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MANAGING THE ACOUSTIC CLIMATE IN LOCAL GOVERNMENT UNITS – A NEW APPROACH

Waldemar PASZKOWSKI
Silesian University of Technology

Abstract:
The paper presents a new approach to shaping acoustic comfort as a process of managing the acoustic environment in urbanised areas. The research in this area focuses on the psychoacoustic aspect of shaping acoustic comfort in an urban environment. This approach permits, depending on the purpose of land, not only to reduce the noise to the allowable limits but also to evaluate the acoustic quality of sounds originating in different sources. In this context, a review was performed of the research carried out on identifying soundscapes as a way of shaping acoustic comfort in the urban environment.
In this paper it is suggested that the entropy method be used for the assessment of auditory sound perception. The research carried out by the author shows that linking the relationship between the quality of perceived sounds with the elements/factors which shape the acoustic environment can be used to valorise soundscapes.

Key words: *acoustic climate, acoustic comfort, acoustic environment, soundscape, entropy, stimuli*

INTRODUCTION

In recent years the problem of shaping the acoustic climate of public spaces in cities has been gaining more and more importance. Generally, the tasks of shaping the acoustic climate are performed on the basis of data/information from measurements and simulations of the distribution of acoustic parameters in the environment. Apart from the information concerning the acoustic parameters coming from the established reference points in measurement sites also map information obtained from the sound level simulation in a given area is used.

At the moment, the noise threat for the inhabitants of urban areas is assessed according to the existing regulations and requirements. The directive [6] imposes on cities the duty of creating and managing acoustic maps. An acoustic map provides information and indicators concerning the level of noise exposure that affects the environment in different areas. The permitted noise exposure parameters vary depending on the purpose of the developed land [16]. In the approach used combining the map information on the threat of excessive noise exposure in a given area with the permitted values is the starting point for undertaking actions in order to reduce noise in a given area.

An effective process of managing the acoustic environment within local government units should be the result of a consensus worked out among the representatives of, for example, the following: the society, the local government, entrepreneurs, entities and institutions which manage the infrastructure.

The result of the process of managing the acoustic environment are decisions, which directly influence the type of activities used in different ways of shaping the acoustic climate. In this approach choosing an appropriate method of shaping the acoustic climate becomes of vital importance, the result of which will be the implementation of technical and organisational solutions or a combination of the two.

In the light of the above, due to the specificity of the acoustic environment management process, the activities carried out by the local government units (lgu) can be categorised as follows:

- Planning activities – which consist in including the appropriate acoustic criteria and solutions for the process of assigning purpose and function to land in strategic documents of lgu's i.e. in the land use plan and the local general plan,
- Organisation – these activities include acoustic information exchange and consultations among the representatives of communities/institutions and finding an agreed solution,
- Implementation – implementing the agreed solution in the environment as a consequence of the planning and organisation activities carried out previously and supervising the implementation works at each stage.
- Monitoring – regularly updating the acoustic maps with changes to infrastructure and sound sources and making periodic acoustic measurements in the environment.

Depending on the needs, decisions in this area may be connected with implementing the following:

- technical solutions, i.e. using noise reduction structures/elements, noise source removal, introducing into

the environment an additional source to mask undesirable sounds,
- formal and organisational solutions, i.e. using legal regulations, changing traffic organisation, making changes to land use and purpose.

A proper implementation of appropriate solutions for noise reduction and management of the acoustic environment depends greatly on the knowledge of decision makers and on the degree to which information from experts is used.

At the moment a coefficient of the number of inhabitants exposed to excessive noise levels (the M coefficient) and the changing values of long-term allowable sound levels allocated to the area connected with its function (the LDWN, LN coefficients) are used as a starting point for undertakings aiming to shape the acoustic climate in the urban environment [16].

