ISSN: 1231-4005
e-ISSN: 2354-0133
ICID: 1133189
DOI: 10.5604/12314005.1133189

THE INFLUENCE OF ROAD TRANSPORT ON EMISSION OF TOXIC SUBSTANCES IN POLAND AGAINST THE EU COUNTRIES

Marianna Jacyna, Tomasz Ambroziak

Warsaw University of Technology, Faculty of Transport
Department of Logistics and Transport Systems
Koszykowa Street 75, 00-662 Warsaw, Poland
tel.:+48 22 2345855, fax: +48 22 2347582
e-mail: maja@wt.pw.edu.pl

Agnieszka Merkisz-Guranowska, Jacek Pielecha

Poznan University of Technology, Faculty of Machines and Transportation
Piotrowo Street 60-965 Poznań, Poland
tel.: +48 61 6652207, fax: +48 61 6652204
e-mail:merkisz-guranowska@put.poznan.pl

Ilona Jacyna-Gołda

Warsaw University of Technology, Faculty of Production Engineering
Institute of Organization of Production Systems
Narbutta Street 85, 02-524 Warsaw, Poland
tel.:+48 22 2348126, fax: +48 22 8499390
e-mail:jacyna.golda@gmail.com

Konrad Lewczuk, Dariusz Pyza, Mariusz Wasiak, Emilian Szczepański, Jolanta Żak

Warsaw University of Technology, Faculty of Transport
Department of Logistics and Transport Systems
Koszykowa 75, 00-662 Warsaw, Poland
tel.+48 22 2346017, fax: +48 22 2347582
e-mail: kle@wt.pw.edu.pl

Abstract

The paper is a result of research work carried out under the project EMITRANSYS for shaping ecological transport system. The paper presents selected aspects of emission and concentration of harmful compounds of exhaust gases generated by road transport. It also presents the share of harmful compounds emitted by road transport in comparison with the emission from other sectors of economy. Transport policy should encourage the usage of energy-efficient and less environmentally damaging modes of transport and their efficient use. The paper analyses the emissions of selected pollutants and their estimated contribution to the total emissions of road transport. It also presents selected aspects of the identification of areas with the highest emissions of harmful compounds in Poland against the European Union. This analysis provides a basis to identify the instruments to prevent and reduce pollution arising from transport activities. In particular, variable emission of selected components of fumes according to the velocity of passenger vehicle. the measured values for NO_2 concentration in the UE countries in 2011, the measured values for CO concentration in UE countries in 2011, the measured values for PM10 concentration in UE countries in 2011, the measured values for PM2.5 concentration in UE countries in 2011 are presented in the paper.

Keywords: *road transport, emission of harmful compounds, ecology of transport*

1. Introduction

Emissions originating from the transport are more harmful to humans then those resulting from industrial pollution, because impurities are spread by vehicles in close proximity to humans and at high concentrations at low altitudes. Air pollution [4] depends on many factors. These include fuel composition, engine characteristics and the standard of maintenance, type and basic characteristics of vehicle, deployment of infrastructure, rate and place of congestion, etc. During the combustion of fuel in the engines of motor vehicles many different volatile products and mechanical particles appear. Recently conducted researches on emission under real conditions present that levels of emission of harmful gaseous compounds [4, 8, 9], and solid particles [12], [13] is much higher than from industry. European Union directives focus mainly on particles that significantly contribute to the destruction of environment, health and global climate change.

The exhaust gases contain compounds harmful for living organisms like carbon monoxide (chad) – CO, hydrocarbons, including – THC, nitric oxide – NO_x, particulate matter (soot) – PM, which are governed by the exhaust EURO standards and NO_2 – nitrogen dioxide, SO_2 – sulphur dioxide, NMHC – non-methane hydrocarbons as well as harmful to the environment: CO_2 – carbon dioxide, CO_2E – equivalent carbon dioxide, NH_3 – ammonia, N_2O – nitrous oxide, CH_4 – methane.

