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Development of a methodology for monitoring the environmental impact of waste of the year-round maintenance of highways

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Abstract. The analysis of environmental impact of the public highway maintenance was carried out. The dynamics of the road traffic, the length of highways and the road safety was revealed for the 1990-2019 period. The analysis of the existing regulatory framework for monitoring the impact on the environment in the year-round maintenance of highways has been carried out. The system of placement of monitoring points depending on the category of road, the category of land, the presence of roadside forest belts with the definition of zones of impact on the environment by various groups of pollutants was substantiated.

1. Introduction

Relevance of the study is linked to the growing traffic flows. The road network developing actively, increasing traffic intensity, and the number of the road anti-dust and anti-ice treatments. This increases an anthropogenic load on the environment. The existing recommendations on the placement of the monitoring points for the road operation environmental impact control refer only to the roadside lane. The level of environmental impact is controlled according to the pollutant list which is established by regulations. The impact zone outside the roadside lane is not evaluated. The number of observation points per kilometer of the route, the frequency of sampling, and the methods for determining the pollutant concentration in the operation zone of the roads of different categories are not established. There are no data on the availability of industrial environmental control programs for operating highways, as well as the open reporting on the results of such control.



The purpose of the study was to develop a methodology for determining the locations of observation points, the frequency of sampling, clarifying the list of controlled pollutants, and methods for determining pollutants concentration in the operation of roads of different categories.

The objectives of the study were: to study the current Russian legislation; Russian and foreign experience on the natural environment protection in the operation of highways; to determine the zones of highway environmental impact; to justify the locations of the observation points and the frequency of sampling; to clarify the list of controlled pollutants in the components of environment.

Automobile today has become a means of transportation for the different segments of population. In the Russian Federation in the last decade the public road traffic increased sharply. The road network develops intensively. Due to this, an increased impact of the road transport on the environment is observed. Between 1991 and 2018, the number of buses in the country increased for 6 times, the number of trucks for 17.4 times, and the number of cars for 50.4 times (Figure 1). According to statistics, one passenger car accounts for three Russian citizens, 1 truck – for 22 people, 1 bus – for 168 people. The length of public roads has increased by 3.3 times (Figure 2).



Figure 1. Dynamics of the number of motor vehicles for the period 1991 to 2018 (compiled from <https://fedstat.ru>)

2. Object of research and methodology

Increasing car traffic requires road maintenance services to ensure the road traffic safety. Main objective is improving the year-round maintenance, which ensures high-quality road surface and visibility conditions.

