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DIAGNOSTIC OF EXCEEDANCES OF PERMISSIBLE NOISE LEVELS IN THE ENVIRONMENT

Summary. The article analyses the calculation rules for assessing the exceedance of permissible noise levels generated by road transport vehicles, their interpretation and application. Possible limitations and interpretation errors associated with the currently used rules for quantifying exceedances of permissible noise levels in the environment are highlighted. The related application consequences were discussed. Attention was drawn to the advisability of searching for a different methodology for classifying the results of exceedances of permissible noise levels, in relation to the acoustic protection of the environment applicable in practice. It was proposed that the methodology of modeling should be linked to the choice of a metric appropriate for comparisons of decibel numbers in the space of modeling the conditions of their reception by humans. Examples of metrics meeting the new criteria for the analysis of exceedances of permissible noise levels in the environment are provided. The authors, using the example of the analysis of noise monitoring results on one of the main communication arteries of the city of Kielce, presented the functioning of the new idea of classifying exceedances of permissible noise levels. The article presents a verification of the noise threat assessment using

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the Euclidean measure of exceedances of permissible noise levels, and using a measure that meets the requirements of the metric for the decibel space of human perception of acoustic phenomena. Statistical characteristics of the analyzed measures of exceedances of permissible noise levels are presented.
Keywords: noise, regulations, traffic

1. INTRODUCTION

The current criteria for assessing exceedances of permissible noise levels in the environment defined by national regulations [6], acoustic standards and World Health Organization (WHO) [4,5] guidelines - are based on the Euclidean measure [1] of the difference between the measured (or calculated) level of the analyzed noise indicator and the permissible value for it.

In the practice of environmental research, such assessments are used for the analysis of exceedances of various noise indicators, e.g., daytime and evening noise level (L_{DEN}), equivalent sound level, tonal or impulse noise, or peak exceedances [12]. In the article, the authors raised the problem of the correctness of the quantification of acoustic hazards based on the Euclidean value of the difference [10] between the control result and the permissible value for it. They paid the attention to the fact that in the control assessments there may be exceedances described by numbers from the lower range of the decibel scale, i.e. values less than 30 dB. The interpretation of such results, in relation to the guidelines defining permissible noise levels in the context of their perception and potential harmfulness to human health, developed by WHO - raises questions about the correctness of the assessment of acoustic hazards. The procedures for assessing exceedances of permissible noise levels are inconsistent (in the interpretation of their results) with the guidelines intended to protect public health by minimizing the negative effects of noise [13], such as sleep disturbances, concentration problems, hearing damage and other health problems.

It is therefore reasonable to ask the question, to what extent are such assessments correct? The authors verified them based on analyses of their compliance with:

- laws describing human perception of acoustic hazards and the resulting nuisance and health risks;
- interpretation of exceedances in the context of the sensitivity of the decibel scale
- requirements that apply to the measurement result comparison measures specified in the identification process methodology
- the logic of evaluating the result of calculations of exceedances of permissible noise levels in relation to the calculation, inverse to the analysis of exceedances of controlled noise indicators, consistent with the relations of decibel algebra
- relating the results of the estimation of the uncertainty of control measurements of acoustic hazards to the calculated exceedances of permissible noise levels.

It should be noted that the problem of assessing the correctness of the current rules for classifying acoustic hazards discussed in the article applies not only to the assessment of the risk of nuisance resulting from exceeding the permissible noise levels in the environment and the negative health effects caused by them, but it also influences the answer to what extent current regulations and legal provisions take into account the perception of noise hazards and whether they provide an effective and adequate system of instruments for the protection of the acoustic climate.

The analysis results obtained in this work should be treated as a starting point for the construction of new rules for the assessment of acoustic hazards to the environment and an incentive for a broader discussion on the advisability of changing the current rules for the quantification of acoustic hazards to the environment.

2. INFORMATIONAL CONTENT OF CURRENT MEASURES OF EXCEEDING PERMISSIBLE NOISE LEVELS IN THE CONTROL OF ACOUSTIC ENVIRONMENTAL HAZARD

In scientific research and its applications concerning the "object-environment-human" system, an anthropocentric approach is necessary, where the human is the most important part of the system. The results of research on acoustic hazards must generate results that determine the solution of many technical and decision-making problems related to human functioning in the surrounding environment. Relating this requirement to the currently used Euclidean measure of exceedances of permissible noise levels in the processes of quantifying acoustic hazards, it should be stated that it is not selected correctly. This measure does not properly relate to the conditions of human perception of acoustic hazards and the resulting nuisance and health risks.

