

INFLUENCE OF VEHICLES ON POLLUTION OF ATMOSPHERIC AIR OF SEASIDE TOWNS

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Summary. The way the microclimatic features of the Crimean seaside towns influences the dispersion of “weightless” admixture from vehicles has been analysed in the article. The received results of the calculation of contaminants concentration along the different motorways have been estimated and calculated according to the existed methods. The calculation results demonstrate imperfection of these methods application in the conditions of the foothills and mountain relief, they don't take into account the following climatic conditions: reverse temperature inversion, atmospheric air temperature gradient, geomorphologic features of relief, anthropogenic landscape and others. The aim of the present work was to improve the existing methods on calculation of disperse of “weightless” admixture in the boundary layer of the atmosphere in the conditions of the mountain relief by introduction of the additional coefficients.

Key words: vehicles, dispersion, “weightless” admixture, mountain relief, microclimate of territories.

INTRODUCTION

Quality of atmospheric air is one of the basic vital elements of the environment. To provide a safe person's activity and prevent harmful influence on the environment it's necessary to keep favorable state of atmospheric air, to renew and improve it.

The main source of the atmospheric pollution in modern towns and settlements is motor transport – up to 85-90%. Pollution caused by vehicles is of linear – vector character [Lukanin 2001].

The main pollution substances entering the atmospheric air and the wayside territory are oxide of carbon (CO), dioxides of sulfur (SO₂), nitrogen (NO₂), hydrocarbons (C_nH_m), phenol (C₆H₆O), formaldehyde (CH₂O), petrol, technical oil, fuel oil and others [Jakubovsky 1979].

In Ukraine for calculation of pollution caused by vehicles, the existing methods are used. [Method of calculation of pollution 1985, 1995, 2000]. The calculation is done according to the specific emissions, mileage and product of coefficients of a number of factors.

According to the other two methods [1995, 2000], the calculation of the atmospheric emission is done with the amount of emission and the fuel used with the consideration of the type of movement, coefficients, technical state of the vehicle.

In the EC countries the method used is close to the one described above, the difference is in the classification of vehicles and the emission of pollutants into the atmosphere.

The methods mentioned are aimed at calculation of the disposed quantify per second, hour, month, they are used to calculate the amount of the money paid for ecological services, but they don't allow us to estimate the atmospheric air pollution.

The methods of calculation of concentration of harmful substances in the atmospheric air have been worked out for 30 years (from 1970-s till 1990-s) and were summarized in the method [Method of calculation 1987] where calculation of harmful substances concentration have been given. While district planning and road construction great attention was paid to the regulation of the atmospheric emissions in the unfavorable meteorological conditions [Methodical pointing 1986]. However, all the described methods don't show the amount of "weightless" admixture on the territory along the motorways in the conditions of foothills and mountain relief that is characteristic of the most seaside towns in Ukraine.

The main aim of this work is improvement of the present method on calculation of disperse of "weightless" admixture along motorways of different functions located in various geomorphologic relief forms.

MATERIALS AND METHODS

To solve the set problem the territories of the following resort towns in the Crimea have been chosen: Simferopol, Yalta, Feodosiya, since there are motorways in them. On the selected territories, the model measuring of quantitative and qualitative characteristics of transport streams on motorways has been done. Fig. 1 demonstrates the results of the observation.

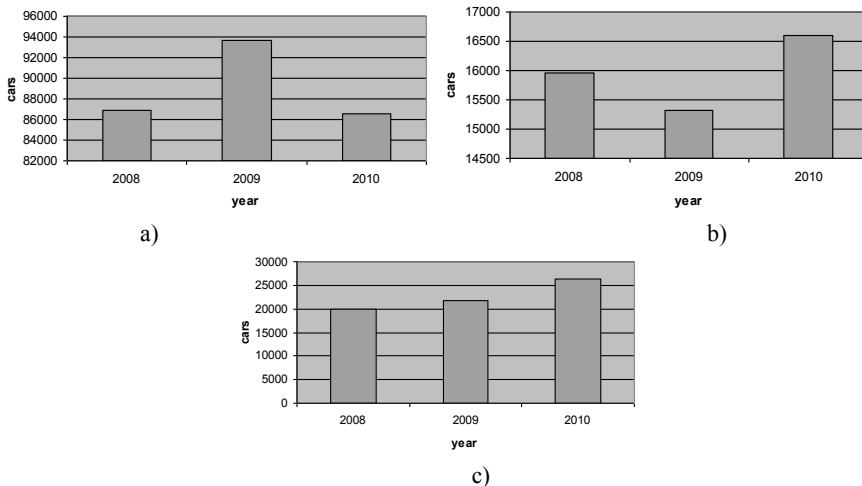


Fig. 1. Quantitative characteristics of motor transport streams on the selected motorway of cities: a) Simferopol, b) Yalta, c) Feodosiya

