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Diagnosis of Acoustic Hazards of The Environment and its Identification Problems

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Abstract

Diagnostic procedures for control and evaluation of the state of environmental acoustic hazards have numerous standard and legal regulations. They formalize how to perform control studies and assess the state of acoustic hazards in the environment . However, their implementation procedures have some unrecognized scientific and application potential. They can be associated with the failure to comply with the methodological requirements that apply to identification tasks carried out in the metric measurement space. The measurement dimension of the task of controlling acoustic hazards in the environment - based on decibel values - has a number of specific properties, projecting doubts about the currently used solutions .The problem undertaken in the article, analyzes the correctness of operations of decibel processing of measurement results from the point of view of algebra, used for modeling of recognized states of acoustic hazards of the environment. It focuses attention on the correctness of the estimation of exceedances of permissible noise levels by the Euclidean measure of the distance of the control evaluation result from the normative values. Discusses the shortcomings of the classification used in relation to the interpretation of the conditions of their perception by humans, as well as metrological considerations related to the evaluation of the uncertainty of the control result. I emphasize the need to look for new measures of exceedances of permissible values of noise levels in the environment, suitable for their perception by humans. The analyses and considerations presented in the article formulate a new program framework for undertaking a broader discussion and research on the advisability of changing some of the implementation activities that are commonly present in existing procedures for identifying noise hazards in the environment. It outlines a certain research area that needs to be resolved in the area of implemented tasks of environmental acoustics.

Keywords: Noise Modelling, Identification of Acoustic Hazards, Decibel Algebra, Acoustic Diagnostics of the Environment.

Admission

The effectiveness of measures taken to improve the acoustic climate of the environment depends on correct diagnostic diagnoses of the hazards present in it. The rules of calculation associated with their estimation are derived from the knowledge describing the human response to noise. It associates many adverse effects on the human body with an increase in noise levels described by decibel numbers. The adoption of the decibel state variable for describing environmental noise in acoustic hazard identification studies is related to Weber-Fechner's psychoacoustic law. It relates the perception of acoustic disturbances p(t) acting on humans, to the decibel measure describing them. It has no sense or physical dimension; it is only a decibel quantifier of human response to acoustic disturbances present in the environment. It determines their potential effects on the possibility of certain disease risks in humans.

Its values are defined by a logarithmic relation determined on the value of the ratio of the energy of sound pressure disturbances p(t) acting on the human body, related to the conventional value of pressure energy pL=$^{10\,lg\left[\frac{p_{RMS}^2}{p_0^2}\right]_0}$, related to the threshold of its reception.

The range of acoustic hazards considered in the process of identification is determined by decibel numbers with values in the range of [0, 130] dB. The value of 0 dB corresponds to the acoustic disturbance pressure $p_0 = 2 * 10^{-5}$ [Pa], which is the arbitrary threshold of identifiable auditory sensations in a human being, caused by this stimulus. On the other hand, the value of 130 dB corresponds to the pressure of acoustic disturbances p(t), at which damage to the hearing organ may occur.

In the practice of controlling the state of acoustic hazards in the environment, the research diagnoses carried out are linked to the adopted method of modeling the identified states, described by decibel numbers. Their realizations, depending on the questions posed, are carried out in three different metric measurement spaces. Their selection in the research process is linked to the adopted way of modeling the identified acoustic phenomena. Each of them has a separate modeling language. It is defined by the algebra adopted for decibel transformations of measurement values and the measure (metric) of comparisons of measurement results.

Their common element, however, is the decibel state variable characterizing the identified phenomena. In acoustic studies of the environment, the identification of the states that describe it is carried out in :

Euclidean Measurement space: In which the mechanisms of generation and propagation of environmental acoustic hazards are identified. The basis for the identification of these phenomena are measurements of changes in the sound pressure values, which in the end are convertible into decibel values of the pressure levels determining them. The implementation of such identification processes is secured by numerous, universal identification algorithms, characteristic of operations on Euclidean numbers, with a Euclidean metric of their comparisons. It should be noted that in the study of the mechanisms of generation and propagation of acoustic hazards - the adoption of a Euclidean metric for comparisons of final identification results expressed in decibel values - is corrected.