The decibel classification of noise resulting from the Weber-Fechner psychoacoustic law [9,14] is described by a nonlinear logarithmic relation. This relation takes into account the fact that human hearing works non-linearly, which means that a 1 dB change in noise is almost imperceptible to humans, a 3 dB change causes barely perceptible differences, and only a 5 dB change causes clearly perceptible changes in the noise level. Hence, not every formal exceedance of the standard resulting from the current rules for assessing exceedances of permissible noise levels is felt by people. This means that if the control measurement and its evaluation show, for example, a formal exceedance of the standard by 2 dB, this may not be noticeable for most people. In environmental acoustic studies, we usually deal with exceedances described by numbers from the lower range of the decibel scale, i.e. with values less than 20 dB. This range of decibel numbers describing noise exceedances in the environment in the light of the noise assessment criteria and their impact on humans proposed by WHO - is classified as practically harmless values. Values in the range of 0 dB - 20 dB are considered comfortable sound levels, while noise levels in the range of 20-40 dB are classified as non-obtrusive, facilitating human concentration.

When analyzing the information content of exceedances of permissible noise levels in the environment, attention should be paid to the problem of the sensitivity of the decibel scale, considered in the perception space of the obtained research diagnosis in various ranges of the values of the analyzed exceedances expressed in decibel numbers. In the range of [0 - 8] dB values, significant deviations from the constancy of decibel numbers' representation of the conditions of their perception by humans were found. From the results of research analyses estimated by the dependence (1):

$$C(L) = \frac{L}{\left(\frac{p_{RMS}^2}{p_0^2}\right)} = 10lg(2 - 10^{-0.1L}) \tag{1}$$

it follows that for noise levels greater than 25 dB it can be assumed that the sound level sensitivity coefficient has a constant value. In the range of sound levels lower than 15 dB, significant deviations from the condition of constancy of representation of acoustic disturbances perceived by humans from noise levels were found, as illustrated in Fig. 1a.

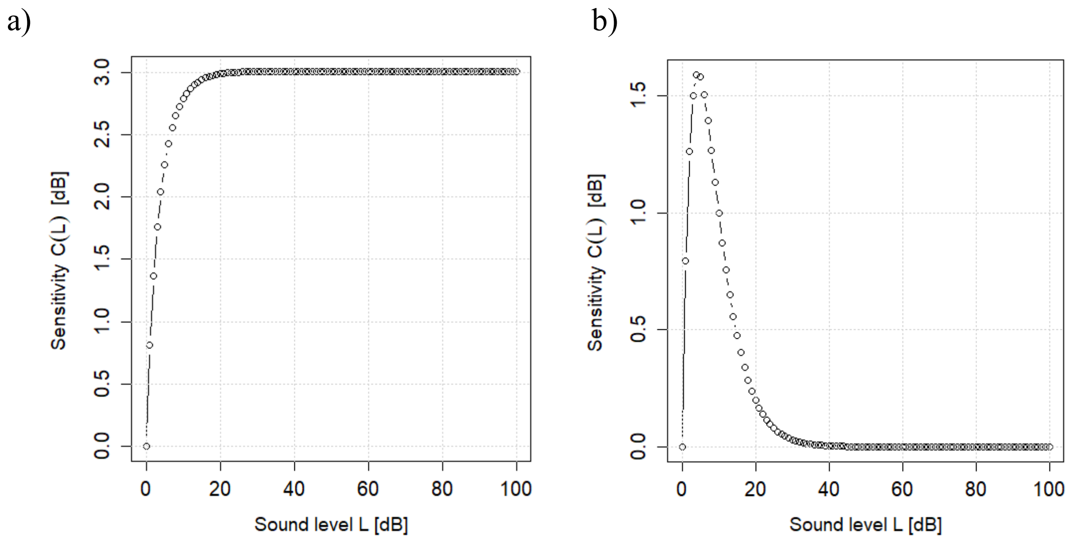

Fig. 1. The sensitivity of the decibel scale C(L) describing the perception of acoustic phenomena characteristic of calculations in the space of numbers: a) decibel, b) Euclidean

