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Noise Pollution Evaluation at UFPR's Jardim Botânico Campus in Pandemic Times

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SUMMARY

This study aimed to evaluate the noise pollution on the Jardim Botânico campus of the Universidade Federal do Paraná (UFPR), in the municipality of Curitiba-PR, during the Coronavirus pandemic (SARS-CoV-2). The evaluation included comparing the acoustic measurements and statistical analysis of the data measured in the field with measurements taken before the pandemic by Vieira (2018). Therefore, the study aimed to identify whether there was a significant impact on the acoustic conditions in the area studied due to the restrictive measures imposed to address the public health emergency. The methodological procedures were based on characterizing the study area, defining the sampling points, collecting data in the field, evaluating the noise pollution according to NBR 10.151/2020 standards and Curitiba Municipal Law 10.625/2002, and statistical analysis of the data. The Shapiro-Wilk test was used to verify normality. The relationship between the noise levels before and during the pandemic was evaluated using analysis of variance and Tukey's post hoc test, with a 0.05 significance level (α). The results and discussions address the values obtained and scored in the locations where the values exceeded the tolerance limit, denoting the possible causes and solutions for noise control according to the literature. We concluded that none of the points evaluated presented sound pressure levels within the limit recommended by NBR 10151/2020, indicating a noise pollution situation at the campus. The pandemic affected the minimum and average values, which were lower when compared to those recorded before the pandemic ($p<0.05$). At the same time, the maximum level (L_{max}) values were similar to each other ($p>0.05$).

KEYWORDS: Environmental noise. Noise pollution. Noise in times of covid-19.

1 INTRODUCTION

The rapidly expanding urbanization worldwide presents a common factor, the aggravation of environmental pollution - from gas emissions, water pollution, and noise pollution. Currently, exposure to urban noise is one of the biggest problems faced by the world population. It is considered a public health issue and can compromise life quality and produce adverse effects in humans and animals, both at the auditory and extra-auditory levels, depending on the noise characteristics, the type of exposure, and the susceptibility of the exposed individual. (WHO, 2018).

The harmful effects of noise pollution involve changes in the hearing system, especially noise-induced hearing loss (NIHL) (ARAUJO, 2002; GANIME et al., 2010; BASNER et al., 2014; MUNZEL et al., 2014). They can compromise the body's organs, systems, and functions, leading to sleep disturbance, irritability, fatigue, difficulty in concentrating, increased stress and blood pressure levels, and the secretion of hormones such as adrenaline and cortisol, which directly influences intellectual performance (CAVALCANTE; ANDRADE, 2007; MUNZEL et al., 2018).

According to recent evaluations published by the European Environment Agency, road traffic is the main component of noise pollution (EEA, 2020). The increase in this pollutant is directly related to the urban population's high demographic growth rate and the consequent increase in generating sources, such as the increase in civil construction activities and the number of vehicles in circulation (ZANNIN et al., 2008; CALIXTO et al., 2008).

In Curitiba, according to a survey conducted by the Brazilian Institute of Geography and Statistics (IBGE, 2020), between 2011 and 2020, the population grew by 10.43%, from 1,764,541 inhabitants to 1,948,626. In turn, the number of registered vehicles in the city increased 18.78%, from 1,232,991 to 1,464,535. According to data from the Traffic Department of the state of Paraná (Detran-PR), this is equivalent to four cars for every Five inhabitants, which shows a worrisome situation in the city (DENTRAN, 2020).

In the educational environment, high noise levels affect students; behavior and comprehension and hinder learning. Teaching, research, and extension activities require a high level of acoustic comfort due to the high degree of concentration necessary to carry them out. Several studies show that noise exposure can decrease cognitive performance, with reduced concentration, communication difficulties, increased excitement, irritation, and sleep disorders, directly affecting school performance (WHO, 2001; HAGEN et al., 2002; ZANNIN et al., 2013; TZIVIAN, 2017; SCHITTINI, 2020).

The UFPR's Jardim Botânico campus is of great importance to the students, faculty, and the population in general. This campus plays a fundamental role in the teaching, research, and extension activities developed in Paraná and Brazil. The campus is located in a residential neighborhood and is bordered by the BR-476 highway (green line) and the Avenida Prof. Lothário Meissner. The facilities were strategically built in the southeast region of Curitiba, Paraná, with direct access to the intermodal transport system.

This system is close to the highways (road system), which provide direct access to the international airport (airway system). Upon the COVID-19 (Sars-CoV-2) pandemic, restrictive quarantine and social isolation measures were imposed, and several studies indicated a significant reduction in environmental noise (ASENSIO et al., 2020; ANDRADE et al.,2020). Thus, the scientific community in the acoustics field mobilized and took advantage of this rare situation to carry out sound measurements in different locations. They aimed to understand and monitor the changes in environmental noise as a function of the actions taken to address the public health emergency.

