ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

The Influence of Seasonal Conditions on the Heavy Metals Emissions during Vehicle Operation.

Nikolay Stepanovich Zakharov*, and Alexander Anatolyevich Panfilov

Tyumen State Oil and Gas University, Volodarskogo st., 38, Tyumen, 625000, Russia.

ABSTRACT

The paper presents theoretical and experimental studies to determine the influence of seasonal conditions of road transport on the roadside areas pollution with heavy metals. The aim of the study is to increase the environmental safety of road transport by establishing patterns of its influence on the formation of mass emissions of heavy metals taking into account the seasonal conditions and on this basis to develop calculation methods for charge for the environmental pollution. The object of the study is the process of heavy metal pollution of roadside areas in the operation of road transport. The subject of the study is the patterns of change in mass emissions of heavy metals from cars in the roadside areas, depending on the seasonal conditions of vehicle operation. Results of the studies: the patterns of formation of heavy metal mass emissions, taking into account the seasonal variations in the ambient temperature and parameters of the traffic flow (speed and intensity), have been established; the mathematical models of the effect of ambient temperature, speed and intensity of the traffic flow on changes in the concentration of heavy metals in the roadside areas have been developed; the numerical values of the mathematical models parameters have been experimentally determined. The practical value of the work is to develop methods for calculating charge for soil contamination by road transport taking into account the ambient temperature, speed and intensity of the traffic flow.
Keywords: road transport, traffic intensity, heavy metals, soil contamination, roadside area.

***Corresponding author**

INTRODUCTION

The road transport meets the needs of freight and passenger traffic and is an integral part of many technological processes. It is one of the main sources of pollution [1,2,3,4,5]. Contamination occurs throughout the space components of our biosphere, namely, air, water basin and fertile soil layer. The number of vehicles is steadily growing, the traffic intensity is increasing, therefore, this leads to an increase in gross emissions of harmful substances. The severe environmental situation in most parts of Russia requires urgent measures for the protection of the environment.

The main components of exhaust gases are various gaseous substances, consisting of the products of complete and incomplete fuel combustion, excess oxygen, aerosols and different impurities (both gaseous ones and liquid and solid particles). The soil contamination of roadside area is characterized by the content of the transport system products in the topsoil layer, in particular, there is accumulation of heavy metals at a distance of 100 meters from a highway [6]. Ultimately, there is a direct impact of harmful substances on health of people living in settlements near roads and through consumption of crops.

The operating conditions of vehicles (climatic conditions, road conditions, seasonal conditions and many others) have the important influence on the emission of harmful substances.

The studies of soil contamination of roadside areas don't help fully to take into account the influence of factors of operating conditions of vehicles. Therefore, it should be noted the relevance of research aimed at the study of patterns of formation of heavy metal mass emissions, taking into account the seasonal conditions of vehicle operation.

It is known that in winter the intensity of traffic flow decreases, but the fuel consumption increases, as well as the wear of friction surfaces intensifies, deterioration of tire studs occurs, which may also influence the soil contamination. In the summer time there is a sharp increase in the intensity of the car traffic, at the same time the radius of dispersion of heavy impurities widens.

METHODS

The contamination of roadside areas with heavy metals is the subject of many research works in our country and abroad. The study of previous research has established the following: vehicles affect the contamination of soils near highways, as evidenced by the decrease in heavy metal concentration away from the road. The exhaust gases, in addition to the basic components, contain heavy metals, that are part of the lubricating oil additives, or are products of wear of engine parts.

Besides, the sources of heavy metals may be the products of wear of brake linings (copper, lead, chromium, nickel, zinc), the tire wear products (zinc, cadmium, copper, lead), the products of wear of road carpet (cadmium, lead), leakage and evaporation of fuel through the feed system, crankcase gases, de-icing mixtures.

The heavy metals emissions are deposited in close vicinity to the pollution sources and are accumulated at a depth of several inches of soil cover. The maximum contamination of roadside occurs in an area up to 30 meters. The most dangerous among the heavy metals, emitted during the vehicle operation, are lead, zinc, copper. The lead intoxication may lead to the damage of the central nervous system, liver, kidneys, brain, reproductive organs, while copper poisoning can cause anemia and hepatitis diseases.

The roadside areas pollution with heavy metals is affected by a large number of factors. In earlier studies the influence of several of them was investigated.

Research of R.H. Izmailov, conducted in MADI in the late 70-ies, as well as works of V.I. Purkin, T.S. Samoilova [3] has become known in establishing patterns of distribution of lead emissions.

