Technological Schemes for Collection, Disposal and Treatment of Surface Run-off and Their Development

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Abstract. The paper focuses on surface wastewater collection and its disposal from railway station tracks. It is described that usually either drainage trays located along the tracks or perforated pipelines arranged in special channels filled with water-permeable material are used to collect and divert surface run-off from the railway track. The analysis reveals the qualitative and quantitative composition of surface run-off. The paper shares data obtained during the investigation of railway stations and enterprises of the Kuibyshev railway and focuses on contamination of the territory of this enterprise with petroleum products and on concentrations surface wastewater contamination with petroleum products, suspended substances and iron. The authors further introduce technological schemes for surface wastewater treatment, which allow achieving the quality of treated wastewater at the level of maximum permissible concentrations for water bodies of fishing purposes.

1. Introduction
With the increase of environmental protection requirements and due to the deterioration of the environment, the relevance of surface sources protection from water pollution becomes increasingly obvious. Some of the pollutants that have a serious impact on the soil and water bodies are carried by surface wastewater from railway transport enterprises, since this wastewater is not purified properly when coming from tracks and bridge crossings.

2. Research foundations
To raise the attention to this issue, the researchers collected the following information about railway stations of the Kuibyshev railway, divided by their category. They are classified as follows:
2.1. **Small-scale stations (434 pcs) with an area from 3000 to 10 000 m$^2$ with their length being 100-200 m.**

All small-scale stations are located in rural areas and outside of large settlements with a storm-water drainage. Wastewater with a flow rate of 1.87-6.25 l/sec is sent to 1-4 storage tanks with a volume of 6-12 m$^3$ with a time reserve of 3-5 days for their subsequent treatment at compact mono-installations located on the border of the railway station site. Then this wastewater is sent to filtration trenches of treated wastewater discharge (see Figure 1); or is transferred from storage tanks to equipped cars of railway treatment facilities for transmission to the urban storm-water drainage [1].

![Figure 1. Location of four mono-compact treatment plants at small-scale railway stations, no longer than 200 m.](image)

Table 1 demonstrates the calculation of wastewater treatment efficiency in a mono-compact installation designed for bridges and bridge crossings and small-scale railway stations. These installations also carry treated wastewater off these stations territory. The calculations are based on the concentrations given in Table 1 (see Table 1.).

| Contamination, initial, mg/l | BOD, 20 mg/l | Suspended substances, 1132 mg/l | Petroleum products, 387 mg/l | Iron, 6.6 mg/l |
|-----------------------------|--------------|---------------------------------|-------------------------------|---------------|
| Sand catcher                | E=10%        | L$_c$=18                        | E=20%                         | C$_c$=906     |
| Oil separator               | E=25%        | L$_c$=13.5                      | E=70%                         | C$_c$=272     |
| Strainer chamber            | E=30%        | L$_c$=9.5                       | E=70%                         | C$_c$=81.6    |
| Flotator                    | E=30%        | L$_c$=6.6                       | E=70%                         | C$_c$=24      |
| Granular-bed filter         | E=50%        | L$_c$=9                         | E=70%                         | C$_c$=7.2     |
| Sorption filter             | E=70%        | L$_c$=2.7                       | E=70%                         | C$_c$=2.2     |
| MAC                         | 3.0          | F+0.25                          | 0.05                          | 0.1           |

**Small-scale stations with an area of 3000 m$^2$ with their length being up to 200 m**

| Contamination, initial, mg/l | BOD, 20 mg/l | Suspended substances, 1798 mg/l | Petroleum products, 120 mg/l | Iron, 4.5 mg/l |
|-----------------------------|--------------|---------------------------------|-------------------------------|---------------|
| Sand catcher                | E=10%        | L$_c$=18                        | E=20%                         | C$_c$=1438    |
| Oil separator               | E=25%        | L$_c$=13.5                      | E=70%                         | C$_c$=431     |
| Strainer chamber            | E=30%        | L$_c$=9.5                       | E=70%                         | C$_c$=129     |
| Flotator                    | E=30%        | L$_c$=6.6                       | E=70%                         | C$_c$=39      |
| Granular-bed filter         | E=50%        | L$_c$=9                         | E=70%                         | C$_c$=11.6    |
| Sorption filter             | E=70%        | L$_c$=2.7                       | E=70%                         | C$_c$=3.5     |
| MAC                         | 3.0          | F+0.25                          | 0.05                          | 0.1           |
2.2. Small stations (173 pcs) with 3-4 tracks, their area varying from 10 000 to 50 000 m² and their length being 200-500 m.

