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Determination of environmental consequences from production processes of motor transport enterprises

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Abstract

Environmental policy in the motor transport complex should be built taking into account the existing ecological situation in certain regions and cities of the Republic of Kazakhstan. If we compile a list of economic regions by the degree of pollution and degradation of the natural environment from the aggregate of anthropogenic impacts (emissions of harmful substances, forest damage, pollution of rivers, water shortages, pollution and soil erosion), we see that the most deplorable situation is in South Kazakhstan, East Kazakhstan, Karaganda, and Almaty economic regions. When developing measures to prevent the negative impact of cars on the environment, it is necessary to focus on the current health and environmental standards. Unfortunately, at present in Kazakhstan, these conditions are not met due to objective and subjective reasons. Meanwhile, in the road transport industries, a direct application of the UNECE Regulation, governing a number of indicators of environmental safety of vehicles, is provided. The solution of the problem (this is confirmed by the experience of foreign countries) is in the step-by-step tightening of the indicators of environmental safety of cars and real control over their observance in the conditions of the production operation. It is advisable to set regional standards (more stringent than national ones) for areas that have a high level of pollution.

Keywords: natural environment, motor transport enterprise, emissions, pollutants, harmful substances, ecology

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INTRODUCTION

In order to activate the nature protection activity of the motor transport complex, to raise its efficiency, it is necessary to develop and implement a set of measures. There are significant reserves of reducing the harmful impact of motor transport on nature, related to the optimization of the operation of the park, the management system based on regulations, rules, and requirements that meet the conditions of a market economy.

The danger of emissions of harmful substances from vehicles for public health is largely determined by the fact that they are carried out in the ground layer not only in close proximity but also within residential areas within the courtyard areas of districts. The wide distribution of motor transport in the urban environment makes it difficult to geographically link this source of atmospheric pollution to certain residential areas. However, differences in the level of anthropogenic load due to the operation of transport can be determined by the structure and level of traffic intensity on the studied highways, by the average traffic intensity in residential areas of the city.

Particles of exhaust gases are a complex mixture, which depends on engine performance, fuel

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composition, lubricating oil, and exhaust gas purification means. Many elements, such as V, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Pb, are widely distributed in solid components of exhaust gases and are therefore presumably an important source of toxic substances.

Contamination of the atmosphere occurs not only with exhaust gases, but also with dust, noise, and thermal pollution.

From the point of view of human health, such components of exhaust gases as solid nano- and microparticles of soot, ozone, carbon monoxide, sulfur oxides and, as has been shown recently, carbon nanomaterials, have the most deleterious effect. When the fuel mixture burns, carbon particles with sizes from 1 to 300 nm are formed. In addition, the composition of the particles includes various metals that get there from the wear of the engine and the elements of the exhaust gas purification systems. The consequences of the influence of particulate matter on human mortality are shown reliably. The relationship between the PM2.5 suspended particle concentration and human mortality and the number of cardiovascular diseases was established.

Solid particles of exhaust gases are studied less in terms of both their composition and concentration sites. It was found that the largest concentrations of fine particles are concentrated in tunnels and bus fleets. Naturally, workers of these places fall into the group of the greatest risk. It was shown that the solid particles of exhausts consist of a core of elemental carbon, organic substances formed during combustion and traces of metal compounds (more often sulfates). While forming, the particles are very small in size, but then they aggregate and form larger particles.

Microparticles (for example, PM2.5) consist of many organic and inorganic compounds, including sulfates, nitrates, organic carbon and elemental carbon, earth dust and biological materials (pollen). Particles (PM10) mainly consist of minerals and rocks (calcium, aluminum, silicon, magnesium, iron), primary organic materials (pollen, spores of fungi, plants, and animal remains). Some components, such as nitrates and potassium, are common for PM2.5 and PM10, although the sources of education are different. These particle characteristics, combined with different rates and depth of deposition in the lungs, can have different biological effects and toxicity.

During the operation of engines, nanoparticles of different nature are produced: soot, metal, and carbon. Inorganic compounds of transition metals such as iron, zinc, copper, nickel, platinum, which are found in exhausts of diesel engines, can play an important role in the immunotoxicity of particles. Researchers of metal nanoparticles contained in car exhausts have noted their potential health hazard; In addition, a number of authors noted the high toxicity and carcinogenicity of metal nanoparticles due to the huge surface area of high adhesion and sorption forces.

It is noted that exhaust products worsen important aspects of vascular function in the human body, such as regulation of vascular tone and endogenous fibrinolysis. These data show a mechanism that links air pollution in the pathogenesis of atherothrombosis with acute myocardial infarction. It was shown that the solid particles of diesel emission induce a pronounced inflammatory response in the airways with increased expression of IL-8 and Gro-α cytokines in healthy individuals.

