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Waldemar Paszkowski

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ACOUSTICS 2012

**Supporting acoustic environment design in spatial
planning of urban areas**

W. Paszkowski

Silesian University Technology, ul. Roosevelta 26-28, 41-800 Zabrze, Poland
wpaszkowski@polsl.pl

1. Introduction

The noise threat for the inhabitants of urban areas is assessed according to the existing regulations and requirements. The directive [2] imposes on cities the duty of creating and managing acoustic maps. An acoustic map provides information and indicators concerning the state of noise threat for the environment in different areas. Depending on the purpose of the developed areas, the permitted noise threat parameters are characterised by variable values. Combining the map information on the threat of excessive noise on a given area with the permitted values is the starting point for undertaking actions in order to reduce noise.

Depending on how severe the noise threat is and on the planned development undertakings, the measures to reduce noise in cities are carried out according to the *Environment Protection Against Noise Programme*.

The measures taken to reduce noise in the environment normally consist in implementing solutions based on 'turning down' sound sources. At the moment, the solutions designed to reduce noise are restricted by, among others, the permitted noise level values, the nature of emission of a sound source and spatial and functional conditions.

A commonly used approach to noise reduction on urban areas does not take into consideration the assessment of how much noise is a nuisance for the population. Depending on the purpose of the area and the type of activity of the population noise perception 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.

When taking measures to reduce noise, it is important to identify the qualitative features of sound in connection with the noise threat level. Consequently, the unpleasant and undesirable sounds and disturbing sound phenomena in the environment should be eliminated.

This article deals with the psychoacoustic aspects of acoustic environment design for the needs of spatial planning in urban areas. It has been assumed in the proposed approach that the most significant aspect of acoustic environment design of urban areas is the public. This approach results in subordinating the elements (variables) shaping public space to the qualitative and subjective aspects of sound. The research undertaken within this approach will aim to elaborate a consistent methodology, which will take into account the psychoacoustic aspects in relation to the planned elements of the environment. In particular, the devised methodology will consist in supporting the tasks of shaping the acoustic environment in spatial planning of urban areas.

2. The description of the problem of designing the acoustic environment of urban areas

Designing the acoustic environment of urban areas can be considered in terms of the function allocated to the areas to be developed. In the process of acoustic design we deal with ensuring that an area will appropriately serve its purpose when the restrictions and requirements of acoustic parameters are in place. The function of land determines its purpose. Consequently, the purpose of land comes down to establishing on it appropriate elements of infrastructure (e.g. residential buildings, industrial facilities, roads) which correspond to various activities of the public.

In the general approach to acoustic environment design we have to distinguish between two cases:

- the design covers undeveloped areas – then shaping the acoustic environment on a given area does not depend on: the fixed spatial and functional structures, the location of sound sources, the course of transport routes or the way the area's functionality is limited,
- the design covers already developed areas – shaping the acoustic environment is conditioned by many variables depending on e.g. the type and nature of sound sources, the infrastructure or the type of activity of the public.

In most cases designs are made for areas with an established development of space. The designed acoustic environment should be represented by the level of sound and the qualitative features of sound.

It is important to identify the sound sources on a given area in terms of their origin, manner of generation and qualitative features such as the sound of nature or anthropogenic sounds [4]. Most frequently the noise which inconveniences the public comes from anthropogenic sources.

In this approach the process of designing the acoustic environment of cities should focus on shaping soundscapes, with special attention placed on the existing acoustic sensations and the way the areas are developed. The physical characteristics of sound and the accompanying phenomena make it harder to allocate precisely the spatial parameters of sound to the defined borders of an area. In the research on shaping soundscapes carried out to date one of the most frequently used method of analysis is the so-called *sound-walking* [5]. This method permits the different sounds coming from the environment to a recipient moving through various zones of developed land to be analysed subjectively. In research on soundscapes we can distinguish sound events, some of which are recognizable sounds and are allocated to specific places. The evaluation of a soundscape can be carried out on the basis of the sequence of sound events (desirable and undesirable) reaching the recipients in relation to the acoustic background.

Each of the acoustic events should be connected to the duration and spatial situation in the environment.

Research in this area will require a way of identifying and selecting sounds to be elaborated.

The state of the acoustic environment can be considered in terms of the comfort of the sensations connected with the multi-sensory perception of the landscape. This is of special significance when creating the so-called sensory gardens in cities, when efforts are made to a simultaneous engagement of the perception of several senses i.e. the sense of vision, hearing, smell and touch [3]. The measure of the appropriately shaped soundscape will be ensuring an acoustic 'well-being' of the recipients allocated to the place in which they find themselves. For the needs of shaping the acoustic environment it will be important to develop methods of shaping a soundscape aimed at exposing and domination of the sound of nature.

3. The conception of supporting the tasks in the acoustic environment design

The conception presented here is a suggestion of a way of supporting the tasks in the acoustic environment design in urban areas. It is a starting point for research on the elaboration of a psychoacoustic model of sound perception in the environment. As the recipients are not capable of identifying acoustic sensations according to different sound sources or assess the quality of sound, comprehensive research must be carried out.

