

STUDIES AND ASSESSMENT OF TRANSPORT NOISE IN POZNAŃ

Małgorzata Orczyk¹, Franciszek Tomaszewski²

Poznań University of Technology, Institute of Combustion Engines and Transport,
Poznań, Poland

¹e-mail: malgorzata.orczyk@put.poznan.pl

²e-mail: franciszek.tomaszewski@put.poznan.pl

Abstract: *In many cities in Poland, because of the lack of ring roads, the main traffic routes of state roads go through the cities affecting local and regional traffic. This causes high traffic and also many undesired effects for inhabitants such as environmental pollution with fumes, vibrations of buildings, high level of noise and increase of accidents.*

This article presents results of measurements of volume of traffic and noise level in selected traffic routes in Poznań. For the research the sections of roads and crossings that belong to state roads and important urban roads of Poznań were selected. The research was conducted according to recommendations included in the regulation of the Minister of the Environment of 16 June 2011 on requirements for conducting measurements of the levels of substances or energy in the environment by administrators of road, railway, tram line, airport or sea port.

In most of the streets of Poznań, where measurements were made, registered equivalent sound levels exceed permissible levels defined in the regulation of the Ministry of the Environment about permissible noise levels in the environment. Equivalent sound levels registered at defined measurement points show values in scope between 53 and 78 dB.

Key words: *noise, traffic volume, vehicles*

1. Introduction

The number of noise sources and the intensity of noise they generate have increased steadily in recent years. As a result, the acoustic environment has become unfavourable. Maximum permissible noise levels are exceeded in the majority of locations, and the mental and physical limits of human endurance are being put to the test. Consequently, there is growing awareness of the need to eliminate noise as a threat to people's well-being. Noise exposure has an adverse effect on people's auditory system and central nervous system. It may impair the hearing ability or even result in hearing loss. One of the most serious types of auditory nuisance nowadays is noise generated by means of transport which, in the majority of cases, exceeds maximum permissible levels set out in environmental standards and regulations (Campbell, 2001; Nader, 2006).

In 2012, the Minister of Environment introduced new standards applicable to 24-hour and long-term traffic noise (PME, 2012). The new regulations provide that residents of large cities are expected to tolerate noise exposure of up to 70 dB during the

day and 65 dB at night. These limits, which are legally in place in Poland, are much higher than the recommendations issued by the World Health Organization (WHO). According to the WHO, exposure to noise levels above 55 dB has an adverse impact on human health, resulting in fatigue, irritability, headaches, stomach aches and muscular pain (Czechyra & Tomaszewski, 2008).

The European Union recognized the problem a long time ago, and has been undertaking consistent efforts to reduce the level of noise of exposure. In order to prevent the negative effects of noise in urban agglomerations on the life of EU inhabitants, the EU has passed Directive 2002/49/EC relating to the assessment and management of environmental noise. The purpose of the Directive was to lay down a set of common rules to avoid, prevent and reduce harmful noise in urban agglomerations. Every EU member state was obligated to take definite steps to this aim, e.g. prepare noise maps and adopt noise-control programmes.

Between 20 August and 16 December 2013, the Supreme Audit Office conducted an inspection at the Ministry of Environment and the Chief

Inspectorate of Environmental Protection. The main aim was to review the period 2005-2013, but measures introduced prior to that timeframe were also assessed with a focus on the implementation of EU laws.

With respect to 2007-2013, the inspection concentrated on urban agglomerations with more than 250 thousand inhabitants, and for the years 2012-2013, the inspectors assessed cities having between 100 and 250 thousand inhabitants (taking into account public procurements awarded for the compilation of the first noise maps). The main aim of the inspection was to evaluate the progress in the implementation of tasks stemming from Directive 2002/49/EC, concerning protection of the environment against noise in large cities.

In the wake of the inspection, the Supreme Audit Office submitted a set of conclusions to the Minister of Environment, including the need to:

- assess whether maximum permissible sound levels had been defined correctly and, depending on the result of the assessment, take suitable action;
- determine to what degree the alleviation of requirements contributed to a change, as shown by noise maps, in the extent of areas in which maximum permissible noise levels are exceeded;
- establish and introduce a methodology for determining areas and populations that are exposed to noise for the purpose of preparing noise maps;
- consider an amendment to the Environmental Protection Law with a view to introducing instruments that would enforce applicable local government bodies to perform their obligations relating to the compilation of noise maps in a timely manner.

Since a number of Polish cities lack ring roads, the main traffic routes of Poland's national roads pass through cities, increasing local and regional traffic volumes. This trend results in high traffic intensity, which in turn triggers a number of unfavourable effects for city dwellers, such as (Johnson & Saunders, 1968):

- pollution of the environment with exhaust gases,
- vibrations in buildings induced by passing vehicles,
- high noise levels,
- damage to the road infrastructure,
- increase in the number of accidents involving pedestrians,

- traffic problems faced by inhabitants.

