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Estimation of Noise Influence to the Health of Population of Urban Territories: Italian and Russian Approaches

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Negative noise influence to the population health is increasing every year. Italian and Russian approaches to noise influence estimation are described. Acoustic comfort in urban areas cannot be completely separated by other factors influencing the quality of life. Results of estimation of noise influence are presented. Modeling of noise propagation and noise mapping in Russia are considered. Formalization and modeling of transport flows it is suggested to do by using of influence diagrams. Example of transport noise estimation in Italy is described.

1. Introduction

Noise negative impact is increasing every year [1–3]. More than 60 % of population of large cities is living in exceeding noise conditions [4–8, 11]. Disturbing acoustical impact is appreciated by half of Earth population [9, 10]. Damaging influence of intensive noise to the human's health is not restricted only by impact to ears. It is known, that noise is affecting to the human's central and vegetative nervous systems, influencing to the human's psychological condition etc.

In this paper some approaches and results of Italian and Russian experience of noise influence and perception are described.

Noise sources and perception of noise have been considered and relative actions planned according to a Participatory Design approach, where not only noise is considered as disease and annoyance factor.

The results of work are allowing reduce negative impact of noise to the human health and to estimate noise influence more efficiently.

2. The Russian Experience of Estimation of Noise Influence

2.1. General Approaches and Examples of Estimation of Noise Influence to the Population Health in Russia

In Russia for estimation of noise influence to the health of population typically different approaches are used:

- analysis of inhabitants complaints to noise disturbance:
- analysis and comparison of population sick rate in database of Russian medical institutions (polyclinics, hospitals etc) with measured results of noise measurement for the certain territories;
- Inhabitants self-estimation of health state depending on the conditions of protection from noise disturbance etc.

The following criteria of determination of risk of noise damage of the population health are suggested by authors (table 1).

As an example of approaches to estimation of noise influence to the health of population used in Russia let us show some results of estimation of noise impact to the

Table 1

Ceiling Sound Levels (dB) for the Different Kind of Population Life for Different Classes of Conditions (degrees of risk)

The kinds of life activity during the 24 hours	Optimal conditions (risk is absent)	Admissible conditions (negligible risk)	Harmful conditions (endurable with protective measures risk)	Damage conditions (unadmissible risk)
Sleeping	20	30	45	60
Rest	35	50	65	80
Work	50	80	100	110

health of population of Komsomolsky district of Togliatti city of Russia. Investigation of noise impact to the health of population included statistical data analysis of illnesses related with biological impact of noise to the inhabitants. The group of such illnesses includes in total 14 units of illnesses: cardio-vascular system, nervous system, alimentary canal etc.

Materials of population of Komsomolsky district of Togliatti city primary coming to the medical institutions for advice for the certain time period were used as sources of information about population sick rate. Using of certain procedures (one of which is method of I.A. Liepa) together with collaborators of the Institute of ecology of Volga basin of Russian Academy of Science estimation of parameters of equation of the plural linear regression and checking of significance of influence of investigated factors to the sick rate have been carried out [8]. Taking into account the results of measurements of noise levels of living territory of Komsomolsky district of Togliatti city and the primary medical statistical data of coming of population of Komsomolsky district to the medical institutions for advice, it is possible to make a conclusion that there is exist reliable, statistically significant dependence of all 14 units of illnesses growth from the impact of acoustical pollution.

Surveying of population of Komsomolsky district of Togliatti city have been carried out in order to determine their subjective perception of real noise load. The main purpose of surveying was to reveal the dependence of receptivity to noise affection from the general state of health, age, duration of inhabitants residing etc. In total inhabitants of 4 houses were polled (about 100 people), here 2 houses were selected with noise levels exceeding normative values, and 2 houses with noise levels corresponding to sanitary norms. The quantity of polled inhabitants (respondents) have been selected proportionally to the quantity of flats in above mentioned houses for comparison of surveying results.

