THE RESULTS OF SURFACE WASTEWATER TREATMENT OF A MACHINE-BUILDING ENTERPRISE FROM PETROLEUM PRODUCT CONTAMINATION

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Abstract – Petroleum pollution is an urgent and serious problem that has a negative impact on environmental safety and the state of the environment. Petroleum products that enter water resources cause a number of negative consequences, including water and soil pollution, reduced quality of natural ecosystems, as well as threats to biodiversity and human health. The purpose of this study is to assess the effectiveness of methods for treating surface wastewater of a machine-building enterprise from poll
ution by petroleum products. In the course of the work, the results of cleaning the surface wastewater of the machine-building enterprise from pollution by petroleum products, samples of which were taken from the rainwater intake well at different depths – 30, 60 and 80 cm. A purification scheme has been developed and optimized, which includes the introduction of $Al_2(SO_4)_3$ coagulant and A-19 flocculant into wastewater. Purification efficiency is achieved at about 95% at optimal reagent doses of 60-80 mg/L coagulant and 2-2.5 mg/L flocculant. The advantage of the conducted studies is the possibility of using the obtained data and methods for the analysis of wastewater with a similar composition of contaminants. It has been experimentally established that the simultaneous administration of reagents or the use of only one of them has lower efficiency and leads to insufficient purification of water from petroleum products. Neutralization of ion resistance contributes to the formation of coagulation structures, and to increase them it is recommended to use a flocculant to form and increase the size of aggregates. The results of the studies confirmed the prospect of using flotation to further separate the emerging petroleum flocculi, which allows to reduce the amount of reagents used and improve the efficiency of water treatment. The obtained data are important for practical application in the field of wastewater treatment from petroleum products at machine-building enterprises, contributing to the improvement of the quality of water resources and compliance with environmental safety requirements.

Keywords: Petroleum products, Flocculant, Coagulant, Wastewater, Water treatment, Environmental safety, Environment.

1. Introduction

The problem of assessing the pollution of storm and melt water flowing from the paved surfaces of industrial enterprises and the roadbed, as well as methods of cleaning such water, has not been sufficiently studied to date. Currently, at most enterprises, surface wastewater enters water bodies almost without treatment and causes significant damage to aquatic ecosystems [1]. Even in developed European countries, the issue of the need to clean surface runoff from highways has been put on the agenda only in recent years. At the same time, it is known that during the operation of highways, storm drains directly exert tangible anthropogenic pressure on the environment. Particularly critical is the pollution of storm and melt wastewater with petroleum products, suspended substances and heavy metals, reaching levels that are dangerous to ecosystems.

The issue of cleaning stormwater runoff from roads, bridges and overpasses in the water protection zone at the intersection of rivers and near reservoirs is particularly acute.

The roadside strip is characterized not only by pollution of surface waters, but also of soils, groundwater, and roadside vegetation.

The number of impurities in wastewater that arise because of washing road surfaces depends mainly on the intensity of vehicle traffic, the level of improvement of adjacent streets, as well as on the organization and technology of cleaning this surface.

Surface runoff, which is formed because of precipitation, snow melting, watering of roadways, washes away and carries various soluble and insoluble contaminants to roadside areas. During precipitation, rainwater is saturated with dust and atmospheric gases, and cleans the surface of the earth from dust, grease, debris and other contaminants. In the case of rainwater runoff from the territory of industrial enterprises, they may contain specific impurities specific to a particular type of production. The peculiarity of atmospheric wastewater is the episodicity and unevenness.

Atmospheric pollutants enter the storm runoff as a result of two processes: dry deposition under the action of gravity, wind and turbulence in the absence of precipitation, as well as dissolution of gases and deposition of particles by water droplets (wet deposition). The main pollutants carried by effluents from streets and roads are suspended solids (CS), surfactants (SAS) and heavy metals such as Pb, Zn, Cd and Cu [2]. The concentration of these contaminants depends on the frequency of street cleaning, the intensity of traffic, the degree of landscaping, the intensity of precipitation, the duration of the previous period without precipitation, the presence of industrial enterprises near them, their profile, etc. Therefore, it is important to control heavy metal pollution of urban water sources [3], for which it is important to know the ways of transporting heavy metals from the source of origin to impermeable surfaces [4].