The fundamental quantity stating ecological characteristics of vehicles is emission of pollutants, which is a derived from emission (the mass of pollutants) compared to the distance travelled by the vehicle. Pollutant emission is a function of velocity. It is assumed that the total emission of pollutants from motor vehicles in the area is the sum of emissions [7]:

– from engines heated to normal operating temperature,
– resulting from heating engines to normal operating temperature,
– related to evaporation of fuel from the fuel system of the vehicle.

Thus, the indicators should embrace the average speed for the road [17] as well as the unit emission levels of various pollutants per unit of distance (g / km) or energy (g / kWh) for CO, HC, NO_x, CO_2. In addition, the mass and concentration of particle matters of each type per unit of distance (g/km) or energy (g/kWh) depending on the type of fuel used or the type of vehicle propulsion should be taken into account. Fig. 1 presents the emission of selected exhaust gases components depending on the vehicle speed.

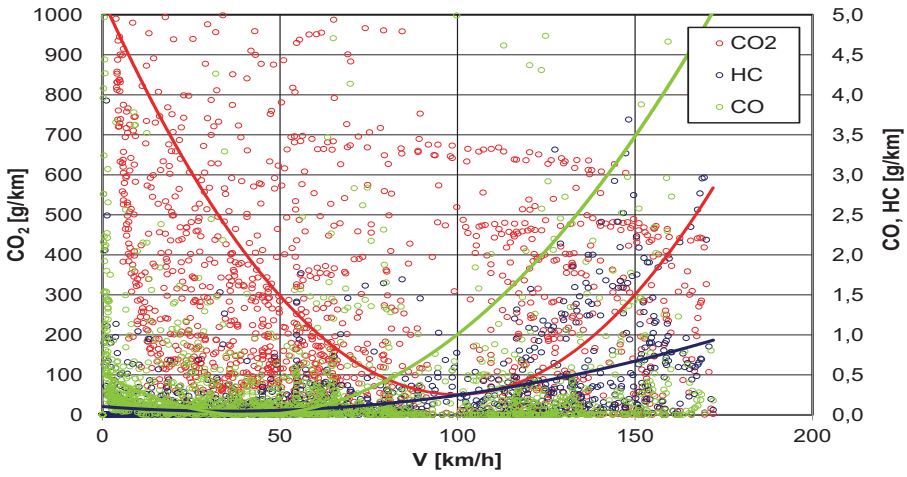

Fig. 1. Variable emission of selected components of fumes according to the velocity of passenger vehicle. Source: own research based on [18]

The article analyses the emissions of selected pollutants and their estimated contribution to the total emissions of road transport. It also presents selected aspects of the identification of areas with the highest emissions of harmful compounds in Poland against the European Union. This analysis

provides a basis to identify the instruments to prevent and reduce pollution arising from transport activities.

2. The share of emissions from road transport

Although the road infrastructure in Poland consumes about 3% of the country, about 50% of Poland stays in the area of direct impact of transport pollution [2]. In addition to road transport, other sources of air pollutant (resulting from the combustion of fuels) must be considered [7]:

- combustion processes in production and transformation of energy,
- combustion processes from outside of the industry,
- combustion processes in industry; production processes,
- mining and distribution of fossil fuels,
- the usage of solvents and other,
- other vehicles and equipment; waste management and agriculture.

To compare the share of road transport to other sectors, appropriate percentages were presented in Tab. 1.

Tab. 1. The share of sectors in national emission of NO_x, CO, PM, SO_2 in Poland in 2011 r

