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SERBIAN ROAD TRANSPORT AND POLLUTANT EMISSIONS: AN INDICATOR BASED REVIEW AND COMPARATIVE ANALYSIS

Ivana Kecman[1], Katarina Antić[2], Marija Babić[3], Vesna Pavelkić[4]
[1, 2, 3, 4] Institute Kirilo Savic, Vojvode Stepe Street 51, 11000 Belgrade, Serbia

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Abstract: Road transport has contributed significantly to increasing air pollution in Serbia. This paper deals with characteristics of road transport in Serbia examined from the aspect of its contribution to overall air pollution. This is done by comparative analysis of changes in amounts of air pollution substances produced by road traffic in Serbia and in EEA-32 countries, in a last two decades. The goal of this paper is to examine the causes for current situation in road transport in Serbia in terms of air pollution and attempt to identify some of the most important measures that have contributed to transport related air pollution reduction in EEA-32 countries. This paper also attempts to give brief review of the level of inventorying and reporting of transport related emissions in Serbia and emphasize the importance of establishing and maintaining accurate and reliable transport related emission databases.

Keywords: road transport, pollutant emissions, core set indicator, environmental trends in Serbian transport sector, EEA-32, inventorying and reporting.

1. Introduction

Among several other environmental problems, air pollution is one of the most serious, heaving significant harmful effects on public health and the environment as a whole. As air pollution had a very low priority on political agenda in the past, so far not enough has been done to control air pollutant emissions (Fiala et al. 2011). The Kyoto Protocol, under the United Nations Framework Convention on Climate Change (UNFCCC) as well as Convention on Long-range Trans-boundary Air Pollution (CLTRAP) are in place to curb climate change, acidification, air pollution from human activities including transport.

World Environmental crisis, whose first indications began to occur in 60s of the last century, was a result of intensive growth and development of science and technology. Transport, whose development proceeded development of industry and technology, had contributed to improvement of human life conditions but also had various damaging effects on the environment. Efficient, modern and flexible transport system is, however, essential for economic activity, development and quality of life (EEA, 2000). The sustainable development strategy aims for the continuous improvement of quality of life for current and future generations. In accordance with objectives of sustainable development the reductions of pollutants emission and energy consumption, reduction of negative impact on the environment became the pledge. Developing policies that integrate environmental and other sustainability concerns into transport decision-making and related policies are the key to finding a balance between these seemingly opposing concerns.

[1] Corresponding author: ivana.kecman@iks.rs

Serbia as non-Annex I Party of the Convention UNFCCC has no quantified Green house gases (GHGs) emission reduction targets but is required to fulfill general obligations stipulated in the Convention and Protocol. Republic of Serbia accepted CLTRAP as legal successor from the Socialist Federal Republic of Yugoslavia (SFRY). So far, Republic of Serbia has not ratified any of the Protocols except the European Monitoring and Evaluation Programme Protocol (EMEP).

The emission inventory and reporting in Serbia is organized preferably by the Serbian Environmental Protection Agency (SEPA), which works under the Ministry of Environment, Mining and Spatial Planning (MoESP). The SEPA annually collects data from emission sources according to the Integrated Pollution and Prevention Control (IPPC) and Large Combustion Plants (LCP) Directives and European Pollutant Release and Transfer Register (E-PRTR) regulation. The sources are divided into industrial and energy sectors and include only stationary sources, while data on quantities of emitted pollutants from mobile sources (especially from transportation sector) are not collected.

The Republic Hydro meteorological Service of Serbia (RHMS) is responsible for the reporting of emission data to the EMEP/CLRTAP. The last report for the year 2007 (Fiala et al. 2011) includes only two sectors: Public electricity and heat production. This report covers only two pollutants (SO_2 and NOx) and only from stationary sources.

Relate to transport and its impact on air pollution, for EEA-32 member countries, there are a few comprehensive databanks available. The air pollutant emissions data viewer provides access of the data on emissions of air pollutants submitted to the LRTAP Convention by member parties. All these National emissions reports to the LRTAP Convention are copied to EEA and contained in the Annual EU LRTAP Convention emission inventory report 1990-2009. Some data on transport related emissions on the country level are also available in the World Bank databanks (Haghshenas and Vaziri, 2011).

In addition to these databanks, a number of papers and publications are attempting to quantify the environmental cost of transport and analyze its impact on the air quality (Colvile et al. 2000). Kummer examines heavy metal releases from the road transport in Europe by using country-specific data such as the diesel and gasoline fuel consumption per country, the content of lead in gasoline and diesel fuel and the share of different vehicle types (Kummer et al. 2008). When it comes to data on transport related emissions in Serbia, Papic have estimated emissions from road traffic in Serbia in a period from 1990 to 2009, (Papic et al. 2010). Djukic and Vukmirovic, and Pesic and Djokic, (Djukic and Vukmirovic, 2011), give some reviews of the impact of road transport on air quality in certain urban areas in Serbia (Pesic and Djokic, 2007).

