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## Traffic-related noise pollution in the town of Szczecinek (Poland)

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**Abstract:** Increased intensity of automotive traffic has a negative impact on the human body, and on the safety and comfort of living. The hazards of transportation are primarily associated with road accidents, air pollution, noise and transport blockages. The present study includes a temporal and spatial analysis of the intensity of traffic-related noise in the summer season of 2015 in the tourist part of the town of Szczecinek. In addition, it includes a comparative analysis of the noise levels and traffic volumes in Szczecinek against the background of the village of Iwin. Assessment of noise pollution was carried out at a total of 37 different sites, both on working days and at weekends. A spatial image of noise intensity in the central part of Szczecinek was obtained, and sites with excessive levels of traffic noise were flagged. These locations are particularly burdensome to residents and cause a decrease in the tourist value of the city. Our tests confirmed the advisability of building a beltway for Szczecinek.

**Keywords:** noise pollution, traffic intensity, traffic noise, Szczecinek

### 1. Introduction

In geographical space, the most troublesome source of noise is road transport. Seventeen percent of Poland's area are affected by roads (Rymarz et al., 2012). Noise is harmful to human health, as it reduces work efficiency, hinders rest and increases the risk of accidents. The average daily annual traffic of motor vehicles (GPR, 2001, 2016) in the years 2000-2015 on the national road network increased from 7,009 to 11,178 vehicles per day, by an average of 59 percent. At the same time, passenger car traffic extended to 62 percent, and truck traffic to 82 percent. Increasing volumes of car traffic result in higher noise levels in the vicinity of transport routes. Noise generated by motor vehicles depends to a large extent on the structure of traffic (types of vehicles). As a consequence of road transport, changes occur in the health of people subjected to noise emissions. According to a report by the European Environment Agency (EEA, 2000, 2014), approximately 125 million residents of the European Union may be exposed to medium levels of long-term exposure to noise generated by road

traffic exceeding 55 dB, of whom more than 37 million people are exposed to noise levels above 65 dB. Negative effects of noise are felt by every third resident of Europe (WHO, 2011). Residents of Szczecinek most often indicated the impact of car traffic as the most uncomfortable factor (Piątkowski and Kraczkowski, 2016). Under Directive 2002/49/EC of the European Parliament and the Council of Europe (June 25, 2002), noise is classified as a pollutant against which the same measures should be taken as against other pollutants. Relevant provisions also exist in Polish law: in the Environmental Protection Law (Dziennik Ustaw, 2001, Nr 62, poz. 627) and in the Notice of the Minister of the Environment regarding permissible noise levels in the environment (Dziennik Urzędowy, 2007, Nr 120, poz. 826, Dziennik Urzędowy, 2014, poz. 112).

Constantly developing cities mean that safe levels of noise emission accepted by the human body are under threat. The aim of the present study was to determine the spatial diversity of noise in Szczecinek and to identify places par-

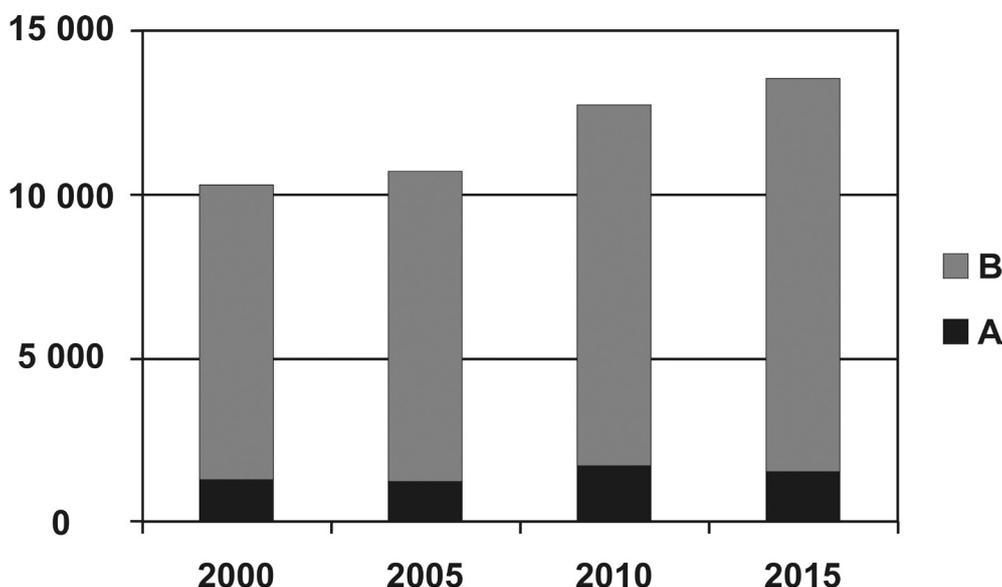
ticularly contaminated by traffic-related noise. The tests were carried out in the most attractive tourist area of the city – the Old Town, and the zone of the Town Park by Lake Trzesiecko. The area of Szczecinek that was analyzed is characterized by varied residential buildings (including single and multi-family units) and a recreation and tourist zone with a diversi-