Table 1. Annual mass of extras of pollutants for the selected highways of cities of Crimea

City	Mass of extras of pollutants, ton/year		
	Year of supervision		
	2008	2009	2010
Simferopol	22850	24650	22774
Yalta	4199	4034	4367
Feodosiya	5214	5750	6928

The received results allow us to mark total pollution, but we can't have the concentration of emissions along the motorways that is thought to be more important. Therefore, these data can't be used for the estimation of the atmospheric air quality along the motorways.

To solve that problem on estimation of the emission concentration along the selected motorways, the authors used the methods existing in Ukraine [Method of calculation of pollution 1995, Berland 1985].

RESULTS

Table 2 demonstrates the results of the atmospheric emission concentration related to intensity of an average transport stream where the methods of model measuring along the selected motorways in Simferopol were used [Method of calculation of pollution 1995, Berland 1985].

Table 2. Dependence of n·LPC on CO on the side of a road of motorway route from intensity of an average transport stream in Simferopol (2008 year)

Types of motorways	Motorway	Intensive, car/hour	n·LPC CO, measured	n·LPC CO, calculation on [Method of calculation 1995]	n·LPC CO, calculation on [Berland 1985]
Motorway intercity	Kievskaya str.	3600	5,17	6,38	11,52
	Sevastopolskaya str.	3400	3,78	5,84	10,88
Inside city motorways	Pavlenko str.	2200	1,65	3,39	7,04
	Kechkemetskaya str.	2100	1,49	3,24	6,72
	Vorovskogo str.	2100	2,51	3,68	6,72
	Lugovaya str.	1150	2,09	1,77	3,68
	Frunze str.	1300	3,35	1,91	4,16
	Tolstogo str.	1200	2,78	1,85	3,84

According to tab. 2, we can say about the links between n·LPC and the atmospheric emissions along the motorways.

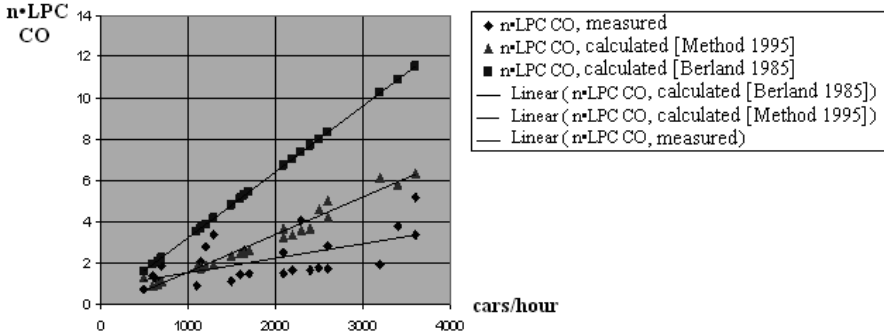


Fig. 2. Graphic dependence of the measured and calculation values of $n \cdot \text{LPC}$ on CO from intensity of a average transport stream

The received mark differences are significant, therefore, to regulate the atmospheric emission from vehicles it's necessary to take into account the additional characteristic: the wind speed, the amount of emission from the source, exchange coefficient. Thus, the application of the existing mathematical models without taking into consideration the meteorological conditions, the relief of the region can lead to results of calculation distortion and doesn't meet the demands as for the forecast quality, especially in the conditions of the foothills and mountain relief.

While calculating the admixture concentration from a linear source $q(x)$, the authors used the modified formula of Lihtman [Bizova 1973], the formula takes into account the missing parameters:

$$q(x) = \frac{Q \cdot e^{-\frac{R}{x}}}{\Gamma(1 + \rho) \cdot U \cdot H} \left(\frac{R}{x}\right)^\rho, \quad (1)$$

where: $q(x)$ – concentration of admixture from a linear source;

Q – amount of the produced admixture;

R – dimensionless auxiliary parameter for the calculation of vertical dispersion;

ρ – dimensionless auxiliary parameter for the calculation of vertical dispersion;

U – middle in a layer from 0 to H the wind speed;

H – height of a source;

x – coordinate along the ax of x ;

$\Gamma(1+\rho)$ – gamma-function.