Dz. Zh. Berinya, I.M. Lapinya, L.V. Karelina [7] have obtained a large amount of data of the presence of heavy metals and other elements in roadside soil and plants taking into account a number of different factors.

V.N. Denisov [8] indicates that of the total amount of heavy metals emissions by automobile transport about 25% remains to flush on the roadway, 75% is distributed on the surface of the adjacent territory, including the road shoulders.

Since lead has long been used as an antiknock component in ethyl gasoline, and the gasoline engines represent a significant portion of the total number of power plants of rolling stock, most of the work was associated with the determination of the area of excess soil contamination by lead compounds. excess soil contamination by lead compounds. The influence of seasonal conditions of vehicle operation on the heavy metal emissions in roadside areas has not been not studied properly.

To characterize the behavior of the traffic flow on the roads outside of a town, it is possible to apply macroscopic models that can adequately describe this process.

The analysis of the state of the question has formulated the following tasks, the solution of which provides the achievement of this goal:

To establish a list of factors of operating conditions of vehicles significantly affecting the soil contamination near roads.

To develop mathematical models of the influence of factors of operating conditions on soil contamination in the roadside areas.

To develop a mathematical model of changes in parameters of traffic flows outside of a town in time.

To determine numerical values of parameters of the mathematical models. To estimate the adequacy of the obtained models.

To develop ways of practical use of the results and to assess the economic effectiveness of their implementation.

In order to determine the influence of motor transport on the soil contamination with heavy metals a systematic approach has been used. In accordance with this, at the first stage the criterion of effectiveness of functioning of the system investigated is determined.

In the general case, the minimization of total heavy metals emissions ($\sum M_E$) from the road transport, assuming the following expression for a target function, can be determined as a criterion of effectiveness:

$$\sum M_E \rightarrow \min. \qquad (1)$$

The localization of the system is to establish a list of factors most significantly affecting the formation of heavy metal emissions near roads.

The selection of factors includes the following stages: the definition of the list of all factors influencing the heavy metal emissions; the preliminary selection on the basis of a priori estimate of their impact; parameterization, i.e. the choice of indicators to characterize factors; the final selection based on the results of the experiment using formal mathematical methods.

The factors of operating conditions affect the quality of working processes in the engine and as a consequence determine the composition and intensity of heavy metals emissions in the environment.

The system operates with an initial condition of the general operability of the vehicle, according to the regulations of the regulatory and technical requirements. In this regard, the influence of the technical state on the process of formation of the mass emissions of pollutants is not considered in this system.

The change in total emissions depends both on the composition of the emissions of harmful substances and the intensity of their income in the environment.

The composition of the emissions depends on the type of the rolling stock, the quantity and quality of the fuel consumed, which can be measured by running exhaust emissions of harmful substances with the exhaust gases of a single vehicle. The intensity of the emissions is characterized by a number of sources of emissions per unit of time.

There is a correlation relationship between the ambient temperature and the elements of the system. The analysis of relationship of elements of the system considered has shown, that the patterns of the influence of seasonal conditions of vehicle operation on the intensity of heavy metal emissions have been studied to a lesser extent.

Based on the fact that there is a close correlation among the climatic factors of operating conditions [9], it is sufficient to use the indicators of one of the seasonal factors – the ambient temperature M=f(t) at accounting for the influence of them.

From the analysis of previous studies and literary sources it is known that the ambient temperature has a great influence on the change in emissions of harmful substances [10,11,12,13]. It is hypothesized that the change in emissions of heavy metals at the change in the ambient temperature is represented by a quadratic model:

$$C = a + b \cdot \left(t - t_0\right)^2, \qquad (2)$$

where

C	-	concentration of heavy metals, mg/kg;
a, b	-	empirical coefficients;
t	-	ambient temperature, ^{0}C;
t_0	-	optimal temperature corresponding to the minimum heavy metals emissions, ^{0}C.

The influence of the quantity of transport means on the contamination of roadside areas can be evaluated by the intensity of the movement of the transport steam.

The seasonal changes in climatic conditions lead to corresponding changes in road conditions, the fluctuations of which in time lead to variations in the speed of the traffic flow that affects the emissions of pollutants.

The hypothesis about a possibility of representing the influence of intensity and speed of the traffic flow on the heavy metal emissions by the exponential models has been advanced on the ground of the study of the asymptotic behavior:

$$C = d \cdot e^{f \cdot N_h} \qquad (3)$$

where

C	-	concentration of heavy metals, mcg/dm^3;
d, f	-	empirical coefficients;
N_h	-	average intensity of the traffic flow, veh/h.

$$C = g \cdot e^{h \cdot V}, \qquad (4)$$

where

C	-	concentration of heavy metals, mcg/dm^3;
g, h	-	empirical coefficients;
V	-	the traffic speed, km/h.

