

METHODS OF ASSESSING NOISE NUISANCE OF REAL ESTATE SURROUNDINGS

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Abstract

Testing what factors create the market value of real estate is key information when preparing property valuations as well as other opinions and professional evaluations on the basis of which court verdicts or administrative decisions are made. One of the factors influencing the value of some real estate is the level of noise present in the surroundings, which can lead to the occurrence of noise nuisance negatively affecting social relations.

Due to the fact that the analysis of the attractiveness of a location is the basis for properly determining the market value of real estate, the present article is dedicated to the methodology of assessing the noise nuisance of real estate surroundings. Four methods of assessment are proposed in the work: two of an objective nature, based on the measurements of noise and spatial analyses of data included in a strategic noise map, as well as two of a subjective nature, accounting for, among others, the individual perceptions of real estate users. The results of studies using the above methods can serve as a source of information on real estate as well as aid decision processes in the scope of real estate management. Theoretical deliberations were supported by a sample assessment of the noise nuisance of real estate surroundings carried out using two of the presented study methods.

Keywords: noise, methods of assessing noise nuisance, residential real estate, Poland.

JEL Classification: Q51, Q53, Q24,R31

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1. Introduction

A diagnosis of the real estate market is the basis for the proper assessment of real estate market value, while assessing what factors create it is key information when preparing property valuations as well as other opinions and professional evaluations on the basis of which court verdicts and administrative decisions are made.

Surely an important factor influencing the value of some real estate is the noise level occurring in the surroundings and creating the acoustic climate, which can lead to the occurrence of noise nuisance negatively influencing social relations. A similar viewpoint is expressed by SZCZEPAŃSKA, SENETRA and WASILEWICZ-PSZCZÓŁKOWSKA (2015). Noise, differentiating space in terms of acoustics, influences the assessment of the attractiveness of real estate location, which has also been brought to attention by GNAT and BAS (2014). In the opinion of BRANDT and MAENNIG (2011), quiet residential areas are more

attractive to live in than areas exposed to noise, which, as ascertained by CELLMER (2011), can pose a significant problem in the process of real estate management in urban areas. Among buildings located in space, we can differentiate real estate which, due to their intended use and function served, are referred to as buildings of noise sensitivity (KRAJEWSKA, SZOPIŃSKA, 2014). Residential real estate, including: the actual plot of land on which a residential investment can be realized, real estate already built-up with a residential building, and multi-family housing real estate is particularly sensitive to the negative influence of noise. The price level of residential real estate is connected with different levels of environmental variables, including noise, the level of which changes depending on the distance from the source (BLANCO, FLINDELL 2011). The carried out analyses show that, in relation to the above real estate, their prices fall by 0.5% for each decibel above 50-55 dB¹ (EEA, 2010). This is why it is extremely important to carry out a complete assessment of the noise nuisance of the surroundings, the results of which will become the basis for determining the location attractiveness of residential real estate. Due to characteristics of noise travelling throughout urban space, the assessment of the noise nuisance of the surroundings requires accounting for the objective and subjective nature of noise, which creates the specific acoustic climate of the given space. In connection with the above, carrying out the complete assessment of noise nuisance, accounting for the dualism of acoustic phenomena, points to the application of various study methods. A portion of them, being of an objective nature, are possible to apply using measurement tools, measuring the level of noise in decibels, or the analysis of data found in the resources of strategic noise maps (SNMs). Other methods, being of a subjective nature, are possible to apply by assessing the annoyance caused by noise phenomena. Annoyance, as well as sensitivity to noise, is a subjective concept, dependant on the predispositions of a person as well as the characteristics of the noise itself. In connection with the above, when carrying out studies of a subjective nature, the authors propose applying two methods. One of them is the method of noise indicator correction, based on objective data, e.g. from a SNM, corrected accordingly to amounts resulting from the social assessment of exposure to noise and referred to evaluation scales applied in other scientific studies. The second method is carrying out an interview among users of the area on the topic of the individual perceptions of noise phenomena in the real estate surroundings.

As a result of the above, the aim of the present article is to propose a methodology for the complete assessment of the noise nuisance of the real estate surroundings, including the method of noise indicator correction designed by the authors, as well as showing an example of applying two of the presented methods in relation to a selected residential real estate. The posed aims were realized using the following study methods:

- 1) an analysis of literature on the subject, as well as European Union and Polish law regulations regarding the protection of the environment from noise pollution,
- 2) a study of source materials, including entries of planning records and strategic noise map resources of the analyzed terrain,
- 3) field inspection,
- 4) analysis of qualitative data using computer programs: CadnaA and GeoMedia Professional.

2. Noise nuisance – basic information

The set of noise phenomena occurring in a given area is referred to as its acoustic climate. In the case of the occurrence of undesirable, unpleasant, bothersome or harmful sounds referred to as noise, noise nuisance can emerge, which negatively influences people's quality of life and can lead to decreasing the attractiveness of real estate lying within reach of its effect (SZOPIŃSKA, KRAJEWSKA, 2013).

The negative effects of noise nuisance vary greatly. Their scope and consequences depend on many factors which NURZYŃSKI (2013, p.15) divided into three groups. In the first, he included effects dependant on the characteristics of the actual sound, its level, the presence of impulses, spectral characteristics, the content of tonal components, time behavior and others. In the second group, he included factors resulting from the function of the area, its use, as well as the type of activities assumed by people spending time in the given area, including their individual sensitivity to sound. Finally, he included local and cultural factors in the third study group, which also decide about the expectations, reception and subjective assessment of noise. Accounting for the above deliberations,

¹The drop in prices was in the range of 0.2-1.5%, with a tendency towards greater values in the case of air traffic noise, and pertained to areas for which the L_{DEN} indicator for various groups of noise sources exceeded the level from the 50-50dB range.

only the full assessment of noise nuisance, including the objective and subjective scope of noise, will make it possible to adequately determine the effects of undesirable sounds in the real estate surroundings.