The seriousness of the impact of road transport emissions is evidenced by the fact that the EU revises the guidelines every year to reduce emissions of toxic substances into the atmosphere, prohibits the use of cars that do not meet environmental requirements, and in the United States at the congressional level, traffic on certain streets is restricted as a measure to reduce the level of pollution in those areas of the cities where the situation is the worst.

The regulatory and technical support of the vehicle maintenance and repair system should provide for the regulation of pre-operational training, maintenance, and repairs during the warranty period, as well as on routine numbering maintenance types, taking into account environmental requirements. In this regard, it is necessary to create, or rather restore, the regulatory and technical legal framework for strengthening technological discipline and the introduction of unified approaches to the organization of environmental activities.

Undoubtedly, to create a state system of environmental certification of the rolling stock of road transport, operational materials for vehicles. It is time to organize the revision and development of state and industry standards for the environmental characteristics of vehicles and create effective control systems for rolling stock in these parameters; To review, develop and implement regulatory and technical documentation on the control and regulation of environmental parameters of vehicles, develop an environmental passport of a trucking enterprise.

MATERIALS AND METHODS

The current methodology provides for an inventory of emissions for road transport enterprises from mobile and stationary sources. Mobile and stationary sources include cars moving and stored on the territory of the enterprise, stationary sources include facilities and production areas intended for maintenance and repair of vehicles, their components, and units, as well as auxiliary workshops and sites (Methodology of calculating 1996).

An analysis of the environmental activities of road transport enterprises shows that the current environmental legislation of the Republic of Kazakhstan requires adjustments since it has omissions in the regulatory framework. For example, the Environmental Code of the Republic of Kazakhstan does not contain any comprehensive measures to reduce the negative impact on the atmosphere that would be placed on public bodies, as well as specific requirements for economic and other activities that have a harmful effect on the atmosphere (Methods for the determination 2005, Davoodabadi and Shahsavari 2013).

The norms concerning the protection of atmospheric air are not reflected in the Environmental Code of the Republic of Kazakhstan and are defined only in Art. 204 of the Environmental Code (Ecological Code 2007) - requirements for the production and operation of motor vehicles and other vehicles - in place of the no-longer-valid laws of the Republic of Kazakhstan “On Environmental Expertise”, “On Environmental Protection”, “On the Protection of Atmospheric Air.” Previously, this issue was regulated by the Law “On the Protection of Atmospheric Air”, which allowed local representative and executive bodies to solve problems on the protection of atmospheric air in their administrative territory. Local representative bodies approved regional programs for the protection of atmospheric air, set rates for payment for its pollution, approved expenditures in local budgets, heard reports from local executive bodies, determined and regulated emissions of pollutants into the air, taking into account the wind patterns and periods of unfavorable weather conditions etc. At present all this is not provided for in the current environmental code of the Republic of Kazakhstan.

The fight against air pollution is one of the important problems for the employees of motor transport enterprises and requires a comprehensive solution (Skvortsov et al. 2016, Tursun 2015).

RESULTS AND DISCUSSION

The activities of road transport enterprises associated with the implementation of transportation processes, loading and unloading operations, storage of goods and the performance of maintenance and repair of rolling stock of motor vehicles, also cause significant pollution of the environment. It is due to the activities of production sites and zones, as well as parking spaces for vehicles (Dyachuk et al. 2018, Levkin and Lazeba 2014).

The processes of maintenance and repair of the rolling stock of vehicles require energy costs and are associated with a large release of pollutants into the atmosphere, the formation of waste, including toxic waste.

When servicing vehicles, divisions, zones of periodic and operational forms of maintenance are involved. The repair work is carried out at the production sites.

Table 1. Nomenclature of substances emitted during the restoration of the operability of transport facilities at specialized sites

Area	Emitted harmful substances
Storage	Vapors of sulfuric acid, sulfur dioxide, lead compounds, aerosols
Mechanical	Dust, aerosols
Welding	Manganese and silicon compounds, chromium oxide, hydrogen fluoride, nitrogen oxides, carbon monoxide
Forge and thermal	Carbon monoxide, nitrogen oxides, sulfur oxide, hydrogen cyanide and hydrogen chloride, ammonia, oil vapors, aerosols, alkalis, salts, soot, ash, dust
Copper	Compounds of silicon, white spirit, aromatic hydrocarbons, alkalis, soda ash, phosphates, synthamide, synthopol, sodium dodecylbenzenesulfonate, acids (hydrochloric, sulfuric, nitric, phosphoric, hydrocyanic, chromium), sulfates, aerosols, nickel chloride
Painting	Aerosols of paints, toluene, xylene, solvent, chlorobenzene, dichloroethane, alcohols, inhibitors of organic and inorganic fillers, film-forming substances

