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ASSESSMENT OF JOINT HAZARD TO THE OUTER ENVIRONMENT FROM ROAD AND INDUSTRIAL NOISE BY THE EXAMPLE OF THE KATOWICE VOIVODESHIP

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An analysis of available professional papers on the subject shows that, in spite of the fact that some theoretical base exist, there is no general formulation of the problem discussed in this study. This is reason for undertaking the task and making a quantitative analysis of acoustic climate for the Katowice voivodeship. This paper is a report on the first attempt in Poland to work out an acoustic map which takes into consideration all traffic and industrial sources of noise located in a large and diversified area. The purpose of this paper is create on acoustic map of Katowice voivodeship and quantitative analysis of acoustic climate which takes into consideration noise of industrial and transportation.

1. Introduction

The increasing level of social consciousness in relation to hazards of the natural environment from physical and chemical factors entails the necessity of a quantitative determination of those hazards coming from different sources, among other things also the noise sources. The instructions of the European Union, taking into account the widespread presence of noise in various domains of human activity, point to the people's right to live in silence. This implies the necessity to make an assessments of the acoustic climate not only at workplaces but also at every dwelling-places outside the working posts. In Poland, the Katowice voivodeship is one of the areas with an increasing shortage of places not endangered by excessive noise. The noise hazard in the Katowice region is a result of many unfavourable factors, the predominant ones being: an excessive urban development, concentration of obsolete industry and, as the result, a high density of population. An additional burden to the environment is the transport service that has been lackiing modernization for many years. These factors make the environmental noise, that is the noise in the places of human habitation and recreation, exceed very often the values assumed as admissible and increase further. The incoordinate land planning conducted for many tens of years has resulted in an urban aggregate which is unique in the world's scale.

Presently at the area of the Katowice voivodeship, covering ca. 6650 km^2 (2.1% of the whole area of Poland), live nearly 4 million people, which constitutes ca. 10.4% of the population of the country.

During the year 1988–1997, at the Department of Technical Acoustics of the Central Mining Institute the work on the quantitative assessment of the noise hazard in the area of the Katowice voivodeship has been conducted taking into account its main components, i.e. the road and railway traffic and industrial noise.

The initial materials for preparing an acoustic map of such an area as the Katowice voivodeship region are the following ones: a surveying map adapted for the needs of this plan (by elimination of unnecessary information) and indices of the acoustic climate assessment. In practice, different indices are used in the assessment of the environmental noise. They are extensively described in the bibliography of the subject [3, 4, 16, 17, 20]. The following ones are most often used:

1. Indices of the source noise $L_{Aeq,r}$ and $L_{Am,r}$, dB, calculated as averages of the measured sound levels A in all measuring points characterizing these objects as noise sources.

2. Indices of the degree of disturbance of the acoustic climate of the environment L_{AN} dB, calculated as the difference between the averaged level of the noise disturbing the environment and the corresponding admissible level.

3. Indices defining the percentage ratio of the length of transport routes with defined noise level to the length of all routes on which the measurements were conducted.

4. Indices defining the number of people in the analysed area endangered by noise of a level in excess to the standard value.

5. Indices defining the area of the zone under assessment endangered by the import of noise of a level in excess to the standard value.

6. Indices taking into account subjective reactions of humen to the noise influence.

2. Investigation methods

The variety of noise sources appearing in the field requires the application of manifold classification sections [6, 9, 10, 12, 13]. In relation to the shape, they are divided into:
— linear (transportation routes, ...),
— superficial (airports, depots, railway stations, large industrial plants, ...),
— punctual (small industrial plants, individual machines, ...),
— spatial (building type).

Instead, considering the environment in which the noise exists and the type of the source generating it, one can divide the noises into:
— noise coming from the means of transportation, the so-called traffic noise,
— industrial noise, and
— noise in habitable rooms, public utilities and rest and recreation areas, i.e. municipal noise.

Apart from the size, the way in which the noise is emitted into the surroundings is also of importance in assessing the impact of a specified type of noise on the environment. Its prediction in the environment is presently based on calculation methods of the external noise determination.