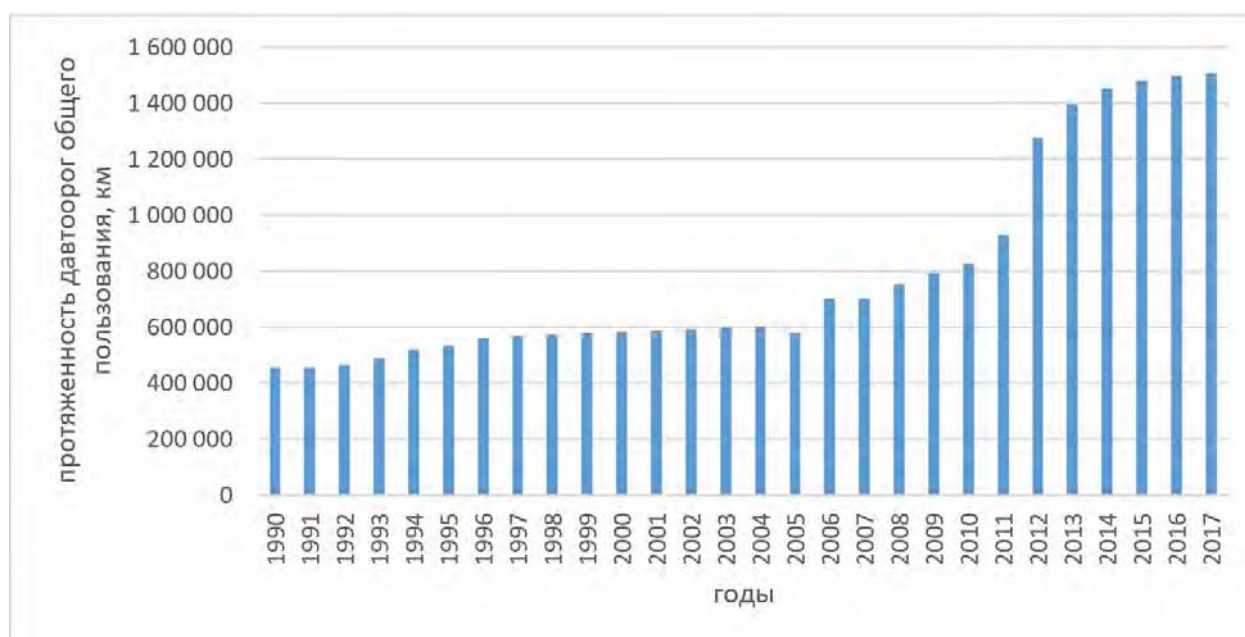


Figure 2. Dynamics of the length of public roads for the period 1990 to 2017 (compiled from <https://fedstat.ru>)

According to the FKU "NC BDD of the Ministry of internal Affairs of Russia" [1], at the end of 2018, every third accident (37.1%) in Russia related to the state of the road network, 14.6% of the accidents related to the shortcomings of the winter maintenance. The dynamics of the road accidents number with victims and deaths for the period 1991 to 2019 is shown in Figure 3 (compiled according to the Rosstat data).

To ensure the road safety, a large number of chemical reagents, salts, and sand are used by road maintenance services throughout the year. In the warm period of the year, roads are de-dusted, and in winter and frost, snow removal and de-icing are carried out. In addition, an intensive traffic flow causes emissions of household waste, petroleum product, heavy metal, fuel combustion product into the environment. As a result, atmospheric air, adjacent land, water systems are polluted, and the flora, fauna, and people health in this territory are negatively affected.

The list of emissions during the operation of the road is as follows: nitrogen dioxide, nitrogen oxide, nitric acid, benzopyrene, gasoline, cadmium oxide, copper oxide, copper chloride, lead and its compounds, carbon disulfide, carbon oxide, hydrocarbons, inorganic dust containing silicon, phenol. All these substances belong to the list of pollutants that are subject to state regulation in the field of environmental protection in accordance with paragraph 2 of article 4.1 of the Federal law of 10.01.2002 N 7-FZ and Appendix 1 of the Order of the Government of the Russian Federation 08.07.2015 n 1316-p. The maximum permissible concentration of these substances as a result of road operation are set by ODN 218.5.016-2002.



Figure 3. Dynamics of the number of road accidents with victims and deaths for the period 1991 to 2019 (compiled from <https://fedstat.ru>)

Taking into account a variety of chemicals currently used for road de-dusting and de-icing, we consider the list of environmental pollutants specified in ODN 218.5.016-2002 to be incomplete and requiring clarification.

3. Results and discussion

Highways are classified in accordance with the article 4.2 of the Federal law of 10.01.2002 N 7-FZ and the Decree of the Government of the Russian Federation of September 28, 2015 N 1029 "On approval of criteria for classifying objects that have a negative impact on the environment as objects of categories I, II, III and IV". Highways can be classified as objects of categories III – having a minor negative impact on the environment.