As a rule, when the working capacity of vehicles is restored, harvesting, washing, control and adjustment, fastening, lifting and transport, dismantling, assembly, hacksaw and mechanical, forging, tinning, welding, copper, cleaning and washing, lubricating and filling, storage, painting and other works. They involve pollution of atmospheric air, water, and soil with harmful substances, consumption of structural, operational materials and energy resources at stationary posts, sections, maneuvering vehicles along the territory of parking lots and service areas (Fandeev et al. 2014, Kilitci et al. 2018).

Table 1 shows the nomenclature of harmful substances released at the production sites of the motor transport enterprise.

The calculation of the maximum permissible emission is mandatory for all operating enterprises, including motor vehicles, regardless of the form of ownership and industry. The calculation allows monitoring of pollutant emissions and fixing violations.

The analysis of existing methodological recommendations on the calculation of pollutant emissions into the atmosphere by motor transport enterprises (Tulenov et al. 2015a, 2015b), necessitated the development of new methodological recommendations. The emissions of any harmful substances regardless of their mass and degree of exposure to atmospheric air, as well as a large number of harmful substances, the emissions of which do not have a significant impact on atmospheric air were subject to control. In the end, this increases the amount of work to control emissions (Pytaleva et al. 2016).

Since the production potential of motor transport enterprises is different, it is necessary to determine their category by the impact of polluting substances on the atmospheric air and to develop emission standards for stationary sources of pollution, taking into account the background pollution of atmospheric air in the area of the enterprise location, technical and environmental standards. To maintain a safe level of pollutants, their composition and amount, the emission concentration, are identified; Any changes in technological processes (new technologies, raw materials, fuels) are monitored.

When calculating the maximum allowable emissions, specific hydrometeorological characteristics were taken into account, as well as existing background concentrations of harmful emissions in the area of the location of the motor transportation enterprise of the regional center of Shymkent, the Republic of Kazakhstan, specializing in servicing the city's population by passenger bus services.

Both organized and unorganized sources of emissions into the atmosphere are taken into account.

Pollutants, discharged into the atmosphere, move in it (dissipate) due to molecular and turbulent diffusion. The dispersion of a gas jet due to molecular diffusion is insignificant. The main influence on the scattering of pollutants in the atmosphere is provided by turbulent diffusion, which facilitates the transport of particles in the direction from high pressure to low (Rusakova 2015).

Let us consider the process of dispersion of an impurity in the atmosphere on the simplest example of a stationary medium:

Let us assume that a particle of a gas of volume δV has shifted in atmospheric air from a layer with pressure P_1 into a layer with another pressure P_2. In this case, the gas particle changes its density from p_1 to p_2. The sum of all the forces applied to a particle after displacement is determined by the expression (Tulenov et al. 2015):

$$F = (p1 - p2) \cdot g \cdot \delta V \cdot e \qquad (1)$$

Where $p_1 \cdot g \cdot \delta V \cdot e$ is the hydrostatic lift (e is a unit vector), which tends to push the particle up;

$p_2 \cdot g \cdot \delta V \cdot e$ is the gravity that depends on the density p_1.

The ratio of the forces considered determines the direction of the vector of the total force.

When a particle moves up in the atmosphere, it expands, since the pressure decreases with altitude. At the same time, work is performed on the environment and the particle temperature decreases. Since this process occurs quickly enough, it can be adopted adiabatically. Moreover, if the temperature distribution in the atmosphere or the stratification of the atmosphere also obeys the adiabatic law, the particle, having risen to a certain height, will be at the same pressure and temperature as the environment. The density of the particle p_1 is equal to the density of the environment p_2 and, consequently, the sum of all the forces F applied to the particle is zero. Thus, the displaced mass of air will not strive to return to its former position or to continue its movement, i.e. we are dealing with an indifferent balance of the system (Beliayev et al. 2016).

It is another matter if the temperature of the atmosphere decreases with altitude faster than in the adiabat. In this case, the particle, moving to a new altitude, will have a temperature higher than the ambient air, and the density will be lower. Therefore, the particle will tend to further rise.

If the temperature of the atmosphere decreases with altitude more slowly than in the adiabat or even increases (ie, there is a temperature inversion), then the particle, having moved to a new altitude, will have a temperature lower than the ambient air, and the density is higher. Therefore, the particle will tend to fall into the denser layers of the atmosphere.

