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RESEARCH AND MODELLING OF NOISE OF THE CENTRAL PART OF PANEVĖŽYS CITY

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Abstract. Panevėžys city is divided into three parts – Southern, Northern and Central. Noise level in the central part of Panevėžys city is discussed in this paper. Noise level at streets is measured at different time of the day. Noise level modelling is carried out in the central part of Panevėžys. Modelling results are compared to measured ones. The inadequacy of measured and modelled results d being up to 10%, assumption is made that the modelled and the measured results correlate, and noise level in residential areas as well as at streets is analyzed according to the results of modelling in the day – time and by night. The main sources of noise and the highest noise level zones where the inhabitants are affected by the increased noise level most are revealed.

Keywords: noise, equivalent and max noise level, noise modelling.

1. Introduction

In Panevėžys as well as in many other bigger cities cars make up about 90% of the total level of city noise (Baltrėnas *et al.* 2007; 2008).

In many cities city noise increases by 1–3 decibels during the year in average (Gražulevičienė *et al.* 2003). Noise level is supposed to double in 15 years (Grubliauskas, Butkus 2004).

Transport distinguishes for being a dynamic noise source. Noise affects man's ear most negatively. The entire man's activity, even the man's entire body are affected negatively as well (Baubinas, Vainauskas 1998; Jarup *et al.* 2005).

Noise tires people not only in a noisy workplace but also in the surrounding he lives at home. Noisy surrounding at work or at rest irritates, causes tiredness, weakens attention, and slows down psychological reaction, distresses neurotic system. In a noisy surrounding it is difficult to concentrate, to hear, to remember important information (Stansfeld *et al.* 2000; Jonasson 2007).

Traffic flow is a random process characterized by random variables. A study of random processes requires extensive statistical material, profound mathematical knowledge and performance assurance, but, unfortunately, we still lack much of this (Kapski *et al.* 2008). Research confirms that increased noise level (Willich *et al.* 2006) is related to increased risk to get heart attack (Zavadskas *et al.* 2007a; 2007b). The simplest way to assess acoustic pollution of the environment is to measure environmental noise. However, the measurement method may not always be applied in all situations. It may not be done for many reasons such as: the background noise level is close to the source spreading noise; it is impossible to predict environmental noise levels if changes are going to be made in the environment; because of the geographical position when the place is difficult to access (Baltrėnas *et al.* 2009; Burinskienė 2009; Vaiškūnaitė *et al.* 2009; Žeromskas 1998).

The main cause of noise increase in streets is the increasing number of old, technically badly-maintained cars and the developing activity of transport undertakings. During the past ten years the transport flow in Lithuania has increased 2.4 times. Because of this car accidents increased as well. Longer transport lines and time losses at junctions are experienced (Antov *et al.* 2009). As a result the pollution of the environment with exhaust fumes and the traffic noise has increased considerably.

For the assessment of the environment computer models and simplified model noise evaluating model are made use of most frequently.

Traffic noise prediction models are currently used to predict average noise descriptors (e.g. L_{den}), as required for example in noise mapping or in legislation. Those models usually consider traffic flow as a steady noise source whose level depends on flow rate and mean speed. Unfortunately, this static representation does not take urban traffic dynamics into account. An accurate description of average noise levels is bound to dynamic representation of traffic flows (Babisch *et al.* 2007; Steele 2001).

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Noise modeling program MapNoise operates in geoinformatic system. The model is GIS, the applied program of program MapInfo. It gives the possibility to calculate noise influence level on the lower storey's and in front of buildings on the upper storeys. It is also possible to determine the number of houses entering the noise influence zone grouping them according to the level of noise influence.

This geoinformatic system model used for noise assessment has the following possibilities:

It can select all the information necessary for the predicted model from a digital map having contours, axis lines of roads, structures and acoustic borders. It ensures that the same data source will be used for calculations.

Calculations are made quickly, precisely and comprehensively, including the screening and locality reflection effect, one or some-storeyed buildings and noise borders.