Analysis of collected questionnaire data allows to make the following conclusions:

- inhabitants of houses situated in zones with combined increased noise and electromagnetic fields levels the worse are appreciating their own living conditions the longer term of their living in the territory of investigations;
- the older age of inhabitants, the evidently their negative perception of presence of combined acoustical and electromagnetic fields pollution;
- the worse the respondents are appreciating the state of their own health, the negatively (from the point of view of noise impact) they are appreciating the comfort of living conditions.

3 kinds of comfort of living conditions are selected: poor, satisfactory, good.

2.2. Modeling of Noise Propagation and the Methods of Noise Mapping

Modeling of noise propagation in the open space is more difficult task [6, 10, 11]. Concerning transport noise evaluation it is better to model not noise of separate cars, but transport flow noise. Formalization and modeling of transport flows it is convenient to do by using of influence diagrams. Such diagrams are usually describing some formalized presentation of modeled categories (objects, processes, properties etc.) in a form of multitude of graphical symbols (assemblies, vertexes) and relations between it. In Russia the types of influence diagrams are the most popular to use in a form of flow graphs, trees of events and functional nets. Flow graphs are including the variety of vertexes and a set of regulated and of unregulated couples, using for visual presentation of modeling process. Trees — non orientated graph, not having cycles, finite and coherent. During last time semantic or functional nets are rapidly developing, which are present graphs, but with additional information in it assemblies and rib. The most popular functional nets PERT (program evaluation and research technique) and GERT (graphical evaluation and review technique). For mathematical description of street-road nets of city methods of graph theory have been taken. Information about city street-road net geometry may be taken from the automobile road schemes, road atlases, drawings etc. For noise maps creation it is necessary to convert graph information to analytical. Presently the following steps have been done:

1. Mathematical apparatus of description have been analyzed and mathematical model of street-road transport nets have been worked out.

Variables and constants, meaning graph assembles-vertexes, are indicating as symbols set:

$U = \{1, 2, 3, \ldots, j, \ldots u\}$ — assembles-vertexes multitude;

$V = \{v_1, v_2, v_j, \ldots v_u\}$ — multitude of variables corresponding to assembles-vertexes;

$\Omega_j = \{\omega_1, \omega_2, \omega_3, \ldots\}$ — set of meanings of j-variable;

$f_j \in F$ — density of probability of distribution of variable y;

$\pi \in \pi$-function of accessory of linguistic variable.

For indication of relations between variables corresponding symbol mass data are using. These mass data may be presented as:

$D_{ij} = \{d_1, d_2, d_3, \ldots\}$ — multitude of ribs, connecting assembles I and j;

A_j — vector of bows-predecessers;

B_j — vector of bows-successers;

P_{ij} — vector of probability of transition between I and j.

Geometry of two-side graph G is determined by incidence matrix (setting a numbers of vertexes) and cor-

responding coordinates matrix $\{y^{(i)}\}$. To each rib $\{x^{(i1)}, x^{(i2)}\}$ of graph G numerical characteristic are comparing, which are describing street-road net:

n — number of traffic paths;

α — road profile;

β — quality of road surface;

γ — directives about structure and dynamic of transport flow;

δ — meteorological conditions;

ε — surrounding landscape;

θ — other characteristic (lighting, presence of traffic distribution zones etc.).

Thus, graph is totality of vertexes and ribs. Information about graph structure is determined by matrix form.

2. By using of developed mathematical model street-road transport nets have been created. Transport nets are consisting of the roads with intensive load (marked in the program by black bold strip) and a net of local roads. Numeration of graph assembles-vertexes is using. Procedure of graph cleaning from insignificant details is foreseeing.

3. Algorithms of coding and of information restoring about street-road graph structure have been developed.

4. Software have been developed to investigate noise situation in Togliatti city streets and roads. Graf networks of the transport mains of Avtozavodsky district of Togliatti city is shown in figure 1.

