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THE ENVIRONMENTAL INFLUENCE OF NOISE CAUSED BY MEANS OF TRANSPORT

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Means of public and individual transport, as well as various emergency vehicles, are some of the most common and most problematic sources of noise in the urban areas. Sound levels generated by means of transport are in the range of 70 to 95 dB. This article presents results of noise level measurements, which were carried out in the urban agglomeration, alongside main traffic routes and in selected important places like crossroads. The paper also contains data on the general number of means of transport, taking into account the increase in the quantity of road vehicles. Apart from that, this work includes results of traffic measurements made to determine the periods of daytime noise measurements.
Keywords: noise, means of transport, safety

1. Introduction

Among all the factors that affect environment, noise is especially problematic because of a negative influence on almost all of Earth's inhabitants and their life functions. Noise is a problem encountered on a daily basis by every person in the place of living, during the travel, at work and in leisure time. It is one of the major problems that reduce quality of life. The population of large cities with 24-hour public transport is most greatly exposed to the noise.

The most common and most annoying noises, especially in urban areas, are the sounds caused mainly by means of public transport (buses and trams) and various emergency vehicles. Sound levels generated by means of transport are within the range of 70 to 95 dB. Particular sources of road noise are: single-track vehicles – 79 ÷ 87 dB, cars – 75 ÷ 84 dB, trucks – 83 ÷ 93 dB, buses and tractors – 85 ÷ 92 dB [1].

In 2015, the number of cars in the world was 1.1 billion—one car per 6.5 inhabitants on average. However, the number of cars is steadily increasing. By 2025 it will amount to 1.5 billion, and 15 years later it will be 2 billion. In Poland there are 599 cars per 1000 inhabitants, which is 35 more than the European average. As for the increase in the number of cars, it is most significant in developing countries, mainly in China and India. This increase in the number of cars in recent decades has resulted in an increase in road risks, as well as in noise levels in cities and along major traffic routes.

This article presents results of noise level measurements made in the urban agglomeration, alongside main traffic routes and in selected important places like crossroads. The increase in the number of road vehicles and its impact on traffic safety are also discussed.

2. Problem of noise in the city

The negative impact of noise is greatest in large cities with more than 100,000 inhabitants. These cities are required to develop protection programs against the noise. Such programs are prepared every five years. The need to develop them follows from the Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002. These programs are part of a strategic environmental management. The authorities of large cities should regularly carry out noise monitoring and develop acoustic maps. Basing on such maps, specialists should detect the places of exceedances of norms and find sources of these exceedances. Maps are created in layered format, separately for car, tram, air, rail and industrial noise. Maps, in addition to the informational function, are also tools for creating strategic noise protection programs. These programs determine what actions should be taken by the local government in the next few years in relation to the places where the noise exceeds the permissible level. They are also helpful in specifying the costs of planned actions and the number of people involved. During the development of the noise protection program, specialists take into account the number of people exposed to excessive noise and the cost of actions leading to the reduction of noise in the city [2].

The Ordinance of the Minister of the Environment of 22 January 2014 concerns acceptable noise levels in the environment. According to this regulation, acceptable noise levels for urban areas of multi-family housing and collective residence should be: L_{AeqD} = 65 dB and for L_{AeqN} = 56 dB [3]. The comparison of permissible noise levels specified in the Ordinance of the Minister of the Environment with actual noise levels in the loudest cities in Poland is shown in Figure 1. This figure shows the number of inhabitants of major cities in Poland exposed to different levels of road noise expressed by L_{AeqN} according to acoustic maps [4].