This study is justified by the need for constant evaluation and control of noise pollution in school environments to improve learning performance and ensure the life quality of students and teachers. Even though there are several studies worldwide on noise pollution in educational environments, none have evaluated the impact of the Coronavirus pandemic (SARS-CoV-2) on the acoustic conditions in these environments.

This study aimed to evaluate the noise pollution on the Jardim Botânico campus of the Universidade Federal do Paraná (UFPR), in the municipality of Curitiba-PR, during the Coronavirus pandemic (SARS-CoV-2). The evaluation included comparing the acoustic measurements and statistical analysis of the data measured in the field with measurements taken before the pandemic by Vieira (2018). Therefore, the study aimed to identify whether there was a significant impact on the acoustic conditions in the area studied due to the restrictive measures imposed to address the public health emergency.

2 THEORETICAL REFERENCE

2.1 Noise Pollution Impacts on Learning

Learning is associated with exchanges within the spoken language. Modern teaching methods are especially dependent on high-quality oral communication, particularly when using new media or a variety of learning stimuli. High sound pressure levels increase interference with communication and speech interpretation, automatically requiring additional effort from teachers and students. As a result, they lead to exhaustion sooner than one might expect, consuming cognitive resources that would be more effectively spent on understanding the contents and thinking. (LUBMAN D, SUTHERLAND LC, 2001; KLATTE, 2002).

The capability of reading, understanding, and extracting information is a fundamental requirement for successful learning. Thus, we can assume that a good listening atmosphere influences not only language acquisition but also the learning of reading and writing. Excessive noise in teaching environments leads to difficulties in paying attention and concentrating and can lead to exhaustive learning (ARELT et al., 2001; ZANNIN et al., 2013; TZIVIAN, 2017; SCHITTINI, 2020)

Speaking loudly to drown out noise causes voice and throat problems for teachers and hinders the quality of the statements, making them shorter and simpler. Speech speed is slower, and the intonation becomes monotonous. Overall, there is less teaching. Learning becomes less and less interesting and motivating (LUBMAN D, SUTHERLAND LC, 2001; TIESLER, 2002; GILAVAND AND JAMSHIDNEZHAD, 2015).

Chiang and Lai (2008) report the harmful effects of noise on the students' mental and physical well-being. Out of a myriad of demonstrable effects, the following negative outcomes have been reported in a noisy room: getting tired easily, reduced activity efficiency, increased heart rate, dyspepsia, poor appetite, insomnia, headache, tinnitus, and facial pallor.

Furthermore, sleep disorders caused by the effect of environmental noise can directly impact school performance. Sleep influences all brain and body functions and uninterrupted quality sleep is a requirement for good physiological and mental functioning in healthy people (HAGLER, 2007). These effects include reduced perceived sleep quality, increased fatigue, changes in mood, depression, and well-being, and decreased performance in daily activities (WHO, 2001; HAGEN et al., 2002).

2.1 The Impacts of the COVID-19 Pandemic on Noise Pollution

In December 2019, SARS-CoV-2 broke out in the Wuhan animal market in China and spread worldwide, infecting more than 200 million people by July 2021 (WHO, 2021; Wang et al., 2020). The World Health Organization (WHO) has named it Coronavirus 2019 disease (COVID-19), and the International Committee on Taxonomy of Viruses (ICTV) provided the nomenclature; SARS-CoV-2; (Serve Acute Respiratory Syndrome Coronavirus-2) for the new Coronavirus (KANDEEL et al., 2020).

Given an exponential increase in cases by 2020, several countries have initiated restrictive measures. During the lockdown, many human and industrial activities remained suspended to minimize human-to-human interaction. During the lockdown, many human and industrial activities remained suspended to minimize human-to-human interaction.

Amid the quarantine imposed by the covid-19 pandemic, a study conducted by the Brazilian Association for Acoustic Quality showed that in central areas of São Paulo, the sound level decreased by up to 10 dB(A) compared to previous measurements. This value corresponds to half (50%) of the sound sensation commonly perceived in these places (PROACÚSTICA, 2020).

Asensio et al. (2020) monitored noise pollution reduction from March to June 2020 in Madrid, Spain. The results showed that the noise level decreased by 4-6 dB during the lockdown period.

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In Dublin, Northern Ireland, 12 monitoring stations monitored noise pollution from January to May 2020. Among these, 80% of the stations observed a 60% noise reduction in the lockdown period compared to the normal situation (BASU et al., 2021).

