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UNDUSTRIAL ECOLOGY

Intensification of Water Purification by Reagent Method

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Abstract—On the example of real dispersal system (effluent) are tested coagulants and flocculants of different nature. A decrease in the content of harmful impurities after working up of the system by the reagents is established by the methods of physicochemical analysis.

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The effluents entering into the cleaning facility of the joint stock company "Almetevsk water channel" contain the pollutants of organic and inorganic nature. The admixtures in the effluent are the result of the activity of industrial, housing and agricultural objects and determine the combined nature of the effluents. The complexity of the chemical composition of effluent, the large volume of the workable drains, the influence of external factors (temperature and pressure), the presence of the extreme ejections of pollutants substantially decrease the vital activity of the bacteria of the active silt, the basic cleaning agent of the technological chain of water purification [1, 2].

Under the conditions of the increased volume of drains entering into the operational cleaning facility, besides the biological cleaning can be applied the reagent stage of cleaning based on the use of coagulants and the compositions of coagulants with the flocculants.

The purpose of this work was the study of the influence of coagulants and flocculants on the quality of the purification of waste water of complex composition at the joint stock company "Almetevsk water channel."

EXPERIMENTAL

The chemical composition of the water entering into the cleaning facility, is given in Table 1.

The salts of aluminum and iron were used as the coagulants: aluminum sulfate (AS) GOST (All-Union State Standard) 12966-85; liquid aluminum polyoxychloride (OCAliq) GOST 3759-75; aluminum polyoxychloride crystalline (OCAcr) TU 6-00-05795731-250-96; iron chloride (IC) GOST 4147-74. As the flocculants were used the flocculants of the sort "Praestol", its main characteristics are given in Table 2 [3–5].

A study of the processes of coagulation and flocculation was carried out by the methods of the clarification [6] and of spectrophotometry [7].

RESULTS AND DISCUSSION

In Fig. 1 are depicted the curves of clarifying of the effluent samples, which are the colloidal systems, at the optimum concentrations of coagulants. The analysis of curves shows that the most effective coagulating properties possesses crystalline aluminum oxychloride, providing aggregation and precipitation of particles (with the degree of clarification H = 70–80%) in 10 minutes. Attention is drawn to S-shaped nature of the curve of clarification in the presence of this coagulant. The initial section of the curve can be explained by the destruction of crystal structure. The steep climb of curve in the region of the time spaces of 5−10 minutes testifies about the active aggregation of particles as a result of the processes of complex formation.

Figure 2 gives the results of measuring of the optical density of dispersal system in the presence of coagulants. The data obtained by this method indicate sufficiently wide region of coagulation in the presence of crystalline

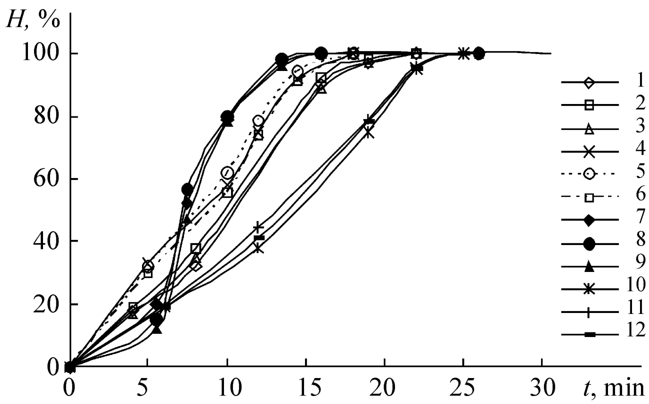
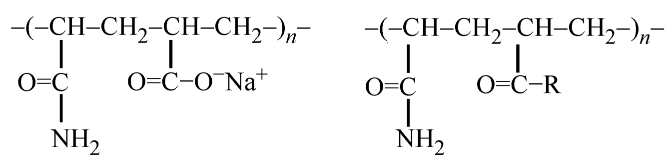


Fig. 1. Plots of the degree of clarification H (%) on the time t (min) at the optimum concentrations of coagulant C, %. Aluminum sulfate: (1) 0.04; (2) 0.06; (3) 0.08; Aluminum oxychloride liquid: (4) 0.01; (5) 0.015; (6) 0.02; Aluminum oxychloride cryst.: (7) 0.04; (8) 0.049; (9) 0.06; Iron chloride: (10) 0.01; (11) 0.015; (12) 0.02.

aluminum oxychloride (C = 0.01–0.05%), a bit smaller for the liquid aluminum oxychloride (0.01–0.015%). The scope of the data obtained by the method of clarification and by measuring the optical density (time of the aggregation of particles, the region of coagulation) make it possible to estimate the coagulating ability of the used coagulants as a sequence OCAcr > OCAliq > AS. Action of iron chloride occurs in the same range of concentrations as that of aluminum oxychloride crystalline (C = 0.01–0.05%), and coagulation period sufficiently prolonged (about 20 min, see. Fig. 1). This behavior of the coagulant can be explained by the features of complex formation at the hydrolysis of the iron compound.