3. Methods of assessing the noise nuisance of the surroundings

The subject of the below deliberations is presenting a method for assessing the noise nuisance of the surroundings, which may be the basis of determining the attractiveness of the location of a given residential real estate, accounting for environmental noise. In line with the definition accepted by KOMPALA (2011), the method of studying noise in the environment is based on a repeatable manner of action, based on the conscious application of rules of disciplined behavior, due to the probability of achieving the desired aim under the given circumstances.

In order to obtain the proper result of the assessment of noise nuisance, it is beneficial to apply a few study methods. Depending on the function and characteristics of the terrain, how the plot of land is developed, the complexity of the occurring noise phenomena, and the availability of source materials (here: noise maps included in SNM resources), the authors propose that the full assessment of the noise nuisance of the surroundings result from the following study methods (Figure 1):

- 1) Objective methods, which include: the measurement method and the method of analyzing source documentation,
- 2) Subjective methods, which include: the method of noise indicator correction, based on source data from SNMs, accounting for the correction of noise resulting from the social assessment of exposure to noise and the method of interview.

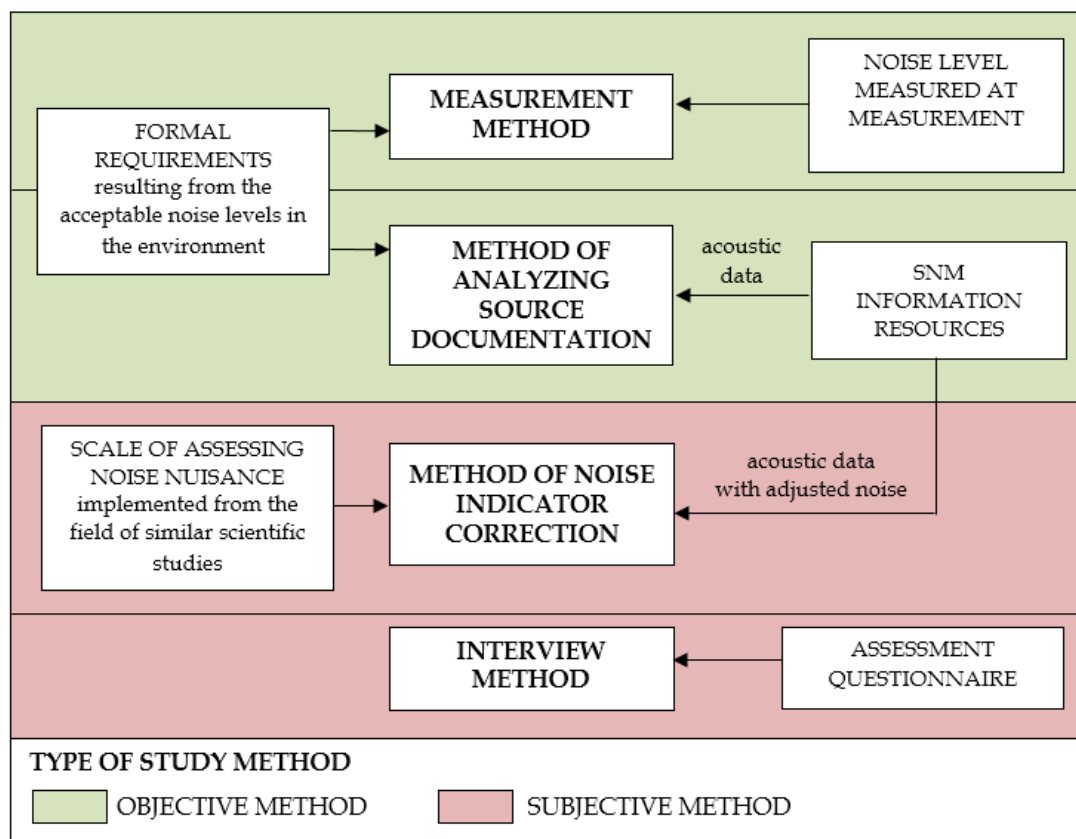


Fig. 1. Classification of study methods for the complete assessment of the noise nuisance of real estate surroundings. *Source:* authors' own elaboration.

3.1. Objective methods in the assessment of noise nuisance

Upon carrying out the assessment of the noise nuisance of real estate surroundings, it is recommended that two methods of an objective nature be used. The first is the method of measurement, the aim of which is to assess noise nuisance by taking direct noise measurements using a sonometer, measuring

the level of noise in decibels. The second method is the method of analyzing source documentation, which is based on noise data contained in strategic noise map resources.

3.1.1. Method of measurement

Under the assumption that the analyzed sound travels through open space, in which disturbances in the propagation of the acoustic wave do not take place as a result of changes in the level of terrain or the occurrence of natural or artificial noise barriers (e.g. building structures), the method of measurement most precisely reflects the acoustic climate of the surroundings. A sound-measuring device (sonometer) is needed to carry out such analyses, making it possible to take the measurement of the equivalent sound level in type A frequency correction, used to measure environmental noise. Moreover, preparing the assessment of noise nuisance using the method of measurement requires qualified personnel who will carry out a direct acoustic measurement for the indicated noise source in a proper manner, with an understanding of the law and normative methodology. The method is costly and time-consuming. As a result of the above, the authors propose applying it only in specific cases, resulting from the specification of the problem and complexity of noise emitters.