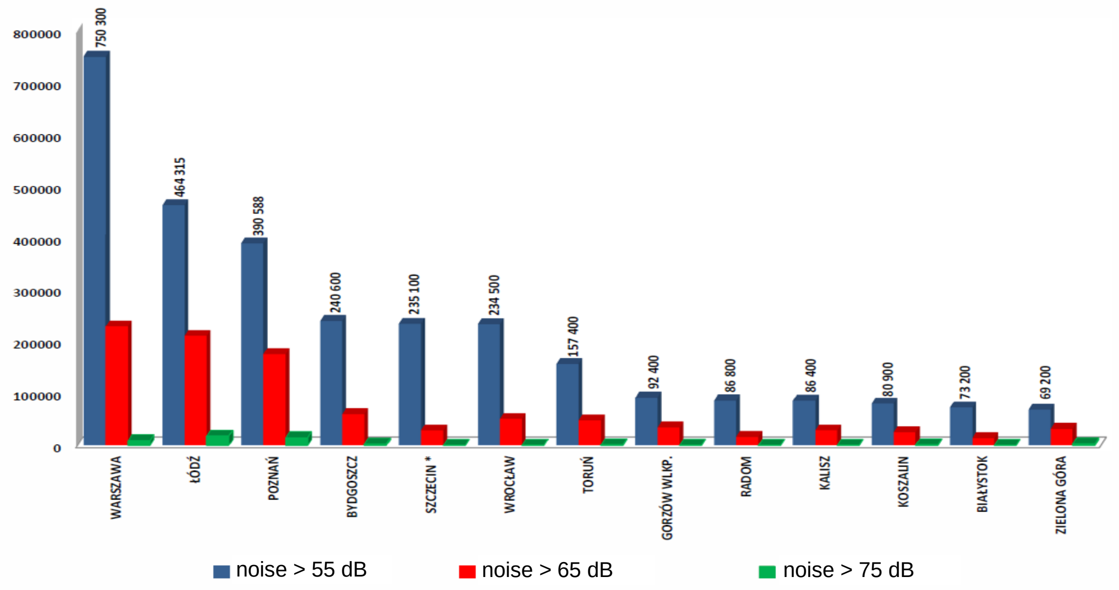

Figure 1: The number of inhabitants exposed to different levels of road noise.

Figure 2 shows the percentage of inhabitants of major cities in Poland exposed to road noise exceeding 55 dB, cities under control of acoustic maps according to L_{AeqN}.

As can be seen from the data presented in Figure 1, residents who are the most exposed to noise beyond the allowable levels are those living in large agglomerations such as Warszawa, Łódź and Poznań. People living in smaller cities are mostly exposed to the noise of over 55 dB [4].

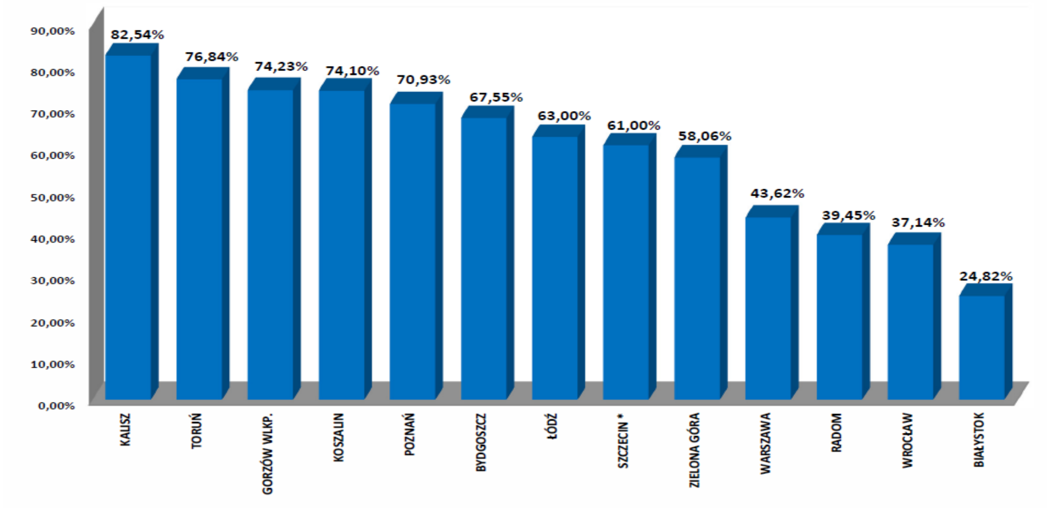

Figure 2: Percentage of people exposed to road noise of over 55 dB.