This paper aims to analyze road transport system in Republic of Serbia today, by aspect of environmental sustainability. Special attention is paid to contribution of road transport system in Serbia to overall air pollution, trends analysis in pollutant emissions originating from road transport and mechanisms for tracking and their reporting. Overview of these changes in European Environment Agency member countries (EEA-32) is given in parallel to trend changes in road transport emissions in Serbia, with emphasis on measures for emission reduction undertaken in EEA-32 in order to meet European Union (EU) emission targets.

2. Methodology

Methodology is based on review and monitoring of changes in values of core set indicators in order to register the impacts of road transport system in Serbia on environmental and health performance, particularly to air pollution and climate change. Two core set indicators are selected from the list of The transport and environment reporting mechanism (TERM) set indicators, which directly reflect the impact of transportation system on air pollutant emissions and emissions of GHGs, Transport emissions of greenhouse gases (TERM 02) and Transport emissions of air pollutants (TERM 03) (EEA, 2011). TERM was set up by European Commission (EC) and EEA in order to facilitate progress gauging of integration of policies. The main aim of TERM is to monitor the progress and effectiveness of transport and environment integration strategies on the basis of a core set of indicators (EEA, 2000).

In indicator TERM 02, Total Greenhouse Gas emissions, CO_2, CH_4 and N_2O from transport, are analyzed. The indicator TERM 03 is based on the emission trend assessment of CO, CH_4, NH_3, NO_x, NMVOCs, SO_x and primary particulates.

One indicator is chosen from the list of EEA list of core set indicators of air pollution (APE005 Heavy Metals emission) (EEA, 2011). In EEA Core set of indicators guide, environmental indicators are defined as a measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time. Core set indicators are selected by the EEA from the list of environmental indicators as indicators that most precisely demonstrate EU policy priorities (EEA, 2003).

All selected indicators are based on data contained in official country reports on the national total and sector's emissions to EEA, EMEP/CLRTAP and UNFCCC. These indicators have been selected to monitor the impact of the stricter emission standards on the specific emissions of air pollutants for the road transport mode, and are expressed as percentage over the 1990 levels.

While it is the ambient concentration of pollution that affects people, regulators can only control emissions at the source. In some cases, the two are closely related. Carbon monoxide and sulphur dioxide disappear relatively quickly when emissions disappear. The relationship is much weaker in other cases: ozone and aerosols (which count in the readings of ultra fine particulate matter) are formed in the atmosphere depending on the concentrations of other pollutants, as well as wind patterns, sunlight, geography and temperature. Changes in emissions of the precursor pollutants may or may not affect regional concentrations, depending on how these other factors change at the same time.

3. Trend in Transport Related Emissions – an Indicator Based Review

3.1. Transport Emissions of Air Pollutants (TERM 03)

Air pollutant emissions from transport, while just one of the economic sectors from which emissions occur, contribute significantly to climate change, acidification, photochemical pollution (ground-level zone) and poor urban air quality (Colvile et al. 2000; Papic et al. 2010). Road transport, as well as other modes of transport, produces air pollution from the combustion of liquid fossil fuel, although relative amounts of these emissions varies, depending on the exact composition of the fuel and combustion conditions (Colvile et al. 2000).

The main pollutants important for transport sector emissions are: Particulate matter (PM), Nitrogen dioxide (NO_2), Carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), Ozone (O_3) and Sulfur dioxide (SO_2).

Each liter of consumed fossil fuel produces approximately 100 g of carbon monoxide, 20 g of volatile organic compounds, 30 g of nitrogen oxides, 2.5 kg of carbon dioxide and many other harmful and toxic substances such as compounds of lead (Papic et al. 2010). Contribution of transport sector to overall emissions of air pollutants differs for every air pollutant, as presented in Table 1.

In addition, various transport modes contribute differently to total transport related air emissions, with road transport being the biggest source of the majority of air pollutants as presented in Table 2.

Since 1990, in EEA-32 countries significant progress has been made in reducing the emissions of many air pollutants from the transport sector. In contrast, air pollutant emissions from transport sector in EEA-32 countries, situation in Serbia differs. Serbia is still facing challenges in meeting concentration limits set in EU legislation for air quality pollutants, where road transport in particular makes a large contribution to urban air quality.