Perceptual Measurement Space: In which the quantification of human perception of acoustic hazards occurring in the environment takes place. The basis for their estimation is the adopted method of modelling the measured changes in decibel values of sound pressure levels, obtained with the use of sonometers; L_i ; $i = 1,2,$.,n (i.e. the measurement instrumentalisation inherent in such tests). It requires processing the decibel database of measurement results and their comparisons in a way that quantifies their reception by humans. This process is carried out on operations proper to the algebra on decibel numbers, defined by the axiom of addition of two sources with levels L_1 and L_2 and the measure of comparisons of their distances, consistent with the operation of subtracting decibel values present in this algebra.

Probabilistic Measurement Space: In which the probability of occurrence of acoustic hazards described by random decibel numbers is identified. The process of their modelling results from assigning to decibel measurement results the attribute of randomness of events, which is processed by the calculus of probabilistic at the metric of their comparisons given the density function of the probability distribution of their occurrence. In the practice of measuring acoustic hazards, this type of identification process has a relatively limited number of representations. It is limited to tasks in which the uncertainty of the conducted research is estimated, i.e. the results of the control of the state of environmental acoustic hazards.

When analysing the process and identification of environmental acoustic hazards commonly occurring in research practice - reported in numerous publications and standard indications relating to their implementation - it is necessary to pay attention to some of their unrecognized scientific and application potential.

It can be linked to the occurrence of deviations from the methodological requirements assigned to the correct modelling activities of the identified states in the appropriate metric measurement space adopted for them.

In particular, this objection should be formulated for the tasks of classifying acoustic hazard conditions. The rules existing in control solutions - the rules for quantifying the decibel values of measurement results, a Euclidean measure of their comparisons - are inconsistent with the conditions of their reception by humans and the modelling conditions that are used when processing them in the decibel measurement results database.

It is also possible to notice - present in the operations of decibel transformations of measurement results - some interpretation paradoxes associated with them. They concern operations: addition " $\oplus$ " and subtraction " $\ominus$" of decibel numbers characterizing the conditions of interaction of noise sources , or division " $\oslash$ " relative to each other of decibel numbers at certain characteristic values of them .

Taking into account the above objections is a premise for asking two fundamental questions concerning:

the existence of correct decibel algebra in the tasks of developing measurement data described by decibel values, which are determined by research diagnoses in the processes of controlling the state of acoustic hazards of the ??? environment the use of correct measures in the decibel comparisons of measurement results that I use in the process of identifying acoustic hazards ??? . References to these questions are the content of the author's analyses included in the article and will be developed in its following paragraphs.

Decibel Algebra in Environmental Acoustics

Theoretical Foundations of Decibel Algebra

The analysis of the correctness of the relations between decibel transformations of measurement results present in the research practice - which we are dealing with in the process of modelling the assessment of environmental acoustic hazards - will be considered through the prism of the correctness of the algebra defined by them.

It is made up of operations on decibel numbers related to the following activities:

"+" " addition, " – " subtraction, "summation", " scalar multiplication “ k$\odot$L", “$\overline{L_i}$“ averaging, or " $\oslash$ " - dividing decibel numbers.

Their computational relationships should conform to the axiomatic conditions of the algebra adopted for modelling.

The operations of algebra for numbers are determined by the conditions :x ∈ X

Axiom addition of $x_1 + x_2 \in X$, $x_1, x_2 \in X$
(a)

the presence of an element 0 satisfying for each x € X relation
(b)

x+0 = x known as Archimedes "principle"
(c)

the existence of an element (–x) opposite to x, such that x+ (- x) = 0 (d)

commutativity of addition operations $x_1 + x_2 = x_2 + x_1 + x_2$
(e)

resolves of the addition operation $x_1 + (x_2 + x_3) = (x_1 + x_2) + x_3)$
(f)

The process of identification of acoustic hazards, and the computational relations on decibel measurement results present in it - are related to the basic relation, which is the axiom of adding two acoustic disturbances p_1 (t) and p_1 (t), described by the levels of their sound pressures: $L_1 = 10\ lg \frac{p_{1\ RMS}^2}{p_0^2}$, . $L_2 = 10\ lg \frac{p_{2\ RMS}^2}{p_0^2}$

Their decibel values quantify the conditions of their reception by humans, their nuisance and harmfulness causing specific disease effects in their recipients.