Taking decisions concerning the shaping of acoustic environment on the basis of this kind of data/information usually focuses on choosing the way of reducing acoustic threats and adapting the noise which exceeds the allowed values to the norms. In most cases adopting this approach leads to expensive modernisation and investment solutions being used (e.g. noise barriers), which do not always conform to the planned acoustic requirements in terms of effective reduction of noise in developed areas. An additional problem connected with installing additional noise reducing structures is making sure that the distance between these structures and the existing infrastructure is within limits. Solutions of this type as potential protective barriers degrade the functional capacity of the areas, also through reducing visibility.

In most cases, the measures taken to reduce noise in the environment consist in implementing solutions based on 'turning down' sound sources. The solutions designed to reduce noise are usually restricted by, among others, the permitted noise levels, the nature of emission of a sound source and spatial and functional conditions.

The best solution in reduction of a noise sources is shaping the acoustic environment in spatial planning process, according to the way of development of the areas [10, 14].

A commonly used approach to noise reduction in urban areas does not take into consideration the assessment of acoustic comfort of the population. Depending on the purpose of the area and the type of activity of the population the perception of sound signals is interpreted in different ways. Due to its complexity, the subjective nature of perceiving acoustic sensations should not come down to the assessment of the permitted noise level. Extending the assessment of noise threat by including the subjective reception of sounds directs the process of managing the acoustic climate towards preserving acoustic comfort in areas with different land use.

DESCRIPTION OF THE CONCEPTION OF SOUNDSCAPES IN THE ENVIRONMENT

The idea of soundscapes is gaining more and more interest in the approach to acoustic ecology, which in a significant way uses the aspects of sound perception as a subjective assessment of noise. In this context the state of noise threat is a product of quantitative and qualitative mapping of acoustic and non-acoustic features in the urban environment. The research carried out in this field shows that the qualitative features of mapping and acoustic assessment of the environment are not sufficiently recognised. Using the conception of soundscapes in analysing an urban environment first and foremost means using diverse information resources in assessing acoustic quality (acoustic comfort). Obtaining the relevant quantitative and qualitative information resources from the environment is a starting point for elaborating a method of evaluating the acoustic state of the urban environment.

The complexity of the problem requires that a coherent methodology is elaborated which should include the application/elaboration of the appropriate methods of describing and assessing soundscapes. Generally the present soundscape analyses make use of questionnaire-based methods of obtaining information from the public necessary to assess the acoustic quality of the urban environment. The premise of the soundscapes conception is that there is a subjective balance in the acoustic environment in terms of the quantitative and qualitative approach to receiving sound signals.

In the research on assessing soundscapes methods of obtaining and processing information from the public necessary to assess and predict the acoustic state of the urban environment, other than questionnaire-based ones, will be sought. The idea of soundscapes directs the research towards looking for a qualitative response of sound signals from various sound sources in a source-receiver system.

There is a justified need to obtain acoustic and non-acoustic information resources from the environment, which subsequently should be properly classified, ordered and evaluated. The currently developed methods of evaluating noise threat using soundscapes do not include the analysis of the acoustic quality of the environment. Many factors and variables affect the quality of the intensity of receiving sounds in the environment. The commonly used approach to noise reduction in urbanised areas only takes into consideration the quantitative aspect of noise threat. The approach currently in use also lacks appropriate measurements and coefficients which would refer to the subjectivity of perceiving sounds in a standardised way. Taking the above into consideration, there is no standardisation in the assessment of the acoustic quality of the environment.

Taking a more general view, taking actions which focus only on reducing noise from sources is not always justified due to the fact that only one criterion of exceeding the sound level limit in the environment is used. A given sound level and the qualitative features of sounds generally determine the specificity of a soundscape connected with the character of the places which shape the recipients' psychoacoustic sensations in a positive manner.

Consequently, there is a need to elaborate a method of shaping the urban environment that will not only be based on reducing noise levels in places where limits are exceeded. Extending the problem of shaping the urban environment to the psychoacoustic aspect it seems appropriate that various factors (including non-acoustic factors), the specificity of the sources and phenomena describing the acoustic state are taken into consideration together with the spatial features of the environment. Obtaining the data in the wider extent than is the case at present will make it possible to identify the urban environment not only 'through the prism' of the sound level value.