The mass heavy metals emissions of vehicles is affected by a number of factors, because of that the mathematical models, describing the patterns of the influence of these factors, are multifactorial. Using equations (2), (3) and (4), on the ground of rules of constructing multifactor models a three-factor multiplicative mathematical model of formation of heavy metals emissions by cars has been developed:

$$M_{\Sigma} = \left(a + b \cdot (t - t_0)^2\right) \cdot \frac{C_{Ni}}{\bar{C}_{Ni}} \cdot \frac{C_{Vi}}{\bar{C}_{Vi}}, \quad (5)$$

where

M_{Σ}	-	total heavy metal emissions in the roadside areas with different variations of air temperature, speed and intensity of the traffic flow;
C_{Ni}, C_{Vi}	-	concentrations of heavy metals depending on the intensity and speed of the traffic flow, mcg/dm^3;
$\bar{C}_{Ni}, \bar{C}_{Vi}$	-	average values of concentration of heavy metals for the considered intervals of the intensity and speed of the traffic flow, mcg/dm^3;
i	-	type of heavy metals (j=1,2,3…n).

Based on the analysis of literature sources a macroscopic mathematical model of traffic flow outside of town has been proposed. The intensity of traffic flows is subject to a significant temporal change [14], there is not only daily, but also weekly and seasonal periodicity, which may be represented by the harmonic model:

$$N_T = N_C + \sum_{k=1}^{g} C_k Cos(m(kT_i - T_k)) + N_P, \quad (6)$$

where

N_c	-	average value of the intensity per cycle, veh/h;
k	-	number of harmonics;
g	-	quantity of harmonics;
C_k	-	half-amplitude of fluctuations of the k-th harmonic;
m	-	interval between T_i and T_{i+1} in degrees;
T_k	-	initial phase of the fluctuation.

RESULTS

The goal of the experiments is the determination of the numerical values of the parameters of mathematical models and test of their adequacy.

Experimental studies were carried out in parallel in several directions.

The first one was to determine the influence of seasonal conditions of vehicle operations on the pollution of soil with heavy metals. In order to avoid the background contamination the assessment of the impact of seasonal conditions of the operation of vehicles on soil contamination with heavy metals was performed outside the city limits for the purity of the experiment.

In the works [15,16] the ability of plants to absorb from the environment almost all known chemical elements from the environment is described. The in-situ experiments [17] show that on the sides of trees, facing the road, the content of heavy metals is much higher, and the more distance from the road is, the less concentration is.

To study the environmental pollutions with heavy metals the bioindicators were used. The bark of Scots pine (Pitras sylvestris) was chosen as a bioindicator. Since the bark has a rough surface, it is capable to hold heavy metal compounds for a long time, which facilitates their penetration inside [18].

Sampling bark was made throughout the year. The incision was taken from several tree trunks at the same distance from the road on the left and right sides. After that, the averaged sample was placed in a sterile marking package and was delivered to the laboratory for analysis. Sampling was carried out in dry weather on different paths with different traffic intensity and manmade load.

The second direction was to determine the influence of the speed and intensity of the traffic flow on the level of soil contamination of roadside areas with heavy metals. The samples of snow, taken at 5-meter distance from the roadway on the left and right sides of the road at the speed limit of the traffic flow: 30 km/h – STSI post, 50 km/h – town, 70 km/h – narrowing of road, 90 km/h – straightway of road were studied and analyzed.

Processing of bark and snow samples was carried out on the basis of the laboratories of the department of general and special chemistry of TSOGU. Determining the concentration of heavy metals in plant samples was carried out in accordance with GOST 30692-2000. The measurement of the mass concentration of ions of the detectable metals in the solution was carried out by an inversion voltammetric method using polarography ABC-1.1 which provides a sufficient level of accuracy. The method is based on the electrochemical concentration of the measured elements on the working electrode with the subsequent registration of the maximum anode currents of electro-dissolution of the accumulated elements.

The impact of cars on the level of soil contamination of roadside areas with heavy metals was determined by the most negative indicators (copper and lead) which have the largest share on concentration in the roadside area. In addition, the work was estimated the cumulative impact of elements of the traffic flow on soil contamination of roadside areas.

