Cleaning and reusing backwash water of water treatment plants

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Abstract. The article deals with the treatment of wash water of water treatment plants open water sources. The results of experimental studies on the choice of effective reagent, cleaning and disposal of wash water of filters. The paper proposed a new two-stage purification technology and multiple reuse of wash water of water purification stations from open surface sources

1. Introduction
Backwash water of filtration plants according to the recommendations of existing regulations [1, 3] in the stations of water treatment, depending on the technology of cleaning is pumped in head of treatment facilities after settling in a decanter or without. It is also possible the use of the clarified backwash water for washing the contact clarifiers [1].

Experience revealed in operating water treatment facilities of natural waters some shortcomings of the technological scheme of recycling wash water returning to the head of water treatment facilities. The disadvantages include: an increase in the hydraulic load on the main purification facilities, the complexity of ensuring the constancy of the concentration of impurities in the wash water supplied to the head of water treatment plants, the selection of working reagents doses for optimal process of natural water purification, etc.

Technologically and economically expedient to allocate the backwash water of the filter facilities from the main process water treatment and use them after treatment for another purpose, for example, for the same washing of filters. However, recommended this washing of rapid filters produce filtered water [1]. Thus, the quality of the water used for repeated washing of filters must match the quality of the purified natural waters.

2. Materials and Methods
Novosibirsk State Architectural University (Sibstrin) developed water technology of clarification and reuse of wash water of filtration plants for water treatment plants, including water treatment by coagulant, sedimentation in the sump drive, lightening in reactor-clarifier (RC), the accumulation in the tank of purified water wash and use in confined filter washing cycle. The technological scheme of cleaning and recycling of wash water treatment plant is shown in Figure 1. In wash water of treatment plant discharged via line 1 to sedimentation basin 2, is introduced through conduit 3 complex of coagulants, a mixture of water solutions of aluminum sulphate and oxychloride with dose ratio 2:1 counting on alumina. At sedimentation basin 2 occurs coagulation in a volume, separation of hydroxide sediment and other impurities from water to be purified settling-vat water by pump 5 via conduit 6, fed to the reactor-clarifier 7 [4,5,10], clarified and directed through line 8 to the storage tank 9 of treated
backwash water. Accumulated and purified backwash water by pump 10 is supplied via line 11 for a repeated washing of the filtering facilities. The precipitate of aluminum hydroxide and other impurities carry over from the sedimentation basin 2 into densifier 4. Compacted sediment containing aluminum hydroxide and other impurities, by the pump 12 from the densifier 4 on line 13 is pumped to the dewatering equipment, and recycle for the production of building materials or taken to wastewater treatment plant and used as a reagent for the dewatering from sewage sludge at wastewater treatment plant. Transfer pump of sludge water 14 pumps water from the densifier 4 via line 15 through line 1 into sedimentation basin 2. Washing of the reactor-clarifier carried by means of hydraulic elevator 17. The spent wash water from the reactor-clarifier 7 is reset via line 16 and 1 into the sedimentation basin 2. Application of a complex mixture of aqueous solutions coagulant sulfate (AS) and aluminum oxychloride (AOC) a dose ratio of 2:1 aluminum oxide improves the quality of treated water and reduces the amount of sludge produced. Subsequent clarification in the reactor-clarifier provides a high quality of clarified backwash water, to meet quality of the filtered water and regulatory requirements for waters used repeatedly for the washing the filtration installations of water treatment plants [1]. Reducing the volume of sludge produced during reagent treatment of backwashing water by a mixture of sulphate and aluminum oxychloride lowers cost of his dehydration or transport for recycling.

The developed technology of cleaning and recycling backwash water of filtration installations was studied under natural conditions of river water purification plant of town Kuibyshev Novosibirsk region. Diagram of installation is shown in Figure 2.