The results of acoustic measurements in the form of noise level measured in decibels ought to be referred to formal requirements regarding the acceptable noise levels in the environment (REGULATION OF 1 OCTOBER 2012...). They will become the basis for assessing the noise nuisance of the surroundings, where meeting or failing to meet the above requirements will result in the occurrence of two states of noise impact, i.e.:

- 1) A positive state (meeting the formal requirements) – lack of nuisance,
- 2) A negative state (failing to meet the formal requirements) – occurrence of a nuisance.

This method is a well-known and widely-applied method of assessing acoustic climate.

3.1.2. Method of source documentation analysis

Due to the fact that carrying out the assessment of noise nuisance by means of the method of measurement requires specialized knowledge regarding direct field measurements as well as using expensive measuring devices, the authors propose applying another generally available method of analysis of an objective nature. This is the method of analyzing source documentation, the basis of which are acoustic data derived from strategic noise map (SNM) resources for a given city. At this point, it ought to be highlighted that using the above method is possible only when the area possesses an SNM.

MURPHY and KING (2010) defined four key problems which are of particular importance in assessing and managing the noise level in the environment, i.e.: preparing strategic noise maps, estimating the number of people exposed to noise levels exceeding the norm, creating protection plans, and spreading information on the harmful effects of noise and the amount of its emission into the environment. The strategic noise map, accordingly to the specifications of Directive 2002/49/WE, is the main instrument of tackling noise in urbanized areas (DIRECTIVE 2002...). According to the definition contained in the above-mentioned directive, a SNM is an averaged map of noise emitted into the environment by various groups of sources, making it possible to comprehensively assess the level of noise pollution within the area of a given city, the possibility of determining the reasons behind such a state, and the possibility of realizing general noise change forecasts. A SNM is a part of all key areas of the noise protection policy (KOMPALA, 2011; KWIECIEŃ, SZOPIŃSKA, 2013; MURPHY, KING, 2010) and may serve as a basic and objective source of information on the acoustic climate of the area (LEE, CHANG, PARK, 2008).

Assessing the noise nuisance of the surroundings on the basis of SNM resources covers the analysis of data presented on noise maps, which were obtained on the basis of measurements of parameters describing noise as well as their so-called evaluation, which is based on carrying out calculations according to an accepted algorithm, along with their assessment. In connection with this, the presented method is of a measurement and computational nature, and when accounting for formal requirements, serves as the basis for assessing the noise nuisance of a given real estate. The assessment ought to be carried out on the basis of long-term indicators² for all groups of noise sources, which are

²L_{DEN} – long-term, medium level of noise (dB) determined for all days throughout the year, accounting for: daytime (from 6:00 am to 6 pm), evening hours (from 6 pm to 10 pm) and nighttime (from 10 pm to 6 am), L_N –

presented in the form of digital noise maps (ACT OF 2001...). It is worth highlighting here that noise data presented on emission maps ought to be used in the described method. The results of the analyses then ought to be referred to the formal requirements resulting from the acceptable noise levels in the environment specified by the legislator. New law provisions (REGULATION OF 1 OCTOBER 2012...) introduced more liberal norms in Poland, the level of which is dependent on the type of terrain as well as the source of noise, and ranges from 50-70 dB during the daytime and 45-65 at night. When carrying out the assessment of noise nuisance using the SNM system, formal requirements set for the real estate surroundings lead to distinguishing two states of noise impact, the range of which was specifically described when discussing the method of measurement.

Depending on the study subject, the above assessment can be carried out for all groups of sources of environmental noise, as well as various noise indicators which will enable the comprehensive analysis of the acoustic climate of the area and make it possible to indicate whether the surroundings meet or fail to meet formal requirements. The decision regarding the noise indicator, as well as the choice of the source of noise should be made by the researcher preparing the assessment, and depend on the subject and aim of the assessment, the function of the terrain and type of development, and the characteristics of the individual groups of noise sources. In cases when it is not possible to access an SNM, carrying out the assessment of noise nuisance will be possible using only the measurement and interview methods.

3.2. Subjective methods in noise nuisance assessment

Formal requirements, i.e. acceptable noise levels in the environment determined by the lawmaker, refer only to the objective scope of noise, which foresees two states for the assessment of noise nuisance. The surroundings either meet or fail to meet the requirements. The harmful effect of noise, however, is a more complex problem, as it regards all aspects of life, therefore meeting or failing to meet formal requirements does not provide complete information on the acoustic quality of the terrain, especially when analyzing the constantly changing legal situation regarding the acceptable noise levels in the environment (NURZYŃSKI, 2013, pp. 46-47). As a result of the above, when carrying out the assessment of the noise nuisance of the real estate surroundings, especially for buildings characterized by high sensitivity to noise (among others, residential real estate), it is particularly important to carry out an assessment which also accounts for the subjective scope of noise. The importance of this problem results from the necessity of reflecting the behaviors of real estate market participants, e.g. buyers, in market value. This can be done using the method of noise indicators, which is based on acoustic data from SNMs, corrected by values resulting from the social assessment of the level of exposure to noise.

The second method, which does not require the availability of an SNM, is the method of direct interview. It is based on a simple standardized interview carried out among the inhabitants of the analyzed area using a questionnaire aimed at obtaining information regarding individual perceptions as to the nuisance of sound phenomena.

The subjective sensitivity to noise depends on the physiological predispositions of each person, thus including real estate market participants, and the characteristics of sound. Specific sounds can induce positive feelings, as well as constitute a nuisance. The type of effect depends on the age of the person, gender or mental condition. Moreover, the nuisance of noise increases when it occurs unexpectedly, and from an unknown source. Analyzing the degree in which noise affects the human body, LIPOWCZAN (2001) distinguished four categories:

- 1) range of discomfort – the state is commonly described as silence resulting in ringing in the ears; when affecting people for a long period, especially those living alone, it can lead to the feeling of isolation (level ranging from 0 to 20 dB),
- 2) range of comfort – regeneration processes are initiated in the organism. This range covers the sounds of nature (level ranging from 20 to approx. 55 dB),
- 3) range of exposure risk – the organism begins to initiate a defense mechanism. People subjected to the noise begin to experience its negative impact. Certain acceptable values fall in this range (level ranging from approx. 55 to 85 dB),

long-term medium level of noise (dB), determined for all nighttime hours throughout the year (from 10 pm to 6 am) (DIRECTIVE 2002...).