The third direction was to study the dynamics of the traffic flow on the highways of Federal and regional significance. As objects of the study the paths around the city of Tyumen with the intensity of traffic flow from 500-1000 veh/h – Tobolsk, Yalutorovsk, Chervishevsky and Moscow – were chosen.

The experiment was conducted on all paths simultaneously, one hour of maximum intensity was studied every day at the same time during all the week. The peak of maximum intensity of the day was determined through a preliminary experiment. The studies of the traffic flow were held during all four seasons. While studying the dynamics of traffic flows the actual dynamic characteristics were experimentally determined and the nature of their changes in time.

The studies of traffic flows were carried out using different methods: in-situ observation, recording the traffic flow on a video camera, the study on stationary posts and through mobile means.

The fourth direction involved the collection of statistical data on the changes in the ambient temperature during the study of the roadside areas pollution.

After processing the experimental data on the repeated measurements of plant samples for heavy metal contents for each month the graphs of the changes in lead and copper concentrations during a year were constructed (Figures 1, 2).

The change of concentration of heavy metals during a year is represented by the models (mg/kg):

$$C_{Pb}=0.62 + 0.14\cdot \cos (30\,(T - 1.01)); \quad (7)$$
$$C_{Cu}=0.68 + 0.26\cdot \cos (30\,(T - 0.94)). \quad (8)$$

As it can be seen from the above graphs, the changes in the heavy metal concentrations during a year has pronounced the seasonal fluctuations. The first harmonic is the most important one in all cases (with a period of 1 year), the impact of other harmonics is not important based on the Student statistic in the program “REGRESS 2.5”.

It was further established the influence of the ambient temperature on lead and copper concentrations in the roadside areas (Figures 3, 4).

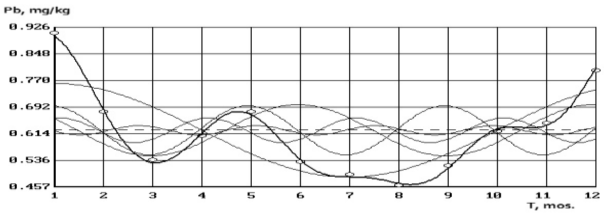

Fig.1. The pattern of the change in the lead concentration during a year

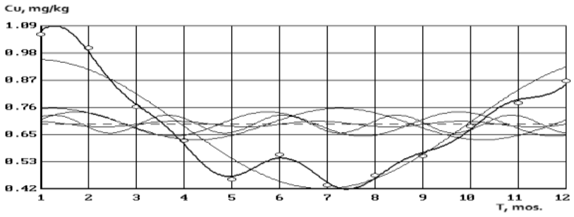

Fig.2. The pattern of the change in the copper concentration during a year

The influence of the ambient temperature on heavy metal concentrations is represented by the models (mg/kg):

$$C_{Pb} = 0.53 + 0.000432 \cdot (t - 9)^2 ; \quad (9)$$

$$C_{Cu} = 0.54 + 0.00073 \cdot (t - 9)^2 . \quad (10)$$

The fuel consumption depends on the ambient temperature. At low temperature the working processes of the engine, caused by the low thermal behaviour, worsen, which leads to the increased fuel consumption.

In the summer time the evaporation of the fuel increases, filling the cylinders of the engine worsens, there are additional losses in the fan drive of the cooling system, all this leads to the increased fuel consumption and inefficient engine operation.

Besides, the heavy metals emissions in the roadside areas depend on the wear processes occurring during the movement of vehicles. At the low ambient temperature, the fuel consumption increases due to the increase of the resistance of the transmission and tires, the increased aerodynamic drag, this can lead to high levels of toxic substances in the exhaust gases.

TABLE 1. The statistical characteristics of mathematical models of the influence of the ambient temperature on the heavy metal concentrations

Name of characteristics	Numerous values of characteristics	
	Lead	Copper
Correlation coefficient	0.82	0.87
Determination coefficient	0.67	0.76
t-statistics of the correlation coefficient	4.59	5.6
Significance level of the correlation coefficient	0.99	0.99
Average approximation error, %	10.17	12.6
$S_{res.}$	0.082	0.11
Fisher dispersion relation	2.54	3.4
Level of adequacy	0.9	0.95
Elasticity coefficient	0.14	0.21
Influence coefficient	0.21	0.31

ISSN: 0975-8585

The Fisher dispersion relation for the models exceeds the tabular value with the probability of more than 0.90, the average approximation error does not exceed 12.6 %. This indicates the adequacy of the models to experimental data.

