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Modern Invisible Hazard of Urban Air Environment Pollution When Operating Vehicles That Causes Large Economic Damage

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Abstract: Currently, the planet population is terrified of the deaths of more than 4 million people from the coronavirus as they do not know that, according to the WHO, about 8 million of the population die annually in silence from urban atmosphere pollution by and with hazardous substances and particulate matters from the industry and automobile transport operation. These materials show the results of Russian studies proving that current urban pollution shall be defined not only by hazardous substances and particulate matters emitted with vehicle exhaust gases, but also by particulate matters from vehicle operation, first of all, from asphalt roadway wear, from tyre wear and from brake systems wear, which are not legally regulated either by nations or at the international level (UN Regulations) yet. The Russian studies (2015-2017) are presented regarding the comparative analysis of average emissions of particulate matters less than 2.5 microns (μm) from different sources: with exhaust gases (EG) (25%); from wear of brake systems (5%); from wear of tyres (8%) and from wear of roadways (65%), which were substantially confirmed by the studies conducted in Great Britain: from EG – 32%; from tyres – 18%; from brakes – 18% and from wear of roadways – 40%. Based on these results of the comprehensive studies, calculations of economic damage caused by the ecological situations and technogenic disasters of the current and future periods analyzed above, which amount to 65 quadrillion ($65 \cdot 10^{15}$) US dollars for the today's world and ca. 100 million dollars for the Russian Federation. According to the data of the World Health Organization (WHO), as of 2018, 9 out of 10 people around the world breathe air with high concentrations of pollutants. For that very reason, from 7 to 8 million people die annually because of the consequences of breathing the air containing particulate matters less than 2.5-10 μm in size which are able to penetrate deep inside the lungs and cardiovascular system, causing such diseases as stroke, cardiac diseases, lung cancer, chronic obstructive pulmonary disease and respiratory infections, including pneumonia.

Keywords: Urban Atmosphere Pollution, Particulate Matters, Hazardous Cancerogenic Substances, Automobile Transport, Fuel Types, Driving Modes

1. Introduction

According to the data of the World Health Organization (WHO), as of 2018, 9 out of 10 people around the world breathe air with high concentrations of pollutants. For that very reason, up to 8 million people die annually because of the consequences of breathing the air containing particulate matters less than 2.5-10 μm in size which are able to penetrate deep inside the lungs and cardiovascular system, causing such diseases as stroke, cardiac diseases, lung cancer, chronic obstructive pulmonary disease and respiratory infections, including pneumonia [1, 2].

Figure 1 provides the WHO information on elevated concentrations of particulate matters (PM) in the air by regions and continents of our planet within the controlled period of 2008-2013 caused by the massively increasing coal and oil consumption in order to provide energy for the developing civilized population of our planet [1, 2].

Following this arisen global problem, the European Economic Union (EU) countries have coordinated & agreed

the European Green Deal project, which is a program of economic reforms aimed at combating climate change and improving the environmental situation. Thus on 14 July 2021, the European Commission (Brussels) accepted a package of proposals aimed at making the environmental, energy, land use, transport and tax policy of the EU suitable for reduction of greenhouse gas emissions by at least 55% by 2030 compared to the level of 1990. One of the primary goals is complete decarbonization (zero carbon dioxide CO_2 emissions or carbon neutrality) by 2050 [3].