All small stations are located in rural areas and outside of large settlements with a storm-water drainage. Wastewater here is generated with a flow rate of 6.25-31.25 l/sec.

First option. Wastewater treatment can be carried out according to the scheme proposed for small-scale stations, provided that 4-6 storage tanks with a volume of 10-20 m³ with a time reserve of 3-5 days for their subsequent treatment at compact mono-installations located on the border of the railway station site. Then this wastewater is sent to filtration trenches of treated wastewater discharge; or is transferred from storage tanks to equipped cars of railway treatment facilities for transmission to the urban storm-water drainage [2, 3].

Second option. Development, design and construction of treatment facilities for a particular construction object. According to the proposed classification by area, Base No 47 of OJSC "Russian Railways" of the Kuibyshev railway is a typical example of a small station (enterprise).

Base No 47, being a Joint Stock Company "Russian Railways" enterprise, is used mostly for transportation and equipment storage for railway transport. Scheme of drainage networks for Base 47 is determined by terrain and hydrogeological conditions (see Figure 2). Tracing drainage networks, at small stations especially, should be arranged while using the maximum advantage of the surface slope of the territory. Then it will enable wastewater disposal through self-flowing piping that will be laid at a depth of 6-7 m. With this depth of network laying, an open method of developing trenches for pipeline installation is used. Wastewater from Base No 47 with a flow rate of 2400 m³/day (27.7 l/sec), containing BOD = 32.0 mgO₂/l, suspended substances Cs/s=196.4 mg/l; petroleum products Cp/p=86 mg/l; iron 2.3 mg/l flows to wastewater treatment facilities. Wastewater from Base No 47 comes at the local waste-disposal plants (see Figure 2) [4].

At the first stage there is mechanical purification from sand and sludge in sand catchers, then drain water is mechanically purified from settling and pop-up substances in vertical pits. At the next stage we apply physic-chemical purification using pressure-proof flotation plants to reduce the residual concentration of suspended substances and petroleum products. After physic-chemical purification wastewater goes into special blocks for advanced treatment. Purified wastewater is exposed to UV-disinfection. After UV-disinfection wastewater goes into water basins. Sludge coming from strainer chambers and pressure-proof flotation plants enters skimmer seals and vacuum filters where it undergoes mechanical dehydration. The authors and their colleagues from the Department of "Water Supply and Wastewater Disposal", Academy of Construction and Architecture, Samara State Technical University developed a technological scheme for the conditions of Base No 47. The degree of wastewater treatment for the structures accepted in the project is given in Table 2 (see Table 2).

| Contamination, initial, mg/l | BOD, 32 mg/l | Suspended substances, 196.4 mg/l | Petroleum products, 86 mg/l | Iron, 2.3 mg/l |
|-----------------------------|-------------|-------------------------------|---------------------------|---------------|
| Sand catcher                | E=10%       | L_e=28.8                      | E=20%                    | C_e=157       | E=10%         | C_e=77.4       | E=3%          | C_e=2.2       |
| Oil separator               | E=0%        | L_e=28.8                      | E=0%                     | C_e=157       | E=0%          | C_e=77.4       | E=0%          | C_e=2.3       |
| Strainer chamber            | E=30%       | L_e=20.16                     | E=70%                    | C_e=41.1      | E=70%         | C_e=23.2       | E=50%         | C_e=1.1       |
| Flotator                    | E=30%       | L_e=14.1                      | E=70%                    | C_e=14.1      | E=70%         | C_e=6.9        | E=50%         | C_e=0.55      |
| Granular-bed filter         | E=50%       | L_e=7.0                       | E=70%                    | C_e=4.2       | E=95%         | C_e=0.34       | E=85%         | C_e=0.08      |
| Sorption filter MAC         | E=70%       | L_e=2.1                       | E=70%                    | C_e=1.3       | E=90%         | C_e=0.03       | E=85%         | C_e=0.01      |

