State, in a residential neighborhood, with houses in its surroundings, and another in São José city, Santa Catarina State, on top of a residential building. Both transmission stations had metal cabinets with the same technical characteristics. Figure 1 shows the location of stations.



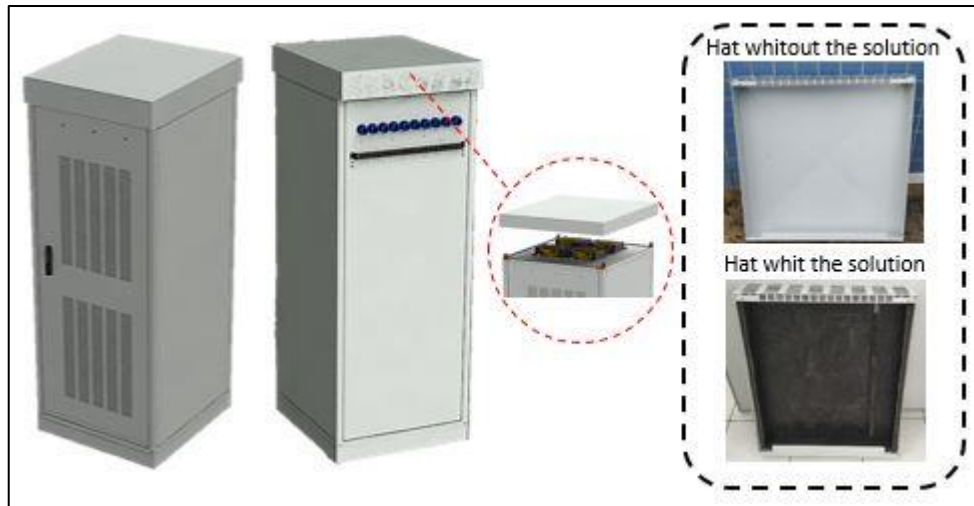
Source: Elaborated by the authors (2021).

2.2 PILOT TEST AND INITIAL SOUND MEASUREMENTS

Metallic cabinets, with exhaust systems composed of fans (indispensable for system cooling), are responsible for the noise emissions under study. To test the feasibility of the change in the cabinet, we initially inserted a high-density glass wool (Climaver Acoustic 25 mm, 80 kg/m³) with sound absorption characteristics (sound absorption coefficient of 0.75 = 75% of the sound energy that comes into contact with the material surface is absorbed) on the inner top (called hood) of one of the cabinets. This top region comprises the cooling fans of the cabinets, as shown in Figure 2. Another cabinet with an unchanged hood was used as a standard to check

whether there was a reduction in sound levels. The test speeds of fans were the average and maximum. The pilot test was conducted in Guaratuba city (Figure 1).

Figure 2: Illustration of the type of cabinet installed and detail of the hood with absorbent solution



Source: Elaborated by the authors (2021).

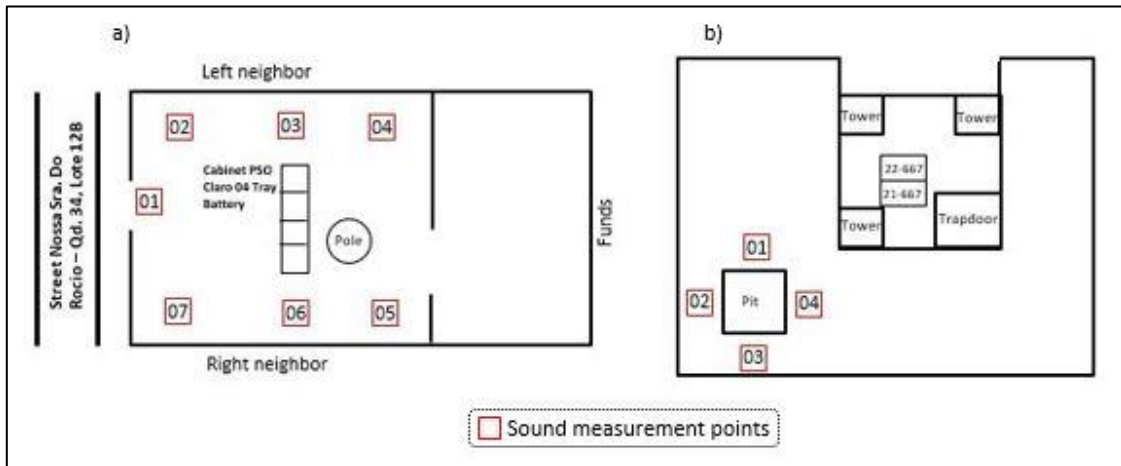
At this initial stage, the BK 2250 analyzer was used to measure equivalent sound levels (L_{eq}), weighted by the “A” curve. The results were expressed in dB(A). Measurements were performed for three minutes at each point around the cabinet, with a total of four positions, following the recommendations of standard NBR 10.151/2019. Ambient noise, that is, noise generated by activities in the surrounding area, was measured for ten minutes, with the microphone facing the street in front of the study site. The reference value used to assess the effectiveness of the proposed change was 55 dB(A), as recommended by NBR 10.151/2019 for residential areas during the day (ABNT, 2019).

