

# Surface wastewater purification from emulsified and dissolved organic pollutants with the city of Samara as an example

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**Abstract.** This paper considers the impact of surface wastewater from residential areas and industrial enterprises, including enterprises of railway transport on ecological environment. It also describes the content of harmful substances of organic and inorganic origin in the surface runoff. The researchers consider practical methods of cleaning wastewater from oil-containing contaminants and put forward technological schemes of surface wastewater purification including its biological treatment.

## 1. Introduction

The devastating impact of human activities on the environment and its dramatic increase is considered as one of the most serious problems of today. The root cause of the problem lies in the fact that the growth of cities, the introduction of new production technologies, the expansion of transport networks negatively affects the composition and properties of production waste. To eliminate harmful consequences of human activities damaging impact there is a need to analyse the impact of production waste on the environment, to modernize industry and production and, at the same time, to develop measures and find technical solutions for industrial waste neutralization.

## 2. Problem specification

Surface wastewater is currently one of the main sources of pollution. Melt-water and rainwater washing residential areas, sites of industrial enterprises and other urban infrastructure, and wastewater formed as a result of filtering precipitation through the layer of railway soil, in particular, contain organic (easily oxidized solids and dissolved solids resistant to oxidation) and inorganic (suspended solids) pollutants as well as pathogenic microorganisms. In order to study the question of wastewater purification from emulsified and dissolved organic pollutants the researchers decided on a runoff discharged to Depovskiy ravine. The runoff under investigation is formed both in the residential area and on the sites of railway infrastructure and contains hard-oxidized and easily oxidized organic compounds [7].

## 3. Data Analysis



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Data derived from the paper [1] is summarized in Table 1 below and shows the content of contaminants in the surface wastewater discharged into Depovskiy ravine (located in Samara).

**Table 1.** Content of pollutants in surface wastewater discharged into Depovskiy ravine (Samara)

Pollutant	Unit of Measurement	Average value	Maximum value	MAC
pH	Units	7.9	8.3	6.5-8.5
BOD <sub>total</sub>	mgO <sub>2</sub> /dm <sup>3</sup>	4.94	25.7	3.0
Ammonium ion	mg/dm <sup>3</sup>	0.8	5.6	0.5
Nitrite ion	mg/dm <sup>3</sup>	0.176	1.67	0.08
Nitrate ion	mg/dm <sup>3</sup>	3.4	24.1	40.0
Phosphate (R)	mg/dm <sup>3</sup>	0.154	1.31	0.2
Iron Total	mg/dm <sup>3</sup>	0.59	3.8	0.1
Copper	mg/dm <sup>3</sup>	0.006	0.02	0.001
Zinc	mg/dm <sup>3</sup>	0.01	0.018	0.01
Aluminium	mg/dm <sup>3</sup>	0.017	0.1	0.04
Dissolved and emulsified oil and oil products	mg/dm <sup>3</sup>	0.155	4.1	0.05
ASSAS /anion synthetic surface active substance/ (sodium alkyl sulfate & a mixture of primary sodium alkyl sulfates)	mg/dm <sup>3</sup>	0.074	0.6	0.1
Suspended substances	mg/dm <sup>3</sup>	22.96	109.0	Background noise +0.25
Dry residue	mg/dm <sup>3</sup>	558.0	1236.0	1000.0
Chloride ion	mg/dm <sup>3</sup>	81.0	382.0	300.0
Sulfate ion	mg/dm <sup>3</sup>	125.0	304.0	100