fied neighborhood of wooded green areas. The urban green zone in the area under study, due to its limited spatial coverage and large dispersion, did not have a significant impact on the spread of noise. The background reference for the study was the level of noise recorded in the Commune of Grzmiąca, between the villages of Iwin and Storkowo.

## 2. Research material and methods

The object of the study was the city of Szczecinek (over 40,000 inhabitants) located in the West Pomeranian Voivodeship. Traffic-related noise in Szczecinek is generated mainly by local and transit traffic. Important transport routes run through the city, including national roads no. 11 and 20, and provincial road no. 172. In the years 2000-2015, on the order of the General Director of National Roads and Motorways, a General Measurement of Traffic Intensity was carried out on the existing national road network in Poland (GPR, 2001, 2006, 2011, 2016). The parameters and characteristics of the traffic thus obtained pointed to a steady increase in the number of vehicles on road No. 11 – from over 10,000 vehicles to over 13,500 vehicles per day (Fig. 1). In the multi-annual period analyzed, the average daily number of vehicles increased by 31 percent, including passenger cars by 51 percent,

and trucks by 35 percent. The research carried out in 2009 as part of the European transport project CiViTAS Renaissance (Piątkowski and Kraczkowski, 2016) enabled the creation of a forecast of peak traffic volumes for Szczecinek. It also assessed the average daily noise emission for daytime in 2015. For the center of Szczecinek, renovation and construction works were planned and carried out improve the acoustic and transport-related situation. The forecast assumed a reduction in the number of cars and trucks by 29 percent, among others by constructing a beltway for the town. At that time (GPR, 2011, 2016), the average daily traffic on National Road no. 11 running through Szczecinek increased by six percent (Fig. 1). It should be noted that the structure of the traffic had changed: the number of passenger cars had increased by 18.8 percent, whereas the number of trucks had decreased by 13.8 percent.



**Figure 1.** Average annual daily traffic in Szczecinek on National Road no. 11, between kilometer markers at 112.565 km and 114.783 km, measurement point 60502: A – trucks, B – passenger cars (Prepared based on GPR, 2001, 2006, 2011, 2016).