Installation included the models of the main units of the new technological scheme of river water purification developed in NSABU (Sibstrin) [6]. It consisted of equipment for pre-oxidation and disinfection of river water 1-8; pumping and dosing of 9-11; clarification in process of upward filtration through a suspended contact media bed 12; rapid filtration 14 and carbon adsorption 15; collection, purification and reuse of backwash water 12, 16 -18. The reactor-clarifier 12 had a dual purpose: to treat the river water and backwash water by appropriate switching pipelines provided for in the facility design.

To installation was supplied the original water of river Tom and did its reagent treatment. The water temperature was 4°C; turbidity - 7.2 mg/l; chromaticity - 180 deg.; alkalinity - 5.8 mmol/l; oxidability - 24 mg O₂/l; iron concentration - 1.93 mg/l; the concentration of manganese - 0.31 mg/l; aluminum concentration of 0.35 mg/l. During the purification was achieved of drinking water quality. Backwashing of the reactor-clarifier and a quick filter was carried out by purified water 1 time per day. Fence backwash water of the filter facilities was carried out from the left tank of washing water 18. The spent wash water with the reagents introduced into it was dumped into the right tank 17. After settling during 2 hours the washing water was pumped into reactor-clarifier 18 for purification. The purified backwash water, bypassing filters by the waste pipe was sent for storage to the left tank of the wash water 17. The choice of reagents and effective determination of optimum doses of coagulants and flocculants for treating backwash water were produced on the basis of test results of coagulation and sedimentation of water samples in the glass cylinders 1 liter performed according to standard methods in the laboratory plant [2].

3. Results
Investigated the efficacy of following reagents: aluminum sulphate (AS), aluminum oxychloride (AOC), MC-1, Praestol 650 TR. Features of reactants: Aluminum sulfate Refined technical, Russian State Standard 12966-85, mark B, grade 2, the mass fraction of the basic substance in terms of Al₂O₃ - 15%, the chemical formula Al₂(SO₄)₃ · nH₂O. Aluminum oxychloride, 2152-001-59254368-2002 TU, Grade A, the mass fraction of Al₂O₃ of the base material - 21%, the basicity factor - 5/6, the chemical formula Al₂(OH)nCl₆-n, where n = 4-5. Praestol 650 TR - cationic flocculant. Complex MC-1 coagulant developed NSABU (Sibstrin) is a water solution mixture of AS and AOC in the ratio 2:1 of Al₂O₃ [8].

Results coagulation studies and the spent wash water clarification filters are shown in Table 1 and Figure 3.
Table 1. The results of experimental studies of backwashing water treatment

| Measured parameters | Backwashing water purification process, input reagents | | |
|---------------------|------------------------------------------------------|---|---|
|                     | Settling, (AS / AOC) + Praestol | Settling, MC-1 + Praestol | Settling and clarification in RC MC-1 + Praestol |
| The quality of the initial wash water: | | | |
| Turbidity, mg / l   | 160 | 160 | 160 |
| Chromaticity, degree| 140 | 140 | 140 |
| Oxidability, mg O₂ / l | 19  | 19  | 19  |
| Iron concentration, mg / l | 1.52 | 1.52 | 1.52 |
| Manganese concentration, mg / l | 0.29 | 0.29 | 0.29 |
| Doses reagents, mg / l | 25/22 + 0.05 | 18 + 0.05 | 8 + 0.05 |
| The quality of purified wash water: | | | |
| Turbidity, mg / l   | 7.1/5.2 | 4.3 | 1.1 |
| Chromaticity, degree| 24/19 | 17 | 6 |
| Oxidability, mg O₂ / l  | Iron | 4.3/3.2 | 2.6 | 1.3 |
| concentration, mg / l | 0.94/0.36 | 0.23 | 0.12 |
| Manganese concentration, mg / l | 0.12/0.10 | 0.10 | 0.06 |
| Aluminum concentration, mg / l | 0.15/0.07 | 0.07 | 0.05 |
| Volume of sludge in the settler, % by volume of washing water | 12 /18 | 13 | 13 |