Curovic et al. (2021) also investigated the COVID-19 lockdown effect on noise pollution. The authors analyzed sound pressure data in several traffic areas in the city of Koper, Slovenia, in January 2018 (before the pandemic), February 2020, and April 2020. They reported a noise pollution reduction of 2.2 dB and 5.7 dB in the pandemic.

3 METHODOLOGY

This study aimed to evaluate noise pollution on the Jardim Botânico campus of the Universidade Federal do Paraná (UFPR) during the Coronavirus pandemic (SARS-CoV-2).

The evaluation included comparing the acoustic measurements and statistical analysis of the data measured in the field with measurements taken before the Pandemic by Vieira (2018). Therefore, the study aimed to identify whether there was a significant impact on the acoustic conditions in the area studied due to the restrictive measures imposed to address the public health emergency.

The methodological procedures were based on characterizing the study area, defining the sampling points, collecting data in the field, evaluating the noise pollution according to NBR 10.151/2020 standards and Curitiba Municipal Law 10.625/2002, and statistical analysis of the data. The Shapiro-Wilk test was used to verify normality. The relationship between the noise levels before and during the pandemic was evaluated using analysis of variance and Tukey's post hoc test, with a 0.05 significance level (α).

Equipment and software included: a sound analyzer (Brüel & Kjaer 2238) capable of frequency analysis (class 1 according to IEC 60651), calibrator model BK 4231, adjustable tripod, and R statistical software to compare results.

3.1 Study Area Characterization

The Universidade Federal do Paraná (UFPR) is the oldest university in Brazil and a symbol of the city of Curitiba, a reference in higher education for the state and Brazil. The University offers undergraduate, specialization, master's, and doctorate programs, with teaching, research, and extension activities (UFPR, 2020).

The Jardim Botânico campus is located in the Jardim Botânico district, Curitiba. The campus includes the Applied Social Sciences Sector, which comprises the Administration, Accounting Sciences, Economic Sciences, and Information Management programs.

The main highways surrounding the campus are the Green Line (BR 476) and Avenida Prefeito Lothário Meissner. The BR 476 has six lanes of 3.6 meters each and a maximum speed of 70 km/h, while Avenida Prefeito Lothário Meissner has four lanes of 3.6 meters and a top speed of 60 km/h. The Jardim Botânico Park is located in front of the campus and is also tangent to Av. Prefeito Lothário Meissner. The campus has a total área of 455,184.49 m2, with a built-up area of 56,408.84 m 2 , including 22 buildings.

According to Curitiba's Urban Zoning, based on Law 9800/2000 and decrees 188/2000, 733/2001, and 992/2004, the study area is classified as a Special Educational Zone (SEZ). However, according to Municipal Law 10.625/02, even though the study area is located

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in a SEZ, the most appropriate classification due to the site's characteristics would be Noise Sensitive Zone - hospitals, schools, and public libraries.

Municipal Law 10625/02 defines the tolerance limits for sound pressure values for Special Educational Zones ZE-E at 60 dB(A) for the daytime period (07:01 am to7:00 pm), 55 dB(A) for the evening period (7:01 pm to 10:00 pm), and 50 dB(A) for the nighttime period (10:01 pm to 07:00 am). For the Noise Sensitive Zone or Quiet Zone, the daytime limit is 55dB(A), evening 50 dB(A), and nighttime 45 dB(A).

3.2 Sampling Points Definition

The sampling points were strategically determined considering the streets with the highest traffic volume, mainly pedestrian and vehicle entrances and exits. Five internal streets and two roads surrounding the campus were evaluated, totaling 12 sampling points.

The selected points were the same as those analyzed in Vieira (2018) before the pandemic for better standardization and comparison of results.

The location of the sampling points was established using their geographical coordinates in terms of latitude and longitude, as shown in Table 1.

Figure 1 - Sampling Points Location

Fonte: Google Earth (2022).

Table 1 – Sampling Points Coordinates

Pontos de medição	Latitude	Longitude
P1	25°26'39.57"S	25°26'39.57"S
P2	25°26'39.55"S	49°14'22.95"O
P3	25°26'41.10"S	49°14'24.90"O
P4	25°26'40.86"S	49°14'21.86"O
P5	25°26'42.67"S	49°14'19.39"O
P6	25°26'41.09"S	49°14'18.99"O
P7	25°26'46.42"S	49°14'18.34"O
P8	25°26'48.11"S	49°14'19.21"O
P9	25°26'43.85"S	49°14'14.42"O
P10	25°26'53.29"S	49°14'16.60"O
P11	25°26'53.95"S	49°14'14.77"O
P12	25°26'51.78"S	49°14'13.42"O

3.3 Data Collection in the Field

Data collection in the field was carried out according to the procedures described in NBR 10151:2019 - Noise Evaluation in Communities and recommendations of ISO 1996 parts 1 and 2 - Acoustics - Descriptions, measurements, and evaluation of environmental noise.

