25th ABCM International Congress of Mechanical Engineering
October 20-25, 2019, Uberlândia, MG, Brazil

COBEM2019-2237
SMARTPHONE APPLICATION EFFECTIVENESS ANALYSIS FOR ENVIRONMENTAL NOISE MEASUREMENTS

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Abstract. *The noise pollution is one of the main problems in the world, mainly related to the growth of urbanization. In function, the noise exposure can provoke diseases for people who are exposed for a long time, and many times they do not perceive the danger. According to the Telecommunications International Union, approximately 7 billion people have been using mobile and almost half have internet access at home, then it is possible to verify the fact that the smartphones are the main tool for facilitating many human tasks. Besides, studies of acoustic should be orientated in this way, mainly to give more facility for people for using their cell phones without large difficulties. Aiming to fulfill a preliminary study about application uses for measuring sound pressure levels, the comparative analysis was undertaken among the outcomes obtained by the normalized meter and the smartphones, following the NBR 10151 requirements. These apps were selected through some criteria, as follow: users' evaluation, the capacity of measure in A-weighted filter and in the fast mode measurement configuration. Therefore, pressure sound level results were measured through different modes and compared each other for verifying their capability to make measurements in daily situations, without a standard meter.*

Keywords: *Environment Noise, Smartphone, Applications, Sound Pressure Level, NBR 10151.*

1. INTRODUCTION

The mobile using have been becoming more present in people's daily as the global process grows, although the existence of many social inequalities around the world. According to the Telecommunications International Union (2015), the use of smartphones reached 7 billion, being 3,2 billion people with internet access, also being more present in developed countries. These data confirm the manners of society thoughts through the innovations presence, and some activities that were difficult to fulfill, nowadays there are easier and provoking the development of innovative terms referring to these technologies insertion in the daily, as the Internet of Things (IoT). As a result, surveys about the importance of smartphones and how can they improve human life have been developing in parallel with the smartphone upgrades (processing, big storage, high qualities of the components, etc.).

Another theme, not less important, is related to noise pollution, which is present in many parts along the world, in different environments. The World Health Organization (2000) considers the noise pollution as a public health responsibility, given that is directly related to the people life quality and it is the cause of some diseases appearing (as cardiovascular and metabolic) in function of cases with high noise exposures. Oliveira et. al (2015) highlights the importance of noise exposure evaluating, in the developing mathematic models from the noise source identification and characterization. Thus, noise control should be treated with more attention to keeping the people healthy and avoid some uncomfortable environments, in view of many problems that can originate from the high time and uncontrolled exposure.

In this way, researchers have been working in smartphone uses as a useful tool for increasing its utilities in some still unknown areas for the majority people, giving more descriptions about the use and decreasing the high costs for measuring in comparison to the traditional meter. Li, H. e Trocan, M. (2017) developed a study about mobile sensor uses for personal healthcare, based on artificial intelligence methods. Also, Vij, D. and Aggarwal, N. (2018) proposed a system capable of detecting the traffic state through smartphones. Lastly, Soni, A., and Jha, S. K. (2018) used an optical biosensor based on a smartphone for urea detecting on saliva. Then, it is possible to verify that mobile device utilizations are present and ramifying in distinct areas, which characterizes the importance of using that equipment for facilitating future measurements and evaluations for avoiding health risks, in function of noise exposure.

Therefore, this paper goal is to develop an analysis about the efficacy of more common mobile devices for acoustic measurements, mainly referring to the noise analysis, according to the Brazilian standard requirements (NBR 10151). Some applications available in Google Play Store and in Apple Store were used for measuring environmental noise and characterizing what are the mobile applications more adequate for each situation and evaluate the outcomes through the comparison with the data obtained by a traditional meter.

2. METODOLOGY

Aiming to realize a preliminary study of the pressure sound level meter app utilization as tools in evaluations about environment noise in communities, the comparative analysis was undertaken by the noise level obtained using the standard meter and the smartphones, following the NBR 10151 (2019) procedures.

Firstly, a preliminary study was fulfilled for verifying the possibility of developing some analysis about the use of applications for measuring sound pressure level. To the finish, three environments were used, but one of them was used just for making preliminary analysis and the two others used for the final analysis, where was got more samples from each application.