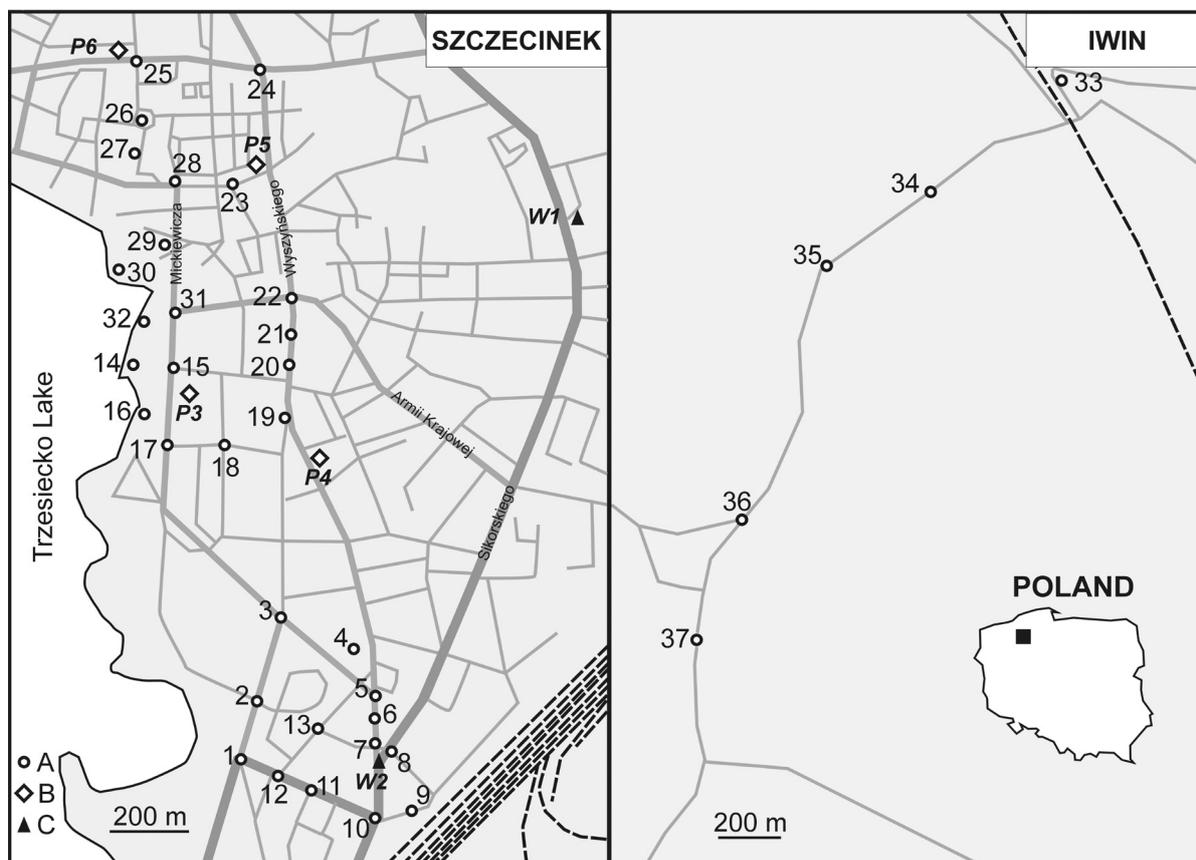
The forecast also assumed, a reduction of the average daily noise emission for the daytime by a range of 0.5 dB to 11.9 dB in the center of Szczecinek by the year 2015. It was supposed to happen as a result of a change in traffic intensity and the structure of the vehicle stream. The calculated annual average noise emission level after taking into account the background in the peak hour of the day for 2009 in Szczecinek ranged at individual locations from 58.9 dB to 65.9 dB (Rak et al., 2010; Piątkowski and Kraczkowski, 2016). The noise measured in 2009 in agricultural areas located far from roads and airports was 40.2 dB (Wójcicki et al., 2011).

To verify the above assumptions, direct field tests were conducted on August 16-24, 2015. 32 measurement sites were selected within the city, both at the main arterial roads and along estate roads (Fig. 2). For the same period, five sites were also designated in rural areas, in the commune of Grzmiąca, on the section of Poviát Road no. 17624 between the villages of Iwin and Storkowo (Fig. 2). The results of these mea-

surements were treated as background values, not exposed to the impact of heavy traffic.

The sites in Szczecinek (Fig. 2) were selected by taking into account the local conditions. Attention was paid to representing both places that were particularly exposed to traffic noise emissions (e.g. Gdańska Street, Sikorskiego Street, Jana Pawła II Street, and Ordonia Street) and places distant from sources of noise (e.g. recreational areas: a beach, a wooded park). A section of the road between Iwin and Storkowo was selected in the Commune of Grzmiąca. In total, 1,032 measurements were made at one-hour intervals (872 in Szczecinek, 160 in Iwin), from 9:00 AM to 5:00 PM, of which 318 measurements during working days, 300 measurements on Saturday and 414 on Sunday.

Noise levels in Szczecinek and Iwin were measured based on the method of direct measurements of noise levels by sampling. The measurements were taken using the Sound-Test-Master 082.070A (Laserliner) digital sound level meter, meeting the requirements of



**Figure 2.** Locations of the noise intensity measurement sites in the Poviát of Szczecinek: the City of Szczecinek and rural areas in the Commune of Grzmiąca: A - the sites in 2015, B - the sites in the years 2008-2009 (Rak et al. 2010; Piątkowski and Kraczkowski 2016), C - the sites in 2009 (prepared based on WIOŚ, 2010).