The present research on soundscapes draws attention to the semantic meaning of the contents of sound as information obtained for planning activities [15]. The present

research focuses on the diversity of soundscapes and on a sound identity as important factors in a balanced shaping of a soundscape. Such a soundscape is shaped, among others, on the basis of identified noise sources, the analysis of the duration of sound signals and the existing interactions between the source and receiver [1]. In this context the receiver means the human organ of hearing. The specific nature of a soundscape in terms of sound quality makes it necessary for the collection of variable features characterising a given sound event to be classified and ordered. At this point a distinction must be made between key sounds on the background of other audible sounds. The description of the soundscape assigned to a given community, apart from the typically physical properties of sound, should include certain variable features of the nature of sound, i.e. [2]:

- sound events identified according to the source (e.g. natural, human, mechanical, artificial),
- sound signals,
- sounds recognisable for a given community,
- sound profile/acoustic space, defining the spatial range of sound,
- the azimuth defining the direction of sound in a horizontal plane,
- the acoustic horizon specifying the maximum distance in a given direction from which sounds can be heard,
- the 'hi-fi' sound quality of clearly audible sounds, without sounds overlapping and without the occurrence of the masking phenomenon,
- the 'lo-fi' sound quality of overlapping sounds, as a result of which masking or reduced clarity occurs,
- the intervals at which the sound occur (rhythm, pattern, cycle).

One of the methods used to evaluate soundscapes are sound walks. Observations have been made during sound walks in the cities of Brussels, Barcelona, Bristol and Genoa (the Silence project, [7]). In the project the influence on the soundscape of the features of the urban structure was analysed in terms of the extent of development, topography, vegetation and various types of activities connected with sound sources. Quantitative methods (measurements) and qualitative methods consisting in the use of questionnaires were used in the project.

In many cases, to shape the acoustic environment of cities the sound quality in different places where people spend time must be created from scratch. Due to the specificity of the qualitative features of sound and the subjective perception of sounds discussed here, it is important that positive characteristic sounds be amplified, a variety and an appropriate sequence of soundscapes during the so called soundwalks be shaped. A soundscape is connected with the identity of urban spaces, and consequently with community groups and should be perceived as part of the city's culture. New places in which to relax and which will create the acoustic environment, e.g. sound gardens, where there will only be positive, desirable sounds will have a special significance in shaping soundscapes in urbanised areas.

Due to the fact that the acoustic character of cities is diverse areas are zoned according to the type of activity for the needs of soundscape shaping; acoustic measurements, sound distribution forecasts and subjective assessments of the public will be used for these zones [4]. As part of acoustic shaping new sounds are assessed before they are introduced, it is assessed whether the function of the area matches the existing or expected soundscape, some characteristic sounds are protected and an attractive, stimulus-based acoustic environment is created through the use of a variety of sounds. [3].

In the design and management of soundscapes several stages of the execution of tasks were suggested [5]. At the first stage the factors which characterise the places where people are defined (the type of activity, time of day, weather conditions, etc.). At the second stage the aims connected with the identified places should be established (the aims elaborated with the public's agreement). The third stage consists in identifying the desirable and undesirable sounds, which can affect the aims established at the second stage. The last, fourth, stage, depending on needs, consists in activities connected with managing/designing the soundscape by masking the sound:

- the undesirable sound does not mask the desirable one,
- masking the undesirable sound with a desirable one.

Moreover, premises of acoustic nature for the approach presented here [5] have been identified for various places where the public spends time, which should be taken into consideration in soundscape design, e.g.:

- the murmur of water should be the dominant audible sound,
- 'a special sound' should be clearly audible from the analysed place,
- sound connected mainly with people's activity (not mechanical, not amplified),
- inaudible sounds,
- sounds originating in nature should be the dominant audible sound,
- only natural sounds should be audible,
- unamplified speech (or music),
- amplified speech (or music),
- an acoustic sculpture/sound installation should be clearly audible,
- sounds originating in the city should be the dominant audible sounds.