At the same time, according to the clause 2.3 of ODN 218.5.016-2002, the highways are classified as the objects of environmental hazard. Depending on the level of environmental hazard, the highways are divided into three classes: class I – large objects that have a significant impact on the environment – Federal and regional highways and expressways of categories I and II with at least four lanes and artificial structures on them, individual bridges and overpasses longer than 500 m. International standards and Federal documents classify the construction of the 1 class road objects as environmentally hazardous activities; class 2 – objects that have a significant impact on the environment. Category II and III roads with an estimated (prospective) traffic intensity of more than 2000 units per day and buildings on these objects. Individual sections of other roads in localities and specially protected areas, as well as in complex conditions of individual design; class 3 – objects that have a minor, local impact on the environment. Highways with an estimated traffic intensity of less than 2000 units per day and transport facilities on them. This is: technically simple road objects according the projects of the common or repeated use, road repair work.

In accordance with the requirements of the article 67 of the Federal law of 10.01.2002 N 7-FZ for the objects of category III, an economic entity develops and approves a program of industrial environmental control, and carry out industrial environmental control for the road this entity operates.

From our point of view, when developing a program for industrial environmental control of highways, the key issue is the placement of observation points, determining the list of pollutants controlled at each point by components of the environment, methods for determining concentrations and sampling frequency.

Requirements to the content of the industrial environmental control program, the procedure and deadlines for submitting a report on the organization and results of industrial environmental control are established by the Order of the Ministry of natural resources and ecology Of the Russian Federation No. 74 of February 28, 2018. This document obliges the industrial monitoring program to indicate the geographical coordinates of observation points and each observation point number, the list of pollutants controlled at each point, the methods for determining concentrations and sampling frequency.

Industrial environmental control of Federal highways is carried out in accordance with STO AVTODOR 7.5-2016. But this document does not contain instructions on the placement of observation points for monitoring the state of the natural environment in the zone of the highway impact during its operation. The content of STO AVTODOR 7.5-2016 contains recommendations related mainly to the control of the state of the environment during the construction, reconstruction and major repair of the road.

The national requirements for industrial environmental control and monitoring GOST R 56059-2014, GOST R 56061-2014, GOST R 56062-2014, GOST R 56063-2014 also do not contain requirements on the location of observation points, the list of pollutants controlled at each point by components of the natural environment, methods for determining concentrations and sampling frequency.

According to the clause 8.2.5 of GOST 32847-2014, proposals for organizing local environmental monitoring during construction (reconstruction, major repair) and operation of highway should be contained in the conclusion of the report on engineering and environmental survey conducted during the development of the project for new construction, reconstruction, and major repair of highway [2]. But there are also no rules for developing such proposals.

There are separate scientific studies by different authors devoted to environmental monitoring during the operation of highways [3-14], but none of them deals with the issues of determining the location of observation points by zones of influence of the highway, the list of controlled pollutants and methods for determining their concentrations, and the frequency of sampling during the operation of the road of different categories.

The ODM of 31.12.2002 provides the following recommendations [15]:

1) road beginning and the road end sections are determined in accordance with the requirements of the BCH 1-83;

2) outside the locality, the negative impact of the road is controlled within the roadside lane, within locality – between the lines of development (at a distance of no more than the width of the roadside lane);

3) following indicators are measured on both sides of the roadbed at the beginning, middle, and end of each ecological zone (but at least every 10 km):

- concentration of the harmful substances in the atmospheric air at a height of 1.5 m (CO, NO, NO₂, SO₂, soot, mineral dust), as well as speed, wind direction, temperature, relative humidity – at three points-at the border of the roadside, right-of-way, roadside (sanitary protection zone);

- concentration of the impurities (petroleum products, suspensions, chlorides) and water quality characteristics (turbidity, color, BOD_{full}, pH) – before and after treatment facilities or before discharge to terrain, within locality – in ditches and trays along the roadway in front of a drainage well;

- concentration of the harmful substances in the soil at a depth of 0-10 cm (petroleum products, lead, chromium) – at three points: at the border of the roadside, the right-of-way, the roadside within locality and at the junction of farmland;

- noise level – at the border of the roadside and at the nearest buildings at a height of 1.5 m (only within localities);

- level of effective specific activity of radio-nuclides in the soil – in depressions that accumulate surface runoff within the roadside lane.

