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ACTION PLANS FOR NOISE PREVENTION AND REDUCTION IN THE CITY OF TIMISOARA

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Abstract. *The noise generated by transportation means and industrial activities is present in the city of Timisoara influencing the comfort and the health of inhabitants. The EU Environmental Noise Directive 2002/49/EC, which Romania should comply with, obliges the local authorities to elaborate action plans for management of urban noise, whose implementation will lead to solving the problems identified after noise mapping. In this paper, we present the action plans designed to reduce the noise in the city of Timisoara, taking into account the noise map of the city last updated in 2013. The elaboration of action plans was performed taking into account the requirements of the Directive 2002/49/EC.*

Key words: *urban noise, reduction, action plans*

1. INTRODUCTION

As it is known, the European Parliament and the European Council have adopted the Directive 2002/49/EC on 25 June 2002, with the main goal to create a common basis for all the states of the European Union concerning the assessment and management of urban noise. This common basis includes:

- Monitoring some environmental problems by imposing local authorities to develop strategic noise maps for roads, railways, airports, industrial zones and main urban areas, using the noise indicators L_{den} and L_n. These maps will be used for evaluating the number of persons exposed to noise in the whole European Union, Romania being a member state.
- Informing and consulting inhabitants on noise exposure and its effects as well as on the measures which can be adopted to fight against noise.

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- Elaboration of action plans for noise management in order to prevent and reduce the urban noise with the aim to protect inhabitants' health and to preserve quiet zones.
- Ensuring an active involvement of inhabitants to the whole process of planning activities related to noise management.

In the first stage, member states of the European Union reported on 30 June 2007 strategic noise maps for all urban zones having more than 250.000 habitants, as well as for main roads having more than 6.000.000 passing per year, railways with more than 60.000 passing per years and airports located near main urban zones. Following these strategic noise maps, member states reported on 18 July 2008 action plans intended to reduce the noise where the noise maps have identified exceeding of admissible limits.

The city of Timisoara is placed on the list of urban zones who must comply with the rules described above, due to the presence of more than 250.000 habitants, so that local authorities were concerned with the problems related to noise management.

According to the noise Directive, the strategic noise map and consequent action plans for prevention and reduction of urban noise should be renewed every 5 years, and therefore, the strategic noise map of Timisoara city was last updated in 2013. Based on the data resulting from this renewed noise map, the authors of the present paper elaborated the action plans aimed to prevent and reduce the noise in the city of Timisoara. .The noise Directive 2002/49/EC clearly states the requirements for the content of action plans, and starting from this fact, action plans for Timisoara city were built up taking into account all these requirements.

2. General Requirements for Action Plans

As it has been already acknowledged, an action plan must contain at least the following elements:

- A short description of the urban area, major roads, major railways and airports, as well as and other noise sources taken into account by the responsible authority
- Legal context and values taken into account to apply Art.5 from the Directive 2002/49/EC
- A brief summary of the results of strategic noise maps
- An evaluation of the number of habitants exposed to noise
- Identification of problems and situations which request attention from the point of view of the noise
- Information concerning public consultations on noise reduction problems
- Measures already taken to reduce the noise and other projects envisaged to reduce the noise
- Actions which local authorities intended to perform within the next 5 years, including measures intended to preserve quiet zones and the long term strategy
- Financial information (if available)
- Measures intended to evaluate the implementation of action plans and the obtained results.

3. Description of the Agglomeration, Responsible Authority and Legal Context

Timisoara, the capital of Timis county, is located at $45^{o}47$'N and $21^{0}17$'E. The town is extended on a surface of 130.5 km^2 having a population of 306.466 habitants and, therefore, is the largest agglomeration from the West part of Romania and also a very important industrial, historical, social and cultural centre. Timisoara is an important economic and industrial pole of Romania, where many national and European road, rail and air transportation routes are intersecting.

The authority responsible for realizing noise mapping and action plans for reducing the environmental noise in the city of Timisoara is the *Primaria Municipiului Timisoara*.