In actual conditions, the process of dispersion of an impurity in the atmosphere depends on many factors: meteorological conditions, the height of the pipe, the temperature and density of the gas in the pipe, the aggregate state of the pollutants etc.

Consider the calculation of the dispersion of pollutants sources of a motor transport enterprise.

The initial data (g/sec, t/year) for pollutants was obtained by calculation in accordance with normative and methodological documents on environmental regulation approved by the orders of the Minister of Environmental Protection. Data on the annual consumption of materials, the operating mode of the equipment were obtained at the enterprise (Tumureeva and Sanzhiyeva 2015).

The polluting substances of this motor transport enterprise are suspended solids (metal dust), manganese and its compounds, dust abrasive, carbon oxide, hydrogen fluoride, iron oxide, mineral oil, nitrogen dioxide, nitrogen oxide, sulfuric acid, xylene, white spirit, ethylene.

To maintain the rolling stock in a technically good condition, the enterprise has the necessary production and technical base equipped with the necessary equipment, which is the source of emissions of harmful substances into the atmosphere: a mechanical section; a welding section; a painting section, mini boiler rooms in the administrative building, the control room, in the production building; Accumulator, copper, vulcanization (Makarova and Giliova 2015).

Mechanical processing of metals is made by turning, drilling, milling, grinding, and other machines. Gross emission for sources not provided with local suction (Tulenov et al. 2015):

$$M_{year} = \frac{k \cdot Q \cdot T \cdot 3600}{10^6}, t/year \qquad (2)$$

where k is a coefficient of gravity settling;

Q – a specific release of dust by technical equipment;

T – an actual annual fund of working time of one unit of equipment, per hour.

Maximum one-time emission for sources not provided with local suction:

A lathe. A specific release of dust metal is 0, 0056 g/sec, a working time – 253 hours/year.

$$M_{metal} = \frac{0.2 \cdot 0.0056 \cdot 253 \cdot 3600}{10^6} = 0.00102\ t/year$$

The specific allocation of mineral oil $5{,}6 \cdot 10^{-5}$ g/sec per 1 kW of lathe's capacity:

$$M_{oil} = \frac{3600 \cdot 5.6 \cdot 10^{-5} \cdot 6.0 \cdot 253}{10^6} = 0.000306\ t/year$$

Table 2. Annual gross release by mechanical section

Name of substance	g/sec	t/year
Metallic dust	0.00798	0.0072676
Abrasive dust	0.0032	0.002914
Mineral oil	0.0009688	0.000876

For the milling machine, the specific release of metallic dust is 0.0042 g/sec, the working time – 253 hours/year (Golokhvast et al. 2016):

$$M_{metal} = \frac{0.2 \cdot 0.0042 \cdot 253 \cdot 3600}{10^6} = 0.000765\ t/year$$

The specific release of mineral oil $5.6 \cdot 10^{-5}$ g/sec per 1 kW of machine power:

$$M_{oil} = \frac{3600 \cdot 5.6 \cdot 10^{-5} \cdot 7.5 \cdot 253}{10^6} = 0.00038\ t/year$$

For the grinding machine (a diameter is 400 mm), the specific release of abrasive dust is 0,016 g/sec, the metallic dust - 0,029 g/sec, the working time - 253 hours/year.

$$M_{abrasive} = \frac{0.2 \cdot 0.016 \cdot 253 \cdot 3600}{10^6} = 0.002914\ t/year$$

$$M_{metal} = \frac{0.2 \cdot 0.029 \cdot 253 \cdot 3600}{10^6} = 0.0052826\ t/year$$

For the drilling machine, the specific release of metallic dust is 0.0011 g/sec, the working time - 253 hours/year.

$$M_{metal} = \frac{0.2 \cdot 0.0011 \cdot 253 \cdot 3600}{10^6} = 0.0002\ t/year$$

The specific release of mineral oil is $5.6 \cdot 10^{-5}$ g/sec per 1 kW of machine power:

$$M_{oil} = \frac{3600 \cdot 5.6 \cdot 10^{-5} \cdot 3.8 \cdot 253}{10^6} = 0.00019\ t/year$$

The total gross emission by the mechanical section is given in **Table 2**.

The sources of separation in the administrative building and the control room are mini-boiler rooms with a working time of 4320 hours/year, the annual consumption of natural gas is 8640 m^3/year and 5760 m^3/year, respectively (Shcherbatiuk 2014).

To calculate the emission of pollutants when burning liquid and gaseous fuels, the same formulas are used as for solid fuel. At the same time, the same formulas are used both to calculate the gross outflow (t/year) and the maximum one-time (g/s). For the first calculation, the annual fuel consumption (t/year) is substituted in the formulas, for the second - fuel consumption per second (g/s).

