

ENVIRONMENTAL POLLUTANTS EMISSION FROM PUBLIC TRANSPORT ASSESSMENT AND ANALYSIS IN VILNIUS CITY

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Abstract. The transport is one of the major air polluter. The transport sector accounts for about 75% of total pollutants in Lithuania. One of the most characteristic feature of environmental pollution from transport is that in particular pollution is the largest on the city streets, especially in densely populated and high-intensity areas of transport.

On the basis of emissions from internal combustion engine calculations, the emissions of carbon monoxide (CO), hydrocarbons (CH), nitrogen oxides (NO_x), sulfur dioxide (SO₂) and particulate matter (PM) emissions from Vilnius bus fleet vehicle engines were determined. It was found out that the largest pollutants are carbon monoxide and its emission is changing from 1,000 to 1,500 tons per year. In addition, in the article presented environmental pollution from public transport during the 2002-2009 year changing analysis in Vilnius city.

Vilnius bus fleet regularly updates its vehicles. Assessing the ecological situation in the city of Vilnius, now park is exploiting 100 average age buses and in the next year is planning to buy new gas-efficient buses. The authors present modelling way for determining the future influence of public transport on the environment according Vilnius bus fleet technical content.

Keywords: Vilnius bus fleet, air pollution, internal combustion engine, nitrogen oxides, carbon monoxide.

1. Introduction

Urban areas air pollution is different in summer and winter time. In summer the main sources is transport (motor and railway transport, aviation). It spreads about 82% of pollution, industry and energy by 14% of the pollution. In winter the municipal economy contributes to urban areas air pollution (up to 22%), and the pollution from vehicle is reduced (Klibavičius 2009).

The combustion gas from internal combustion engines (gasoline and diesel) composition depends on composition and quality of the fuel, engine mechanical condition and operating mode. Car fumes from vehicles have about 200 chemical compounds, many of which are harmful to the biosphere and humans. There are carbon monoxide, nitrogen oxides, hydrocarbons, aldehydes, soot, etc. However, not only car fumes from vehicles pollute the atmosphere. Also the engine crankcase gases and entering into environment from the fuel tank hydrocarbons pollute the atmosphere (Štreimikienė 2001).

Harmful substances entering into atmosphere can lead to climate change (greenhouse effect), acid rain, tropospheric ozone formation and photochemical smog for

mation. Transport is one of the main source of pollution, generates greenhouse gas emissions. In this case the main harmful substances are CO₂, N₂O and CH₄. Vehicle emissions performance of one-fifth of total emissions of harmful causing the greenhouse effect. Most of this process contributes to CO₂ gas. It part in this one-fifth amounts 97% (N₂O and CH₄ is 2.8% and 0.4% respectively). It appears that the transport still remains the largest source of pollution, particularly in terms of CO and NO_x emissions volumes (Klibavičius 2009). Vilnius public transport emits the part of all pollutants.

Clearly, in terms of transport pollution, to be assessed and in what part of town it goes, whether it is a residential area, industrial area or a out-of-town. It is also important as quickly resolves the pollutants in the area.

2. Description of Vilnius bus park technical structure

In order to satisfy social and economic needs of the population's Vilnius bus fleet regularly supplemented and updated its technical bases. Changes of buses number in 2002 - 2009 are presented in Figure 1.

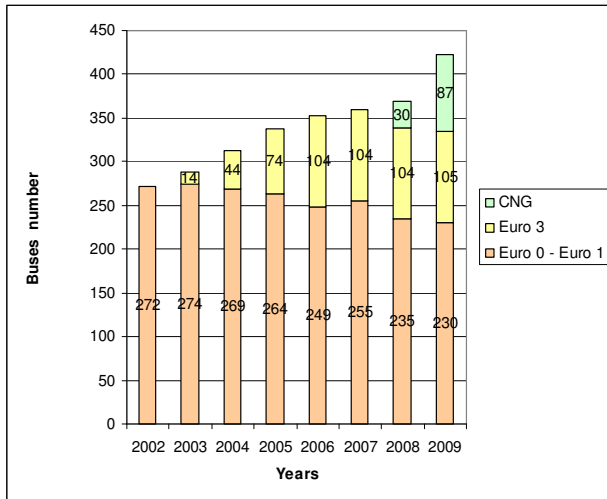


Fig 1. Buses number in Vilnius bus fleet in 2002–2009

There are reduced absolute and relative number of the buses that meet Euro 0 and Euro 1 standards. These standards regulate the composition of car exhaust gas, which depends on the technical condition of the engine. In new commercial vehicles a special catalytic system assembled to help achieve the standards. Since 2003 Vilnius bus fleet purchased Euro 3 standard buses. These buses are more environmentally-friendly. In addition, in 2008, Vilnius bus fleet started to appear the first compressed natural gas (CNG) powered buses. In 2008 purchased 30 buses and in 2009 purchased 57 buses an additional. In 2011 is planned to purchase 18 gas-powered buses. Natural gas - the cleanest cars currently used for fuel. Natural gas-fueled cars now emit less pollutants than those required by the standard Euro 5 and Euro 6 standards. Using these fuels instead of gasoline or diesel exhaust pollutants and particulate matter emissions reduced by 90%. In addition, compressed natural gas-fueled vehicles emit into the environment only 80% of greenhouse gases compared to petroleum-fueled cars.