To present information on the transport emissions of air pollutants in Serbia, published estimations of the amount of road transport related gaseous pollutants in Serbia in period from 1990 to 2009, were used. Emissions have been estimated by taking into account vehicle type, vehicle stock and technology, as well as, vehicle activities in the form of mileage on

Table 1

Contribution of Transport Sector to Total Air Pollutant Emissions in EEA-32 Countries (in %)

Air pollutants	**Carbon monoxide (CO)**	**Nitrogen oxides (NO_x)**	**Sulphure oxides (SO_x)**	**Particulate matter ($PM_{2.5}$)**	**NMVOC**
Non-transport sectors	66	44	83	75	82
Transport sectors	34	56	17	25	18

Source: EEA, 2011

Table 2

Contribution of Different Transport Modes to Overall Transport Related Air Pollutant Emissions in EEA-32 Countries (in %)

Air pollutants	**Carbon monoxide (CO)**	**Nitrogen oxides (NO_x)**	**Sulphur oxides (SO_x)**	**Particulate matter ($PM_{2.5}$)**	**NMVOC**
Transport modes					
Road transport non-exhaust	0.0	0.0	0.0	13.9	10.0
Road transport exhaust	91.1	55.3	1.1	42.4	72.6
Railways	0.5	1.78	0.3	0.5	1.0
Domestic shipping	4.5	7.13	11.1	4.5	10.0
International shipping	1.9	26.7	84.6	1.9	5.0
Domestic aviation	1.0	1.78	0.5	1.0	1.0
International aviation	1.1	7.13	2.4	1.1	2.0

Source: EEA, 2011

different road types and specific emission factors for different types of fuel (Papic et al. 2010).

These results, obtained from literature data on estimated quantities of air emissions of (CO, NO_x, VOC, PM, NH_3, SO_2, heavy metals) and GHGs (CO_2, N_2O, CH_4), (SEPA, 2010) produced by different categories of vehicles, were analyzed and utilized to assess air pollution trends in Serbia throughout the period from 1990 to 2009 (Fig. 1).

Emissions of all observed air pollutants increased in a period from 1990 to 2009, except emissions of CO and NMVOC. Emissions of SO2 in 2009 were for 2.41% higher comparing to emissions in 2008. Comparing to amounts emitted in 1990 SO2 emissions in 2009 increased for 61.171%.

Transport emission reduction in 1992, 1993 and 1999 comes because of social, political and economical crises in the country, when number of vehicles was significantly reduced.

Upward trend in transport related air emissions, especially increase of SO_2 emission is inconsistent to corresponding trend in air emissions in EU-32 (Fig. 2).

These relative changes in emissions of air pollutants from transport sector across EEA-32 countries shows decline for NO_X by 25 %, $PM_{2.5}$ by 27 %, SO_X by 37 %, CO by 75 % and NMVOCs by 77 %, in a period between 1990 and 2009 (EEA, 2011).

Analyzing presented data in Fig. 1 and Fig. 2, covering the period from 1990 to 2010 finds the annual concentrations of emitted air pollutants in Serbia are much greater than emitted air pollutants from transport sector across EEA-32 countries. Furthermore, the trends of air pollutants from transport sector in Serbia show continuous increase from year to year, started from 1999. Only emission of CO and NMVOCs show slightly decrease in 2009 (below index of 100) and keep that trend in 2010. Compared to the same data from EEA-32 countries, the percent of emitted pollutants are steel much more greater in Serbia.

3.2. Transport Emissions of Greenhouse Gases (TERM02)

Transport is responsible for around a quarter of EU greenhouse gas emissions making it the second biggest greenhouse gas-emitting sector after energy. Road transport accounts for more than two-thirds of EU transport-related greenhouse gas emissions and over one-fifth of the EU's total emissions of carbon dioxide, the main greenhouse gas (*EC,* EU Transport GHG: Routes to 2050, 2011). In no other sector have GHG emissions increased as rapidly between 1990 and 2009 in the 32 member countries of the EEA, as in transport sector (EEA Technical report 6/11, 2011).

Based on the data published in EEA TERM 11 Report in 2011 transport emits 24 % of all GHG emissions in the EEA member countries (Fig. 3).

Transport related CO_2 emissions represent 23% of overall CO_2 emissions from fossil fuel combustion. Global CO_2 emissions from transport have grown by 45% from 1990 to 2007, led by emissions from the road sector in terms of volume, and by shipping and aviation in terms of highest growth rates (OECD and IFT, 2010).

Speaking of Serbia, in a period from 1990 to 2008 different trends in transport related CO_2 emissions were noted (Djukic and Vukmirovic, 2011; Krstic-Furundzic and Djukic, 2009).

Total CO_2 emission in Serbia decreased during the period from 1990 to 2008 for 20%.