As a result of experiments, have been defined the optimal dose of reagents to ensure minimum turbidity and oxidability the clarified backwashing water. Aluminum sulphate dose was 25 mg / l, aluminum oxychloride - 22 mg / l with the addition of a flocculants at a dose of 0.05 mg / l (Tab.1). When using a coagulant AS the quality of water was lower than with AOC, but have been received more dense hydroxide precipitate of a smaller volume relative to the volume of washing water. After treatment of the washing water by a mixture of coagulants AS and AOC in the ratio 2:1 due to a synergistic effect when used together and using a flocculants, has been obtained the best quality of clarified water: 4.3 mg / l of turbidity, 17 degrees of chromaticity, 0.23 and 0.10 mg / l of iron content and manganese, respectively. The purified wash water on the main indicators of quality meets the requirements of drinking water and can be used for repeated flushing of the reactor-clarifier and filter. With this has occurred the formation of dense flocs of aluminum hydroxide 30% and reduced the sediment volume in comparison to its volume, obtainable by using AOC. According to the results of laboratory tests of experimental setup for treatment of the backwashing water was adopted coagulant MC-1 represents a mixture of aluminum sulfate and oxychloride dose ratio of 2:1 with the addition of the flocculent Praestol 650 TR.

4. Conclusions
Washing water from the reactor clarifier and filter was treated with reagents and collected in the left tank of washing water 17. Then the wash water was pumped by pump 18 through a separator 11, purified by reactor-clarifier and directed in the right tank of the wash water 17. It has provided its drinking water quality for turbidity, chromaticity, iron and manganese. Clarified water from the right tank 17 of wash water had been used to wash the filters after the next filtration cycle. The sediment has been subjected to condensation and used in experimental dewatering sludge sewage treatment plant [7, 9]. The sediment has been subjected to condensation and was used in experimental dewatering sludge sewage of treatment plant [9, 10]. The loss of the wash water with sediment removal from the tanks 17 have been recovered
in the first filtrate discharge fast filters in the wash water tanks of up to 5% of the total volume of washing water per day.

Thus, the developed processing technology washing water of filtering facilities provide their normative quality, allows you to use the water again for washing the filter facilities, reduce sludge volume, the cost of dewatering or transport to the sewage plant for recycling, which increases the technological, economic efficiency of clarification and recycling of wash water filtration plants water treatment plants.

References
[1] 1986 Building regulations 2.04.02-84 Water supply External networks and buildings Gosstroy SSSR (Stroyizdat) pp 45 118
[2] Draginsky V L and Alekseeva L P 2001 Techniques of research and technological modeling of water treatment processes on the waterworks NII KVOV Vodkommuntech pp 1-18
[3] Filter Backwash Recycling Rule Technical Guidance Manual EPA 816-R-02-014 pp 1-6
[4] Skolubovich Y L and Voitov E L 2015 Improving the efficiency of waterworks Voda i sanitarna tehnika 5-6 51-57
[5] Voitov E L and Skolubovich Y L 2007 Water purification device R.F. Patent 2307075 September 10 2007
[6] Skolubovich Y L, Voitov E L and Nikitin A M 2011 Increased efficiency waterworks Water Supply and Sanitary Equipment 2 21-25
[7] Skolubovich Y L, Voitov E L and Saveleva L N 2005 The process of joint dehydration natural and waste water treatment plants precipitation R.F. Patent 2246452 February 20
[8] Voitov E L and Skolubovich Y L 2010 Preparing drinking water from underground sources ecologically unfavorable regions NSABU (Sibstrin) pp 157-204
[9] Voytov E L and Scolubovich Y L 2010 Preparation of drinking water from surface sources with a high natural and anthropogenic pollution NSABU (Sibstrin) pp 158-202
[10] Voytov E L, Scolubovich Y L and Scolubovich A Y 2007 Solution to the Problem of Production of Drinking Water from Underground Sources of Ecologically Unfavourable Regions In the Proceedings of the 2007 International Forum on Strategic Technology (IFOST) pp 315-317