In the framework of the action plans, based on the results of noise mapping, the zones strongly affected by noise generated by road, rail and air traffic, as well as by industrial activity were identified. Besides, solutions to reduce the environmental noise in these critical points were also identified.

In the process of noise mapping, as well as in the elaboration of action plans, the legal requirements adopted by the following legal documents were taken into consideration: HG 321/2005 re-published, concerning assessment and management of environmental noise; OM 1830/2007 concerning approving the Gide to realize, analyse and asses the noise maps; OM 152/558/1119/1532/2008 for approving the Guide concerning adopting the limit values of L_{den} and L_n, and their application when elaborating action plans, for the road traffic, rail, air and industrial noise.

According to OM MMDD no. 152/13.02.2008, the maximum values allowed for the noise indicators L_{den} and L_n are presented in Table 1.

Table 1 Admissible values for noise indicators L_{den} and L_n

L_{den} [dB(A)]			L_n [dB(A)		
Source of noise	Target 2012	Max. value	Source of noise	Target 2012	Max. value
Roads	65	70	Roads	50	60
Railways	65	70	Railways	50	60
Airports	65	70	Airports	50	60
Industry	60	65	Industry	50	55
Roads	65	70	Roads	50	60

4. Synthesis of Information Obtained by Noise Mapping

In the following part, we present the data revealed by the strategic noise maps updated in 2013 for the city of Timisoara, related to the noise generated by roads, railways and industrial activities, using harmonized noise indicators L_{den} and L_{night}.

In this respect, the main results of the noise mapping process, for both L_{den} and L_{night} noise indicators are available at the addresses:

http://www.dmmt.ro/uploads/files/harta_zgomot_ziua.pdf

http://www.dmmt.ro/uploads/files/harta_zgomot_noapte.pdf

The most important conclusions which could be obtained from the noise maps are related to the number of people and also on the number of residential buildings exposed to noise.

Consequently, the number of people annoyed from the point of view of both L_{den} and L_{night} indicators is presented in tables 2 and 3, while the number of buildings exposed to noise from the point of view of the same harmonized noise indicators is presented in Tables 4 and 5.

Table 2 Number of people exposed to noise-L_{den}

Source of noise	55-59 dB	60-64 dB	65-69 dB	70-74 dB	>75 dB
Roads	28363	17839	14580	8349	1365
Rails-CFR	686	158	5	0	0
Rails-trams	0	0	0	0	0
Airports	0	0	0	0	0
Industry	140	10	0	0	0

Table 3 Number of people exposed to noise-L_{night}

Source of noise	45-49 dB	50-54 dB	55-59 dB	60-64 dB	65-69 dB	>70 dB
Roads	22531	18540	15288	9600	1808	326
Rails-CFR	850	520	12	3	0	0
Rails-trams	0	0	0	0	0	0
Airports	0	0	0	0	0	0
Industry	184	98	1	0	0	0

Table 4 Number of buildings exposed to noise-L_{den}

Source of noise	55-59 dB	60-64 dB	65-69 dB	70-74 dB	>75 dB
Roads	8539	7335	6890	3651	600
Rails-CFR	237	59	1	0	0
Rails-trams	0	0	0	0	0
Airports	0	0	0	0	0
Industry	64	4	0	0	0

Table 5 Number of buildings exposed to noise-L_{night}

Source of noise	45-49 dB	50-54 dB	55-59 dB	60-64 dB	65-69 dB	>70 dB
Roads	8948	7581	6519	4176	796	141
Rails-CFR	291	188	2	1	0	0
Rails-trams	0	0	0	0	0	0
Airports	0	0	0	0	0	0
Industry	85	44	1	0	0	0

Analysing the obtained results, one can observe that, concerning the road traffic noise, there are 24.294 people exposed to noise levels which exceed 65 dB from the point of view of L_{den} indicator and 45562 people exposed to a noise level which exceeds 50dB from the point of view of L_{night} indicator.

As regards the noise generated by the rail traffic, one can identify 5 people exposed to a noise level which exceeds the limit of 65 dB from the point of view of L_{den} indicator

and 535 people exposed to noise levels which exceed 50 dB from the point of view of L_{night} indicator.