Solving the problem of stormwater pollution from roads and industrial enterprises requires an integrated approach covering scientific research, the

2. Analysis of the Scientific Literature on the Formation of Petroleum-Containing Surface Runoff

Surface, or rain, wastewater is formed during rain and snow melting on the surface of the enterprise, much of which has an artificial coating (concrete, asphalt). Surface wastewater from the territory of industrial zones, construction sites, automobile enterprises, etc. should be treated at local treatment facilities before being discharged into the rainwater drainage of a settlement or a centralized general-alloy sewerage system [5]. Recently, most of the literature pays attention to the characteristics of runoff from highways [6, 7]. The correct characteristic depends on the sampling strategy chosen and the analytical methods used. Since runoff from roads is associated with precipitation, it is recommended to carry out sampling during such weather events [8].

Over the past 20 years, various experimental water collectors have been equipped to assess the qualitative characteristics of urban runoff; in these studies, attention was paid to monitoring runoff from the road surface and combined sewage runoff [9]. According to the results of the measurements, there was an excess of the average annual concentrations (according to the MPC for fishery reservoirs) of petroleum products, sulfates and metals (aluminum, total iron, cobalt, manganese, copper, chromium, zinc).

The surface runoff composition is marked by a large amount of petroleum products. The concentration of the main impurities in the rainwater runoff is higher, the smaller the precipitation layer and the longer the period of dry weather, and changes in the process of rainwater runoff. Thus, in the first minutes of runoff, the concentration of suspended solids is 10 times, and in case of heavy rains – 20 times higher than the MPC than at the end of the rain. The presence of petroleum products, engine oil and heavy metals in the wastewater does not allow the discharge of contaminated runoff into the sewerage system in accordance with applicable regulations. All of the above indicates the need for the use of local treatment facilities at enterprises.

Studies have shown that particle size plays an important role in the accumulation and movement of pollutants [10]. In addition, contaminants tend to accumulate in small particles that can be easily carried by rain [11].

The wastewater of industrial sites and industrial sites of industrial enterprises contains: benzene, acetone, petroleum products, acids and alkalis, dissolved compounds of various metals – aluminum, copper, iron, chromium, etc. In wastewater, petroleum products may be in a free, bound, and dissolved state. The composition of wastewater that is discharged is closely related to the types of production activities, raw materials and various additional products involved in the technological process, and also depends on the course of these processes, the type and perfection of production equipment. Surface wastewater from industrial sites should be treated. The development of measures for surface wastewater treatment at enterprises should be based on these analyses with the definition of the name of pollutants and their concentration [5].

The main amount of pollutants enters the atmospheric precipitation when they drain from the surface of the urban area. Pollutants are washed off into storm wastewater from the surface of roads and roofs and are products of corrosion of roofing materials, exhausts of cars with different types of engines, the result of irrational use of household chemicals, pesticides, fertilizers, etc., as well as elements of the sand and salt mixture used in winter to prevent glaciation of roads. Typical pollutants in the surface runoff are suspended and soluble organic and inorganic substances, such as petroleum products, ammonium nitrogen, phosphates, total iron, synthetic surfactants, heavy metals (zinc, lead, copper, cadmium, chromium, nickel). Oil is recognized as the most important hydrocarbon product (HPP) in the developed countries of the world [12]. Emulsions tend to be very strong and difficult to break down because of their stability. Oil has limited biodegradability in the natural ecosystem, and the oily structure may interfere with the functioning of the environment for an extended period. As a result, the removal of oil from wastewater before disposal is crucial [13].