It is planned that mapping the information about the environment will be used for the needs of supporting the tasks of the acoustic design process.

For this purpose the information about the acoustic environment will be represented by means of models mirroring e.g. the natural and anthropogenic sound sources, the recipients of sound, elements of infrastructure, the characteristics of the materials the structures are made of and

the way the elements are distributed in space. The elements of the acoustic environment are connected with and dependent on one another making up an integrated system.

At this stage, the conception presented here refers to mirroring the elements of the environment and will be the basis for the elaboration of a method of evaluation of the acoustic quality of the designed environment.

In the proposed approach, the representation of the acoustic environment is based on the integrated GIS tool platform. It is assumed that the individual elements of the environment's structure will be placed on maps constituting separate layers, i.e.:

- a digital map showing the topography of the area and elements of infrastructure,
- an acoustic map showing the distribution of the simulated sound level along with sound sources and acoustic characteristics of structures,
- a map indicating the position/movement of recipients in the environment,
- a soundscape map.

The conception needs to be completed with a soundscape map corresponding to the assessment of the subjective acoustic sensations felt by the recipients.

Combining the information from the maps specified above (except the soundscape map) will only be enough to identify the state of noise threat in terms of the permitted sound level in relation to a spatial position.

The generalised conception presented here can be used to generate land development solution scenarios, with special focus on the public's participation in providing opinions about the different versions of the solutions.

The information maps along with the elaborated soundscape map published on a website will facilitate consultations with the public regarding the choice of the method of developing the area.

It is planned that the developed method will consist in a visualisation of soundscapes and the acoustic assessment from the recipients for the needs of designing a friendly acoustic environment.

4. Applying the information about the acoustic environment in spatial planning

Due to its complexity the general plan should be made with the co-operation of specialists in many areas and of the public.

Elaborating a general plan should be subject to various statutory requirements; therefore the acoustic environment is one of the important aspects the ready general plan should take into account.

Using the acoustic information in the tasks of spatial planning should be preceded by generating solution scenarios within the agreed consensus. Each scenario should be analysed and evaluated in terms of acoustic quality of the environment in order to choose the best solution.

It is assumed that each of the scenarios will satisfy the rules of a balanced development of shaping the environment.

The conception presented here (chapter 3) is a collection of input information for the process of spatial planning. The input acoustic information for the tasks of spatial planning should include the agreed version of a soundscape. A soundscape consists in an acoustic analysis and evaluation of the environment.

Combining the map information from the conception presented here and the map of planned land use and purpose will be the basis for the elaboration of a general plan.

Determining the borders according to the land use and the method of developing the area should result from the interrelations between the information included in the maps.

Borders should be marked out between areas with different land use. In this respect marking out borders of areas in accordance with the spatial variability of a soundscape becomes problematic.

The best solution in designing the acoustic environment is a spatial allocation of the variability of a soundscape to the land use of given areas, taking into consideration the way it is developed. This type of approach will frequently be confronted with spatial and functional restrictions, e.g. the layout of buildings, the road network, recreational and industrial areas.

Borders between areas with different land use with respect to the desired acoustic sensations can be determined in the following ways:

- shaping the soundscape according to the specificity of the places where the public are (e.g. place of residence, recreational areas and places to do sports, parks, shopping centres),
- analysing acoustic sensations using the soundwalking method. This is particularly important when analysing how the public move around the busiest areas (urban areas).

Shaping the acoustic environment should ensure the desired psychoacoustic sensations perceived by the public. In many cases there are dominant and undesirable sound sources on developed areas, the reduction of which may result in lower noise nuisance, but will not ensure desired psychoacoustic sensations. Therefore, it will be justified to introduce to the analysed environment additional (friendly) sound sources dependent on the land's function and type of development, whose activity will induce positive psychoacoustic sensations.

Conclusions

The presented conception of supporting the design tasks integrates in an orderly manner the elements which shape the acoustic environment. The conception makes it possible for the spatial and functional relationships between environment elements to be analysed. Supporting the design tasks in the proposed conception is oriented towards mapping the information about the acoustic environment. In this case the information about the state of the acoustic environment concentrates on the public who are the recipients of the sound level, psychoacoustic sensations and the qualitative characteristics of sound.

The key aspect in the presented research method is assessing sound events and using a soundscape map. For this purpose a psychoacoustic model of identifying and evaluating sound perceptions in the environment must be elaborated.

In the elaborated model it will be important to provide appropriate conditions representative of the acoustic events taking place e.g. atmospheric conditions, the changing seasons, repeatability during the time of the acoustic research.

Combining the maps thematically will make complete acoustic information available for the needs of supporting the tasks of the acoustic environment design.

Within the proposed method of supporting the tasks solution scenarios can be generated in order to choose the best design solution through a consensus with the public.

The method presented here assumes that the map information will be used to support the tasks of spatial planning, regardless of the degree to which various areas are developed.

The evaluation of the acoustic state of the environment is the input information for supporting the tasks of creating or changing the general plan.

Elaborating a general plan with respect to the acoustic criteria should include complete acoustic information about the environment in connection with the information about the land use and the way of its development.

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