The analysis of the decibel database of acoustic measurement results and their computational processing are related to all diagnostic activities determining the control of the acoustic state of the environment. They are defined by algebraic relations performed in the decibel database of measurement results in the metric identification space adopted for them, with the appropriate language for modelling their states.

The algebraic language for modelling recognized states follows from the axiom of adding sound levels, i.e., adding their decibel values. It is defined by the dependency:

$$\boldsymbol{L_1 \oplus L_2 = 10\ lg[10^{0.1\ L_1} + 10^{0.1\ L_2}\ ]} \quad (1)$$

It results from the Weber-Fechner law describing the total perception of two acoustic disturbances $p_1(t)$ and $p_2(t)$ by humans. Its derivation is described in the paper [11].

This form of the axiom of adding two decibel values results from the calculations $(p_1 + p_2)^2 = p_1^2 + 2p_1p_2 + p_2^2$, with the averaging of the analysed disorders, and their references to the values of p_0^2 and the operation of their conversion into decibel values.

$$L_1 \oplus L_2 = 10\lg\frac{(p_1 + p_2)^2}{p_0^2} = 10\,log\left[\frac{< p_1^2 >}{p_0^2} + \frac{< p_2^2 >}{p_0^2}\right] + 10\lg\left[1 + \frac{< 2p_1\ p_2\ >}{< p_1^2 > + < p_2^2 >}\right]$$

to the form described by Equation (1) .

It defines the total impacts of sources at levels and on the conditions of their reception by humans. $L_1 = 10\log\frac{<p_1^2>}{p_0^2}$ $L_2 = 10\log\frac{<p_2^2>}{p_0^2}$

The form of the axiom of adding two levels of sound with values i refers to analyses in which there is an interaction of incoherent L_1 L_2 p_1 p_2 □0disturbances of sound pressures p_1 i p_2 , which is a generally accepted assumption in noise hazard analyses. It results in the zero value of the component $10\lg\left[1 + \frac{<2p_1\ p_2\ >}{<p_1^2> + <p_2^2>}\right]$ in equation (1). The influence of this simplification on the result of the operation of adding and subtracting noise levels in the case of coherence of a specific value was analyzed in the paper [4]. This action is alternate, and cumulative because:

$$L_1 \oplus L_2 = 10\ lg[10^{0.1\ L_1} + 10^{0.1\ L_2}\ ] = 10\ lg[10^{0.1\ L_2} + 10^{0.1\ L_1}\ ] = L_2 \oplus L_1$$

$$[\boldsymbol{L_1} \oplus (L_1 \oplus L_2)] \oplus L_3 = 10\ lg[10^{0.1\ L_1} + 10^{0.1\ L_2}\ ] \oplus L_3$$

$$= 10\log(10^{\frac{10\ lg[10^{0.1\ L_1} + 10^{0.1\ L_2}\ ]}{10}} + 10^{0.1L_3}) =$$

$$10\ \log\left(10^{0.1L_1} + 10^{\frac{10lg(10^{0,1L_2} + 10^{0,1L_3})}{10}}\right) = 10\ \log\left(10^{0.1L_1} + 10^{\frac{10lg(10^{0,1L_2} + 10^{0,1L_3})}{10}}\right) = L_1 \oplus (L_2 \oplus L_3)$$

The zero element of decibel algebra $L = 0 \quad = 10\,lg\left[\frac{p_0^2}{p_0^2}\right]$

$$L \oplus 0 = 10\ lg(10^{0.1L} + 10^0) = 10\ lg(10^{0.1L} + 1) \approx 10\ lg(10^{0.1L}) \approx L$$

On the axiom of addition of decibel values of pressure levels so derived from Weber-Fechner's law, given by equation (1), are determined the other operations of decibel transformations of measurement results, which we use in the process of identifying acoustic hazards of the environment.

They are defined by their relationships:

subtracting sound levels: $L_1 \ominus L_2 = 10\log\{10^{0.1\ L_1} - 10^{0.1\ L_2}\}$ (2)

The subtraction operation makes sense in the case of $\boldsymbol{L_1 > L_2}$.

summation of n - sources: $L_1 \oplus L_2 \oplus +,.. ..,\oplus L_n = 10\log\sum_{i=1}^{n} 10^{0.1\ L_i}$ (3)

scalar multiplication k : $k \odot L = L + 10\log L$ (4)

averaging L_i; i=1,2,.. ..,n: $L_{śr} := 10\log\left\{\frac{1}{n}\ \sum_{i=1}^{n} 10^{0.1\ L_i}\right\}$ (5)

divisions, i.e. references of decibel numbers to each other: $L_1 \oslash L_2 = \frac{L_1}{L_2} := 10^{0.1\ [L_1 - L_2]}$ (6)

which is used in the analysis of the multiplicity of exceedances of a certain noise level.