Concerning the noise generated by the industrial activity, there are 10 people exposed to a noise level beyond the admissible limit of 60 dB for the L_{den} indicator, and 99 people exposed to more than 50 dB, which is the limit for the L_{night} indicator.

According to the strategic noise maps of Timisoara city, is related to noise generated by tramways and air traffic, there are not people exposed to a noise level which exceed the limit of 65 dB admissible for L_{den} indicator, respectively 50 dB admissible for L_{night} indicator.

Starting from the data offered by the strategic noise maps, the roads with the most important impact on the exposure of people to noise were identified as follows: on 24 roads, on some sections, the L_{den} equivalent noise level exceeds 75 dB, whereas on 29 roads, this noise indicator ranges between 70-75 dB. On other 19 roads in the city, the noise indicator L_{den} ranges between 65-70 dB.

This exceeding of the noise limits is mainly due to the condition of the roads' superstructure, the intensity of the road traffic and also the presence of heavy vehicles in traffic.

People affected by the rail traffic reside near the railway route and those affected by the industrial noise reside in the vicinity of the city thermal station "CET Centru" and near a beer factory.

The situation of noise pollution in Timisoara city is relatively normal due to the fact that, in the last decades, the local administration have been very concerned with reducing the noise levels. Years ago, in 1996, an intensive programme aimed at identifying noise sources and reducing the noise level in Timisoara city was initiated by the research team from the Mechanics and Vibration Department, Faculty of Mechanical Engineering, "Politehnica" University of Timisoara. Moreover, responding to the requirements of EU policy on environmental noise, the first strategic noise map of the city and consequent action plans, whose stipulations have already been implemented, were realized in 2007.

5. Synthesis of Actions Aimed at Informing and Consulting the Public

The stipulations of the Environmental Noise Directive 2002/49/EC concerning the action plans include organizing actions aimed at informing and consulting the public about noise exposure, its effects, and the measures considered to address noise problems and possible solutions.

In this respect, at a first stage of public consultations, the public opinion on noise exposure was revealed by some questionnaires filled in by various people who reside in Timisoara near the most affected zones. These questionnaires contain questions related to the position to the roads, the degree of annoy produced by the urban noise, possible health disturbances, possible proposals to reduce the urban noise, etc.

Synthesizing the responses obtained by means of these questionnaires, one can draw some important conclusions:

- 72.4% of the buildings are placed frontal to the roads
- 34.5% of the habitants are disturbed by the street noise during displacement within the town, 24.2% are disturbed by the noise in buildings, 34.5% are disturbed by both street and building noise, and 6.9% are not disturbed.
- the noise has affected the health of 17.2% of the questioned habitants causing stress and headaches.

The questioned inhabitants have made different proposals for reducing the noise generated by transportation means and other sources, such as: introduce free public transportation that would discourage the use of individual cars; finish the works at the city road-ring in order to eliminate a part of transitory traffic; build noise screens and improving the superstructure of the roads; increase the green areas; replace old and noisy transportation means with a new and silent ones.

These proposals collected from the participants were used in designing action plans along with the data resulting from the noise maps.

In order to inform the habitants, the action plans were published on the website of the municipality.

6. Measures Implemented for Reducing the Noise

Before the elaboration of the action plan with the aim to prevent and reduce the noise, the municipality implemented a set of measures intended to reduce the environmental noise in Timisoara, such as: building of a ring-road in the northeast part of the city; the improvement of infrastructure and superstructure of the railway for trams on a significant length; the improvement of the state of an important number of roads from the city; purchasing new and more silent trams and buses for local transportation; modernization of some crossings and roads; imposing some speed limitations on some roads; imposing one-way traffic on some routes; banning the access to heavy traffic in the central area of the city; encouraging phonic and thermal insulation of buildings; enlargement of green areas and green screens; building of an acoustic screen in a critical point; investigation of sound absorbing effects of rubberized asphalt in order to be used at large scale as a solution to reduce traffic noise; construction of bicycle lanes, and so on.