In particular, this problem raises doubts as to the validity of performing identification calculations according to formulas assigned to Euclidean numbers. The sensitivity of the decibel scale C(L) specific to calculations in the Euclidean number space is given by the relation (2) and is presented in Fig. 1b:

$$C(L) = \frac{L}{\left(\frac{p_{RMS}^2}{p_0^2}\right)} = L \cdot 10^{-0.1L} \tag{2}$$

The plot in Figure 1a for pressure levels in the range 0 dB to 15 dB is non-linear. The sensitivity increases to approximately 3 dB and remains constant for higher noise values, which is a desirable property of any electromechanical transducer. Interpretation of the waveform from Fig. 1b in the decibel range from 0 dB to 10 dB shows the presence of strong non-linearity and a maximum sensitivity value. It is a strong message of detachment of acoustic disturbances perceived by humans from the representing noise levels [8]. It follows from this that in the scope of current administrative proceedings aimed at improving the acoustic climate in the environment - based on the Euclidean measure of exceedances of permissible noise levels, there may be significant errors of interpretation and discrepancies in the correct connection of standard exceedances of noise levels with the conditions of their perception by humans, and thus with their nuisance and harmful effects on health. They refer to the non-linear sensitivity range of the decibel scale. For noise levels greater than 30 dB, it can be assumed that the value of the sensitivity coefficient of the equivalent sound level does not change and has a constant and linear course. The maximum value of the sensitivity is 1.6 dB, and the average value in the range [30 dB, 120 dB] is 0.0003 dB. The obtained results indicate the need to depart from the Euclidean calculation of their identification, common in the control of acoustic hazards to the environment, in the case of the analysis of noise levels described by low decibel numbers.

Another interpretation problem concerning exceedances of permissible noise levels in the environment is the issue of the correctness of using the Euclidean measure to represent the conditions of their perception by humans, analyzed through the prism of the requirements placed on the metrics of decibel comparisons of measurement results. The commonly used

Euclidean measure ρ_{ij} of comparisons of decibel values of noise levels L_i, L_j used in the process of identifying acoustic hazards to the environment - determined by the results of the differences $\rho_{ij} = L_i - L_j$ of noise levels - does not meet the requirements of the metrics that specify conditions (a ÷ c). Consequently, this measure is not appropriately chosen for comparisons of decibel measurement data [15]. It is invalid for identification tasks performed in the metric identification space appropriate for diagnostic tasks of the state of acoustic hazards in the environment. The requirements of the measure (metric) for data comparisons in the adopted space of modeling recognized states are determined by the following conditions:

a) $\rho(x, y) = 0 \Leftrightarrow x = y$,

b) $\forall\, x, y \in X : \rho(x, y) = \rho(y, x)$ (symmetry condition),

c) $\forall\, x, y, z \in X : \rho(x, y) \leq \rho(x, z) + \rho(z, y)$ (triangle condition).

In the decibel database of measurement results – the implementation of the comparison of three values $x = L_1, y = L_2, z = L_3$ evaluated by their Euclidean differences – is an improper process. These distances in the decibel space of human reception do not meet condition (c).

Example 1:

When we analyze the measurement results defined by the noise level values: $L_1 = 55$ dB, $L_2 = 50$ dB, $L_3 = 45$ dB, their distances calculated using the Euclidean measure are:

$\rho_{12} = 55\,dB - 50\,dB = 5\,dB, \quad \rho_{23} = 50\,dB - 45\,dB = 5\,dB, \quad \rho_{13} = 55\,dB - 45\,dB = 10\,dB.$

They do not meet the requirements that should be assigned to a measure correctly selected for their comparisons in space consistent with the conditions of their reception by humans. This is because condition (c) is not met:

$$\rho_{12} + \rho_{23} = 5\,dB + 5\,dB = 8\,dB \quad < \quad \rho_{13} = 10 \text{ dB}$$

This means that the Euclidean measure of comparison of decibel scores in the acoustic hazard identification process is inappropriate. This objection can be applied to tasks related to the classification of acoustic hazard states. The current practice of using the Euclidean measure in assessing exceedances of permissible noise levels generates results with interpretational results that are difficult to accept.

In the evaluation of the Euclidean metric of exceedances of permissible noise levels, one can notice an inconsistency in the perception of the result of exceedances given by the difference between the control value and the permissible value in relation to the perception of its inverse relationship, i.e. the perception of the result of the sum of exceedances and the permissible value.