- 4) range of exposure danger – upper value of noise level described as the threshold point (level ranging from approx. 85 to 120-135 dB).

3.2.1. Method of noise indicator correction

Depending on the type of noise source, a given sound can be subjectively assessed differently (more mildly or severely) than the result presented on the noise maps. On the basis of studies (POSITION PAPER 2002...) prepared within the scope of works regarding the social assessment of the level of exposure to noise, air traffic noise is subjectively assessed 5-6 dB higher than noise resulting from road traffic, whereas train traffic – 5-7 dB milder. In connection with the above, when assessing noise nuisance by method of noise indicator correction, it is suggested that the approximate correction of acoustic data obtained from SNMs, proposed by NURZYŃSKI (2013 p. 29), be used in the following way:

- 1) for areas under the influence of air traffic noise – correction at the level of +5 dB in relation to noise data from the SNM,
- 2) for areas under the influence of rail traffic noise – correction at the level of -5 dB in relation to noise data from the SNM,
- 3) for areas under the influence of road traffic noise – correction at the level of 0 dB (noise data in the indirect method coincide with values presented in the SNM).

In analyses carried out using the method of noise indicator correction, the corrected noise data from emission maps ought to be referred to the evaluation scale of acoustic comfort proposed by the National Institute of Hygiene (KUCHARSKI, 2005):

- 1) low noise nuisance (value under 50 dB) – full acoustic comfort,
- 2) medium noise nuisance (value between 50-60 dB) – average acoustic conditions,
- 3) high noise nuisance (value between 60-70 dB) – average risk of exposure to noise,
- 4) very high noise nuisance (value above 70 dB) – high risk of exposure to noise.

In the described method, we obtain a positive result of the assessment (lack of nuisance – state of positive noise impact) when the corrected noise data expressed in decibels fall within the first two ranges of the above-presented evaluation scale, i.e. small or medium nuisance accounting for the degree in which noise affects the human organism proposed by LIPOWCZANA (2001). A negative result (the occurrence of a nuisance – state of negative noise impact) is obtained when the corrected data fall within the ranges of high and very high noise nuisance.

The method of noise indicator correction is an innovative proposition put forth by the authors of the work, based on the compilation of earlier-known methods and making use of study results from other fields of science.

3.2.2. Method of interview

The correction of noise data applied in the method of noise indicator correction is a kind of simplification, which can influence the credibility of the obtained results. For purposes of verification, it is suggested that the method of direct interview be introduced to the assessment of noise nuisance; the purpose of such an interview is to determine the individual perceptions of the annoyance of sound phenomena among the residents of the analyzed area. The measurement tool in this method is a standardized questionnaire with scaled answers (KACZMARCZYK, 2003, p. 204); it is suggested that its closed-end questions be prepared accounting for the following four-level evaluation scale of noise nuisance: low, medium, high and very high.

The area from which respondents are selected ought to account for the fragment of terrain from which, accordingly to SNM data, a similar spatial distribution of zones within the reach of noise was noted. The scope of the study carried out ought to result from a preliminary field assessment and depend on: the availability of planning documents, land use, dominant land function on which the analyzed real estate is located and identification and characterization of individual groups of noise sources.

It is mandatory that the questionnaire be divided into three parts. In the first part, respondents ought to express a general view on the topic of the acoustic climate of the surroundings. In the second part, they should determine the individual degree of noise nuisance for the listed noise source groups. The number of groups and their differentiation depends on the results of the site inspection carried out earlier. The last part of the questionnaire is a data sheet containing information about the respondents.

In the interview method, a positive result of the assessment (lack of nuisance, i.e. state of positive noise impact) is obtained when the respondents, through their answers accounting for the four-level grading scale, determine the noise nuisance to be low or medium. A negative result (the occurrence of a nuisance, i.e. a state of negative noise impact) is obtained when the respondents indicate answers at a high or very high level. Results obtained in such a way will be the basis for assessing the noise nuisance of the analyzed area.

For the final result of the complete assessment of the noise nuisance of the surroundings, it is very beneficial to simultaneously apply all of the presented study methods. In this way, we can obtain a comprehensive and reliable image of the problem, at the same time avoiding the danger of one-sidedness. It seems reasonable that the proposed criteria of assessment, for objective as well as subjective methods, can and ought to be used by property valuers in the process of valuation.

4. Example of assessing the noise nuisance of residential real estate surroundings using selected study methods

4.1. Study area

A residential real estate located in Bydgoszcz on Władysława Bełzy 49a (district No. 473, land property No. 6, area of the land parcel: 0.0524 ha), built-up with a single-family, two-storey house was selected for the studies. The chosen real estate is located in the south part of the city of Bydgoszcz, in the Wyżyny housing estate.