It is assumed for a weightless admixture that a laying surface does not take an admixture in and isn't influenced by it.

A linear source is assumed to be long enough. For a linear source the followings parameters are estimated:

- maximal value of concentration - $q_0 = D_1 \frac{QB}{UH^2}$, (2)

where: B – basic parameter of vertical dispersion;

- coordinate along the ax of x - $x_0 = A_1 \frac{H}{B}$, (3)

where: A_1 – dimensionless parameter for the calculation of x_0 ;

- parameter for the calculation of vertical dispersion - $R = \frac{CH}{B}$, (4)

where: C – dimensionless parameter for the calculation of R .

While calculating it's necessary to define the parameters of the source and admixture, meteorological data and the type of laying surface. In order to use the common results in the meteorological network, a number of classifications of the ground layer stability is introduced. According to [Berland 1985], there are six classes of stability of the ground atmospheric layer: $n = 1, 2, 3$ (corresponding to strong, moderate and weak instability); $n = 4$ (corresponding to equally weight or indifferent state); $n = 5, 6$ (corresponding to weak and moderate stability). Each class corresponds to the certain of wind speed, insolation degree and the time of a day [Bizova 1972]. The seventh, additional class is introduced in the work, it is used in the specific conditions (calm and weak winds, anomalous types of the wind, temperature inversion, transitional time of a day).

The value of the parameters forming part in the formulas 2 – 4, are used for the plain territory, therefore, they are not used in the conditions of foothills and mountain relief and additional coefficient for the mountainous conditions is needed.

The value of laying surface roughness z_0 influences the distribution of admixture in the boundary layer of atmosphere. For the towns located in the foothills and mountain relief $z_0 = 80, 100, 120$.

The value of the vertical dispersion parameter B^* (the parameter of the authors) for $z_0 = 80, 100, 120$ and $n = 4, 5, 6, 7, 8$ at $H < 25$ m that is missing in [Bizova 1973] has been estimated by the method of extrapolation of the existing information with preliminary degree approximation (Fig. 3), that is $B^* = f(z_0, n)$.

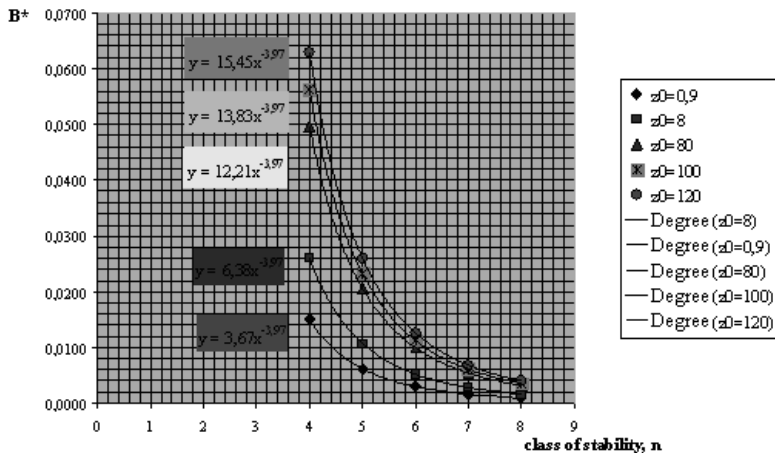


Fig. 3. Chart of degree approximation of dependence of B^* from n and z_0

The given degree approximation formulas allows us to estimate the vertical dispersion parameters B^* at the different value of z_0 and give possibility to transit from one class of stability to another one.

Vertical dispersion of admixture is influenced by the slope shape, the bottom width, the sides exceeding height, azimuth of extension and the position of the sun above horizon. With these factors having been taken into consideration, the authors set a number of the coefficients taking into account the vertical dispersion parameter (R) and the admixture parameter for the marked motorways of Simferopol (Tab. 3).