They are commonly used in analyses of acoustic environmental hazards and standard regulations defining their implementation in diagnostic practice. In common parlance they are known as decibel algebra [1- 6].

From a methodological point of view, the language for modelling the variability of decibel values based on it is not consistent with the axiomatic theory of the calculus of algebras, and the operations that define it cannot be called decibel algebra.

In Particular:

the axiom of adding sound pressure levels, which is the basic element of the calculus on the sets of decibel measurement results, is inconsistent with the Archimedean principle. It generates a paradox described and unexplained in the literature [4, 7], in which the result of adding two zero values 0 [dB] ⊕ [dB] = 3 [dB] takes the value of 3 [dB].

there is no opposite element –L to L, so that the operation of subtracting equal pressure levels is indeterminate $L \ominus L = 10\ lg[10^{0.1L} - 10^{0.1L}]$the decibel number divisibility relation L_1/L_2□= 10^(0.1 [L_1- L_2]) is inconsistent with the expected results of the division, when in the references of decibel numbers one of their values will take a zero value , such as when L_1= 0 [dB] or L_2= 0 [dB].

Modification of the Calculation Formulas of Decibel Algebra

The fact that zero values are omitted from the processing of the decibel base of results limits the ability to model a number of important research problems encountered in the process of identifying acoustic hazards. It is also a source of computational paradoxes that can be the basis for disqualifying calculus on sets of decibel values. Recognize them as a full-legal tool for modeling the acoustic climate of the environment and ascribe to them the attribute of decibel algebra. The aforementioned limitations of the calculus on sets of decibel values prompted the author to seek necessary corrections to the currently used calculation formulas of acoustic environmental diagnostics. These are presented in the works [8, 9] .

The starting point of the proposed modifications of the computational re-lations on the sets of decibel values was the proposed correction of the axiom of adding decibel values:

$$\boldsymbol{L_1 \oplus L_2 = 10\ lg[10^{0.1\ L_1} + (10^{0.1\ L_2} - 1)]}$$

It took into account the need to subtract the relative energy of the reference level in the summation operation of the two sound levels. That condition $e_0 = 10^{0.1\ L_0} = 10^0 =$ The author [9] related to the need to eliminate in the assessment of the total effects of acoustic disturbances, the energy of the reference level, twice occurring in the values of each of the sources with L_1 and L_2. The fact that zero values are omitted from the processing of the decibel base of results limits the ability to model a number of important research problems encountered in the process of identifying acoustic hazards. It is also a source of computational paradoxes that can be the basis for disqualifying calculus on sets of decibel values. Recognize them as a full-legal tool for modelling the acoustic climate of the environment and ascribe to them the attribute of decibel algebra.

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The aforementioned limitations of the calculus on sets of decibel values prompted the author to seek necessary corrections to the currently used calculation formulas of acoustic environmental diagnostics. These are presented in the works .

The proposed correction of the axiom of adding two decibel values generated the need for necessary modifications in the remaining operations performed on decibel numbers. Their inclusion allowed the related basis of algebraic operations to be determined by decibel algebra, appropriate to the description of acoustic hazards perceived by humans.

They are defined by dependencies:

subtracting the sound pressure levels L_1 and L_2:

$$L_1 \ominus L_2 = 10\ \lg\ [10^{0.1L_1} - (10^{0.1L_2} - 1)] = 10\ \lg\ [10^{0.1L_1} - 10^{0.1L_2} + 1] \quad (8)$$

summation of n- decibel values:

$$L_1 \oplus L_2 \oplus, .. \quad .., \oplus L_n = 10 \log \sum_{i=1}^{n} \{10^{0.1\ L_i} - (n-1)\} \quad (9)$$

averaging :

$$\bar{L} := 10 \log \left\{ \frac{1}{n} \sum_{i=1}^{n} 10^{0.1\ L_i} - \left(1 - \frac{1}{n}\right) \right\} \quad (10)$$

multiplication by scalar k :

$$\boldsymbol{k \odot L} = L + 10 \log k + 10 \log \left\{ 1 - \left(1 - \frac{1}{k}\right) 10^{-0.1L} \right\} \quad (11)$$

dividing decibel numbers L_1□L_2:

$$\frac{L_1}{L_2} := 10^{0.1\ [L_1 - L_2]} \left[\frac{1 - 10^{-0.1\ L_1}}{1 - 10^{-0.1\ L_2}} \right] \quad (12)$$