When determining the acoustic climate, we ought to take into account not only the sources of noise located in the direct vicinity of the analyzed area but also noise derived from neighboring areas³ creating the surroundings of the selected real estate. Upon carrying out a field inspection of the area on 12 December 2014, the terrain was determined to be flat, containing single-family housing development, with three pieces of real estate built-up with single- or two-storey houses. Moreover, it was determined that the noise in the analyzed area is generated by the following sources: road traffic noise from Władysława Bełzy Street, rail traffic noise generated by the tram lines No. 2, 4, 7, 8 and 9, and noise generated by the inhabitants themselves. As a result of the above, an area of land with a total surface of 0.1833 ha, co-created by two properties neighboring the selected land real estate (plot of land No. 9 with a surface area of 0.0777 ha and plot of land No. 3 with a surface area of 0.0532 ha), was accepted as the surroundings of the selected real estate. Due to the location of the noise emitters, the eastern and western border of the terrain are created by line emitters of noise, i.e. Władysława Bełzy street to the west and two tram lines to the east.

4.2. Assessment of noise nuisance using the method of source documentation analysis and method of noise indicator correction

Due to the fact that the road traffic on Władysława Bełzy Street does not result in exceeding noise levels on maps of the SNM emission system, the assessment of noise nuisance of the surroundings was carried out for tram noise. This noise is generated by tram traffic on two lines located at a distance of 70 m east of the selected real estate. The rail lines have a traditional surface of 180 S rails (Ri60) with welded connections. A total of 556 trams (on workdays) and 342 (on weekends and holidays) use these rail lines, with the speed limit being 20 km/h.

Data presented in maps contained in the SNM of the city of Bydgoszcz (STRATEGIC NOISE MAP OF BYDGOSZCZ, 2013) were used to assess noise nuisance. In particular, data contained in the long-term emission map of a medium level of noise of the L_{DEN} indicator for tram noise (Figure 2a) was used, as well as data presented on the map of excessive tram noise of the L_{DEN} indicator (Figure 2b). On the emission map, the areas within reach of the noise, thus the area in which the value of the long-term medium level of noise falls between two predetermined levels, e.g. 50-55 dB were presented graphically. The map of excessive noise levels was created for areas of sensitivity, and their acceptable noise levels based on noise data presented in emission maps.

³Neighboring land ought to account for a fragment of space for which, in accordance with data from the SNM, a similar spatial distribution of areas reached by noise was noted, and should also result from preliminary site inspection and depend on the location and characteristics of individual sources of noise and manner of land development.

In accordance with data presented in SNM maps, the selected residential real estate is located in an area subjected to tram noise exposure at a level of 60-75 dB, with the eastern part of the real estate, in the direct neighborhood of the tram lines, subjected to noise in the range of 70-75 dB (Figure 2a). Along with an increase in the distance from the rail lines, the level of noise decreases, ultimately reaching levels in the 60-65 dB range in the western part of the real estate. Analyzing the formal requirements determined by legal regulations (REGULATION OF 1 OCTOBER 2012...) as well as noise data found on maps of excessive levels of tram noise for the L_{DEN} indicator, it can be stated that the analyzed real estate on Władysława Belzy 49a is partially at risk of excessive levels of tram noise - exceeded by 5 dB (Figure 2b), and **the assessment of the noise nuisance of the surroundings carried out on the basis of SNM data can be negative or positive. At the same time, the analysis of source documentation did not provide a complete determination of the acoustic climate.**

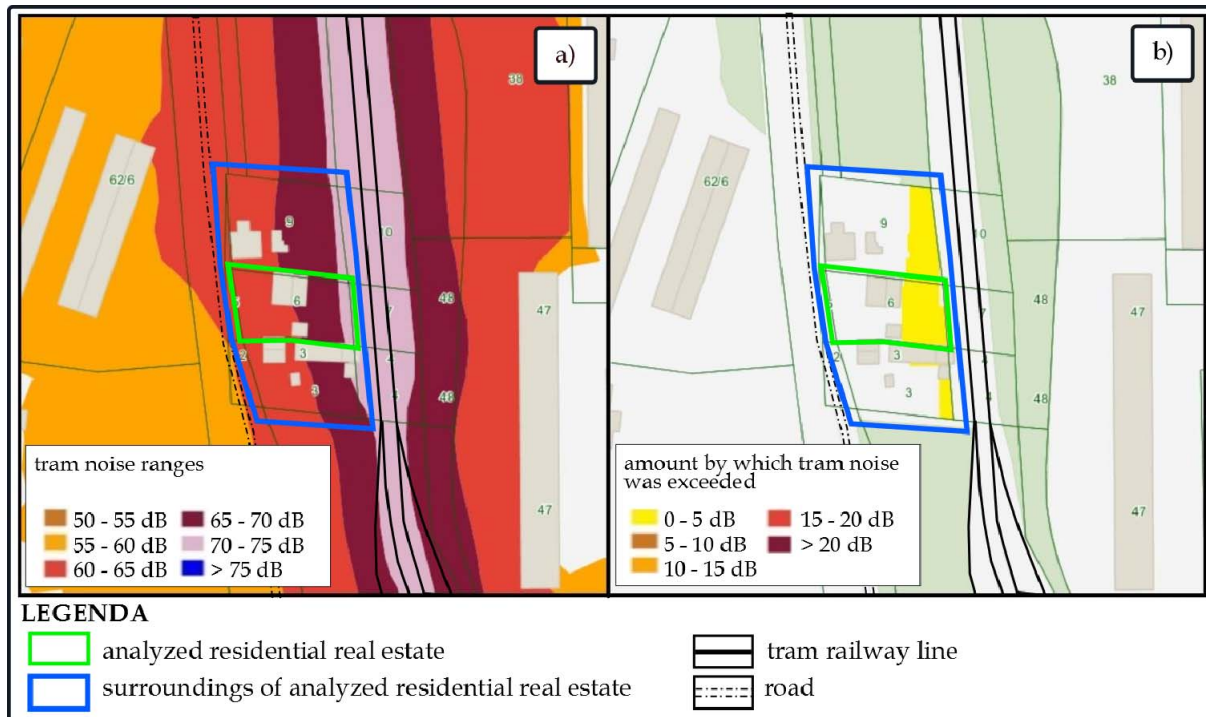


Fig. 2. Noise map of tram noise levels: a) emission map for L_{DEN} indicator, b) degree in which values for the L_{DEN} indicator are exceeded *Source:* own elaboration on the basis of the SNM of the city of Bydgoszcz.