|            | 3.0         | F+0.25                       | 0.05                     | 0.1           |
2.3. Middle-scale stations (84 pcs) with 5-7 tracks, their area varying from 50 000 to 100 000 m² and their length being 500-1000 m.

To middle-scale stations the researchers refer central railway stations of the Samara region, as well as railway transport enterprises. They also can be located in a remote part of the city of Samara. As a rule, there is a storm-water drainage in such settlements. Wastewater discharge varies from 31.25 to 62.5 l/sec. Development, design and construction of unique treatment facilities for every particular facility is recommended. According to the proposed classification by area, Rechnaya Station of OJSC "Russian Railways" of the Kuibyshev railway (JSC "Abdulinsky plant Remputmash") is a typical example of a middle-scale station (enterprise).

Rechnaya Station of OJSC "Russian Railways" of the Kuibyshev railway. Runoff rainwater should be regulated in order to reduce and level discharge entering the wastewater treatment plant or pumping stations. Drain averaging should be also used in case they enter long collectors spur for reducing the diameters of pipes. At the moment, there is no system of surface run-off collection, disposal and purification in Rechnaya station [5-8].

To regulate the flow of rainwater, containers or reservoirs should be installed. In some cases, it is advisable to use control tanks as a waste-disposal plant. Thus, in such a case all surface run-off should be sent into this pond. This should include special equipment for removing sludge, garbage and oil products. Figure 1 shows the location of drainage trays for collecting surface wastewater. It also shows sewage treatment facilities. When designing the technological scheme of treatment facilities, the researchers resorted to mechanical and physico-chemical treatment as sewage discharge is prohibited at railway stations and residential areas of cities and other settlements. Surface run-off is directed to free-standing treatment facilities since there is no surface run-off drainage in this area. Sewage treatment plants receive wastewater from the Rechnaya railway station and nearby residential buildings at a surface slope of more than 0.03, with a flow rate of 4800 m³/day (200 m³/h) and containing BPK5=20mgO₂/l, suspended substances Cs/s=1380 mg/l; petroleum products Cp/p=68.0 mg/l, iron Ci=2.1 mg/l. The technological scheme for Rechnaya station conditions was also developed at the Department of "Water Supply and Wastewater Disposal" of Academy of Construction and Architecture, SamSGU. The following structure of facilities is proposed: for water this structure consists of flow-equalization basin, grates, sand catchers, vertical storage tanks, reagent equipment, pump station, 1 and 2-stage filters, filter presses, UV-disinfection; for sludge it consists of gravel hoppers, filter presses, stand-by silt grounds (1440 m² is enough for placement) in the immediate vicinity of the railway track [9].

The authors and their colleagues from the Department of "Water Supply and Wastewater Disposal", Academy of Construction and Architecture, Samara State Technical University developed a
technological scheme for the conditions of Rechnaya station (see Figure 3). The degree of wastewater treatment for the structures accepted in the project is given in Table 3 (see Table 3).