Source of emission	NO_x		CO		PM_{10}		$PM_{2.5}$		SO_2	
	[Mg]	%	[Mg]	%	[Mg]	%	[Mg]	%	[Mg]	%
Total	850 745	100.00	2 915 783	100.00	257 391	100.00	138 857	100.00	910 045	100.00
Combustion processes in production and transformation of energy	275 663	32.40	62 401	2.14	24 204	9.40	17 921	12.91	479 667	52.71
Combustion processes from outside of the industry	88 242	10.37	1 789 513	61.37	134 705	52.33	61 144	44.03	243 565	26.76
Combustion processes in industry	74 761	8.79	253 840	8.71	19 604	7.62	10 996	7.92	180 240	19.81
Production processes	15 877	1.87	31 079	1.07	15 007	5.83	7 296	5.25	4 966	0.55
Mining and distribution of fossil fuels	-	-	-	-	6 965	2.71	696	0.50	-	-
The usage of solvents and other	-	-	-	-	1 952	0.76	1 952	1.41	-	-
Road transport	**282 235**	33.18	**674 995**	23.15	**26 655**	10.36	**23 853**	17.18	**1 345**	0.15
Other vehicles and equipment	101 850	11.97	86 203	2.96	9 689	3.76	9 689	6.98	184	0.02
Waste management	1 362	0.16	17 751	0.61	7 836	3.04	4 819	3.47	79	0.01
Agriculture	10 755	1.26	-	-	10 773	4.19	490	0.35	-	-

Source: own research based on [13]

The harmful substances like CO (carbon monoxide), NO_x (nitrogen oxides), PM (particulate matter PM_{10} and $PM_{2.5}$) were chosen to analyse due to the fact that the amount of their emissions are regulated by Euro standards. Sulphur dioxide SO_2 is presented in order to show that the share of road transport in its emissions is negligible.

Analysing participation of harmful emissions from road transport in relation to total emissions

in Poland against the EU countries reveals that Poland has 19th place due to CO emission, 25th place due to NO_x emissions, 20th and 16th place due to emission of particulate fractions PM_{10} and $PM_{2.5}$, and 24th place due to SO_2 emission (Tab. 2).

Tab. 2. The contribution of particular pollutants from road transport in relation to total emissions in 2011 [%]

UE country	The contribution of pollutants from road transport in relation to the total emissions in 2011 [%]				
	Oxides of carbon (CO)	Nitrogen oxides (NO_x)	Particular matters		Oxides of sulphur SO_2
			PM_{10}	$PM_{2.5}$	
Austria	22.3	59.5	19.8	21.8	0.7
Belgium	14.7	49.9	28.9	31.5	0.2
Bulgaria	54.5	51.3	12.5	0.7	0.1
Cyprus	71.5	41.4	18.3	23.9	0.5
Czech Republic	40.8	33.6	22.6	31.4	0.4
Denmark	24.8	37.0	11.4	10.4	0.6
Estonia	11.2	34.5	3.8	3.2	9.1
Finland	36.5	30.8	12.1	18	0.2
France	15.6	55.2	11.3	11.8	0.4
Greece	60.3	38.0	no data	no data	0.3
Spain	14.8	39.1	23.4	26.4	0.2
Holland	51.2	41.4	26.0	33.7	0.8
Ireland	54.5	48.9	25.0	29.7	0.3
Lithuania	38.9	60.8	22.1	22.5	13.5
Luxembourg	no data	38.9	no data	no data	1.9
Latvia	3.3	40.5	4.5	1.6	0.5
Malta	94.0	30.9	56.5	78	0.1
Germany	33.6	42.1	18.9	23.7	0.3
Poland	**23.15**	**33.18**	**10.4**	**17.18**	**0.15**
Portugal	20.3	42.9	6.3	6.6	0.8
Romania	26.1	48.8	6.3	0.7	0.1
Slovakia	25.1	47.2	9.4	8	0.4
Slovenia	29.4	55.3	12.1	11.5	0.4
Sweden	27.7	45.9	28.9	24.3	0.4
Hungary	67.3	60.6	31.1	29.6	0.4
Great Britain	43.9	34.9	24.3	29.4	0.3
Italy	43.4	53.8	21.2	21.6	0.3

Source: own research based on [5]

3. The level of concentration of harmful compounds of exhaust gases in Poland and in the EU countries

All documents stating the position of European Union and Poland on transportation include the concept of the so-called sustainable transport. For example, the Constitution of Poland contains the statement "The Republic of Poland shall ensure protection of the environment, guided by the principle of sustainable development of transport". Sustainable transport system is one that provides a balance between social and economic factors and the development of spatial and environmental protection in the country. This means that the development of the transport system cannot be based only on the consideration of economic or social factors, but must include environmental protection issues. This implies a commitment to the integration of environmental objectives of transport sector with the tasks of economic development.