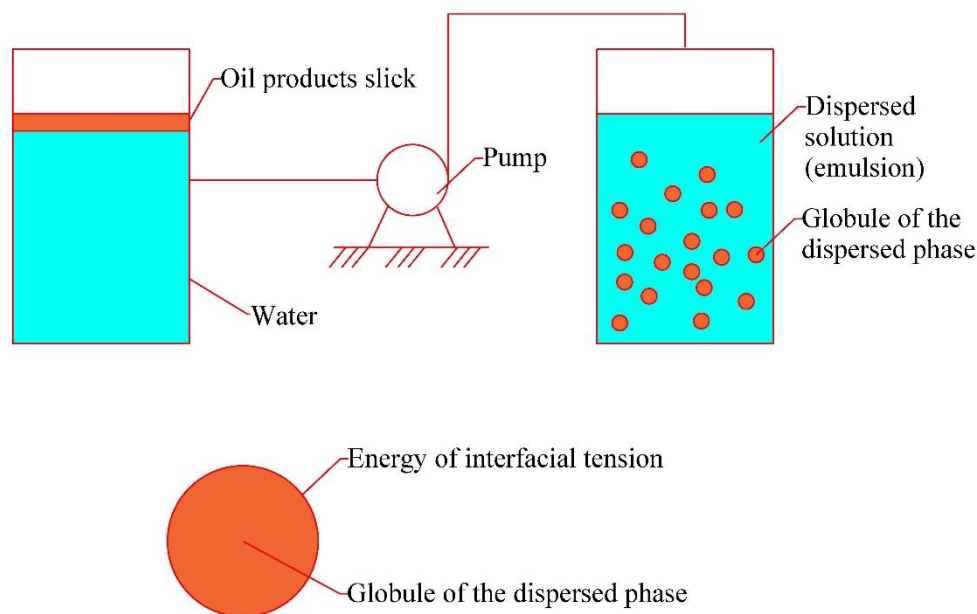
Table 1 demonstrates that the pollution exceeds the maximum acceptable concentration. This exceedance of MAC (with account of BOD<sub>full</sub>) concentrations may result either from the possible unauthorized discharge of domestic sewage into storm-water drainage or from other unknown factors. Such wastewater must be purified before being discharge into water bodies

#### 4. Discussion

When surface sewage flows from its source to sewage treatment plants and while pumping sewage is pumped from storage tanks to treatment facilities, this sewage wastewater is constantly mixing with pollutants from the drain itself [2].

Thus, wastewater from residential areas and railway bed surfaces is a dispersed solution of hard-oxidized and easily oxidized organic matter. The energy released by the mixing or pumping of wastewater, is used for dispersion of organic substances contained in the aquatic environment. The more energy is expended, the smaller globules of petroleum products and oils fill the aquatic environment, whereby the resistance to separation of the formed emulsion increases, and the energy expended is converted into the energy of interfacial tension. The interfacial tension energy, or free energy, is concentrated at the phase interface and contributes to the fusion (coalescence) of globules and the destruction of unstable emulsions. This process is known as "spontaneous stratification of the system". As a rule, water-oil emulsions are unstable systems and they seek separation. However, the required time for complete separation of oil-water emulsions can come to several years, which is much longer than the liquid duration time in strainer chambers, which, according to Paper [4], does not exceed two hours. Thus, surface wastewater purification in strainer

chambers and oil traps cannot provide a reduction in the concentration of dispersed oils and petroleum products required by MAC standards. For this reason, it becomes necessary to use special facilities and purification methods for oily wastewater neutralization at treatment plants.



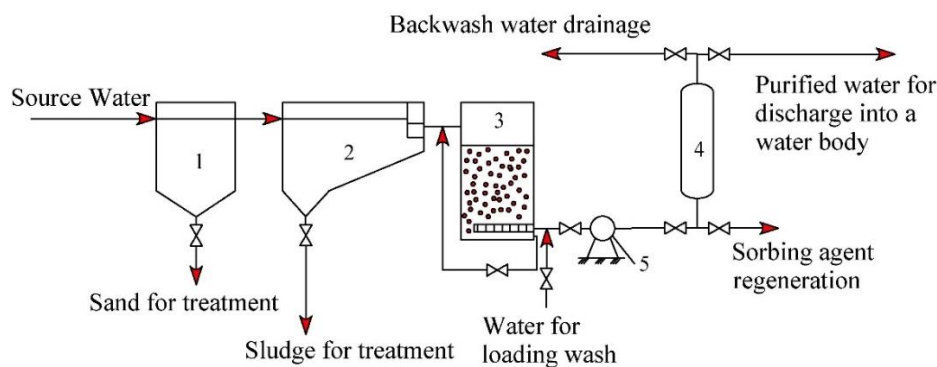
**Figure 1.** Process of dispersed solution formation.