2.3 RECALL OF CABINETS AND FINAL MEASUREMENTS

After the initial tests, the glass wool plate was fixed in all the cabinets present in the study areas (recall). At this stage, the equipment used in the measurements was the Minimpa MSL-1350 sound analyzer. The same criteria of the pilot stage were followed for acoustic descriptor, measurement times, and reference standard.

In the Guaratuba station site (Figure 3a), seven measurements were taken in total, six around the cabinets and one near the site gate. For the São José station (Figure 3b), four points around the ditch of the building were selected for measurements. According to the residents’ reports, the noise from the two cabinets propagates from this place to the apartments.

Figure 3: Sketch of sound measurement locations in Guaratuba-PR (a) and São José-SC (b)



Source: Elaborated by the authors (2021).

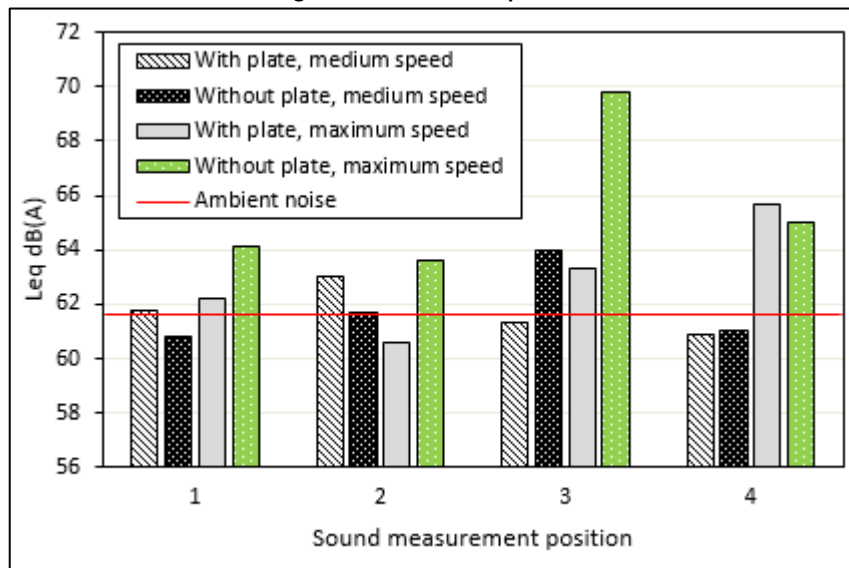
3 RESULTS AND DISCUSSION

3.1 PILOT TEST

The background noise measured in the pilot test was 61.6 dB(A). Ambient sound pressure levels are very high in the locality. In front of the site in Guaratuba there is an avenue with intense and continuous traffic for a good part of the day.

Figure 4 shows the results of the pilot test for the four positions of the measuring equipment, comparing the average and maximum speeds of fans and the cabinets with and without the glass wool plate.

Figure 4: Results of the pilot test



Source: Elaborated by the authors (2021).

At maximum fan speed, the solution with the glass wool plate proved to be efficient, reducing noise in the most critical measurement position (position 3) by 6.5 dB(A). Although in position 4 the value was slightly higher, it is very likely that some background noise in the region

had interfered with the results at the time of measurement, causing this inconsistency. This fact can also be observed in position 2.

Regarding the average speed of fans, both situations have small differences between them and both have values very close to those of ambient noise. However, in the most critical position (position 3), the test condition with the acoustic plate had a slight advantage over the case without the plate, which also occurred in the test with maximum fan speed.