The model is useful when optimizing the designing and laying out noise borders. Calculation results are given in the geoinformatic system visually.

The area of the central part of Panevėžys city is bordered by Nemuno, Pušaloto, Marijonų, Radijo (up to the loop of the Nevėžis river), Basanavičiaus, Vilniaus, Klaipėdos streets, including the area in the Nevėžis river loop. The central part distinguishes for the intensity of traffic and the abundance of car flow. From 2 to 5-storeyed residential buildings dominate in this part of the city. There is no industry, however, there is the greatest concentration of restaurants, cafes, shops and banks. The public transportation and cars dominate there. The stretch of Smėlynės street entering the city centre as well as Basanavičiaus, Vilniaus, Klaipėdos streets are most heavily loaded with traffic flow.

The old river bed of the Nevėžis, lying to the north of the central part of the city is loved and mostly visited by the town -dwellers.

The central part of Panevėžys city is illustrated in Fig. 1, where the central part is divided into three segments.

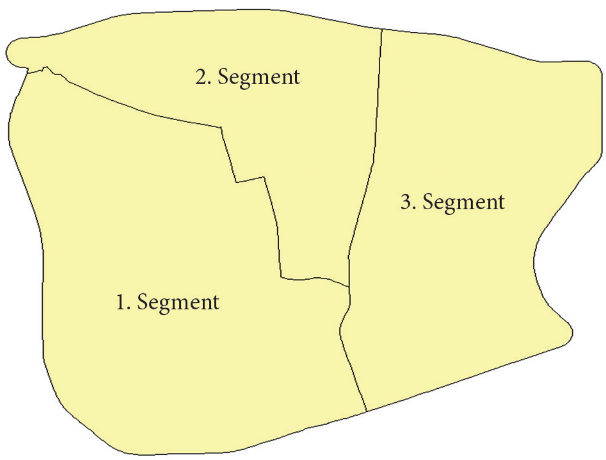

Fig. 1. Panevėžys city central part

Objectives and tasks of this work are: to determine noise levels during measurements at streets and compare them to the modelled level; having proper data correlation noise level is analyzed according to modelling data in the residential environment at different time of a day.

Evening or night time is of great importance because then inhabitants are more sensitive to noise.

2. Research methods

Measurements of the noise level produced by motor vehicles are carried out in the area of the motor transport influence zone.

Noise measurements are made by means of selecting Panevėžys city which sites are the most suitable to describe the acoustics of the environment under consideration. The sites of measurement are chosen taking into account the amount and speed of motor vehicles passing different street sections, the street pavement, the background noise of the locality, its plants and development. The positions and number of sites under measurement depend on the necessary spatial dispersal of the environment under consideration (Vaišis, Januševičius 2008).

Having the aim to find out the level of noise made by motor transport and taking into account different time of the day the research into each of the 6 sites of measurements were carried out at different time of the day, i. e. during the day (from 6 to 18 o'clock), in the evening (from 18 to 22 o'clock) and at night (from 22 to 6 o'clock).

Motor transport noise measurements were done in April, May, June and in autumn (September, October). During these seasons the motor traffic flow is the greatest in cities. Besides, under heavy weather conditions during the cold season it is impossible to carry out the noise studies. Thus, no measurement is done when it rains or snows, or there is fog or wind velocity is greater than 5 m/s. When wind velocity is from 1 to 5 m/s the microphone is covered by a special screen. Noise measurements are carried out when relative humidity is no more than 80%, the weather temperature may range from 0 °C to 30 °C (Vasarevičius, Graudenytė 2004).

Taking into account the development of the locality and its noise dispersal peculiarities distances are adjusted. In the areas, which are not closer than 7.5 m from the axial car trajectory line to the buildings, the noise measurement points are chosen at 1 to 2 m distance from the building wall, at 4 m height from the surface of the area directing the microphone towards the side of noise source (Petraitis, Januškevičius 2008).