Chief Inspector of Environmental Protection (Główny Inspektor Ochrony Środowiska), in

accordance with art. 2 of the Law on Inspectorate of Environmental Protection, is responsible for coordinating Polish co-operation with European Environment Agency – EEA. The European Environment Agency was established as a legally independent entity of the community by Council Regulation (EEC) No 1210/90 on the establishment of the European Environment Agency and the European Network Environment Information and Observation Network (EIONET).

The Agency's objective is to promote sustainable development and help achieve significant and measurable improvement in Europe's environment through the provision to decision-making centres and to the public relevant and reliable information on the environment [5]. This is not an easy task; the more that the development of transport infrastructure requires not only appropriate decisions in this regard but mainly large financial outlays. According to the Polish transport policy, documents the main problems that must be solved for 2020 include[1]:

- congestion, especially on national roads and in large urban areas;
- growing negative impact on the environment and civilization;
- health hazard in transport, especially in road transport;
- poor condition of technical infrastructure, especially the roads;
- low productivity and low competitiveness of railway;
- risks arising from market opening.

The EEA has published in 2013 a report on the air quality in Europe. The graphs on Fig. 2-5 show the measured values of emissions across the EU, with regard to acceptable levels.

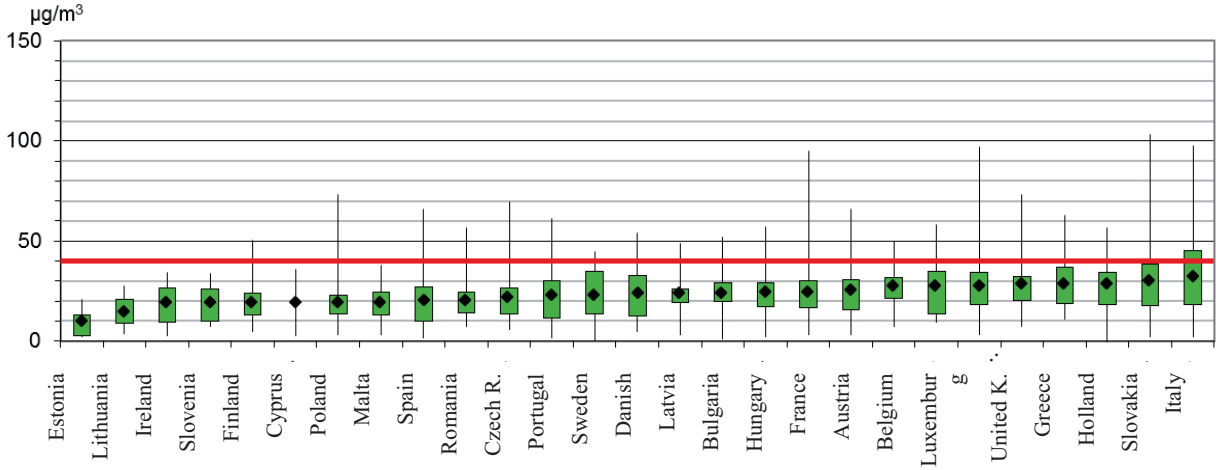

Fig. 2. The measured values for NO_2 concentration in the UE countries in 2011 [5]

