Investigation on the content of petroleum products in the surface run-off from the road pavements

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Abstract. Road transport is considered to be one of the leaders from the viewpoint of damage caused to the environment. One of the principal problems, which specialists encounter with in connection with exploitation of automobiles, is the discharge of highly contaminated surface wastewaters from highways onto the close ground territories and into the close water reservoirs. The objective of the present investigation presumed determination of the real content of oil products in the surface run-off waters from the surfaces of automobile roads. Within the frames of the present investigation, we studied the available experience in assessment of the content of pollutants in storm drain from the objects of transport infrastructure. The content of petroleum products in surface waste waters formed on highways was studied.

1. Introduction
The problem of assessment of the pollution of storm and melt waters flowing down from the road pavement, and also the methods of purifying such waters, has been studied insufficiently. In recent years, the issue of the necessity of cleaning up the surface run-off from automobile roads has been put onto the agenda even in developed European countries.

At the same time, it is well-known that in the process of exploitation of highways, storm run-off exerts a perceptible anthropogenic pressure upon the natural environment. The pollution of storm and melt wastewaters with oil products, suspended solid products, heavy metals reaches ecologically hazardous concentrations.

The issue of purification of storm run-offs from roads, bridges and overpasses in the water protection zones, i.e. near water bodies, and at the points, where the road crosses rivers, is particularly urgent. According to the government normative documents, on the roads within water protection zones, it is necessary to provide for organized removal of the water from the surface of the carriageway as well as subsequent cleaning of the water or its drainage to other places in order to avoid polluting the water supply sources [1].

According to SanPiN 2.1.5.980-00 [3], forbidden are any organized discharge of storm sewage waters within the boundaries of settlements; any organized discharge of storm sewage waters within the first and second districts of sanitary protection of resorts; any organized discharge of storm sewage waters in places of tourism, sport events and mass recreation of the population.

Storm waters from the carriageway can be discharged both directly into water reservoirs but also into the public sewer system [12]. Noteworthy, for example, in some large cities, there are rather strict requirements to the concentrations of pollutants in the wastewaters discharged by subscribers to the sewerage system [11].
As far as suspended solids are concerned, permitted is the discharge of 10 – 15 mg/l to 300 mg/l of suspended solids and 0.3 – 0.7 mg / l of oil products. In most cases, storm waters from road pavements do not correspond to these high requirements.

In this connection, in recent years, the issue of cleaning storm run-off from roads was widely discussed. Furthermore, considering the need for a large number of sewage purification facilities (SPFs), the issue of necessity of a nomenclature range of such SPFs to satisfy the needs of the road constructing industry. So, the objective of our investigation was – assessment of true values of pollution of wastewaters from the road pavements with hazardous oil products.

The approach to solving this problem presumes:
1. Determination of both the scheme and the interval of wastewater sampling at the sites to be studied;
2. Investigation of the water samples taken in accordance with the accepted normative requirements.

The objective of this investigation was to determine the actual contents of pollutants (oil products) in storm waters discharged from the surface of the carriageway and consider these contents for definite sections of the highways.

The following undertakings were defined on the way to reaching this objective:
- determination of the current technical parameters of a section of road under scrutiny;
- investigation the climate conditions;
- development a methodology for finding out the content of oil products in the wastewaters.

The scientific novelty of the author’s approach presumes:
1) determination of actual concentrations of petroleum products in the surface run-off from the road pavements for definite sections of highways,
2) subsequent development of measures for water purification until the concentration reaches to accepted values.

2. Materials and methods
As noted above, the objective of the present investigation presumes obtaining plausible results bound up with assessment of the value of the concentration of harmful substances, in particular, oil products, which appeared on the road pavement during rains or after discharge of water onto the carriageway by a sprinkler.

The investigated section of highway R-258 (M-55) "Baikal" km 217 + 800 km 218 + 000 is located in Kabansky district, Republic of Buryatia.

The settlement Tankhoy is the nearest to the investigated section. The climate of the territory is sharply continental. Some moderate influence of Lake Baikal is registered. In other words, Lake Baikal influences the climate of the territory. This territory belongs to the climate subdistrict IB, and it is located in the road climatic zone I3.

The average temperature of the coldest month is minus 17.7°C, the average temperature of the hottest month is + 14.6°C. The warmest months are July and August.

The maximum precipitation corresponds to summer period (July, August). This leads to the formation of floods on the rivers. The average precipitation corresponds to the period from April to October is 752 mm (Table 1).

| Weather station Tankhoy | I  | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | year |
|-------------------------|----|----|-----|----|---|----|-----|------|----|---|----|-----|------|
| Average precipitation, mm | 23 | 15 | 21  | 38 | 70| 128| 179 | 180  | 109| 48| 35 | 43  | 889 |
| Average maximum daily | 5  | 4  | 7   | 12 | 19| 44 | 53  | 49   | 33 | 14| 7  | 8   | 80  |
The section of highway R-258 (M-55) "Baikal" km 217 + 800 km 218 + 000 belongs to the III technical category, and it is located within the boundaries of the water protection zone of Lake Baikal (in accordance with [10]).

The traffic intensity is 1985 vehicles per day.

Sampling on the territory under scrutiny was carried out from a transverse spillway in accordance with the requirements of PND F 12.15.1-08 "Methodological guidelines for sampling in wastewater analysis".

Water samples were poured into dark glass containers with metal lids.