The sound pressure level analyzer was the B&K 2238, classified as third generation and first class. This equipment complies with IEC (International Electrotechnical Commission), ANSI (American Standards Institute) standards, and the Brazilian NBR 10151/19 standard. The equipment was calibrated by B&K 4231, set in fast response mode, and evaluated on the A-weighting curve over a dynamic range of 30 to 110 dB. Sound levels were measured using the “A” scale weighted equivalent level indicators, LAeq, maximum and minimum levels, LAmax, and LAmin, respectively.

The analyzers were positioned at a minimum distance of 2 m from sound-reflecting surfaces such as walls and buildings and a 1.2 m height from the ground.

The measurements were performed on days with favorable weather conditions, with the absence of atypical sound sources, such as rain and strong wind, between July and December 2021 in the daytime period (09:30 am - 11:00 am hours and 01:30 pm - 5:00 pm), on the same days of the week, month, and time performed in the comparative study - Vieira (2018).

The measurement time was set at 15 minutes (MURPHY and KING, 2011; SOARES, 2013; ZANNIN et al., 2013a; SUÁREZ and BARROS, 2014; BRITO, 2017; VIEIRA, 2018, PAIVA; CARDOSO; ZANNIN, 2019). The instruments were calibrated before beginning the measurements with a BK 4231 calibrator.

The vehicle count at points near highways and streets was performed during the measurement time using a spreadsheet. The data was then transferred to an electronic table with other important data from the measurement points.

3.4 Collected Data Evaluation

For the noise pollution evaluation, we compared the levels of equivalent sound pressure (Leq) collected in the field with the values established by NBR 10. 151/2020, which sets the conditions required for noise acceptability in communities in Brazil. The NBR10. 151/2020 defines noise levels for the daytime period (50 dB) for urban residential areas or hospitals or schools. The Curitiba municipal legislation, which governs the noise emissions of the urban environment for Special Educational Zone (60 dB) and Noise Sensitive Zone or Quiet Zone (55 dB), sets the most appropriate classification for the study site's characteristics, which includes hospitals, schools, public libraries and the like.

3.5 Statistical Analysis

The data collected in the field were compared by statistics, verifying normality through the Shapiro-Wilk test and the relationship of the sound levels measured before and during the pandemic, to evaluate the impact of this event on the sound pressure values found. Furthermore, a correlation was performed between the sound levels and the number of vehicles to see if there is an interrelationship between the different vehicles and the observed sound pressure level. The statistical tests were developed using R statistical software (R CORE TEAM, 2020).

3.5.1 Relationship of sound levels before and during the pandemic

For evaluating pollution before and during the pandemic, measurements from the same measurement point are expected to show similarities, while measures from different points are expected to differ. Thus, observations of the same measurement point are dependent, which makes the usual tests for comparison of two or more samples inappropriate since the assumption of independence of observations is violated.

Then, the variable of interest is numerical to verify the difference between measurements before and during the pandemic. They should be compared with the value of the same measurement point to determine if there is a significant difference in this variable between the two groups of interest. Thus, the time of evaluation (before and during the pandemic) was adopted as a fixed effect, and the random effect was the point at which they were recorded using a mixed analysis of variance.

Tukey's post hoc test was applied upon finding statistically significant variation ($p>0.05$). This multiple comparisons test is widespread and widely used. It stands out for being powerful in making comparisons between all pairs and also for being easy to apply. It is known as the Tukey HSD test (Tukey Test of Honestly Significant Difference). The calculated value was compared with the tabulated value at a given significance level (α) of 0.05 using the R statistical software (R CORE TEAM, 2020).

3.5.2 Correlation between sound levels and number of vehicles

Pearson's correlation was used to verify the correlation between sound levels and the number of vehicles. This correlation coefficient is a test that measures the statistical relationship between two continuous variables. The R statistical software developed Pearson's correlation calculation (R CORE TEAM, 2020).