2.1 Applications

The Applications used during the measurements are listed in table 1, according to the operating system and the developer. The selection criteria were adopted as follow: the user’s evaluation, capacity of measure in A-weighted filter and be capable of measure in fast mode, have a calibration option and, for the finish, present an automatic method for data extraction for avoiding losses. The table 1 presents the operating system for all the apps used during the experiment and their respectively developers. Also, the table 2 present the recent evaluation in each app’s store, their capability of measure in frequency bands, the type of calibration available and the others filters that they have.

Table 1. Apps used during the experimental procedure.

Number	Applications	Operating System	Offered by:
1	iNHV	Android 5.0 and up	Bosch Ltd.
2	Sound meter (Decibelimeter)	Android 4.0 and up	Abc apps
3	Sound Analyzer	Android 4.3 and up	Dominique Rodrigues
4	Acoustic Pocket	Android 6.0 and up	Thiago H G Lobato
5	NIOSH Sound Level Meter	IOS 10.0 and up	The National Institute for Occupational Safety and Health (NIOSH)

Source: Author.

Table 2. Others app’s features.

Applications	Evaluation (stars)	Calibration Mode	Filters Available
1	4,5	Automatic and manual	A and Z
2	4,6	Manual	A
3	4,7	Automatic and manual	A, C and Z
4	5,0	Automatic and manual	A and C
5	4,9	Automatic and manual	A, C and Z

Source: Author.

As the calibration method, all apps have a comparison methodology, which should have a calibrated meter and some noise source. The app calibration differs in the manner that the adjust is fulfilled. Whereas the iNHV and Acoustic Pocket can be adjusted manually in 1/3 octave bands frequency, the Sound Meter app and the NIOSH make the manual adjust in the noise global value. In parallel, the Sound Analyzer has an internal adjust provided that the noise source presents levels between 60 and 80 dB (A).

2.1 Experimental procedure

Following the requirements exposed in the procedures, the pressure sound meter "Solo" was used. It was calibrated by Bruel e Kjaer calibrator with 94 dB) and configurated for getting LAeq (A- weighted, equivalent sound level) measures. Besides that, the results were acquired every five minutes during the daytime period for environment 1 and five minutes for environment 2 (figure 1), in the fast condition with A-weighted filter. Also, the meter was positioned distant 1 meter from any surfaces and localized 1,2 meters of height, with the tripod support, and, during the procedure did not happen any influence of nature.

Figure 1. The environments used for getting results can be seen next. The right side shows the environment 1 and the left shows the environment 2.

Source: Authors.

For fulfilling the measurements, the apps were used for getting sound pressure levels. The apps were also calibrated according to the recommendations of their developers. After that, the outcomes from applications were compared to the meter results for making the analysis. The evaluations follow the steps proposed in the standards, according to the adjusted sound level pressure and the evaluation criteria level (NCA).

As the paper goal is present the smartphones' capabilities for measuring environment noise through the LAeq value and the spectrum, the individual influence of sound sources was not considered during the NCA evaluation and the criteria for evaluating the application was the sound pressure level between the standard meter and the measured by the app.

2.2 Case Study

The measures were got in the daytime period in three separate places in the city of Belém (Pará) called in this paper as points (1,2 and 3) and each one presents specific criteria according to the regulations (it can be seen in Table 3).

Table 3. Levels of criteria per area and measurement point adopted.

Types of areas	Daytime	Nightly	Point
Mixed area, with recreational vocation.	65	55	1
Strictly residential urban area, hospitals or schools.	50	45	2
Mixed area, predominantly residential.	55	50	3

Source: Adjusted from NBR 10151 (2019).

3. RESULTS

3.1 Preliminary results

The preliminary results of environment 1 (point 1) appear in table 4, presenting only the difference (in dB) between de Laeq value got by the normalized meter and the Applications.

Table 4. Sound Pressure Level in point 3.

Applications	LAeq (dBA)		Difference (dB)
	By app	By standard meter	
iNHV	65,5	63,9	-1,6
Sound meter (Decibelimeter)	63,0	64,0	1
Sound Analyzer	68,5	67,1	-1,4
Acoustic Pocket	60,5	62	1,5

Source: Authors.