The variety of factors affecting the content of pollutants in the surface runoff, their direct quantitative ratios at each catchment complicate the establishment of the chemical composition of this category of wastewater and the development of measures for their disposal. According to foreign studies, the accumulation of pollution on the surface of roads on average for cities is 395 kg per 1 km of road, and in industrial areas, the accumulation is twice as high as the average for the city.

The degree of surface runoff pollution depends on both the contamination of the territory and the layer and intensity of rainfall, the snowmelt process, and the rate of water consumption when washing coatings. When assessing the quality of rainwater, it is necessary to have a summary of the content of impurities in them throughout the duration of the flow of rainwater. The quality of surface runoff is due to a variety of simultaneously acting factors, the main of which are atmospheric pollution, contamination of the territory, the regime and volume of precipitation, the duration of the period without precipitation. In turn, the contamination of the territory depends on the availability, number and sectoral affiliation of industrial enterprises, the intensity of pedestrian and automobile traffic, the state of roads, population density, the type of development and its functional significance, the sanitary condition of the territory where the runoff is formed, etc. A significant feature of atmospheric runoff is the uneven distribution of pollutant concentrations in the runoff during the rain. With a significant range of fluctuations in pollution concentrations, there is a certain pattern in the change in runoff quality over time depending on the intensity of precipitation. The concentration of impurities in the rainwater runoff increases rapidly to a maximum and then decreases until the end of the rain.

Another factor affecting the nature of stormwater runoff is the quality of the coatings used in the runoff formation area. The increase in the number of impermeable surfaces and areas with compacted soil, which are often part of the development and landscaping, increase the volume of surface runoff and reduce the amount of water penetrating into groundwater. Such changes can lead to an increase not only in the volume, but also in the speed of storm runoff, the frequency of flooding, as well as lead to a change in the type, concentration and number of pollutants in the runoff. Moreover, studies of storm runoff show a direct relationship between the percentage of impermeable surfaces in the catchment area and the level of negative impact of storm runoff on water quality, the ecosystem and its inhabitants. Thus, controlling stormwater runoff is very important because stormwater runoff directly affects catchment functions and water quality. The treatment of surface runoff from urban areas is an important issue when planning water protection measures.

The degree and nature of surface runoff pollution from residential areas and sites of enterprises are different and depend on the sanitary condition of the catchment basin and the surface atmosphere, the level of landscaping, as well as the hydrometeorological parameters of incidental precipitation: the intensity and duration of rains, the previous period of dry weather, the intensity of the spring snowmelt process.

The amount of pollutants carried from industrial and urban areas by surface runoff is determined by the population density, the level of landscaping, the type of surface cover, the intensity of traffic, the frequency of street cleaning, as well as the presence of industrial enterprises and the amount of emissions into the atmosphere.

The main sources of surface runoff pollution formed in urban areas and industrial sites are soil erosion products, dust, building materials at the time of their transportation, raw materials, products and semi-finished products stored in open storage areas, atmospheric air emissions, petroleum products.

Due tothe rapid development of industry and urbanization over the past few decades, a significant amount of petroleum products has been released from numerous sources [14]. As a result, surface and groundwater resources are seriously contaminated. The flow of petroleum products to the surface of roads is associated with the flow of fuel, engine, transmission oil, lubricants from various vehicle systems. Petroleum products can also get in the storm sewer system because of flushing from the territory of the enterprise of spills of petroleum products, lubricants, in case of accidents and extinguishing fires of fuels and lubricants.

Petroleum products in the surface runoff are bactericidal and disrupt the operation of city-wide biological treatment facilities. In addition, in the sewer network, petroleum products can accumulate in wells and create an explosive concentration.