**Table 3.** Effect of wastewater treatment at the railway station Rechnaya, the city of Samara.

| Contamination, initial, mg/l | BOD, 20 mg/l | Suspended substances, 1580 mg/l | Petroleum products, 68 mg/l | Iron, 2.1 mg/l |
|-----------------------------|-------------|---------------------------------|-----------------------------|---------------|
| Sand catcher                | E=5%        | L_c=19.0                        | C_c=1422                    | E=5%          | C_c=64.6     | E=1%          | C_c=2.07     |
| Oil separator               | E=0%        | L_c=19.0                        | C_c=1422                    | E=0%          | C_c=64.6     | E=0%          | C_c=2.07     |
| Strainer chamber            | E=10%       | L_c=17.1                        | C_c=995                     | E=10%         | C_c=58.14    | E=3%          | C_c=2.0      |
| Flotator                    | E=30%       | L_c=11.9                        | C_c=199                     | E=70%         | C_c=17.4     | E=50%         | C_c=1.0      |
| Granular-bed filter         | E=50%       | L_c=5.9                         | C_c=39.8                    | E=95%         | C_c=0.87     | E=85%         | C_c=0.15     |
| Sorption filter             | E=70%       | L_c=1.8                         | C_c=11.9                    | E=90%         | C_c=0.08     | E=85%         | C_c=0.02     |

![Figure 3. General plan of the Rechnaya station.](image)

OJSC "Russian Railways" of the Kuibyshev railway, JSC "Abdulinsky Remputmash plant": the main purpose of wastewater treatment complex is collecting, averaging (blending) and cleaning of household production and surface wastewater which comes from JSC "Abdulinsky factory "Remputmash". Wastewater is then discharged into the sewage system of Abdulino town. In accordance with the research conducted by LLC Research and Production Company "EKOS", it was found that the volume of household and surface run-off in the total volume of wastewater is significant. This confirms the following values: BPK5=124.2 mgO2/l, suspended substances=950 mg/l, petroleum products=112 mg/l, iron=6.86 mg/l. Because of this and in regard with techno-economic calculations done by the authors, it is required to install some local biological sewage treatment plants
involving the use of nitrification and denitrification methods to purify this kind of sewage. Treated sewage water disinfection is done by use of UV-irradiation. Sludge dewatering is performed on a special dewatering installation. The performance of wastewater treatment facilities is 6000 m$^3$/day [10, 11].

Stages of the technological process are shown in Figure 4 (see Figure 4). Mechanical treatment, reception, averaging and mixing of sewage water; coarse cleaning – sieves; cleaning from mineral contaminants – thin-layer strainer chamber; dispensing of reagent installation. Biological treatment: first-stage aeration tank; second-stage aeration tank; third stage aeration tank; precipitation-nitrifikator; secondary strainer chamber. Advanced treatment: floating filter; granular filter. Disinfection of treated wastewater: UV-irradiation. The dewatering of sludge: the filter press.

The authors and their colleagues from the Department of "Water Supply and Wastewater Disposal", Academy of Construction and Architecture, Samara State Technical University developed a technological scheme for the conditions of JSC "Abdulinsky Remputmash plant". This project passed the State Expertise. The degree of wastewater treatment for the structures accepted in the project is given in Table 4 (see Table 4).

Table 4. Effect of wastewater treatment at JSC "Abdulinsky Remputmash plant".

| Contamination, initial, mg/l | BOD, 124 mg/l | Suspended substances, 950 mg/l | Petroleum products, 112 mg/l | Iron, 6.86 mg/l |
|----------------------------|--------------|-------------------------------|-----------------------------|----------------|
| E=5%          | L$_c$=117.8 | E=10%  | C$_c$=855                  | E=5%          | C$_c$=106.4    | E=1%          | C$_c$=6.7   |
| E=10%         | L$_c$=106   | E=50%  | C$_c$=428                  | E=50%         | C$_c$=53.2     | E=3%          | C$_c$=6.5   |
| E=90%         | L$_c$=10.6  | E=5%   | C$_c$=406                  | E=10%         | C$_c$=48.7     | E=3%          | C$_c$=6.3   |
| E=15%         | L$_c$=9     | E=80%  | C$_c$=81.2                 | E=70%         | C$_c$=14.3     | E=50%         | C$_c$=3.1   |
| E=50%         | L$_c$=4.5   | E=80%  | C$_c$=16.2                 | E=95%         | C$_c$=0.71     | E=85%         | C$_c$=0.47  |
| MAC           | 3.0          | E=70%  | C$_c$=4.8                  | E=90%         | C$_c$=0.07     | E=85%         | C$_c$=0.07  |