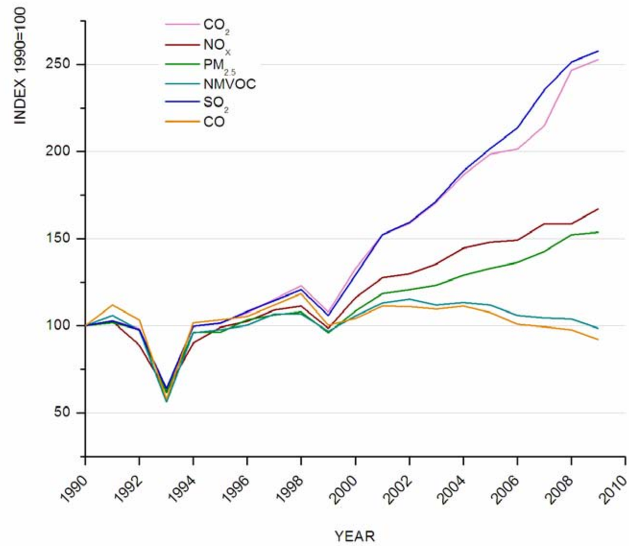

Fig. 1.
Trend in Emissions of Air Pollutants from Transport in Republic of Serbia
Source: SEPA, 2011; Calculations by Authors

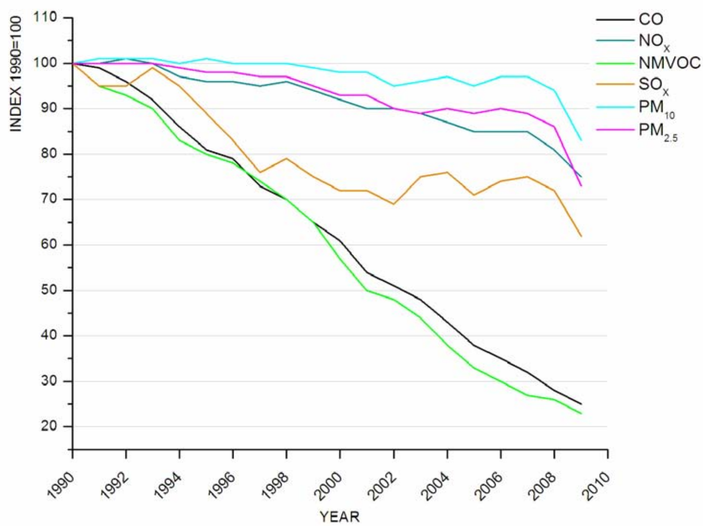

Fig. 2.
Trend in Emissions of Air Pollutants from Transport in EEA-32
Source: EEA, 2011; Calculation by Authors.

However, transport related CO_2 emissions have increased 36%, of which 26% of increase was from road transport, during the same period. These results were published in International transport forum report (OECD and ITF, 2010).

According to the data published by OECD and ITF in 2010, share of transport related CO_2 emissions in total CO_2 emissions in Serbia and contribution of road transport to overall CO_2 emissions emitted by transportation sector are presented on Fig. 4.

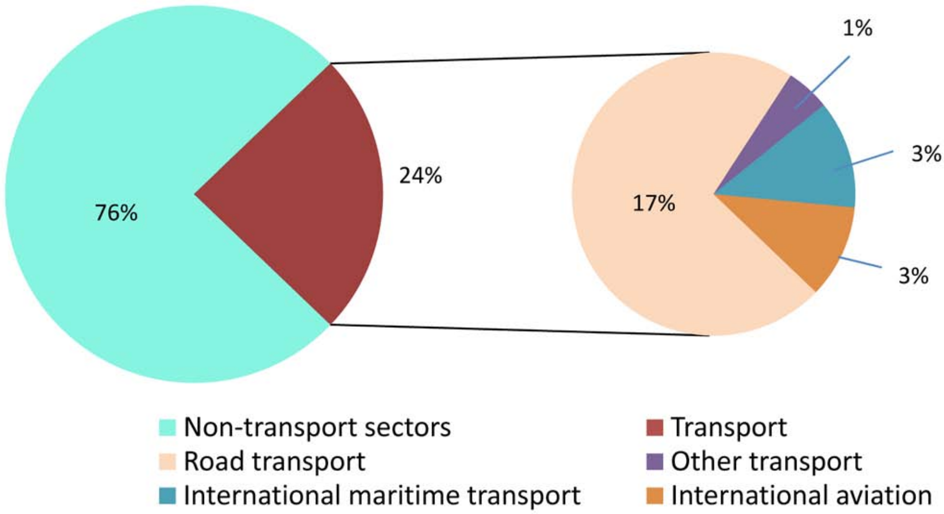

Fig. 3.
Transport Sector Contribution to Total GHG Emissions, 2009 (EEA-32)
Source: EEA, 2011; Calculation by Authors

