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Megacities land drainage and land runoff features and treatment

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Abstract. The land runoff of major cities is a significant factor in pollution of the hydrosphere. Sorption-filtration treatment technology of large volumes of water runoff most cost-effective, it is as deep purification technology. Their application in the complex composition of runoff from urban areas gives the best results in combination with the technology pre-separation main quantity of suspended solids and emulsified oil products in different kinds of traps and sumps.

Introduction

The land runoff of major cities is a significant factor in pollution of the hydrosphere [1, 2, 3, 4, 5]. In recent years, its composition is determined more technical results of human activity. The composition of land runoff permitted to discharge into sewers stormwater is regulated [6]. If the level of contamination exceeds the standards, the runoff needs to be cleaned. In the city there are three areas of functional use: residential, industrial and recreational landscape [7]. Be cleaned land runoff generated on residential and industrial areas. The main pollutants runoff components are known [8]. Fresh data on the real situation with the level of pollution of surface runoff in urban areas is quite small. Mainly used measurements data taken over 20 years ago [9, 10].

Investigations revealed road runoff increase the content of suspended solids in the effluent, petroleum and heavy metal ions [11, 12]. This is due to an increase in the intensity of vehicular traffic on the roads. Roads are the main component of both residential and industrial areas. Therefore, their influence is on the parameters of the runoff from these areas.

Analysis of the effluent. The land runoff of major cities is a significant factor in pollution of the hydrosphere [1, 2, 3, 4, 5]. In recent years, its composition is determined more technical results of human activity. The composition of land runoff permitted to discharge into sewers stormwater is regulated [6]. If the level of contamination exceeds the standards, the runoff needs to be cleaned.

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Average concentrations of manganese ion in the storm drain and thawed do not exceed the recommended [9]. This indicates a low solubility product of the oxidation of the manganese-containing antiknock additives in fuel, which are now widely used instead of lead-containing additives. The obtained values of COD (at low BOD20) significantly higher than the recommended (for both storm and thawed for runoff). This means that the waters are seriously polluted difficult to oxidize organic substances. The composition of these organic contaminants requires more attention and detailed study.

Table 1. Pollution characteristics of runoff in 2012 - 2013 with the industrial areas of located in St. Petersburg enterprises

To be controlled	Stormwater runoff			Snowmelt runoff		
	Interval oscillation min/max	Average value	According [6]	Interval oscillation min/max	Average value	According [6]
pH index	6.5 ÷ 8.0	7.3	–	6.8 ÷ 7.8	7.2	-
COD [mg/l]	26 ÷ 244	160	90 ÷ 120	160 ÷ 550	350	150 ÷ 200
BOD_{20} [mg/l]	1.6 ÷ 19	8.0	20 ÷ 40	3.5 ÷ 28	14.3	70 ÷ 150
Suspended material [mg/l]	4 ÷ 150	52	300 ÷ 600	3 ÷ 150	60	600 ÷ 1200
Petrochemicals [mg/l]	0.01 ÷ 2.0	0.38	7 ÷ 12	0.24 ÷ 29	4.2	10 ÷ 15
Synthetic surfactant [mg/l]	0.03 ÷ 1.5	0.32	–	0.15 ÷ 0.25	0.19	–
Phenols [mg/l]	0.002 ÷ 0.100	0.017	–	0.001 ÷ 0.005	0.003	–
Phosphate ions [mg/l]	0.03 ÷ 0.20	0.09	0.5 ÷ 0.8	0.08÷ 0.16	0.13	1.2 ÷ 1.8
Ammonium ions [mg/l]	0.1 ÷ 19	2.1	8 - 10	0.4 ÷ 4.5	1.8	18 ÷ 20

Table 2. Characteristics of runoff pollution in 2012 - 2013, heavy metals (St. Petersburg, 2012-2013)