However, the necessity of mathematical simplification of the assumed models introduced at every stage of the calculations leads to many mistakes; the results obtained from those operations are of lower practical importance than one could expect [4, 6, 7, 9, 10, 12, 18]. For such a complex system as the Katowice voivodeship, the creation of acoustic models proves to be difficult or simply impossible. Therefore, it has been decided to develop an assessment method based on the measurements actually performed.

The choice of the approach results also from the fact that the most accurate transformation of the existing state is ensured by a measuring method relying upon determination of the sound levels A under maintaining strictly defined and neutral methodology conditions [4, 5, 6, 7, 8, 11, 19].

The application of a suitable method depends on the way of determining an initial parameter of the acoustic field. Knowing the sound level A for any characteristic time range t_i, the basic parameter of the noise hazard assessment in the environment is determined over the time T, i.e. an equivalent sound level is given by the relationship

$$L_{A,eq} = 10 \log \frac{1}{T} \sum_{i=1}^{n} t_i 10^{0.1 L_{Ai}}, \tag{1}$$

where L_{Ai} – sound level occurring at the time t_i, dB, t_i – time of occurrence of the noise of the level L_{Ai}, min, T – time for which the equivalent level value is determined.

Under ideal conditions, the method of determining the sound level A at a certain distance from the source is based on the fundamental assumption that the noise propagates in open space without any disturbance and that the change of its level is determined solely by the distance of the observation (measurement) point from the source [7, 9, 10, 11, 12].

Under real conditions, if the sound level $L_{A,0}$ at a distance r_0 from the considered source is known, one can calculate the sound level A value at any distance r_x from the source from the relationship

$$L_{A,X}(r) = L_{A,0} - K \log \frac{r_X}{r_0} - \Delta L(d), \tag{2}$$

where $\Delta L(d)$ is the total effect of all additional factors influencing either an increase or drop of the sound level A at the observation point localized at the distance r_x from the source of noise, K is the coefficient accounting for the noise attenuation along a distance, r_0 distance of the point of reference.

From among many factors, the influence of which on the level of annoyance is the highest one, one can quote [11, 12, 13]:

— sound level A at the source,

— type of noise emitted,

— course of the spectrum of noise emitted by the source,

— type of the casing of the source or lack of thereof,

— occurrence and localization of areas liable to anti-noise protection.

In addition, several assumptions were made for carrying out tests and an noise hazard assessment for such a large area as a voivodeship:

— the testing was divided into three stages taking into account different types of sources in each case – road traffic, railway and industrial noise [14, 15],

— the area of the voivodeship was divided into squares of 5 km sides by a geodetic graticule according to the assumptions of the so-called Upper-Silesian Area Information System (GSIoT) [14, 15],

— the values of admissible levels for all types of noise were assumed to be: 55 dB for the day-time and 45 dB for the night [1, 2, 14, 15],

— the results of measurements carried out in accordance with the assumed testing procedure were collected in the database constructed on the basis of the MS ACCESS 2 PL programme.

The procedure described above enabled to calculate an index defining the percentage of the area of a defined square endangered by the noise impact of a level exceeding the admissible one. This index was determined from the relationship [4]

$$W_{KZH} = \frac{T_{KZH}}{T_{K0}}, \tag{3}$$

in which W_{KZH} – index defining, in accordance with the GSIoT, the percentage of the area of the square, endangered by the noise in excess to the standard value, T_{KZH} – area of the square endangered by the noise in excess to the standard value, T_{KO} – total area of the square.

The method described was subject to verification for the whole area of the Katowice voivodeship. On the basis of the results of measurements obtained, the values of the indices were calculated defining the percentage of the areas of individual squares – according to the assumed division graticule of the area-endangered by the noise of a level in excess to the standard value, separately for the day- and night-time. The division of the Katowice voivodeship into 300 squares the 5 km sides is in agreement with the assumptions made by the local Government of the Upper-Silesian Area Information System. Taking into account these assumptions, it was possible to utilize the results obtained for a general assessment of the hazard for the Katowice voivodeship [14, 15].

Presently, the following documents concerning the assessment of the hazard for the environment by noise are in force:

— Act of the 31-th of January, 1980 on the protection and formation of the environment,

— Order of the Cabinet of the 30-th of September, 1980 on the protection of the environment against noise and vibration.