They form the basis for modelling relationships of observed decibel changes in environmental acoustics processes. They determined the form of decibel algebra, appropriate for descripttions of human perception of acoustic disturbances described by decibel values .

Error And Limitations Of The Calculation Formulas Used In The Decibel Processing Of The Results Of Acoustic Tests Present In The Processes Of Identification Of Environmental Acoustic Hazards With currently widely used formulas for decibel base processing results in environmental acoustic hazard assessments; (determining the executive actions of their identification processes in environmental acoustics); It is possible to relate a certain numerical error that they generate.

Their calculation is determined by the equations presented in papers [8] . Their estimation formulas result from the calculation of the difference in sound levels between the proper relations for the processing of decibel numbers (7 ÷ 12) and the relations (1 ÷ 6) currently used in the processing of the decibel database of measurement results. Appropriate calculation formulas for their estimation are presented in Table 1.

Table 1: Numerical Error of Decibel Operations in Environmental Acoustics.

	Operation	**Numerical error of existing computational relations on decibel sets of values**
1	$L_1 \oplus L_2$	$\mathbf{10 \log \left(1 - \frac{1}{10^{0.1L_1} + 10^{0.1L_2}}\right)}$
2	$L_1 \ominus L_2$	$\mathbf{10 \log \left(1 + \frac{1}{10^{0.1L_1} - 10^{0.1L_2}}\right)}$
3	Summation operation L_i	$\mathbf{10 \log \left(1 - \frac{n-1}{\sum_{i=1}^{n} 10^{0.1L_i}}\right)}$

4	The (duplication) operation of multiplying L by the k scalar	$10\log\left\{1-\left(1-\frac{1}{k}\right)\cdot 10^{-0,1L}\right\}$
5	Averaging operation L_i	$10\log\left(1-\frac{1-\frac{1}{n}}{\sum_{i=1}^{n}10^{0,1L_i}}\right)$
6	Decibel number division (reference) operation	$10^{0.1(L_1-L_2)}\left[\frac{10^{-0.1L_2}-10^{-0.1L_1}}{1-10^{-0.1L_2}}\right]$

An analysis of decibel value processing errors - associated with the use of current calculation formulas in environmental hazard inspections - indicates a negligible impact of the proposed adjustments. In particular, this property refers to operations on decibel values relating to the levels of [35, 130] dB that characterize the nuisance and harmfulness of the noise present in environmental studies.

Significant errors in the processing of decibel measurement data may occur when analysing decibel measurement data with small values, e.g. in the range [0, 10] dB.

Such a range of decibel values, in which it is advisable to use the modified algebra of decibel number processing, can be more widely used in the tasks of estimating the uncertainty of environmental acoustic hazards [6], especially in the assessments of "B-type uncertainty". It is also important in the tasks of minimizing errors related to the identification of model descriptions used in environmental acoustic hazard assessments. The calculation process that determines it is based on the processing of small decibel values of the residual errorε_i; i=1,2,. . . ., n , conditioned by the selected form of the model description .

A high potential of research reconnaissance can be associated with attempts to use the modified subtraction operation for borderline processing of small decibel values. With such a conditioning, the task of differentiating variations on the monitored histories of their decibel variations can be linked.

The possibility of defining such an operation in space and algebra of decibel numbers opens up a wide field of research for analyses of the state of acoustic hazards. Attempts to use it can be related to the tasks of improving the solutions of systems monitoring the acoustic state of the environment. The operation of differentiation of the monitored noise secures the conditions for the search for optimal filtration and prediction of the monitored variability of the state of environmental acoustic hazards.

It can also be the basis for the search for new quantifiers of the state of environmental acoustic hazards - not only in the integral categories of their impact on humans, as it is currently - but also on the results of differential analyses of their variability.

