Improving the purification method of circulating water in the POOLS

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Abstract. The article presents the research results of the sorption purification peculiarities of aquatic environment where surface-active substances (SAS) appear during the operation.

Introduction
The paper presents the research results devoted to the study of characteristics of the sorption purification of aquatic environment where surface-active substances (surfactants) appear during the operation.

When the water is purified in water pools, the most complicated task is the liquidation of all surface-active agents and specifically of nonionic surfactant (NAEI).

In aquatic environment (SAS), the surface-active substances are polarized and adsorbed. Then they create a new surface with specific physical and chemical characteristics that practically are not taken into account during the purification cycle. First, these parameters are important during the filtering process through the sorbent and at the concentration calculation of the mentioned substances in the water solution under analysis.

The preliminary research showed that at the recycling water supply system in water pools the nonionic active agents, which contain the ammonium nitrogen molecule return to the water pool and in the course of time they are accumulated in the water substance under analysis and they act as a “poison” for the sorbent surface. In this work, the reason for early efficiency reduction of the used sorbents was identified. As it is well known the sorption increases and the purification effect is higher if the aquatic environment contains the substances capable of changing the water surface tension and then a “positive adsorption” is observed.

During the experiment, the following substances were taken as the “working” agents for a standardized test solution:

I – is an anion surface-active agent Sodium Dodecyl Benzene Sulfonate (sulphanole) SDBS.
II – is a nonion active agent N-methylaminophenol (metol).

Among the sorbents that were used in the water purification system of the water pools under analysis the substances were isolated by means of the existing analytical methods that were adsorbed during the first and the second treatment cycles. The analysis results of the isolated substances showed that only 43-46% of sorbent surface were involved in the sorption process and the rest remained unused [1 - 4].
The organic substances that present the associations of molecules of nonionic and anion surface-active agents were isolated from the activated carbon. The content of these ballast substances did not change significantly (about 30%). That is why in the “purified” water that responds to normative regulations after the purification cycle the share of the ammonium nitrogen met the requirements (probably the free ammonium ions changed the form during the oxidation) and the used methods of chemical analysis could not isolate the substances under analysis.

The study of the physical qualities of aquatic environment in the water pools after the purification showed that the density, viscosity, surface tension (except the electrical conductivity) change according to the concentration growth of surface-active agents.

For the control, selection and further development of the most efficient technology of fresh water purification in water pools that would provide a stable normative water quality some variants of the filtrating substances improvement were analyzed [5,6]. In the result, it was suggested to use the modified natural mineral i.e. the silica clay from the Kamennoyarsky deposit of the Astrakhan region as a filtrating substance.

The experiment was carried out in the laboratory using the experimental set up of the purification facility with the capacity of 200 liters.

The scientists proved that the anion surface active agents having a high emulsifying and wetting abilities can be found in aquatic environment at an extreme low concentration and at the same time they can help reach the desired effect if the molecules of nonionic surface active agent (for instance, phenacetin homologues, metol or nonionic active agent N-methylaminophenol) will be added together with them. A lot of nonionic surface active agents also fulfil the function of the coloring substance in detergents [7].

Thus, the modern efficient detergents especially gels, shampoos obligatory contain the anion surface active agents (alkylsulfonates, alkylaryl sulfonates) and also the nonionic active agents in which molecules an aromatic nucleus (organic radical) obligatory exists and there is also the ammonium nitrogen that is connected with this nucleus as a substitute.

The water quality of four swimming pools in the city of Volgograd was taken as the real working data for this research.

These four swimming pools are united by several indicators:
- High water quality, low percentage of remarks from supervisory organizations during the period from 2013 to 2018;
- Use of high technologies in the water purification system; disinfection by means of ozone treatment;
- Recycling water supply (no more than 10% for an additional feeding);
- High share (40-43%) of the unused working resource of the filtrating substance (activated carbon or crushed coking coal of NWC type. This means that the filtrating substance is renewed or regenerated more often and consequently it results in the growth of water purification costs;
- Source water is the running water in the city of Volgograd;
- Water pool capacity (average number of people per year/m³).

Table 1. The results of the experimental set up use

| Water pool №1 | Chroma level (Cr-Co) | Sediment load [mg/l] | pH | Concentration of nonionic active agent [mg/l] |
|---------------|----------------------|----------------------|----|---------------------------------------------|
| Water pool №2 | 1                    | 2                    | 6.5| 1.6                                         |
| Water pool №3 | 2                    | 1                    | 6.8| 1.4                                         |
| Water pool №4 | 1                    | 2                    | 7.1| 2.0                                         |
| Standardized test solution 1 is presented | 0                    | 0                    | 7.2| 0.8                                         |
Various fractions tests of the suggested sorbent were carried out using the filtrating facility which diagram is shown in Figure 1.

The adsorbing facility was loaded from above. The content with the help of a rod was put into the adsorption tank as soon as the lacunas between the grids were filled. The adsorbing facility was dismantled and the sorbent was removed in an inverse order.

The filtrating of dirty water was carried out at the water pH = 7, 0.

The containing of a surface-active agent was calculated by gravimetric and photo colorimetric methods that were developed for this study.

In order to determine and study the hydraulic resistance $\Delta P$ of the sorbent layer, the pressure of one solution at the beginning and at the end of the filtrating process was recorded by manometer (3) and then the difference between the obtained values was calculated and analyzed.