As show numerous studies of the processes of coagulation, the application of coagulants does not always lead to a sufficient degree of cleaning of the colloidal system [8]. In such cases the flocculants of different nature are introduced additionally [9]. For the systems requiring sufficiently high degree of cleaning is expedient to use the compositions of coagulants with the flocculants. Testing



Anionic flocculant

Cationic flocculant

where R: $NH(CH_2)_3-N^+(CH_3)_2CH_3Cl^-$

Table 1. chemical composition of effluent and the norms of the maximum permissible discharge of pollutants.

No.	Indices of the composition of effluents	Entering drain, mg/l	Norms of maximum permissible discharge (PDS), mG/l[a]	Limits of temporarily matched discharge (VSS), mG/l[b]
1	Biochemical consumption of oxygen (BPK)	204	20.0	19.92
2	Chemical consumption of oxygen (CPK)	312	15.0	85.9
3	Suspended matter	172	16.7	16.7
4	pH	8.0	6.5–8.0	8.0
5	Nitrogen ammonium	more than 40	0.4–0.5	19.78
6	Nitrates	less than 0.1	0.02–0.027	3.90
7	Chlorides	214	66.5	66.5
8	Sulfates	151	100	149
9	Phosphates	6.6	0.2	0.55
10	Iron	1.5	0.1	0.79

[a] Norms of maximum permissible discharge (PDS)are established by administration for the ecological and technological supervision of the Federal Service for ecology and technology of Republic Tatarstan.
[b] Temporarily matched discharge of pollutants (VVS) are established by administration of town Almetevsk.

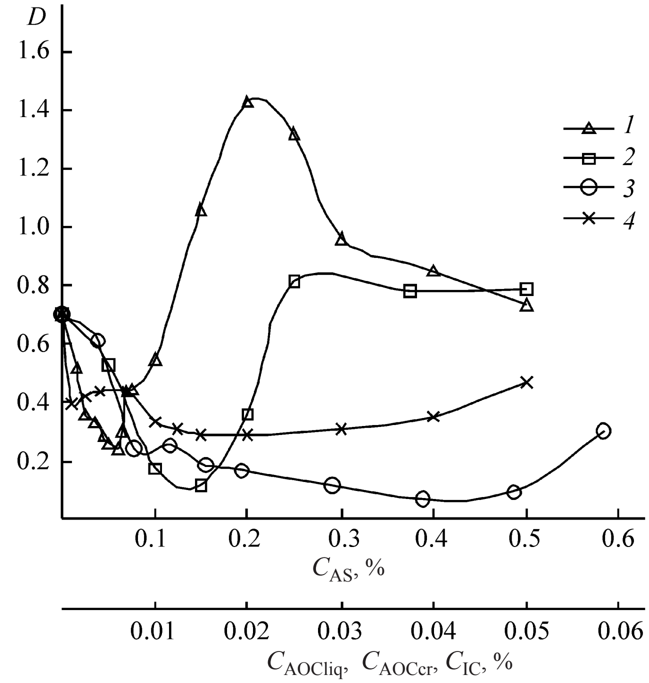


Fig. 2. Plots of the optical density of the solutions D on the concentrations of coagulants C, %: (*1*) aluminum sulfate, (*2*) aluminum oxychloride liquid, (*3*) aluminum oxychloride cryst., (*4*) iron chloride.

the compositions of the coagulants aluminum oxychloride liquid and aluminum sulfate with the flocculants on the basis of polyacrylamide (6 types, see Table 2) showed that most active in chemical sense are the compositions with the flocculants Ps 2515 and Ps 650. This is seen from the plots of clarifications and the curves in the coordinates of optical density–flocculant concentration (Figs. 3 and 4). The duration of the formation of associates in the presence

Table 2. Characteristics of flocculants

No.	Flocculant type	$[\eta]$,cm^3/g	$M_\eta \times 10^{-6}$	Content of ionogenic centers, mol %	Activity
1	Ps 611 TR	920	–	9	Weak cationic
2	Ps 650	690	3.5	20	Medium anionic
3	Ps 2515	1020	2.8	11	Weak cationic
4	Ps 2640	1350	2.7	28	Medium anionic
5	Ps 2540 TR	1600	4.4	28	Medium anionic
6	Ps 2530 TR	1800	4.6	20	Medium anionic

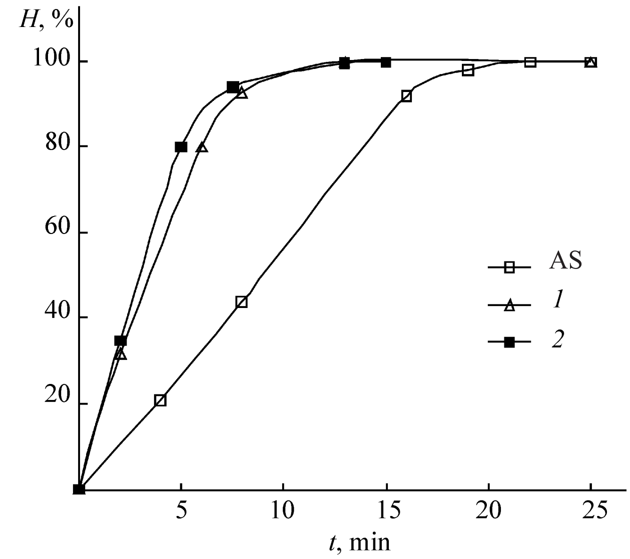


Fig. 3. Plots of degree of clarification H (%) on time t (min) at the optimal concentration of aluminum sulfate (0.06%) and flocculants ($C_{fl} = 0.7 \times 10^{-3}$): (*1*) Ps 650, (*2*) Ps 2515.

of flocculants is shortened to 5 min., and optical density D takes value of 0.1.