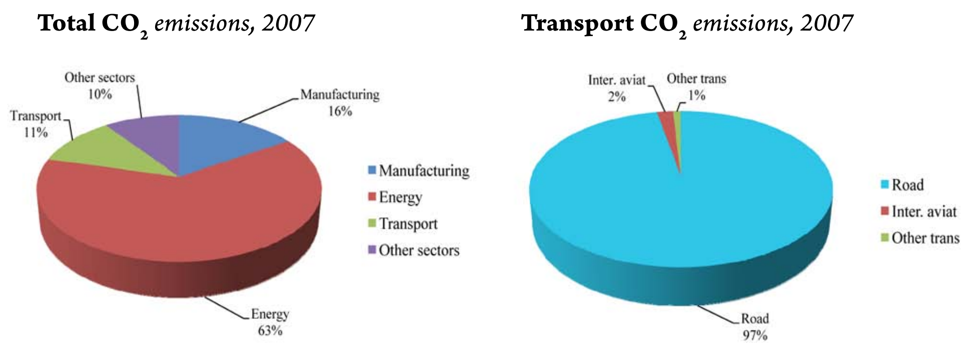

Fig. 4.
Share of Transport Sector in Overall CO_2 Emissions and Distribution of CO_2 Emissions by Mode in Serbia
Source: OECD and ITF, 2010

In 1990 transport related CO_2 emissions, amounted to 7.8% of total CO_2 emissions in Serbia. After that period, during the years of economic and political crises, downward trend is noticed until 2000 (1995: 6.4% and 2000: 5.6%). After 2000, because of economic growth, transport related emissions have increased, and in 2008 this emissions accounted to 13.4% of total CO_2 emissions in Serbia. Analysis shows that emissions of CO_2 in 2009 were for 2.71% higher comparing to emissions in 2008. Comparing to amounts emitted in 1990, CO_2 emissions in 2009 increased for 60.41%. (Papic et al. 2010; Djukic and Vukmirovic, 2011).

3.3. Heavy Metal Emissions (APE005)

Heavy metal (HM) emissions from road transport, especially lead, cadmium, chrome, nickel and arsenic, are main source of these pollutants in the atmosphere. High ambient concentrations of these metals can not only lead to environmental damage but also to a variety of adverse health effects such as the damage of body organs and cancer (Roorda-Knape et al. 1998; Hoek et al. 2002; Järup, 2003; Kummer et al. 2008).

Heavy metal emissions (APE005), as a core set air pollution indicator tracks trends since 1990, and is not limited only on transport related emissions but compromise all anthropogenic emissions of heavy metals. This indicator tracks changes of lead, mercury and cadmium in anthropogenic related air emissions across the EEA-32.

This paper deals only with transport related emissions of lead and cadmium from road traffic in Serbia, in a period from 1990 to 2009.

Once again, trend in transport related heavy metal emissions (in particular cadmium and lead) in Serbia in period from 1990 to 2009 is presented at Fig. 5. Since contribution of road traffic to overall mercury emissions is significantly small, trends of mercury emissions in Serbia are not elaborated within this paper.

Comparing to emitted amounts of lead in 1990, emissions in 2009 increased for 64.17%. Emissions of cadmium increased for 60% in comparison to emissions in 1990 (Papic et al. 2010).

The atmospheric levels of cadmium and lead are generally low in Europe with few overflows of limit or target values (EEA Technical report 11/12, 2011).

Across the EEA-32 countries, emissions of lead have decreased by 88% and cadmium by 56% between 1990 and 2007 (EEA, 2011). This reduction has been made by combination of specifically targeted legislation and improved controls and abatement techniques in car industry.

The promotion of unleaded gasoline within the EU-32 through a combination of fiscal and regulatory measures has particularly contributed to these reductions. EU Member States have completely phased out the use of leaded gasoline in 2000, a goal that was regulated by Directive 98/70/EC. From being the largest source of lead in 1990 when it contributed to more than 70% of total emissions, emissions from the road transport sector decreased since then, by more than 95%. However, road transport sector remains a significant source of lead, contributing around 25% of total lead emission in the EEA-32 region (Fig. 6).

In 2011 Serbia has still not ratified Arhus Protocol on Heavy Metals (to the 1979 UNECE Convention on Long-range Trans-boundary Air Pollution) and has no obligation

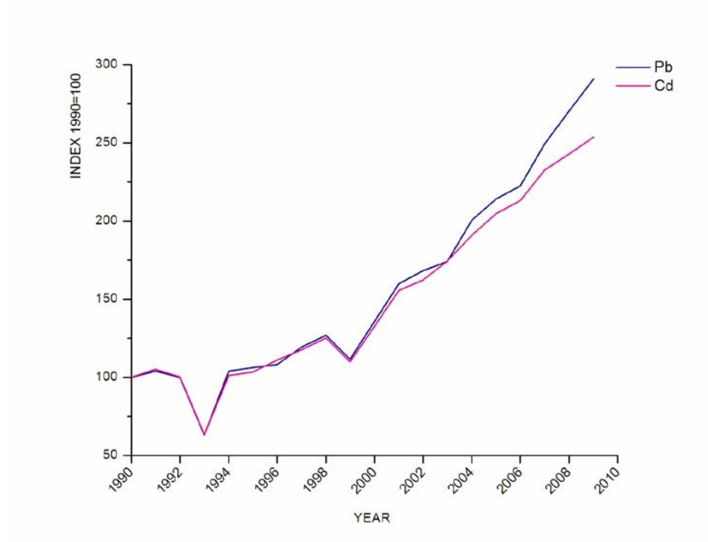

Fig. 5.
Trend in Emissions of Heavy Metals (Lead and Cadmium) from Transport in Republic of Serbia
** Data from Papic et al. (2010) were used to assess air pollution trends*
Source: SEPA, 2011; Calculation by Authors