DIN EN 61672-1, Class 2. The measurements were carried out on the basis of the guidelines contained in the Regulation of the Minister of Environment on the requirements for conducting level measurements of a substance or energy in the environment by the administrator of a road, railway line, tram line, or airport (Dziennik Urzędowy, 2011, Nr 140 poz. 824). To avoid the impact of atmospheric conditions,

the measurements were taken at air temperatures higher than 5°C, at wind speeds up to 5 m/s and in the absence of precipitation. The measurement device was placed at a height of  $2 \pm 0.2$  m above ground level and was directed perpendicular to the axis of passing vehicles. The recording time of each measurement was 1 minute. The minimum, average and maximum values were recorded.

### 3. Results

The assessment of noise intensity in Szczecinek and Iwin was based on the admissible values specified in the announcement of the Minister of the Environment (Dziennik Urzędowy, 2014, poz. 112) of October 15, 2013, amending the regulation on permissible noise levels in the environment. Permissible noise levels in

the environment caused by particular groups of sources for the type of terrain tested, in the reference period equal to 16 hours (daytime), amount to 65 dB. The results of direct measurements of the noise level caused by road traffic in Szczecinek and Iwin are shown in Table 1.

**Table 1.** Transportation-related noise levels [dB] recorded at the sites in Szczecinek and Iwin, from Aug. 16 to 24, 2015 (the authors' own study)

Location	Weekdays			Saturday			Sunday		
	min.	avg.	max.	min.	avg.	max.	min.	avg.	max.
Szczecinek: roads no. 11, 20, and 172 sites 1, 7, 8, 10-12, 24, 25	57.1	<b>68.6</b>	86.9	52.9	<b>73.1</b>	95.1	41.2	60.1	73.9
Szczecinek: other main roads and intersections sites 2-6, 13, 15, 19-23, 26, 28, 31	52.9	<b>66.9</b>	93.8	40.0	<b>65.3</b>	94.7	41.3	57.2	80.4
Szczecinek: residential roads, parking lots sites 4, 17, 18, 27, 29	52.4	60.3	72.2	44.3	64.3	89.9	38.4	52.3	76.3
Szczecinek: recreation areas – beach, park sites 14, 16, 30, 32	46.4	55.3	61.8	49.4	64.7	88.6	38.3	51.8	88.7
Iwin: farmland and forest areas sites 33-37	34.1	43.4	55.3	31.8	38.3	46.4	34.2	43.7	77.9

The standards were exceeded in the vicinity of transit roads (8 sites) and other major roads and intersections (15 sites), both during working days and on Saturdays (Table 1, Fig. 3). The maximum noise levels recorded at the time ranged from 86.9 dB to 95.1 dB.

In 2015, increased noise in urban traffic in Szczecinek was particularly troublesome near Szczecińska Street (site 1, average noise level of 70.1 dB), Gdańska Street (sites 10-12, average noise level of 70.3 dB) and Sikorskiego Street (sites 7 and 8, average noise level of 66.3 dB).

Transit through the city occurs via these roads. High noise levels were also recorded in the vicinity of other major roads and intersections in Szczecinek, ranging from 66.9 dB on weekdays to 61.0 dB on weekends. The best acoustic conditions in Szczecinek were observed near residential roads (an average of 58.1 dB) and in the recreational zone of the beach and within the parks (an average of 56.7 dB). At the same time, the noise level in agricultural areas near Iwin was 41.5 dB on average. In urban conditions, the burden of traffic noise is almost



**Figure 3.** Average noise intensity levels in Szczecinek in August 2015: A > 70 dB, B >65÷70 dB, C >60÷65 dB, D >55÷60 dB, E <55dB (the authors' own study).

impossible to eliminate. The acoustic climate in Szczecinek, surrounded by roads 11, 20 and 172, is not satisfactory. Permissible sound intensity standards are exceeded for street sections by an average of up to 5.1 dB, and at certain points by an average of even 8.7 dB (site 11 at Gdańska St.).

The noise level in rural areas measured between 2015 between Iwin and Storkowo was,

on average, 41.5 dB (Table 1). These values are comparable to the results for 2009 (Wójcicki et al., 2011). The average daytime intensity of car traffic in 2015 in Iwin ranged from twenty vehicles per hour on Sunday, through 36 vehicles per hour on Saturdays, up to 51 vehicles per hour on business days. The share of heavy goods vehicles ranged from 2.3 percent on weekends to 25.7 percent on weekdays.