4 RESULTS AND DISCUSSION

4.1 Analysis of Equivalent Sound Pressure Levels (Leq)

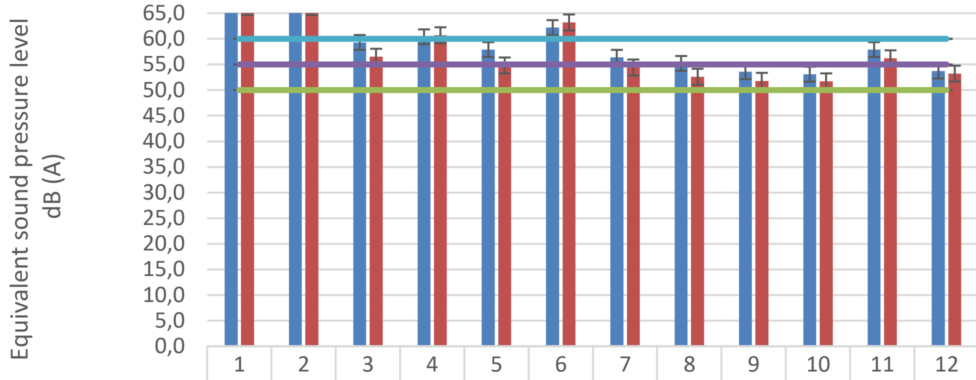
The equivalent sound pressure levels (Leq) were evaluated for each of the 12 measurement points compared to the maximum value allowed by current legislation. Among which: NBR 10151 of 2020 establishes 50 dB (A) for urban areas with schools and hospitals; Curitiba Municipal Law No. 10,625 of 2002 establishes 60 dB (A) for Special Educational Zone (SEZ) and 55 dB (A) for Quiet Zone, a classification more suitable for the area in which the university campus is located.

Table 2 – Presentation of the data measured in the field and the current legislation

Measurement points	Before the pandemic (Leq)	During the pandemic (Leq)	NRB 10151	Quiet Zone Municipal Law	Educational Zone Municipal Law Special
P1	66.70	66.20	50	55	60
P2	68.50	66.20	50	55	60
P3	59.30	56.50	50	55	60
P4	60.40	60.70	50	55	60
P5	57.90	54.80	50	55	60
P6	62.20	63.20	50	55	60
P7	56.40	54.40	50	55	60
P8	55.20	52.60	50	55	60
P9	53.60	51.80	50	55	60
P10	53.10	51.70	50	55	60
P11	57.90	56.20	50	55	60
P12	53.70	53.20	50	55	60

Based on the values found for the equivalent sound pressure level (Leq) of the measurements taken in the field, we evaluated compliance with the legal requirements and characterized the acoustic conditions. Figure 2 presents the graphic of the equivalent sound pressure levels (Leq) crossed by the three lines according to NBR 10151 (gray line), Municipal Legislation - Quiet Zone (yellow line) and Special Education Zone (blue line).

Figure 2 - Comparison of Measured Sound Pressure Levels and the Limits Allowed by Law



	1	2	3	4	5	6	7	8	9	10	11	12
BEFORE THE PANDEMIC	66,70	68,50	59,30	60,40	57,90	62,20	56,40	55,20	53,60	53,10	57,90	53,70
DURING THE PANDEMIC	66,20	66,20	56,50	60,70	54,80	63,20	54,40	52,60	51,80	51,70	56,20	53,20
NBR10151	50	50	50	50	50	50	50	50	50	50	50	50
SILENCE ZONE	55	55	55	55	55	55	55	55	55	55	55	55
ZE-E	60	60	60	60	60	60	60	60	60	60	60	60

4.2 Noise Pollution Evaluation

A comparison between the data obtained in the field and the maximum values allowed by law showed that the equivalent sound level (Leq) at the points (P1, P2, P4, and P6) was above the 60 dB required limit of Curitiba's Municipal Law 10.625 of 2002 for noise emissions in Special Education Zones during the daytime. These points are located in front of the Health Sciences Sector and Applied Social Sciences Sector.

These points present high values because they are places with greater exposure to Av. Professor Lothário Meissner. This avenue presents intense vehicle traffic. Furthermore, in front of the Campus access gate, there is a traffic light next to a U-turn, through which hundreds of trucks make the U-turn every day to access BR 277 or to access BR 476 (green line). At these points, it is possible to verify the noise pollution situation.

Although the study area is located in an SEZ, the most appropriate classification due to the characteristics of the site would be the Noise Sensitive Zone or Quiet Zone, which encompasses hospitals, schools, public libraries, and the like. Regarding the Quiet Zone (55 dB), only the points (9, 10, and 12) presented values within the allowed limit. Thus, 75% of the measured points were above the limit. Therefore, this is a noise pollution situation in these environments.

Regarding NBR 10151 - Acoustics - Measurement and evaluation of sound pressure levels in inhabited areas, which defines 50 dB for urban residential areas or hospitals and schools. The analysis indicated the worst-case scenario since none of the measured points presented values within the standard for the referred standard. Therefore, indicating noise pollution at all points.