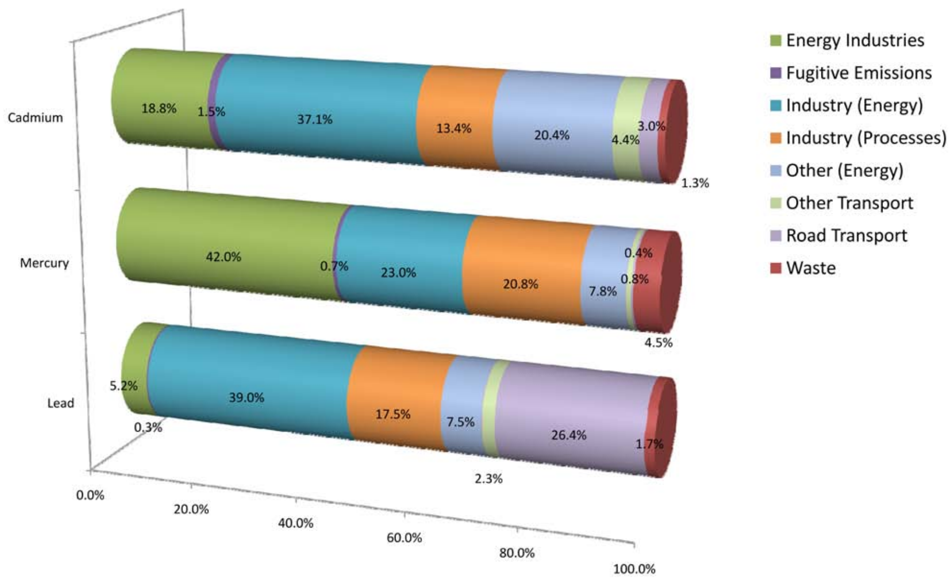

Fig. 6.
Sector Split of Emissions of Selected Heavy Metals (EEA Member Countries)
Source: EEA, 2011; Calculation by Authors

on targeting heavy metals emissions in air (State at November 2011) (UNESCE, 2011). Although heavy metals are substances for which emission reporting obligation exists under CLRTAP, they are still not included in emission inventorying and reporting to CLRTAP in Serbia.

4. Discussion

Emission of air pollutants originating from mobile sources is primarily determined by technology level applied to a vehicle, vehicle's technical condition, traffic intensity and density, fuel quality, local climate conditions, etc. (Pesic and Djokic, 2007).

In that sense, old vehicle fleet, constant increasing in number of vehicles, inadequate vehicle maintenance, bad fuel quality, as well as, insufficient and badly maintained road network can be identified as main reasons for increasing trend in air emissions from transport sector and significant contribution of these emissions to overall air pollution in Serbia in a past two decades. As opposed to increasing trend in transport related emissions in Serbia, EEA-32 notices steady decline in air emission from transport sector. This downward trend is the result of increasing number of policy actions undertaken in Europe to specifically addressed issues concerning air pollution.

In EU, different legal mechanisms for air quality management related to traffic were used. The most significant were limiting or targeting values for ambient concentrations of pollutants, limits on total emissions (e.g. national totals), and regulating emissions from the traffic sector either by setting emissions standards (like EURO 1–6) or by setting requirements of fuel quality (WHO, 2000; EEA, 2011; Defra, 2010).

EU stopped using leaded gasoline in 2000, following the Directive 98/70/EC and its amendment (Directive 2003/17/EC).

Gasoline quality in Serbia is governed by Ordinance on Technical and Other Requirements for Liquid Fuel Oil Origin ("Official Gazette of RS", no. 64/11). This Ordinance defines the type and quality of the motor gasoline and diesel fuels on Serbian market. Production of leaded gasoline in Serbia finally stopped in August 2010, and in the same year, free import of fuels, which are compliant with EU Norms for unleaded gasoline (EN 228), and diesel fuel (EN 590) has been allowed in Serbia.