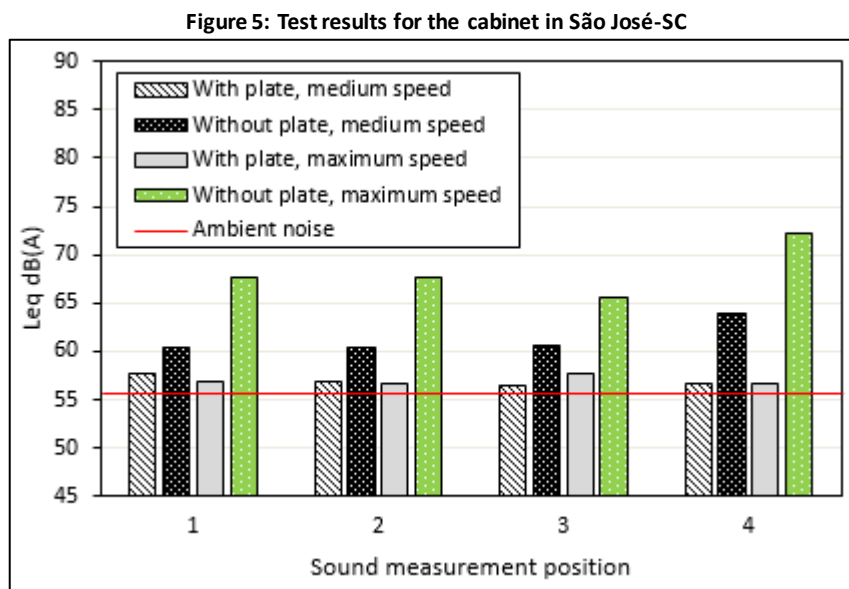
During the tests, the sound coming from the cabinet with the board improved not only regarding sound level values, but also in the field, providing better acoustic comfort when the ambient noise was milder. Considering preliminary tests, the solution with acoustic absorption was efficient. The cabinets installed in the study stations were recalled with the exchange of their hoods for new ones containing the absorbent glass wool solution.

3.2 FINAL MEASUREMENTS AFTER THE RECALL OF CABINETS IN SÃO JOSÉ-SC

In this installation, four points of interest were analyzed around a ditch near two cabinets located at the left end of the top of the building, before and after the installation of the glass wool board. Residents made a formal complaint pointing out that the noise coming from the cabinet was disturbing during certain times of the day.

Ambient noise was measured with the exhaust system of fans turned off. Results show that nearby roads account for most of the background noise. The value for ambient noise was 55.7 dB(A).

Figure 5 shows the results of measurements performed with and without the absorbent solution, at the average and maximum speeds of exhaust system fans.



Source: Elaborated by the authors (2021).

The reduction in Leq when the system is operating at full speed was significant, showing the efficiency of using glass wool plate for this type of application. The values reached a reduction of up to 15.5 dB(A). Despite the installation of the attenuating solution, the values

were still above the allowed by NBR 10151, which is 55 dB(A). As shown in Figure 5, ambient noise is also above the permitted level, as it is influenced by nearby highways.

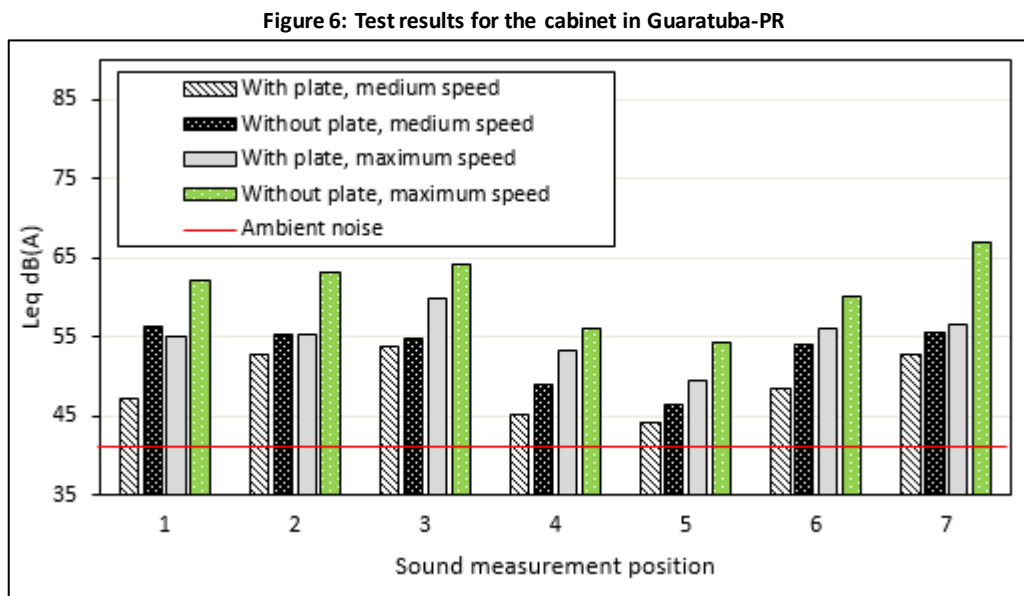
Even so, when the system needs to operate at full speed, system noise and ambient noise show very close values. In this case, there may be a conflict between the measured value and the ambient value, which shows that the reductions could be more significant.