Discharge of these effluents into water bodies has an adverse effect on water quality. Discharge of wastewater is allowed only in cases where it will not lead to an increase in the concentration of pollutants in the water body in excess of the established standards. Precipitation of suspended particles contained in melt and rain runoff leads to siltation of the reservoir, disruption of the ecological balance in the water system, and the oil film formed on the surface of the reservoir disrupts gas exchange with the atmosphere, changes the content of oxygen dissolved in water, as a result of which the vital activity of the inhabitants of the reservoir is suppressed, until their death. Hygienic standards of surface water quality are regulated by documents and include general requirements for the composition and properties of surface water for various types of water use (a list of maximum permissible concentrations of harmful substances in water bodies of domestic and domestic water use and for fishing purposes). Thus, when the concentration of petroleum products in the reservoir is 0.05-0.1 mg/dm^3, fish caviar and young fish die, when the concentration is 0.1-1 mg/dm^3 – plankton (simple organisms that live in the reservoir and are food for fish), and the concentration of 10–15 mg/dm^3 is fatal for adult fish. In addition to the direct toxic effect, petroleum products that have fallen into the reservoir, at a concentration of 0.05-0.5 mg/dm^3 add an unpleasant "kerosene" odor to water and fish. Just 1 gram of any petroleum product renders 2,000 liters (dm^3) of water unfit for consumption.

Thus, the above indicates the need to clean storm and surface wastewater from petroleum products and suspended particles. One of the promising methods of treating such wastewater at the enterprise can be physical and chemical treatment using coagulants and flocculants with subsequent settling or flotation. Violations of the aggregative stability of finely dispersed suspensions using flocculation-coagulation methods are widely used to purify finely dispersed and polydispersed suspensions [15, 16]. However, there are no clear recommendations and dependencies that can be used to clean polluted water. That is why, to solve this scientific problem, it is necessary to conduct experimental studies to determine the optimal consumption of reagents with real liquids and wastewater.

3. Goal and Objectives of the Research

The purpose of this study is to determine the effectiveness of the use of physical and mechanical reagent methods for cleaning surface wastewater from petroleum products. This is necessary to obtain the dependencies of the consumption of reagents in the development of a scientifically sound method of wastewater treatment from petroleum products.

To achieve this goal, it was necessary to solve the following tasks:

– explore the possibility of purifying water from petroleum products using flocculants and coagulants;

– determine the dependence of the efficiency of cleaning from petroleum products;

– to propose promising areas of surface wastewater treatment from petroleum products.

4. Research Materials and Methods

Wastewater of surface runoff contaminated with petroleum products are formed as a result of washing of petroleum products from the surface of the asphalt area of an industrial enterprise that contains oil and fuel spills. To analyze the pollution, wastewater was taken from a rainwater intake well at one of the machine-building enterprises (Fig. 1) from different depths: 30, 60 and 80 cm from the bottom.

a b c

Figure 1: Sampling of oil products from the sewage well

The results of the wastewater analysis showed slight fluctuations in the concentration of petroleum products by height, which amounted to, mg/l: 163, 176 and 187. For experimental experiments, storm water with a concentration of petroleum products of 187 mg/l was used. Under laboratory conditions, coagulants and solutions of flocculants were added to volumetric flasks and cylinders with wastewater, mixed, settled and the concentration of petroleum products was determined by the gravimetric method according to the standard method MMB081/12-57-00. Each reagent injection run was repeated three times.

Flocculants and coagulants were prepared and applied according to the procedure described in [17]. For micrographs of the process of formation of aggregates after the introduction of reagents, a digital USB microscope with a magnification of up to 1600 times Digital Microscope (China) is used.

The results were processed using the StatSoftStatistica v6.0 package (USA). A complete second-order factor experiment was used and optimal conditions for wastewater treatment with flocculant and coagulant were established and the function of the response from these factors – the concentration of petroleum products – was determined.