NIS "Petrol" oil refinery, the only oil company in Serbia, in 2010 has started with production of high quality gasoline and diesel fuels that fully meets quality requirements of European Norms EN 228 and EN 590. EU norms non-compliant fuels are still producing and these fuels still are sold in Serbia. Production as well as sale of these non-compliant fuels will finally cease in December 2012. In 2008 share of leaded gasoline in total fuel consumption in Serbia was only 11%, which is 35% less than in 2007 (Papic et al. 2010).

Over the past few years Liquefied petroleum gas (LPG) has been increasingly used as motor fuel in Serbia. In 2008 its consumption on Serbian market has increased dramatically and amounted the same as consumption of unleaded gasoline (Papic et al. 2010), which is consistent with trend in LPG usage in EU. Diesel fuel, however, is by far the most used motor fuel in Serbia (60.51% share in total fuel consumption in 2008) (Papic et al. 2010).

Fuels produced in Serbia are not made by co-blending of bio-fuels, although Energy strategy implementation Plan of Serbia in field of renewable energy sources state, that until 2012, bio-fuels must amount to 5.57% of total transport related fuel consumption. Implementation of these measures for promotion of bio-fuels usage in transportation sector has also become obligation after Serbia had ratified The Treaty on Energy Community under the Directive 2003/30/EC on the promotion of the use of bio-fuels or other renewable fuels for transport. Action plan for bio mass (Official Gazette of the RS, nr. 56/10) state that target bio fuels share in 2012 shall be achieved by introducing obligatory minimum 2,2% biodiesel content in diesel fuel. Production of bio-ethanol and bio-diesel in Serbia today, even thought is negligibly small, there are certain capacities for bio-fuel production.

When it comes to EU-27 countries, in 2009 most of these countries had not yet met the target (5,75 % bio-fuels share in total transport related fuel consumption until 2012) (EEA, 2011). However, some countries as Slovakia, Austria and France had made significant progress towards realization, or even fulfilled these objectives (EEA, 2011).

Besides consumption of low quality fuels until 2010, usage of inefficient and old vehicle fleet can be considered as one of the main reasons for high transport related emissions in Serbia. From 2005, vehicle that does not comply with EURO 3 Emission Standards cannot be imported into Serbia. However, estimations are that in Serbia 91% of vehicle fleet is over 11 years of age (UNEP, 2010). Today, because of world economic crises, purchase of new vehicles had slow down after 2009 and purchase and import of used vehicles increased.

Control of exhaust emission is the responsibility of the vehicle technical control, but so far vehicle tests were not very rigorous and the estimations are that large percent of vehicle fleet in Serbia is not technically correct. More strict requirements for technical control of vehicles will be introduced after the adoption of Ordinance on technical control of vehicles that was planned in 2011.

5. Conclusion

Vehicles today produce 80% less polluting substances than did vehicles in the 60s of the last century. However, transport related emission has dramatically increased due to the constant growth in number of vehicles today.

By the increase of vehicle, fleet Serbia is not different from the rest of the world. In a last decade, public and political awareness of the importance of environmental protection has considerably developed in Serbia. The public in Serbia became aware of the importance that clean air has on quality of living, especially in urban areas. Since 2002, Serbia has made significant progress in developing environmental and air quality management legislation. Yet much more needs to be done, particularly in the implementation of adopted legislation.

Aim of this paper was to present changes in transport related emissions in Serbia in a last two decades and to show in what way the introduction and implementation of different legislative measures, specially designed to address air pollution issues, contribute to reduction of environmental degradation. Improvement in vehicle technology had performed a key role in reducing the environmental impacts from road transport in last two decades in developed countries. Economic factors, are for sure, greatly responsible for condition of a vehicle fleet in Serbia, but many non-economic measures can still be done in order to contribute to reduction of air pollution from road transportation.

In EEA-32 after the lead has been phase out of gasoline, lead emissions from the road traffic have dropped remarkably. Effect of this measure in Serbia is yet to come in the following years.

Brief review of the obligations for inventorying and reporting, that Serbia has towards the ratified international conventions, show that inventorying of transport related emission in Serbia at this moment practically does not exist. However, there are some notable plans and programs for improvement of inventorying and reporting of transport related emissions. Accurate and reliable data on air pollution emissions from transport sector are necessary for further assessment of legal, technical and incentive measures that will contribute to reduction of air pollution.

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References

Colvile, R. N. et al. 2001. The transport sector as a source of air pollution, *Atmospheric Environment,* 35(9): 1537-1565.

Defra, 2010. Air Pollution: Action in a Changing Climate. Department for Environment, Food and Rural Affairs. Available from internet: <http:// www.defra.gov.uk>.

Directive 2003/30/EC.

Đukić, A.; Vukmirović, M. 2011. Walking as a Climate Friendly Transportation Mode in Urban Environment. Case study: Belgrade, *International Journal for Traffic and Transport Engineering,* 1(4): 214-230.

EC. 2011. Project EU Transport GHG: Routes to 2050. Available from internet: <http://www.eutransportghg2050.eu>.