Figure 4. General plan of the construction site of JSC "Abdulinsky Remputmash plant".
2.4. **Major stations (56 pcs) with 8-10 tracks, their area varying from 100 000 to 500 000 m² and their length being 1000-2000 m.**

To major stations the researchers refer central railway stations of cities and districts in the Samara region, as well as railway transport enterprises. As a rule, there is a storm-water drainage in such settlements. Wastewater discharge varies from 62.5 to 312.5 l/sec. Development, design and construction of unique treatment facilities for every particular facility is recommended. According to the proposed classification by area, Stakhanovskaya station of OJSC "Russian Railways" of the Kuibyshev railway is a typical example of a major station (enterprise) [12].

Stakhanovskaya Station of OJSC "Russian Railways" of the Kuibyshev railway (see Figure 5.) At the moment there is no system of surface run-off collection, disposal and purification in Stakhanovskaya station. Tracing drainage networks from Stakhanovskaya Station should be arranged while using the maximum advantage of the surface slope of the territory. Then it will enable wastewater disposal through self-flowing piping that will be laid at a depth varying from 1-2 to 6-8 m.

![Figure 5. General plan of Stakhanovskaya station.](image)

To dispose surface waste waters from the territory of Stakhanovskaya Railway Station (Samara) centralized drainage scheme is now used (see Figure 5). At the end of each drainage tray there is a catch basin. Wastewater from the Stakhanovskaya railway station enters treatment facilities with a flow rate of 12,000 m³/day. It contains BOD=20 mgO₂/l, suspended substances Cs/s=1105 mg/l, petroleum products Cp/p=468 mg/l, iron Ci=7 mg/l. The designed treatment facilities are located on the territory of Stakhanovskaya Station. The process is followed by the release of purified surface waste waters into the Samara river. The technological scheme was also developed at the Department of "Water Supply and Wastewater Disposal" of Academy of Construction and Architecture, SamSGU. Figure 14 shows the location of surface wastewater collection drainage trays. Then they are sent by gravity to the receiving chamber (flow-equalization basin), sand trap (sand bunkers), vertical settling tanks, pressure flotators, pumping station, granular filters, sludge densifier, vacuum filters, UV
disinfection, reserve silt platforms. The BOD content in wastewater is in this case negligible. There is no need for biological purification in these waste-disposal plants (see Table 5).

### Table 5. Effect of wastewater treatment at Stakhanovskaya railway station, Samara.

| Contamination, initial, mg/l | BOD, 20 mg/l | Suspended substances, 1211 mg/l | Petroleum products, 478 mg/l | Iron, 7.0 mg/l |
|-----------------------------|-------------|---------------------------------|-----------------------------|---------------|
| Sand catcher                | E=5%        | L_c=19.0                        | C_c=1089.9                  | E=5%          | C_c=454.1   |
|                            | E=10%       | L_c=17.1                        | C_c=762.9                   | E=10%         | C_c=108.6   |
|                            | E=30%       | L_c=11.9                        | C_c=228.8                   | E=70%         | C_c=122.6   |
| Oil separator chamber      | E=30%       | L_c=8.4                         | C_c=45.                      | E=70%         | C_c=36.7    |
|                            | E=50%       | L_c=4.1                         | C_c=9.1                      | E=95%         | C_c=1.8    |
| Flotator                   | E=30%       | L_c=8.4                         | C_c=45.                      | E=70%         | C_c=36.7    |
| Granular-bed filter        | E=50%       | L_c=4.1                         | C_c=9.1                      | E=95%         | C_c=1.8    |
| Sorption filter MAC        | E=70%       | L_c=1.2                         | C_c=2.7                      | E=90%         | C_c=0.18   |

2.5. Large stations (22 pcs) with more than tracks, their area varying from 500 000 to 1 000 000 m² and their length being 2000-4500 m.