3. The Italian Experience

The Directive 2002/49/EC of the European Parliament and of the Council of 25 of June 2002 refers to the assessment and management of environmental noise [1].

Annex II of Directive 2002/49/EC lays down four interim computation methods for the production of strategic noise maps based on the determination of Lden and Lnight indicators for road traffic noise, railway noise, aircraft noise and industrial noise are recommended. These methods are:

- the French national computation method 'NMPB-Routes-96 (CSTB) referred to as 'XPS31–133' in the French standard, for ROAD TRAFFIC NOISE;
- the Netherlands national computation method published in "Reken en Meetvoorschrift", referred to as RMR, for RAILWAY NOISE;
- the ECAC Standard Method of Computing Noise Contours around Civil Airports', referred to as ECAC Doc.29, for AIRCRAFT NOISE
- the General Method of Calculation described in ISO 9613–2 "Acoustics abatement of sound propagation outdoors", referred to as ISO 9613, for INDUSTRIAL NOISE.

Member States that have already adopted strategic noise mapping and action planning methods are now involved in the general problem of joining the adopted methods with the main requirements of Directive 2002/49/EC.

Of course the use of interim methods and data provided in the relative guidelines is not compulsory, and Member States willing to use the interim computation methods are free to use other computation methods.

General problems are:

- the need to adapt methods and collected data expressed with noise indicators different from Lden and Lnight;
- the definition of standard emission data, that could cover all the specific situations that may be encountered in all Member States, in particular for road and railway noise; consequently, also specific methods for collecting data through measurements must be provided.

The acoustic design of a square, the residual soundscapes of a freshly realized pedestrian area and, in the frame of HUSH project, the requalification of two sites (a school courtyard and a suburban area, identified as acoustic hotspot), have followed the planning and designing approach that considers the several aspects of global comfort, based on participation, soundscape analysis and on the principles of temporal design in architecture.

A design methodology is based on integration of urban plans and participation of stakeholders has been developed and applied in the frame of EU LIFE+ HUSH (Harmonization of Urban noise reduction Strategies for Homogeneous action plans) project and in the Strategic Action Plan provided for the Florence City agglomeration.

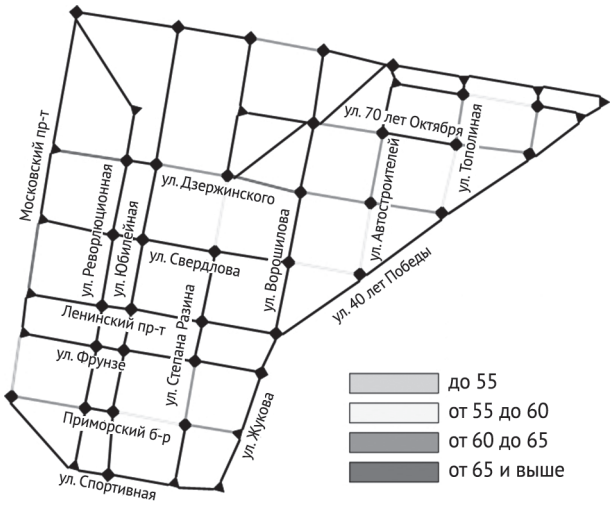

Figure 1. Graphical presentation of transport networks of Avtozavodsky district of Togliatti city

The acoustic analysis and the noise reduction remediation design have been included in a more general approach to integrated management of urban design. The trend of protecting urban spaces using specific remedies like barriers against noise sometimes generates "physical" and/or "psychological" cages. Thus, in the proposed methodology, alternative and strategic systems have been adopted, in a way that can preserve the identity of spaces, not just from the single factor point of view, but in a global quality of life approach.