5. The Results of the Study on the Purification of Surface Wastewater from Petroleum Products

5.1 Investigation of the Possibility of Purifying Water from Petroleum Products and the Selection of Flocculants and Coagulants

In the first stage of storm water studies, coagulants and flocculants were added to 250 ml measuring cups and visual analysis of samples was carried out (Fig. 2 and Fig. 3). Without the addition of reagents, the presence of fine particles of oil and other contaminants that form an emulsion in the liquid is observed (Fig. 2a) with a thin film at the top of the beaker. Prolonged settling does not lead to stratification of the emulsion. When $Al_2(SO_4)_3$ coagulant is added, the formation of fine agglomerates of petroleum products and the thickening of contaminants in water are observed (Fig. 2b), demulsification and violation of the stability of the disperse system occurs as a result of hydrolysis of aluminum ions. However, the particles are finely dispersed and the illumination of the liquid is slow. The formed units in the form of oily drops rise upwards. The addition of flocculant demonstrates the formation of large flocculi, which are more quickly separated from the liquid (Fig. 2c), but the water does not become completely transparent. Among the flocculants studied, the anionic flocculant A-19 showed the greatest activity, so it was used in further studies.

The combined action of coagulants for the demulsification of petroleum products and the subsequent flocculation of the formed coagulated flakes was more effective in a series of experiments. However, the use of $FeCl_3$ in the concentration effective for purification from petroleum products stains the solution (Fig. 2d) and requires further iron removal from the treated water. Completely clear water without staining was obtained using coagulant $Al_2(SO_4)_3$, followed by the addition of flocculant A-19 (Fig. 2.d).

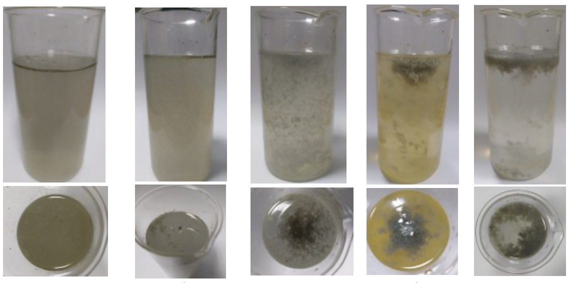
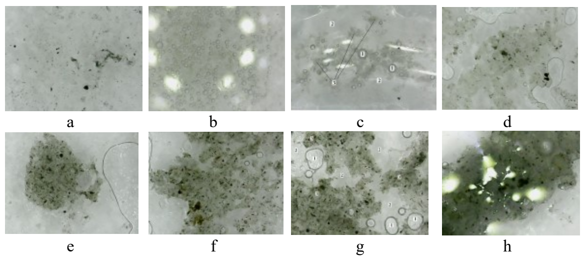

a b c d e

Figure 2: Visual analysis of wastewater samples with petroleum products: a – without adding reagents; b – flake formation when adding coagulant $Al_2(SO_4)_3$; c – water sample with the addition of anionic flocculant A-19; d – water sample with the addition of anionic flocculant A-19 and coagulant $FeCl_3$; e – water sample with the addition of anionic flocculant A-19 and coagulant $Al_2(SO_4)_3$

Microscopic analysis of processes in the formation of aggregates shows a change in the stability of the dispersed medium (Fig. 3). As a result of hydration of aluminum ions and interaction with electron layers, there is a formation of gas bubbles that partially cavitate with characteristic cracking, which begins about 7-10 seconds after the introduction of the coagulant (Fig. 3b.) As a result of neutralization of the ionic stability (the double electron layer around the emulsion particles), the demulsified particles of petroleum products and the aqueous phase converge to each other (Fig. 3c) with the subsequent formation of coagulation structures (Fig. 3d). The delamination process is quite long, therefore, the use of a flocculant is recommended for its intensification, which, after mixing due to the formation of polymer bridges, will contribute to the formation and increase of aggregates (Fig. e, f ,g ,h).

