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Assessment of atmospheric air pollution from traffic flows on road and street network in Omsk

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***Abstract*—The paper gives the results of studies devoted to determining the degree of influence of the traffic flow on environmental situation near trunk road areas in Omsk. The research was conducted in accordance with the methodology presented in GOST R 56162-2014 [xx], which allows calculating the amount of pollutant emissions from a moving traffic flow. The results of studies are graphically represented. Graphics reflect the amount of emissions of carbon monoxide (CO) and nitrogen oxides (NOx) into the atmosphere over a time interval of 20 minutes in Omsk highway sections with a length of 500 m. In addition, the authors made a suggestion to add the current methodology by the values of extra emissions of pollutants that take into account driving regimes of traffic flow in the urban highway section (acceleration, deceleration, idling). Traffic flow regimes can be significantly influenced by: technical means of traffic regulation, the location of street pedestrian crossings, the location of bus stops, street parking places and by the presence of areas intended for maneuvering (turning and turning around).**

Keywords—traffic flows, environmental pollution, air pollution, traffic density, traffic regimes.

I. INTRODUCTION

Among the branches of the Russian economy, the transport complex makes the biggest contribution to environmental pollution [1]. Along with pollution of soils, surface and groundwater, automobile transport produces the greatest negative impact on the quality of atmospheric air because of its vibrational, thermal and electromagnetic influence. Environmental pollution produced by transport complex can be divided into technological and transport pollution [2]. Technological pollution is a pollution, the sources of which are road construction machinery, special vehicles, asphalt-concrete plants, etc. [2]. The source of transport pollution is transport flows, which are formed by different automobile transport. The volume of transport emissions of harmful substances into the atmosphere on urban highways is much higher than the amount of technological emissions; that is why it is more dangerous for the ecological situation of the city [1]. The pollution level produced by urban traffic flows depends on a large number of factors, the major of which are the traffic intensiveness, speed and composition of the traffic flow. Air pollution made by traffic flows is an acute problem for the majority of large cities, including Omsk. In addition, the President of the Russian Federation named in his address to the government, on April 18, 2018, cities, where environmental problems are especially acute. Omsk was among them.

One of the most important tasks of "the transport strategy of the Russian Federation for the period up to 2030" is reduction of the harmful transport impact on the environment [3].

In connection with the above-mentioned, the issue of developing and implementing measures (including traffic regulation) to reduce the negative impact of road transport on the environment and to assess its effectiveness is becoming increasingly important.

II. TASK ASSIGNMENT

It is proposed to draw up an ecological passport for all main streets of the city in order to evaluate the air pollution level made by traffic flows along the road and street network (RSN) [4].

Ecological passport is a document containing information on the volume of use of natural resources (raw, secondary, etc.) and the degree of production impact on the environment, as well as information on permission for the right to use natural resources, standards of impact and payments for environmental pollution and for the use of natural resources [5].

In this research, the user of nature is the transport stream; the degree of impact is the amount of pollutant emissions along the trunk road over a certain period of time [6].

This document allows identifying the unfavorable places and sites on each of the trunk roads for the further development of measures reducing the harmful impact from the traffic flow [5].

To obtain the initial data for the calculation of pollutants made by automobile transport into the atmosphere, it is required to conduct a surveys of the structure and intensity of traffic flows with its mode division, as well as to determine the average speed of movement in sections of the surveyed highways.

III. THEORY

Pollutant emissions from traffic flow on city trunk roads are subdivided into mileage (emissions made by moving cars) and additional (emissions made by vehicles, that are in the intersection zone because of the prohibiting signal of traffic light) [7]. This research is devoted only to mileage emissions.

According to the methodology, the emission of the i-pollutant produced by the moving flow of vehicles on a road section with a fixed length, with a constant speed M_{L_i} g/km, is calculated according to the formula [7]:

$$M_{L_i} = \frac{L}{1200} \sum_{1}^{k} M^{L}_{k,i} \cdot G_k \cdot r_{V_{k,i}}, \qquad (1)$$

where L – road length (or its section), km; $M^{L}_{k,i}$ – specific mileage emission of the i-pollutant produced by vehicles of the k- group; k is the number of vehicle groups; Gk is maximum traffic intensity, i.e. number of vehicles of each of the k groups passing through the fixed cross-section of the selected zone of the road per time unit (20 min.) in both directions across all lanes; $r_{V_{k,i}}$ is the correction coefficient taking into account the average speed of the vehicle flow $V_{k,i}$ (km/h) on the selected road (or its section) [7].