Before and after doing measurements the device is calibrated according to the device usage instructions. If the results of the calibration differ by more than 2 dB the noise measurements are repeated (Baltrėnas *et al.* 2007).

Bruel and Kjaer mediator 2260, the relative error of measurement of which is ±1.5% is used.

Before carrying out noise level measurements weather conditions are determined first: relative air humidity, temperature and wind velocity. Having these data, it is decided if measurements can be done.

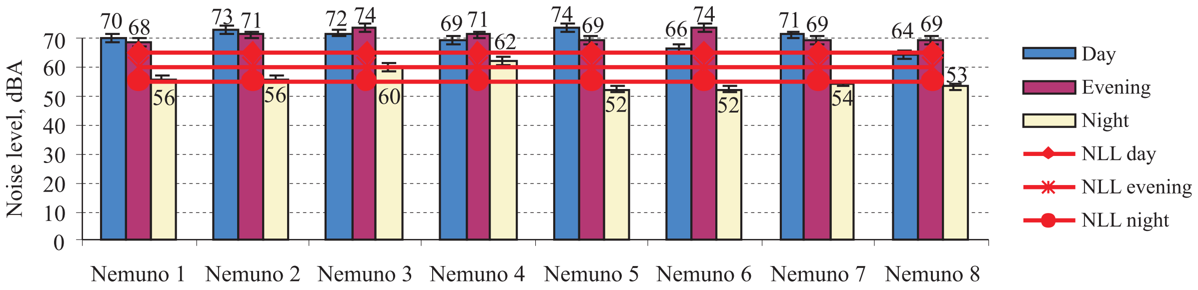

Fig. 2. The changes of equivalent noise levels in Nemunas street (NLL – noise level limit)

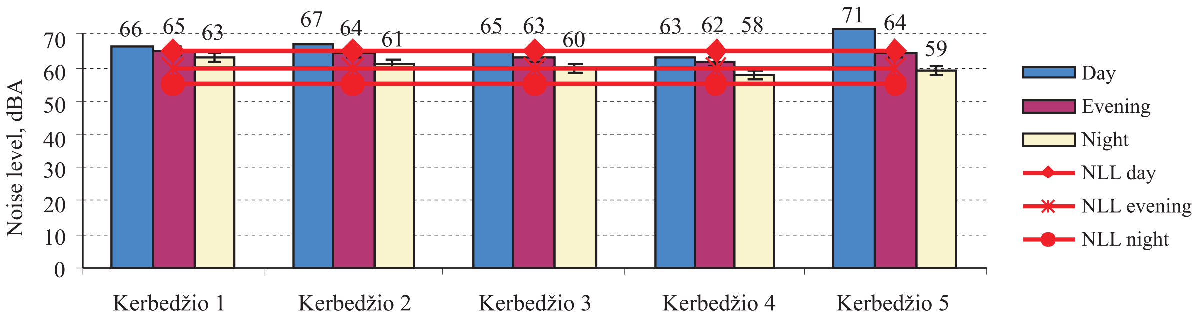

Fig. 3. Change of equal noise levels in S. Kerbedžio street in the course of a day (NLL – noise level limit)

3. Research results and their analysis

Modelling noise levels in Panevėžys city the greatest attention was paid to the central part of the city because it is this area where most people are in the day-time. Much attention was also given to this part because there are many crossings where noise level takes the summary value expression because of all intercrossing streets.

During the experimental research it was ascertained that the main transport flow in this part and, thus, the greatest noise level are in four streets, accordingly in Nemuno, S. Kerbedžio, J. Biliūno and Smėlynės streets (Figs 2–4).

Having performed the noise modelling operations the results are compared to the field data of experimental research. The differences being more than 10 dBA street clusters and other parameters that can have influence on the common equivalent noise level in the chosen section of the street were checked. The difference of the noise level being less than 10% both from the value measured and from the modelled quantity, this indefiniteness meets our requirements, and the data obtained correlate.