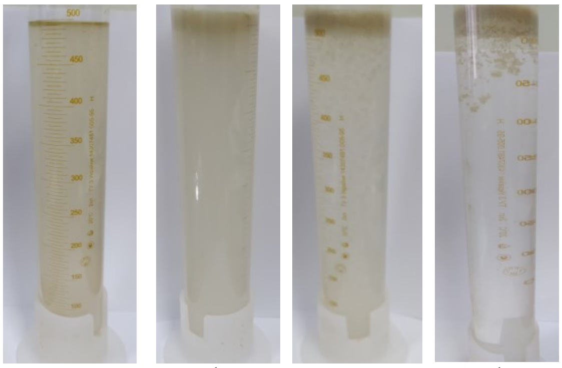


1 – gas bubbles formed after the introduction of coagulant; 2 – purified deemulsified water; 3 – formation of oil aggregates (flakes and flocs)
Figure 3: Analysis of samples under a microscope in the process of reagent cleaning:
a – water contaminated with oil products and suspended particles; b, c, d – formation of flakes after introduction of coagulant $Al_2(SO_4)_3$; e, f, g - the formation of flocs on the surface of the cylinder after the introduction of the flocculant.

Thus, the analysis of the results of the selection of reagents allows us to recommend the following stages for water purification: the introduction of $Al_2(SO_4)_3$ coagulant into wastewater and mixing the mixture for 8-10 seconds, followed by the introduction of flocculant A-19, followed by mixing and settling to form aggregates. Simultaneous administration of reagents or administration of flocculant followed by administration of coagulant had a worse effect: did not lead to effective aggregation; increased the settling time until the formation of illuminated liquid; did not lead to the appearance of completely transparent water.

5.2 Investigation of the Dependence of the Efficiency of Purification from Petroleum Products on the Consumption of Reagents

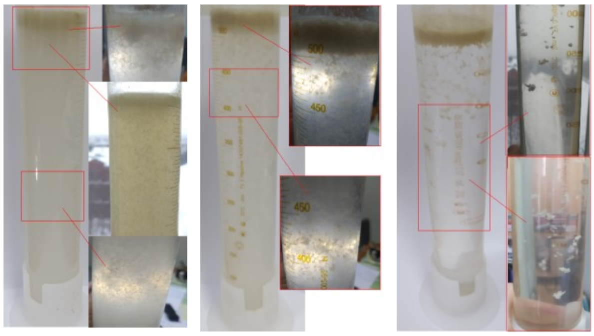
In the next step, in 500 ml measuring cylinders, the dependence between the degree of purification of water from petroleum products and the amount of reagents was determined. To do this, the runoff samples (Fig. 4a), reagents were introduced: coagulant (Fig. 4b), then after stirring the flocculant (Fig. 4c), was stirred and settled for 15-30 minutes until a transparent layer of liquid was formed (Fig. 4d), from which a sample was taken to analyze the residual content of petroleum products.



a b c d

Figure 4: Comparative analysis of samples in the process of reagent cleaning: a - water contaminated with oil products; b – settling with the addition of coagulant $Al_2(SO_4)_3$; c – water sample with the addition of coagulant $Al_2(SO_4)_3$ and anionic flocculant A-19; d – water sample after standing for 2 hours

During the experiments, the dose of coagulant was changed from 0 to 80 mg/l, and the dose of flocculant from 0 to 2.5 mg/l in terms of pure reagents. After the phased introduction of reagents, the formation of coagulated aggregates was observed (Fig. 5a), their consolidation during flocculation (Fig. 5b), stratification and lighting of water to a transparent state (Fig. 5c);



a b c

Figure 5: Comparative analysis of wastewater samples: a – floc formation when adding coagulant $Al_2(SO_4)_3$; b – water sample with addition of anionic flocculant A-19 to the coagulant; c – settled water with reagents

The results of the analysis of samples of purified water illuminated after settling are shown in Table 1, 2 and in Fig. 6.

Table 1. The results of the study of the effectiveness of water purification from petroleum products

Dose of coagulant, mg/l	Dose of flocculant, mg/l:					
	0	0,5	1	1,5	2,0	2,5
0	187	179	157	120	61	40
20	164	149	97	82	44	31
40	116	84	38	33	23	20
60	76	42	28	23	16	13
80	36	30	23	17	10	9

Analysis of the results of the study shows that the efficiency of purification depends on the amount of reagents, and the use of only coagulant or only flocculant is ineffective (purification efficiency of about 80%) for complete water purification.