The sampling schemes:

- Water sampling was carried out 20 minutes after the beginning of rain: 1 sample was taken (No. 1475).
- Water sampling was carried out during the process of water dispensing from the watering machine (Figure 1) (the length of the section of dispensing was 200 m, the width – 4 m, the volume of water – 8 m³), 4 samples were taken (No. 1829, 1830, 1831, 1832). The sampling interval was 15 minutes.

![Figure 1. The place of sampling of waste water from the surface of the carriageway.](image)

The samples chosen were examined at the test center TsLATI, the East Siberian region.

Tests of waste water samples were carried out in accordance with PND F 14.1: 2: 4.128-98 “Quantitative chemical analysis of water”. The technique for measurement of the mass concentration of oil products in samples of natural water (including sea water), drinking water and waste water presumed application of the fluorimetric method and hence the fluid analyzer «Fluorat-02». The results of assessment of the content of oil products are shown in Table. 2.
Table 2. Results of the test implying assessment of the concentration of oil products in the wastewater.

| №  | Sample number / code of the sample | Test report number | Results of the test (an error being (Δ, P = 0.95), uncertainty (U, at k = 2)), mg/dm³ | ND per method | Notes |
|----|-----------------------------------|-------------------|-------------------------------------------------------------------------------------|---------------|-------|
| 1  | 1475                              | B400Vs            | 0,54±0,14                                                                            |               |       |
| 2  | 1829                              | B459Vs            | 0,14±0,05                                                                            | PND F 14.1:2:4. 128-98 | samples taken during the rain |
| 3  | 1830                              | B459Vs            | 1,03±0,26                                                                            |               |       |
| 4  | 1831                              | B459Vs            | 1,90±0,50                                                                            |               |       |
| 5  | 1832                              | B459Vs            | 1,40±0,40                                                                            |               |       |

Table 3 shows the admissible contents, maximum admissible concentrations (MAC) of oil products in the wastewater.

Table 3. Normative / admissible content of oil products in the wastewaters.

| №  | Designation of normative documents (ND), recommendations, ODM. | Admissible content of oil products in wastewater / requirements / MAC ND | Section, clause (ND) |
|----|----------------------------------------------------------------|-----------------------------------------------------------------------|----------------------|
| 1  | Instruction No. 83 of the Ministry of Natural Resources and Ecology of Russian Federation (dated February 21, 2020) "On approval of standards for maximum admissible impacts on the unique ecological system of Lake Baikal and the list of harmful substances, including those, which belong to the categories of especially hazardous, highly hazardous, hazardous and moderately hazardous for the unique ecological system of Lake Baikal". | 0,05 mg/dm³ | Appendix 1, clause 2, table 2.3. |
| 2  | Instruction No. 552 of the Ministry of Agriculture of Russian Federation (dated December 13, 2016) "On approval of the water quality standards for water bodies of fishery significance, including standards for maximum admissible concentrations of harmful substances in the waters of water bodies having fishery significance" (as amended on March 10, 2020) | According to these Instructions, no oil films, oils, fats or accumulations of other impurities can be found on the surface of water bodies of fishery importance in the zone of anthropogenic impact. | Appendix, table.1. |
| 3  | SanPiN 2.1.5.980-00 represents hygienic requirements related to protection of the surface waters. | Oil films products, oils, fats and the accumulation of other impurities should not be found on the surface of the water | paragraph 5.2. |
| 4  | There also are the recommendations bound up with the consideration of the existing environment protection requirements to the | 14,4 (0,6·24) mg/l | paragraph 4.4.8., table 4.4.1. |
design of roads and bridges, issued by the Ministry of Transport (Ministry of Transport, Federal Highway Department. – M., 1995).

5. There also is ODM 218.8.005-2014. This contains methodological recommendations for the maintenance of purification facilities on highways. 0,05 mg/dm$^3$

### 3. Conclusion

On account of the results of testing samples (Table 2), one can conclude that the actual content of oil products in the wastewater (0.14–1.9 mg/dm$^3$) from the surface of the carriageway on the target section of the highway R-258 (M-55) "Baikal" Km 217 + 800 km 218 + 000 substantially exceeds the admissible value of 0.05 mg/dm$^3$ assessed on the basis of Instruction No. 83 of the Ministry of Natural Resources and Ecology of Russian Federation of February 21, 2020 "On approval of the standards for maximum admissible impacts on the unique ecological system of Lake Baikal and the list of hazardous substances, including substances, which belong to the categories of especially hazardous, highly hazardous, hazardous and moderately hazardous for the unique ecological system of Lake Baikal "Appendix 1. Clause 2, Table 2.3. The data obtained as a result of our investigation may be used to develop measures and design the systems intended for purification of the wastewaters to the accepted norms in accordance with the requirements established by the regulatory documents, including the requirements, which are in effect in the water protection zone of Lake Baikal.

### References

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[10] Federal Law On the Protection of Lake Baikal 94-FZ

[11] Order of the Government of the Russian Federation No. 368-r dated 05.032015 "On the approval of the boundaries of the water protection and fish protection zones of Lake Baikal".

[12] Conditions for the reception of pollutants in wastewater discharged by subscribers to the sewage system of St. Petersburg (as amended on November 28, 1997, March 3, 1999, August 2005). Appendix 1 to the order of the Committee for urban management of the Administration of St. Petersburg dated November 25, 1996 N 201.

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