The study below presents results of traffic intensity and traffic noise measurements performed in selected traffic routes in Poznan city. The assessment involved road sections and intersections which are parts of national roads and other major city roads within the limits of the Poznan agglomeration.

2. Road structure in Poznan city

Poznan is a road junction dominated by five roads of national importance: no. 5 (Bydgoszcz – Poznan – Leszno – Wrocław – Lubawka), no. 11 (Kolobrzeg – Pila – Poznan – Ostrow Wlkp – Kluczbork – Bytom), no. 92 (Rzepin – Poznan – Konin – Kutno – Warsaw), A2 motorway and national road no. 32 which ends in Sęszew, a town situated near Poznan. A2 has the status of the European route E30, and the national road no. 5 – route E261. In addition, Poznan is the end-point for four regional roads: no. 184 (Przezmierowo – Poznan – Szamotuly – Wronki), no. 196 (Poznan – Koziegłowy – Murowana Goslina – Wagrowiec), no. 307 (Poznan – Buk – Opalenica – Bukowiec) and no. 430 (Poznan – Lubon – Puszczykowo – Mosina). Since 1 December 2011, Poznan has had a direct motorway connection with Western European countries, and since 6 June 2012 – also with the capital city of Warsaw. Fig. 1 illustrates the target layout of the Poznan road junction (Poznan City Council, 2008).

In 2012, two new express roads were put into service in the vicinity of Poznan, ending in the city section of the A2 motorway: two (out of three) parts of the Poznan Western Ring Road within the stretch of the S11 express road (from the “Poznan West” junction as far as the “Poznan Tarnowo Podgorne” and from the “Poznan Rokietnica” junction to the “Poznan North”), and the entire Poznan Eastern Ring Road within the stretch of the S5 express road (from the “Poznan East” junction as far as the “Gnieszno South” junction). After the completion of the projects referred to above the current course of the national roads 5 and 11 will be modified. Fig. 2 shows population increases (2015) in areas adjacent to the main transport routes in the Poznan agglomeration included in the scope of the present study (Poznan City Council, 2006).

In 2011, Poznan had around 551,600 inhabitants, however existing housing estates keep expanding,

and new estates are built. The current trend stems from several factors such as the growing wealth among the society, desire to escape from the cramped and congested city centre and lack of available land for housing developments in the inner parts of the city. Since 2006, Poznan has had a positive natural increase rate, mainly due to a rise in the number of births. At the end of December

2010, the rate of natural increase in Poznan was 0.8%. The only factor contributing to a decline in the population of Poznan inhabitants is migration. In 2010, the migration rate was 5.5%. The majority of people who migrated out of the city chose their new place of residence within the limits of the Poznan district (Poznan City Council, 2011).

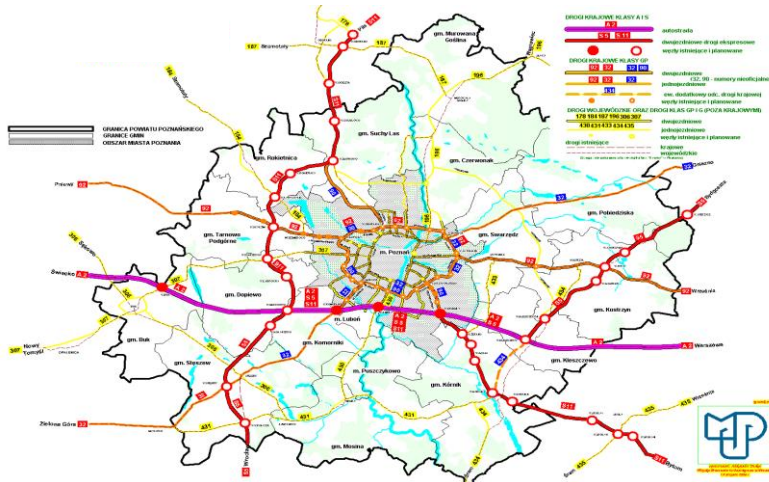


Fig. 1. Junction of national and regional roads around Poznan (target system)
 source: Poznan City Council (2008).