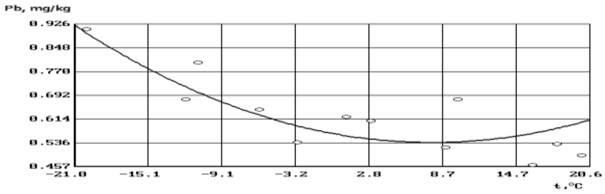

Fig.3. The influence of the ambient temperature on the lead concentration in the roadside area

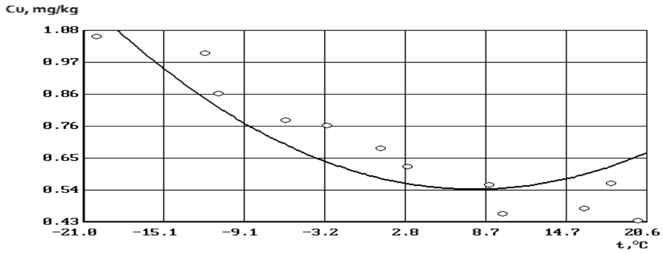

Fig.4. The influence of the ambient temperature on the copper concentration in the roadside area

After the analysis of the aqueous extract (slush) the types of mathematical models for the influence of speed and traffic intensity on the lead and copper concentrations were determined.

The influence of the traffic flow intensity on the lead and copper emissions is represented by the following models, mcg/dm^3:

$$C_{Pb} = 1.66 \cdot e^{0.0042 \cdot N_h}, \quad (11)$$

$$C_{Cu} = 2.79 \cdot e^{0.0024 \cdot N_h}, \quad (12).$$

The traffic intensity is determined by the number of vehicles passing through a section of a road per unit of time, which greatly influences the manmade load of the adjacent territory.

The traffic intensity is subject to the seasonal fluctuations related to the seasonal changes in the volumes of work in industry, construction, agriculture, seasonal changes in operating conditions (road conditions: spring and autumn slush in rural areas, the seasonality of the work of winter roads, snow drifts, ice-slick, low ambient temperature), seasonal vacations of workers (drivers).

The influence of the traffic flow intensity on the lead and copper emissions are presented in Figures 5 and 6.

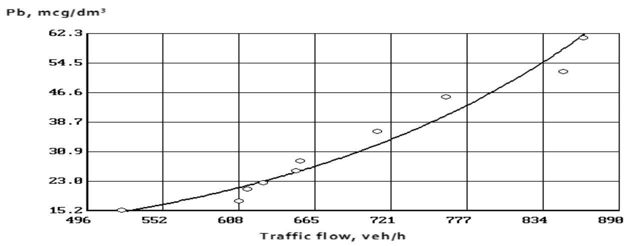

Fig.5. The influence of the traffic flow intensity on the lead emissions

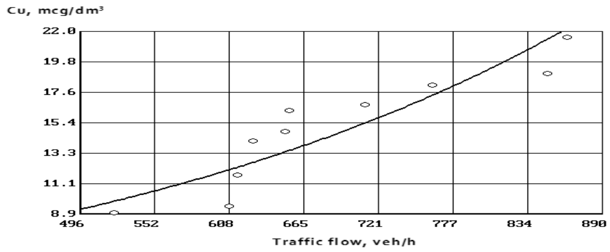

Fig.6. The influence of the traffic flow intensity on the copper emissions

TABLE 2. The statistical characteristics of mathematical models of the influence of the traffic flow intensity on the heavy metals emissions

Name of characteristics	Numerous values of characteristics	
	Lead	Copper
Correlation coefficient	0.97	0.89
Determination coefficient	0.95	0.79
t-statistics of the correlation coefficient	13.59	5.63
Significance level of the correlation coefficient	0.99	0.99
Average approximation error, %	7.33	10.6
$S_{res.}$	3.69	2.05
Fisher dispersion relation	17.82	4.02
Level of adequacy	0.99	0.95
Elasticity coefficient	0.85	0.61
Influence coefficient	0.85	0.43

The influence of the traffic flow speed on the lead and copper emissions is represented by the following models, mcg/dm^3:

$$C_{Pb} = 52.4 \cdot e^{-0.015 \cdot V}; \quad (13)$$

$$C_{Cu} = 36.52 \cdot e^{-0.017 \cdot V}. \quad (14)$$

The influence of the traffic flow speed on the lead and copper emissions is presented in Figures 7 and 8.