Calculation of carbon monoxide emissions per unit time (t/year, g/s) is carried out according to the formula (Tulenov et al. 2015):

$$P_{CO} = 0.001 C_{CO} B \cdot \left(1 - \frac{g_4}{100}\right) \quad (3)$$

where B is a fuel consumption;

C_{CO} – the release of carbon monoxide in the combustion of fuel, it is calculated by the formula:

Table 3. Emissions of a mini-boiler room in an administrative building

Name of substance	g/sec	t/year
Carbon Oxide	0.00507	0.0789
Nitrogen (IV) oxide (Nitrogen dioxide)	0.0013056	0.0203
Nitrogen (II) oxide (Nitrogen oxide)	0.000212	0.003299

Table 4. Emissions of a mini-boiler room in the production building

Name of substance	g/sec	t/year
Carbon Oxide	0.003383	0.05261
Nitrogen (IV) oxide (Nitrogen dioxide)	0.00087	0.013536
Nitrogen (II) oxide (Nitrogen oxide)	0.000141	0.0021996

$$C_{CO} = g_3 \cdot R \cdot Q_i^r \quad (4)$$

where g_3 is the loss of heat due to the chemical incompleteness of fuel combustion (%);

R is the coefficient that takes into account the share of heat loss due to the chemical incompleteness of fuel combustion caused by the presence of carbon monoxide in the combustion products (Volnov and Tretyak 2014);

Q_i^r is the lower heating value of natural fuel (MJ/kg, MJ/m^3);

g_4 is the loss of heat due to the mechanical incompleteness of fuel combustion (%).

$$C_{CO} = 0{,}5 \cdot 0{,}5 \cdot 36{,}72 = 9{,}18$$

$$P_{CO} = 0.001 \cdot 9.18 \cdot 8.640 \cdot \left(1 - \frac{0.5}{100}\right) = 0.0789\ t/year = 0.00507\ g/sec$$

The number of nitrogen oxides (in terms of NO_2) emitted per unit time (t/year, g/s) is calculated by the formula (Tulenov et al. 2015):

$$P_{NO_2} = 0.001 B \cdot Q_i^r \cdot K_{NO_2}(1 - \beta) \quad (5)$$

where Q_i^r is the combustion heat of natural fuel;

K_{NO_2} is a parameter characterizing a number of nitrogen oxides generated per 1 GJ of heat (kg/GJ) – 0.08;

β is a coefficient depending on the degree of reduction of nitrogen oxide emissions as a result of the application of technical solutions.

$$P_{NO_2} = 0.001 \cdot 8.640 \cdot 36.72 \cdot 0.08(1 - 0) = 0.02538 \frac{t}{year} = 0.001632\ g/sec$$

Nitrogen oxides contain: 80% nitrogen dioxide and 13% nitrogen oxide, then

Nitrogen dioxide:

$$P_{NO_2} = 0.02538 \cdot 0.8 = 0.0203\ t/year = 0.0013056\ g/sec$$

Nitrogen oxide:

$$P_{NO_2} = 0.02538 \cdot 0.13 = 0.003299\ t/year = 0.000212\ g/sec$$

The total amount of emissions for a mini-boiler room in the administrative building is given in **Table 3**.

Similar calculations of emissions are completed for a mini-boiler room in a control room and a mini-boiler room in a production building (Oberemok et al. 2016).

The total amount of emissions for a mini-boiler room in a production building is given in **Table 4**.

When charging batteries filled with sulfuric acid, sulfuric acid vapors are released into the atmosphere. The specific amount of pollutants released from the surface of the batteries is 25.2 g (h·m^2) of sulfuric acid vapors. The total evaporation area from one battery is 0.0049 m^2. A number of sulfuric acid vapors produced from 506 batteries that were under the charging during the year will be 2024 h/year, taking into account the charging time of the batteries (Yaroslavtsev, 2014):

$$M_{H2SO4} = 25.2 \cdot 0.0049 \cdot 506 \cdot 10^{-6} = 0.000062\ t/year = 0.0000085\ g/sec$$

When preparing the electrolyte from sulfuric acid, it is diluted. The specific emission of sulfuric acid vapors is 0.56 mg/kg of sulfuric acid. The amount of sulfuric acid consumed by a road transport enterprise is 50 kg. Then, emissions into the atmosphere during the year will be:

$$M_{H2SO4} = 0.56 \cdot 50 \cdot 10^{-9} = 2.8 \cdot 10^{-8}\ t/year = 6.0 \cdot 10^{-8}\ g/sec$$