Natural gas is the cleanest of the fossil fuels, and thus its many applications can serve to decrease harmful pollution levels from all sectors, particularly when used together with or replacing other fossil fuels. The natural gas industry itself is also committed to ensuring that the process of producing natural gas is as environmentally-friendly as possible.

3. Pollutants emission from Vilnius public transport internal combustion engines calculations

COPERT 4 estimates emissions of all major air pollutants (CO, NO_x, VOC (Volatile organic compounds), PM (particulate matter), NH₃, SO₂, heavy metals) produced by different vehicle categories (passenger cars, light duty vehicles, heavy duty vehicles, mopeds and motorcycles) as well as greenhouse gas emissions (CO₂, N₂O, CH₄). The programme also provides speciation for NO/NO₂, elemental carbon and organic matter of PM and non-methane VOC. Emissions estimated are distinguished in three sources: Emissions produced during

thermally stabilized engine operation (hot emissions), emissions occurring during engine start from ambient temperature (cold-start and warming-up effects) and VOC emissions due to fuel evaporation. Non-exhaust PM emissions from tyre and break wear are also included. The total emissions are calculated as a product of activity data provided by the user and speed-dependent emission factors calculated by the software (Gkatzoflias *et al.* 2006).

4. Results

Using COPERT 4 methodology of calculation the major environmental pollutants (CO, nitrogen oxides, volatile organic compounds, particulate matter, NH₃, heavy metals) and gases (CO₂, N₂O, CH₄) causing the greenhouse effect, emissions from the public transport bus engines are carried out. Emissions averages in 2002 - 2009 shown in the Figure 2.

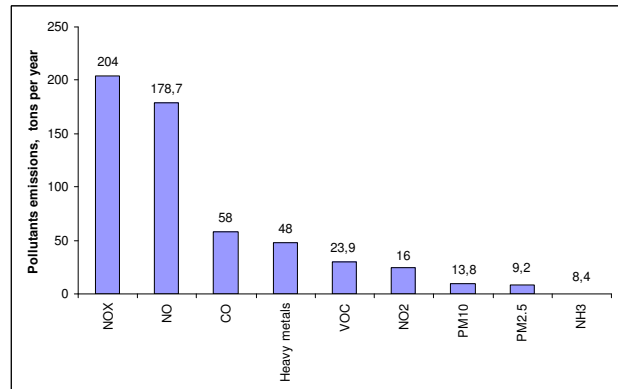


Fig 2. Pollutants emissions from Vilnius bus fleet vehicle engines averages in 2002–2009

The main anthropogenic source of nitrogen oxides are diesel engines. In Vilnius bus fleet the vehicles with engines of this type is the most. There is a high temperature and high pressure in these engines. Nitrogen oxides (NO_x) formed when molecular nitrogen combines with atmospheric oxygen in burning process in engines. The main product is nitric oxide (NO), a lower parts are nitrogen dioxide (NO₂) and other nitrogen oxides (NO_x). Assessment of absolute values, road transport is caused by emissions of CO (due to incompletely burned fuel). Assessment of absolute values, road transport is caused by emissions of CO (due to incompletely burned fuel). From the road transport to the atmosphere fell by almost 55% of all CO emissions. This has implications for the Vilnius bus fleet vehicle emissions. Its CO emission is about 58 tons per year.

Detrimental to the health of particulate matter (PM), primarily due to diesel engine operations (the latter issue in this regard is 30 or 70 times, compared with gasoline engines). These particles remain airborne for quite a long time and contribute to smog formation. This smog may have adverse effects on human health - cause respiratory and lung diseases (Poszyler-Adamska and Czerniak 2007; Bezchlebová *et al.* 2006; Jullien and Francois 2003.). For

evaporative emissions from vehicles released volatile organic compounds – hydrocarbons, benzapiren, aldehydes and other substances. Compared to gasoline and diesel fuel evaporation of VOCs from diesel stand out less. Gasoline has a high ability to vaporize its losses from 50 to 100 times higher than diesel fuel in the same environmental conditions. (Jučas 1992).

