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V. I. Romanovski, PhD (Engineering), assistant lecturer (BSTU); **N. A. Andreeva**, student (BSTU)**PURIFICATION OF WASHING WATERS OF IRON REMOVAL STATIONS**

The article presents the results on use of water preparation waste, namely the fulfilled ionites of KU-2-8 and AV-17-8 as a coagulant for purification of washing waters of iron removal stations. In this work the optimum dose of offered coagulants, degree of washing waters clarification, residual iron concentration in washing waters after 2 h of sedimentation were defined. Specific resistance to filtering of received deposit was also established. This deposit is suggested to be used for ceramic goods manufacture.

Introduction. For economic and drinking water supply of the population of the Republic of Belarus water of underground sources is generally used. In underground water of the republic there is a higher content of iron (to 20 mg/l) and other compounds which worsen its indices and properties [1]. Technical normative legal acts of the Republic of Belarus regulate iron content in drinking water not more than 0.3 mg/l [2].

In the Republic of Belarus the most widespread method of water iron removal is filtering through granular loading with preliminary deep or simplified aeration [3]. Filter regeneration is carried out by water-airing or water washing [4]. The portion of the water spent for washing, can reach 10% of the total consumption of water being cleared [5]. The washing waters which are formed in the course of regeneration are characterized by high iron content whose concentration reaches 300 mg/l [6].

When recommended period of time for sedimentation is up iron concentration in washing water under static conditions is high. Residual iron content thus makes up to 35 mg/l, subsequent decrease in iron concentration is slowed down. The deposit quantity with humidity of 98–99%, which is formed after two-hour sedimentation, reaches 3–5% of washing waters volume [5].

Today washing waters of iron removal stations both in our country, and abroad, are in most cases dumped into water objects or on municipal sewerage clearing systems. This way is applied both after preliminary sedimentation of washing waters, and without it. However in this way there is considerable soil pollution of surface and underground waters.

It should be noted that the Veridoks method of iron removal in a layer is very effective and wasteless [7]. However nowadays this technology has been introduced only in some water intakes of the Republic of Belarus.

Thus, it is necessary to take measures for improvement of technological operating mode to increase the effectiveness of facilities work of washing waters reuse of iron removal stations by means of perspective methods of washing waters clarification.

The analysis of information provided in literature, and modern situation at iron removal stations testifies to an urgency and expediency of creation of highly effective technologies for processing washing waters and uses of iron containing deposit. It will allow to cut down water expenses on own needs of the stations, to reduce the cost of water preparation, to prevent impact on the environment, to reduce an intake of underground waters.

The purpose of carried-out research is to define the efficiency of washing water purification at iron removal stations with use as a coagulant of the spent ion exchange resins pitches AV-17 and KU-2 [8] which are formed in the course of water preparation.

It has been determined in the article [8] that the increase of the degree of dispersion changes the distribution of the functional groups located on the surface and in the grain volume of spent ionite and raises their concentration at surface. When crushed to a certain degree of dispersion the ionite shows the properties similar to the properties of polymeric flocculants.

Thus the purpose of the work was to investigate the intensification process of purification of washing waters of iron removal stations with the use of a waste of the spent ion-exchange resins as a coagulant. The second aim was to study the properties of formed precipitation.

Washing waters of iron removal stations with high concentration of iron were applied to solve the above mentioned objectives.

Research methods. Water of washing filters of iron removal station (iron removal station of Beryozovskaya GRES) was used with average concentration of 200 mg/l in terms of iron (averaged iron concentration in washing waters [9]).

In carrying out experimental research the following methods were applied: titrimetric and photocolourimetric analyses, a method of microelectrophoresis, microphotography, the element analysis by a method of X-ray fluorescent power dispersive spectroscopy and others.

Results of research. To substantiate coagulant choice it is necessary to know the value of its electrokinetic potential (zeta-potential), and also col-

loidal particles of $\text{Fe}(\text{OH})_3$ in washing waters of iron removal stations.

Zeta-potential of colloidal particles $\text{Fe}(\text{OH})_3$ defined by an electrophoresis method, is -40.45 mV that causes aggregative stability of system and emergence of intermolecular forces of repelling particles. The charge of colloidal particles can be lowered to zero or very small values with water processing by various coagulants which disturb aggregative stability of impurities or form owing to hydrolysis colloids, on which impurities are sorbed [10].

In the article reagent purification of washing waters of iron removal station was investigated by means of waste of spent ionic exchanger AV-17-8 and KU-2-8 used as a coagulant. The value of zeta-potential for previously crushed cationic exchanger reaches -47.8 mV, and for anionic exchanger it is $+96.3$ mV [8]. Opposite-charged dispersed particles of crushed ionic exchanger form a complex as a result of hetero-coagulation [9]. Therefore the use of the hetero-coagulant complex as a coagulant is of interest and for obtaining this complex crushed ionic exchanger AV-17-8 and KU-2-8 were used. The results of the researches of application of aluminum sulfate, a coagulant "Akwa Aurate - 30" and a coagulation by aluminum sulfate in the presence of phosphates [9] were used to compare efficiency of the chosen coagulants.