Estimating the data obtained at the day-time the greatest noise level was found on the western side of the central part where two streets meet, i. e. the above-mentioned Nemuno and Klaipėdos streets. The noise level fixed at the crossing amounts 66 dBA. The highest equivalent noise level in the-day-time exceeds the permissible standard of 1 dBA. During experimental research the site in Klaipėda street next to a crossing was chosen. The excessive noise level at this point was 7 dBA.

Analyzing Nemunas street one can see evidently that the increased noise level occurs because of two reasons, i. e. because of a heavy flow of car traffic and of a rather considerable part of heavy loaded transport in general flow. The modelled noise level varies from 55 dBA to 65 dBA. Average value is 58 dBA. Noise level is exceeded at crossings where the summary action is obtained because of two crossing streets.

The two other crossing streets, S. Kerbedžio and J. Biliūno, distinguish for having less number of cars, but there is a greater part of heavy transport.

It influences the change of noise level as well. The noise is more stable in the entire street. There are no sudden changes of noise. The noise level found in S. Kerbedžio street differs from the modelled noise in average about 5–6 dBA, that's why the conclusion can be made that modelling was carried out correctly and the

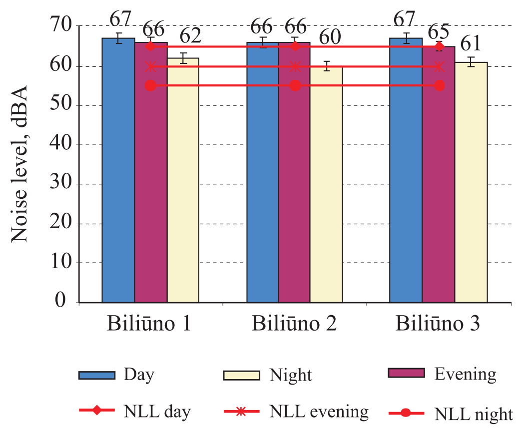

Fig. 4. Change of equivalent noise levels in J. Biliūno street in the course of a day (NLL – noise level limit)

data obtained are reliable. S. Kerbedžio street depending on the number of passing traffic, is divided into two main strethes, the first one starting from the crossing with Elektros street up to the crossing with Smalinės street; the second one being from this crossing up to the ring with Nemunas street. This can be explained by the fact that a part of heavy-loaded transport enters the second stretch from Smalinės street. In the first section of S. Kerbedžio street average value of modelled noise came to 59 dBA, while in the other there are 62 dBA. However, it should be noted that noise level change in the second part makes only 2 dBA and is almost entirely constant. The same tendency was observed during field experiments as well.

Noise level in J. Biliūno street is not so constant and the change involves 10 dBA. The greatest value was 65 dBA and it was modelled in the street section, where motor transport has no obstacles as there are no traffic lights, no crossings nor passages. The flow moves in two lines. Almost in the same place noise measuring post No 2 in J. Biliūno street was installed. By comparing field measurements and the results of modelling the inadequacy was found to be only 1 dBA. Distinct decrease of noise level was observed at the dam of the Ekrano sea.

One of the main highway arteries, passing along the very centre of Panevėžys city, is Smėlynės street. Research results concerning this street are given in Fig. 5.

Comparing field measurements and modelling results the greatest diversions were obtained in this street-up to 10 dBA. However, the results obtained correlate within the chosen limits of 10%.

The modelled noise level is almost constant varying the noise level limiting from 57 to 61 dBA. The greatest value is fixed at the crossing with Vilniaus street. The bus terminal next to it had influence on it. Another extreme point in this street is at the crossing with Pu aloto street. During field measurements the greatest noise level was fixed in this place, namely, 73 dBA. Having modelled, the noise level value of 66 dBA was found. In both cases the determined noise level exceeds the standards. In the central part of Panevėžys city the streets of Pušaloto, Nemuno and Vilniaus should be distinguished as the noisiest. Increased noise level close to standards is observed.