To be controlled	Stormwater runoff			Stormwater runoff		
	Interval oscillation min/max, [mg/l]	Average value [mg/l]	According [6] [mg/l]	Interval oscillation min/max [mg/l]	Average value [mg/l]	According [6] [mg/l]
Iron (total)	0.24 ÷ 5.2	3.3	3 ÷ 10	0.40 ÷ 9.6	3.0	-
Manganese	0.02 ÷ 1.0	0.31	0.3 ÷ 0.5	0.12 ÷ 0.67	0.35	0.35 ÷ 0.55
Copper	0.002 ÷ 0.037	0.014	0.03 ÷ 0.04	0.030 ÷ 0.080	0.055	0.04 ÷ 0.05
Nickel	0.002 ÷ 0.020	0.006	0.007 ÷ 0.009	0.01 ÷ 0.040	0.002	0.010 ÷ 0.012
Zinc	0.01 ÷ 0.35	0.10	0.25 ÷ 0.30	0.06 ÷ 2.2	0.5	0.30 ÷ 0.40
Aluminum	0.04 ÷ 0.78	0.23	1 ÷ 3	0.55 ÷ 6.6	2.7	1.3 ÷ 4.0
Lead	0.04 ÷ 0.12	0.055	0.05 ÷ 0.07	0.04 ÷ 0.75	0.580	0.06 ÷ 0.08

Sampling conditions and the objects are the same as in Table 1.

During warmer months, petroleum products fall into storm runoff only during rain because on dry pavement, they evaporate quickly, and their non-evaporated part slightly soluble in water [12]. In winter, a significant portion of petroleum remains in a solid state (as snow particles with sand). When snow melts there is a gradual saturation of the water soluble components of petroleum products and the formation of their film and emulsified forms.

Fig. 1 shows the concentration of substantially water-insoluble turbine oil HS-22c after emulsification by a paddle stirrer (3300 rev/min, 20 min). It is seen that in one month after the emulsification of the oil concentration in the water is constant and at least 6 mg/l. Formation of such stable form of emulsified oil on roads with high-speed traffic is very likely. Water with a stable form of emulsified oil cannot be removed in any of the known types of sumps (including thin shelf samp). The presence of water in a variety of synthetic surfactants makes them more stable form.

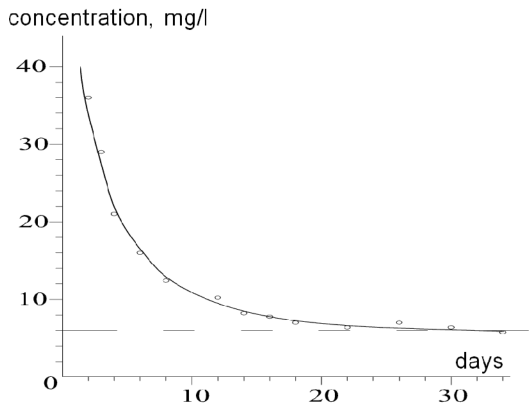

Fig. 1 - Kinetics of changes in the concentration in water emulsified turbine oil TH-22s

Table 3. Contents of oil on the surface of suspended solids in the melt water

Phase state	Particle size in suspended matter [um]	Petroleum products concentration [mg/g]
Melt water after settling	-	0.00037
Foam	< 3	219.8
Very fine sand	3 ÷ 60	27.3
Fine sand	60 ÷ 125	11.5
Medium sand	125 ÷ 250	6.24
Coarse sand	250 ÷ 2000	0.87

The most effective method of purification of water may be filtered through the porous fibrous material (Dorn padding polyester, polypropylene fiber, etc.) or granular hydrophobic load (activated carbon, anthracite, shungite etc.). In this case, the pore size of these materials is commensurate with the size of emulsified oil microparticles, which helps to maximize the coalescing phase separation.

Another, important factor affecting the oil content of the surface waters is their fixation on the surface of the particles of suspended solids by adsorption, adhesion, coalescence, etc.