As a result of the above, the noise indicator method was included in the assessment of noise nuisance. For this purpose, eight control points were appointed in the surroundings of the indicated real estate. Six of them were distributed along the border of the study area, which was aimed at identifying the acoustic climate of the surroundings. Due to the subject of the studies, the following two points were situated near the single-family house on the analyzed plot of land. These points were located 2m from walls containing openings (eastern elevation - point P7, western elevation - point P8). The location of all control points stemmed from the manner in which the area was developed and the characteristics of the noise source. The value of the long-term level of tram noise was taken from the emission map included in the SNM, confirming that the surroundings of the eastern part of the selected real estate pose a noise nuisance. This is confirmed by Figure 3, where the formal requirements were not met for control points: P1, P2, P3 and P7.

Next, the decibel values obtained at the control points were corrected by data resulting from the social assessment of the degree of exposure to noise (POSITION PAPER 2002...). A correction of data at a level of -5dB was accounted for in the studies. By doing so, in the method of noise indicator correction, corrected decibel values calculated for the L_{DEN} indicator were accepted for further analysis, the location of which coincides with the control points presented on the tram traffic noise emission map (Figure 3). Analyzing the adjusted levels of tram noise for the selected points, the surroundings of the indicated real estate cause a high nuisance of tram noise in its eastern part. This is confirmed by data

compiled in Table 1, in which the corrected levels obtained at control points P1, P2 and P3 indicate medium noise pollution. In the remaining areas of the analyzed real estate (including control points located on the elevation of the single family building), a medium level of tram noise nuisance was noted, which results in average acoustic conditions.

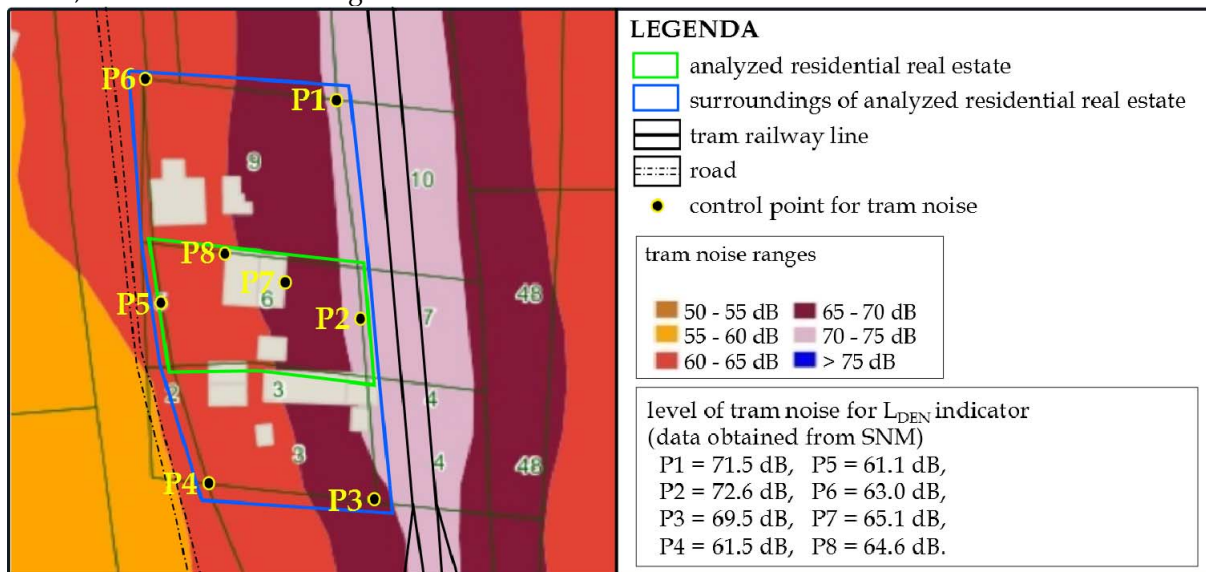


Fig. 3. Location of control points for daily tram noise in the surroundings of the selected residential real estate. *Source:* own elaboration based on SNM of the city of Bydgoszcz.

Table 1

Results of the assessment of noise nuisance of the surroundings for tram noise by means of the method of noise indicator correction for residential real estate on Władysława Bełzy 49a in Bydgoszcz.

Control Point	Noise level from SNM [dB]	Corrected noise level*) [dB]	Scale of assessing noise nuisance implemented from the field of similar scientific studies	
			Noise nuisance	Acoustic comfort
P1	71.5	66.5	high	average noise pollution
P2	72.6	67.6	high	average noise pollution
P3	69.5	64.5	high	average noise pollution
P4	61.5	56.5	medium	average acoustic conditions
P5	61.1	56.1	medium	average acoustic conditions
P6	63.0	58.0	medium	average acoustic conditions
P7	65.0	60.0	medium	average acoustic conditions
P8	64.6	59.6	medium	average acoustic conditions

Source: own elaboration.

On the basis of corrected tram noise levels (Table 1) of the generated GIS data base using the Geomedia Professional program and applying the CadnaA program for noise analysis, zones effected by tram noise were determined for the positive (medium noise nuisance) and negative state (high noise nuisance). The spatial distribution of the above states for the selected residential real estate has been presented in Figure 4.