This is the result of the obligation to produce acoustic maps in large cities that contribute to better noise management, ie the use of various measures to prevent excessive noise generated by road transport. Small and medium-sized cities have no such obligation.

3. Development of road transport

Figure 3 shows the quantity of goods and people transported between 1998 and 2015 by rail and road transport, and Figure 4 shows number of people travelling by collective rail and road transport.

a) b)

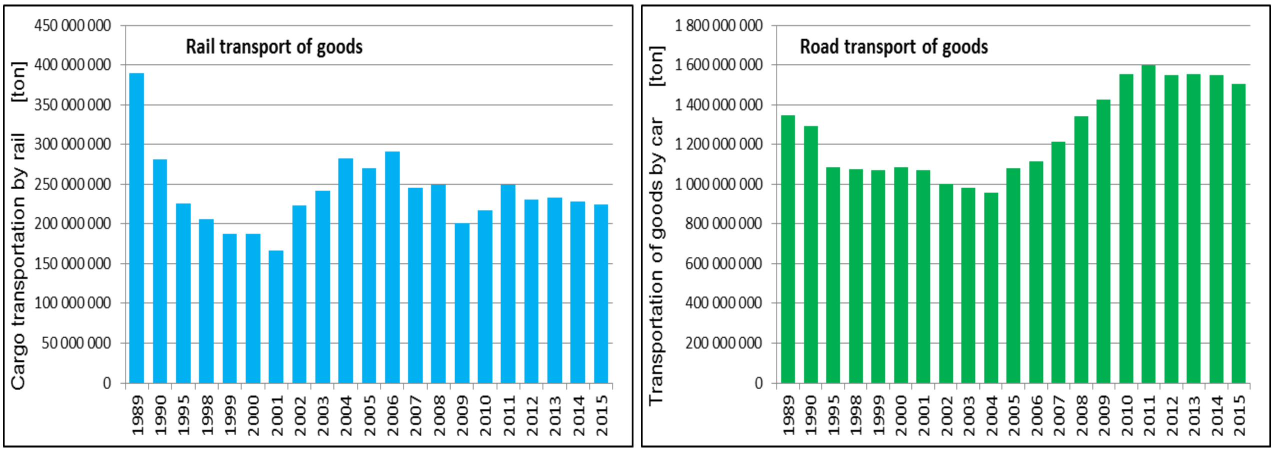

Figure 3: The quantity of goods transported between 1989 and 2015 a) by rail, b) by road.
Source: the authors' work on the basis of Statistical Yearbooks and Ministry data.

The values presented in Figures 3 and 4 for the two basic branches of rail and road transport, which are the most important in the development of each country's economy, have shown that in the field of freight transport, after the decrease before 2001, the growth and stabilization in the quantity of transports in subsequent years has occurred. In the case of road transport after 2004, the quantity of transports has increased and stabilized since 2010. The passenger rail transport after a systematic decline since 1989 has been on a steady level since 2001, while collective passenger road transport is constantly declining. This is due to the systematic increase in the number of passenger cars, as shown in Figure 5a.