After analyzing the effectiveness of making sound pressure level measurements with apps, through the short error between the real and experimental value in the validation phase, some analysis was fulfilled with more samples than the first evaluation, with the goal of verifying what is the behavior of each application individually.

3.2 Measurements evaluation

Thus, 50 measures were undertaken – adding the measures from all apps, being 5 in different situations, for each application in each environment. As soon, during the experimental procedure for environment 2 (point 2), the presence of moderate traffic was observed and, also, the constant bus arrival and departure near the measurement region. The table 5 presents the experimental values difference from the pattern meter of Sound Pressure Level (SPL) for each application.

Table 5. Experimental values for each app, in parallel to its respectively errors.

Applications	App SPL (dB)	Diference of SPL (dB)
iNHV	62,8	2,2
	62,3	2,2
	62,2	0,9
	62,4	1,2
	65,3	4,1
Sound Meter (Decibelimeter)	71,6	11
	55,9	-4,2
	62,8	1,5
	60,8	-0,4
	71,1	9,9
Sound Analyzer	62,3	-1
	58,6	-0,2
	67,5	2,4
	62,7	2,2
	66,9	3,6
Acoustic Pocket	63,1	-9,7
	63,9	0,7
	66,3	3,6
	63,7	2,5
	66,5	3,2
NIOSH	59,4	-1,2
	59,2	-0,9
	60,1	-1,2
	59,8	-1,4
	60,8	-0,4

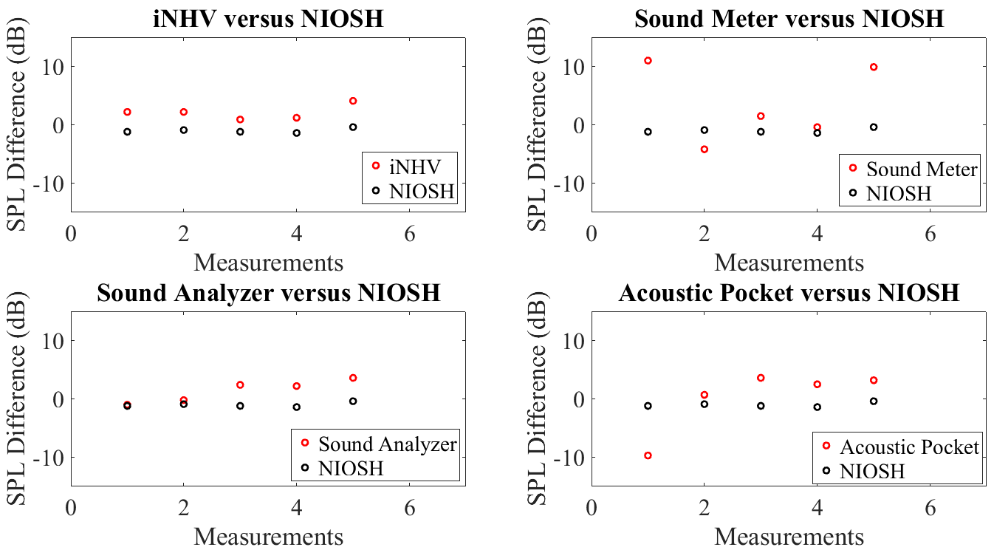
Source: Authors.

After tests, it was observed that some applications showed more accuracy than others – which presented distorted values from the reference. In this way, it was analyzed that the best app for measuring sound pressure global by global value is the NIOSH, with A-weighted filter, given that outcomes did not extrapolate the relative error equal to 2%, which returns a quantitative difference between 1 and 1,5 dB – which can be considered acceptable, given the measurement conditions. The others did not show the same uniformity among their errors, though they presented some points with more precision than NIOSH.

Some facts could have affected the measurements, but an explanation for the NIOSH be considered the best app for measuring – considering the relative error as the evaluation method -, it is related to the manual calibrating. In situations of manual or automatic calibrating, without adequate equipment, the meters may get outcomes incompatible with the expectations. Thus, as some apps were calibrated automatically – using the internal microphone and the stationary noise produced by the smartphone – e others were calibrated manually, it is possible that they did not have an equal calibration, producing some deviations in the comparative results.