EC. 2011. Sustainable development in European Union. Available from internet: <http://epp.eurostat.ec.europa.eu>.

EEA Technical Report 12/2011. 2011. Air quality in Europe. Available from internet: <http://www.eea.europa.eu>.

EEA Technical Report 6/2011. Greenhouse gas emissions in Europe: a retrospective trend analysis for the period 1990–2008.

EEA Technical Report 7/2011. 2011. Laying foundations for greener transport – TERM 2011. Transport indicators tracking progress towards environmental targets in Europe. Available from internet: <http://www.eea.europa.eu>.

EEA. 2000. EU TERM 2000. Are we moving in the right direction? Available from internet: <http://www.eea.europa.eu>.

EEA. 2003. EEA Core set of indicators. Available from internet: <http://www.eea.europa.eu>.

Fiala, J. et al. 2011. Air quality Protection in Serbia. Available from internet: <http://www.ekoplan.gov.rs>.

Haghshenas, H.; Vaziri, M. 2011. Urban sustainable transportation indicators for global comparison, *Ecological Indicators* 15 (2012): 115-121.

Hoek, G.; Brunekreef, B.; Goldbohm, S.; Fischer, P.; Van den Brandt, P. A. 2002. Association between mortality and indicators of traffic-related air pollution in the Netherlands: a cohort study, *Lancet*, 360: 1203-09. Available from internet: <http://image.thelancet.com/extras/01art7366web.pdf>.

ITF. 2010. Reducing transport Greenhouse Gas Emissions, Trends&Data. OECD/ITF. Available from internet: <http:// www.internationaltransportfoum.org>.

Järup, L. 2003. Hazards of heavy metal contamination. *Br. Med. Bull*. 68: 167-182.

Krstić-Furundžić, A.; Đukić, A. 2009. *Chapter XV: Serbia, In European Carbon Atlas: Low Carbon Urban Built Environment.* Cardif: The Welsh School of Architecture Cardiff University: 156-170.

Kummer, U. et al. 2008. Assessment of heavy metal releases from the use phase of road transport in Europe, *Atmospheric Environment,* 43(2009): 640-647.

Official Gazette of the RS, no. 56/10.

Papić, V. et al. 2010. Determination of the amount of air polluting substances originating from the road traffic using COPERT IV Model of European Environmental Agency, Institute of Traffic Engineering Faculty, Belgrade. Available from internet: <http://www.sepa.gov.rs>.

Pešić, R.; Đokić, D. 2007, Air Quality and vehicle fleet on citz of Kragujevac example, In Proceedings of the 2nd National life quality Conference. Available from internet: <http://www.cqm.rs>.

Roorda-Knape, M. C.; Janssen, N. A. H.; Hartog, J. J.; Harssema, H.; Brunekreef, B. 1998. Air pollution from traffic near major motorways, *Atmos Environ*, 32: 1921-30.

UNEP. 2010. Global Fuel Economy Initiative CEE and EECCA Regional Dialouge Session Discussion and Background Paper. Available from internet: <http://www.unep.org>.

WHO. 2000. Air quality guidelines for Europe, 2nd edn. Copenhagen, World Health Organization Regional Publications, European series 91.

DRUMSKI SAOBRAĆAJ U SRBIJI I EMISIJA ZAGAĐUJUĆIH MATERIJA: KOMPARATIVNA ANALIZA

Ivana Kecman, Katarina Antić, Marija Babić, Vesna Pavelkić

Sažetak: Drumski saobraćaj značajno doprinosi sve većem zagađenju vazduha u Srbiji. Ovaj rad se bavi karakteristikama drumskog saobraćaja prikazanim sa aspekta njegovog doprinosa na ukupno zagađenje vazduha u Srbiji. Prikaz je dat uporednom analizom promena koje su se u poslednje dve decenije odigrale u količinama emitovanih zagađujućih materija poreklom od drumskog saobraćaja u Srbiji i zemljama članicama EEA-32. Cilj rada je da se ispitaju razlozi koji su doprineli sadašnjem stanju drumskog saobraćaja u Srbiji, u smislu njegovog doprinosa zagađenju vazduha, i da se identifikuju neke od najznačajnijih mera koje su doprinele smanjenju ovih emisija u zemljama članicama EEA-32. Prikaz nivoa prikupljanja i izveštavanja podataka o emisijama zagađujućih materija u vazduh poreklom od drumskog saobraćaja u Srbiji je dat sa ciljem da se istakne značaj uspostavljanja i održavanja tačnih i pouzdanih baza podataka o ovim emisijama.

Ključne reči: drumski saobraćaj, emisije zagađivača, skup osnovnih indikatora, životna sredina, transportni sektor Srbije, tendencije, EEA-32, prikupljanje, izveštavanje.