Shaping the acoustic environment becomes an important issue in designing public spaces because the aspects of acoustic environment and acoustic comfort are directly connected. For this reason the acoustic parameters and sound perception as well as mutual interactions between sound sources and the community should be studied. This is a long-term process and it depends on many variables at different levels: legislation, spatial structure planning, functional and utility, social and financial.

The tasks of shaping the acoustic environment of cities require that a coherent methodology be elaborated in terms of acoustic comfort, including the soundscape, with a special consideration of identifying acoustic perceptions of the public in relation with the type of activity and the place of stay. This requires a model to be elaborated which should include information connected with obtaining acoustic sensations and information about the shaped environment. Presenting the relationships between different sound sources and subjective perceptions of the public will make it possible to shape the acoustic environment using the conception of soundscape shaping.

THE SIGNIFICANCE OF ACOUSTIC QUALITY IN THE ENVIRONMENT

The acoustic environment of cities may be analysed according to the relationships present among the elements forming that environment. The elements which make up the acoustic environment can generally be grouped into the category of structures and the category of variable features [11]. The group of structures characterising the elements of the environment is represented by, among others, the spatial structures of buildings, infrastructure, open spaces, which are described through material features. The group of variable features of the environment, on the other hand, depends on the various existing sound sources and the features connected with the physical description of sounds together with their characteristics as sounds of natural origin and sounds connected with human activity.

Consequently, shaping the acoustic environment in cities can be done in several ways, i.e. by means of the following: modifying the group of structures, the group of variable features by using appropriate relationships between the elements of the group of structures and the group of features of variables. Often, when the spatial and functional structure of cities is already established shaping the acoustic environment of cities is restricted only to operations on the group of variable features. The consequence of this is a significant narrowing of the pool of possible solutions, which in most cases come down to using protective barriers (e.g. sound barriers), which often makes the solution ineffective and more expensive. The most effective way of shaping the acoustic environment takes place in newly created urban areas - then, because there are many possible solutions to choose from, a rational combination of elements from the group of structures and variable features can be used.

The problem of shaping soundscapes in urbanised areas comes down mainly to the removal of undesirable sounds from the environment and amplifying positive sounds. Thus, it becomes justifiable that research should be carried out to identify the acoustic perceptions of various sources of noise depending on the variables and existing accompanying factors. Estimating the qualitative acoustic features of the environment relative to the places where people stay and relative to the type of activity of the public will make it possible to rationally shape the function of and the way of developing urbanised areas.

Shaping soundscapes requires looking at the issue of sounds existing in the environment from a different perspective and consequently at the way of reducing noise in different places where the public goes. Thus, concentrating the environmental research on soundscapes requires that the qualitative features of sound are addressed in detail taking into consideration the quantitative methods of assessing noise threat. Because they are easily recognizable, the sounds which occur in nature can generally be classified as positive sounds and harmful sounds. The subjective nature of human sound perception is not unambiguous in classifying sounds due to the division into positive and harmful sounds. The presented idea assumes a certain systematisation and classification of the category and features of sounds present in a given area by means of preserving, developing, 'multiplying' the positive sounds and isolating the harmful sounds for removal.

According to the findings of the research on hearing perception sounds coming from their sources have informative and semantic values, which, as are recognised by the hearing organ are associated with the type of source, with reference to the quality of the acoustic perceptions [15]. A clear-cut division into pleasant and unpleasant sounds in the environment is relative because the subjective nature of noise and the factors accompanying acoustic perceptions influence the assessment of sounds.

A complicated and complex aspect of the acoustic perceptions depend on many different factors other than auditory ones, connected, among others, with culture, social groups, tradition, places where people stay, accompanying emotions etc. Linking the various non-auditory factors with the multi-sensory reception of sounds is a staring point for the research on the assessment of acoustic quality in the environment.