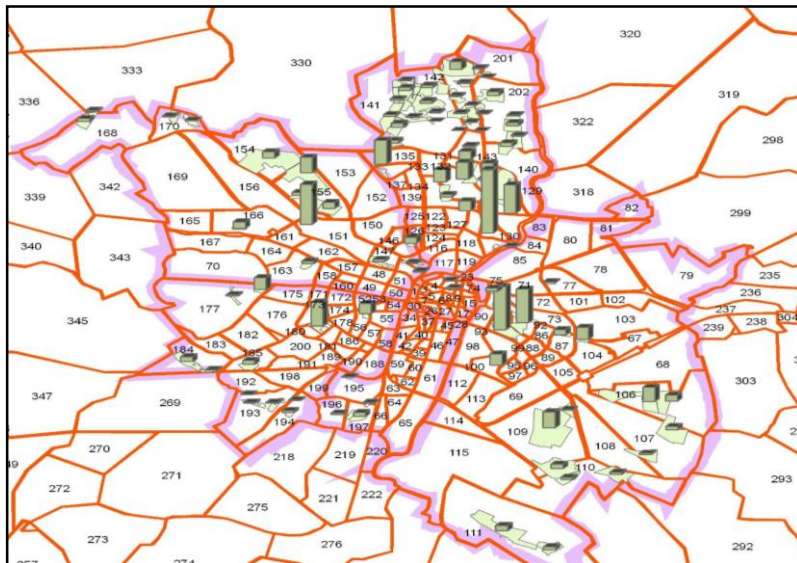


Fig. 2. Regions of urban population increases against the background of Poznan transport networks
 source: Poznan City Council, (2006).

The structure of the city's road system has a radial-ring pattern. It comprises road rings, referred to as "rings" for short, and outbound roads running radially from the city centre. The development of the city's urban structure involves three transport rings. At present, ring I and ring II exist in whole, and ring III only in fragments. Ring I runs at the shortest distance from the centre of Poznan and serves as the city's ring road. Ring II, where most of the transit activity and intra-city traffic take place, runs at the perimeter of the inner city, serving as its arbitrary boundary.

Ring III, which has not been completed yet, has been designed as a fast-traffic intra-city ring road, and it is expected to take over most of the traffic taking place between the city's district as well as heavy destination traffic. An element of the ring is a stretch of the A2 motorway between two intersections: Komorniki and Krzesiny. Fig. 3 shows a map of Poznan and its surroundings together with the main traffic system including rings II and III, and a section of the A2 motorway which is an element of ring III.

The motorway part of the Poznan ring road is a 13.3 km section within the course of the A2 motorway connecting Świecko and Kukuryki which is in the process of construction. The Poznan ring road, despite being a part of the toll A2 motorway, is available to users via Komorniki, Debina and Krzesiny intersections without any payment. It extends from 158+300 km (Komorniki intersection) to 171+300 km (Krzesiny intersection). The Poznan section of the A2 motorway cuts across the southern part of the Poznan agglomeration, areas lying in the Komorniki commune, the town of Lubon and Krzesiny.

The motorway section under study has been constructed for the most part in a deep trench (western and central parts) – along allotment gardens, single-family housing and multi-family residential development areas, but also on an embankment and at the level of the surrounding terrain – across the Debina drinking water intake and farmlands (central and eastern sections).

Since the road infrastructure in Poznan lacks a closed ring road outside the agglomeration (only fragments have been completed), a part of the transit traffic makes use of ring II, which should essentially only handle fast city traffic.

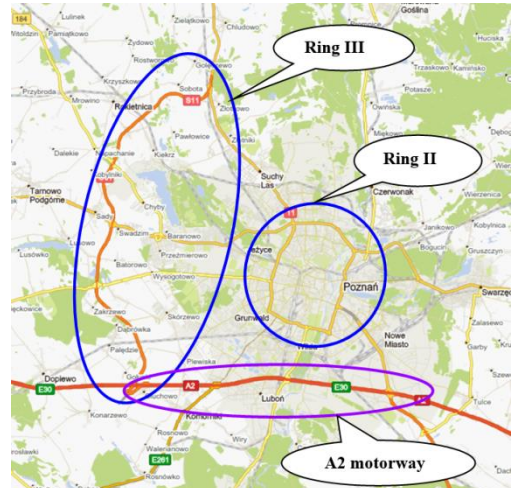


Fig. 3. Poznan transport system with ring II and ring III marked

source: based on a map available at Targeo.pl.

3. Methodology and scope of study

The study comprised measurements of traffic intensity and noise levels in selected traffic routes in Poznan, mainly within ring II (Fig. 3). The purpose of the study was to determine the intensity of vehicle traffic (local and transit) and its impact on the level of urban noise.

Noise measurements in selected transport routes within Poznan city were conducted in compliance with guidelines set out in the Regulation of the Minister of Environment of 16 June 2012 on requirements applicable to measurements of substance or energy levels in the environment conducted by road, railway line, tram line, airport or port operators. The Regulation lays down the methodology that should be adopted for measurements of noise in the environment which is related to the operation of means of land, waterborne and airborne transport.

Noise generated by means of land transport can be measured by using methods listed below:

- continuous recording of noise generated by road traffic, applicable to uninterrupted measurements of noise levels performed for several hours or days, during the reference period T , in a defined measurement point,

- measurements of sound exposure levels with respect to isolated acoustic events,
- measurements of levels of noise induced in the environment by road traffic performed by sampling,
- calculation method based on models of sound propagation in the environment.