The Order of the Cabinet on the protection of the environment against noise and vibration is an administrative act to the Act mentioned above. It wad dated at the end of 1980 and since that the moment that it coms into force has not been amended. The criterial values of the equivalent sound level A determined by in it are given separately for the day (6.00 – 22.00) and the night (22.00 – 6.00). It was assumed that during the day there are 8 most unfavourable hours, while during the night there are only 30 most unfavourable minutes.

Basing on this Order, the criterial values of the sound level A have been taken from it and assumed for the noise assessment in the area of the Katowice voivodeship. The necessity to introduce uniform values for such a diversified area was the main problem. After carrying out a number of consultations both with the representatives of the local Government (Voivodeship Office, Katowice) and the centres engaged in studying the effect of noise on health of the humans, the following co-ordinated values were assumed:

— 55 dB for the day-time,

— 45 dB for the night-time,

as the admissible ones for the whole area of the Voivodeship.

The following factors speek in advocacy of the assumed values: the way of the land development (an urban area with many centres of individual municipal units), high intensity of the road traffic, existence and size of recreation grounds (parks and chiefly allotments) situated in the periphery of towns and settlements.

3. Test results

The determination of the noise hazard condition in the Upper-Silesian urban aggregate and creation of a database of the occurring acoustic hazard had required a widespread investigation in this domain. As the result, the following picture of the hazard from individual noise components was obtained for the Upper-Silesian urban aggregate.

3.1. Road traffic noise

Measurements were made for the day-time at 1369 measuring points located along roads of different categories and of a total length of ca. 3900 km. For the night-time, the measurements were limited to 50 representative squares at the area of which 250 measuring points were localized along ca. 950 km of roads.

The following results of the performed assessment have been found that [14]:

— for day-time, about 13% of the area of the Katowice voivodeship is endangered by the influence of road traffic noise, characterized by a sound level A exceeding the assumed critical value of 55 dB,

— for night time, it has been assessed from the performed sound measurements, that ca. 20% of the area of the Katowice voivodeship is endangered by the influence of road traffic noise characterized by a values of sound level A exceeding the assumed critical value of 45 dB.

3.2. Railway noise

The total length of the railway lines in the Upper Silesia region is 2230 km (of which 29% are trunk-lines, 38% first-rank lines, 21% second-rank lines and 12% are lines of local importance). The Upper-Silesian regional railway operates over a much larger area than that of the Upper-Silesian urban aggregate analysed (the total length of railway lines of the Katowice voivodeship constitutes 62% of the total length of the Upper-Silesian railway). The railway lines of a length of 1100 km constituting, ca. 80% of their total length in the Katowice voivodeship area, were included in the tests.

From the performed measurements and calculations of the emission and immission it follows that [15]:

— for day-time, about 11% of the area of the Katowice voivodeship is endangered by the railway noise characterized by a sound level A exceeding the assumed critical value of 55 dB,

— for night-time, about 57% of the area of the Katowice voivodeship is endangered by the influence of the railway noise characterized by values of the sound level A exceeding the assumed critical value of 45 dB.

3.3. *Industrial noise*

The 200 industrial plants localized in various communes and towns within the limits of the Katowice voivodeship have been subject to acoustic assessments. Their choice reflects the industrial structure in the Upper Silesia region.

From the performed measurements and calculations it follows that

— for day-time, about 1.5% of the area of the Katowice voivodeship is endangered by the influence of noise coming from the industrial activity conducted here and characterized by values of the sound level A exceeding the assumed critical value of 55 dB,

— for night-time, about 1.9% of the area of the Katowice voivodeship is endangered by the influence of industrial noise characterized by values of the sound level A exceeding the assumed critical value of 45 dB.

4. Assessment of the error in determining the equivalent sound level A at the point of reference

All the measurements carried out are related to signals which are characterized by random changes of the acoustic pressure vs. time. Each of the measurement results at a defined measuring point is encumbered by some error. This error was influenced by different factors. The total error of a single, continuous measurement of an equivalent level lasting 8 hours during the day-time or 0.5 hour during the night-time, is affected by:

— the error introduced by the equipment used in performing the measurements,

— the error introduced by the atmospheric conditions taking place during the measurements,

— the error caused by the effect of the acoustic background.