## 4. Discussion and conclusions

The results of the measurements taken in August 2015 are higher than the results from 2008-2009 (Rak et al., 2010; Piątkowski and Kraczkowski, 2016). From December 2008 to September 2009, the noise levels registered at Mickiewicza Street (site P3) indicated an average annual daytime noise emission of 59.8 dB. In 2015, the average noise level in this area (site 15) was 59.2 dB. At 28 Lutego Street (site P4) in 2008-2009 the average noise level was 61.4 dB, while in 2015 (site 19) it was 63.1 dB. At Kardynała Wyszyńskiego Street (site P5) the level had increased from 65.9 dB in 2008-2009 to 66.7 dB (site 23) in 2015. A similar situation occurred in Jana Pawła II Street (site P6), where noise levels from 2008-2009 were 63.9 dB and in 2015 (site 25) they already reached 64.4 dB.

Sites P3-P6 are located in the vicinity of major roads and intersections and at some distance from transit routes no. 11, 20, and 172. Both in 2008-2009 and in 2015 the average daytime noise level here was 62.8 dB. These results fall within the permissible values (Dziennik Urzędowy 2014, poz. 112). It should be noted that both on business days and on Saturdays the values exceed the permissible standards by 1.9 dB and 0.3 dB respectively.

In 2009, the Voivodship Environmental Protection Inspection in Szczecin carried out long-term measurements of traffic noise in Szczecinek at two sites, on the common section of national roads No. 11 and 20, at Cieślaka and Sikorskiego streets (Przybycin et al., 2010; WIOŚ, 2010). These measurements were taken using automated stations for monitoring noise

by means of continuous measurement. For the site at Cieślaka Street (Fig. 2, site W1) the long-term average sound level was recorded at 68.0 dB. At the site at Sikorskiego Street in 2009 the average long-term noise level was 69.6 dB (Fig. 2, site W2). In 2015, at sites 7, 8, and 10, the average noise level was also 69.6 dB and it exceeded the permissible standard by 4.6 dB.

The overall level of traffic noise is affected by the volume of traffic, the speed of vehicles and the share of heavy trucks in the total flow. In the case of Szczecinek, transit-related traffic is both the main nuisance and the chief source of transport-related noise. In the coming years, it is likely that the acoustic conditions in the city will improve due to the construction of the beltway. One way to reduce noise and improve safety is also to ensure a sufficiently low vehicle speed. It is necessary to take comprehensive measures, including appropriate marking of roads and introduction of physical traffic calming measures, such as elevated intersection surfaces, and elevated central lanes. The use of traffic calming measures within the former transit routes in Szczecinek will help to reduce noise from traffic, improve the safety of users and the comfort of living of residents of the areas in the immediate vicinity of traffic routes. However, simply calming the traffic without reducing its intensity will not significantly reduce traffic noise in the center of the city. The results presented in this article confirm the need to reduce noise and the advisability of building a beltway on the outskirts of the city.

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## References

- EEA, 2000. Are we moving in the right direction? Indicators on transport and environmental integration in the EU: TERM 2000. Environmental issue report No 12. Indicator 4: Traffic noise: exposure and annoyance. Copenhagen. Denmark.