The noise measurements carried out for the purpose of the study were based on the sampling method. Before selecting periods for performing noise measurements, the intensity of traffic in the studied sections of transport routes was assessed. Data for the assessment were provided by the Municipal Roads Authority in Poznan and own measurements of traffic intensity along the A2 motorway (Poznan ring road section). Noise measurements were carried out at a distance of 0.5-2 m from buildings and 1.5 m from the roadway, at a height of 4 m above the land level. The results obtained in the measurements were compared with maximum permissible levels set out in the Regulation of the Ministry of Environment of 1 June 2007 on permissible noise levels in the environment (PME, 2007).

Representative measurement periods were selected on the basis of an analysis of vehicle traffic intensity noted in roads forming a part of ring II and in a section of the A2 motorway. Based on these data, the mean traffic intensity was determined for every hour during a 24-h period, for working days (i.e. between Monday and Friday). With the aid of monthly traffic intensity data

obtained from the Municipal Roads Authority in Poznan, a 24-h empirical distribution of vehicle traffic intensity was determined. On that basis, the grouping of hours was performed. Traffic intensity data are collected by the Municipal Roads Authority in Poznan via automatic vehicle counters installed in the roadways. The counters record traffic intensity for every hour over a 24-h period separately for every road lane. The hours included in respective measurement periods were selected following the grouping of hours during which vehicle traffic intensity did not differ by more than 10% from the maximum traffic intensity recorded in a given street. Fig. 4 presents results of traffic intensity measurements in Warszawska Street, and Fig. 5 – measurements performed in Lechicka Street, with measurement periods marked. Fig. 6 shows the intensity of vehicle traffic in the city's ring road – A2 section between Komorniki and Debina.

Noise measurements were performed using a type 2250 sound level meter from Brüel & Kjær. It is an advanced single-channel sound measuring instrument for performing high-precision class 1 measurement tasks. The analyzer complies with all international and national standards applicable to sound level measurements. Based on two detectors of effective and peak values, the meter makes it possible to conduct measurements using various frequency corrections A, B, C or Z, and time constants of "F" (Fast=125 ms), "S" (Slow=1 s) and "I" (Impulse=1.5÷35 ms).

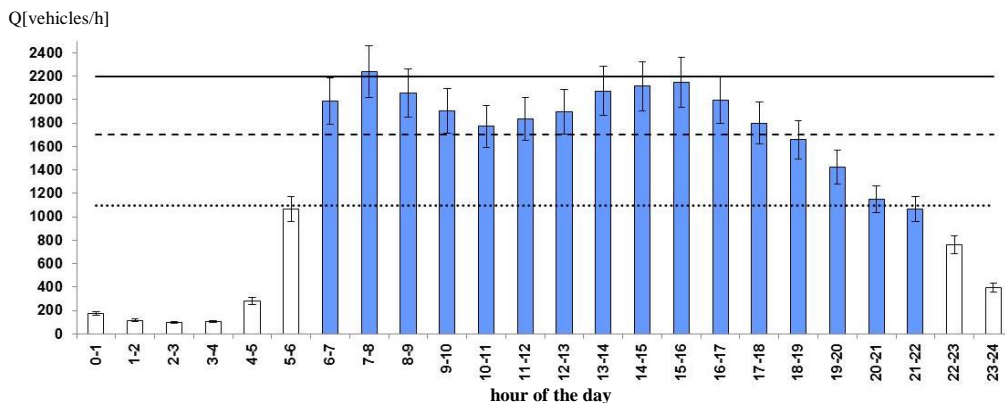


Fig. 4. Differences in traffic intensity in Warszawska Street over a 24-h period
source: based on Regulanty (2013).

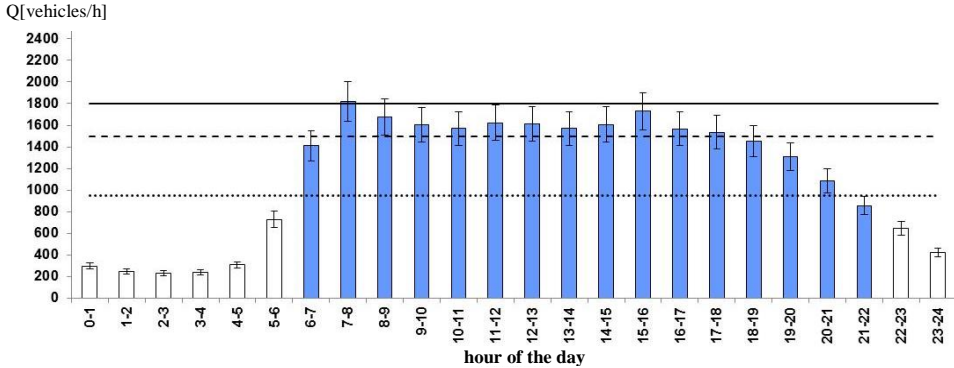


Fig. 5. Differences in traffic intensity in Lechicka Street over a 24-h period
source: based on Regulanty (2013).