To large stations the researchers refer central railway stations of large cities in the Samara region, as well as railway transport enterprises. As a rule, there is a storm-water drainage in such settlements. Wastewater with a flow rate of 312.5 – 625 l/s. Recommended: development, design and construction of treatment facilities for each specific individual object. According to the proposed classification by area, Samara, Syzran, Tolyatti, Kinel and Pohvisnevo stations of OJSC "Russian Railways" of the Kuibyshev railway (the city of Samara) are typical example of a large station (enterprise) [13-18].

Precipitation in the form of rain and snow falling on the railway track forms a water drain. Part of this run-off settles in the thickness of the railway track, another part seeps into the ground, causing infiltration and infiltration (weepage which goes through cracks, passages and voids in the ground), and the third part evaporates from the surface. The volume of run-off depends on the location of drainage trays at different heights of the slope of the ballast section and can vary up to 50-60%. The remaining amount of precipitation seeps into the ground and evaporates (up to 31-37% of the precipitation in the European part of Russia). Surface wastewater coming from various territories is very diverse in its composition and sediments and therefore in its properties. The authors introduce the most effective operation scheme wastewater treatment facilities while basing on qualitative and quantitative composition of surface wastewater and contaminants it contains.

3. Elevated railway tracks: technological schemes of surface wastewater collection, disposal and purification

For railway stations with three or more tracks surface run-off diversion scheme depends on topography, railway tracks types, flow discharge and is compiled individually for each object.

Stations and sections with elevated track of the Kuibyshev railway, OJSC "Russian Railways". Drainage of surface wastewater from individual sections of the railway, in particular from elevated tracks that have a pronounced slope of the terrain, is carried out using a system of drainage trays and drain shafts. Pollutants concentration in surface run-off changes during rainfall. It has been experimentally established that rainfall run-off coming from elevated railway tracks contains a high content of loose material particles, sand, and dust. The concentration of suspended substances in it varies from 100 to 50 000 mg/l. The limits of fluctuations in the content of petroleum products range from 30 to 4000 mg/l. Studies of the concentrations and flow rates of surface run-off from railway tracks conducted by the authors made it possible to implement a system for collecting and diverting surface wastewater from the territory of the tracks of the stations in question [19].
For example, at the Krasnoe Ozero station, Samara region, a system of open side drainage trays and drain shafts for drainage and collection of surface run-off was proposed (see Figure 6). Run-off is collected while flowing down a concrete surface. It is then diverted through local wastewater treatment plants (LWP) to the urban storm-water drainage.

![Figure 6. Krasnoe Ozero station: surface run-off diversion scheme (new construction).](image)

At Severnaya station, the Republic of Mordovia (OJSC "Kuibyshev railway"), an alternative drainage scheme with a system of perforated cross pipes and side drainage trays was designed and put into operation. Effluent is discharged through LWP and containment pond to a surface water body (see Figure 7).

![Figure 7. Severnaya station: surface run-off diversion scheme (new construction).](image)

Currently, there are elevated railway tracks that were put into operation more than 20 years ago. Drainage problems have not yet been solved there during the entire period of their operation. Promyshlennaya Station in the Ulyanovsk region (OJSC "Kuibyshev railway") is a station with such elevated tracks. The territory under consideration has a high level of ground flow. During the period of high water and flooding, the section of the elevated path is flooded, and in case of heavy rainfalls the situation with drainage becomes critical. Here, a system of drain shafts was proposed for drainage and...
accumulation of ground water, followed by further gravity drainage or pumping (if necessary) in the rain sewer network. The authors also designed a network consisting of four drainage trays and drain shaft to divert surface run-off from the territory of the elevated track while making it flow to LWP and then to the urban storm-water drainage (see Figure 8).

Figure 8. Promyshlennaya station: surface run-off diversion scheme (reconstruction).

To make a decision, the estimated wastewater consumption was calculated by using different formulas. The calculation results are shown in Table 6 (see Table 6).