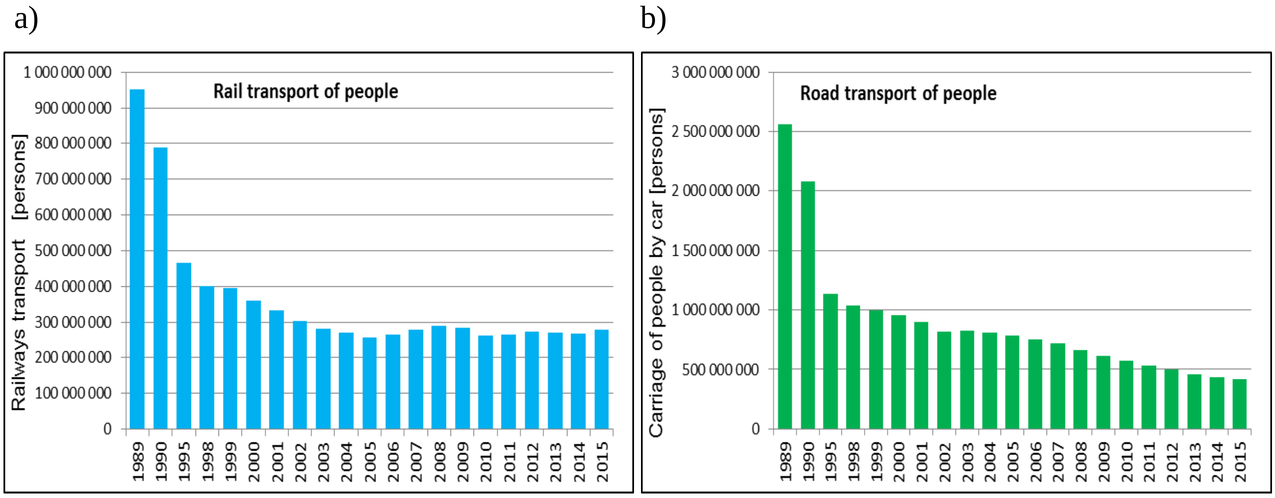

Figure 4: The quantity of people transported between 1989 and 2015 a) by rail, b) in collective road transport

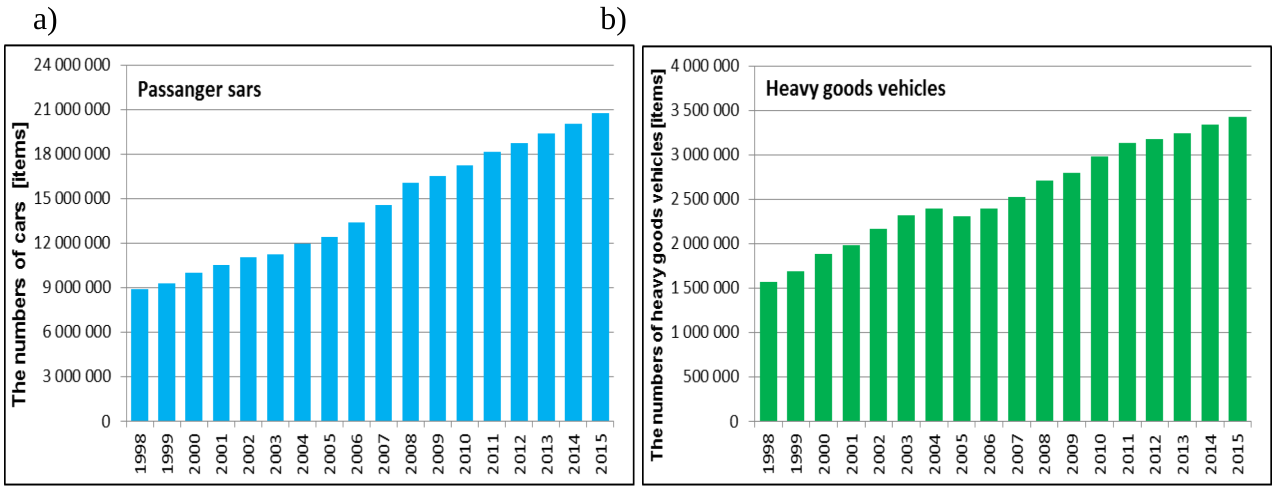

Figure 5: Number of cars in 1989–2015, a) passenger cars, b) trucks
Source: the authors' work on the basis of Statistical Yearbooks and Ministry data.

The shift of passenger and freight traffic towards road transport, the most non-ecological transport sector, has increased noise in cities and along major traffic routes, pollution, disturbances and risks in road transport environment.

4. Noise measurements in Poznań

Measurements of noise on selected transport routes of Poznań were carried out in accordance with the recommendations of the Ordinance of the Minister of Environment of 22 June 2014 on the requirements for measuring the levels of substances or energy in the environment by the manager of the road, railway, tramway, airport or port. This Ordinance defines the methodology for the measurement of environmental noise in relation to the operation of land, water and air transport [2].