Even if these measures were implemented, noise mapping would still reveal the zones where the admissible limits are exceeded. That is why the identification of noise sources is a very important task which must be accomplished.

7. Identification of Noise Sources

The main sources of noise in the urban environment are the road, rail and air transportation means as well as industrial activities. Concerning transportation means, the noise and vibration are generated by the engine, transmission system, braking system, air resistance and rolling. The noise generated by transportation means is significantly influenced by the intensity and composition of traffic, speed of displacement, the technical state of vehicles, as well as rolling and state of the superstructure of roads.

In case of rail transportation means, noise and vibrations are due to variation of speed, imperfection and elasticity of railway, joints of railways, guiding of rolling wheels, etc.

In case of air transportation means, the sources are represented by the engines, propulsion propellers, cooling and oil pumps, turbochargers, etc. Due to the noise produced by airplanes, the functioning of an airport represents an important problem for the personnel and neighbour residential areas.

In case of industrial activities, noise appears due to collisions of rigid bodies, friction on contact surfaces, aerodynamic turbulences, forced oscillations of rigid bodies, vibration of

membrane-shaped parts, hydraulic operated devices, deployment of mechanical, electromagnetic, aerodynamic, hydrostatic processes, etc.

The presence of noise affects a large number of inhabitants which are disturbed. Having an action upon the human body, the noise can affect the auditory system and different internal organs and systems of the body, reduce the work productivity and speech intelligibility. The noise may also affect the nervous system producing psychophysiological modifications, blood circulation problems and sleep disturbances, influences the visual function and the functioning of endocrine glands, influencing iochemical disturbances. The noise can produce auditory fatigue, sonorous trauma and a general fatigue of the body. All these affect physical activity, especially for individuals which need focus of attention, mainly in the intellectual work.

Having in view the detrimental effects of the noise, in order to ensure proper conditions for human life and activity, the levels of noise which should not be exceeded were established. In order to characterize admissible limits of the environmental noise, specific noise indicators are used, such as those presented in Table 1, where L_{den} is defined by [3]

$$L_{den} = 10 \lg \frac{1}{24} \left[12 \cdot 10^{\frac{L_d}{10}} + 4 \cdot 10^{\frac{L_e + 5}{10}} + 8 \cdot 10^{\frac{L_n + 10}{10}} \right] \quad (1)$$

where L_d is the long term noise measured in the day during 12 hours, between 7.00 and 19.00; L_e is the long term noise level measured during 4 hours between 19.00-23.00; L_n is the long term noise level in the night during 8 hours, between 23.00 and 07.00.

In case when the admissible limits are exceeded, some measures aimed at reducing the noise are needed for each particular case.

8. Methods for Noise Reducing

Establishing the methods for noise reducing is done taking into account the causes of noise generation, which are in our case the presence and positioning of roads, railways, airports and industrial areas.

In what concerns the noise generated by the road traffic, one can introduce restrictions regarding traffic composition and speed limitations.

Reducing the noise generated by tyre-road contact can be achieved by replacing normal asphalt with a rubberized one, obtained by combining normal asphalt with crumbled rubber. This will ensure a reducing of the rolling noise of 1 up to 6 dB, depending on the speed of displacement, the most important reducing being obtained in the frequency bands corresponding to 1 kHz and 2 kHz. It was proved that sound absorption properties of rubberized asphalt are more important at high speeds of displacements [7].

In order to reduce the noise generated by vehicles, trains, trams and industrial activities, one can resort to acoustic screens and protective zones (green zones) between residential areas and these sources. Such screens were mounted in a zone located at the entrance to Timisoara city with the aim to protect a school against noise generated by the road traffic, and near the railways which cross the city in order to protect the residents from against rail traffic noise. Attenuation achieved by these screens depends on the relative position of sources and receivers, dimensions, wavelength, acoustic transparency of the screens and so on [9].

Attenuation of the noise generated by tyre-road contact in rolling of cars can be achieved in an ecological way by mounting a hedgerow of shrubs and trees. Moreover, the noise generated by rolling of trams can be attenuated by employing an insulation system for the railway using modern technologies. Taking into account that significant noise levels are identified in Timisoara city due to transitory heavy traffic, it is necessary to to complete works on the city ring-road so that the heavy traffic will be completely eliminated and a noise source disappear.