It is necessary to note that at the high content in the effluent of petroleum products, fuels and lubricants the most effective are the compositions of aluminum sulfate and aluminum oxychloride liquid with Ps 650. The latter

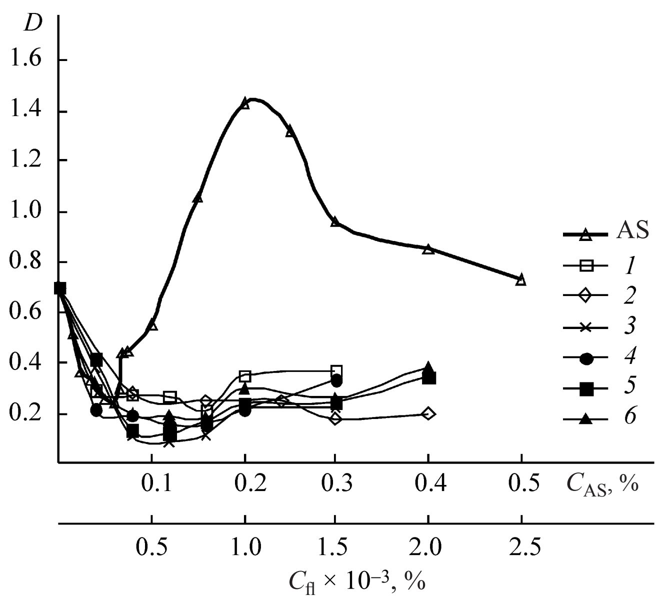


Fig. 4. The plots of the optical density of the solutions D on time at the optimum concentration of aluminum sulfate (C_{AS} 0.06%) and the flocculants C_{fl} (%):(*1*) Ps 611 TR = $(0.4–0.80) \times 10^{-3}$; (*2*) Ps 2640 = $(0.125–0.20) \times 10^{-3}$; (*3*) Ps 2515 = $(0.4–0.80) \times 10^{-3}$; (*4*) Ps 650 = $(0.4–1.0) \times 10^{-3}$; (*5*) Ps 2540 TR = $(0.4–0.80) \times 10^{-3}$; (*6*) Ps 62530 TR = $(0.4–1.00) \times 10^{-3}$.

Table 3. Results of the reagent purification of waste water of joint stock company "Almetevsk- water channel"

Pollutant	Initial water, mg/l	Results of the reagent cleaning of				Maximum allowed concentration, mg/l
		Aluminum sulfate	Aluminum oxychloride liquid	Aluminum oxychloride cryst.	Aluminum oxychloride liquid + Ps 650	
Phosphates	7.32	less than 0.1	0.154	0.124	less than 0.1	0.55 0.2
Iron total	1.42	0.52	0.52	0.34	0.38	0.1
Sufates	136.8	101.2	35.9	25.9	31.6	100
Chlorides	214	88.6	312	167	310	66.5
Ammonium ion	more than 40	33	30	31	30.5	0.4–0.5 19.78

in contrast to Ps 2515 is of weak cationic activity. Use of Ps 650 as the flocculating agent leads to the flotation of the particles of dispersed phase. The introduction of the flocculants of different molecular weight (Figs. 3 and 4) with the different number of ionogenic fragments in the molecules of polymers leads to the shortening of the coagulation–flocculation period to 5 minutes at the increase in molecular weight and the number of the ionogenic fragments, and to the change in the optical density D from 0.2 to 0.1.

The results of the reagent purification of waste water of joint stock company "Almetevsk-water channel" show that an improvement in the chemical composition of water is observed for the majority of indices. Normative indices are achieved (Table 3) toward phosphates, sulfates (in the case of using aluminum oxychloride crystalline, aluminum oxychloride liquid and aluminum oxychloride liquid + Ps 650, and toward iron (according to the temporarily matched discharge, VSS, Table 1)

CONCLUSIONS

1. The coagulating activity of the utilized coagulants falls in the sequence: aluminum oxychloride crystalline > aluminum oxychloride liquid > aluminum sulfate. The region of coagulation of iron trichloride is commensurate with that of aluminum oxychloride crystalline, the coagulation period is approximately 20 min.

2. The best action at the cleaning of the samples of the tested effluent showed the compositions of aluminum oxychloride liquid and aluminum sulfate with Ps 650 (flotation) and Ps 2515 (sedimentation).

3. The use of coagulants and of the compositions of coagulants with the flocculants makes it possible to reach standard of maximum allowed concentration (PDK) toward phosphates, iron, sulfates; to decrease the content NH_4^+ ion by 20–30% of the initial.

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