Noise measurements were carried out in the places with the highest daily traffic, in selected locations on the ring road of Poznań (Figure 6). Measurements were made at a height of 1.6 meters above the surface of the roadway at a distance of one meter from its edge.

Noise measurements were made with the use of a sampling method. Selection of measuring periods was preceded by traffic analysis on the sections of examined traffic routes (Figure 7).

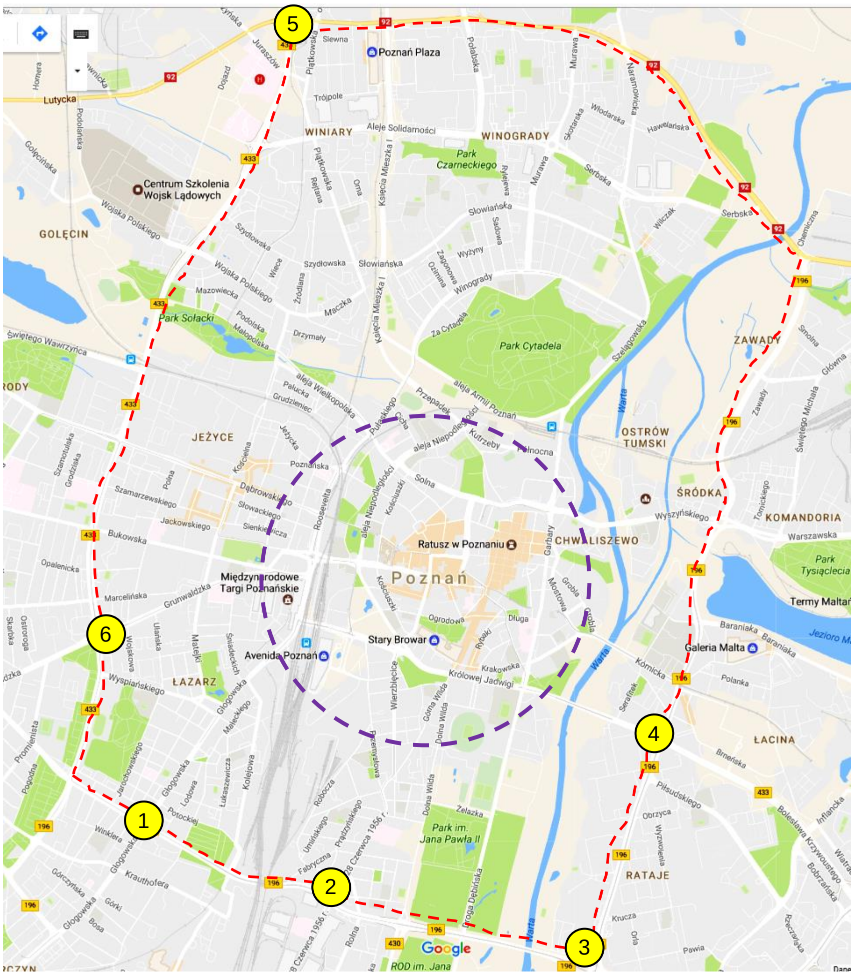

Figure 6: Fragments of map of Poznań with small and medium ring roads marked. Source: authors’ own work on the basis of a Google map.