In order to elaborate a method of qualitative assessment of sounds new information from the field of urban environment engineering will have to be obtained. In this respect it is considered important to elaborate a model acoustic representation of sound features in mapping the environment for the needs of shaping acoustic comfort.

The research carried out by the author of the paper on mapping the features of the acoustic environment shows that it can be represented by means of thematic maps. Representing acoustic conditions by means of thematic maps will be the basis for the elaboration of a method of identifying and evaluating acoustic comfort.

Therefore, research to identify typical sound signals which characterise an urbanised environment, with reference to the general differentiation (classification) into pleasant and unpleasant sounds will be justified. It is assumed that on the basis of the qualitative classification of sounds in the environment it will be possible to predict the quality of acoustic reception of typical sources. Depending on the various types of sources of origin (natural and anthropogenic) sounds can shape the qualitative acoustic state of the environment in different ways, which is why predicting significant sounds is also the subject of the research.

PSYCHOACOUSTIC ASPECTS OF SHAPING SOUNDSCAPES

The aspects of hearing perception can be linked with the surroundings taking into consideration the information character of the features of sound. The quantity of information coming from the surroundings grows in terms of a greater recognition of the soundscape including structures and acoustic phenomena. The following have an influence on the information resource in the structure-observer system [9]:

1. Properties – the characteristics of the landscape,
2. The individual characteristics of the observer,
3. The conditions of the observation – the kinds of relationships between the observer and the environment.

The signals which reach a recipient through signals are received by various senses. In the course of the research carried out on multi-sensory perception of sounds [8] by the author of the paper it was suggested that the information entropy method be used to assess qualitatively sounds in the environment [13]. It was assumed that the amount of information can be measured by means of the probability with which an acoustic event can occur. In the approach presented here the information entropy describes a quantitatively averaged multi-sensory and subjective reception of sounds in the source-receiver system in an urban environ-

Table 1
The Analysis of the stimuli induced by traffic noise relative to the place of stay [12]

Traffic noise					
City park	Attributes				Undesirable emotions
	Visual	Auditory	Olfactory	Tactile	
1.	Yes	High	Bad	No	Yes
2.	No	Very high	Bad	No	Yes
3.	Yes	Neutral	Good	No	Yes
4.	No	Neutral	Good	No	No

ment. With the above in mind it is assumed that the entropy method will make it possible to classify the occurrence of various signals with a certain probability.

The probability of the signals occurring in the researched landscapes depends on the characteristics of the signal sources [9]. In the approach presented here the entropy of information indicates the value and the type of emotion a soundscape induces in a person through stimuli. The entropy value does not provide information about the structure of the landscape or about the way it functions, so it will be justified to complete the information entropy of stimuli reception by the information of the elements of the soundscape while it is being valorised.

Assessing information entropy in the approach presented here will consist in choosing representative features which will determine the significance of the signal from a sound source in the multi-sensory reception of an acoustic event.

It has been assumed that A is an attribute with values a1,

$$H(D) = -\sum_{i=1}^{n} p(d_i) \times log_2\, p(d_i) \quad (1)$$

a2 ,...., am and it has been assumed that D is a decision with values d1, d2, ,..., dn. Then information entropy I(aD) equals

$$H(D/A) = \sum_{j=1}^{m} p(a_j) \times H(D/a_j) \quad (2)$$

H(D) – H(D/A), where H(D) is the entropy of decision D.
and H(D/A) is a conditional entropy of decision D with the given attribute A,
where:

$p(d_i)$ – the probability of the occurrence of the value of decision di,

$p(a_j)$ – the probability of the occurrence of the value of decision aj.

In the research on the multi-sensory identification of sound perception a theoretical analysis was performed and an attempt was made to evaluate the emotions induced by the stimuli, relative to the activity of several and single sound sources in the environment. Below there is a list of variants of the probability with which undesirable emotions would occur as a result of traffic noise, relative to the place where they were staying, for various configurations of information coming from receiving the stimuli (table 1), [12].