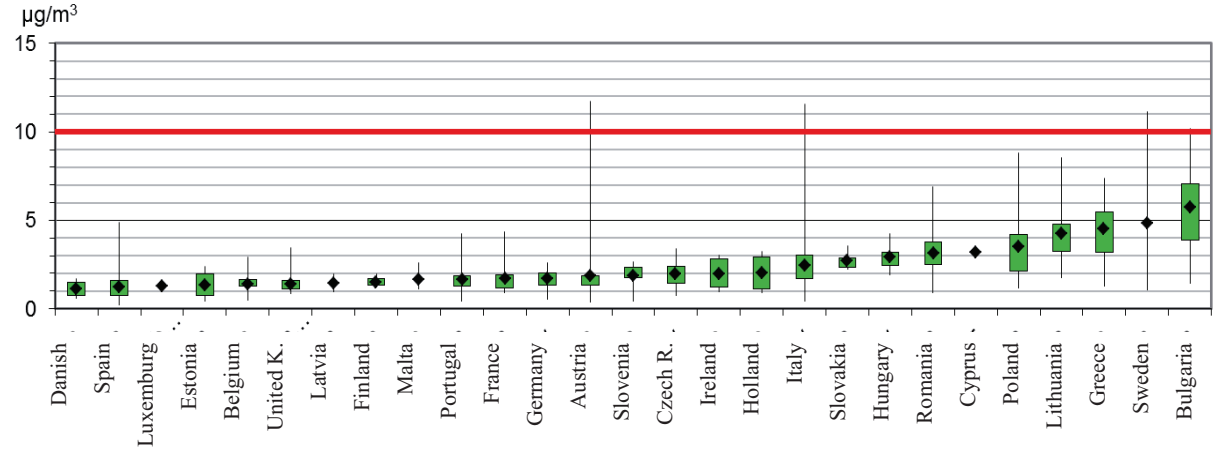

Fig. 3. The measured values for CO concentration in UE countries in 2011 [5]

[1] Transport Policy for the years 2005-2020, 2001-2015 National Transport Policy for Sustainable Development.

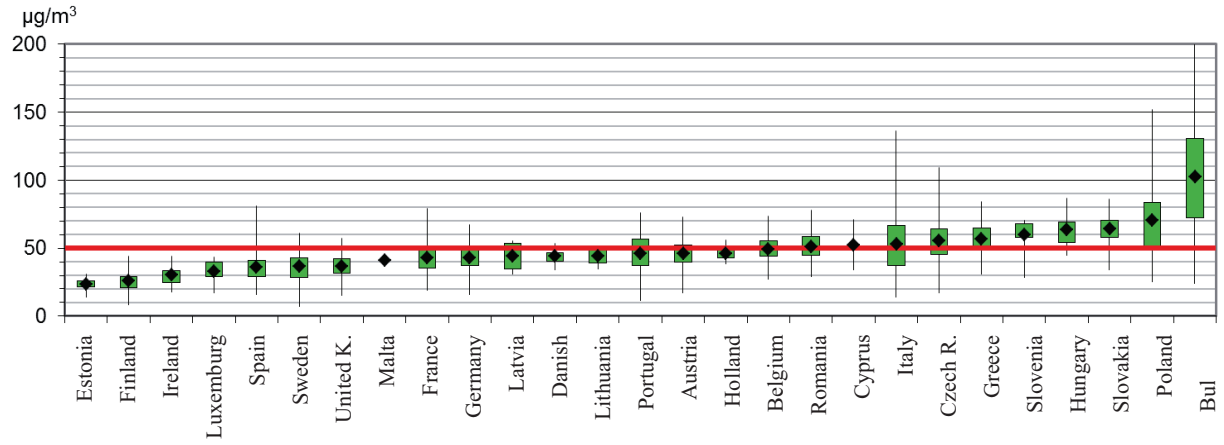

Fig. 4. The measured values for PM10 concentration in UE countries in 2011 [5]