Table 6. Calculation results of surface run-off costs for three railway stations.

| Calculation methodology | Krasnoe Ozero Station, the Samara region (3015 m²) | Severnaya station, the Republic of Moldavia (6045 m²) | Promyshlennaya station, the Ulyanovsk region (6574 m²) |
|-------------------------|---------------------------------|---------------------------------|---------------------------------|
| 1. Method of limiting intensities | $Q = \frac{z_{mid} \cdot A^{1.2} \cdot F \cdot K \cdot K_{L}}{t^{12e-01}}$, l/sec | 19 | 38 | 41 |
| 2. Method of M.V. Molokov | $Q = \frac{20^*q_{20}(1+C lg p)}{t^2}$, l/sec | 187 | 187 | 187 |
| 3. Formula of V.S. Dikarevsky | $Q = q \cdot F \cdot \psi_{cp} \cdot \eta \cdot m$, l/sec | 132 | 141 | 153 |
| 4. Formula used in railway transport enterprises | $Q = q_{p\%} \cdot F$, l/sec | 21 | 42 | 46 |
| 5. Determination of surface run-off flow rate while using the histogram of precipitation at railway transport enterprises | $Q = K_p (a - i) F$, m³/sec | 101 | 202 | 219 |
| Discharge value accepted for calculation in the project documentation | 132 l/sec (475 m³/h) | 141 l/sec (508 m³/h) | 153 l/sec (551 m³/h) |
As the area of the watershed is less than one hectare, and the length of drainage networks is less than 200 m, the researchers used V.S. Dikarevsky formula for further calculations. After determining the discharge of surface run-off, it becomes possible to perform the calculation and design of treatment facilities for this wastewater treatment [20].

Under the guidance of the authors, systems for collecting and diverting surface run-off, as well as small-sized LWP for mechanical and physic-chemical cleaning were designed at the stations under consideration. According to the calculated data (and with account of the specifics of each station), the concentrations of treated surface run-off for the following indicators will not exceed the following values: suspended solids – up to 3.0 mg/l, petroleum products – up to 0.05 mg/l.

The advantages of the proposed technological schemes for local wastewater treatment facilities are presented in Table 7 (see Table 7).

Table 7. Railway service enterprises: the comparison of technological schemes of surface wastewater collection, disposal and purification.

| Classification by groups | Object | Technological schemes and structures | Advantages |
|--------------------------|--------|-------------------------------------|------------|
| Bridge crossings, 5661 pcs. | Mono-compact installations (filtration trenches when necessary) – 1-2 pcs. | Standard degree of cleaning, compactness, location at the site of wastewater formation. |
| Small-scale stations, 434 pcs. | Tanks for accumulation and averaging of discharge, mono-compact installations (filtration trenches when necessary) – 2-4 pcs. | Standard degree of cleaning, compactness, location at the site of wastewater formation. |
| Small stations, 173 pcs. | Tanks for accumulation and averaging of discharge, mono-compact installations (filtration trenches when necessary) – 4-8 pcs. | Standard degree of cleaning, compactness, location at the site of wastewater formation. |
| Base 47 | Discharge – 2400 m³/day (100 m³/h), Facilities structure: sand catchers, vertical storage tanks, pressure filter, skimmer, UV-disinfection. | Mechanical + physic-chemical purification; high degree of purification. |
| Middle-scale stations, 84 pcs. | Discharge – 4800 m³/day (200 m³/h), Facilities structure: flow-equalization basin, grates, sand catchers (gravel hoppers), vertical storage tanks, reagent equipment, pump station, 1 and 2-stage filters, filter presses, UV-disinfection, stand-by silt grounds. | Mechanical + physical + chemical purification; high degree of purification. |
| "Abdulin'sky factory "Remputmash" | Discharge – 6000 m³/day (250 m³/h), Facilities structure: averaging and mixing of sewage water; sieves; thin-layer strainer chamber; dispensing of reagent installation, first-stage aeration tank; second-stage aeration tank; third-stage aeration tank, nitrifier aeration tank, secondary clarifier, filter with floating load, filter with granular filter loading, UV irradiation, filter press. | Mechanical + biological + physic-chemical purification; high degree of purification. |
| Large stations, 56 pcs. | Discharge – 12 000 m³/day (500 m³/h), Facilities structure: holding chamber (flow-equalization basin), sand catcher (gravel hoppers), vertical storage tanks, pressure-tight | Mechanical + physic-chemical purification; high degree of purification. Compact |
flotation units, pump station, grainy filters, sludge densifier, vacuum filters, UV-disinfection, standby silt grounds.