![Figure 1](image-url) - Diagram of the experimental set up: 1 – pressure vessel with water; 2 - valve; 3 - manometer; 4 – adsorption tank; 5 – sorbent layer; 6 – volumetric vessel for the purified water; 7 – three neck flask; 8 – vacuum pump; 9 – U-type manometer.

In the research, the temperature influence on the filtrating process through the sorbent was studied.

The impact of the standardized (model) dirty water on the intensity of the filtrating process was studied at the height of the sorbent in the adsorption tank of 100 mm and at the same time, the standardized test solution with the concentration of 2, 5 and 10 mg/l was used. The specific flow rate of the adsorption tank was 6, 5 m³ / (m² hour). The study of the temperature impact of standardized test solutions and real existing dirty water on the intensity of filtrating process showed that at the reduction of the temperature the removal efficiency of nonionic surface agent (№1) and of the surface active agent in a real water solution (refer with Table 2) grows.
This situation can be explained by the fact that the electrophilicity of an ion active agent grows but the electrophilicity of a nonion active agent reduces. The situation is repeated when the interaction products of nonion active agent and anion surface active agent make out of the sorbent surface an inert substance and by doing this they reduce the chemisorption.

At the same time, the whole volume of the filtrating layer is used more fully but the purification efficiency reduces.

In addition, the provided data show that when the basic concentration of the pollutants (surface-active agents) and the fraction size grow the purification efficiency increases. At the temperature of 20°C, at the basic concentration of surface-active agent in the water up to 5 mg/l and the sorbent fraction size that does exceed 1.5 mm, the efficiency of water purification is higher than 95%.

### Summary

1. When the water of swimming pools and similar aquatic environment is purified, it is necessary to adjust the sorption process in the filtrating tanks taking into account the characteristics of the surface-active agent. The activated carbons and their combinations do not adsorb the nonionic surface-active agents.

### Table 2. Temperature influence on the purification degree at the rate of consumption 6.5 m³/(m²·per hour)

| Basic concentration of a surface active agent in the water C₀ [mg/l] | Size of sorbent fraction [mm] | 10 °C | 20 °C | 30 °C | 40 °C | 50 °C | 60 °C |
|---|---|---|---|---|---|---|---|
| №1 | №2 | №3 | №4 | №5 |
| 0.1-0.5 | 68.6 | 67.3 | 70.4 | 73.8 | 71.4 | 73.8 | 72.0 | 73.3 | 75.0 | 72.5 | 76.9 | 70.4 | 66.2 | 63.2 | 64.7 | 66.9 |
| 1.0-5.0 | 95.9 | 94.2 | 95.1 | 95.2 | 95.3 | 92.0 | 94.8 | 94.5 | 92.4 | 93.7 | 94.1 | 92.2 | 93.9 | 90.4 | 93.6 |
| 5.0-10.0 | 78.5 | 79.8 | 78.0 | 78.1 | 87.9 | 83.2 | 88.4 | 87.3 | 87.3 | 84.8 | 83.0 | 83.3 | 81.8 | 78.2 | 79.5 | 81.5 |

| №1 | №2 | №3 | №4 | №5 |
| 0.1-0.5 | 89.0 | 88.2 | 87.7 | 87.9 | 87.8 | 87.6 | 87.6 | 78.0 | 77.6 | 73.6 | 75.3 | 77.3 |
| 1.0-5.0 | 96.7 | 95.0 | 95.6 | 96.2 | 96.4 | 92.6 | 95.7 | 96.1 | 95.2 | 91.1 | 93.4 | 95.2 | 94.5 | 90.4 | 92.3 | 94.2 |
| 5.0-10.0 | 89.7 | 84.0 | 86.4 | 88.2 | 88.8 | 83.7 | 87.4 | 86.6 | 86.9 | 82.5 | 84.7 | 86.9 | 82.8 | 77.6 | 78.4 | 82.5 |

| №1 | №2 | №3 | №4 | №5 |
| 0.1-0.5 | 93.5 | 92.0 | 97.2 | 96.3 | 97.2 | 96.5 | 99.0 | 98.9 | 96.8 | 97.0 | 78.7 | 78.3 | 83.3 | 76.5 | 68.1 |
| 1.0-5.0 | 97.6 | 93.3 | 96.0 | 97.3 | 92.2 | 93.6 | 95.8 | 94.0 | 96.1 | 93.6 | 93.5 | 75.9 | 85.2 | 91.3 | 84.2 | 95.0 |
| 5.0-10.0 | 88.8 | 85.7 | 78.7 | 76.1 | 88.4 | 92.8 | 92.5 | 93.1 | 90.4 | 92.3 | 87.3 | 86.1 | 84.9 | 81.2 | 83.1 | 84.6 |

№ 1 - 4 standardized test solution: №1 – nonionic active agent (metol); №2 – anion surface active agent (sulfanole); №3 combination №1:№2 = 1:1; № 4 – real water solution taken from a pool, recycling period is 2. According to the concentration of a surface-active agent it was evaporated 20÷22; 47÷50; 100÷112 times.
2) The study of temperature influence of standardized (model) test solutions and real world dirty water on the filtrating process intensity showed that at the temperature reduction the efficiency of nonionic active agent removal grows

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