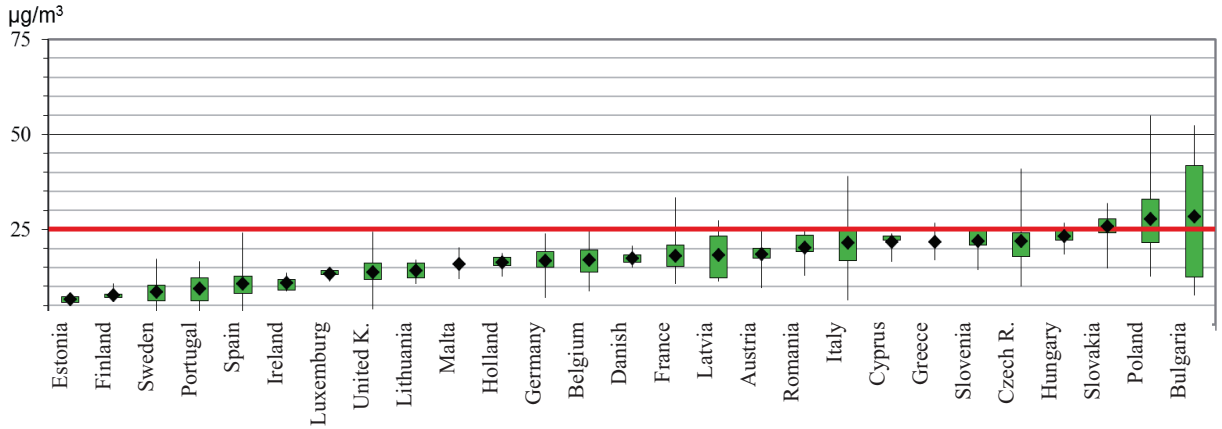

Fig. 5. The measured values for PM2.5 concentration in UE countries in 2011 [5]

The report prepared by the European Environment Agency (EEA) shows that average number of days in Krakow, where the acceptable level of PM_{10} (50 mg/m^3) was exceeded is 150.5, in Nowy Sącz – 126, in Tarnow – 82 while the European Union allows only 35 days in a year with exceeded particulate matter PM_{10} standard. Selected cities in Poland where standards are exceeded are shown in Fig. 6.

4. Conclusions

Transport policy should encourage use of energy-efficient and less environmentally damaging modes of transport and their efficient planning. Moreover, it should take steps to apply and enforce standards for exhaust and noise emissions for vehicles.

Exceeding the permissible concentrations in Poland against the EU was observed for PM_{10} and $PM_{2.5}$. In the case of $PM_{2.5}$ value of maximum concentration measured in Poland was the highest in Europe. NO_2 concentration exceeded the permissible value in five areas: Częstochowa, Wrocław, Warsaw agglomeration, Cracow and Silesia conurbation. Since the share of road transport in total emissions of this substance is up to 33.18%, it can be concluded that one of the reasons for exceeding the limit of this compound is an intense traffic in large cities.

Therefore, in these areas it is proposed to introduce so-called *low emission zones* or areas with enter restricted only for vehicles that meet certain emission standards or charging for entry depending on EURO standards. The introduction of such zones will be used to improve the quality of air and the motivation of the public to buy more environmentally friendly vehicles.