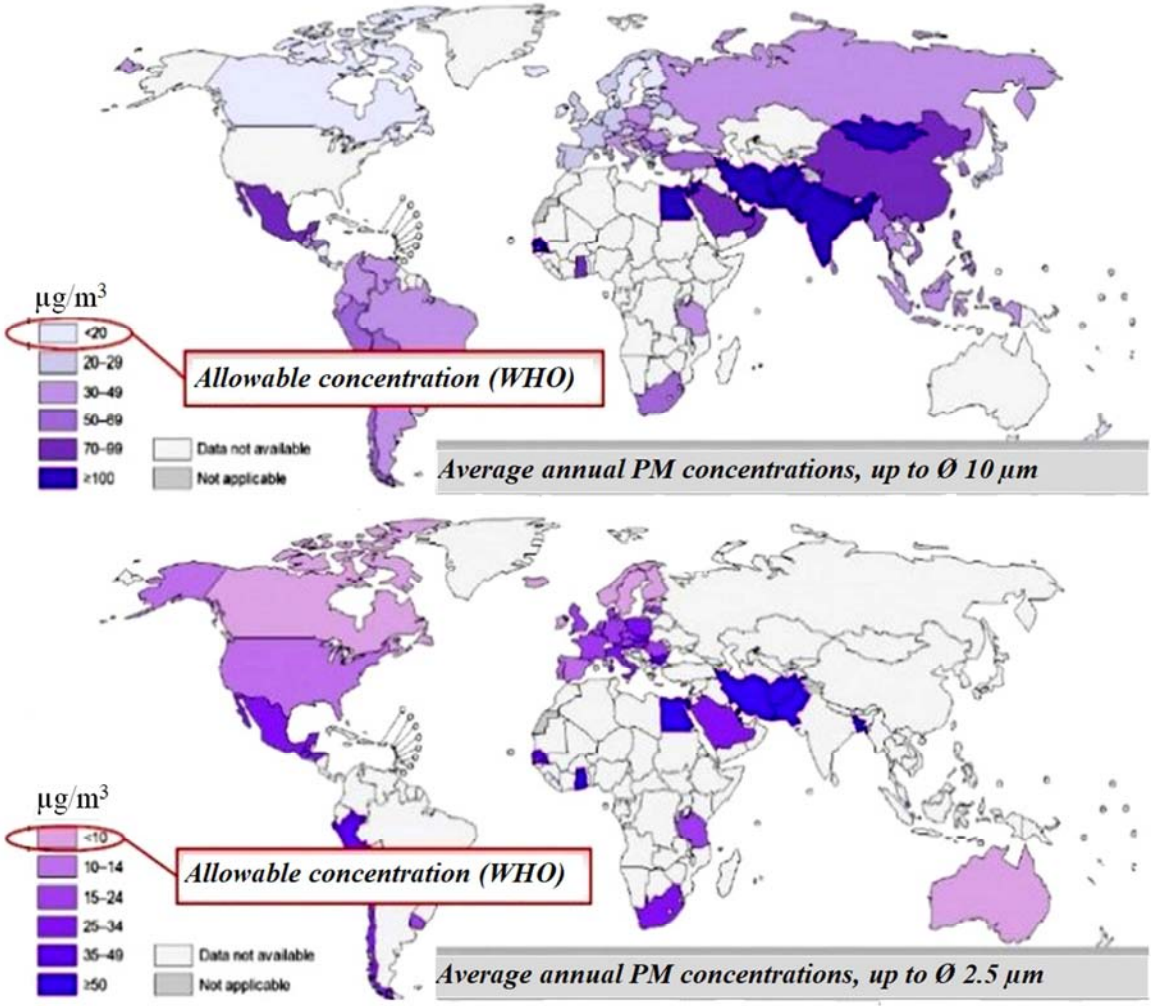


Figure 1. *Global average annual PM concentrations in the air (µm) (within the period of 2008-2013).*

At the moment, the world community is planning a major manufacturing technologies reboot to decarbonize the global economy.

2. Result

The hydrocarbon fuel energy sector is the main focus of these reforms. According to the plan, hydrocarbons will be severely combated. Financing of new coal power station construction will be prohibited. Moreover, all subsidies on hydrocarbon fuel will be abolished, while investments in economies producing oil and gas are to be limited through international regulations [3].

It is important to highlight the second issue, which also becomes the global one originated with the local urban atmosphere pollution with hazardous substances (HS) in exhaust gases (EG) of vehicles, which has been addressed for more than 50 years by international UN Regulations No. 49 and No. 83.

It should be emphasized that a sharp limitation of particulate matter emissions in EG introduced with the international UN Regulations for the gasoline and diesel vehicle engines more than 10-20 times starting from 1992 to the present day has been performed by the manufacturers due to the engine design improvement and due to application of the exhaust gas after-treatment systems.

It is important to note the efficiency of works on fuel consumption reduction by way of example of passenger cars within the period from 1970 to the present day, due to which the fuel consumption has been reduced on average from 12.5 l / 100 km to 4.7 l / 100 km, i.e. almost 3 times, which means the greenhouse gas (CO_2) emissions as well as highly hazardous particulate matters emissions (Figure 2) have also been significantly reduced [4].