Discharge – up to 24 000 m³/day (1000 m³/h).

Due to the long length of the stations (2.5–5 km), their design is only possible on an individual basis.

| Large stations, pcs. | 22 |
|----------------------|----|
|                       | wastewater treatment facilities |

Elevated tracks

| Small stations | Krasnoe ozero station | Discharge – 2.4 m³/day | Mechanical + physicochemical purification; high degree of purification. Compact, small-sized treatment facilities located in receiving sink holes |
|----------------|-----------------------|------------------------|-----------------------------------------------------------------------------------------------------------------|
| Facilities structure: sand catcher, oil separator-strainer chamber, flotation unit-strainer chamber. | filter with granular loading, sorption filter |

| Small stations | Severnaya station | Discharge – 100 m³/day | Mechanical + biological + physicochemical purification; high degree of purification. Compact wastewater treatment facilities System of perforated cross pipes and side drainage trays |
|----------------|-------------------|------------------------|-----------------------------------------------------------------------------------------------------------------|
| Facilities structure: averaging and mixing of sewage water; sieves; thin-layer strainer chamber; dispensing of reagent installation. | first-stage aeration tank; second-stage aeration tank; third stage aeration tank; precipitation-nitrifikator; secondary strainer chamber, filter with floating load, filter with granular filter loading, UV irradiation, filter press. |

| Small stations | Promyshlennaya station | Discharge – 100 m³/day | Mechanical + physicochemical purification; high degree of purification. Compact wastewater treatment facilities System of drain shafts for drainage and accumulation of ground water, followed by pumping in the run-off water system |
|----------------|------------------------|------------------------|-----------------------------------------------------------------------------------------------------------------|
| Facilities structure: averaging and mixing of sewage water; sieves; thin-layer strainer chamber; dispensing of reagent installation. | filter with floating load, filter with granular filter loading, UV irradiation, filter press. |

Thus, the researchers point out the following advantages. Local treatment facilities for mechanical and physical-chemical treatment are small-sized, can be applied with considerable variance in the discharge of surface sewage. They can be installed in residential construction, do not require a lot of sanitary protection zones (as for biological purification). All that simplifies their placement and review. Besides, the required level of purification at the wastewater exit from structures is achieved here.

4. Conclusions
The research yielded the following conclusions:

- When choosing a treatment method and calculating treatment facilities, the qualitative and quantitative composition of surface wastewater and its impurities is essential. For railway transport enterprises, the most effective technological schemes of sewage treatment plants were proposed, including: a storage and regulating tank, a stationary (mobile) device for surface wastewater treatment (with mechanical and physical and chemical treatment).
The survey of railway transport enterprises showed the consistency and correctness of methods for determining the contamination of surface wastewater and the run-off coefficient from railway tracks of various contamination to determine the criteria and boundary conditions of the initial data for the development of technological treatment schemes.

As an example of mobile environmental structures, the researchers developed and manufactured a compact combined unit (100 l/h) for treating wastewater with a high content of suspended solids, petroleum products and iron. Its distinctive features include compactness, placement of the entire composition of physical and mechanical cleaning in one unit, transportability, high purification degree. The results of research prove the effectiveness of wastewater treatment for petroleum products and iron to the MAC standards. Patents for the invention and utility model have also been obtained. Technological schemes for the removal and treatment of surface wastewater from the territory of railway stations and elevated tracks of railway stations have successfully been implemented in design practice.

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