An example of the interpretational inconsistency of exceedances of permissible noise levels calculated according to the current Euclidean measure is the evaluation of the result of its reverse operation. The result exceeding the permissible noise level added to the permissible noise level value gives a result that does not match the measured noise level. This means that such a result is separated from the calculation of decibel numbers. It shows the lack of logic assigned to the interpretations assigned to the description of the identification of acoustic hazards in the space of their perception, i.e. their reception by humans. Such a situation is illustrated by the data described in the example below.

Example 2

For the Euclidean measure of exceedance $\Delta L = 6$ dB defined as the difference between the measured noise $L_{Mea} = 51$ dB and the permissible value $L_{Per} = 45$ dB, the perception of the inverse relation, i.e. the result of adding two noise sources given the permissible level value of 45 dB and exceedances of 6 dB will take an almost unchanged value. This results from the calculation of the addition operation: 45 dB $\oplus$ 6 dB = $10\, lg\{10^{4.5} + 10^{0.6} - 1\}$ = 45 dB. The result of such an operation of 45 dB is different from the measured noise level $L_{Mea} = 51$ dB.

When considering the usefulness of the Euclidean measure of exceedances of permissible noise levels, its usefulness should be considered in the context of the uncertainty of acoustic environmental measurements. In control tests, a range of exceedances not exceeding 12 dB is often found. Therefore, their references to the error tolerance field that may be present in the processes of controlling acoustic hazards to the environment are important. According to the work [3, 11], the type B uncertainty in the assessment of environmental acoustic hazards is in the range of [0 - 5] dB. In control practice, there will often be situations in which the uncertainty analyses of exceedances of acoustic environmental hazards assessed using the Euclidean measure will be at a level comparable to the control results. This fact may be a basis for questioning their credibility and certain administrative and legal actions related to them. This situation is well illustrated by the measurement data described in the example below.

Let the measured noise level in the environment as a result of the control measurement be $L_{Mea} = 48$ dB, with the permissible noise value $L_{Per} = 45$ dB. The basis for admiralty actions, determining the requirements for the entity responsible for excessive noise emission, will be the value of the Euclidean measure of exceedance ΔL = 3 dB, i.e. the difference between the measured noise $L_{Mea} = 48$ dB and the permissible value $L_{Per} = 45$ dB. Relating such a result - to the uncertainty of type "B" encountered in environmental acoustic studies [3] shaped at the level of [0, 5] dB - gives grounds to question the validity of its recognition as a reliable basis for enforcing a decision based on such a result.

The arguments presented above justify the need for a broader verification of the usefulness of using the Euclidean measure to assess exceedances of permissible noise levels and the search for new measures of exceedances of permissible noise levels in the environment consistent with their perception by humans. To more effectively assess the impact of environmental noise on people, it is worth considering extending the current methods with additional measures of exceedances of permissible noise levels. These measures should be free from the interpretational limitations of Euclidean measures of exceedances of permissible values of the analyzed noise indicators, discussed in the previous point. An example of such a measure is the operation of subtracting the levels of two noise sources in the decibel number space, which determines the conditions for the perception of their result:

$$\Delta L_i = 10\,\mathrm{lg}\left\{10^{0.1L_{DEN\,i}} - 10^{0.1L_{DEN_{REF}}} + 1\right\} \quad \text{for } L_{DEN_i} \geq L_{DEN_{REF}} \tag{3}$$

This measure meets the requirements in terms of the exceedances it shows:

- correct references to the conditions of their perception by humans and the nuisances and health risks resulting from them,
- they are within the fully acceptable sensitivity range of the decibel scale,
- meet the metric requirements for measuring comparisons of human perception of the difference in noise levels between two sources,
- the correctness of the perception condition of the inverse relation to the operation of assessing exceedances of the permissible noise level, i.e. the result of the sum of adding two noise sources given the value of the permissible level and the value of its exceedances,

- acceptability of the interpretation in the control process of uncertainty estimates of the result of exceedances of permissible noise levels, conditioned by a significant difference in the noise levels defining them.

3. RESULTS OF EXPERIMENTS VERIFYING PERCEPTUAL MEASURES OF ACOUSTIC (NOISE) THREATS

The basis for the analyses were the results of the equivalent sound level recorded by the noise monitoring station located in Kielce at Popiełuszki Street [2]. The location of the station in the urban layout of Kielce is shown in Figure 2.