- EEA, 2014. Noise in Europe 2014. European Environment Agency. EEA Report No. 10/2014, <http://www.eea.europa.eu/publications/noise-in-europe-2014>.
- GPR, 2001. Generalny pomiar ruchu w 2000 roku. Średni dobowy ruch w punktach pomiarowych w 2000 roku. [https://www.gddkia.gov.pl/userfiles/articles/g/GENERALNY\\_POMIAR\\_RUCHU\\_2000/0.1.3.2\\_SDR\\_w\\_pkt\\_pomiarowych\\_w\\_2000\\_roku.pdf](https://www.gddkia.gov.pl/userfiles/articles/g/GENERALNY_POMIAR_RUCHU_2000/0.1.3.2_SDR_w_pkt_pomiarowych_w_2000_roku.pdf) [In Polish].
- GPR, 2006. Generalny pomiar ruchu w 2005 roku. Średni dobowy ruch w punktach pomiarowych w 2005 roku. [https://www.gddkia.gov.pl/userfiles/articles/g/GENERALNY\\_POMIAR\\_RUCHU\\_2005/0.1.2.2\\_SDR\\_w\\_pkt\\_pomiarowych\\_w\\_2005\\_roku.pdf](https://www.gddkia.gov.pl/userfiles/articles/g/GENERALNY_POMIAR_RUCHU_2005/0.1.2.2_SDR_w_pkt_pomiarowych_w_2005_roku.pdf) [In Polish].
- GPR, 2011. Generalny pomiar ruchu w 2010 roku. Średni dobowy ruch (SDR) w 2010 roku. [https://www.gddkia.gov.pl/userfiles/articles/g/GENERALNY\\_POMIAR\\_RUCHU\\_2010/0.1.1.4\\_SDR\\_w\\_pkt\\_pomiarowych\\_w\\_2010\\_roku.pdf](https://www.gddkia.gov.pl/userfiles/articles/g/GENERALNY_POMIAR_RUCHU_2010/0.1.1.4_SDR_w_pkt_pomiarowych_w_2010_roku.pdf) [In Polish].
- GPR, 2016. Generalny pomiar ruchu w 2015 roku. Średni dobowy ruch roczny (SDRR) w punktach pomiarowych w 2015 roku na drogach krajowych. [https://www.gddkia.gov.pl/userfiles/articles/g/generalny-pomiar-ruchu-w-2015\\_15598//SYNTEZA/WYNIKI\\_GPR2015\\_DK.pdf](https://www.gddkia.gov.pl/userfiles/articles/g/generalny-pomiar-ruchu-w-2015_15598//SYNTEZA/WYNIKI_GPR2015_DK.pdf) [In Polish].
- Dziennik Urzędowy, 2007. Rozporządzenie Ministra Środowiska z dnia 14 czerwca 2007 r. w sprawie dopuszczalnych poziomów hałasu w środowisku. Dz.U. 2007 nr 120 poz. 826 [In Polish].
- Dziennik Urzędowy, 2011. Rozporządzenie Ministra Środowiska z dnia 16 czerwca 2011 r. w sprawie wymagań w zakresie prowadzenia pomiarów poziomów substancji lub energii w środowisku przez zarządzającego drogą, linią kolejową, linią tramwajową, lotniskiem lub portem. Dz.U. 2011 nr 140 poz. 824 [In Polish].
- Dziennik Urzędowy, 2014. Obwieszczenie Ministra Środowiska z dnia 15 października 2013 r. w sprawie ogłoszenia jednolitego tekstu rozporządzenia Ministra Środowiska w sprawie dopuszczalnych poziomów hałasu w środowisku. Dz.U. 2014 poz. 112 [In Polish].
- Dziennik Ustaw, 2001. Ustawa z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska. Dz.U. 2001 nr 62 poz. 627 [In Polish].
- Piątkowski P., Kraczkowski A., 2016. Road traffic flow influence on traffic noise emission in the city centre. *Autobusy. Technika, Eksploatacja, Systemy Transportowe* 196(6), 384-388 [In Polish with English abstract].
- Przybycin W., Witkowska J., Grek M., Ferfét M., 2010. Program ochrony środowiska dla miasta Szczecinek na lata 2010-2013 z uwzględnieniem lat 2014-2017. Załącznik do uchwały Rady Miasta Szczecinek nr XXIV/204/2012 z dnia 21 maja 2012 [In Polish].
- Rak D., Mikołajewska J., Makselon M., Drewnowski W., Kłyk B., 2010. Strategia Transportowa Miasta Szczecinek na lata 2010-2020. Szczecinek [In Polish].
- Rymarz J., Caban J., Drożdżel P., 2012. Research of noise emission and traffic in the city. *Zeszyty Naukowe Instytutu Pojazdów* 3(89), 127-133 [In Polish with English abstract].
- WHO, 2011, Burden of Disease from Environmental Noise. Quantification of Healthy Life Years Lost in Europe, WHO Regional Office for Europe: Copenhagen, Denmark. [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0008/136466/e94888.pdf](http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf).
- WIOŚ, 2010. Informacja o stanie środowiska w powiecie szczecineckim w 2009 roku [In Polish].
- Wójcicki T., Podedworna-Łuczak M., Pajewski P., Adamczyk-Gorzkowska A., Jermaczek A., Osadowski Z., Prac M., Hauler A., Sobczyk A., Ozdarska I., 2011. Raport o oddziaływaniu na środowisko dla przedsięwzięcia polegającego na dostosowaniu drogi krajowej nr 11 do parametrów drogi ekspresowej na odcinku Koszalin (S6) - początek obwodnicy m. Szczecinek od km 0+352 do km 67+205. Tom II, Część opisowa [In Polish].