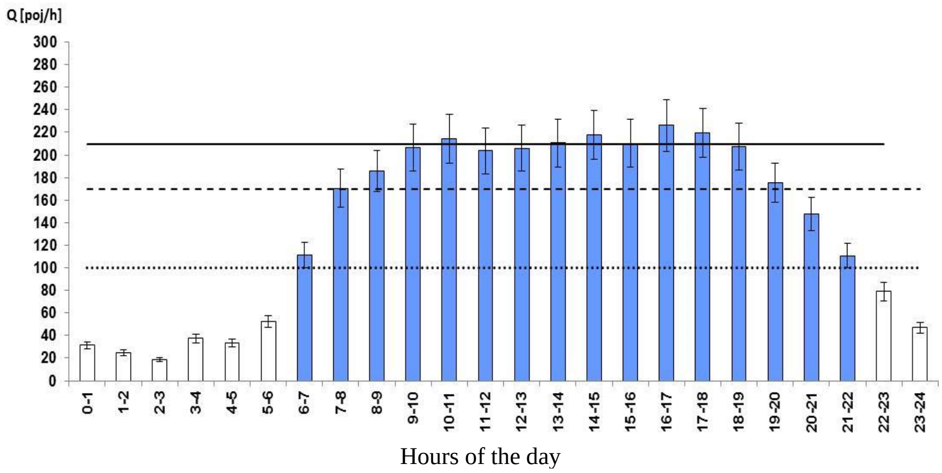

Figure 7: Daily weekly fluctuations in traffic on Przybyszewskiego street (measuring point 6).

Table 1 shows the results of noise measurements at the points indicated in Figure 6 for the measurement periods according to Figure 7 [7].

Table 1: Results of noise measurements at the selected measurement points on main traffic routes in Poznań

Measurement point	Measurement period	Level of noise [dB]	LAeq level [dB]
1	I	65,9	65,4
	II	65,5	
	III	64,8	
2	I	69,2	69,3
	II	69,1	
	III	69,5	
3	I	66,9	65,9
	II	65,8	
	III	64,6	
4	I	67,3	66,8
	II	67,0	
	III	65,9	
5	I	78,6	78,1
	II	78,2	
	III	77,5	
6	I	69,6	70,9
	II	69,8	
	III	72,7	

According to the measurement data presented in Table 1, the measured noise levels in the sample points along the main traffic routes of Poznań exceed the permissible levels specified in the Ordinance of the Minister of the Environment. The main reason for this is that these traffic routes are used for transit traffic consisting mostly of light trucks and trucks. These vehicles, as already mentioned in the introduction, generate noise of 83 ÷ 93 dB and they are mainly responsible for high noise level in the city.

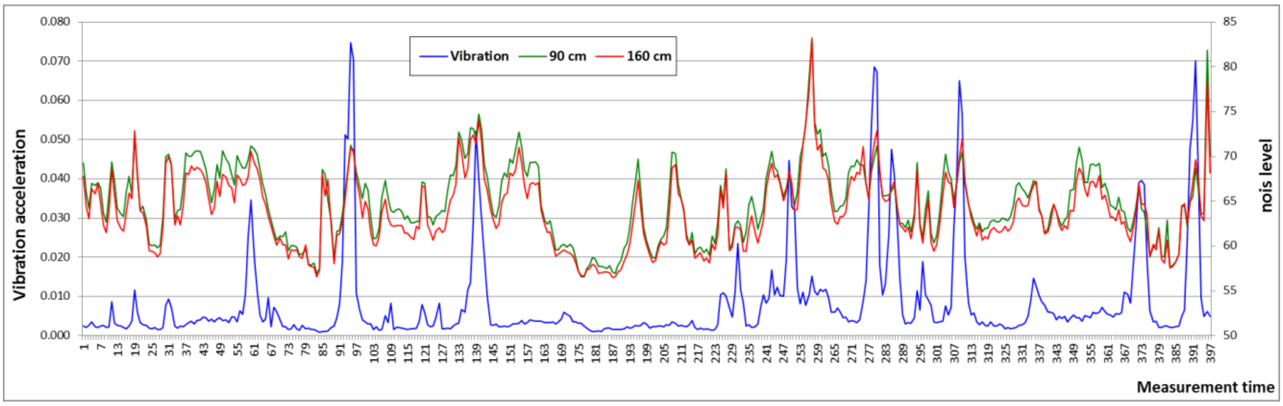

Figure 8: Time variations of noise level at the heights of 90 and 160 cm and changes in acceleration of surface vibrations at the tram stop (microphones set parallel to the direction of motion).

Figures 8 and 9 show changes in noise level (time waveforms) at two measurement heights: 90 cm (statistical average height at which child's ear is located) and 160 cm (statistical average height at which adult human ear is located according to standards). In addition to point measurements of noise (made with the use of microphones), binaural measurement was carried out with the use of Brüel&Kjær dummies with microphones in ears (Figure 10).