In the copper section, the source of the emission is a gas burner using a propane-butane mixture. The specific release of nitric oxide is 15 g/kg of the mixture. The annual consumption of propane-butane mixture is 0.12 tons, the operating time is 506 hours per year. Nitrogen dioxide emissions (Pshenichnykh and Nalesnaya 2015):

$$M_{NO_2} = \frac{15 \cdot 120}{1000000} = 0.0018\ t/year = 0.00099\ g/sec$$

The sources of emission in the vulcanization area are vulcanization devices and a grinding machine. When vulcanized, various components are emitted into the atmosphere, more ethylene is released - 261 mg/kg and the rest is much less. The annual consumption of raw rubber is 0.005 t/year, working time = 253 h/year (Khegai 2014). Ethylene emissions:

$$M_{ethylene} = \frac{0.005 \cdot 261}{10^6} = 1.3 \cdot 10^{-6}\ t/year = 1.4 \cdot 10^{-6}\ g/sec$$

The specific emission of abrasive dust is 0.011 g/sec, metallic dust - 0.016 g/sec. The working time is 253 hours/year.

$$M_{abrasive} = \frac{0.2 \cdot 0.011 \cdot 253 \cdot 3600}{10^6} = 0.002\ t/year$$

$$M_{metal} = \frac{0.2 \cdot 0.016 \cdot 253 \cdot 3600}{10^6} = 0.002914\ t/year$$

The formation of a coating on the surface of the product is, as a rule, in the application of paint and varnish materials (PVM) and its drying. At the same time, an aerosol of paint and solvent components' vapors are emitted into the air, the composition of which is identical to the composition of the applied mixture of paint and solvent (Ponomarev 2014).

After the completion of painting and drying, volatile components in the product do not remain, they almost completely evaporate. The smaller part passes into the gaseous state during coloring, the larger part - during drying. After a certain time, the solvent from the liquid droplets of the aerosol passes into the gas phase, and the aerosol of the color represents a mixture of air with solid particles of the dry residue of paint and varnish materials. The applied materials of the paint area enamel area 150 kg/year, solvent - 70 kg/year. The released harmful substances: xylene, white spirit. The gross release of individual volatile components of paint and varnish materials is calculated by the following formulas (Tulenov et al. 2015):

When coloring:

$$M_{col}^{x} = \frac{m_a \cdot f_p \cdot \delta_p' \cdot \delta_x}{10^6}(1-\eta)\ t/year \qquad (6)$$

where $\grave{\delta_p}$ is a share of solvent in the paint and varnish material released during coating, (%);

δ_x– the content of «*x*» component in the volatile part of paint and varnish materials, (%);

m$_a$- actual annual consumption of paint and varnish materials, (t);

f_p- the share of volatile part (a solvent) in paint and varnish materials, (%);

η - the degree of air purification by gas cleaning equipment;

Emissions from the use of enamel in the amount of 0.15 tons.

Xylene:

$$M_{col}^{x} = \frac{0.15 \cdot 45 \cdot 25 \cdot 50}{10^6}(1-0) = 0.008437\ t/year = 0.00463\ g/sec$$

White spirit:

$$M_{col}^{x} = \frac{0.15 \cdot 45 \cdot 25 \cdot 50}{10^6}(1-0) = 0.008437\ t/year = 0.00463\ g/sec$$

Emissions from the use of a solvent of 0.07 tons.

Xylene:

$$M_{col}^{x} = \frac{0.07 \cdot 100 \cdot 25 \cdot 30}{10^6}(1-0) = 0.00525\ t/year = 0.00288\ g/sec$$

White spirit:

$$M_{col}^{x} = \frac{0.07 \cdot 100 \cdot 25 \cdot 70}{10^6}(1-0) = 0.01225\ t/year = 0.00672\ g/sec$$

When drying (Tulenov et al. 2015):

$$M_{dry}^{x} = \frac{m_a \cdot f_p \cdot \delta_p'' \cdot \delta_x}{10^6}(1-\eta)\ t/year \qquad (7)$$

Where $\grave{\grave{\delta_p}}$ is a share of solvent in paint and varnish materials, released during drying of the coating (%) (Akopova 2014).

Emissions from the use of enamel in the amount of 0.15 tons. Xylene:

$$M_{dry}^{x} = \frac{0.15 \cdot 45 \cdot 75 \cdot 50}{10^6}(1-0) = 0.0253\ t/year = 0.013895\ g/sec$$

White spirit:

$$M_{dry}^{x} = \frac{0.15 \cdot 45 \cdot 75 \cdot 50}{10^6}(1-0) = 0.0253\ t/year = 0.013895\ g/sec$$

Emissions from the use of a solvent of 0.07 tons.