Fig. 2. Location of the monitoring station at Popiełuszki Street in the urban layout of Kielce

Popiełuszki Avenue is part of the eastern bypass of Kielce and national road no. 73 (Warsaw/Łódź – Kielce – Tarnów), which is directly connected to the Trans-European Transport Network. Popiełuszki Av. is the main section of the exit route from the center of Kielce towards Tarnów and serves both urban, suburban and transit road traffic. All measurements were performed 24 hours a day. The equivalent sound level $L_{Aeq,T}$ (equation 4) was recorded for three-time intervals: from 6:00 to 18:00, from 18:00 to 22:00 and from 22:00 to 6:00.

$$L_{Aeq,T} = 10 \cdot lg\left[\frac{1}{T}\int_0^T \left(\frac{p_A(t)}{p_0}\right)^2 dt\right] = 10 \cdot lg\left[\left(\frac{p_{A_{RMS}}}{p_0}\right)^2\right] \qquad (4)$$

where: T - represents the overall measurement time, s; $p_A(t)$ - A-weighted sound pressure, Pa; p_0 - is the reference sound pressure of 20 μPa; $p_{A_{RMS}}$ - represents the effective sound pressure. The results coming directly from the monitoring, i.e. the course of the recorded values of the equivalent sound level for the times of the day: day, evening and night are shown in Figure 3. These data were recorded in 2011. It should be noted that for technical reasons, the station recorded data for 158 days.

The parameter used in environmental protection programs against noise is the day-evening-night noise index L_{DEN}. For this reason, the authors analyzed exceedances of the permissible values of this parameter. This index is a measure of the long-term or daily average sound level, expressed in decibels (dB) [7] and determined according to the relationships (5) and (6).

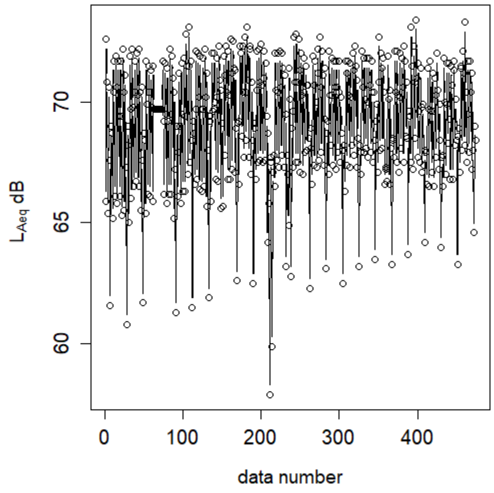

Fig. 3. Equivalent sound level values recorded by the noise monitoring station

The daily noise index L_{DEN_i} is determined according to the following relationship:

$$L_{DEN_i} = 10\lg\left[\frac{12}{24}10^{0.1L_{D_i}} + \frac{4}{24}10^{0.1(L_{E_i}+5)} + \frac{8}{24}10^{0.1(L_{N_i}+10)}\right] \tag{5}$$

The long-term day-evening-night noise index L_{DEN} is determined according to:

$$L_{DEN} = 10\lg\left[\frac{1}{365}\sum_{i=1}^{i=365}10^{0.1L_{DEN_i}}\right] \tag{6}$$

where: L_{D_i}, L_{E_i}, L_{N_i}- equivalent sound level for three time periods: from 6:00 to 18:00, from 18:00 to 22:00 and from 22:00 to 6:00, corresponding to the times of the day, evening and night. The course of the noise index L_{DEN_i}on the subsequent days is shown in Figure 4. For the analyzed data, the value of the noise level index was $L_{DEN} = 74{,}5$ dB.

The basis for the assessment of acoustic threats to the environment in the noise monitoring system was the Euclidean measure of exceedances of the permissible value expressed by the following relationship:

$$\Delta(L_{DEN}) = L_{DEN_i} - L_{DEN_{REF}} \tag{7}$$

Selected values of statistical parameters of this quantity in relation to the permissible value of noise level $L_{DEN_{REF}} = 70$ dB are presented in Table 1.