The figure 2 shows the SPL difference between the NIOSH and each one application.

Figure 2. Difference of each one application in relation to the NIOSH of the Environment 2.



Source: Authors.

As the NIOSH app was considered the app with short SPL difference, the results from the others were compared with it for making a better perspective of analysis. By the graphic is perceptive some interesting points of analysis, like the dispersion of outcomes from Sound Meter, which may not have perceptible only with table results. Also, it was observed more clarity about the concision of results (though the error superior in relation to the NIOSH) from Sound Analyzer, iNHV, and Acoustic Pocket – being that this last app presented one measure point totally different from its sample.

The environment 3 was characterized by mixed area, predominantly residential, with a little traffic of vehicles, no conversations near to the points of measurements, but sometimes some activities had done while the apps were measuring in the neighborhood. The table 6 presents all the measurements from apps and its error from the reference.

Table 6. The values acquired in the environment 3.

Applications	App SPL (dB)	Diference of SPL (dB)
iNHV	58,8	-1,4
	55,5	-1,4
	58,2	-2,2
	60,1	-1,6
	56,5	-1,4
Sound Meter (Decibelimeter)	52,9	4,5
	51,4	2,7
	48,9	7,1
	54,5	4
	52	3,1

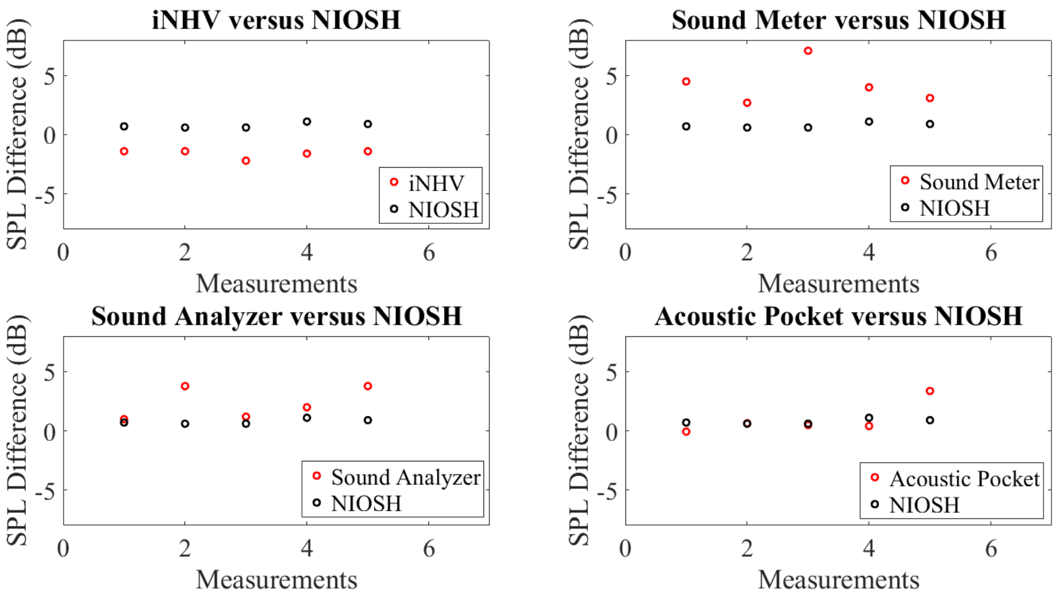
Sound Analyzer	53,1	1
	49,9	3,8
	53	1,2
	50,9	2
	53,4	3,8
Acoustic Pocket	54,2	-0,07
	54,3	-0,6
	54,7	-0,5
	53,7	-0,8
	60,5	-3,4
NIOSH	53,4	0,7
	53,1	0,6
	53,6	0,6
	54	-1,1
	56,2	1

Source: Authors

During the experimental procedure for environment 3, the results were quite like the environment 2, only short differences for Sound Meter app, which had presented short errors than the last. Also, the Acoustic Pocket presented efficacy for measuring sound pressure level, its error was minimum, and it can be considered equal to or better than NIOSH, but the last measure did not follow the others and provoke a certain deviation from its sample. Sound Analyzer, iNHV and NIOSH showed behavior quite equal to the other experiment.