The analysis (table 1) presents four theoretical variants of multi-sensory sound perception connected with the place where the given person would be. A city park was adopted as the place where the person stays. In this context the city park should be unambiguously understood as a place of rest and relax, which should be free from any negative auditory stimuli. When assessing the reception of the stimuli induced by a sound source the following evaluation criteria were adopted:

- Visual: yes/no,
- Auditory: very high, high, neutral,
- Olfactory: good, bad,
- Tactile: yes/no.

The suggested evaluation criteria are arbitrary and refer to a subjective perception of sound through auditory stimuli, at the same time taking into consideration other stimuli in the reception of an acoustic signal. Three evaluation criteria were adopted for describing auditory stimuli in order to precisely imitate the qualitative nature of sound reception.

Table 1 presenting the reception of a group of stimuli induced by traffic noise must be completed with additional information connected with the representative features of sound emission signals, weather conditions, the phenomena of sound propagation in space and the features of the public, including among others: the source-receiver distances, the direction of the emission, traffic volume, time of day, spatial structure of the infrastructure elements, the age of the public. The presented approach is a generalised attempt to identify acoustic quality in a quantitative manner. The undertaken research is a starting point for the elaboration of a model evaluation of emotions induced by typical sound sources in an urban environment. The values of conditional entropy obtained for each group of stimuli were worked out by associating the columns of evaluation criteria for each stimulus with the columns of criteria for the undesirable emotions induced.

After substituting the information from table 1 to (1) and (2) the values of entropy of the stimuli shown in table 2 were obtained. The values of individual stimuli are conditional entropy (2) and the value of emotions is represented by entropy of decision (1).

The results presented in table 2 indicate an increase/decrease in information about the quality of sound perception induced by stimuli. If entropy of information reaches its minimum (the 0 value), it means that there is uncertainty. If an event occurs with a probability equal 1, then its entropy equals 0. In this case, with the value of entropy of information approaching 1 we have more information regarding the undesirable emotions induced by stimuli (table 2).

The occurrence of a specific emotion induced by the source results from the complex relationships between the

Table 2
Stimuli information entropy values in the reception of traffic noise in a city park [12]

Evaluating the significance of the source	Visual	Auditory	Olfactory	Tactile	Undesirable emotions
Conditional entropy/entropy of decision	0.5	0.5	0.5	0.81	0.81
Entropy of information	0.31	0.31	0.31	0	-

various signal receiving senses and the information obtained from the receivers.

As the analysis of the environment is acoustic in nature, the auditory information stimuli should be subject to a detailed identification in the multi-sensory signal reception from the environment. In fact we often meet a situation when several sound sources are active at the same time and with situations when there is a dominant source on the background of other sources.

The obtained values of entropy of information for varied sources can be used to valorise the attractiveness of soundscapes. It will be possible to work out a landscape acoustic nuisance index by means of linking the value of the entropy of stimuli with the entropy of emotions. The closer the index is to 1 the more information inducing negative emotions the landscape will have – it will be less attractive.

Following the research in this area it is considered important to adopt an appropriate number of sensation classification grades (a scale) to represent the reception of sound by sound stimuli.

It is assumed that entropy of information will be determined for the generated possible variants of multi-sensory reception of stimuli from typical sources existing in an urban environment which will take the following relationships into account: the type of activity – place of stay – type of source.

Further research to elaborate a psychoacoustic model of the acoustic quality of sound perception will focus on identifying representative values, characteristics and factors used to describe the vector of auditory stimuli.

Linking the vector of auditory stimuli with evaluating the entropy of information for possible variants of stimuli reception will be the basis thanks to which a database will be created for the representative sources in relation to the type of activity and the places where the public stays. Thus elaborated database will be an approximation of emotion quantification for model situations of the public being exposed to noise threat in an urban environment.

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CONCLUSIONS

The process of managing the acoustic climate in local government units requires complex and integrated actions, starting with identifying the acoustic state of the environment, organising and planning the course of action, implementing technical/organisational solutions and finishing with noise exposure monitoring.

