BLOCK-MODULAR WASTEWATERS TREATMENT PLANT

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ABSTRACT

Development of block-modular wastewaters treatment and sanitation plant from the perspective of the needs of the structures of JSC «Russian Railways» has become important in view of attention to the problems of rational use of natural resources. Such a plant comprises a system of automatic operational control of the quality of water in different areas of technological process, improves the efficiency of wastewaters purification from oil products. In addition, it provides an opportunity to reuse the spillway, thereby reducing the need of railway enterprises for natural water, as well as providing a return to natural reservoirs without environmental laws violation. A universal technology of water purification, which contains any quantities of oil products and other related contaminants, is offered.

ENGLISH SU MMARY

Background. *At railway transport enterprises water participates in almost all production processes. A large proportion of water is consumed irrevocably (refueling of passenger cars, steam generating, ice-making). The greater part of it is discharged into surface water bodies-sea, rivers, lakes and streams. Despite the fact that environmental conservation is one of the main activities of JSC «Russian Railways», the volume of untreated and inadequately treated industrial wastewaters is steadily increasing.*

Currently, wastewaters of railways enterprises with high concentration of organic compounds either do not have wastewaters treatment plants, or are cleared insufficiently. They are characterized by high chemical oxygen demand (COD), biological oxygen demand (BOD) and contain oil products, oils, suspended substances.

Objective. *The most important aspect of rationalizing the use of water resources at the holding enterprises remains reduction of water consumption, moving to closed (undrained) water use cycles, where treated wastewaters are not discharged, but repeatedly rotated in technological processes. Closed industrial water supply cycles enable completely eliminate wastewaters discharges into surface water bodies and replace with fresh water only irretrievable losses.*

As long as the amount of recycling and reuse of water is only about 30%, becomes apparent the relevance of creation of technology and devices that could improve the effectiveness of wastewaters purification from oil products, reduce the need of railway enterprises for natural water and provide wastewaters discharge into natural reservoirs under environmental standards.

Methods. *The authors use technical and economic methods of evaluation, engineering instruments.*

Results. *First, information about oil products should be given. Oil products belong to the most common and dangerous pollutants of water.*

In natural environment, oil products exist in various migration forms: dissolved, emulsified, adsorbed on the solid particles of suspensions and bottom deposits in the form of a membrane on the water surface. Typically, at the moment of inflow oil products volume is concentrated in the membrane. As the distance from the pollution source grows, redistribution between the main forms of migration and increase in the portion of their dissolved, emulsified, adsorbed types occur.

Background levels of oil products in river, lake, sea, groundwater and atmospheric precipitations vary quite widely and often are hundredths and tenths of mg/dm^3.

Oil products affect humans, wildlife, aquatic vegetation, physical, chemical and biological condition of the water body negatively. Low molecular aliphatic, naphthenic and aromatic hydrocarbons, contained in pollution, have toxic and somewhat narcotic impact on the body, affecting the cardiovascular and nervous systems. Polycyclic condensed hydrocarbons of 3, 4- benzpyrene type have carcinogenic characteristics and pose the greatest danger.

Maximum allowable concentration (MAC) of oil products in water under sanitary regulation and standard 2.1.4.1074–01 «Drinking Water. Hygienic requirements for water quality of centralized drinking water supply. Quality Control» is 0.1 mg/dm^3. MAC$_v$ is 0.3 mg/dm^3 (limiting health hazard indicator – organoleptic by discharge into sewer networks), MAC$_{vr}$ is 0.05 mg/dm^3 (limiting health hazard indicator – fishery). The presence of carcinogenic hydrocarbons in water is unacceptable.

Wastewaters, generated at JSC «Russian Railways», are contaminated with oil products. In accordance with relevant regulations, they are subject to quite a deep cleaning. Its technology is determined by phase-dispersed state of the formed system «oil products- water». Oil products in water tend to lower density relative to the density of water and an extremely low solubility. The main methods of water purification from oil products are mechanical and physical- chemical.

For the preparation of recycled water from wastewaters, technical and economic evaluation of the applied methods is of great importance. Primarily closed water use systems have an economic advantage.

Wastewaters generated at railway enterprises contain contaminating components in various phase-dispersed states, so to achieve the desired effect of wastewater treatment, it is necessary to implement integrated systems incorporating various methods of differentiation and destruction.