Applying the simplified methodics relying upon the shortening of the measurement time introduces an additional error which requires a separate approach (estimation) depending on the type of noise and the time assumed for carrying out the measurement.

Efforts have been made to reduce the equipment error by applying in the measurements high class meters serviced by measuring teams experienced and specialized in field tests. Also the effect of atmospheric conditions, i.e. atmospheric pressure, velocity of the wind, temperature and humidity of the air, were minimized by controlling them and carrying out the measurements when the values of these factors were within the ranges defined in the proper standardizing documents [21, 22, 23] and the instruction manuals of the devices.

The error in determining the sound level A for individual types of noise and resulting from the remaining factors has been assessed below.

The equivalent sound level A occurring at a specified point is calculated from the relationship

$$L_{A,eq} = 10\log\left[\frac{1}{T}\sum_{i=1}^{n} t_i 10^{0.1L_i}\right] \tag{4}$$

or

$$L_{A,eq} = 10\log\left[\frac{1}{T}\sum_{i=1}^{k} n_i 10^{0.1SEL_i}\right], \tag{5}$$

where t_i – action time of the i-th source, T – time during which the equivalent level was determined, L_i – value of the sound level of the sound emitted by the i-th source in the time t_i, SEL_i – averaged exposition sound level A, eg. for the i-th category of train, n_i – number of elementary events numbered among the i-th category, and occurring within the time T.

When determining the value L_i, one should take into account the noise level existing at the considered point with a lack of activity of the investigated source (the level of the measuring background – L_T). In accordance with the above, the following relationship should be used:

$$L_i = 10\log\left(10^{0.1L_Z} - 10^{0.1L_T}\right), \tag{6}$$

where L_Z – measured noise level at the measuring point, L_T – measured level of the acoustic background at the measuring point.

As $L_{A,eq}$ has been determined (following (4) or (5), at the measuring point it depends on the level of the sound emitted by the i-th source and the time of its action) the error value $\Delta L_{A,eq}$ of determining the equivalent level is calculated from the relationship:

$$\Delta L_{A,eq} = \left[\left(\frac{\delta L_{A,eq}}{\delta L_i}\right)^2 \Delta L_i^2 + \left(\frac{\delta L_{A,eq}}{\delta t_i}\right)^2 \Delta t_i^2\right]^{1/2}, \tag{7}$$

where ΔL_i – error of determining the level value of the noise emitted by the i-th source at the measuring point, Δt_i – error of estimation of the action time, identical for each source.

Substituting (4) in (7) one obtains finally, after differentiation, the following relationship for the error of determining the value of $L_{A,eq}$:

$$\Delta L_{A,eq} = \left[\Delta L^2 + \left(\frac{\sum_{i=1}^{n} 10^{0.1L_i}}{\sum_{i=1}^{n} t_i 10^{0.1L_i}} 10\log e\right)^2 \Delta t^2\right]^{1/2}. \tag{8}$$

The calculation error of the emitted noise is determined from the formula:

$$\Delta L = \left[\left(\frac{\delta L}{\delta L_Z}\right)^2 \Delta L_Z^2 + \left(\frac{\delta L}{\delta L_T}\right)^2 \Delta L_T^2\right]^{1/2}. \tag{9}$$

Substituting (6) in (9) one obtain after differentiation

$$\Delta L = \frac{\Delta L_Z \left(1 + 10^{-0.2\Delta K_T}\right)^{1/2}}{1 - 10^{-0.1\Delta K_T}}, \tag{10}$$

where ΔL_z – measurement error, ΔK_T – difference between the measured value and that of the measuring background (L_T) which, at the time of measurement, was at least 6 dB.

The results of calculation of the maximum error in determining the level of the equivalent sound A are presented below.

4.1. *Road traffic noise*

Continuous measurements (8 hours during day-time or 0.5 hour during night-time) of the sound level A at the point of reference in which there is a large difference between the investigated signal and the existing acoustic background enables to determine the equivalent level at this point with an accuracy equal to that of the instrument used in the tests [6].