The cabinet operates at average speed during most of the day. In this condition, the values were also very close to those of ambient noise, resulting in uncertain measurements. However, after installing the attenuating solution, the building residents mentioned a significant improvement in the sound quality coming from the installation, especially at night, which was the main complaint.

This shows that another important factor of noise pollution, the subjective part, had a great contribution to improve the environment after the implementation of the proposed solution. Many studies address the subjective issue of noise, discussing acoustic assessment (ZANNIN et al., 2013; PAIVA; CARDOSO; ZANNIN, 2019). This issue is as important as the concrete reductions in sound pressure levels.

3.3 FINAL MEASUREMENTS AFTER THE RECALL OF CABINETS IN GUARATUBA-PR

The ambient noise measured for the installation in Guaratuba was 41.2 dB(A). Figure 6 shows the results of measurements in the cabinets with and without the absorbent solution, at average and maximum speeds, in the seven positions of the measuring equipment.



Source: Elaborated by the authors (2021).

Although some points are above the allowed value of 55 dB(A), when the system operates at full speed, the reduction in Leq by using the attenuating solution was significant. The exhaust system operates at full speed only when outside temperatures are very high, operating at average speed during most of the day. In the latter condition, the system achieved good results for the equivalent sound pressure level in relation to the standard without the solution.

Neighbors observed an improvement in the quality of ambient sound around the facility, especially during the summer, when high temperatures in the region make the system always operate at full speed.

The application of the glass wool board proved to be an efficient solution for attenuating the noise generated by the cabinets. The solution was more efficient than other techniques used to reduce noise in urban environments, such as modifying the vehicle exhaust system (SHINDE et al., 2017), installing porous asphalt (FIEDLER; ZANNIN, 2015), and implementing acoustic barriers (ZANNIN et al., 2018).

4 CONCLUSION

Noise reduction after the installation of the attenuating system, both for the plant installed in Guaratuba and for the installation in São José, despite not fully meeting NBR 10151, proved to be efficient for the cases under analysis. The values decreased by 6.5 dB(A) in Guaratuba and by 7.8 to 15.5 dB(A) in São José, considering the maximum fan speed (maximum demand from the exhaust system, with higher noise levels).

Another important issue considered in this study was the subjective part of noise. Residents in the vicinity of the systems reported an improvement in the sound coming from the cabinets, reducing nuisance. This reinforces that the proposed solution achieved positive results.

Additional solutions should be implemented in the study areas, such as applying speed reducers on nearby roads or changing the asphalt for a porous one, since the ambient noise in the places under study was above that recommended by NBR 10151/2019.

REFERENCES

AGÊNCIA NACIONAL DE TELECOMUNICAÇÕES (ANATEL). **Proporção da população coberta por rede móvel**. Disponível em: <https://dados.gov.br/dataset/proporcao-da-populacao-coberta-por-rede-movel/resource>. Acesso em: 04 mar. 2021.

ANDRADE, E. L.; LIMA, E. A.; SIMONETTI, V. C.; OLIVEIRA, R. A.; ZANNIN, P. H. T.; SILVA, D. C. C.; MARTINS, A. C. G. Influence of the COVID-19 pandemic on the external environmental noise of a public hospital in Sorocaba, Brazil. **Revista Nacional de Gerenciamento de Cidades**, v. 9, n. 69, p. 44-51, 2021. DOI: <http://dx.doi.org/10.17271/2318847296920212790>.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS (ABNT). **NBR 10151: Acústica – Medição e avaliação de níveis de pressão sonora em áreas habitadas – Aplicação de uso geral**. Rio de Janeiro, 2019.