Figs 6–11 illustrate modelled noise level in the central part of Panevėžys city in the day-time and at night.

Getting sure that modelled and measured results correspond, the noise level at residential buildings and streets is analyzed. It the day-time the inhabitants which live in Nemuno street in the section from Taikos alley up to Vasario 16 street, are effected by the most increased noise level. The noise level at dwelling houses reaches up to 55–60 dBA here. The highest noise level in Nemuno street was modelled in the section from Vasario 16 street crossing to the crossing with Klaipėdos street. The high level of noise there is determined by the greater flow of cars. The greatest modelled noise level is at Nemuno and Klaipėdos streets crossing, single residential houses nearby are affected by noise level of 60–65 dBA. In Nemuno street from the crossing Tilvyčio street towards the crossing Ramygalos street the flow of cars is less, thus, the noise level by the of 60–65 dBA. In Nemuno street from the crossing Tilvyčio street towards the crossing Ramygalos street the flow of cars is less, thus, the noise level by the street reaches about 50 dBA.

In inner yards noise level is higher because of diffraction of sound from buildings and reaches 45 dBA as being modelled from the crossing of Taikos alley and Klaipėdos street.

In the day-time inhabitants next to Parko, Vasario 16, Tulpių and Respublikos streets are subjected to a lower noise level which amounts to 50 dBA. Still lower noise level is in inner yards, where the multi-storeyed houses themselves perform the noise barrier function. In inner yards the noise level reaches about 45 dBA and does not exceed permissible noise level.

At the night-time the modelled noise level is shown in Fig. 7. The inhabitants are subjected to a higher noise level because of greater transport flow along Nemuno street, i. e. the same as in the day-time. Noise level next to these streets amounts 50–55 dBA, and permissible noise level in the night-time is 55 dBA. At Parko, Vasario 16, Tulpių and Respublikos streets noise level in the night-time reaches about 45 dBA, and does not exceed the permissible noise level. Noise level is lower and amounts to about 40–35 dBA in inner yards and near small streets.

Fig. 8 gives the modelled noise level in segment 2. S. Kerbedžio and Smėlynės streets distinguished for the greatest traffic flow and highest noise level. Lower noise level about 60 aBA was at Stoties, Pušaloto and Marijonų streets. The lowest noise level about 55 dBA at Upės, Jakšto and Nevėžio streets. In residential areas which are sepa-

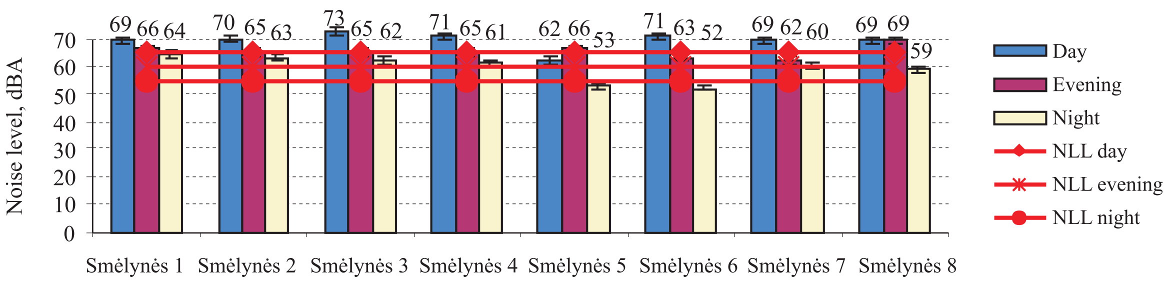

Fig. 5. Change of equivalent noise levels in Smėlynės street in the course of a day (NLL – noise level limit)

Fig. 6. Modelled noise level of segment 1 of the central part of Panevėžys city by night

Fig. 7. Modelled noise level of segment 1 of the central part of Panevėžys city in the day-time