These results agree with the values found in Paz and Zannin (2012), Soares et al. (2014), and Viera (2018), in which, in all points, the equivalent sound pressure levels did not comply with the standard.

An analysis of variance with a linear mixed model was applied to verify whether there was an influence of the Coronavirus pandemic (Sars-CoV-2) on the sound pressure levels on the Jardim Botânico campus of the UFPR. In this model, the time of evaluation (before and during the pandemic) was adopted as the fixed effect, and the random effect was the point at which they were recorded.

Tukey's post hoc test was applied upon finding statistically significant variation ($p<0.05$). Before this analysis, the data obtained from the equipment in the field were submitted to a normality analysis by the Shaphiro-Wilk test. This analysis showed that the maximum and minimum values were normal ($p>0.05$), while the average value of Leq did not show normality ($p<0.05$). Therefore, we applied a hyperbolic transformation (1/y) to obtain normality ($p>0.05$).

We observed that the pandemic affected the minimum and average values, registering lower values when compared to those recorded before it ($p<0.05$). However, for the maximum level (Lmax), the values were similar to each other ($p>0.05$) (Table 3).

Table 3 - Mean and Standard Deviations of the Minimum, Average, and Maximum Equivalent Sound Pressure (Leq) before and during the Sars-Cov-2 CoronaVirus Pandemic at the Jardim Botânico Campus of UFPR, Paraná, Brazil 2021 (N=12).

(Leq) value	Before the pandemic	During the pandemic
Minimum	51,92 ± 6,02a	47,35 ± 2,79b
Average	58,74 ± 5,02a	57,29 ± 5,41b
Maximum	75,22 ± 9,48a	76,94 ± 5,81a

Different letters in the same column indicate difference ($p<0.05$) by Tukey's test

On the other hand, we observed positive and significant correlations between the minimum, maximum, and average values, suggesting that any of them can be a criterion for evaluating noise pollution in educational environments. Moreover, we observed that the minimum value (Lmin) showed a low and non-significant correlation ($p>0.05$) with the number of vehicles and motorcycles (Table 3).

Tabela 4. Pearson's Correlation Between the Values of the Minimum, Average, and Maximum Equivalent Sound Pressure (Leq) before and during the Sars- Cov-2 Pandemic at the UFPR's Jardim Botânico Campus, (N=12).

	Médio	Máximo	Mínimo	Veículos leves	Veículos pesados
Maximum	0,65 (0,003)*				
Minimum	0,52 (0,026)*	0,46 (0,054)			
Light vehicles	0,61 (0,002)*	0,48 (0,045)*	-0,03 (0,921)		
Heavy vehicles	0,64 (0,001)*	0,56 (0,015)*	0,30 (0,229)	0,76 (<0,001)*	
Motorcycles	0,57 (0,003)*	0,65 (0,003)*	-0,05 (0,829)	0,91 (<0,001)*	0,73* (<0,001)

*Values with statistical significance ($p<0.05$).

4.3 Possible Measures to Control Noise Pollution in the Studied Area

According to Annecke and Zimmerman (2008), the vehicle flow on the road (the number of vehicles) is a determining factor regarding the noise generated. Higher vehicle flows consequently mean higher emitted noise. For a larger number of vehicles, we will have a 3 dB increase in the emitted noise every time the number of vehicles on the road doubles.

Therefore, a possible solution to reduce the number of vehicles in circulation would be to implement a license plate rotation, as it is done in the city of São Paulo.

Another relevant factor regarding traffic noise is vehicle speed. An increase in average traffic speed significantly increases environmental noise because it increases engine rpm, exhaust system noise, tire-paving interaction, acceleration and deceleration noises, and possible braking noises. Thus, reducing vehicle speed makes it possible to reduce the noise emitted. A 50% reduction in average traffic speed can reduce the overall noise level by up to 6 dB (ANNECKE; ZIMMERMAN, 2008; ELLEBJERG, 2007).

The United States, Japan, and Europe have adopted the combined solution of noise-absorbing paving and acoustic barriers. In some cases, noise-absorbing paving can be more effective in reducing traffic noise than acoustic barriers, according to Ulf Sandberg, assistant professor at the Swedish National Road and Transport Research Institute (VIT) and the Swedish Chalmers University of Technology, Téchne Magazine (2007).

In Aps and Bernucci (2020), the reduction in noise levels was evaluated on a stretch of the Mario Covas highway (Rodoanel) in São Paulo. They employed silent paving with asphalt-bearing layers of the CPA type (porous friction layer) using polymer-modified binders and ground tire rubber since this mixture has a large volume of interconnected voids, an essential condition for absorbing sound waves in the layer itself. The results showed an 8.1 dB(A) reduction in the generated noise levels.