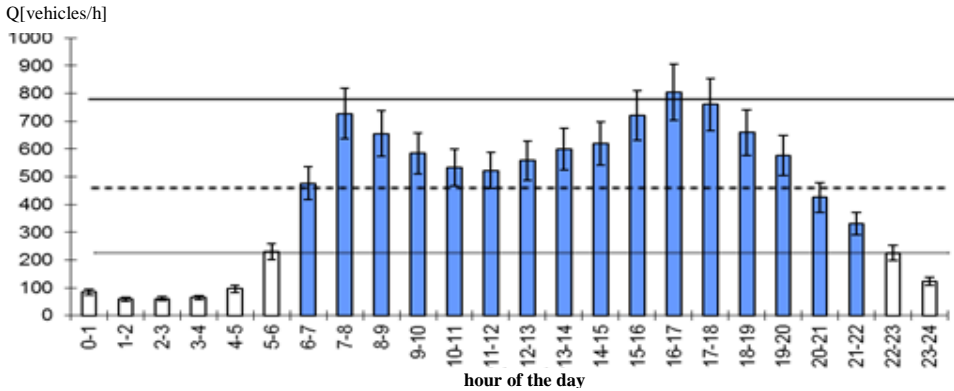


Fig. 6. Differences in traffic intensity in the Komorniki-Debina section of the A2 motorway

The measurements involved the BZ-7224 module which allows the drafting of a basic time history profile with a simultaneous recording of broadband parameters as a function of time. A single measurement lasting 10 minutes included the recording of the following acoustic signal parameters:

- equivalent sound level L_{Aeq}
- minimum sound level L_{minF}
- maximum sound level L_{maxF}

Furthermore, the following meter settings were adopted:

- correction characteristics A
- time constant Fast

The measurements were conducted during daytime, for 16 hours between 6 am and 10 pm, from Monday to Friday in July and August. The weather conditions during the measurements were

consistent with the guidelines issued by the Minister of Environment: no rainfall, with air temperature higher than 20°C and wind speed of ca. 5 m/s.

4. Results

Fig. 7 shows a chart with weekly 24-h traffic intensities recorded in Przybyszewskiego Street and Fig. 8 – in Hetmanska Street. The two streets are a part of the city’s ring II.

An analysis of weekly traffic intensity in Stanisława Przybyszewskiego Street shows a high level of traffic with a total of 2,186 [vehicles/h] recorded during the afternoon rush hour (Fig. 7) between 3 pm and 4 pm, and 2,156 [vehicles/h] recorded during the morning rush hour (from 7 am to 8 am). Between 7 pm and 9 pm, there is a rapid decrease in traffic intensity. With respect to

weekends, the lowest intensity of traffic is 130 [vehicles/h] and occurs between 2 am and 3 am. The intensity of vehicle traffic (Fig. 8) increases from 3 am to 4 am, starting at 97 [vehicles/h], growing until the afternoon rush hour between 2 pm and 3 pm, when traffic intensity reaches 1,695 [vehicles/h].

Fig. 9 shows a chart illustrating weekly 24-h traffic intensity values recorded in Ksiecica Mieszka I Street. The street is very specific in that it does not constitute an element of any of the city's transport rings. It connects two city districts (Winogrady and Piatkowo) and adjacent communes with the centre of Poznan.

24-h traffic intensity measurements performed in Mieszka I Street (Fig. 9) showed that the lowest traffic intensity, recorded between 2:00 and 3:00 am, was 88 vehicles per hour. During the night, the city's roads are mainly used by professional users (e.g. for the delivery of goods) and public transport purposes. Between 7 am and 8 am, there is a rapid surge in the intensity of traffic – the morning rush hour – with as many as 2,272 [vehicles/h] recorded. Other high values – 2,385 [vehicles/h] and 2,394 [vehicles/h] – were recorded during the afternoon rush hour, between 3 pm and 4 pm, and between 4 pm and 5 pm, respectively. After 5 pm there is a decrease in traffic persisting until 3 am.