Table 3. Values of correction coefficient α^* for the calculation of R , taking into Δh and i [Murovskiy 2005]

Angle of slope of sides of valley, i	Absolute exceeding of sides, Δh , m		
	15-30	30-50	50-80
	α^*		
10-20	0,30	0,28	0,25
20-30	0,27	0,25	0,23
30-50	0,24	0,23	0,22
50-80	0,19	0,18	0,17

Tab. 4 demonstrates the estimation results of the parameters of the contamination zone from motor transport streams on the marked motorways of Simferopol with the consideration of the correction coefficients.

Table 4. Calculated parameters of “weightless” admixture dispersion in Simferopol

	Parameter					
	$B (B^*)$	z_0 , cm	R , m	x_0 , m	q_0 , mg/m ³	Δ , %
Experiment Results	-	80	20,0	120,0	16,2	-
Calculation according to [Bizova 1973]	0,0030	80	266,7	266,7	9,8	35
Calculation with the consideration of the correction coefficient	0,0054	80	22,0	137,0	19,2	18

The method approved by the authors was tested in the seaside towns of Yalta and Feodosiya located in different geomorphological zones at the most unfavorable meteorological conditions (calm). The results of the calculation were compared to data of the experiments (Tab. 5).

The error of estimated data according to the method of the authors with the consideration of the correction coefficients shown in Tab. 5 is withing the limits for the forecast of pollution of the ground layer of the atmospheric air along the motorways located in different geomorphological conditions.

The calculations give right to forecast pollution of the ground layer of the atmospheric air along the motorways. While making up general plans of towns or while reconstructing the existing motorways located in the conditions of the foothills and mountainous relief it is necessary to do calculations of the pollution of the ground layer

of the atmospheric air to provide safe, vital activity of a man in the specific zones around the motorways.

Table 5. Comparison of the results of the calculation of CO concentration from vehicles to the results of the experiments in Yalta and Feodosiya

Street	Geomorphologic location	Transport stream intensity, car/hour	Results of experiments q_0 , mg/m ³	Roughness, Z_0	Calculation with correction coefficient q_0 , mg/m ³	Δ , %
Yalta						
K. Marksa str.	street (canyon)	1522	10,30	80	14,17	27
Moscow str. – Kievskaya str.	valley of the river	1805	15,42	120	17,22	11
Sevastopol motorway	south slope of mountain ridge	2145	14,52	100	18,06	20
Feodosiya						
Fed'ko str. – Gen. Gorbacheva str.	street (canyon)	977	6,98	80	8,51	18
Kuybysheva str. – Ukrainian str.	street (canyon)	1203	9,26	100	10,53	12
Kerch motorway	valley of the river	1013	5,38	80	7,26	26

CONCLUSIONS

1. The use of the methods [Method of calculation 1995, Berland 1985, Bizova 1973] for the calculations of the parameters of “weightless” admixture dispersion in the foothill and mountainous conditions leads to great mistakes.

2. Evaluation of the error of the calculated parameters of the pollution zone with consideration of correction coefficients is within the limits of permissible error for forecast of pollution of the ground layer of the atmospheric air.

3. The calculation results with the correction coefficients being used allow us to explain the norm exceeding (“smog”) in the lower ground layer ($h = 20 - 25$ m) in mountainous vallies inversion when reverse temperature inversion takes place.

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ВОЗДЕЙСТВИЕ ПЕРЕДВИЖНЫХ ИСТОЧНИКОВ НА ЗАГРЯЗНЕНИЕ АТМОСФЕРНОГО ВОЗДУХА ПРИМОРСКИХ ГОРОДОВ

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Анотация. В работе проведен анализ влияния микроклиматических особенностей территорий приморских городов Крыма на рассеивание «невесомой» примеси от передвижных источников (автотранспорта). Проведена оценка полученных результатов расчета концентрации загрязняющих веществ вдоль автомагистралей различного функционального назначения, рассчитанных по действующим методикам. Результаты расчета показывают несовершенство применения данных методик в условиях предгорного и горного рельефа, они не учитывают микроклиматические условия: обратную температурную инверсию, градиент температуры атмосферного воздуха, геоморфологические особенности рельефа, антропогенный ландшафт и др. Целью данной работы явилось усовершенствование существующей методики по расчету рассеивания «невесомой» примеси в пограничном слое атмосферы в условиях предгорного и горного рельефа путем введения дополнительных коэффициентов.

Ключевые слова: автотранспорт, рассеивание, «невесомая» примесь, горный рельеф, микроклимат территорий.