Table 3 shows the concentrations of oil extracted from various factions in the sand melted water obtained by melted snow from the side of the road in St. Petersburg. For foam and petroleum fractions of sand concentration is given in terms of dry matter. It is seen that the particle size decreases, the amount of oil per unit mass of sand increases significantly. Thus, the maximum concentration of dissolved oil in the supernatant water (contact time - 12 hours) is very small - (0.37 mg/l). This shows their low solubility. Dissolved in water, melt oil amounted to only 0.05% of the total content in the solid and liquid phases.

On the other hand, with a significant accumulation of oil containing suspended solids in the settling tanks (especially in thin shelf samps) they can significantly increase the concentration of dissolved oil in storm drains. Oil film and foam for a long time are in sumps and traps. So they pollute the water in contact with them.

A very important component of runoff is infiltration (i.e. leakage) groundwater into sewer pipes through their walls, joints, as well as wall and the bottom of wells. In networks, drainage, located below the groundwater level, the influx of water infiltration occurs almost continuously throughout the year. Therefore, rain and snowmelt runoff always diluted in varying degrees infiltration waters.

On the composition and amount of pollution runoff infiltration is considered cleaner than stormwater runoff and snowmelt runoff [9]. However, this statement is valid only for suspended solids and oil, which can linger soil components. If infiltration flow is formed from non-pressurized layer water, then quite often it contains high concentrations of iron and manganese ions and soil biogenic origin. As seen in Figure 2a, the maximum concentration of these ions observed in the summer and autumn months, i.e. during soil biological activity.

Drainage network in urban areas can be laid in the bulk soil at the site of construction waste landfill, mixed with household and industrial waste. In such buried under a layer of soil bulk waste are processes of degradation (electrochemical dissolution of metals, biochemical anaerobic decomposition, etc.). As a result, the drain water in such areas fall not only iron and manganese ions in high concentrations, but also ions of zinc, aluminum, copper (and in some cases - of mercury, cadmium, lead). As seen in Figure 2b excess real concentrations compared with the MPC in this case much more. Peak concentration falls during the spring months, ie during snowmelt or immediately after it. Such water Excess concentrations of heavy metal ions in tens and hundreds of times over the MPC require mandatory cleaning.

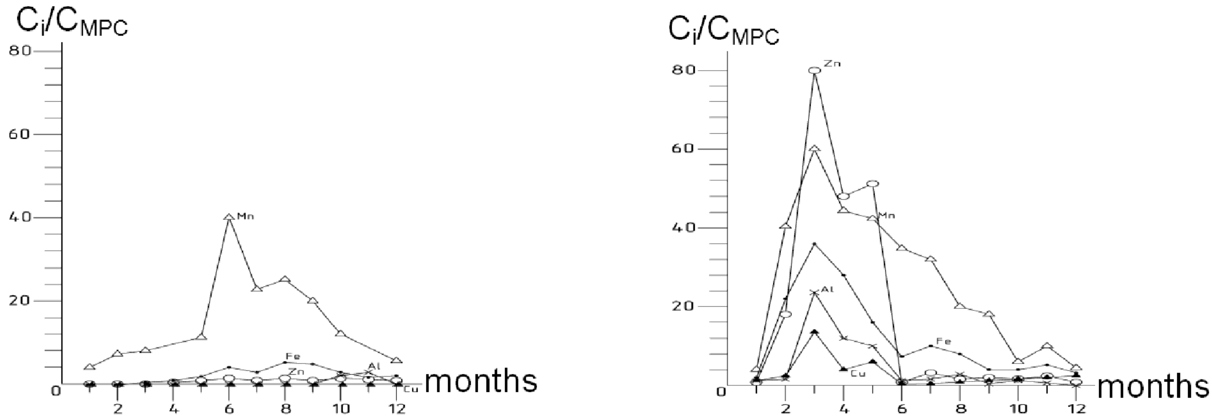

Fig. 2. Changing the time of infiltration of runoff from different areas.

a - the natural infiltration in the presence of iron-manganese groundwater.

b - infiltration from the territory of a buried dump industrial debris.