The ODM of 31.12.2002 does not specify what should be understood as an ecological zone. The explanatory dictionary gives the following definition of an ecological zone – a part of the territory (region) of the Earth, characterized by a combination of similar environmental conditions. Large ecological zones of the Earth (and corresponding ecosystems) are located as belts in accordance with latitude and altitude of the terrain. As you can see, this concept does not suit the definition of environmental zones provided by ODM of 31.12.2002.

Roadside lane size is established by the item 1 of article 26 of the Federal law of 08.11.2007 N 257-FZ. According to the item 4.10 of SP 34.13330.2012, when designing newly constructed highways of I-III categories, their route is laid bypassing localities. In cases where technical and economic calculations have established the feasibility of laying the route of a category II-III road through a locality in order to ensure its further reconstruction, take the distance from the edge of the roadbed to the development line of the locality in accordance with the General plan of localities, but not less than 200 m. If it is impossible to meet this requirement, the road category within the locality and its design parameters are assigned in accordance with the requirements of SP 42.13330. On the roads of I and II categories designed at a distance less than 50 m from residential development, protective screens should be provided for the length of residential development of the locality [16].

Maximum one-time, average daily and average annual concentrations of harmful substances, noise levels at the points where the corresponding measurements were not made, are determined by calculation using current methods and results of engineering and environmental surveys.

The state of green spaces, station-destructive changes (erosion, flooding, water-logging, landscape disturbances) are determined visually or using photo and video shooting [16].

Determination of traffic intensity (hourly and daily), composition, and speed of traffic flow is performed according to approved methods in control sections of the road – places where atmospheric air concentration is measured – visually or using photo or video shooting [16].

The volume of solid waste (domestic and industrial) is determined as a result of their collection on both sides of the road in each of the environmental zones or at the location of the road infrastructure object and is attributed to the 1 km of road length [16].

The available regulatory recommendations for the placement of environmental monitoring observation points are summarized in Table 1. Based on the data in the ODM from 31.12.2002 recommendations, we have compiled an approximate scheme for placing the minimum number of observation points outside the locality (Figure 4) and within its boundaries (Figure 5).

Table 1. Requirements of the current legislation for the placement of environmental monitoring points depending on the category and class of environmental hazard of the road and the conditions for its placement

Road class (Decree Of the government of the Russian Federation of September 28, 2009 N 767)	Additional requirements of Federal law No 257-FZ 08.11.2007	Category of road (Decree Of the government of the Russian Federation of September 28, 2009 N 767)	Class environmental hazards of the road (ONE 218.5.016-2002)	The size of the road's right-of-way in accordance with 30. Resolution of the Government of the Russian Federation of September 2, 2009 N 717, but no more than m	The distance between the observation points		The location of the observation points	
					By roadside lane width	The length of the road	In the precincts of the locality	Outside the locality
Motorway	Sections of roads that bypass cities with a population of more than 250 thousand people. Access roads connecting the administrative centers of the Russian Federation subjects, Federal cities with other localities, for sections of public roads of Federal significance built for detours of cities with a population of up to 250 thousand people.	1A	I	155	Not assigned	At the beginning, middle, and end of each ecological zone (but at least every 10 km)	50	Between building lines (at a distance of no more than the width of the roadside lane) 200
Expressway		IB	I				50	75
Normal road (not		IB	I				50	

high-speed)								
	II	I	127	50	200	75		
	II	II		50	200			
	III		78		200	50		
	III				200			
	IV		55	between building lines (at a distance of no more than the width of the roadside lane)	between building lines (at a distance of no more than the width of the roadside lane)	50		
	V	III	54			25		

