"Sapsan"-carriages defrosting station of Nizhniy Novgorod railway service enterprise and its surface waste water purification

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Abstract. Surface water disposal is one of the most relevant problems for Nizhniy Novgorod railway service enterprises. Waste water must be quickly removed with special drainage devices and water drainage facilities (culverts, slope drains, pipes, ditches, etc.). During "Sapsan"-carriages defrosting waste water is aggregated on railroad tracks. It leads to track bed structure sagging, roadbed washaway and damages to point switches. In this paper the authors describe a concrete system of waste water disposal from railway service enterprises. This system is realized through culverts readjusted at the foot of ballast section. Thereafter, the collected water is pumped into a water collector and to local sewage waste-disposal plants. For railway stations with three or more tracks surface runoff diversion scheme depends on topography, railway tracks types, flow discharge and is compiled individually for each object. This paper examines "Sapsan"-carriages defrosting station of Nizhniy Novgorod railway service enterprise. It presents a technology scheme and equipment consisting of Sand catcher LOS-P, Oil catcher LOS-N, pressure-tight flotation unit; drain feed pump; solution-consuming tank of the coagulant, the solution-consuming tank of flocculant. The proposed technology has been introduced into the project practice. Keywords: surface run-off, railway tracks, waste water purification, waste-disposal plants, operation schemes.

1. Introduction
Rail transport enterprises are among the main sources to pollute different objects of the natural environment with waste-water discharges. Therefore, surface wastewater disposal is highly relevant for these enterprises. The main purpose of this study is to introduce a new solution to this problem [1, 2, 3].

2. Literature review
There is atmospheric runoff from rainfall and snow melt, as well as relatively clean water from carriages and equipment replanting, appearing constantly at the sites of railway enterprises [4, 5, 6]. To avoid track bed structure sagging, roadbed washaway, damage to point switches, especially when water turns into ice, interference with automatic activities and other emergency situations [7, 8, 9, 10], the water on the territory of an industrial railway site shall be disposed and purified. First of all, surface waste water should be discharged from point switches, train yards constructions,
loading bays, platform slings, trade houses, warehouses, depots and the like [11, 12]. It is therefore necessary to propose effective technology schemes for collection, disposal and purification of surface run-off.

3. Methods
Based on the above, let us consider a system of wastewater disposal from railway service enterprises in the form of trays at the foot of ballast section, and from the site of railway service enterprises [4, 5, 8, 19]. Thereafter, the collected water is pumped into a sewage collector and later to local sewage waste-disposal plants. For railway stations with three or more tracks surface runoff diversion scheme depends on topography, railway tracks types, flow discharge and is compiled individually for each object. "Sapsan"-carriages defrosting station of Nizhniy Novgorod railway service enterprise is located on the area, 2000 m² of which are railway tracks area. For this enterprise, we propose the following technological equipment and a technological scheme.

The proposed scheme of waste-disposal facilities is designed for several technology lines. The first line is designed for a discharge of 19.5 m³/h. When the discharge rises to 91.5 m³/h, the second line is included in the scheme, with discharge of 72 m³/h.

4. Results
In the first phase of waste water purification, wastewater from a sewage pumping station is sent into a sand catcher. A sand catcher is designed to grit removal and is used as a pretreatment facility for surface and industrial wastewater purification. The wastewater goes down a delivery pipe-line and enters the downstream stream zone, where this water evenly flows along the perimeter of the interior of a sand catcher. Then it flows from the partition to the center and goes down, spreading evenly across the entire section of the inner part. When the waste water goes down, the flow loses its carrying capacity. It results in the deposition of suspended particles. The intensive separation of liquid and solid phases occurs at the turn of the flow. Then, the wastewater flows through a collecting tray and is transferred via a discharge tube. Floats from wastewater accumulate in the upper part of the downstream zone and are periodically removed, and suspended particles accumulate in an outside drainage pit, fitted with a sediment pumping, for its periodic removal by a special machine and transportation to urban treatment facilities.