On the basis of experimental studies, taking into account technical and economic indicators, an optimal method is selected. The choice depends on many factors:

– Number of different types of wastewaters, their consumption, opportunities and economic feasibility of extraction of detected harmful impurities;

– Requirements for the quality of purified water while using it for water reuse and recycling and discharge into the reservoir, reservoir capacity, the availability of regional or municipal wastewater treatment plants.

The next topic of the article is the search for optimal technological methods of water purification, which is quite complicated.

The determinal factor in creation of a treatment plant is its performance and composition of the wastewater treatment system. Design of the system should be carried out consistent with the use of the best available technologies, advanced technical solutions, process automation.

Selection of units for water purification device depends on the type of pollutants that can be divided into seven groups:

– General physic-chemical characteristics of water quality;
– Organoleptic characteristics;
– Bacteriological and parasitological indicators;
– Radiological characteristics;
– Inorganic impurities in the water;
– Organic impurities;
– Disinfectants and disinfection products.

Set of units determines the choice of treatment technology, and thus the construction of the water treatment device structure as a whole.

If all pollutants are present in the water (which is quite hypothetical), the most appropriate is the following sequence of unit allocation in the technological scheme of a plant:

– Filtration (coagulation) unit;
– Ion exchange (deferrization, lightening) unit;
– Reverse osmosis (nanofiltration) unit;
– Flotation unit;
– Sorption unit;
– Broadband UV irradiation unit.

The number of units included in the water purification device depends on the list of removable pollutants and the desired purification degree.

Despite all the benefits of such a process scheme, which allows solving the most complex problems of water treatment, it is the most energy-intensive and requires certain water conditioning to increase the resource of reverse osmosis membranes. Application of this technology is suitable only in the case when other methods are not able to help execution of the task.

Process scheme, which uses all six units at the same time, is not possible, since some of them solve the problems of the same type- removal of contaminants from the water. In this situation, a unit should be selected, the operation of which is most favorable in the light of the principle «efficiency – quality».

The main methods of water purification from oil products at the JSC «Russian Railways»enterprises are coagulation, flotation, air flotation, sorption, biological method.

All these methods are suitable for the creation of water purification device, although with the biological one the technological process takes too long.

Taking this into account, to guarantee water purification from oil products, it is necessary to use modular principle for design of the system, including modules (units) of mechanical purification, flotation, sorption purification, purification with UV irradiation.

If small amounts of oil products (up to 30 mg/l) should be removed, the water treatment device consists of flotation, sorption and UV irradiation units. To remove a large amount of oil products and suspended substances, it is advisable to take coagulation, flotation, sorption and UV irradiation units.

Water purification device working on this process scheme can provide indicators corresponding to water suitable for discharge into natural reservoirs.

The prototype of such plants is «Moidodyr-A (H) -F», designed to purify the wastewaters with a high content of oil products and suspended substances at JSC «Russian Railways».

Then the authors give particular technical and practical characteristics of this plant (hereinafter-plant) «Moidodyr-A (H) -F» [6].

This plant carries out purification of industrial and surface wastewaters in the areas of locomotive depot, industrial plants and other facilities with a catchment area of up to 25 hectares.

Water is purified mainly from suspended substances and oil in emulsified and dissolved states. The plant is located in a separate building, which must have heating and ventilation (mechanical or natural).

There are three successive stages of water purification:

• The first stage (flotator) contains a thin layer shelf sump and flotator located in the same unit.

• The second stage (post-treatment) has four filters with synthetic material «Uremiks-913» installed in parallel.

• The third stage (sorption purification) includes two adsorption filters filled with activated carbon AG-3 brand.

The second and third stages are packed in two parallel lines with the system of water intake from the intermediate tank, located in the room.

The integrated discharge enters the plant from the storage tank, located outside, by a delivery pump (See Pic. 1). Source water is pumped into the receiving compartment of flotator 1.

At the time of supply of water to the flotator 1, water receives coagulating – dosed disinfectant solution, in the thin-layer shelf sump suspended substances and part of oil products are removed due to the processes of coagulation and sedimentation, as well as water disinfection. Undissolved oil products float up and get into the oil trap.

Then flocculent solution (Praestol A 2500) is dosed into the water. Then the water flows into the flotator chamber, where due to air flotation dissolved oil products and the rest of the suspended substances are removed.

From the flotator 1 the cleaned discharge flows in an intermediate tank 2, and then with pumps 3, 4 brand MSm 10/50 it enters post-treatment unit comprising a group of filters with synthetic material 5 and adsorption filters 6.