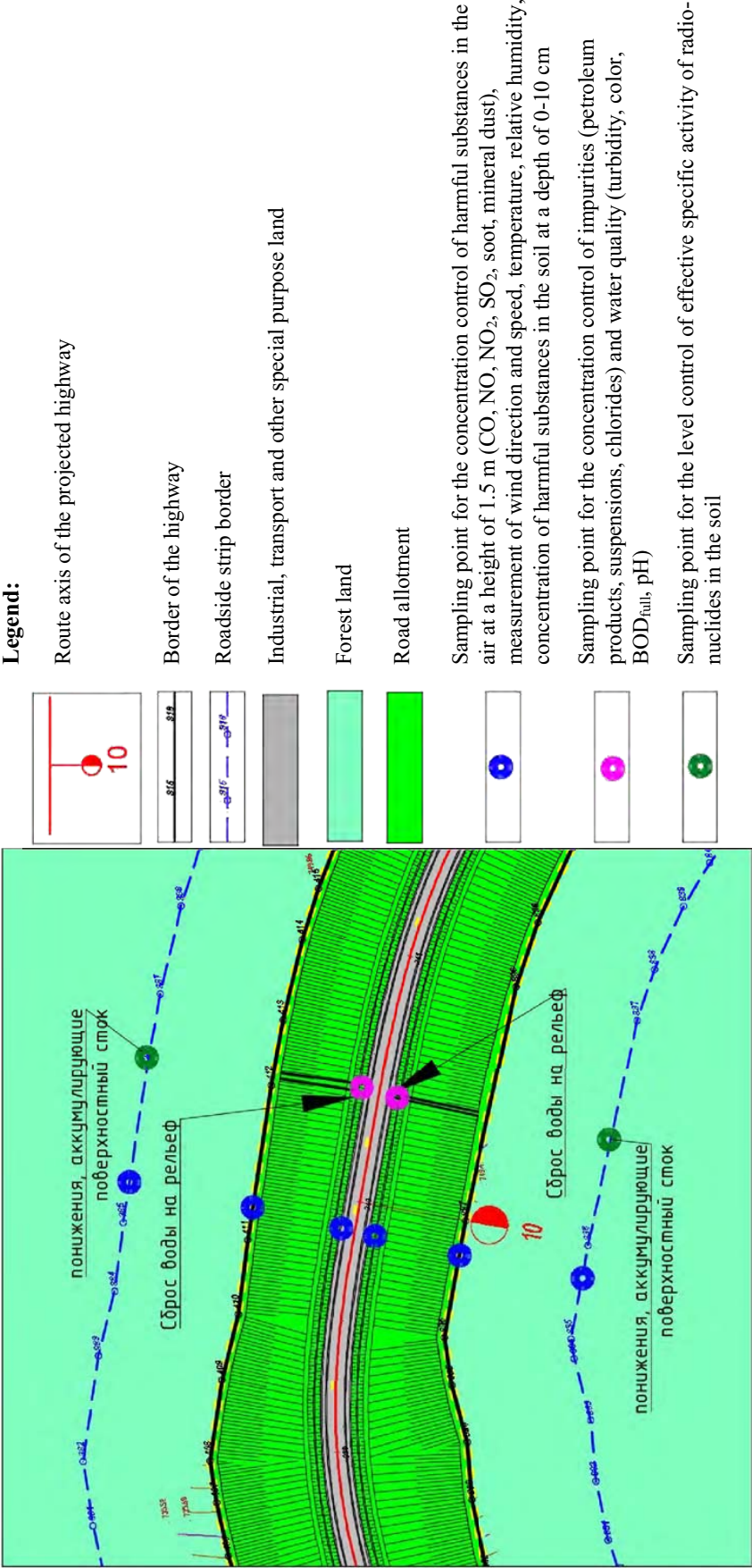


Figure 4. Scheme of placement of the observation points according the ODM from 31.12.2002 norms outside the locality