It should be noted that water infiltration from the territories of the former landfill construction, from the territories of the former to that in industrial use, and as a consequence of having highly contaminated soils approaching the composition and concentration of the components to the drain landfills.

Table 4 shows the composition of the infiltration of runoff from two facilities located in residential areas (business - and shopping center, both - St. Petersburg) compared with the average composition of MSW runoff (Moscow region) [11].

Table 4. Comparison of infiltration of runoff from residential areas located at sites contaminated by industrial waste buried and MSW runoff

Indicators of *runoff*	Concentration [mg/l]			MAC		
	Business -centre *	Shopping center	MSW landfill	In a commercial fishing body of water	In a storm drainage	In a combined sewage system
Petroleum products	710	0.5	0.5 ÷ 10	0.05	0.3	0.7
Fats	1726			-	-	50
Ammonium surfactants	0.90	0.16		0.1	0.1	1.4
Phosphates	2.9	0.20		0.2	0.2	2.0
Phenols	0.162	0.006		0.001	0.001	0.080
Iron (general)	322	26	to 22.5	0.10	0.22 ÷ 0.43	1.10
Manganese	6.0	2.7	to 2.6	0.01	0.01	0.1
Aluminum	17.5	1.9		0.04	0.12 ÷ 0.48	0.50
Zinc	31.90	0.52	to 0.9	0.01	0.02 ÷ 0.04	0.10
Copper	0.720	0.045	to 0.590	0.001	0.006 ÷ 0.009	0.040
COD	1100	700	1200÷ 8700	30	30	-

In the business-center of a small company previously worked on repairing transformers, which contaminate soil production waste (oil, heavy metals). In the shopping center (in the vicinity of St.

Petersburg) was previously unauthorized dump subsequently backfilled soil in preparation for the new construction site.

As can be seen from Table 4 infiltration runoff from the aforementioned sites located in areas related to residential, most of the indicators more polluted than runoff (infiltration) from MSW landfill. Cleaning needs to infiltrate MSW landfills, no one doubts [13], but the infiltration of runoff from residential areas, suggests a more pure [9], until recently, was not considered at all. However, such a high level of pollution in the drainage water, combined with surface runoff, with an extremely «hard» regulations on dumping them into the storm sewer system (Table 4) is classified at present as volley discharge of industrial wastewater. The user area is not a direct polluter.

Methods of cleaning. Task of cleaning large volumes of wastewater with high concentrations of pollutants to very low concentrations for the discharge of water into storm sewers and especially for the discharge of water in the fishery ponds is very complicated. Almost all substances dissolved in water (heavy metals, oil, organic matter) are not removed by the backlog and coalescence-the-art landfill and traps.

The most effective methods of cleaning are chemicals methods [14, 15, 16, 17, 18, 19] and sorption-filtration methods [20, 21, 22, 23, 24, 25]. The first group of methods requires large capital investments, special facilities and supply of electricity. These methods are very sensitive to changes in technology and the purification process requires highly skilled personnel. Disposal of cleaning by-products in this case are complex and expensive.

The second group of methods is hardly sensitive to changes in technology cleaning process does not require a supply of electricity, has higher efficiency and selectivity clean and cheap. The disadvantage of the second group of methods is the limited life of the Sorption-filtering materials. However, used sorption-filtration materials are cheap and easily replaceable. In addition, these materials contain in a fixed form all impurities removed by them from the water, which makes them extremely deposit contaminants simple and cheap.

Sorption-filtration treatment technology of large volumes of water runoff most cost-effective, it is as deep purification technology, ie bring the final composition of these waters at the outlet to discharge their respective regulations. Their application in the complex composition of runoff from urban areas gives the best results in combination with the technology pre-separation main quantity of suspended solids and emulsified oil products in different kinds of traps and sumps.

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