5. Pollution of heavy metals

Recently in the scientific and agricultural literature are often mentioned about pollution of heavy metals. It is a group of chemical elements with a density greater than 5 g/cm^3 (Kadūnas *et al.* 1999). Generally heavy metals are not found in the purity elements forms. Often heavy metals are in salt and other compounds form (Ašmenskas *et al.* 1997; Adomaitis and Antanaitis 2001; Pei and Chaolin 2008). Of the 100 or more elements about 80 can be attributed to metal group and three quarters of their - of heavy metals group. Biologically important and studied metals: cadmium, mercury, lead, zinc, chromium and copper (Ašmenskas *et al.* 1997; Adomaitis and Antanaitis 2003; Baltrėnas and Kliaugienė 2003; Baltrėnas *et al.* 2003; Baltrėnas *et al.* 2009).

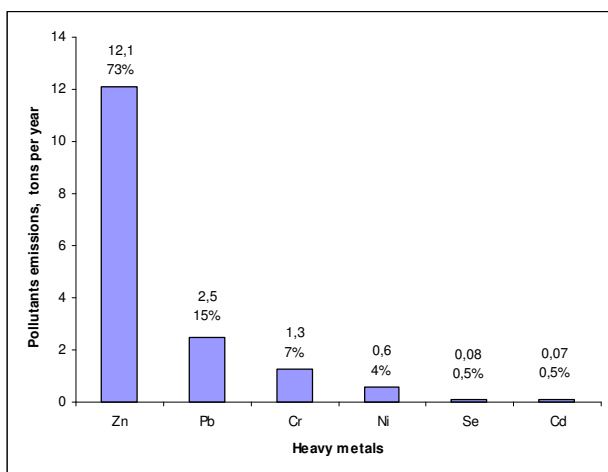


Fig 3. Heavy metals emissions from Vilnius city bus fleet vehicles averages in 2002–2009

As shown in Figure 3. the largest heavy metals content are Zn (73%), Pb (15%) and Cr (8%). Other heavy metals (Ni, Se, Cd) content is much smaller and generally of about 5%.

Heavy metals emission from public transport is limited, therefore its impacts on the environment and human health is low.

6. Changes of emissions from Vilnius city bus fleet vehicles in 2002 - 2009

The composition of the bus fleet is changing and purchased new buses of Euro 3 standard and compressed gas-powered buses. So emission of pollutants into the environment is changing every year. In Figure 4 shown trend of main pollutants emissions changes in 2002 – 2009.

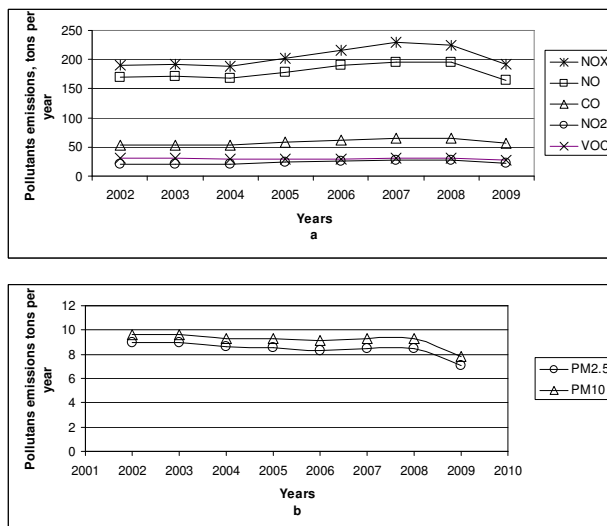


Fig 4. Changes of emissions from Vilnius city bus fleet vehicles in 2002–2009 (a. NO_x , NO, CO, NO_2 , VOC, b. $\text{PM}_{2.5}$, PM_{10})

Although the total number of buses years 2008 - 2009 increases, but after purchase of CNG buses, the emissions are reduced. This is due to the fact that CNG buses emit fewer pollutants.

7. Pollution of gases (CO_2 , N_2O , CH_4), causing the greenhouse effect

In Figure 5 shown air pollution of gases CO_2 , N_2O , CH_4 from Vilnius bus fleet vehicle