For improving the analysis and for better data evaluation, the figure 3 presents the apps measurements in function of the NIOSH values, which was considered the best app for measuring – in parallel of Acoustic Pocket for environment 3. The Sound Meter app was not acceptable in view of its high deviation, approximately 7 dB, that is not indicated as acceptable error (until 1,5 dB can be accepted).

Figure 3. Difference of each one application in relation to the NIOSH of the Environment 3.



Source: Authors.

3.3 Verification of NBR 10151 procedures

For point 2, strictly residential urban area, with hospitals or schools, the measurements were obtained during the daytime and it was observed that the sound pressure level, got by the standard meter, showed all values over the limit cited in NBR 10151 (2019), that is not permitted. Also, the applications present efficacy and all apps presented discrepancy from the threshold value according to the meter and return the same conclusion: the environmental noise is over the limit. But some apps showed considerable difference in relation to the reference, since 9 until 11 dB, and which is not satisfactory, being that respective apps were considered not capable for making the analysis of sound pressure level for environmental noise verification.

For point 3, there are differences between the standard meter and the applications conclusions. Considering that the experimental procedure was fulfilled during the daytime, the maximum value for SPL is 55 dB, it was possible to verify if the outcomes obtained are under or over the limit and if it presents the similar result to standard meter. So, table 7 shows the outcomes from two types of evaluation (standard meter and app).

The disapproved evaluation means that the measurement obtains a SPL value more than permitted. Also, the approved means that the environment have no acoustic problem related to parameters in this proposed set-up.

Table 7. Application test for making the comparison to the NBR, using the standard meter as reference.

Applications	Standard meter evaluation	App evaluation
iNHV	Disapproved	Disapproved
	Approved	Disapproved
	Disapproved	Disapproved
	Disapproved	Disapproved
	Approved	Disapproved
Sound Meter (Decibelimeter)	Disapproved	Approved
	Approved	Approved
	Disapproved	Approved
	Disapproved	Approved
	Approved	Approved
Sound Analyzer	Approved	Approved
	Approved	Approved
	Approved	Approved
	Approved	Approved
	Disapproved	Approved
Acoustic Pocket	Approved	Approved
	Approved	Approved
	Approved	Approved
	Approved	Approved
	Disapproved	Disapproved
NIOSH	Approved	Approved
	Approved	Approved
	Approved	Approved
	Approved	Approved
	Disapproved	Disapproved

Source: Authors.

4. CONCLUSION

Firstly, in function of the preliminary outcomes, it is possible to say that although the applications have shown different standard deviations between each one, which can be explained by the measurement capacity of the mobile itself or the app, these deviations were considered acceptable for making initial verification and non-technical evaluations. In view of this, more samples were acquired, and new analysis was evaluated and, then, it was observed that the applications have been shown different features during the measurements phase, mainly through the dispersion of results in the same conditions. However, as the Sound Meter app presented large errors in the two environments, it was not classified as capable of making the analysis of sound pressure level for environmental noise verification.

Alongside this, it was observed that the Sound Meter (Decibelimeter) app showed values distant from the standard sound meter. Then, this fact could be related to the integration time programmed in the app, because it is the time for taking the sound energy generated in the sound transmission; in this context, a short integration time may do more measures on time, however it is quite susceptible to the energy peaks generated in the experimental procedure, caused by the traffic of motorcycles and cars, besides the motors noise from the bus station near the point of measuring in the results from environment 2. For environment 3, the errors were shorter than the point 2 but still presented a significative difference to the standard meter, which can be a measurement characteristic of this app, as short integration time.

Also, parallel facts can influence in the sound pressure level measures, as the cellphone operating system, the quality of the internal microphone and the time of use, considering that the depreciation is continuing along the time and it can generate failures during the time for capturing the sound.

Meanwhile, the majority showed good capacities for measuring environment noise to get initial parameters without the standard sound meter. This reinforces the idea of these applications working as meters, with more accessibility, for preliminary environment noise evaluation, given that the values acquired are near than obtained by the meter.

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