Another solution widely used in Japan, the United States, and European countries is the implementation of acoustic barriers alongside the highways. These devices work as obstacles between the generating sources and the receivers. According to Costa (2013), implementing acoustic barriers reduces sound pressure levels by more than 4 dB(A).

5. CONCLUSÃO

This study was motivated by the fact that noise pollution is one of the main problems faced by the world's population, being considered a public health issue that can compromise life quality and produce adverse responses in humans and animals.

Furthermore, noisy educational environments are unfavorable for learning and make teaching exhausting. High noise levels affect not only the verbal quality of communication but also contribute to serious problems in the intellectual development of students.

This study made it possible to evaluate the noise pollution on the UFPR's Jardim Botânico campus during the Sars-CoV-2 pandemic by measuring the sound pressure level under current legislation and comparing the measured noise levels before and during the pandemic to verify the influence of this event on the acoustic conditions of the campus. In this regard, we observed that the sound pressure values were reduced due to the measures adopted to control the pandemic.

It was possible to observe that, despite the reduction in noise levels that occurred due to the pandemic, many points evaluated still present values above the permitted levels, demonstrating a worrying situation regarding noise pollution at the site. We believe this is because, although campus activities were suspended due to the pandemic, there has been a gradual return of activities in the city and vaccination progress.

Results such as those obtained in this study can help designers and public administrators understand which environments need priority interventions. Those results can contribute to developing short and medium-term action schedules to adapt the environment and offer better teaching conditions and higher life quality to the population.

Reducing the allowed speed of the roads, installing electronic radars, reducing the number of vehicles with license plate rotation, besides engineering interventions such as acoustic barriers and silent asphalt are just some of the possible solutions to decrease urban noise pollution. (ANNECKE; ZIMMERMAN, 2008; ELLEBJERG, 2007; COSTA, 2013; APS AND BERNUCCI, 2020). However, for Zannin (2013), only joint solutions and public policies can make the city globally think about noise control.

5. REFERENCES

ANDRADE, Erik de Lima. **Covid-19 Ruído Ambiental: Influência da pandemia nos níveis de pressão sonora externa de um hospital público.** Simpósio Brasileiro online de Gestão Urbana. São Paulo 2020.

ANNECKE, R., ZIMMERMAN, U. Examples of using traffic management measures on noise in cities - Munich' in Ellebjerg, L. (ed) Suiça, 2008.

APS, Marcia Liedi; BERNUCCI, Légi Bariani. **Mitigação do ruído proveniente do tráfego de rodovias por meio da implantação do revestimento asfáltico do tipo camada porosa de atrito – CPA: Caso Brasileiro**, São Paulo, 2020.

ARAUJO, Simone Adad. **Perda Auditiva Induzida por Ruído em Trabalhadores de Metalúrgica.** 2002. Disponível em: https://www.scielo.br/j/rboto/a/SGH79Wv6CCkspLhy45ZnNzt/?lang=pt&format=pdf. Acessado em 22/04/2020.

ARELT, C, STANAT, P, SCHNEIDER, W, SCHIEFELE, U. Competência de Leitura: Concepção de Teste e Resultados. Competências Básicas dos Alunos estudantes em uma comparação internacional. Alemanha, 2001.

ASENSIO C., PAVON I., DE ARCAS G. **Mudanças nos níveis de ruído na cidade de Madrid durante o bloqueio COVID- 19 em 2020**. *J. Acoust. Soc. Sou. Madri E*2020;

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS – ABNT (Brasil). NBR-10151: **Avaliação do Ruído em Áreas Habitadas visando o Conforto da Comunidade**, 2020.

BASNER, M., BABISCH, W., DAVIS, A., BRINK, M., CLARK, C., JANSSEN, S. Auditory and non-auditory effects of noise on health. **The Lancet**, v. 383, n. 9925, p.1325-1332, 2014.

BERGLUND, B.; LINDVALL, T.; SCHWELA, D. H. **Guidelines for community noise**. Geneva: World Health Organization: Protection of the Human Environment, 1999.

CAVALCANTE, Taciana Luce de Oliveira; ANDRADE, Wagner teobaldo Lopes. **Efeitos Auditivos e Extras Auditivos Decorrentes do Ruído na Saúde do Dentista 2007**. Disponível em: https://periodicos.ufpb.br/ojs/index.php/rbcs/article/view/11869/7304 Acessado em 22/04/2020.