Xylene:

Table 5. Emissions from the paint area

Name of substance	g/sec	t/year
Xylene	0.030051	0.054737
White spirit	0.045415	0.082737

$$M_{dry}^{x} = \frac{0.07 \cdot 100 \cdot 75 \cdot 30}{10^6}(1-0) = 0.01575\ t/year = 0.008646\ g/sec$$

White spirit:

$$M_{dry}^{x} = \frac{0.07 \cdot 100 \cdot 75 \cdot 70}{10^6}(1-0) = 0.03675\ t/year = 0.02017\ g/sec$$

The total amount of emissions for the paint area is given in **Table 5**.

During the operation of internal combustion engines, pollutants are released. The most famous of them are carbon monoxide, nitrogen oxide, and hydrocarbons. The gross emission (*Mi, t/year*Mi, т/год) of the contaminant of the "*i*" species from the group of "*m*" engine units of one ("*n*") model is calculated by the formula (Tulenov et al. 2015):

$$M_i(q_{ixxn} \cdot V_{hn} \cdot t_{xxn} + q_{iln} \cdot N_{avn} \cdot t_{ln}) \cdot m_n \cdot 60 \cdot 10^{-6} \quad (8)$$

Where q_{ixxn} – the specific allocation of the "*i*" pollutant by the gasoline or diesel engine of the "*n*" model when operating at idling per unit of working volume per second, g/l·s (Riabokon 2015);

V_{hn}- the working volume of the engine of the "n" model, l;

t_{xxn} – the operating time of the "*n*" model at idling, min.;

q_{iln}– the specific release of the "*i*" pollutant by the gasoline or diesel engine of the "n" model when running under load per unit of power (hp) per second, g/hp·s;

N_{avn} – the average power, developed during running-in under the load of the *n*-th model, hp;

t_{ln} $t_{нn}$– the run-in time of the *n*-th model under load, min.;

m_n – the number of rolling engines of the n-th model during the year.

The maximum one-time emission (g/s) of the pollutant of the "*i*" species (G_i) from the engine group of one (*n*) model is calculated when the engines are run-in only under load conditions according to the formula (Tulenov et al. 2015):

$$G_i = q_{iln} \cdot N_{avn} \cdot A_n \quad (9)$$

where A_n is the number of simultaneously tested engines of the "*n*" model (Veretikhin 2017).

At simultaneous running-in of different models, the maximum one-time emission is defined as the sum of the maximum one-time emissions of all simultaneously tested models. At car repair enterprises one of the sources of harmful substances' emission into the atmosphere is a welding section equipped with electric arc welding, a propane-butane cutter, an acetylene generator (Mukhina and Borodkina 2014). Electric arc welding uses electrodes, and iron oxide, manganese, and its compounds, hydrogen fluoride are released into the atmosphere. When the cutter operates on a propane-butane mixture, iron oxide, manganese and its compounds, carbon monoxide and nitrogen dioxide are released into the atmosphere. When the gas acetylene generator is operating, nitrogen dioxide is released into the atmosphere. The processes of welding and heat cutting of metals are accompanied by the release of welding aerosols and gases, the amount and composition of which are proportional to the consumption of welding materials (Tulenov et al. 2015):

$$M_i = g_i^c \cdot B \cdot 10^{-6} \quad (10)$$

where g_i^c is the specific release of "*i*" pollutant for a given welding, g / kg;

B is the total quantity of welding material of a given brand or combustible gas used for a year by technological equipment, kg/year.

The calculation of the release for the electric welding machine, the annual consumption of electrodes of which is 1200 kg/year, the working time of the section is 1012 hours/year, is carried out in accordance with industry guidelines for the standardization of harmful emissions into the atmosphere. The specific release from the electrodes is: iron oxide - 9.77 g/kg; Manganese and its compounds - 1.73 g/kg; Hydrogen fluoride 0.4 g/kg (Burmatova 2014).

$$M_{FeO} = \frac{9.77 \cdot 1200}{1000000} = 0.011724\ t/year = 0.003218\ g/sec$$

$$M_{MnO} = \frac{1.73 \cdot 1200}{1000000} = 0.002076\ t/year = 0.0005698\ g/sec$$

$$M_{HF} = \frac{0.4 \cdot 1200}{1000000} = 0.00048\ t/year = 0.00013\ g/sec$$

The next source is a gas cutter using a propane-butane mixture. The working time is 253 hours/year. The specific emission of pollutants: iron oxide - 72.9 g/h (0.02025 g/sec); Manganese and its compounds - 1.1 g/hour (0.00035 g/sec); Carbon monoxide - 49.5 g/hour (0.01375 g/sec); Nitrous oxide – 39.0 g/hour (0.01083 g/sec) (Pchelnikov 2016).