IV. RESEARCH

To carry out calculations, 5 city roads, which are typical for Omsk according to SP 42.13330.2016, were taken from the total number of streets on which in situ surveys were conducted [8]:

- Mira Avenue (the main street of citywide significance of the regulated traffic with predominance of passenger and public transport);

- Mendeleyev Avenue (the main street of regional significance with predominance of passenger and public transport);

- Barnaulskaya street (the main street of regional significance with predominance of cars and trucks);

- Oktyabrskaya street (the street of local significance in public, business and trade zones with predominance of passenger transport);

- Dimitrova street (the street of local significance in residential areas with predominance of passenger transport).

Because of the different length of the streets, in order to get the correct survey data, the 500-meter long section was taken on each of the trunk roads with approximately similar traffic conditions (Fig.1):

- maximum permitted speed is 60 km/h;

- one pedestrian crossing;

- the right turn is allowed;

- left turn and (or) turning around is allowed;

- presence of the parking zones, parking zones for taxi cabs and (or) places of public transport stops (PTS).

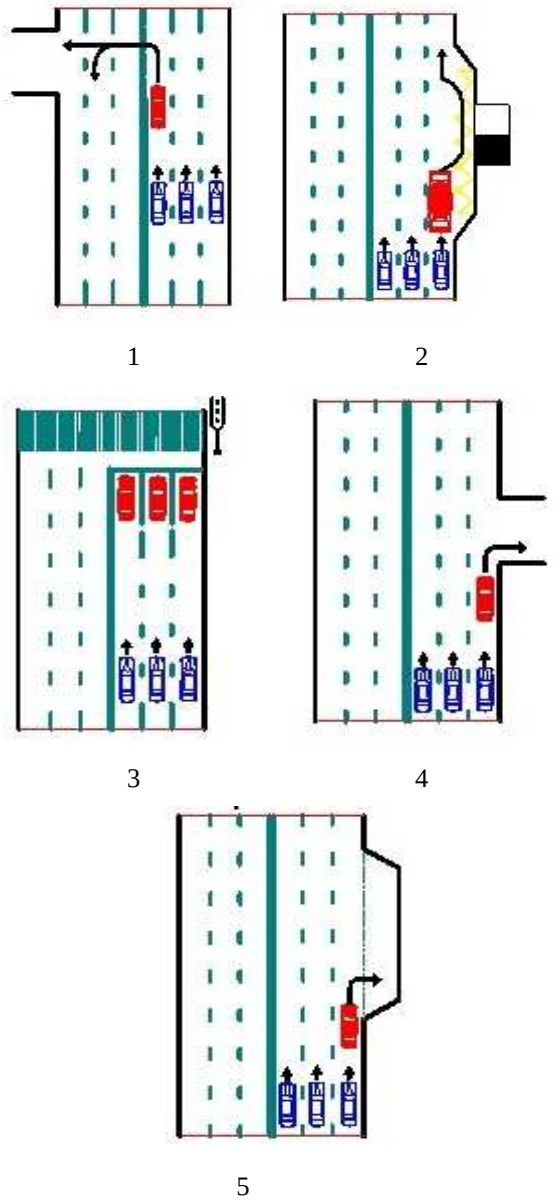

Fig.1. Main factors influencing traffic regimes of transport flow: 1 – left turn and (or) turn around, 2 – areas (PTS), 3 – pedestrian crossing, 4 – right turn, 5 – street parking.

The characteristics of the studied streets are shown in Table 1. The intensity of traffic flows was recorded on a weekday on October 27, 2017, during 3 morning hours (from 7:00 to 10:00), during 3 day hours (from 12:00 to 15:00) and during 3 evening hours (from 17:00 to 20:00) of that day [9].

The article presents the results of the survey of the traffic intensity of the evening time interval from 17:00 to 18:00 p.m.

The last column of Table 1 shows the average speed determined by the time needed to cover the distance by the car moving in the stream.

Direction N_{1i}- traffic on the highway section from north to south or from west to east, N_{2i} - traffic along the highway section from south to north or from east to west.

PC is a passenger car; M is a minibus or a lorry with the weight up to 3.5 tons; B is a bus; T <8t is a truck with the weight from 3,5 to 8 tons; T> 8t is a truck with the weight over 8 tons.