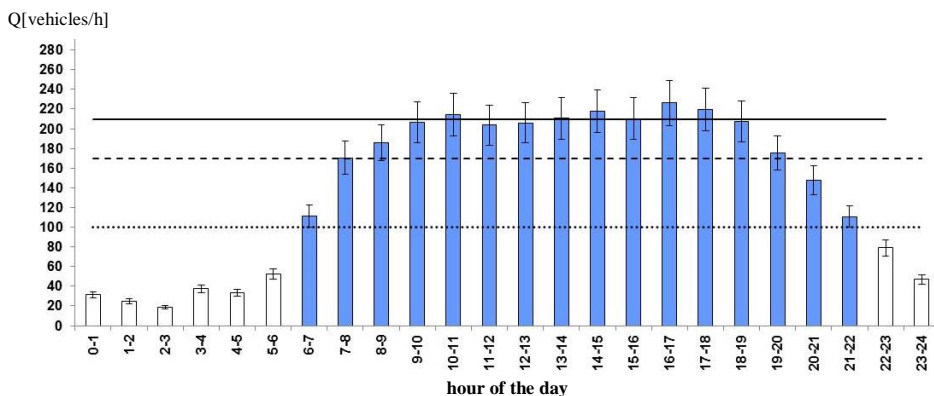


Fig. 7. Weekly 24-h traffic intensity in Przybyszewskiego Street
source: based on Regulanty (2013).

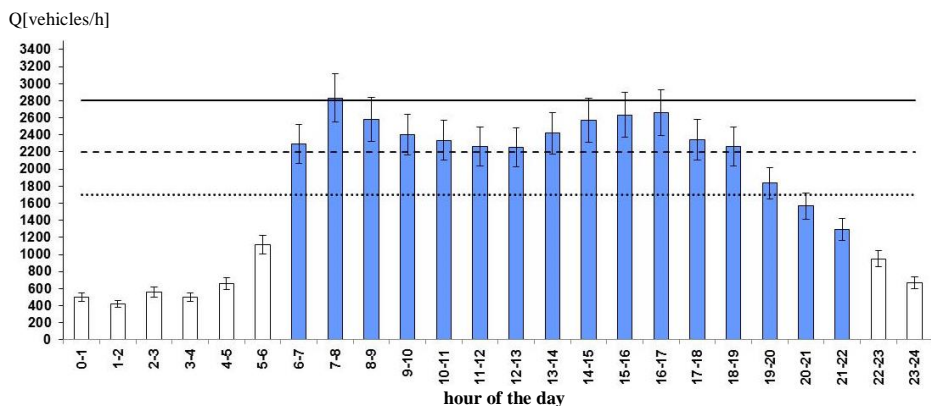


Fig. 8. Weekly 24-h traffic intensity in Hetmanska Street
source: based on Regulanty (2013).

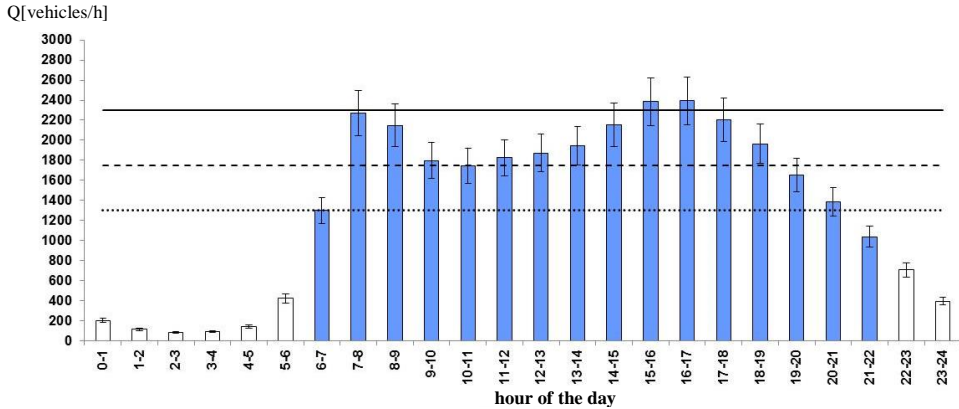


Fig. 9. Weekly 24-h traffic intensity in Mieszka I Street
source: based on *Regulanty* (2013).

The next stage of the study involved noise measurements in major transport routes in Poznan, for which 24-h traffic intensities were determined. Tables 1-3 list results of noise intensity measurements in three sample measurement locations. The measurement periods were selected on the basis of 24-h variation in traffic in the streets under study.

Sample results of noise intensity measurements showed that equivalent sound levels recorded in measurement points located in the section of the national road no. 92 under study (Lechicka Street, Table 1) exceeded 70 dB in all designated measurement periods. The intensity of traffic in Lechicka Street exceeded 1,200 vehicles per hour.

Noise intensity measurements in Przybyszewskiego Street demonstrated that the equivalent sound levels were higher than 68 dB during three measurement periods. At the same time, the intensity of traffic recorded in this section of the street exceeded 2,000 vehicles and 10 trams per hour. In Mieszka I Street, noise intensity was determined next to a 17-storey building located ~80 m from the edge of the roadway (Table 3). The equivalent sound levels recorded along this street were below 57 dB. The intensity of traffic in Mieszka I Street exceeded 2,000 vehicles per hour. The measurement point was thus characterized by a higher traffic intensity accompanied by a lower noise level. This is due to the considerable distance from the edge of the roadway (~80 m), effect of the surrounding noise and lower vehicle speeds during the rush hour.