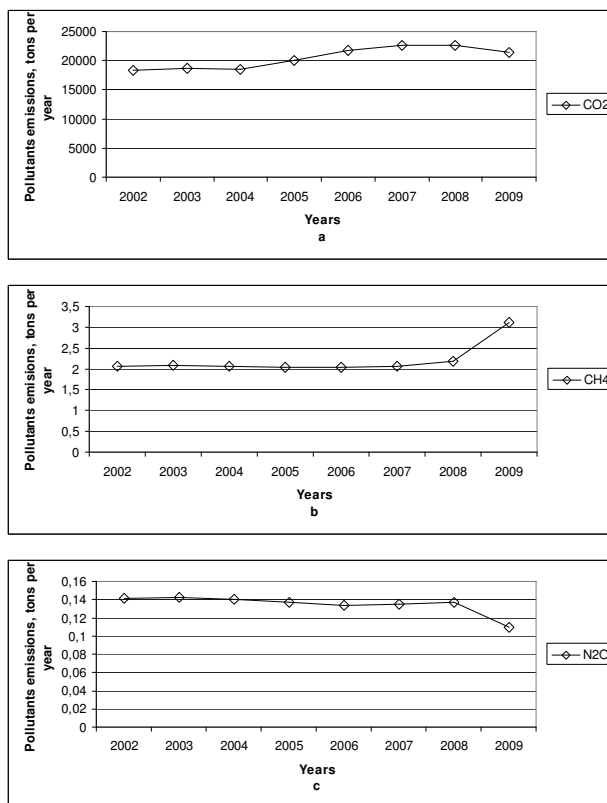


Fig 5. The air pollution gases CO_2 , N_2O , CH_4 from Vilnius bus fleet vehicle (a. CO_2 ; b. CH_4 ; c. N_2O)

As shown in Figure 5 after purchase of gas-powered buses, can be the air pollution CO₂, N₂O gases decrease. But due to incomplete combustion of fuel in CNG engines, increased pollution of methane CH₄.

8. Public transport pollutants emissions into environment in Vilnius city simulation

Vilnius bus fleet plans to acquire cost effective and less polluting environment gas-powered buses. Using the COPERT 4 methodology of calculation carried out how changes the emissions into the environment, if instead of 16 buses of Euro standards (Karosa B-741 and B-841 models), to travel around the city 16 CNG buses. Results are presented in Table 1.

Table 1. Pollutants emissions

Pollutants	Pollutants emissions, tons			
	CNG	Karosa B-741, B-841 (Euro 1)	Difference	Difference, %
CO	1,28	5,329	-4,049	-76,0
VOC	1,28	1,484	-0,204	-13,7
CH ₄	0,8875	0,1585	0,729	459,9
NO _x	3,2	18,26	-15,06	-82,5
NO	0	16,25	-16,25	0
NO ₂	0	2,008	-2,008	0
N ₂ O	0	0,01087	-0,0109	0
NH ₃	0	0,00272	-0,0027	-99,3
PM _{2.5}	0,05049	0,8582	-0,8077	-94,1
PM ₁₀	0,09899	0,9103	-0,8113	-89,1
CO ₂	1608	1761	-153	-8,7
Pb	0,1687	0,1702	-0,0015	-0,9
Cd	0,00069	0,00632	-0,0056	-88,6
Cu	1,398	2,35	-0,952	-40,5
Cr	0,06349	0,09164	-0,0282	-30,8
Ni	0,009429	0,04881	-0,0394	-80,7
Se	0,0008818	0,00664	-0,0058	-87,3
Zn	0,3617	0,983	-0,6213	-63,2

As the data of Table 1 show the compressed natural gas powered buses emissions are significantly lower. In particular decreased dangerous harmful to city and vehicles loaded streets pollutants as CO, nitrogen oxides, particulate matter and heavy metals. Only the pollutant methane (CH₄) releases, because it is the result of incomplete combustion of fuel.

Pollution from public transport is the part of the pollution from vehicle. Its level is particularly important for urban area, its air quality and soil and the quality of human life and health. In addition, the Vilnius bus fleet must pay the tax on pollution from mobile sources. It responds to public transport infrastructure and more specifically, to the ticket price. Therefore, economic benefits

can be obtained by reducing the emission of public transport and the purchase of new gas-powered buses.

9. Conclusions

In the paper carried out the major pollutants emissions from Vilnius bus fleet vehicles engines: nitrogen oxides, greenhouse gases, volatile organic compounds, particulate matter and heavy metals.

NO, CO, NO₂, NO₂ volatile organic compounds, particulate matter pollution decreased in 2008 – 2009, while buses number is growing. This is due to the fact that CNG buses emit fewer pollutants.

The largest heavy metals content are Zn (73%), Pb (15%) and Cr (8%). Other heavy metals (Ni, Se, Cd) content is much smaller and generally of about 5%.

After buying gas-powered buses the air pollution of CO₂, N₂O decreased. But due to incomplete combustion of fuel with CNG engines, increased pollution methane CH₄.

The purchase of new gas-powered buses reduces urban air and soil pollution. This will be particularly effective in densely populated districts and zones. In addition, it will reach economic benefits by reducing the tax on pollution from mobile sources paid by Vilnius bus fleet.

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