In such a way the noise (or other pollutant) abatement becomes a contribution to a quality plan where the city re-conquer its urban space centrality and civic functional role. The interventions on quiet areas can be, in this way, adapted to different urban scenarios, in terms of global conditions, sensible to architectures and users. The comfort comes from landscapes and soundscapes, designed to be close to people needs, to reality.

In the frame of the definition of the methodology, it has to be considered a possible extension of EN ISO 7730 standard to external quiet and confined areas. Some trials have been tested, identifying two indicators that express the relationships between the activity of the human body and the sensation of thermal comfort, in statistical correspondence with the results of the surveys.

With respect to the standard's PMV (*Predicted Mean Vote*), a parameter assessing the wellbeing of an individual, according to subjective preferences and environmental variables has been defined, as a mathematical function representing the state of thermal comfort. A numerical value on a scale from –3 (index of feeling too cold) to +3 (index sensation of too hot) (0 is neutral) has been considered. Similarly, the standard's like PDP representing the *Percentage of Dissatisfied People* in a given place, has been calculated, starting from a weighted equivalent level of dissatisfaction derived by measurements and answer to questionnaires.

A problem arise in similarity with standard's indicators, being the case studies located in open outdoor spaces. Not particularly significant values of some direct environmental parameters have been found. Measured levels of temperature, humidity, thermal resistance of clothing, lighting level, have been included in the algorithm for the assessment of global (thermal, visual, acoustic) comfort but the levels of perceived comfort, derived by social data collections have gained more relative importance than the measured ones, in particular for those primary factors like visibility that can generate discomfort in terms of safety or security. For what concerns noise pollution, mainly caused by road traffic, the measured levels has been considered as important objective factor of discomfort, but the perception of annoyance has got a relevant position as well.

Italian law D.M. 29/11/2000 fixed the general approach for the definition of action plans concerning the reduction of transport noise. All the transportation companies and boards are invited to carry out acoustical studies of the respective contributions in noise pollution of the crossed areas. Systematic plans of monitoring and mapping noise levels leads to intervention plans scheduled in 15 years of progressive improvement, according to a priority scale.

Starting from a preliminary study and data acquisition of railway service conditions and territorial characteristics, the acoustic design process of mitigation actions of transport noise is composed of:

- traffic flows measurement and analysis for acoustical characterization of sources;
- acoustical mapping of areas containing noise receivers, located at fixed distances around roads, railroads and airports;
- assessment of noise produced by the road, rail or airport traffic;
- definition and design of interventions aiming at a reduction of noise levels below limits.

The evaluation of noise level is performed by:

- measuring (over a 24-hours or 7-days monitoring time) the source noise emissions in points at standard distances and heights all along the linear sources and all around the punctual ones;
- characterizing sources by type, speed, traffic volume and density, length or surface and other features;
- calculating the emitted sound power of each category of noise source (for example as logarithmic mean of the measured SEL level of all transits and events in that category);
- applying simulation algorithm to the measured data to find the noise impact levels ante-operam on each floor of each receiver I.

4. Conclusions

The results of analysis of noise influence to the population health are showing the negative noise influence and are proving the importance of the problem. Russian and Italian experience of approaches to estimation of noise influence and effects to human health is considered. Modeling of noise propagation and noise mapping in Russia are considered. Example of transport noise estimation in Italy is described. The results of work are allowing reduce negative impact of noise to the human health and to estimate noise influence more efficiently.

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Оценка влияния шума на здоровье городского населения: итальянский и российский подходы

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Негативное влияние шума на здоровье населения увеличивается с каждым годом. В статье описываются итальянский и российский подходы к оценке влияния шума. Акустический комфорт в городских районах зависит и от других факторов, влияющих на качество жизни. Представлены результаты оценки влияния шума. Рассматриваются модели распространения шума и отображения шума в России. Формализацию и моделирование транспортных потоков предлагается сделать с помощью диаграмм влияния. Описывается пример оценки транспортного шума в Италии.

Keywords: шум, влияние, оценка, здоровье, население.