Colloidal particles of a cationic exchanger, an anionic - cationic complex in a certain ratio and $\text{Al}(\text{OH})_3$ have a charge sign identical with that of colloidal $\text{Fe}(\text{OH})_3$ impurities. In introducing mentioned coagulants coagulation of iron compounds will occur due to iron compounds fixation (fixing) on a sorption surface of a coagulant colloidal particle but not because of forces of intermolecular interaction. However more effective removal of iron compounds from washing waters will need higher doses of the listed coagulants, which will cause a recharge of ashes and as a result their mutual coagulation.

As a coagulant previously crushed wastes of the spent ion-exchange resins with the content of median diameter particles of $10 \mu\text{m}$ not less than 60% were used:

- a coagulant N 1 - cationic exchanger;
- a coagulant N 2 - cationic and anionic exchangers (a ratio 4 : 1);
- a coagulant N 3 - cationic and anionic exchangers (a ratio 2 : 1);
- a coagulant N 4 - cationic and anionic exchangers (a ratio 1 : 1);
- a coagulant N 5 - cationic and anionic exchangers (a ratio 1 : 2);
- a coagulant N 6 - cationic and anionic exchangers (a ratio 1 : 4);
- a coagulant N 7 - anionic exchanger.

The dose of a coagulant was 1, 2.5 and 5 g/l. Sediment time was 10, 30, 60 and 120 min.

It is known that gravitational deposition of the suspended particles comes to the end practically after 1.5-2.0 h, and the most part of a suspension drops out in a deposit for 15-40 min of sedimentation [9]. The effect of clarification made 64.2% when sedimentation of the suspended substances and iron compounds in washing waters took place without any reagents during 2 h. The best effect of reagent clarification for 2 h was reached with the use of the following coagulants doses:

- 1) a coagulant N 1 - 5.0 g/l - 64.4%;
- 2) a coagulant N 2 - 1.0 g/l - 65.2%;
- 3) a coagulant N 3 - 1.0 g/l - 69.6%;
- 4) a coagulant N 4 - 1.0 g/l - 86.5%;
- 5) a coagulant N 5 - 1.0 g/l - 93.2%;
- 6) a coagulant N 6 - 1.0 g/l - 99.3%;
- 7) a coagulant N 7 - 1.0 g/l - 78.6%.

Low extent of cleaning of suspended matter is explained by residual content of the suspended particles of the crushed ionic exchanger with the sizes of particles less than $5 \mu\text{m}$ since diffusion forces in this case prevail over the weight forces.

Residual total iron concentration in the clarified layer of liquid after 2 h sedimentation was: for a coagulant N 1 - 35.2 mg/l; N 2 - 23.4 mg/l; N 3 - 14.6 mg/l; N 4 - 3.7 mg/l; N 5 - 2.2 mg/l; N 6 - 1.3 mg/l; N 7 - 5.6 mg/l.

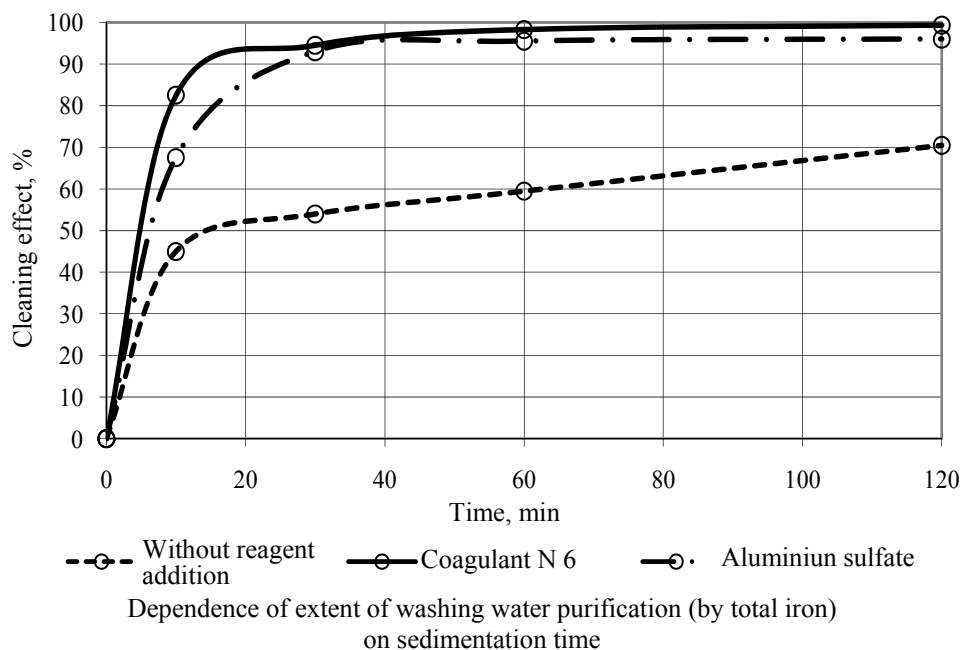
The dependence of extent of washing water purification (by total iron) on sedimentation time by the best results of the table is presented in the figure.