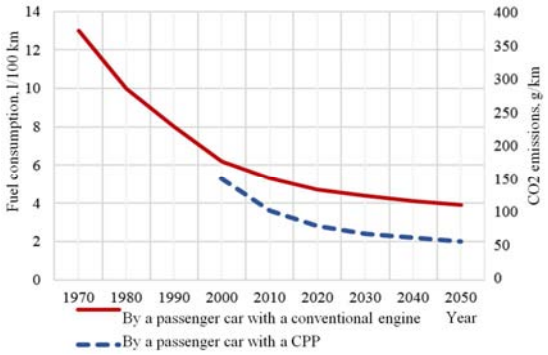
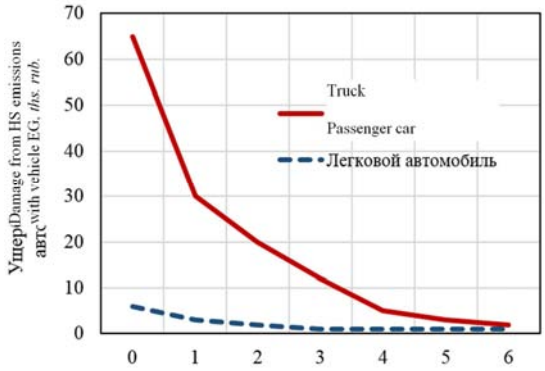


Figure 2. *Achieved and forecast fuel efficiency levels for passenger cars having 1000 kg conventional mass.*



Euro-0 to Euro-6 standards of UN Regulations No. 49 and No. 83.

Figure 3. *Reduction of economic damage from HS and PM emissions in vehicle EG.*

Figure 3 provides the total efficiency of reduction of environmental damage and economic losses in accordance with UN Regulations concerning HS emissions with EG from passenger cars and trucks [4, 5].

Despite such advances in science and industry, in 2012, the WHO proposed to prohibit the usage of diesel vehicles under urban operating conditions.

According to the research conducted in the Russian Federation (RF) within the period of 2009-2012, the WHO statement was unreasonable and partially erroneous as WHO experts did not pay due attention to particulate matter emissions of non-exhaust origin emitted by vehicles during operation due to the wear of vehicle systems and units [5].

At the first stage of the research, the emissions of particulate matters due to the tyre and brake mechanism wear were defined by calculation based on the warranty life set by the manufacturers, which confirmed a considerable excess of their emissions compared to the Euro standards of UN Regulations No. 49 and 83 for exhaust gases by more than 40 to 60 times and as for buses, trucks and public transport by more than 200 to 300 times [5, 6].

Figure 4 shows the averaged summary results of the research on comparative actual ratio and forecast for change of hazardous PM emissions within the period from 2000 to 2030 caused by other vehicle systems (brake systems, tyres) and by asphalt roadway wear against the regulatory requirements of UN Regulations on PM emissions in EG through the example of the growth of Russian vehicle fleet.

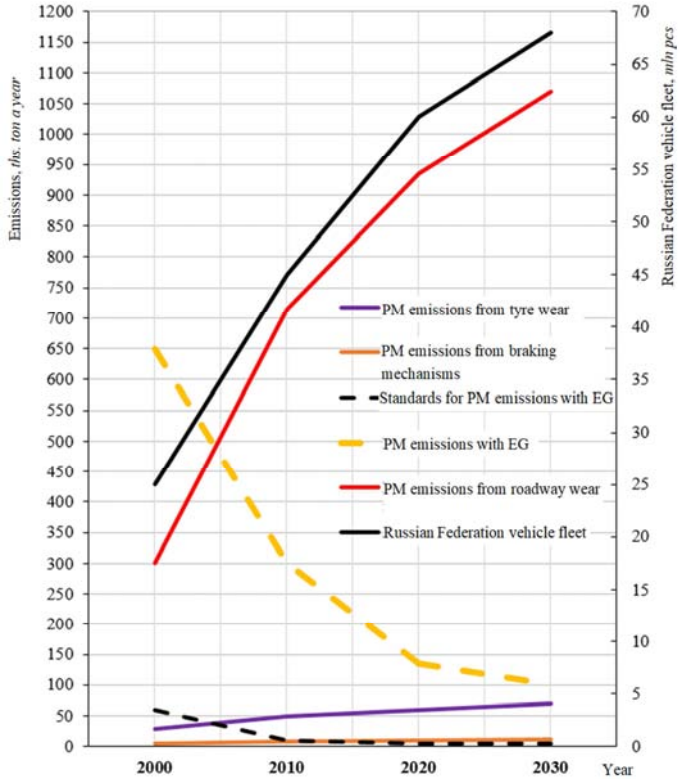


Figure 4. *Dynamics and forecast of annual PM emissions from wear of tyres, braking mechanisms and asphalt roadway in the Russian Federation, in tons, compared to the emissions of and emissions limits (standards) for PM in EG.*

Based on the comprehensive research performed in the Russian Federation (Figure 4) and materials in publication [7], it can be concluded that today we can state the following percentage rate of emissions of especially hazardous PM less than 2.5 μm and less than 10 μm: in urban or city conditions with EG – from 25 to 28%; from braking systems – from 1.5 to 2%; from tyres – from 8 to 10% and from asphalt roadway – from 60 to 65%.