The conception of implementing soundscapes is a new approach to effective management of the acoustic environment. In this approach the choice of solutions for shaping the acoustic comfort depends on the quantitative and qualitative criteria for how the public receives psychoacoustic sensations in the environment.

In the undertaken research on haw to support the shaping of acoustic comfort in the environment it has been suggested that the entropy of information method be used to represent sounds in the environment qualitatively. It is assumed that psychoacoustic emotions will be determined taking into consideration the environmental factors, which will be a certain reference model for typical representations of sound sources.

In further research it will be important to elaborate the vector of auditory stimuli to represent the reception of psychoacoustic sensations in the environment. Including the representation of the auditory stimuli vector in the map representation of the environment will make it possible to classify and evaluate soundscapes.

REFERENCES

[1] Adams M., Cox T., Moore G., Croxford B., Refie M., Sharples S.: Suistainable soundscapes: noise policy and urban experience. Urban Studiem. Vol. 43, 13, 2006.
[2] Bernat S.: Projektowanie akustyczne w planowaniu przestrzennym. Problemy ekologii krajobrazu. T. XIX. PAEK, Gdańsk-Warszawa 2007, s.43-50.
[3] Bernat S.: Projektowanie krajobrazów dźwiękowych miast. III Ogólnopolska Konferencja Szkoleniowa Problemu Hałasu w Mieście. Szczecin 2010, s. 117-122.
[4] Brown A.L.: Acoustic Objectives for designer or manager soundscapes. Soundscape the Journal of Acoustic Ecology. No. 4.2, 2003, s. 19-23.
[5] Brown A.L.: Soundscapes and soundscape planning. 18th International Congress on Sound/Vibration. Rio de Janeiro – Brazil 2011, pp. 1-14.
[6] EU Environmental Noise Directive 2002/49/EC. Official Journal of the European Communities, L 189/12.
[7] http://www.silence-ip.org/site/ (31.08.2007r.).
[8] Klawiter A., Preis A.: Percepcja słuchowa przedmiotów. Szkic teorii i jej testowanie. Kolokwia Psychologiczne. Nr. 14, 2006, s. 144-162 .
[9] Kowalczyk A.: Applying the pieces and corridors model to the valorisation of the natural environment for the needs of recreation. [in:] Cieszewska A. (ed.): Ecological problems of landscape. Volume XIV, 2004, pp. 1-8.
[10] Paszkowski W.: Elementy planowania przestrzennego w projektowaniu środowiska akustycznego na terenach zurbanizowanych. Management Systems in Production Engineering. Nr 3(3), 2011, s. 33-37.

[11] Paszkowski W.: Kształtowanie krajobrazów dźwiękowych w projektowaniu środowiska akustycznego miast. XL Zimowa Szkoła Zwalczania Zagrożeń, Szczyrk 2012, s. 229-236.
[12] Paszkowski W.: Próba identyfikacji jakości akustycznej w środowisku miejskim. 59 Otwarte Seminarium Akustyczne (OSA), Poznań-Boszkowo 2012, s. 191-194.
[13] Paszkowski W.: Psychoacoustic aspects of shaping city soundscapes. Proceedings of the Inter-Noise Congress. USA 2012, s. 1-8.
[14] Paszkowski W.: Supporting the design of acoustic environment in spatial planning in urban areas, Proceedings of the Acoustics 2012 Nantes Conference (France), pp.310.
[15] Raimbault M., Dubois D., Urban soundscapes: experience and knowledge. Cieties. Vol. 22, issue 5, 2005, pp. 339-350.
[16] Rozporządzenie Ministra Środowiska z dnia 14 czerwca 2007r. w sprawie dopuszczalnych poziomów hałasu w środowisku, Dziennik Ustaw Nr 120, poz. 826, str. 8276 -8280.

dr inż. Waldemar Paszkowski
Silesian University of Technology
Faculty of Organisation and Management
Institute of Production Engineering
ul. Roosevelta 26, 41-800 Zabrze, Poland
e-mail: waldemar.paszkowski@polsl.pl

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