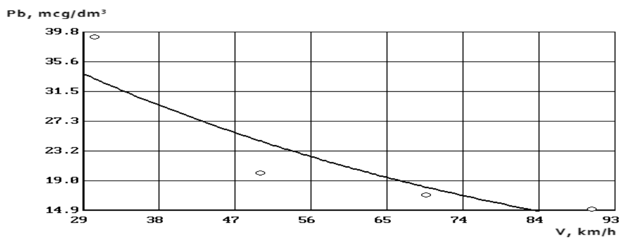

Fig.7. The influence of the traffic flow speed on the lead emissions

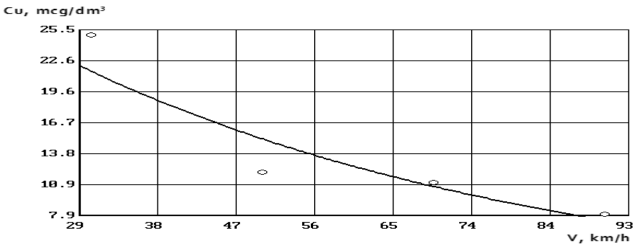

Fig.8. The influence of the traffic flow speed on the copper emissions

TABLE 3. The statistical characteristics of mathematical models of the influence of the traffic flow speed on the heavy metals emissions

Name of characteristics	Numerous values of characteristics	
	Lead	Copper
Correlation coefficient	0.92	0.94
Determination coefficient	0.84	0.88
t – statistics of the correlation coefficient	3.29	3.9
Significance level of the correlation coefficient	0.95	0.95
Average approximation error, %	13.51	11.4
S_{res}	7.59	4.69
The Fisher dispersion relation	2.1	2.57
The level of adequacy	0.9	0.9
Elasticity coefficient	0.3	0.41
Influence coefficient	0.31	0.43

The heavy metals emissions are more important at low speeds, this is due to the change in fuel consumption, the wear processes at low rotation frequencies of the crankshaft. In addition, the increase in high-speed mode of the traffic flow leads to the increase in the radius of pollutant dispersion that reduces the heavy metal concentration in the roadside areas.

The three-factor models can be presented as (mg/kg):

$$C_{Pb} = \left[0.53 + 0.000432 \cdot (t-9)^2\right] 0.05 \cdot e^{0.0042 \cdot N_h} \cdot 2.3 \cdot e^{-0.015V} \quad (15)$$

$$C_{Cu} = \left[0.54 + 0.00073 \cdot (t-9)^2\right] \cdot 0.18 \cdot e^{0,0024 \cdot Nh} \cdot 2.6 \cdot e^{-0.017 \cdot V} \quad (16)$$

where

- t - ambient temperature, ^{0}C;
- N_h - hourly average intensity of the traffic flow, veh/h;
- V - traffic flow speed, km/h.

Figure 9 shows the pattern of the change in the traffic flow intensity outside of a town during a week. This pattern is adequately expressed by the model:

ISSN: 0975-8585

$$N = 1.00 + 0.074 \cdot \cos(30(T - 6.42)) + 0.067 \times$$
$$\times \cos(30(2 \cdot T - 0.25)) + 0.070 \cdot \cos(30(3 \cdot T - 8.44)). \quad (17)$$

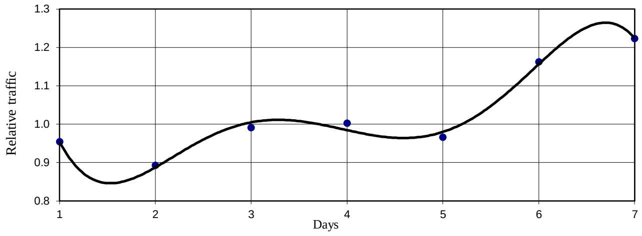

Fig.9. The graph of the change in the traffic flow intensity by days of week

The influence of the ambient temperature and traffic flow speed on the lead and copper emissions when the traffic intensity is 600 veh/h<N<800 veh/h is presented in Figures 10 and 11.

Thus, as a result of theoretical and experimental studies the first four research objectives have been solved.