The reduction of the measuring time, resolving itself, in practice, into "periodical sampling" of the investigated signal, introduces an additional error.

The methodics proposed in [6] enables to determine the values of the equivalent level with a 1.5 dB accuracy. This error was in [2] determined for a single ten minute-lasting, measurement carried out at a random time moment within 8 most unfavourable hours of the day in the surroundings of a road with a medium traffic intensity of 370 vehicles per hour. For a measurement performed in rush hours it is equal to 1.8 dB, while in the time period corresponding with the lowest traffic intensity it is 4.9 dB. Our investigations have shown the dependence of the value of this error on the traffic intensity. These errors are:

— 1.9 dB for roads with a traffic intensity above 800 vehicles per hour,

— 2.1 dB for roads with a traffic intensity between 500 and 800 vehicles per hour,

— 2.7 dB for roads with a traffic intensity between 300 and 500 vehicles per hour.

From the above it follows that the maximum error in determining the equivalent sound level A on the basis of a single ten minutes – lasting measurement during the rush hours does not exceed 3 dB during the day-time.

For the night-time, the measurement duration was 0.5 hour and was equal to the time period for which the admissible sound level A has been determined. In this connection, the error of determining the equivalent value is related only to the error of the instruments used. For further analysis a value of 1 dB has been assumed.

4.2. *Railway noise*

For the assessment of the maximum error in determining the equivalent sound level A for the railway traffic during both the day- and the night-time, it has been assumed that the measurement error of the exposition level for a single measurement ΔSEL is 1 dB. The difference between the measured noise level and the acoustic background level for the measuring points localized in close surroundings of the roads was, at least, 6 dB. For such an value assumed, the error in determining the equivalent level ΔL, formula (10), is 1.4 dB. The maximum error in calculating the equivalent sound level A for eight most unfavourable day-time hours or half an hour during the night-time, and at the assumption that the accuracy of determining the number of trains is 20%, is, from formula (8), equal to 1.7 dB.

4.3. Industrial noise

In accordance with the assumed methodics, the measurements were performed at places localized outside the premises of the plant when the maximum noise emission into the environment took place. The equivalent noise level A, for eight most unfavourable day-time hours and half an hour during the night-time, was determined by performing short 10-minute measurements. On the basis of the performed tests [9, 10, 13, 25, 26, 27] it has been found that a main influence on the formation of the acoustic climate around industrial plants have the following factors: fan station, compressor stations, transformers, cooling towers, etc. The time of their operation is different. However, due to their importance in the technological processes this time is not less than 4 hours for a working shift. In connection with the above, in assessment of the maximum error in determining the value of the equivalent sound level A it has been estimated that this error, for both the day- and night-time is equal to 3 dB.

5. Estimation of the error of determining the area endangered by the influence of noise of a level in excess to the standard value

In the case of assessing the noise hazard of large areas, one utilizes the indices defining the percentage portion of the area "polluted" by the excessive noise in relation to the whole investigated area.

Generally, the scheme of determining this type of index is presented in Fig. 1 ([1]).

As it follows from the above considerations, the accuracy of calculation of the endangered area becomes important. The area in which a noise in excess to the standard value exists can always be extrapolated to determine the area of a rectangle in the case of a linear source, or that of a circle for a punctual source.

For linear sources the area is

$$P = lr, \tag{11}$$

where l – length of the road or railway line being the source of noise, r – determined range of the noise influence.

The error in the determination of the area is

$$\Delta P = \left[r^2 \Delta l^2 + l^2 \Delta r^2\right]^{1/2}, \tag{12}$$

([1]) By the term "linearized source length" appearing in the scheme the considered length of the road or railway line section or the circumference of the analysed plant is meant.