Upon analyzing the spatial distribution of the obtained states of noise impact for daily tram noise (Figure 4), it was confirmed that the assessment of the noise nuisance for the surroundings of the selected residential real estate by means of the method of noise indicator correction led to a positive result, as only the frontal part of the real estate, outside of the area occupied by housing, was within the state of negative noise impact. In the control points located near the single-family house (eastern elevation – point P7, western elevation – point P8), a positive state of noise impact was obtained. Thus,

the final assessment of the noise nuisance of the surroundings of the real estate located on Władysława Bezy 49a in Bydgoszcz also ultimately led to a positive result (Table 2). In the above method, social perceptions were included in the noise assessment procedure as an element of real estate market participants' assessment.

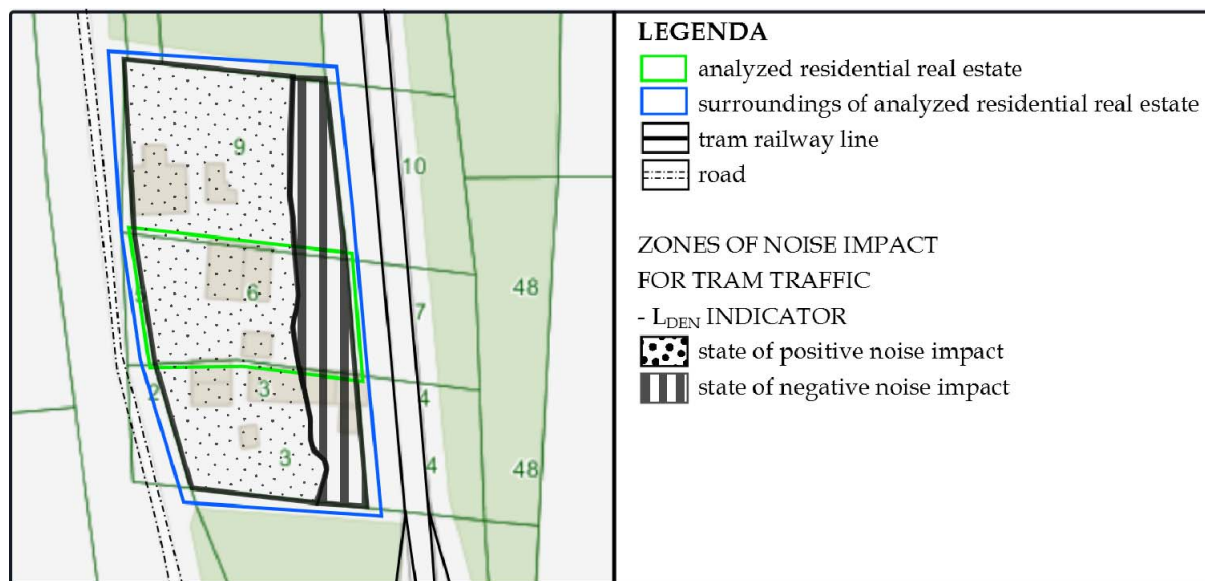


Fig. 4. Assessment of noise nuisance of the surroundings for selected residential real estate for all-day tram traffic noise using the method of noise indicator correction. Source: own elaboration.

Table 2

Results of the complete assessment of noise nuisance for the surroundings of a single family house located on Władysława Bezy 49a in Bydgoszcz

Type of study method	Control point	State of noise impact	Result of assessment
Method of source documentation analysis	P7	positive	lack of unanimous assessment
	P8	negative	
Method of noise indicator correction	P7	positive	positive
	P8	positive	
FULL ASSESMENT OF NOISE NUISANCE			POSITIVE

Source: own elaboration.

5. Summary

In order to carry out a complete assessment of noise nuisance of the real estate surroundings, four study methods were presented in the work: two of an objective nature, including the method of source documentation analysis and method of measurement, as well as two subjective ones, including the method of noise indicator correction and the interview method. Their application is dependent on the availability of source materials. In cities for which a strategic noise map (SNM) was prepared, all four of the methods of assessment can be used. In the case of areas which do not possess an SNM, it is possible to carry out the assessment of noise nuisance using only the methods of measurement and interview.

The work also presented an example which confirmed the possibility of applying various methods of assessing the noise nuisance of real estate surroundings. The carried out analysis indicated that an assessment made only on the basis of SNM data and formal requirements can differ from an assessment which also accounts for the subjective perceptions of real estate market participants. As an effect, depending on the results of studies obtained using the individual methods, the degree to which they vary, the specifics of the terrain, and the researcher's (assessor's) level of knowledge, a final assessment should be made and rationalized. It ought to be emphasized that formal requirements

regarding meeting noise conditions in Polish and European legislation are changing (are currently more liberal than in the past), and do not always reflect the actual state of the noise nuisance in real estate surroundings – the perceptions of people do not change in parallel to the provisions of the law.

The method of noise indicator correction is a novel proposition put forth by the authors of the work, based on a complication of earlier-known methods, and employing the results of studies taken from other fields of science, possible to apply in the field of real estate management. Using this method, one can carry out the assessment at hand accounting for the perceptions and preferences of market participants, which is the basis for shaping market value.

Methods of the complete assessment of the noise nuisance of the surroundings can improve the efficiency of the activities of property valuers and other professions connected with the real estate market: real estate agents and managers. The results of the analyses can be used to aid decision-making processes of developers, shape their awareness in terms of the expectations and preferences of real estate buyers, and allow the market offer and strategy to be developed more accurately. The full assessment of the noise nuisance of the surroundings, in addition to comparative analyses, can also prove to be useful in the process of analyzing the optimal method of using the real estate in which, as indicated by ŻRÓBEK (2011), the first stage is assessing the legal conditions, including those connected with environmental protection.