The best result during 2 h sedimentation is at using coagulant N 6 with expense of 1 g/l. Residual iron concentration was 1.3 mg/l, the cleaning effect thus reached 99.35%. Further decrease of iron concentration is sharply slowed down.

It should be noted that after filtering total iron concentration in water considerably decreases: when the coagulant "Akwa Aurate - 30" is used it falls to 0.1 mg/l. Therefore, it is possible to assume decrease of concentrations to standard at a filtration of the purified water with the use of the spent ionic exchanger.

The important task during processing of washing waters of iron removal stations is not only sedimentation of iron compounds, but also dehydration and utilization of formed deposits. When using traditional facilities on purification of washing water the quantity of a deposit reaches 5% of washing waters volume [6].

The iron containing deposit represents mass with humidity about 60%. Element analysis of iron removal deposits (wt % for dry): C - 4.65; O - 32.01; Mg - 0.48; Al - 0.60; Si - 2.79; R - 2.16; Ca - 9.04; Mn - 2.05; Fe - 45.80.



Dependence of iron content in washing water on sedimentation duration, mg/l

Coagulant	Duration of sedimentation, min				
	0	10	30	60	120
Without reagent addition	200	110	95	81	59
The investigated:					
Coagulant N 1, 5 g/l	200	101	65	52	35.2
Coagulant N 2, 1 g/l	200	88	49	31	23.4
Coagulant N 3, 1 g/l	200	76	37	20	14.6
Coagulant N 4, 1 g/l	200	58	18	5	3.7
Coagulant N 5, 1 g/l	200	49	16	4.5	2.2
Coagulant N 6, 1 g/l	200	35	11	3.4	1.3
Coagulant N 7, 1 g/l	200	66	20	9	5.6
As compared [9]:					
Aluminum sulfate, 100 mg/l	200	65	14	9	8
Coagulant "Akwa Aurate – 30", 50 mg/l	200	78	21	5	2.9
Phosphate of sodium and aluminum sulfate, on 100 mg/l	200	74	19	10	0.9

Deposit specific resistance which is formed in clearing washing waters iron removal stations without any reagents was $27.6 \cdot 10^{10}$ cm/g, and while using aluminum sulfate it is $33.4 \cdot 10^{10}$ cm/g, aluminum sulfate in the presence of phosphates it is $14.0 \cdot 10^{10}$ cm/g, the coagulant "Akwa Aurate – 30" – $35.0 \cdot 10^{10}$ cm/g. For a deposit which is formed while using coagulant N 6 (cationic exchanger : anionic exchanger = 1 : 4), specific resistance to filtering is equal to $6.8 \cdot 10^9$ cm/g, i.e. in 41 times lower.

Conclusion. For intensification of the purification process of washing water iron removal stations the reagents prepared from water preparation waste, i.e. spent ion exchange resins were tested.

As a result of the carried-out experiments it is found out that during processing washing waters

by the reagent prepared from spent cationic and anionic exchangers in the ratio 1 : 4, cleaning effect is 99.35%.

At present the work on selection of optimal reagent dose, the order of reagent input into washing water being processed, the determination of the main properties of deposit being formed is being carried out.

It is expedient to use the formed dehydrated deposit of washing water iron removal stations in manufacturing techniques of pottery as an iron containing pigment. Element composition of the air and dry deposit which is formed at using the coagulant N 6 (wt %): carbon – 26.8; oxygen – 21.0; magnesium – 0.2; aluminum – 0.3; silicon – 1.4; phosphorus – 1.1; calcium – 4.5; manganese – 1.0; iron – 22.9. Humidity is equal to 20.8%.

Particle size of a deposit is less than 500 μ m.

It is experimentally shown (JSC "Keramika", Vitebsk) that use of iron removal station deposit precipitated by spent ion exchange resins gives more intensive dark coloring of a crock, than separately used deposit of iron removal station. Existence of a burning-out ion exchange resins component is multi functional. When the products are baked the additional heat quantity is released that results in more uniform baking and decrease of processing temperature (energy economy).

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