Cleaned water can be discharged into the storage tank for reuse, and its surplus is discharged into the municipal storm sewer or onto land.

Flotator includes: a thin layer shelf sump 7, flotation compartment 8, oil-removal system, system of coagulant and flocculent dosing, foaming and defoaming systems.

The oil- removal system consists of oil trap 9, initial oil storage tank 10 with siphon 11 and tap 12 for discharge of oil products, foaming system – circulation pump 13, an air intake device 14, carbonator 15, defoaming system – conveyor foam catcher comprising a motor-reducer 16 and a comb to catch foam 17, compartment for foam catching 18.

Coagulant dosing system includes coagulant solution tank 19, a dosing pump 20 with level sensor 21 and the intake device 22, the agitator 23; flocculent dosing system – flocculent solution tank 24, a metering pump 25 with a level sensor 26 and the intake device 27, a two-speed agitator 28.

In the post- treatment unit, filters with synthetic material are equipped with automatic air vents 29, intended to remove air from filters. Sorption filters are additionally equipped with gauges 30, taps for air drain 31 and valves 32 which may be used in hydraulic unloading of sorption load. There are taps 33 for sampling of purified water. Discharge of water from sorption filters is made when needed through the taps 34.

The building, where the plant is located, must be equipped with the system of work and maintenance lighting in accordance with construction norms and rules 23–05–95. To power its pumps a three-phase mains with voltage of 380V, designed for power 7.4 kW is used. Launcher and protective equipment is mounted in the control unit 52. For electric scheme of the plant see Pic. 2.

One of the significant drawbacks of the plant is the lack of control of water quality in real time. In this regard, in 2011–2012 block-modular wastewaters treatment and sanitation plant was developed with an automatic

operational control of water quality according to set parameters at different points in the process of water purification [9].

Technology implemented in the system (see Pic. 3) includes coagulation with dosing system, air flotation with foaming and defoaming systems. Water after cleaning does not meet the indicators of drinking quality. Therefore, in this case it is necessary to make amendments to conform to the selected water treatment model.

Indicative list of structural and technological changes, which should be made to receive a new plant with optimal configuration, which allows obtaining water suitable for use in technical water supply and discharge to natural reservoirs for any water pollution by oil products, is as follows.

1. Coagulation unit – its design fully fits for its purpose and will make it possible to remove from the water undissolved oil products and suspended substances.

2. Flotation unit ensures removal from water the remainder of undissolved, and the bulk of the dissolved oil products.

3. Sorption unit is an addition to the construction, which provides the flow of water in a downward direction at a linear velocity of 5 m / h. As absorbing load can be used activated carbon AG-3 with fractional composition of 1–2 mm. As the substrate, quartz sand or crushed anthracite with a grain size of 3–5 mm should be used.

4. UV irradiation unit should be added to the plant, equipping it with high-intensity pulsed irradiation lamp INP-7/80 or INP-16/250 depending on plant productivity.

5. Coagulant dosing system allows dosing the coagulating solution with the desired performance. The composition of 100 l coagulating solution should include:

Aqua aurate-30–4 kg;

Na_2CO_3-2 kg.

To prevent odor in coagulation and flotation units especially during the warm season, 1 liter of disinfectant «Dezofran» should be added to the coagulating solution, which does not affect the coagulation process.

6. Foam system allows performing air flotation process at a pressure of 2 to 4 atm.

7. Defoaming system provides defoaming in the flotation unit.

8. System of foam suppression should be excluded, since presence of surfactants in high concentrations is not expected in the source water.

9. Control unit should provide full autonomy of the plant, including water quality control after each unit.

10. Sensors of the quality control system should be placed on the input and output lines and the output of each plant unit.

11. Piping of the plant should ensure the flow of water according to the technological scheme, the ability to block the water flow from one unit to another on the signal from the control unit when water quality at the outlet of the unit is poor and the direction of the water for re-cleaning in the unit.

Model general view of the modernized plant is shown in Pic. 4.

Conclusions. *By analyzing and evaluating the possible content of oil products and the water in oil and other accompanying contaminants in the water, universal treatment technology of any of its volumes is proposed.*

The proposed guidelines can be used in conducting R & D on a sample of a block-modular water treatment plant for cleaning and disinfection of wastewater at JSC «Russian Railways» enterprises.

Keywords: railway, environmental engineering, wastewaters purification from oil products, block-modular plant, electric system, system of automatic operational control of water quality, universal technology.

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