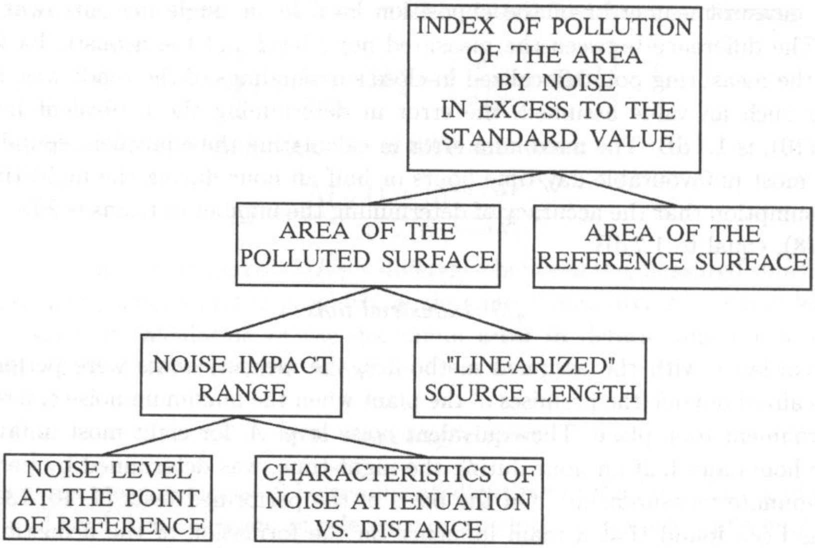

Fig. 1. Scheme of determination of the dependence of the index value of polluting an area by noise in excess to the standard value.

where Δl – error of determining the road or railway line lengths from the map base, Δr – error of calculating the range of the influence of noise.

This range is a complex function depending on the difference between the measured noise level A and the admissible value and on the character of the noise decay with distance. It is calculated from the relationship

$$r = r_0 10^{L_D/a}, \tag{13}$$

where r_0 – distance between the source and the reference point, L_D – difference between the noise level measured at the point of reference and the admissible value, a – coefficient characterizing the course of the decay with distance.

Using the relationships

$$\frac{\delta r}{\delta L} = \frac{r}{a \log e} \tag{14}$$

and

$$\frac{\delta r}{\delta a} = \frac{rl}{a^2 \log e} \tag{15}$$

and taking advantage of the fact that the range r of the noise influence depends on the difference between the measured noise level and admissible one and on the character of decay of the noise level with increasing distance from the source, the Δr value has been determined as:

$$\Delta r = \frac{r}{a \log e} \left[\Delta L^2 + \frac{L_D}{a^2} \Delta a^2 \right]^{1/2}. \tag{16}$$

Substituting (16) in (12) one obtains

$$\Delta P = \left[r^2 \Delta l^2 + \frac{r^2 l^2}{a^2 (\log e)^2}\left(\Delta L^2 + \frac{\Delta L_D^2}{a^2}\Delta a^2\right)\right]^{1/2}. \tag{17}$$

Finally, the relative error of estimating the area polluted by the road traffic and railway noise is:

$$\frac{\Delta P}{P} = \left[\frac{\Delta l^2}{l^2} + \frac{L_D^2}{a^2 (\log e)^2}\left(\frac{\Delta L}{L_D^2} + \frac{\Delta a^2}{a^2}\right)\right]^{1/2}. \tag{18}$$

The estimation of the error in the area endangered by the excessive noise (over 55 dB) has been carried out taking as an example road sources. The following assumptions have been made:

— the value of the error, ΔL, of determining the equivalent sound level A is 3 dB,

— the error, Δl, of determining the lengths of the road sections from the map bases is 10% and is constant for each of them,

— the error, Δa, of determining the drop of the sound level A with increasing distance from the source was determined on the basis of calculations utilized in preparing Fig. 2.

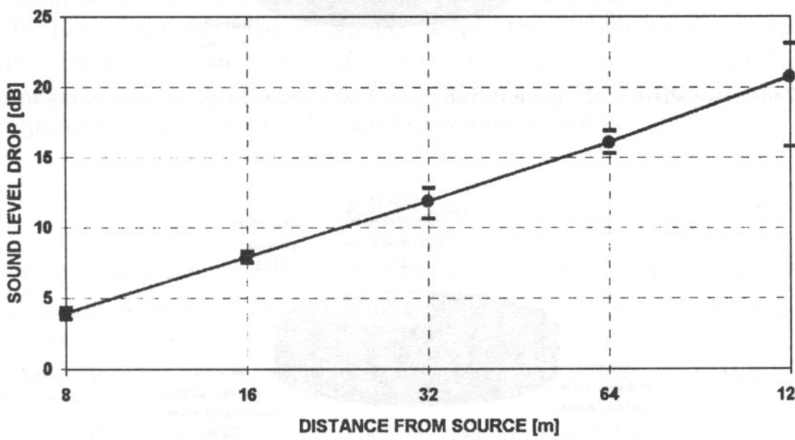

Fig. 2. Experimentally determined characteristics of the decay of the sound level A at a site for road traffic noise, with marked values of the standard deviation.