Due to the abovementioned varying situation in the assessment of causes of pollution of the planet atmosphere and in particular urban environment, there has risen a global energy and environmental conflict between the transport, the community and the environment which by the current time period has become critical both by its level and by its violent aggravation against intensive search for the solutions to this transport ecological problem by means of electric vehicles (EV) and alternative fuels, for development of which large economic resources are being spent.

However, at the same time, allocation of necessary funds is not yet performed or provided for the clearly rising threat to the urban population health and life due to sharply increasing emissions of particulate matters caused by vehicle operation in order to eliminate this emerging danger of air pollution in cities and megalopolises caused by the asphalt roadway and tyre wear.

Due to the abovementioned issues of the increasing urban atmosphere pollution, there arises a need to realize a degree of the economic damage to the economy of the states and global economy.

As previously noted, according to the WHO research, about 8 mln people in the world die currently because of the atmospheric pollution with carbon-bearing particulate matters and more than 1.35 mln people die in road accidents, as well as up to 50 mln people get injuries of various degrees of severity, and taking into account deaths of people during the ongoing pandemic (COVID-19), which has so far killed ca. 4 mln people, the total fatalities in the developing civilization of the modern global society amount to about 13 mln people already [7, 8].

Since as of 1 July 2021 the total Earth population already amounted to about 8 billion people, and in Russia the population amounted to about 146 million people, i.e. in total only about 2% [9].

However, there is some difficulty in estimation of the human life cost in different states for determination of the total amount of economic damage caused by the deaths of people due to the consequences being analysed above. The human life cost (value of statistically average life) is a relative imputed economic value to determine which various methods and parameters are applied [10]. The "human life cost" or the "value of statistically average life" is relative and imputed because human life is not a market commodity. When determining the cost of human life in Russia and around the world, there are several different approaches according to both objective and subjective methods. The most objective assessment is performed based on the gross domestic product (GDP) per capita.

Accordingly, the GDP, which has not been obtained due to a premature death of a person, is the cost of their life [11]. The performed legislation analysis showed that the total cost of human life in the world, as enshrined in the regulations, on the whole amounts to 4.7 million US dollars in 2011 prices [12, 13].

Based on the above, it is reasonable to assess the damage from the premature death of people caused by different disasters and tragedies against the GDP value by the example of the Russian Federation and the global economy in general.

In terms of GDP per capita, as a result of the COVID-19 pandemic, according to this forecast in 2020 the global economy will decrease by 4.4%. According to the International Monetary Fund forecast, in 2021-2025 the global economy will develop at an average annual decrease rate of 4.1%, German economy – of 2.3%, Russian economy – of 2.2% [14, 15].

Assessing global damage from the death of 8 mln people, according to the data of the World Health Organization (WHO), caused only by atmospheric pollution with particulate matters, if the value of human life outside Russia is ≈ 4.7 mln US dollars, we get the annual damage to the global economy amounting to about 4 quadrillion ($4 \cdot 10^{15}$) US dollars.

Thus, assessing the mid-2021 total annual population fatality of 13 mln people, the annual damage caused to the global economy already amounts to 65 quadrillion ($4 \cdot 10^{15}$) US dollars.

With the population of the Russian Federation of about 150 mln people, we have only about 2% (1.825%) of the total global population. Then, the annual damage to the Russian economy can be from 75 to 112 billion dollars.

Based on the abovementioned current situation, we face a question: "What ways do we have today to decrease this enormous damage to the global economy and, in particular, to the state economy by the example of the Russian Federation?".

In essence, the measures to decrease people mortality and injury in road accidents are effectively taken based on the requirements of the international UN Regulations concerning provision of vehicle design safety.

The pandemic response measures are taken by the whole global community on a massive scale.

So, the issue that is not resolved yet consists in reduction of particulate matter emissions from asphalt roadway and tyre wear, and another issue that is not completely resolved concerns reduction of emissions in exhaust gases, especially in cities and megalopolises.