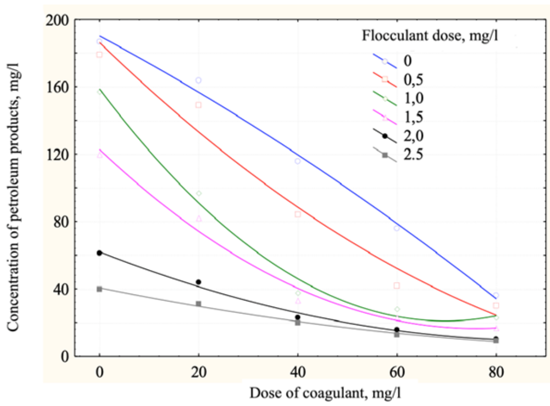


Figure 6: Results of the study of reagent wastewater treatment with the introduction of coagulant and flocculant

The maximum purification efficiency (90-95%) can be obtained with a dosage of 60-80 mg/l coagulant and 1.5-2.0 mg/l flocculant.

6. Discussion of the Results of the Study of Wastewater from Petroleum Products using the Coagulation-flocculation Method

As a result of the studies, the dependencies of the concentration of petroleum products with the addition of only $Al_2(SO_4)_3$ coagulant or only flocculant A-19 were established, which can be calculated by empirical formulas:

$$C_{pp} = 193.8-1.95 \cdot C_c; \quad (1)$$

$$S_{pp} = 191.75-26.9643 \cdot S_{ph} -14.9286 \cdot S_{ph}^2; \quad (2)$$

where C_{pp} is the concentration of petroleum products, mg/l;
C_c – concentration of coagulant $Al_2(SO_4)_3$, mg/l;
C_f –flocculant A-19 concentration, mg/l.

However, the minimum concentration of petroleum products that was achieved when using only a coagulant or flocculant in a series of experiments was only 40 mg/l. However, such a method may be appropriate as a pre-cleaning reagent before additional treatment facilities, for example, biochemical reactors or aeration tanks.

Therefore, it is more appropriate to use a combination of reagents – coagulant and flocculant. According to the results of mathematical processing of the study results (Table 1) the dependence of the concentration of petroleum products (C_{pp}) on the amount of flocculant (C_f) and coagulant (C_c) was established, taking into account the level of significance of the coefficients of the regression equation (p>0.05) and the coefficient of determination (0.999):

$$C_{pp} = 214.2381-3.0345 \cdot C_c -79.1857 \cdot C_f + \\ +0.0103 \cdot C_c^2+0.6991 \cdot C_c \cdot y+5 \cdot C_f^2. \quad (3)$$

A graphical interpretation of equation (3) for the convenience of quickly searching for the concentrations of reagents necessary to achieve a certain water purification efficiency or concentration of petroleum products is shown in Fig. 7.

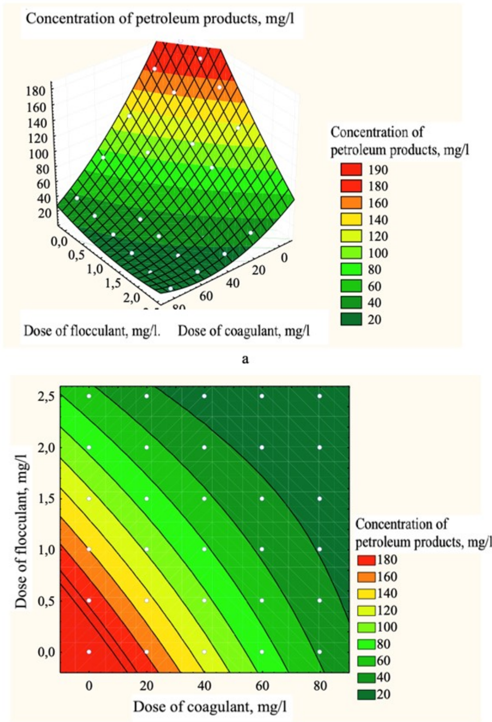


Figure 7: Dependence of the concentration of oil products on the dose of coagulant and flocculant: a – 3D model of values; b – 2D projection