![Structural diagram of a sand catcher](image)

Figure 1. Structural diagram of a sand catcher
1. Delivery pipe-line; 2. Discharge pipe-line; 3. Partition; 4. Collecting tray; 5. Sediment standpipe pump; 6. Ventilation standpipe
Wastewater naturally flows from a sand catcher to an oil catcher. The oil catcher is used to capture floating substances from surface and industrial wastewater. It is also used as a structure for surface and industrial wastewater purification before they are dumped into public drainage after preparatory rough mechanical purification at bars and in sand catchers, and as a construction of mechanical purification before going to sorption filters.

![Figure 2. Structural diagram of an oil catcher](image)

1. Delivery pipe-line; 2. Discharge pipe-line; 3. Block with tube-shaped separator filters 4. Block with filtering elements under loading; 5. Sediment standpipe pump; 6. Ventilation standpipe

The wastewater flows along a delivery pipe-line and enters a setting-out zone which is divided into two parts with a semi-submersible dividing wall. It allows to reduce the speed of the fluid movement and ensure that the wastewater flows from the bottom up through the blocks with tube-shaped separator filters. Tube-shaped separator filters are modules which replace traditional structures of thin elements for strainer chambers. The shape and design of tubular elements significantly increase sediment area, thereby increasing efficiency of the purification in comparison with classical thin-walled strainer chambers. These modules are made of polypropylene and have a high mechanical strength. The residue in the block with tube-shaped separator filters is accumulated at the bottom of the oil catcher and is periodically removed through the pumping of the sediment by a special machine and then transported to urban treatment facilities.

After the setting-out zone, the wastewater is sent to the block with filter elements made of polyethylene tube elements filled with a special loading on the basis of polyurethane. The block is filtered from top to bottom.

Unique loading properties allow continuous filtration of wastewater contaminated with lightweight substances and heavily emulsified petroleum products to be carried out for 100-150 hours. At the end of a filtration cycle, the filtering load is replaced.

Filtering elements are easy to operate and can be serviced manually. After passing the filtration block, the wastewater enters a treated wastewater zone and is collected by a discharge pipe-line.

From the oil catcher, the wastewater flows into the flotation installation. The pressure-tight flotation unit cleans the wastewater from oil, petroleum products and inorganic impurities. In order to intensify the cleanup process in the flotation unit, it is recommended to additionally use coagulants and flocculants (reagent flotation), which sorb on the surface of the polluted area, reduce their wetting quality and thus increase the efficiency of purification. The coagulant and flocculant solution is prepared and measured by a special device of preparations and submission of reagents.

Table 1 specifies purification efficiency of technological facilities which are shown in Figure 3. According to the requirements for the treatment of surface wastewater, three main indicators are regulated: total biochemical oxygen demand (BODtotal), suspended materials, petroleum products.
Iron (general) should also be considered as an ingredient here, since this pollutant is permanently present in the waste waters of railway service enterprises.

Table 1. Purification efficiency of technological facilities

| №  | Ingredient     | Unit of measurement | Sand catcher | Oil catcher | Pressure-tight flotation unit |
|----|----------------|---------------------|--------------|-------------|------------------------------|
| 1  | BOD\textsubscript{total} | %                   | 20           | 25          | 30                           |
| 2  | Suspended materials | %                   | 80           | 70          | 70                           |
| 3  | Petroleum products  | %                   | 75           | 95          | 60                           |
| 4  | Iron (gen)        | %                   | 30           | 40          | 50                           |

Purification efficiency of each technological structure constituting the operation scheme of waste-disposal plants is shown in Figure 4. Such an approach makes it possible to determine pollutants concentrations at the output of each technological structure. The results are shown in Table 2.