From the above assumptions, using the relationship (18) (by applying suitable procedures of transformation of the relative units (dB) into the acoustic pressure units) the maximum relative errors of determining the area endangered by excessive noise for individual reached zones have been found. These values are:

— for the distance from 4 m to 8 m from the reference point – up to 36%,

— for the distance from 8 m to 16 m from the reference point – up to 36%,

— for the distance from 16 m to 32 m from the reference point – up to 37%,

— for the distance from 32 m to 64 m from the reference point – up to 37%,

— for the distance above 64 m from the reference point – up to 37%

(for $r_{\max} = 270$, which corresponds to an equivalent noise level A at the point of reference equal to 80 dB).

The values of these errors result from the considerable simplification related to a very wide range of the measuring work conducted. Their values can be accepted, taking into account that the results obtained are intended for recognition and general administrative purposes.

6. Conclusions

As the result of the performed field testing, the complete assessment of the acoustic climate within the limits of the Katowice voivodeship resulting from the three main noise sources have been obtained. This situation is schematically presented in Figs. 3 and 4.

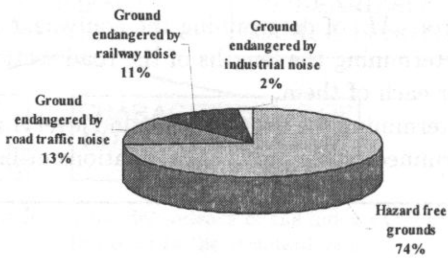

Fig. 3. Percentage share of the grounds endangered by a defined type of noise in the total area of the Katowice voivodeship. The day-time.

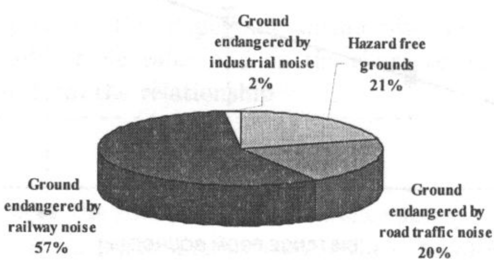

Fig. 4. Percentage share of the grounds endangered by a defined type of noise in the total area of the Katowice voivodeship. The night-time.

The presented test results enable to conclude that the hazard caused by industrial noise is much lower than to the traffic one. This is mainly caused by:

— lower values of the sound levels A of the industrial noise at the point of reference as compared to that of the traffic. The sound levels L_{eq} at the reference point were comprised within the limits:

— from 59 to 84 dB (day-time) and from 50 to 78 dB (night-time) for the road traffic noise;

— from 59 to 76 dB (day-time) and from 69 to 82 dB (night-time) for the railway noise;

— from 43 to 69 dB (day and night time) for the industrial noise;

— faster drop of the sound level A of the industrial noise with the distance;

— lower linearized sum of circumferences of the plants as compared to the length of the transportation lines.

As the result of the performed assessment, also the estimation of the hazard to people from the influence of noise of a level in excess to the standard value (55 dB) has been made. From this, it has been found that during the day-time ca. 30% of the population is endangered which constitutes ca. 1 150 000 inhabitants of the Katowice voivodeship.

In the author's opinion, a further development of the presented investigation should be:

— conduction of research work on plans of development and management of large administrative units, with particular consideration of the decision-making process, which should be advantageous from the point of view of the protection of the environment against excessive noise,

— preparation of acoustic maps of large areas,

— improvements of the methodics of carrying out measurements of various noise components,

— research work on models of noise propagation in the land with different degrees of urbanization,

— verification of the functioning models of surface and linear sources,

— utilization of the database set applied within the framework of this work as well as the GIS software for visualization of other types of environmental hazards,

— development of method of assessment of the noise emitted from roads with pavements of different quality.

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