Based on the results of the analysis and the studies performed, the following basic scheme of storm water treatment can be recommended (Fig. 8).

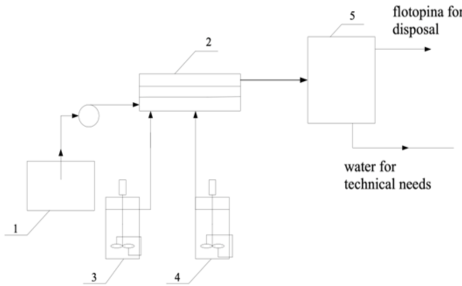


Figure 8: The scheme of wastewater treatment from oil products
1 – primary sedimentation tank for rainwater accumulation and sand deposition from it; 2 – tubular flocculator; 3 – coagulant tank; 4 – flocculant tank; 5 – flotation unit

According to the proposed scheme, storm wastewater, as well as surface runoff contaminated with petroleum products, should be collected and accumulated in the settling tank 1. After filling the tank and initial settling from sand and soil particles, the wastewater is fed for purification through a tubular flocculator 2, into which a coagulant and a flocculant are injected from tanks 3 and 4, respectively. The length and diameter of the flocculator is calculated in such a way that between the introduction of the coagulant and the flocculant, the mixture moves for about 8-10 seconds. This time is enough to start the formation of flakes due to coagulation and subsequent effective flocculation of particles. After the flocculator, it is rational to separate the illuminated water from the pop-up flocculi with petroleum products (flotopin) in the flotator. To intensify the process of cleaning and enlargement of flocculi, it is possible to install an additional settling tank or maturation chamber in front of the flotator. The runoff cleaned after the flotator can be safely discharged into the sewer network or used for technical needs (washing of premises and equipment, washing off paved surfaces, etc.).

The advantage of the studies is that the data obtained and the proposed methodology for the study can be used to conduct experiments with wastewater with a similar composition of contaminants.

The weakness of the studies conducted and the patterns identified is that the studies were conducted on wastewater with an initial concentration of petroleum products of 187 mg/l, so equations (1) – (3) are true for this concentration. In addition, by simple settling, it is difficult to remove all units of petroleum products that floated in the upper part of the graduated cylinder and could fall into the purified water during sampling. Therefore, it should be borne in mind that the use of more efficient methods of removing flocculated petroleum products, for example, flotation will be more efficient and, accordingly, will have a higher degree of wastewater treatment. Therefore, the dependencies obtained in laboratory conditions should be adjusted directly in industrial conditions, taking into account the concentration of real runoff and the characteristics of the treatment equipment.

7. Conclusions

As a result of the study, it was established that storm waters on the territory of the machine-building enterprise contain petroleum products that exceed the concentration allowed for discharge. In the course of laboratory studies, it was found that the most effective for water purification is the combined effect of coagulant $Al_2(SO_4)_3$ and anionic flocculant A-19.

The dependence of purification from petroleum products with the addition of coagulant and flocculant has been experimentally established, by which it is possible to determine the number of reagents necessary for water purification. It was found that the greatest purification efficiency of about 95% is achieved in the range of coagulant consumption of 60-80 mg/l and the dose of flocculant in the amount of 2-2.5 mg/l.

Promising areas of purification are two-stage injection of reagents: coagulation and flocculation, followed by separation of emerging oil floccules by flotation. The number of reagents can be reduced if additional biochemical methods are used to purify the clarified water after the flotator.

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