In what concerns reducing the noise produced by rail traffic, it is necessary to extend green protected areas, reflective or absorbent acoustic screens or green screens between railways and residential areas, along with ensuring a proper technical state of rolling stock.

Concerning the industrial noise, it is necessary to apply a complex of measures comprising both attenuation at source and attenuation on the transmission way. In this way, methods for noise reduction can envisage the noise he noise generated by the main mechanical parts, machine-tools, industrial equipment and installations used in technological processes should be applied within each industrial unit

Taking into account the above mentioned principal measures, one can identify the best possible solutions applicable in order to reduce the noise in Timisoara city.

9. ACTION PLANS

The problem of road traffic noise is still unsolved in Timisoara, even if it was diminished by inaugurating a part of the ring-road.

The configuration of the street network of Timisoara city has a radial-annular shape, better structured in northern part of the city and less contoured in southern part. A lack of sufficient passages over the Bega river which crosses the city and the railway which crosses the central zone of the town show some major dysfunctions of traffic organization, which do not allow a proper connection between different parts of the city. The existing bridges are very congested.

Bega channel and the railway constitute two major obstacles which substantially affect the continuity of street network, whereas the low number of bridges is being confirmed by the values of the noise indicators registered on 24 streets involved.

In order to improve the circulation in the city, with direct benefit on noise reduction, it is necessary to transfer heavy traffic to the ring-road, eliminate the transit traffic from the city, and develop public transportation system including employment of silent transportation means. The proposals to attenuate the noise on the roads in Timisoara city, where admissible limits of the noise indicators are exceeded, were established taking into account the study concerning the circulation in Timisoara.

Analysing the results obtained after noise mapping of Timisoara city, the objectives of the activities for noise reduction were established. Thus, eight action plans aimed at reducing the road traffic noise, rail traffic noise and industrial noise were designed. These provide modernization of some important crossings, mounting acoustic screens on 14 roads, finalizing the ring-road in the South-western part of the city, opening a fourth circulation ring, replacing normal asphalt with rubberized asphalt on six roads, realizing some green protective areas on 60 roads, enveloping residential buildings (with sound-absorption effects), and so on.

Table 6 Number of people exposed to noise-L_{den}

Source of noise	55-59 dB	60-64 dB	65-69 dB	70-74 dB	>75 dB
Roads	17674	14465	8105	1889	0
Rail	149	14	0	0	0
Industry	10	0	0	0	0

Table 7 Number of people exposed to noise-L_{night}

Source of noise	45-49 dB	50-54 dB	55-59 dB	60-64 dB	65-69 dB	>70 dB
Roads	18290	15161	9395	2390	326	0
Rail	508	23	4	0	0	0
Industry	94	5	0	0	0	0

The number of people exposed to noise after the implementation of these action plans taking into account the indicators L_{den} and L_n is presented in Tables 6 and 7.

The difference between the initial total number of persons exposed to noise and the number of persons exposed after the implementation of action plans in terms of L_{den} and L_n, respectively, is presented in Tables 8 and 9.

Table 8 Difference between the number of exposed persons in terms of L_{den}

Source of noise	55-59 dB	60-64 dB	65-69 dB	70-74 dB	>75 dB
Roads	-	-	6475	6460	1365
Rail	-	144	5	0	0
Industry	130	10	0	0	0

Table 9 Difference between the number of exposed persons in terms of L_{night}

Source of noise	45-49 dB	50-54 dB	55-59 dB	60-64 dB	65-69 dB	>70 dB
Roads	-	3379	5893	7210	1482	326
Rail	-	497	8	3	0	0
Industry	90	93	1	0	0	0

From Tables 8 and 9, we can see that after the application of action plans, 14.459 persons benefit from a reduction of noise exposure in terms of Lden, while in terms of Ln the number of persons who benefit is 18.892.