$$M_{FeO} = \frac{0.02025 \cdot 253 \cdot 3600}{1000000} = 0.0184437\ t/year$$

$$M_{MnO} = \frac{0.000305 \cdot 253 \cdot 3600}{1000000} = 0.000278\ t/year$$

$$M_{CO} = \frac{0.01375 \cdot 253 \cdot 3600}{1000000} = 0.0125235\ t/year$$

$$M_{NO} = \frac{0.01083 \cdot 253 \cdot 3600}{1000000} = 0.0098639\ t/year$$

For an acetylene generator, the consumption of calcium carbide is 125 kg/year, the working time of the section is 150 hours/year. The specific release of nitrogen dioxide during gas welding is 22 g/kg of the mixture. As it is known, from 1 kg of carbide 0.265 m^3 of acetylene or 0.265 m^3·1.09 kg/m^3=0.2888 kg (where 1.09 kg/m^3 is the density of acetylene) is formed. For 1 kg of carbide, the consumption of nitric oxide is 22 g/kg

Table 6. Total amount of emissions from the welding section

Name of substance	g/sec	t/year
Nitrogen dioxide	0.01223	0.0106581
Iron oxide	0.023468	0.0301677
Manganese and its compounds	0.0008748	0.002354
Carbon oxide	0.01375	0.0125235
Hydrogen fluoride	0.00013	0.00048

· 0.2888 kg/kg = 6.3536 g/kg (Ivintsova and Kuzmin 2014).

Annual gross emissions of nitrogen dioxide:

$$M_{NO_2} = 6.3536 \cdot 125 \cdot 10^{-6} = 0.0007942\ t/year = 0.0014\ g/sec$$

The total amount of emissions from the welding section is given in **Table 6**.

CONCLUSION

The use of the proposed calculation methods in the study of air pollution gives an opportunity to assess the degree of influence of certain factors on the emission of toxic components to the production sites of motor transport enterprises, significantly expands the ability of researchers to apply the proposed method to other production sites of road-building enterprises.

Air pollution can also be caused by the impurities that are part of the fuel composition, primarily sulfur compounds. Its content in some types of diesel fuel can reach 6%. When this fuel is burned, sulfur dioxide is formed. Dissolving in droplets of water, which condense around the smoke particles, sulfur dioxide significantly reduces its pH. “Acid mist” is hazardous to health, it has harmful effects on plants and animals, causing the destruction of metals and building materials.

One of the main carcinogens, according to some authors, is not engine emission, but tire and roadway wear. According to them, in the cities, one of the sources of carcinogenic substances entering the environment are pneumatic tires of vehicles, which wear out and age under the influence of climatic conditions and driving regimes. In tire dust, there are more than 140 chemical compounds of varying degrees of toxicity. Particularly dangerous are polyaromatic hydrocarbons and volatile carcinogens (N-nitrosamines). Studies of air quality near motorways have shown that in 1 m3 of air there are 3 800-6 900 rubber fragments, 58% of them are less than 10 μm in size, easily penetrate into the upper respiratory tract and affect them.

It has long been studied the ability of heavy metal particles to accumulate in soil and crops. In roadside dust and soils, as well as on plant leaves, there are ions of such metals as Fe, Al, Zn, Mn, Sr, Pb, Ba, Cu. It is also established that due to the small size the metal particles have a high adhesion and they are transmitted to people, domestic and wild animals through roadside dust, soil, plants.

High bioavailability of elements of automotive catalysts and heavy metals is noted in the case of Pt, Pd, and Rh. The availability of Pt was 68%, and Pd, Rh are even higher due to the fact that these metals form mobile soluble complexes. Metal-mediated formation of free radicals causes various changes in nucleic acids, an increase in lipid peroxidation.

Currently, gasoline engines are the main source of air pollution. It is believed that the emission of diesel engines is more toxic.

A group of American scientists assessed the impact of different types of engines operating on different fuels on the environment. It was found that the transfer of engines to ethanol or other fuels does not give the proper ecological effect, but, on the contrary, leads to greater pollution of the environment. It has been proven that the use of biofuels or hybrid modes of transport can reduce CO2 emissions by up to 90%, but emissions of PM10 and PM2.5 can increase 10 fold. This is due to the fact that powerful combine harvesters and other agricultural machinery are used to produce the vegetable base for biofuels, the emissions from which are very significant.

Similar studies have been conducted in China, and it has been proven that the charging of hybrid and electric vehicles requires energy for the production of which a large amount of coal is burned, which leads to even more pollution of the atmosphere.

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