6. References

- BLANCO J. C., FLINDELL I., 2011, *Property Prices in Urban Areas Affected by Road Traffic Noise*, *Applied Acoustics*, 72(4), pp. 133-141.
- BRANDT S., MAENNIG W., 2011, *Road Noise Exposure and Residential Property Prices: Evidence from Hamburg*, *Transportation Research Part D: Transport and Environment*, 16(1), pp. 23-30.
- Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise – Official Journal of the European Communities L 189 of 18 July 2002.
- CELLMER R., 2011, *Spatial Analysis of the Effect of Noise on the Prices and Value of Residential Real Estates*, *Geomatics and Environmental Engineering*, Vol. 5, No. 4, pp. 13-28.
- EEA 2010, European Environment Agency Technical Report No 11/2010 EEA. Good practice guide on noise exposure and potential health effects, <http://www.eea.europa.eu/publications/good-practice-guide-on-noise>, (access: October 2014).
- GNAT S., BAS M., 2014, *Badanie wpływu emisji hałasu komunikacyjnego na ceny lokali mieszkalnych (Studying the Impact of Traffic Noise Immission on the Prices of Dwellings)*, [in:] *Market Analysis and Management of Real Estate*, [ed.] S. Żróbek, *Journal of the Polish Real Estate Scientific Society*, pp. 71-84.
- KACZMARCZYK S., 2003, *Badania marketingowe. Metody i techniki (Marketing Research. Methods and Techniques)*, Polish Economic Publishing House, Warsaw, p. 203.
- KOMPAŁA J., 2011, *A System for Management of Urbanized Areas in the Aspect of Acoustic Effects*, *Archives of Acoustics*, 36(1), pp. 57-63.
- KRAJEWSKA M., SZOPIŃSKA K., 2014, *Hałas środowiskowy jako element oceny lokalizacji nieruchomości mieszkaniowych (Environmental Noise as Part of the Assessment of Residential Property Location)*, *Bulletin SRMWW 3/2014 (41)*, pp. 23-29.
- KUCHARSKI R.J., 2005, *Hałas uliczny w Warszawie. Wielkość ekspozycji i możliwości ochrony przed jego wpływem. Transport publiczny w Warszawie kluczem harmonijnego rozwoju stolicy Polski (Traffic Noise in Warsaw. Level of Exposure and Possibilities of Protection Against its Impact. Public Transport in Warsaw as the Key to the Harmonious Development of the Polish Capital)*, *International Conference and Exhibition*. Ed. The City of Warsaw. Warsaw, pp. 253-275.
- KWIECIEŃ J., SZOPIŃSKA K., 2013, *Implementation of the EU Noise Directive in Process of Urban Planning in Poland*, *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XL-4/W1.
- LEE S. W., CHANG S. I., PARK Y. M., 2008, *Utilizing Noise Mapping for Environmental Impact Assessment in a Downtown Redevelopment Area of Seoul, Korea*, *Applied Acoustics*, 69(8), pp. 704-714.
- LIPOWCZAN A., 2001, *Podstawy normalizacji hałasu w środowisku (Normalization Basics of Environmental Noise)*, *Aura*, 9, pp. 17-18.

- MURPHY E., KING E.A., 2010, *Strategic Environmental Noise Mapping: Methodological Issues Concerning the Implementation of the EU Environmental Noise Directive and Their Policy Implications*, *Environment International*, 36(3), pp. 290-298.
- NURZYŃSKI J., 2013, *Ochrona przed hałasem w zrównoważonym budownictwie (Sustainable Building and the Protection Against Noise)*, Building Research Institute, Warsaw, pp. 29-47.
- Position paper on dose response relationships between transportation noise and annoyance. European Commission, Office for Official Publications of the European Communities, 2002.
- Rozporządzenie Ministra Środowiska z dnia 14 czerwca 2007 r. w sprawie dopuszczalnych poziomów hałasu w środowisku, Dz. U. Nr 120/2007, poz. 826 (Regulation by the Minister of Environment of 14 June 2007 on the permissible noise levels in the environment, *Journal of Laws*, 2007, No. 120, item 826).
- Rozporządzenie Ministra Środowiska z dnia 1 października 2012 r. zmieniające rozporządzenie w sprawie dopuszczalnych poziomów hałasu w środowisku, Dz. U. Nr 0/2012, poz. 1109 (Regulation by the Minister of Environment of 1 October 2012 amending the regulation on permissible noise levels in the environment, *Journal of Laws*, 2012, No. 0, item 1109).
- Strategic Noise Map of Bydgoszcz, 2013, Town Office in Bydgoszcz, Bydgoszcz.
- SZCZEPAŃSKA A., SENETRA A., WASILEWICZ-PSZCZÓŁKOWSKA M., 2015, *The Effect of Road Traffic Noise on the Prices of Residential Property – a Case Study of the Polish City of Olsztyn*, *Transportation Research Part D: Transport and Environment* 36 (2015): 167-177.
- SZOPIŃSKA K., KRAJEWSKA M., 2013, *Prices of Apartments in Relation to Noise Level in Poland*, [in:] *Journal of Civil Engineering and Architecture*, Vol. 7, No. 10, pp.1189-1195.
- Ustawa z dnia 27 kwietnia 2001 r. Prawo Ochrony Środowiska, Tekst jedn. Dz. U. Nr 25/2008, poz. 150, z późn. zm. (Act of 27 April 2001 on the Environment Protection Law, *Journal of Laws*, 2008, No. 25, item 150, as amended).
- ŻRÓBEK S., 2011, *Sposób optymalnego użytkowania nieruchomości – ujęcie definicyjne i metodyczne (The Highest and Best Use of Real Estate – Definition and Methodological Approach)*, *Journal of the Polish Real Estate Scientific Society*, Vol. 19, No. 1, pp. 19-26.