These action plans also contain a section concerned with delineation of quiet zones from the city of Timisoara and actions intended to be performed in the next 5 years by the municipality in order to protect these zones.

10. LONG TERM STRATEGY

The action plan for the next 5 years must be completed with a long term strategy which should include the long term vision regarding noise reduction. In this way, more of

the ideas developed in the elaboration of action plans will find a better solution in a longer term, especially for measures which have expensive solutions. Prevention of noise problems on long term is ensured based on a good planning.

Based on the strategic noise maps, one can adjust urban development plans in order to ensure that new buildings will not be constructed in areas with a high impact of noise and new noisy industrial units will not be placed near residential areas or quiet zones.

According to the development strategy "Vision Timisoara 2030" elaborated by the municipality in collaboration with "Politehnica" University of Timisoara and Fraunhofer Institute Stuttgart, the environmental issues to be integrated with all other aspects have been mainly envisaged.

In the frame of this action plan, there have been some specific politics and projects. Synthesizing the objectives of the projects considered in the long term strategy, one can emphasize the main measures for noise reduction which will be applied: building a closed ring-road (deadline for completion 2020); closing the other rings of circulation (deadline 2019); making some uneven circulation nodes (deadline 2021); building of 5 new bridges over the Bega river (deadline 2020); developing the network of bicycle lanes (deadline 2025); applying a layer of rubberized asphalt on an important number of roads (deadline 2025); mounting acoustic screens to protect hospitals, schools, universities and other buildings (deadline 2020); improvement of technical state of the superstructure of roads (deadline 2025); preserving and extending green areas and green screens along the roads (deadline 2022); replacing the railway which cross the city with an underground line (deadline 2020); expansion of subway network (deadline 2030); rehabilitation and reconversion of industrial units placed near residential zones (deadline 2019); finalizing the program of thermal rehabilitation and phonic insulation of buildings (deadline 2020); rehabilitation of Timisoara rail station and Timisoara airport (deadline 2022); extension of parking places (deadline 2025); rehabilitation of the Bega channel in order to develop naval transportation (deadline 2020); replacing old public transportation means with 100 new trams and 100 new silent electric buses (deadline 2020); rehabilitation of the old tram's railways on 3 roads and extension with new lines (deadline 2020); modernization of an important number of streets and boulevards (deadline 2020).

After the application of the measures from the long term strategy, an important number of persons which will benefit of the noise reduction was estimated: 8349 persons in terms of L_{den} and 15288 persons in terms of L_n. In the same time, the municipality will be concerned about conservation of quiet zones identified in Timisoara city by applying specific measures.

11. FORECASTS REGARDING THE IMPLEMENTATION OF ACTION PLANS

By implementing the results of action plans, an important reduction in the number of people and buildings affected by noise will be achieved, and a healthier environment will be ensured. This will lead to an increase of their work capacity and decrease the costs caused by medical treatments.

The implementation of noise reduction measures should be continued until persons or buildings are not exposed to noise which exceeds the admissible limits. Reduction of noise in residential buildings will indirectly lead to an increase of work productivity since people will live in a quieter environment.

After the implementation of action plans, a set of real measurements should be developed in order to assess the efficiency of the measures and the effect of their implementation.

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AKCIONI PLANOVI ZA SMANJENJE I PREVENCIJU BUKE U TEMIŠVARU

Buka prouzrokovana prevoznim sredstvima i industrijskim aktivnostima u Temišvaru značajno utiče na komfor i zdravlje stanovnika. Direktiva o zaštiti od buke u životnoj sredini 2002/49/EC, koja se primenjuje u Rumuniji, obavezuje lokalne vlasti na izradu akcionih planova upravljanja bukom u urbanim sredinama, čija će implementacija dovesti do rešenja problema koji su identikovani mapiranjem buke. U radu su predstavljeni akcioni planovi za smanjenje buke u Temišvaru, uzimajući u obzir stratešku mapu buke na teritoriji grada iz 2013.god. Izrada akcionih planova je sprovedena u skladu sa zahtevima Direktive 2002/49/EC.

Ključne reči*: buka u urbanim sredinama, smanjenje, akcioni planovi*