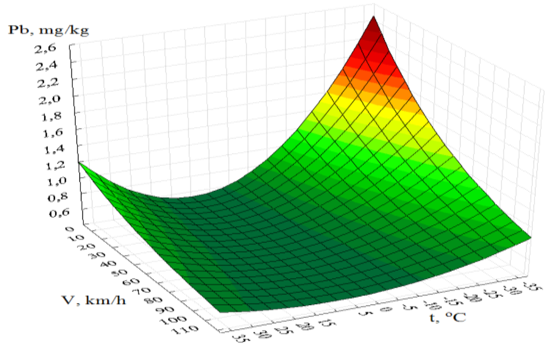

Fig.10. The influence of the ambient temperature and traffic flow speed on the lead emissions when the traffic intensity is 600 veh/h<N<800 veh/h

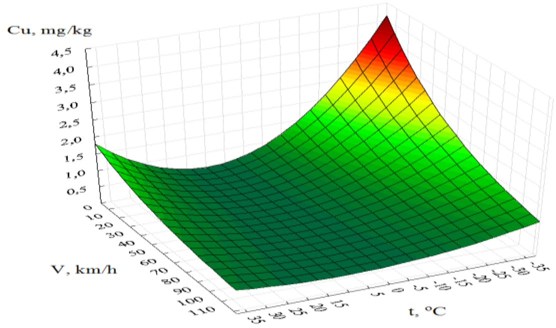

Fig.11. The influence of the ambient temperature and traffic flow speed on the copper emissions when the traffic intensity is 600 veh/h<N<800 veh/h

DISCUSSION

The experimental studies have shown that the concentration of heavy metals varies periodically during a year. Their content varies depending on the seasonal conditions of vehicle operation. The correlation relationship between the changes in the heavy metal concentrations and parameters of the traffic flow (speed and intensity of the traffic flow) has been experimentally proved.

Based on these results, the methods for calculating additional charge for soil contamination by road transport, aimed at the compensation of economic damage associated with the influence of pollutant emissions, the stimulation to reduce emissions, the formation of funds for design and construction of environmental protection facilities have been proposed.

The charge is calculated on the basis of data on running exhaust emissions of single vehicles, rates of charges for emissions from the mobile sources and summing the obtained compositions according to the types of pollutants [19].

In these methods, based on the results of the research an irregularity coefficient of the heavy metals emissions, which takes into account the change in the ambient temperature, in the category of road and type of road carpet during operation of vehicles on the formation of heavy metals emissions, has been proposed. The differentiation of the charge for contamination of soils is based on the climatic region and categories of operating conditions of automobiles.

These methods has been tested in the Rospotrebnadzor administration in the Tyumen region and has been introduced as an experiment in the company of UTT and ST-3 LLC “Gazprom transgaz Surgut”.

The practical value of the results obtained is potential for the development of calculation methods for charge for soil contamination by vehicle emissions, besides, the research may be used and be useful in other areas of practical application – nature-protection measures, traffic management.

TABLE 4. The irregularity coefficient of the heavy metals emissions

The type of the road carpet	Categories of roads	Climatic regions					
		Warm, hot, dry	Moderate	Moderately cold	Arctic	Cold	Very cold
D1	I	1.58	1.60	1.62	1.64	1.66	1.70
	II	1.10	1.11	1.13	1.15	1.18	1.21
	III	0.57	1.59	0.61	0.63	0.65	0.69
D2	II	1.15	1.16	1.18	1.20	1.23	1.26
	III	0.62	0.64	0.66	0.68	0.70	0.73
	IV	0.57	0.58	0.60	0.62	0.65	0.68
D3	II	1.27	1.29	1.31	1.33	1.35	1.39
	III	0.74	0.76	0.78	0.80	0.82	0.86
	IV	0.69	0.71	0.73	0.75	0.77	0.81
D4	III	0.82	0.83	0.85	0.87	0.90	0.93
	IV	0.76	0.78	0.80	0.82	0.84	0.88
D5	IV	0.76	0.78	0.80	0.82	0.84	0.88
D6	V	0.82	0.83	0.85	0.87	0.90	0.93

CONCLUSION

The main results and conclusions:

On the basis of the conducted research an applied research task of establishing the patterns of formation of mass heavy metals emissions taking into account the seasonal conditions of vehicle operation and developing on this basis the calculation methods for charge for contamination of soils has been solved.

The types of mathematical models of patterns of changes in the lead and copper concentrations in time have been established. With the probability of 0.9 these patterns are adequately described by harmonic models. The first harmonic is the most important one in all cases (with a period of 1 year), the impact of other harmonics is not statistically significant.

The types of mathematical models of influence of the ambient temperature on changes in the lead and copper concentrations in the roadside areas have been established. With the probability of 0.9, these patterns are adequately represented by the quadratic models.

The types of mathematical models of influence of the traffic flow speed and intensity on changes in the lead and copper concentrations in the roadside areas have been established. With the probability of 0.9, these patterns are adequately represented by the exponential models.

The pattern of formation of mass heavy metals emissions, taking into account the seasonal variations in average daily run, speed and intensity of the traffic flow, adequately represented by a three-factor multiplicative mathematical model, has been established.