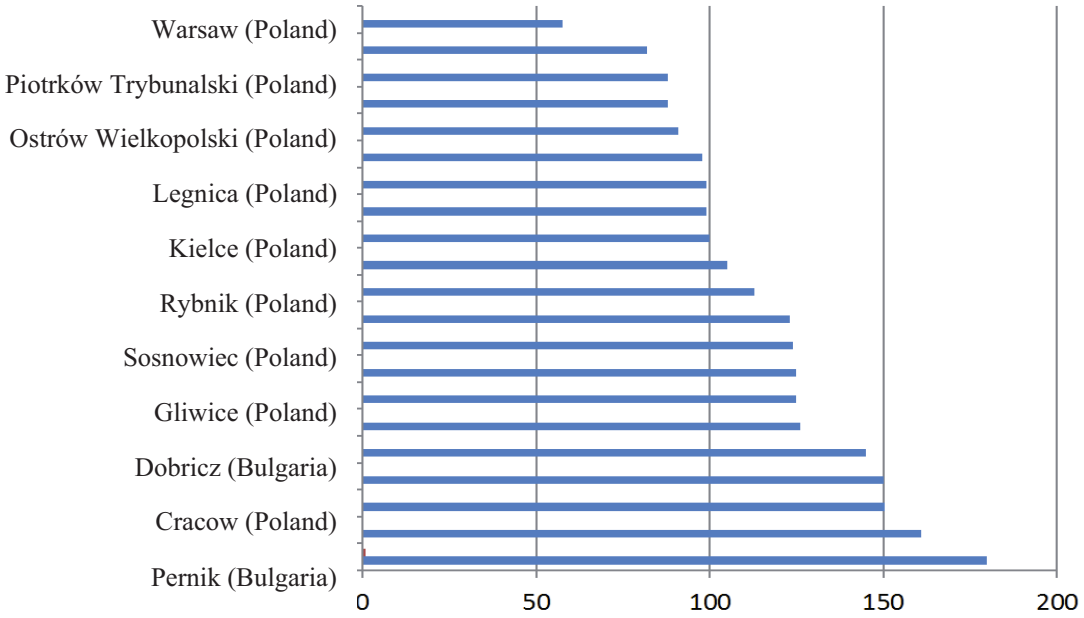

Fig. 6. Selected cities in Poland and Bulgaria, where limit value for PM10 has been exceeded [5]

Acknowledgement

Article was prepared as a part of research project "Proecological transport system designing" (EMITRANSYS), funded by the National Centre for Research and Development in Poland.

References

[1] Ambroziak, T., Gołębiowski, P., Pyza, D., Jacyna-Gołda, I., Merkisz-Guranowska, A., *Identification and analysis of parameters for the areas of the highest harmful exhaust emissions in the model EMITRANSYS*, Journal of KONES Powertrain and Transport, Warsaw 2013.

[2] Badyda, A., *Zagrożenia środowiskowe ze strony transportu*, NAUKA, PAN, 4, s. 118, 2010.

[3] Danklefsen, N., (red), *Obliczanie kosztów zewnętrznych w sektorze transportu*, Parlament Europejski, Bruksela 2009.

[4] Engeljerhinger, K., *Automotive emission testing certification, past, present and future*, 2nd International Exhaust Emissions Symposium, Bielsko-Biała 2011.

[5] European Environment Agency (EEA): Air quality in Europe, www.eea.europa.eu, report, No. 9, 2013.

[6] Główny Inspektor Ochrony Środowiska, Europejska Agencja Środowiska w roku 2012, Udział Polski w realizacji zadań.

[7] Krajowy Ośrodek Bilansowania i Zarządzania Emisjami (KOBiZE), *Krajowy bilans emisji SO_2, NO_x, CO, NH_3, NMLZO, pyłów, metali ciężkich i TZO za lata 2010 – 2011 w układzie klasyfikacji SNAP*, Raport syntetyczny, http://www.kobize.pl.

[8] Merkisz, J., Jacyna, M., Merkisz-Guranowska, A., Pielecha, J., *Exchaust emissions from models of transport under actual traffic conditions*, Energy production and management in the 21st Century (red. Brebbia, C. A., Magaril, E. R., Khodorovsky, M. Y.), Vol. 190, WIT Press, Southampon 2014.

[9] Merkisz, J., Andrzejewski, M., Pielecha, J., *Porównanie emisji dwutlenku węgla w rzeczywistych warunkach ruchu pojazdu z wartościami uzyskiwanymi w teście homologacyjnym na tle norm europejskich*, Combustion Engines, No. 3, s. 1-9, 2011.

[10] Przybyłowski, A., *Strategia zrównoważonego rozwoju transportu w polityce Unii Europejskiej,* Ekonomia i Środowisko, Nr 1 (39), s. 81-91, 2011.
[11] Steiningier, N., *Automotive particulate emissions in European legislation: state of the art and developments to come*, 13th ETH Conference on Combustion Generated Particles, Zurich 2009.
[12] Zbiór aktów legislacyjnych, http://europa.eu/legislation_summaries/environment.