At present, purification methods used to extract oil-containing contaminants from industrial and surface wastewater are as follows:

- 1) Mechanical methods, based on the coalescence of globules of the dispersed phase, followed by their removal from the surface of the treated water. This method consists in using strainer chambers, oil traps with coalescent modules and skimmers at waste-disposal plants.
- 2) Physicochemical methods, based on wastewater treatment with reagent solutions, electrocoagulation, extraction of the dispersed phase from the water by air bubbles (flotation), sorption purification, ozonation.

In practice, the combinations of these methods are used for surface wastewater treatment.

Figure 2 shows the technological scheme developed according to Recommendations [3] used for the removal of hard-oxidized organic matter and suspended particles from wastewater.



1 - Sand catcher; 2 - Strainer chamber; 3 - Filter with granular loading;  
4 - Filter with granular loading; 5 - Pump

**Figure 2.** Technological scheme of surface wastewater treatment.

This scheme is used for purifying surface wastewater from industrial sites, as well as from residential areas. The process takes place as follows: wastewater enters the mechanical cleaning in Sand Trap 1; then then it flows into Strainer Chamber 2 where coarse insoluble impurities are extracted from the liquid. The next stage is wastewater post-treatment in granular filters. At this stage, suspended solids from the strainer chambers are removed and the wastewater is passed through filters with sorption loading from the dispersed phase of organic substances.

This scheme can be improved by including a reagent treatment unit, thereby ensuring more efficient treatment of wastewater from emulsified contaminants, suspended solids, and heavy metal salts. However, there is also easily oxidizable organic substances in the runoff under investigation. This method allows extracting such substances only in part. Thus, if this scheme is carried out to purify the runoff in question, both structures and loading filters might silt up. As a result, the filtration cycle will be rapidly reduced, and the loading will become unusable, which will lead to a decrease in the purification efficiency. For a complex solution of the problem of surface wastewater purification from organic substances, it is important to adopt a technological scheme, providing biological wastewater treatment [6].

The biological method of purification involves biochemical oxidation by microorganisms of organic substances contained in wastewater. The process of oxidation here is carried out through microorganisms' life-sustaining activities in aerobic or anaerobic conditions. Organic matter is thus converted into simpler compounds. A part of these compounds is further oxidized to carbon dioxide and water, other compounds are used for biomass growth. There are several types of facilities appropriate for the process of biological purification. They are an aerotank, a biofilter, a septic tank, a two-tier sump. An aeration tank is a structure in which wastewater biological treatment with activated sludge takes place in two stages. During the nitrification stage, organic substances (with microorganisms and air oxygen present) are oxidized to simpler compounds, as well as to ammonium nitrogen, nitrites and nitrates. From the nitrification chamber, water containing nitrites and nitrates goes to the denitrification chamber via a recirculation pipeline. Return sludge from secondary clarifiers and source wastewater containing organic contaminants are also sent to the denitrification chamber. In the chamber, nitrites and nitrates are oxidized to nitrogen gas and oxygen.

Wastewater purification by this method is effective because of the following factors:

- 1) Oxygen concentration in the aquatic environment;
- 2) Ph-factor;
- 3) Temperature;
- 4) Silt concentration;
- 5) The ratio of organic matter and total nitrogen concentrations.