Table 1. Noise and traffic intensity levels recorded in the measurement point located in Lutycka/Naramowicka Streets

Measurement period	L_{Aeq} [dB]	Traffic intensity [vehicles/h]	
		total	HGV
I	71.1	1,302	360
II	69.5	1,227	399
III	69.1	1,242	372
$L_{Aeq OT}$	70.0		

Source: *Orczyk* (2015).

Table 2. Noise and traffic intensity levels recorded in the measurement point located in Przybyszewskiego/Zeromskiego Streets

Measurement period	L_{Aeq} [dB]	Traffic intensity [vehicles/h]		
		total	HGV	trams
I	69.3	2,220	450	9
II	68.9	2,535	405	9
III	69.1	2,190	390	12
$L_{Aeq OT}$	69.1			

Source: *Orczyk* (2015).

Table 3. Noise and traffic intensity levels recorded in the measurement point located in Mieszka I Street

Measurement period	L_{Aeq} [dB]	Traffic intensity [vehicles/h]	
		total	HGV
I	56.6	2,166	333
II	56.2	2,568	279
III	55.7	1,920	210
$L_{Aeq OT}$	56.2		

Source: *Orczyk* (2015).

Noise measurements in the motorway part of the ring road in Poznan were conducted in three consecutive periods (stages) of construction of the A2 motorway (Orczyk, 2007):

- Stage I involved noise measurements performed before the motorway was put into service, i.e. without vehicle traffic (measurements of background noise);
- Stage II involved noise measurements performed after the motorway was put into operation and a new section, connecting Wrzesnia and Krzesiny, was opened to traffic;
- Stage III involved noise measurements performed after another section of the A2 motorway (Nowy Tomysl – Konin) was put into service;
- Stage IV involved noise measurements after yet another A2 motorway section (Konin – Strykow) was opened to traffic.

The same measurement points were used at every stage. A total of 23 measurement points were selected along the A2 motorway section Komorniki – Krzesiny. The points had different locations in the vicinity of the motorway (Orczyk & Tomaszewski, 2011):

- 16 points were selected in housing estates situated close to the motorway;
- 3 points were designated in the motorway intersections,
- 4 points were selected to account for varying depths of the trench.

Fig. 11 shows the distribution of measurement points in the Komorniki intersection, and Fig. 12 – in the Debina intersection and in housing estates adjacent to the motorway.

All the measurements – at all four stages of the study – were performed at daytime between 8 am and 10 pm, on working days, between July and September. During the measurements, there was no rainfall and the road surface was dry. The wind speed did not exceed 5 m/s. Stage III measurements were conducted before the toll A2 motorway was made available on a toll-free basis to heavy goods vehicles with a total permissible weight over 3.5 t. The measurement points in housing estates situated near the motorway were designated in compliance with guidelines set out in the Polish Standard PN-ISO 1996-1 at a distance of 1 m from the fence of a structure or the outside wall of the building, at a height of 1.2 ± 1.5 m above the ground level (Poznan City Council, 2006).

Table 4 lists sample results of three-stage noise measurements performed in motorway intersections in the Komorniki-Krzesiny section of the A2 motorway.

The three-stage tests of noise levels in the A2 motorway section Komorniki-Krzesiny, which serves as a part of the Poznan city ring road, showed that the background noise (reference level) for the Komorniki-Krzesiny section as a whole could be described as the mean equivalent sound level $L_{Aeq,TLA} = 51$ dB based on the first stage of noise measurements. Putting the motorway into operation resulted in an increase in the equivalent sound level directly at the motorway by about 30 dB, and at the edge of the trench in which the motorway is laid – by 20 dB in relation to measurements performed during the first stage of tests.



Fig. 11. Measurement points in the Komorniki intersection

Source: Orczyk (2007).

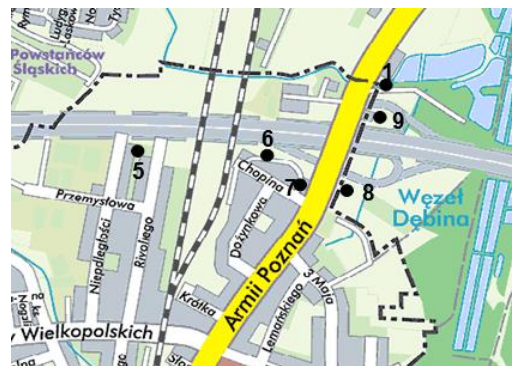


Fig. 12. Measurement points in the Debina intersection

Source: Orczyk (2007).