HLis a hindrance on the left; HR is a hindrance on the right; HM is a hindrance in the middle (pedestrian crossing).

V. RESULTS AND DISCUSSION

Fig. 2 presents the results of calculation of the emission amount of CO and NOx pollutants by traffic flow on five urban highways closely located to residential areas [10].

The values of CO emissions in simulating the speed of the automobile traffic equal to 60 km/h can be used as a standard (minimum emissions).

TABLE 1. CHARACTERISTICS OF THE RESERCH OBJECTS

Name of the street/ number of lanes in both directions		**Intensity of transport flow over a 20-minute time interval regarding the composition of traffic stream**					**Conditions of traffic / objects of traffic regulation**			**Average speed of traffic flow on the section, km\h**
		PC	**M**	**B**	**T<8т**	**T>8т**	**HL**	**HR**	**HM**	
Dimitrova street (from Volodarskogo street to Granichnaya street) / 2	N_{11}	64	21	5	0	0	3	1	1	V1 =30
	N_{21}	64	26	4	0	0	1	4	1	V2 =35
Mira Ave (from 70 years of SibADI street to OOT Medical academy / 6	N_{11}	129	20	13	3	0	3	8	1	V 1 =15
	N_{12}	150	51	0	4	0				
	N_{13}	138	24	0	0	0				
	N_{21}	102	17	9	2	0	4	6	1	V 2 =25
	N_{22}	125	24	7	2	0				
	N_{23}	100	10	0	0	0				
Mendeleyev Ave (from Khimikov street to Belozerova street) / 4	N_{11}	115	13	4	0	2	2	5	1	V 1 =25
	N_{12}	105	7	0	1	2				
	N_{21}	68	2	4	2	3	4	2	1	V 2 =10
	N_{22}	197	8	0	2	0				
Oktyabrskaya street (from Gertsena street to Ordzhonikidze street) / 2	N_{11}	122	12	1	0	0	5	8	1	V 1 =25
	N_{21}	100	2	0	4	0	8	7	1	V 2 =15
Barnaulskaya street (from Zheleznodorozhnaya street to 2-nd Vostochnaya) / 2	N_{11}	171	35	6	18	6	3	4	1	V 1 =15
	N_{21}	126	21	5	10	11	3	5	1	V2 =5

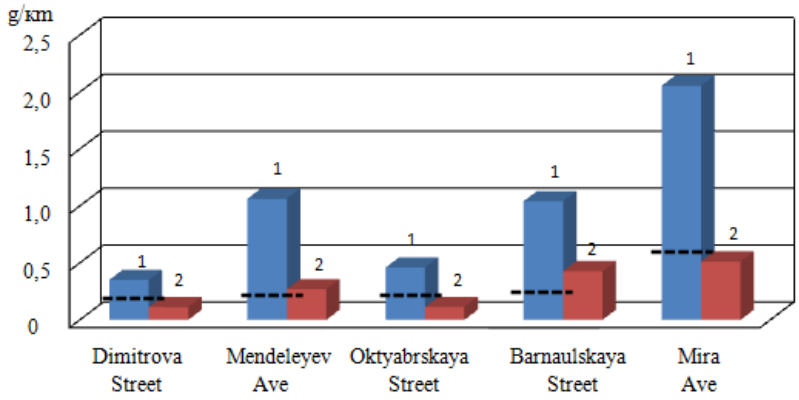

Fig.2 Quantity of pollutant emissions from moving automobile transport in the evening rush hour:
1 - amount of pollutant (CO); 2 - amount of pollutant (NO_x);
- - - - amount of pollutant (CO) at a constant speed of movement of the transport stream (60 km / h).

The survey showed that the most polluted streets are: Mendeleyev Ave and Mira Ave (because of the relatively high traffic intensity), Barnaulskaya street (because of the heavier composition of the traffic flow due to the availability of freight transport) [11].

Fig. 3 gives the results of computing the amount of CO emissions from the moving automotive stream in the forwardand back directions. The difference in the amount of CO emissions in the forward and backward directions at Mira Avenue, Barnaulskaya street and Mendeleyev Avenue (with approximately the same intensity values of N_{1i} and N_{2i}) is explained by different speed regimes of motion

Fig. 4 shows the results of calculating the amount of NO_x emissions produced by moving automotive stream in the forward and backward directions, which allow us to conclude that in addition to the traffic intensity, the composition of the traffic flow influences the quantity of emissions (the presence of a significant number of buses and lorries with the weight more than 3.5 tons).