The premises outlined above indicate the advisability of initiating a broader study on the use of the proposed corrections of the calculus on decibel numbers in numerous tasks of environmental acoustics, in order to recognize them more fully.

Conditions For Decibel Comparisons of Measurement Results

An important problem in the tasks of identifying the state of acoustic hazards - which has not yet received much discussion - is the inappropriate use of the Euclidean measure of decibel value comparisons in their research implementations.

The commonly used Euclidean metrics ρ_{ij} of decibel value comparisons L_i,L_j used in the process of identifying environmental acoustic hazards - defined by the results of the differences $\rho_{ij} = L_i - L_j$ it does not meet the requirements of metrics (i ÷ iii]. It is not properly used in the process of comparison, decibel measurement data. It is incompatible with the identification tasks carried out in the identification metric space appropriate to the tasks of diagnosing the state of environmental acoustic hazards.

The requirements of a properly adopted metric are defined by the following conditions:

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

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

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

In the decibel database of measurement results, the performance of the operation of comparing three decibel values of values: evaluated by their Euclidean differences - is an improper process. Their distances in the decibel space of their human perception do not meet condition (iii).x= L_1 ,y=L_2 ,z= L_3

Example:

When we analyse the distances of decibel measurement results, determined by the values of noise levels: L_1 = 55 [dB], L2 =50 [dB],

L3 =45 [dB], their distances calculated by the Euclidean metric are:

ρ_{12}=55 dB-50 dB=5 dB,

ρ_{23}=50 dB-45 dB=5 dB,

ρ_{13}=55 dB-45 dB=10 dB

They do not meet the requirements to be assigned to a measure correctly selected for their comparisons in the space Their perception by humans, in the space in which the modelling of acoustic hazards takes place using the formulas (7 ÷ 12) adopted for the process of modelling acoustic hazards of the environment.

Condition (iii) is not met:

$\rho_{12}+\rho_{23}$=5 dB+5 dB=8 dB < ρ_13=10 dB

This means that the Euclidean metric of decibel comparisons of results in the process of identifying acoustic hazards is inappropriately used in this process.

This objection is particularly relevant in relation to the tasks related to the classification of acoustic hazard conditions.

The current practice of using the Euclidean metric in the assessment of exceedances of permissible noise levels generates results with difficult to accept interpretative results.

They can be linked to the following grades:
correctness of the obtained result with calculations (7 ÷ 12) appropriate to the modelling process in the decibel measurement space ; compliance of the obtained result with the interpretative conditions of its reception by a person ; metrological correctness of the obtained result in relation to the estimation of the uncertainty of the control result.

For example, for the measurement result determined by the measured value of the noise level L = 55 [dB], with the permissible noise level in the environment Loop = 53 [dB], the following reservations appear.

The estimated exceedance of the permissible noise level, quantified by a Euclidean metric $\rho = L - L_{normative}$=55 [dB]- 53 [dB]=2[dB] practically imperceptible by humans. Human sensations of acoustic disturbances occur at levels greater than this value.

Exceeding the noise level by the value of 2 [dB] in the analysed case gives a result inconsistent with the decibel algebra of the interaction of acoustic disturbances shaping them. The total interaction of the obtained estimate of exceedances of 2 [dB] with the permissible level of 53 [dB]: gives a result different from the input data of 55 [dB] accepted for analysis.L_sum =2[dB]+53[dB] ≅53 [dB].

The estimated exceedance of 2 [dB] is lower than the characteristic uncertainty values of the results of environmental measurements, i.e. the value of the uncertainty component "type B" estimated by this process. According to a long-term study conducted by employees of the University of Salford (M4WT) described in the report, the values of type B uncertainty in acoustic environmental studies are significantly higher than the estimated exceedance in the example under consideration. This means that the administrative action resulting from such estimated exceedances in the case we are considering will not have a rational motive [12].
An appropriate measure of the decibel comparisons of the results of Li and Lj in activities related to the identification of noise hazards may be the relation of subtraction of decibel values (8) consistent with their perception by humans. This measure satisfies the axioms required of a metric.

It is appropriate for estimating exceedances of permissible noise levels, calculated by equation (13):

$$\rho_i = 10lg\left|10^{0.1\,L_i} - 10^{0.1\,L_{dop}} + 1\right| \quad (13)$$

Hence, it is worthwhile to undertake a broader study of the advisability of attempting to implement it more widely in the practice of controlling acoustic hazards occurring in the environment.