Tab. 1

Statistical analysis of exceedances according to currently used Euclidean evaluation rules

Shapiro Wilk Test	Quartile I dB	Logarithmic mean dB	Median dB	Quartile III dB	Standard Deviation dB	COV %	Ua dB	Skewness	Kurtosis
H0 Rejected	3.93	4.46	4.64	5.25	1.45	34.14	0.12	-1.38	4.37

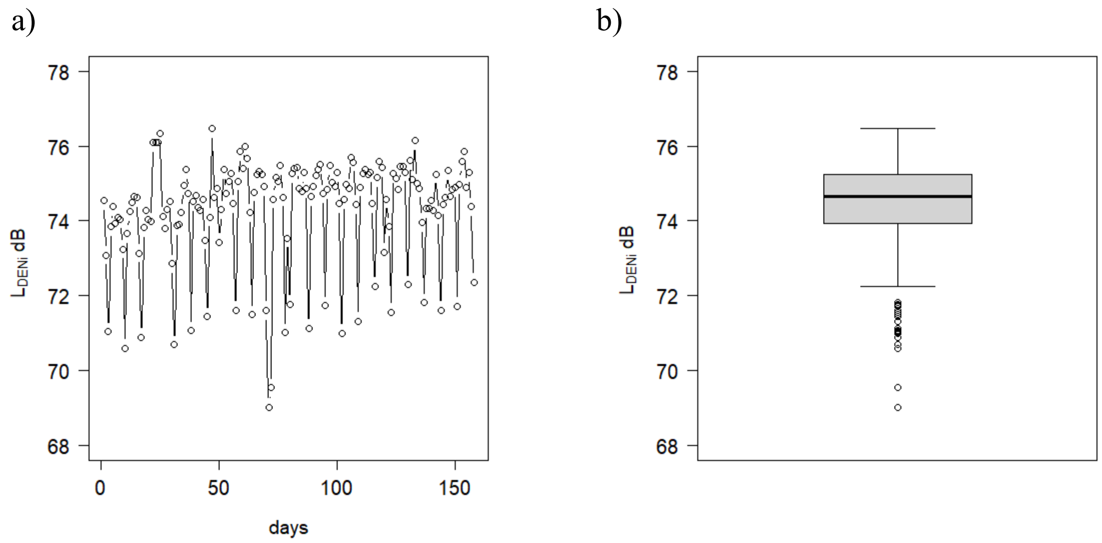

Fig. 4. Daily day-evening-night noise index L_{DEN_i}
a) course on subsequent days, b) box distribution of values

It includes parameters related to the distribution and variability of the exceedance measure being studied. The compliance of the distribution of the analyzed measure with the normal distribution was also analyzed. The acceptability of this hypothesis was verified using the Shapiro-Wilk test, the null hypothesis of which H0 assumes that the analyzed variable complies with the normal distribution. The average value of the analyzed exceedances expressed in decibel values was assumed to be their logarithmic mean according to the following relationships: - $\bar{\Delta}(L_{DEN}) = 10\lg\left[\frac{1}{n}\sum_{i=1}^{n} 10^{0.1L_{DEN_i}}\right]$. Table 1 also shows the value coefficient of variation $COV = \frac{sd(\bar{\Delta}(L_{DEN}))}{\bar{\Delta}(L_{DEN})}$ where sd denotes standard deviation and u_a denotes type A standard uncertainty.

The next analyzed measure is the exceedances assessed by the conditions of their reception by humans in accordance with the Weber-Fechner law. This measure should be determined according to the relationship (8):

$$\Delta_{Li} = 10\lg\left|10^{0.1L_{DEN\,i}} - 10^{0.1L_{DEN_{REF}}} + 1\right| \text{ for } L_{DEN_i} \geq L_{DEN_{REF}} \quad (8)$$
$$\Delta_{Li} = 0 \quad \text{for } L_{DEN_i} < L_{DEN_{REF}}$$

Table 2 shows the values of the statistical analysis of exceedances assessed by the conditions of their perception by humans for the permissible noise level value $L_{DEN_{REF}} = 70$ dB.

Tab. 2

Selected values of exceedances $\Delta(L_{DEN})$ of the permissible noise level $L_{DEN_{REF}} = 70$ dB assessed according to equation (8)

Shapiro Wilk Test	Quartile I dB	Logarithmic mean dB	Median dB	Quartile III dB	Standard Deviation dB	COV %	Ua dB	Skewness	Kurtosis
H0 Rejected	71.74	72.59	72.83	73.71	2.81	3.91	0.23	-1.82	5.6