Table 2. Purification efficiency of technological facilities with end-concentrations at the outlet

| No | Ingredient     | Unit of measurement | Initial concentration | Technological facilities and concentration of pollutants at the outlet of these facilities |
|----|----------------|---------------------|-----------------------|----------------------------------------------------------------------------------------|
|    |                |                     |                       | Sand catcher | Oil catcher | Pressure-tight flotation unit |
| 1  | BOD\textsubscript{total} | mgO\textsubscript{2}/l | 20.0                  | 16.0        | 12.0        | 8.4                           |
| 2  | Suspended materials | mg/l                | 1000.0                | 200.0       | 60.0        | 18.0                          |
| 3  | Petroleum products  | mg/l                | 70.0                  | 17.5        | 0.88        | 0.35                          |
| 4  | Iron (gen)        | mg/l                | 3.0                   | 2.1         | 1.3         | 0.6                           |

Atmospheric precipitation in the form of rain and snow, falling on the surface of moving "Sapsan"-carriages, locomotives and the rail bed, forms the runoff. "Sapsan"-carriages defrosting station of Nizhniy Novgorod railway service enterprise collects and discharges waste water to a special technological installation. This technological installation is also used for treating waste water from the railway bed which adjoins the station.
Figure 3. Installation technology diagram
1 – Sand catcher LOS-P, 2 – Oil catcher LOS-N, 3 – pressure-tight flotation unit; 4 – drain feed pump, 5 – solution-consuming tank of the coagulant, 6 – the solution-consuming tank of flocculant

5. Conclusions
One of the main measures effective for water resources protection is the introduction of new technological processes. New high-efficient methods of wastewater purification, physical-chemical techniques including the use of reagents, in particular, can significantly improve the quality of purification process.

The use of the reagent method for production wastewater purification does not depend on the toxicity of impurities involved, which is essential when this method is compared with biochemical treatment. Wider adoption of this technique, both in combination with biochemical cleaning and separately, may to some extent be used as a solution for the problem of industrial wastewater purification.
This paper examined "Sapsan"-carriages defrosting station of Nizhniy Novgorod railway service enterprise. It presents a technology scheme and equipment that was introduced into the project practice.

References
[1] Kobeleva S A 2013 Biospheric Compatibility: man region technology 1 pp 6-9
[2] Strelkov A K et all 2014 Town Planning and Architecture Vestnik SGASU 4 pp 55-63
[3] Pervov A G 2011 Water delivery and sanitary engineering 11
[4] Shishkina I V and Matyshin D V 2014 Biospheric Compatibility: man region technology 4 (12) pp 93-100
[5] Kalinin A V 2011 Water delivery and sanitary engineering 4
[6] Palagin E D and Strelkov et all 2016 12
[7] Strelkov A K and Teplykh et al 2013 Water delivery and sanitary engineering 8 pp 67-70
[8] Korsya V B Teplykh S Y and Gorshkalev P A 2007 Tracks and tracksid 7 pp 18-19
[9] Gorshkalev P A 2009 KazanGASU Bulletin Kazan 1 (11) pp 211-213
[10] Strelkov A K Teplykh S Y and Bukhman N S 2016 Theoretical Foundation of Civil Engineering Procedia Engineering 153 pp 692-697
[11] Vereshchagina L M 2015 Water delivery and sanitary engineering 1
[12] Strelkov A K Teplykh S Y and Bukhman N S 2016 IOP Publishing Journal of Physics: Conference Series 738 doi:10.1088/1742-6596/738/1/012124
[13] Strelkov A K Teplykh S Y and Gorshkalev P A 2015 Industrial and civil engineering 6 pp 70-73
[14] Morozov A V 2014 Biospheric Compatibility: man region technology 1 (5) pp 60-64
[15] Degtyarev B M 2014 Biospheric Compatibility: man region technology 1 (9) pp 80-87
[16] Ivkin P A et all 2012 Water delivery and sanitary engineering 1
[17] Lantsova E V and Tulyakova G V 2012 Industrial and civil engineering 11 pp 49-52
[18] Fesenko L N Popov D V and Kulikov N I 2013 Water delivery and sanitary engineering 1
[19] Gandurina L V Andriyash E N and Lovlin V M 2012 Water delivery and sanitary engineering 4
[20] Telichenko V I and Bolsherotov A L 2012 Industrial and civil engineering 10