The results of the conducted studies made it possible to identify urban streets with the highest content of CO and NOx in atmospheric air (Mira Avenue - the main line of citywide significance of the regulated traffic, Mendeleyev Avenue, Barnaulskaya Street - the main streets of regional significance).

Having inspected the average speed of movement on highways, the following regularity was revealed. All the surveyed highways had sections, where the traffic flow was uneven (braking, acceleration, stopping), most often it occurred in places where maneuvers were made (turns, turns around, stops, overtaking, lane changes), before pedestrian crossings and public transport stops. This leads to the increase in the number of pollutant emissions produced by vehicles [5].

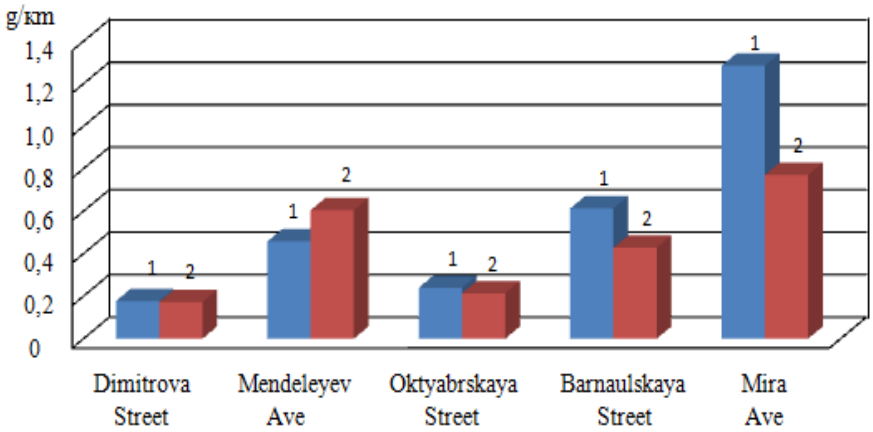

Fig.3 The amount of CO emissions from moving automobile transport
in the evening rush hour: 1 - direction N_{1i}; 2 - direction N_{2i}.

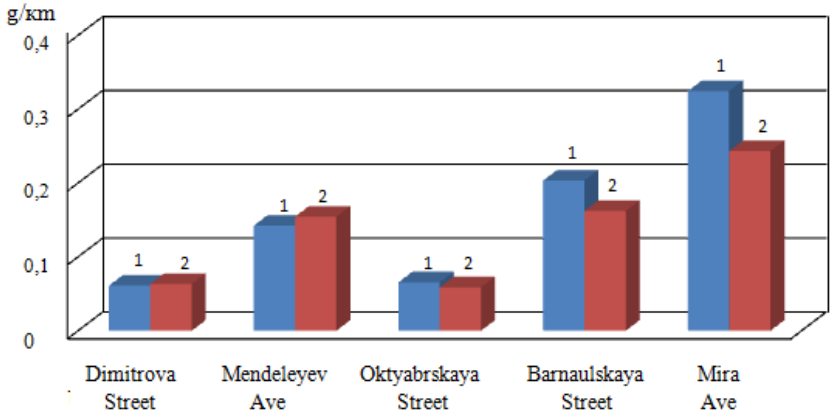

Fig.4 The amount of NO_x emissions from moving automobile transport in the evening rush hour: 1 - direction N_{1i}; 2 - direction N_{2i}.

The research allows us to conclude that the average speed of traffic on the section of the highway does not give enough information about the amount of pollutant emissions, because, as a rule, the flow does not move evenly, there is a speed pulsation of the cars in the flow (stop, acceleration, deceleration) at certain areas. Therefore, compiling an ecological passport of the trunk road, it is suggested to take into account additional local emissions of pollutants made by uneven traffic flow (at pedestrian crossing areas, artificial unevenness areas, public transport stops, etc.).

VI. CONCLUSION

The estimated amount of pollutant emissions produced by traffic flows on the typical streets of Omsk allowed obtaining the initial data for compiling the ecological passports of the surveyed trunk roads.

The results of the research, reflected in the ecological passport of the trunk road, allow us to identify the most polluted sections of the road and street network (RSN), which may become a priority justification for traffic regulation activities aimed to reduce the negative impact produced by the traffic flows. The materials got in the process of municipal contract performance for the transport department of Omsk administration were used in this work.

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