Chiang C, Lai C. **Acoustical environment valuation of joint class- rooms for primary schools in Taiwan**. Build. Environ Taiwan, 2008;

CORTINO, Fabiana R. Dall, **Metodologia Para Definição De Estratégia De Controle E Avaliação De Ruído Ocupacional.**
2011. Dissertação (Mestrado) Universidade Federal do Paraná, Curitiba.

ELLEBJERG, L. Effectiveness and Benefits of Traffic Flow Measures on Noise Control WP H.1 Methods for Noise Control by Traffic Management SILENCE, SILENCE_H.D1_20070105. 2007.

FIEDLER, P. E. K. **Poluição Sonora nos Eixos Estruturais de Transportes da Cidade de Curitiba-PR**. 167 f. Dissertação (Mestrado em Engenharia de Recursos Hídricos e Ambiental), Universidade Federal do Paraná, 2013.

GILAVAND; JAMSHIDNEZHAD, **The Effect of Noise in Educational Institutions on Learning and Academic Achievement of Elementary Students in Ahvaz,** SouthWest of Iran. Iran 2015.

HAGEN, M.; HUBER, L.; KAHLERT, J. Acoustic school easing. In: **Proc. Of the Int. Forum Acusticum Sevilha,** Sevilha, 2002.

KAHLERT, J. **Boas maneiras na escola. Reflexões sobre o valor pedagógico de escuta na escola projetada acusticamente**, Alemanha, 2000.

KAHLERT, J. **Escolas de design de forma auditiva. Audição e promoção da escuta como foco de um desenvolvimento escolar pedagogicamente orientado**. Gestão Escolar, Alemanha, 2002.

LUBMAN D, SUTHERLAND LC**. Uma boa acústica em sala de aula é um bom investimento.** In: Congresso Internacional de Acústica ICA, Roma, Itália; 2001.

MUNZEL, T., GORI, T., BABISCH, W., BASNER, M. Cardiovascular effects of environmental noise exposure. **European Heart Journal**, v. 35, n. 13, p.829-836, 2014.

MUNZEL, T., SCHMIDT, F.P., STEVEN, S., HERZOG, J., DAIBER, A., SORENSEN, M. Environmental Noise and the Cardiovascular System. **Journal Of The American College Of Cardiology**, v. 71, n. 6, p.688-697, 2018.

PREFEITURA MUNICIPAL DE CURITIBA – PMC, SECRETARIA MUNICIPAL DO MEIO AMBIENTE – SMMA. Lei nº 10.625, de 19 de fevereiro de 2002: **Dispõe sobre ruídos urbanos, proteção do bem estar e do sossego público e dá outras providências.** Curitiba, 2002.

SATTLER, M. A. **Ruído de tráfego rodoviário: estimativas a partir do fluxo de veículos**. In: CONGRESSO IBEROAMERICANO DE ACÚSTICA, 1; SIMPÓSIO DE METROLOGIA E NORMATIZAÇÀO EM ACÚSTICA DO MERCOSUL, 1; ENCONTRO DA SOCIEDADE BRASILEIRA DE ACÚSTICA, 18, 1998, Florianópolis. Anais... Florianópolis: SOBRAC, 1998. p. 519-522.

SCHITTINI, Gabrielle Kaminski. **Avaliação Objetiva e Subjetiva do Ruído Ambiental do Campus Politécnico da UFPR.** 138 f. Dissertação (Mestrado em Engenharia Ambiental), Universidade Federal do Paraná, 202

TZIVIAN, L.; JAKISCH, M.; WINKLER, A.; WEIMAR, C.; HENNIG, F.; SUGIRI, D.; SOPPA, V. J.; DRAGANO, N.; ERBEL, R.; JÖCKEL, K.H.; MOEBUS, S. **Associations of long-term exposure to air pollution and road traffic noise with cognitive function - An analysis of effect measure modification**. Environment International, v. 103, p.30-38, 2017.

WHO - WORLD HEALTH ORGANIZATION, Environmental Noise Guidelines for the European Region, **WHO Regional Office for Europe**, Copenhagen, Denmark, 2018. Disponível em: http://www.euro.who.int/en/publications/abstracts/environmental-noise-guidelines-for-the-european-region-2018. Acesso em: 05 set. 2021.

WHO Coronavirus (COVID-19) painel. **Situação por país, território e área. 2021**. Disponível em: https://covid19.who.int/table. Acessado em 19 de julho de 2021.

VIEIRA, THOMAS JEFERSON. **Avaliação Da Poluição Sonora Nos Campi Centro Politécnico E Jardim Botânico Através De Medições E Mapas De Ruído**. Dissertação (Mestrado em Engenharia Ambiental). Universidade Federal do Paraná, Paraná, 2018.

ZANNIN, P. H. T.; ENGEL, M. S.E.; 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.