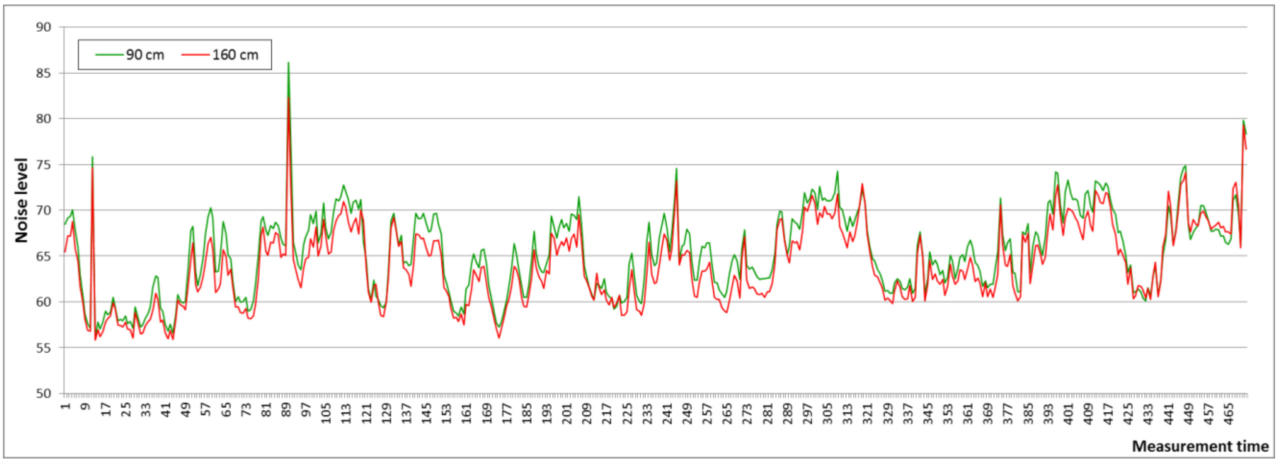

Figure 9: Time variations of noise level at the heights of 90 and 160 cm at the tram stop (microphones set perpendicularly to the direction of motion).

Because some noise measurements were also made at tram stops, vibration of the substrate was measured with the use of seismic vibration transducers. These measurements were aimed at, inter alia, an assessment of the impact of the tram traffic on vibrations of the lower limbs of passengers waiting for a tram. These vibrations are (or may be) an additional source of information about the oncoming tram, especially for people with visual or hearing impairment [8].

Figure 10: Time variations of noise level at the heights of 90 and 160 cm at the tram stop (microphones set perpendicularly to the direction of tram motion).

As evidenced by the waveforms of noise (and ground vibrations) shown in Figures 8 and 9, changes in noise levels are dynamic and vary over time. It can be said that means of transport generate impulse noise. In the case of impulse noise, very often it is not possible to reduce it with known methods, including the use of collective protection measures. Therefore, it is only possible to limit access to the city for vehicles that generate impulse noise or fast-changing (dynamic) noise.

5. Conclusion

This article presented problems related to noise in the city on the example of Poznań. Noise is becoming more and more problematic for the inhabitants due to the increasing number of cars and the limited possibilities of noise reduction.

After carrying out noise and traffic measurements at selected points in the streets of Poznań, within the national roads in Poznań, the following conclusions can be drawn:

- the increasing number of cars and trucks is the main cause of excessive noise in cities,
- on most of the studied streets in Poznań, the recorded noise levels exceed the permissible level specified in the Ordinance of the Minister of the Environment on admissible noise levels in the environment,
- the equivalent sound levels obtained at the measurement points are within in the range of 53 to 78 dB,
- the highest values of equivalent sound level were recorded at the streets of national road No. 92. Noise measurements made on these streets exceeded 70 dB in all measurement periods,
- in the streets selected for the study the traffic did not exceed 2000 vehicles per hour and the share of truck traffic was more or less at the same level and amounted to about 20%,
- the noise problem in cities can not be easily and quickly resolved in times of intensive transport development.

6. Acknowledgements

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