The equivalent sound levels measured at stages II and III at a distance of approx. 100 m from the motorway itself were the same as the level of background noise determined at stage I of testing. Consequently, the increase in traffic intensity on the motorway at a distance greater than 100 m from

the motorway has no effect on the noise level in the surroundings of the motorway.

Table 5 lists sample results of three-stage noise measurements performed in the housing estates located along the A2 motorway section under study.

Table 4. Results of three-stage noise measurements performed in motorway intersections in the Komorniki-Krzesiny section of the A2 motorway

No.	Town/ district	Measurement point location	Stage	Measurement periods			$L_{Aeq,16h}$
				Period I	Period II	Period III	
1	2	3	4	5	6	7	8
1.	Komorniki	Komorniki intersection – exit road in the direction of Świecko	Stage I	50	59	55	56
			Stage II	68	66	63	67
			Stage III	67	64	65	66
2.	Lubon	Debina intersection	Stage I	45	45	50	46
			Stage II	74	74	74	74
			Stage III	77	78	77	77
3.	Poznan Krzesiny	Krzesiny intersection	Stage I	42	42	46	43
			Stage II	74	75	71	73
			Stage III	79	80	79	79

Source: Orczyk (2007).

Table 5. Results of three-stage noise measurements performed in housing estates located along the Komorniki-Krzesiny section of the A2 motorway

No.	Town/ district	Development type/ protected area	Measure-ment point location	Location relative to the motorway		Stage	Periods and measurement of equivalent sound level [dB]			$L_{Aeq,16h}$ [dB]
				Side*	d_{A2} [m]		Period I	Period II	Period III	
1.	Komorniki, Komorniki intersection	Two-storey housing development	Poznanska Street in Komorniki	SS	185	Stage I	46	52	48	49
						Stage II	51	46	54	54
						Stage III	51	51	51	51
2.	Lubon	Four- and five- storey housing development	“Lubonianka” housing estate, building no. 41	SS	165	Stage I	59	59	54	58
						Stage II	56	60	57	58
						Stage III	58	60	60	59
						Stage IV	56	56	–	56
3.	Lubon	Four- and five- storey housing development	“Lubonianka” housing estate, building no. 46	SS	195	Stage I	57	54	42	54
						Stage II	57	59	51	57
						Stage III	56	57	57	57
						Stage IV	57	57	–	57
4.	Lubon	Allotment gardens	Allotment garden – measurement point next to a fence	NS	120	Stage I	46	44	41	44
						Stage II	52	45	52	51
						Stage III	53	47	54	52

*side – motorway side, SS – south side, PN – north side, d_{A2} – distance from the motorway

Source: Orczyk (2015).

The equivalent sound levels measured in the housing estates located near the A2 motorway section Komorniki-Krzesiny do not exceed 60 dB, and the opening of the motorway induced a roughly 8 dB increase in the equivalent sound level in the housing estates situated less than 100 m from the motorway (relative to values determined at stage I). The measurements which were performed at stage IV, after a complete motorway section as far as the A1-A2 intersection (Strykow) was put into use, were aimed to determine whether the opening of yet another stretch of the motorway triggered a significant increase in the level of noise in the housing estates bordering on the motorway part of the Poznan ring road. Stage IV measurements, however, failed to show any significant increases in the noise level within the housing estates under investigation.

5. Summary

The tests determining traffic and noise intensity along roads which form the transport rings for the city of Poznan, national roads passing through Poznan and the motorway section of the city's ring road give rise to the following conclusions:

- The equivalent sound levels recorded in the majority of Poznan's streets under study exceed the maximum permissible level defined in the Regulation of the Minister of Environment of 14 June 2007 on permissible noise levels in the environment;
- The equivalent sound levels obtained in the measurement points selected for the study range from 53 to 78 dB;
- The highest equivalent sound levels were observed along the streets within the stretch of the national road no. 92. Noise tests performed in these locations yielded values exceeding 70 dB during all measurement periods;
- The intensity of traffic in the streets selected for the study was below 2,000 vehicles per hour, and the proportion of HGV traffic was approximately the same in all the study locations, amounting to about 20% in the national roads no. 5 and 11 and along the streets running outside the inner city zone.
- The equivalent sound levels measured at three-stage tests in the housing estates bordering on the motorway were found to be below 60 dB; the value thus complies with the maximum permissible noise level laid down in the

Regulation of the Minister of Environment of 29 July 2004 on maximum permissible noise levels in the environment;

- Putting the motorway into operation triggered an increase in the equivalent sound level directly at the motorway by about 30 dB, and at the edge of the motorway trench – by 20 dB in relation to the background noise level determined during the first stage of tests.
- The opening of the motorway increased the equivalent sound level in the housing estates located less than 100 m from the motorway by ca. 8 dB in relation to stage I tests.

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