BASNER, M., MCGUIRE, S. WHO environmental noise Guidelines for the European Region: A systematic review on environmental noise and effects on sleep. **International Journal of Environmental Research and Public Health**, v. 15, p. 519, 2018. DOI: <https://doi.org/10.3390/ijerph15030519>.

FIEDLER, P. E. K.; ZANNIN, P. H. T. Evaluation of noise pollution in urban traffic hubs — Noise maps and measurements. **Environmental Impact Assessment Review**, v. 51, p. 1-9, 2015. DOI: <https://doi.org/10.1016/j.eiar.2014.09.014>.

HUANG, T.; CHAN, T-C.; HUANG, Y-J.; PAN, W-C. The Association between Noise Exposure and Metabolic Syndrome: A Longitudinal Cohort Study in Taiwan. **International Journal of Environmental Research and Public Health**, v. 17, p. 4236, 2020. DOI: <https://doi.org/10.3390/ijerph17124236>.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). **Malhas Territoriais**. Disponível em: <https://www.ibge.gov.br/geociencias/organizacao-do-territorio/malhas-territoriais.html>. Acesso em: 21 jun. 2021.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). **Uso de internet, televisão e celular no Brasil**. Disponível em: <https://educa.ibge.gov.br/jovens/materias-especiais/20787-uso-de-internet-televisao-e-celular-no-brasil>. Acesso em: 04 mar. 2021.

MONTES-GONZÁLEZ, D.; BARRIGÓN-MORILLAS, J. M.; GÓMEZ ESCOBAR, V.; VÍLCHEZ-GÓMEZ, R.; REY-GOZALO, G.; ATANASIO-MORAGA, P.; MÉNDEZ-SIERRA, J. A. Environmental Noise around Hospital Areas: A Case Study. **Environments**, v. 6, p. 41, 2019. DOI: <https://doi.org/10.3390/environments6040041>.

NASCIMENTO, E. O.; OLIVEIRA, F. L.; OLIVEIRA, L. N.; ZANNIN, P. H. T. Noise prediction based on acoustic maps and vehicle fleet composition. **Applied Acoustics**, v. 174, p. 107803, 2021. DOI: <https://doi.org/10.1016/j.apacoust.2020.107803>.

PAIVA, K. M.; CARDOSO, M. R. A.; ZANNIN, P. H. T. Exposure to road traffic noise: Annoyance, perception and associated factors among Brazil's adult population. **Science of the Total Environment**, v. 650, p. 978–986, 2019. DOI: <https://doi.org/10.1016/j.scitotenv.2018.09.041>.

SHINDE, P. V.; GAVALI, P. M.; BARAWADE, R. A.; MOHITE, Y. B.; SHINDE, P. B. **A Review on Muffler Design for Exhaust Noise Attenuation**. **International Journal of Engineering and Technology**, v. 9, n. 3S, p. 428-431, 2017. DOI: <https://doi.org/10.21817/ijet/2017/v9i3/170903S066>.

SOUZA, D. O.; ZANNIN, P. H. T. Aircraft noise mapping: Bacacheri Airport. **Revista Nacional de Gerenciamento de Cidades**, v. 8, n. 68, p. 23-30, 2020. DOI: <http://dx.doi.org/10.17271/2318847286820202727>.

Van KEMPEN, E.; CASAS, M.; PERSHAGEN, G.; FORASTER, M. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cardiovascular and Metabolic Effects: A Summary. **International Journal of Environmental Research and Public Health**, v. 15, p. 379, 2018. DOI: <https://doi.org/10.3390/ijerph15020379>.

WOSNIACK, G.; ZANNIN, P. H. T. Framework to manage railway noise exposure in Brazil based on field measurements and strategic noise mapping at the local level. **Science of the Total Environment**, v. 757, p. 143721, 2021. DOI: <https://doi.org/10.1016/j.scitotenv.2020.143721>.

ZANNIN, P. H. T.; ENGEL, M. S.; FIEDLER, P. E. K; BUNN, F. Characterization of environmental noise based on noise measurements, noise mapping and interviews: A case study at a university campus in Brazil. **Cities**, v. 31, p. 317-327, 2013. DOI: <https://doi.org/10.1016/j.cities.2012.09.008>.

ZANNIN, P. H. T.; NASCIMENTO, E. O.; PAZ, E. C.; VALLE, F. Application of Artificial Neural Networks for Noise Barrier Optimization. **Environments**, v. 5, p. 135, 2018. DOI: <https://doi.org/10.3390/environments5120135>.