An important implementation proposal presented in the work [5] ; (concerning the correct identification of the state of acoustic hazards of the environment); is the transformation of the decibel base of the measurement results to the Euclidean identification space representing them through the transformation given by the relation (12). The process of transition - from the decibel space of human sensations present in the environment of noise hazards, to scalar values representing them provides the opportunity to correctly use standard identification algorithms and their software commonly used in the identification of physical phenomena in macro space.

In the case of controlling the state of acoustic hazards, the application of this control idea can be realized by relating $\frac{L_i}{L_{norm}}$; i=0,1,2,… …, } norm admissible value .
Representing (12) the scalar values of $k_i = 10^{0.1\,[L_i - L_{dop}]}\left[\frac{1 - 10^{-0.1\,L_i}}{1 - 10^{-0.1\,L_{dop}}}\right]$ give the possibility to perform analyses of interest to the researcher in the Euclidean computational space with their numerical representations. For example, they can be, for example, statistical parameters, such as the average value of them :

$$\bar{k} = \frac{1}{n}\sum_{i=1}^{n} k_i \quad ; \quad i = 0,1,2,\ldots \quad \ldots, n \quad (14)$$

From their calculations, by means of the operation (11) of multiplying the decibel number by the calculated scalar value k¯it is possible to estimate the average value of exceedances of the permissible noise level, which took place in the control task in question.

Associated with this scheme of analysis of exceedances of permissible values is the classical calculus of estimation of uncertainty of the control result . This is because it concerns calculations on scalar numbers. It allows you to use standard estimators for estimating the uncertainty of the control process, in which by the operation of multiplying scalar representations of the parameters determining the uncertainty by the value of L_norm their decibel representation is obtained.

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Related to this scheme of the analysis of exceedances of the permissible values is the classical calculus of the uncertainty estimation of the control result. This is because it concerns calculations on scalar numbers. It allows you to use standard estimators for the uncertainty assessment of the control process, in which their decibel representation is obtained by multiplying the scalar representations of the parameters determining the uncertainty by the value. L_dop Such a solution was tested in the task of assessing the impact of modernization solutions of the road system in the city of Kielce [13]on the improvement of the acoustic climate in its surroundings. On the basis of the results of the annual noise monitoring and the analysis of their statistical characteristics, their acoustic effectiveness was verified.

The comparisons were based on statistical assessments of noise changes, analysed through the prism of the assessment of changes in the Euclidean measure of exceedances of limit values, and their scalar representation described by the values of the coefficient of exceedances of the permissible noise level (12). They showed greater sensitivity of the proposed estimation solution to the description of the acoustic effectiveness of the implemented modernization solutions.

Summary

The article chalks out the problems that take place in the ongoing tasks of identifying the state of environmental acoustic hazards. It emphasizes the problem of the occurrence of certain irregularities that are present in environmental noise assessments. He associates them, with the failure to comply with the methodological rules required of the identification process carried out in the decibel metric measurement space, appropriate for the description of human response to noise.

I emphasize the desirability and need for more discussion and research on the introduction into the processes of diagnostics of the state of environmental acoustic hazards: corrected calculus on decibel numbers; (modified by the correction of the axiom of addition of two decibel values); providing new opportunities for analysis of as yet unrecognized conditions shaping the identified states of environmental acoustic hazards ; analyses aimed at searching for new measures for describing exceedances of permissible values of noise levels in the environment, consistent with the description of their perception by humans ; verification of errors and discrepancies of currently used models for describing environmental noise, which were identified with the use of the Euclidean measure of decibel comparisons of measurement results, inappropriate for describing human response to observed noise levels in the environment.

The considerations presented in the article outline a programmatic framework for undertaking a broader discussion and research on the bulleted limitations of current solutions for identifying environmental acoustic hazards. Attention is drawn to the relationship of the identification concerns discussed in the article, with environmental management procedures. This is because their results have close links with administrative and legal regulations on environmental acoustic protection.

This is because it is important that the applied interpretations of the obtained diagnostic identifications of acoustic hazards of the environment, are appropriate to the queries taking place in resolving social, economic, and political issues related to the choice of specific actions to improve the acoustic climate of the environment.

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