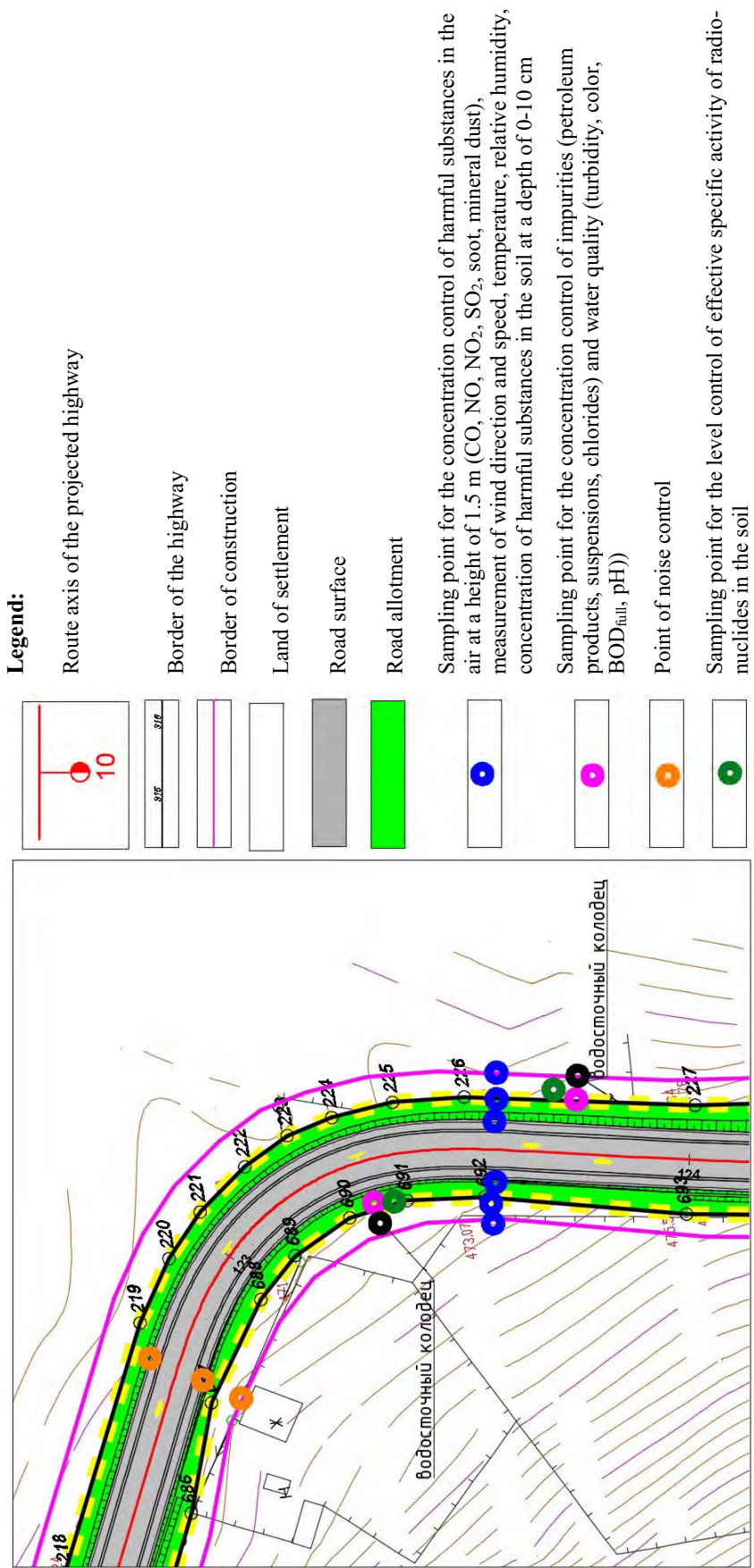


Figure 5. Scheme of placement of the observation points according to the ODM from 31.12.2002 norms within locality

According to article 25 of Federal Law No 257-FZ of 08.11.2007, depending on the class and (or) category of highways of regional significance, with the exception of highways located within the borders of localities, taking into account the prospects for their development, the width of each roadside lane is set: for highways of the I and II categories – 75 meters; for highways of the III and IV categories – 50 meters; for highways of the V category – 25 meters.