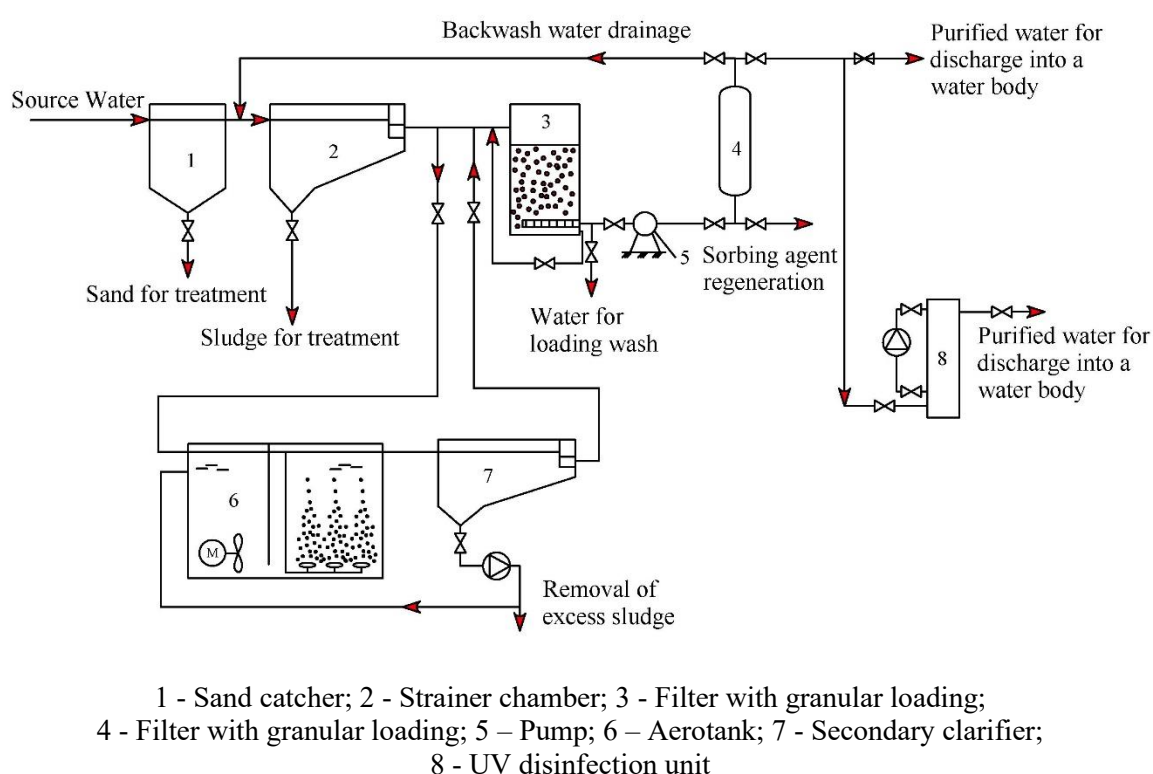
This all is due to the fact that it is vital to secure favorable environment for microorganisms contained in biomass and their life-sustaining activities when using this method for water purification. Therefore, the process of biological purification requires regular monitoring of the treated water parameters, as well as monitoring service equipment operations.

The result of high-quality biological wastewater purification is the reduction of such pollutants concentration in wastewater as phosphorus, petroleum products, phenols, anion synthetic surface active substances, BOD as well as all nitrogen compounds.

Let us further consider the technological scheme of surface wastewater purification in combination with biological treatment facilities.

This scheme is designed to ensure the possibility of switching off the aeration tanks in case when the content of organic substances in the source wastewater is within MAC limits. In this case, wastewater is treated while flowing through Line 1. Its principle of operation was described earlier. If the concentration of MAC norms is exceeded, water treatment is carried out on Line 2. After mechanical treatment, wastewater is supplied to the aeration tank for purification. Aerators are

installed in the nitrification chamber (the process proceeds in aerobic mode). Flow makers are also installed in the nitrification chamber to ensure a uniform concentration of pollutants and activated sludge throughout the whole chamber. From the aeration tank, the wastewater enters the secondary clarifier, where the active sludge is deposited. Then, it is sent to the post-treatment in granular filters and in filters with sorption loading. The final stage of purification on Line 2 is UV disinfection. Then the purified water is discharged into water bodies. This scheme can be provided for both the phased construction of local treatment facilities and for the reconstruction of existing complexes.



**Figure 3.** Technological scheme of surface wastewater purification in combination with biological treatment facilities.

## 5. Conclusions

Currently, in the city of Samara there are about 12 surface wastewater outlets discharging wastewater into water bodies without treatment. Pollutants are regularly discharged into the Volga river, the Samara river and other water bodies of the city and can cause diseases even resulting in various epidemics. In this regard, the problem of surface wastewater purification requires special attention as well as effective measures designed to develop an integrated approach to its decontamination.

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