Within the special research performed in the Russian Federation in 2019 regarding the search for effective solutions to reduce PM emissions with diesel-engined vehicle exhaust gases, our experiments determined that emissions with exhaust gases from diesel engines can be reduced thrice (Figure 5) through development of wide cut fuels to be used in city transport or by a simple method of mixing gasoline

and diesel fuels in 50:50 ratio [5].

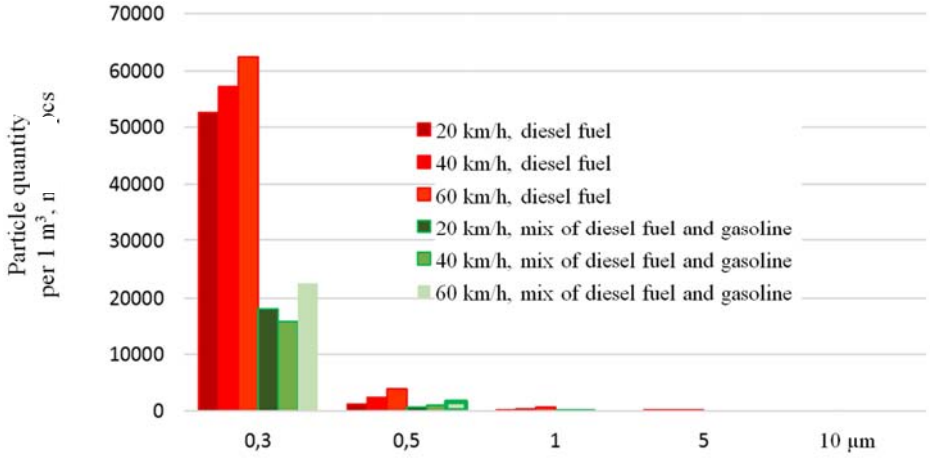


Figure 5. *PM emissions from an engine operating on diesel fuel and diesel/gasoline mixture of 50:50 ratio at constant vehicle speeds.*

Special studies performed in the Russian Federation in 2019 on searching for effective solutions to reduce PM emissions of non-exhaust origin from other vehicle systems defined that, in order to reduce PM emissions when operating the transport in cities with restrained urban conditions, the vehicle speed shall be limited to 40 km/h. Figure 6 provides the assessment results, which show that PM emissions decrease twice when lowering vehicle speed from 60 to 40 km/h. Thus, the rate of PM emissions in EG when decreasing the vehicle speed from 60 km/h to 40 km/h (measures proposed by us) will already amount to no more than 13% compared to the amount of total emissions of particulate matters from other sources – caused by wear of tyres, roadway and brakes – ~ 87%, when operating motor vehicles in the urban environment at the current time.

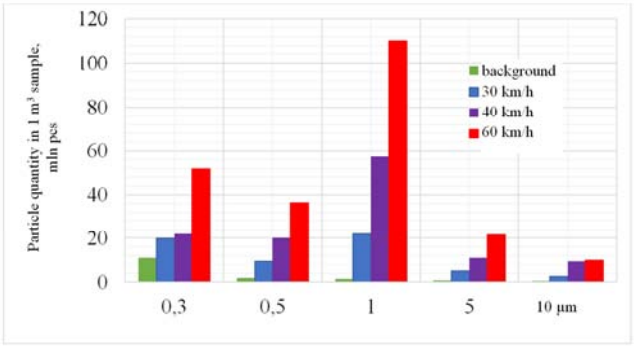


Figure 6. *Dependence of PM emissions on vehicle speed.*

In order to sharply decrease especially hazardous PM content in the urban atmosphere, the public utilities shall be recommended not only to water the asphalt roadway on very hot summer days for effective reduction of its wear but also to perform additional so-called artificial (forced) sprinkling allowing significant cleaning (removal) of particulate matters from the air space of city streets so that people could avoid breathing these invisible hazardous particulate matters shortening their lives (Figure 7).

Figure 7. *Artificial sprinkling / water spraying of city street air space in Moscow in order to eliminate particulate matters from people breathing areas.*

3. Conclusion

So, today we face a less than fully understood and unfair standpoint of international and national legislation in that for more than 50 years, intensive research is being performed and measures are being taken to decrease emissions of hazardous substances and particulate matters in EG, i.e. significant investments are being made to the development of engine and vehicle designs, but, until the present, there are no real investments in research and works regarding the reduction of PM emissions from wear of asphalt roadway and tyres.

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