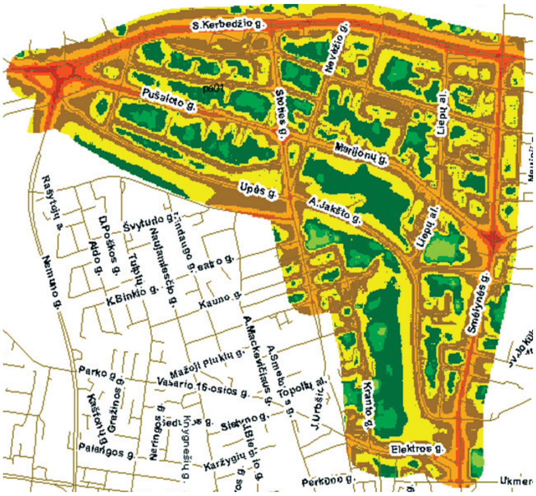

Fig. 8. Modelled noise level of segment 2 of the central part of Panevėžys city in the day-time

Fig. 9. Modelled noise level of segment 2 of the central part of Panevėžys city by night

Fig. 10. Modelled noise level of segment 3 of the central part of Panevėžys city in the day-time

Fig. 11. Modelled noise level of segment 3 of the central part of Panevėžys city by night

1–35 dBA 35–40 dBA 40–45 dBA 45–50 dBA 50–55 dBA 55–60 dBA 60–65 dBA 65–70 dBA 70–75 dBA 75–80 dBA 80–100 dBA rated from the street by buildings noise level is about 40–45 dBA. Inhabitants, the windows of whose dwellings are oriented towards busy and noisy streets are subjected to mostly increased noise level. About 50 dBA noise level was found in the residential area at Smėlynės and S. Kerbedžio streets. It reached 45 dBA in the residential area between Marijonų and Jakšto streets.

The modelled noise level at the night-time is given in Fig. 9. S. Kerbedžio and Smėlynės streets are notable for the highest noise level. At these streets it was about 50–55 dBA. In residential areas noise level of about 45 dBA is in the sites next to streets. Farther from the streets the noise level weakens, smothers and is about 40–35 dBA

Fig. 10 illustrates the noise level in the third segment of the central part of Panevėžys city at the day-time the highest noise level at J. Biliūno and Smėlynės streets reaches about 65 dBA near the streets while farther from the streets noise level becomes weaker and amounts 55, 50–45 dBA. Noise level at S. Kerbedžio street is about 60 dBA. In the residential area between Venslaviškio and J. Biliūno streets noise level is the greatest and reaches about 50–45 dBA. Noise level at Aukštaičių and Vilniaus streets comes to about 55 dBA while in the residential areas nearby these streets it weakens up to 40-45 dBA. The modelled noise level at the night-time is shown in Fig. 11 and it is the highest at J. Biliūno and Smėlynės streets that is the same as it is in the day-time. Noise level in residential areas is about 35–40 dBA.

4. Conclusions

Having measured the change of noise level in the day-time, in the evening and at night the excess of noise level was determined to be 65% in the day-time, 88% in the evening and 71% of carried out measurements at night.

The greatest excess of noise level was measured at Klaipėdos, Nemuno, S. Kerbedžio, J. Biliūno and Smėlynės streets, which distinguish for greater flows of cars and trucks.

In the day-time noise level modelled at the streets reached up to dBA, while in the yards of dwelling-houses where noise is screened by the houses themselves noise level was about 40–45 dBA.

At night the higher noise level remains only at the most active Klaipėdos, Nemuno, S. Kerbedžio, J. Biliūno and Smėlynės streets, where noise level amounts to about 55 dBA.

The modelled noise level does not correspond to the measured one up to 10%. This is a small inadequacy and one can make conclusion that the modelling results are reliable.

By using noise modelling programme noise level can be predicted in residential areas, at street crossings, and in the yards of dwelling-houses without carrying out noise level measurements.

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