Thus, we found that according to the current regulatory documents:

- environmental monitoring points for the operation of highways should be located only in the roadside lane, and the zones of influence of each category of road by type of pollutants and components of the environment are not tracked;
- the number of points within the width of the roadside lane-not set, only indicated that the points must be on both sides of the road;
- it is known that points along the road length should be at least every 10 km, at the beginning, in the middle and at the end of each ecological zone, but it is not specified what is meant by an ecological zone;
- no guidelines existed for monitoring the impact of roads on ground water.

At the same time, it is worth noting that the issue of emissions into the environment of the combustion and decay products of automobile fuel is quite well studied and there are methods for determining pollution depending on the intensity of the automobile flow of the highway. But the issue of water and soil contamination with anti-dust and anti-ice reagents is poorly studied. In connection with the wide range of chemical reagents used for anti-dust and anti-ice, the issue of accumulation of decomposition products of these chemicals in surface and ground waters, soil and identification of contamination zones of the territory adjacent to roads is of particular relevance.

According to our research, the road impact on the natural environment will be stipulated by the factors, not included in the ODM from 31.12.2002. These factors are: construct road (location of cut, fill), the surface of the land terrain (flat, hilly, mountainous), the presence of roadside forest belts, the presence of a noise screen, the amount of precipitation, groundwater level, geological structure of the soil in the zone of passage roads, close and the intersection of road gullies and water bodies, the number and frequency of anti-dust and de-icing treatments. In this regard, we propose the following scheme for placing observation points, based on the methodology of B. A. Dospekhov's field experience. Snow sampling should be carried out during the frosty period of the year in the presence of snow cover before treatment, between treatments and after treatment with deicing reagents according to the schedule of road treatment. During the frost-free period, sampling of surface and ground water and soil to the ground water horizon immediately after the spring flood, then after each downpour until the first frost.

Place observation points for roads that pass outside the borders of localities on both sides of the road if there is a roadside forest lane: at the bottom of the drainage ditch, before the forest strip, after the forest strip, 500 m and 1000 m from the forest strip; in the absence of a roadside forest strip: at the bottom of the drainage ditch, at the border of the roadside strip, at the border of the roadside strip, 500m and 1000 m from the roadside strip. Along the length of the route along homogeneous sections with the same type of relief and vegetation cover at the beginning, end and middle of such a section, with additional control points near spillway road structures.

In a locality, within the boundaries of a built up area, you can set up sampling of flowerbeds, green areas, and alleys adjacent to the road. If the a locality built up area is located on a significant distance from the road, the samples are to be taken 1m, 50 m, 100 m from the edge of the curb or roadside. Along the length of the route along homogeneous sections with the same type of relief and vegetation cover the samples are to be taken at the beginning, end and middle of such a section, with additional control points near spillway road structures.

In addition to solving the problem of waste environmental impact monitoring from year-round maintenance of highways, a waste recycling planning is of high necessity. Waste recycling should be safe for the environment and at the same time is to be capable to provide an extended biogeochemical cycle of the Ecosphere and Agrosphere [17-20].

4. Conclusions

The placement of observation points is substantiated depending on the road type, conditions of the placement, the factors that require thickening the number of observation points. An updated list of controlled pollutants in the natural environment components is proposed. The frequency of sampling recommended in maintenance of roads of different categories.