The analysis of the statistical properties of the solutions for assessing exceedances of permissible noise levels based on the exceedance measure proposed by the authors (3) and the currently used Euclidean measure (7) allows us to state that both measures generate results that do not allow for the acceptance of the null hypothesis about the normality of the statistics of exceedances of permissible noise values in the environment. It is clearly seen that the density function of the normal distribution does not fit the empirical distribution, as illustrated by the values of the skewness and kurtosis parameters. This research result is often reported in environmental noise studies. It forces the use of non-classical statistical methods in the tasks of estimating the uncertainty of acoustic hazards in the environment [1]. Comparing the numerical data contained in Tables 1 and 2, it can be seen that by using the exceedance measure consistent with the conditions of their reception by humans, significantly higher numerical values of all parameters characterizing the distribution of the tested variable were obtained in comparison to the exceedances determined according to the currently used Euclidean assessment rules. In the case of the logarithmic mean, its value determined based on equation (8) was 72.6 dB in comparison to the value of 4.5 dB, which was obtained for the currently used Euclidean exceedance measure. Such representation means the correctness of the references of the results generated by the measure proposed by the authors to the conditions of their perception by humans and the associated nuisances and health hazards. A significant difference in the comparison of the properties of both measures of exceedance of permissible noise levels is the reference values of their coefficients COV. In the case of using the proposed new measure of exceedances, the result of COV obtained was over 11 times lower than the value assigned to the classical assessments of exceedances of permissible levels. Exceedances assessed with classical analysis rules are characterized by a median value of 4.6 dB and a logarithmic mean of 4.5 dB. They are at a level fully comparable to the B-type uncertainty occurring in environmental acoustic measurements [3], which makes them unreliable in assessments of acoustic hazards to the environment using the Euclidean measure of exceedances. When using the new exceedance measure described by function (8a), the obtained result is acceptable. The statistical evaluation of the results generated by it is characterized by a standard deviation of 2.8 dB. Compared to the exceedance estimates described by the median value of 72.3 dB or the logarithmic mean of exceedances of 72.6 dB, it is at a level that ensures the acceptability of the result of noise exceedance control, with an appropriate level of its uncertainty. An important property of the proposed measure for assessing exceedances of permissible noise levels is the compliance of the results it shows with the conditions of their perception and harmfulness, i.e. the criteria for assessing noise and its impact on humans proposed by WHO. The results generated by it are in accordance with the decibel calculus inverse to the analysis of exceedances of controlled noise indicators, which allows for verification of the measurement result based on the calculated exceedances in relation to the adopted permissible values. They also concern the range of the constant sensitivity of the decibel scale, which is not ensured by using the Euclidean measure of permissible noise levels. As a result of the presented empirical analysis of exceedances of permissible noise levels, based on the results of road noise monitoring in the city of Kielce, a need to change the approach to diagnosing the state of acoustic threats to the environment was identified. It is also advisable to introduce new measures of exceedances of permissible noise levels into the practice of diagnosing the state of acoustic threats to the environment.

4. CONCLUSIONS

The analyses carried out have shown that the Euclidean measure of exceedances of permissible noise levels present in the implementation standards of environmental acoustic control has no reasonable references and interpretations in relation to the conditions of their perception by humans. It is detached from the conditions of decibel processing of measurement results appropriate to the decibel algebra used in the processes of identifying acoustic hazards in the environment. This conclusion results from the fact that the noise exceedance levels are not consistent with the classification of noise levels in the context of the conditions of their perception and potential harmfulness to human health, developed by the WHO. The Euclidean exceedance measure used for their estimation does not meet the conditions required for measures of comparison of measurement results used in identification processes. The exceedance results related to it do not allow for correct verification of the measurement result by the reverse operation, i.e. the relation of adding the exceedance values to the value considered permissible. An important premise in favor of rejecting the Euclidean measure of exceedances of permissible noise levels in the control of acoustic hazards may be the references of exceedances of permissible noise level standards to the value of the control measurement uncertainty. In the case of small exceedances with values not exceeding 5 dB, the estimated uncertainty of the control measurement may be comparable to it or even smaller. Such a result will generate doubts as to whether the standard has actually been breached. With higher, relatively small values of exceedances calculated using the Euclidean metric, their reference to the "type B" uncertainty (including those related to errors in measurement instrumentation and measurement conditions) will always generate doubts as to whether they are significant enough to enforce further administrative or legal steps.

As it results from the above reservations regarding the current - Euclidean measure of exceedances of permissible noise levels in the environment - the justification for its use should be verified. It is advisable to abandon it in favor of the presented measure appropriate to the process of identifying the conditions of their perception by humans.

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