The numerical values of parameters of the mathematical models have been experimentally determined. The results have showed that the approximation error of the models obtained is less than 12.6 percent; the probability of the adequacy in all cases exceeds 90%.

The character of changes in weekly traffic flow intensity on the roads outside of a town, which is adequately represented by a harmonic model, has been established.

The method for calculation of the correction irregularity coefficient of heavy metals emissions, depending on the ambient temperature, speed and intensity of the traffic flow, has been developed.

On the basis of the conducted research the methods for calculation of charge for soil contamination with regard to the operating conditions of vehicles in the climatic region, the category of road and type of the road carpet has been proposed.

The further research can be aimed at the determination of benzapyrene, which is one of the most toxic elements formed during the engine operation. The complexity of such studies is associated with a very time-consuming and costly experiment to determine the concentration of benzapyrene in the soil of the roadside areas. It should be noted that research in this field is becoming of increasing interest to ecologists year by year and is an up-to-date direction of scientific activity. The obtained results can be used to assess the level of pollution of the roadside areas with benzapyrene, as well as to develop the necessary preventive measures.

ACKNOWLEDGEMENTS

The work was supported by a grant from the Governor of the Tyumen region, obtained on a competitive basis. The author expresses his deep gratitude to Tulkin V.A., Ph.D. in technical sciences, associate professor, for his advice when conducting research in this paper.

REFERENCES

[1] V. Ambartsumyan, V. Nosov, V. Tagasov, V. Sarbaev, "Environmental safety of road transport" - Moscow: Nauchtekhlitizdat, 1999.
[2] M. Bolbas, E. Savich, G. Kukharenok, R. Parmon, "Transport and the environment". - Minsk: Technoprint, 2003.
[3] V. Lukanin, Yu. Trofimenko, "Industrial and transport ecology". - Moscow: Higher school, 2001.
[4] E. Pavlova, "Transport ecology". - Moscow: Transport, 2000.
[5] V. Protasov, "Ecology, health and environment protection in Russia, 2nd ed.". - Moscow: Finance and statistics, 2000.
[6] P. Douglas, A. Ormrod, "The impact of microelement pollution on plants", Air pollution and plant life, 1998.
[7] "Institute of biology "Zinatne", Pollution of the natural environment by the vehicle". - Riga: Academy of Sciences of the Latvian SSR, 1998.
[8] V. Denisov, V. Rogalev, "Ecologization problems of road transport". - St. Petersburg: MANEB, 2003.

[9] A. Rakitin, "The influence of seasonal changes in operation intensity conditions on the failure rate of vehicles", PhD thesis, TSOGU, Tyumen, 2004.

[10] E. Inasaridze, "Optimization of the warm-up mode of the engine in terms of environmental indicators (the case of VAZ petrol cars)", PhD thesis, TSOGU, Tyumen, 2003.

[11] S. Kolesnikov, "Evaluation of the influence of the dynamic characteristics of traffic flow on pollutant emissions of vehicle", PhD thesis, TSOGU, Tyumen, 2003.

[12] O. Novoselov, "Assessment of the suitability of vehicles to low-temperature operating conditions by toxicity of exhaust gases", PhD thesis, TSOGU, Tyumen, 2002.

[13] A. Sopov, "On the adaptation of vehicles to the operation conditions by the content of harmful substances in exhaust gases", The suitability of vehicles to the harsh operating conditions, pp. 141-142, 1999.

[14] N. Zakharov, "Modeling of changes in the quality of cars". - Tyumen: TSOGU, 1999.

[15] N. Zyrina, S. Malakhova, "Methodical recommendations on conducting field and laboratory studies of soils and plants in the control of environmental pollution with metals". - Moscow: Gidrometeoizdat, 1982.

[16] V. Ilyin, "Heavy metals in the system soil-plant". - Novosibirsk: Nauka, 1991.

[17] W. Smith, "Lead contamination of roadside White Pine", Forest. Sci., vol. 17, 1971. DOI:10.1126/science.176.4040.1237

[18] E. Sobaleva, "Lead in soil and plants as an indicator of the impact of transport on the environment of Ussuriysk town", PhD thesis, FESU, Vladivostok, 2003.

[19] "Instructional and methodological guidelines on charging for environmental pollution", Ministry of natural resources of the RF, vol. 77, 2000.

[20] V. Lukanin, A. Buslaev, M. Yashina, "The transport flows and the environment – 2". Moscow: Infra-M, 2001.