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References

- [1] Road traffic accidents in the Russian Federation for 9 months of the 2018. *Information and analytical review*. Moscow: FKU "NC BDD of the Ministry of internal Affairs of Russia", 2018 p 17
- [2] GOST 32847-2014 Public automobile roads. *Requirements for conducting environmental surveys*.
- [3] Vinokurov E G, Meshalkin V P, Nevmyatullina X A, Burukhina T F, Bondar V V, Khodchenko S M 2019 *Economics and mathematical methods* **55** 1 43
- [4] Dospekhov B A 1985 Method of field experiment (with the basics of statistical processing of research results). (M.: Agropromizdat) p 351
- [5] Stroganov V F, Zavyalova N B, Sharafutdinova A V, Skibinskaya A A 2007 *Proceedings of the Kazan state University of architecture and civil engineering* **1** (7) 105
- [6] Lyashenko G M, Kalinichenko V P 2012 *Scientific journal of the Russian research Institute of land reclamation problems* **2** 60
- [7] Kantyukov R A, Gimranov R K, Ryzhenkov I V, Kantyukov R R, Meshalkin V P, Panarin V M, Goryunkova A A 2015 *Chemical industry today* **3** 25
- [8] Lukanin V P, Trofimenko Yu V 2001 *Industrial and transport ecology*. Textbook for universities. Ed. In N. Lukanina. (M.: Higher school) p 273
- [9] Morozov V P, Serov G P 1993 *Environmental safety of production: research methodology and areas of support: Analytical review*. Ser. Environmental protection and rational use of natural resources, Issue 25 (Moscow: VNITS) P 72
- [10] Pshenin V. 2015 *Engineering protection* **5**(10) 6
- [11] Meshalkin V P 2018 *Materials with specified properties on the transition to a new technological order: chemical technologies*. Collection of materials of the I Scientific and technical conference. Federal state unitary enterprise " Institute of chemical reagents and especially pure chemicals of The national research center "Kurchatov Institute" p 23
- [12] Serov G P 1998 *Environmental safety of the population and territories of the Russian Federation (Legal basis, environmental insurance and environmental audit)*. Textbook (Moscow: Akkil Publishing center) p 207
- [13] Ryabova O V 2006 *Technogenic impact of the road transport complex on the ecosystems of the roadside strip*. Doctor of technical Sciences p 462
- [14] Sukhareva M M 2009 *Technical means and technologies for localization and elimination of technogenic impact on roadside soils of the city of Saint Petersburg*. Candidate of technical Sciences p 175
- [15] ODM from 31.12.2002 *Ecological safety of the highway: concept and quantitative assessment* (approved by the order of the Ministry of transport of the Russian Federation of 31.12.2002 No OS-1181-R)
- [16] SP 34.13330.2012 *Highways*. Updated version of SNiP 2.05.02-85* (with Change No 1)

- [17] Kalinitchenko V P, Meshalkin V P, Makarenkov D A, Glinushkin A P, Minkina T M, Zinchenko V E, Chernenko V V, Mandzhieva S S, Sushkova S N, Il'ina L P, Rykhlik A E, Larin G S and Grishina E V 2019 *HIT-2019* 116 doi: 10.36291/HIT.2019.kalinitchenko.116
- [18] Kalinichenko V P, Glinushkin A P, Sokolov M S, Kozyrev S G, Savostyanov A P and Ilyin V B 2019 Patent RU No. 2692718 C1. <http://www1.fips.ru/ofpstorage/Doc/IZPM/RUNWC1/000/000/002/692/718/%D0%98%D0%97-02692718-00001/document.pdf>
- [19] Kalinitchenko V P, Glinushkin A P, Sokolov M S, Sharshak V K, Ladan E P, Minkina T M, Zinchenko V E, Chernenko V V, Makarenkov D A, Rykhlik A E and Larin G S 2020 *Agrochemistry* **2** 61 DOI: 10.31857/S0002188120020052
- [20] Kalinitchenko V P, Glinushkin A P, Minkina T M, Mandzhieva S S, Sushkova S N, Sukovatov V A, Il'ina L P and Makarenkov D A 2020 *ACS Omega* **5** 28 17553 <https://doi.org/10.1021/acsomega.0c02014>