IOP Conf. Series: Materials Science and Engineering 463 (2018) 022050 doi:10.1088/1757-899X/463/2/022050

The Decision of Questions of Providing Drinking and Technical Water Supply in Cottage Construction at Implementation of The Principles of Complex Resource-Saving Systems

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Abstract. The energy efficiency of the use of complex resource-saving systems, including heat pump technological schemes with batteries, is substantiated, while implementing the principles of "smart home" in cottage construction. The peculiarity of the proposed technologies is the solution of the issue of drinking and technical water supply within the framework of a single hybrid system of resource provision of a residential building. The proposed technical solutions are tested for the conditions of the southern regions of the European part of Russia.

1. Introduction

Currently, for the purposes of domestic and drinking water supply, surface water is mainly used. This situation is typical not only for Russia, but also for most European countries. The use of groundwater as a source of centralized water supply for a large settlement is often very problematic due to the limited groundwater resources and the need for huge capital and operating costs when creating a system of hundreds of water wells, the total flow rate of which can cover the drinking water needs of a large city. In addition, the operation of such systems will inevitably lead to subsidence of the earth's surface, an unacceptable decrease in the amount of surface runoff, and also a gradual increase in the degree of mineralization of groundwater as a result of rising water from deep aquifers. At the same time, taking into account the constant decrease in the quality of surface waters as a result of their contamination by insufficiently purified industrial and communal wastewater, rain and thawed sewage, toxic impurities leached from industrial wastes with their improper storage, other types of anthropogenic pollution, the prospect of wider use Groundwater for drinking water supply is becoming more attractive.

Also, when deciding on the use of groundwater, it should be borne in mind that only groundwater in the pressure aquifers is adequately protected from contaminants, overlaid by aged, weak permeable clay layers. In this case, groundwater contamination will be associated only with the unsatisfactory technical condition of the water intake well itself. Proceeding from the foregoing, it seems expedient to use artesian waters for the purposes of drinking and technical water supply for individual residential buildings.

Despite the above, proving the seemingly full validity and logic of the use of unified hybrid resource supply systems for cottage settlements and individual buildings for individual residential development, nevertheless, the issue of including drinking and technical water supply in these systems remains insufficiently developed, since the individual features of the chemical composition of potential sources of water supply directly affect the technical and economic performance of systems in general and unified recommendations for optimism ation process water treatment circuits is not developed up to the present time.

2. Experimental part

The subject of the study described in this article is the optimization of the technological scheme of water preparation for the purposes of drinking and technical water supply of artesian waters of chloride-carbonate type, which are quite often encountered in the European part of Russia, in particular, the territory of the Rostov region, and the assessment of the economic effectiveness of their inclusion in hybrid building resource management system. The validity of the technical decisions taken during the development of the technological scheme was tested using the example of real natural water of an artesian well located on the territory of the Rostov Region, whose chemical composition is given in table 1.

Table 1. Water chemical composition of technical water supply source.

Index	Value	Index	Value
Color, degree.	28	Concentration of chlorides, mg / l	27
Transparency, cm.	1,9	Aluminum concentration, mg / l	0,14
Total hardness, mEq / l.	8,9	Concentration of iron, mg / l	0,85
Total alkalinity, mmol / l.	11,2	Concentration of nitrites, μg / l	5,64
Total mineralization, mg / l.	786	Concentration of manganese, μg / l	0,28
Dissolved oxygen, mg / l.	7,8	Concentration of zinc, μg / l	0,021
The pH value, units. pH.	7,4	Concentration of sodium, mg / l	64
Concentration of calcium, mg / l.	154	Concentration of potassium, mg / l	2,07
Concentration of magnesium, mg / l.	31	Sulfate concentration, mg / l	73
Ammonia concentration, mg / l.	0,26	Concentration of silicon, mg / l	5,6

Taking into account previous studies [1,2] based on the presence of elevated Fe^{2+} concentrations in the waters of artesian wells in the water treatment technological scheme, a de-ironing unit must necessarily be provided, since residual iron concentrations in drinking water are strictly normalized and should be less than 0.03 mg / l. The most acceptable option for removing iron from artesian water from the point of view of operating costs and minimizing the volume of reagents dosed into the water to be treated is the application of the aeration method, which allows the ferrous iron to be converted into a trivalent one and then precipitated in the form of colloidal compounds.

In Fig. 1 shows the technological scheme of water treatment, including deironing unit, installation of ultraviolet irradiation, cartridge fine filter, nanofiltration and reverse osmosis units.

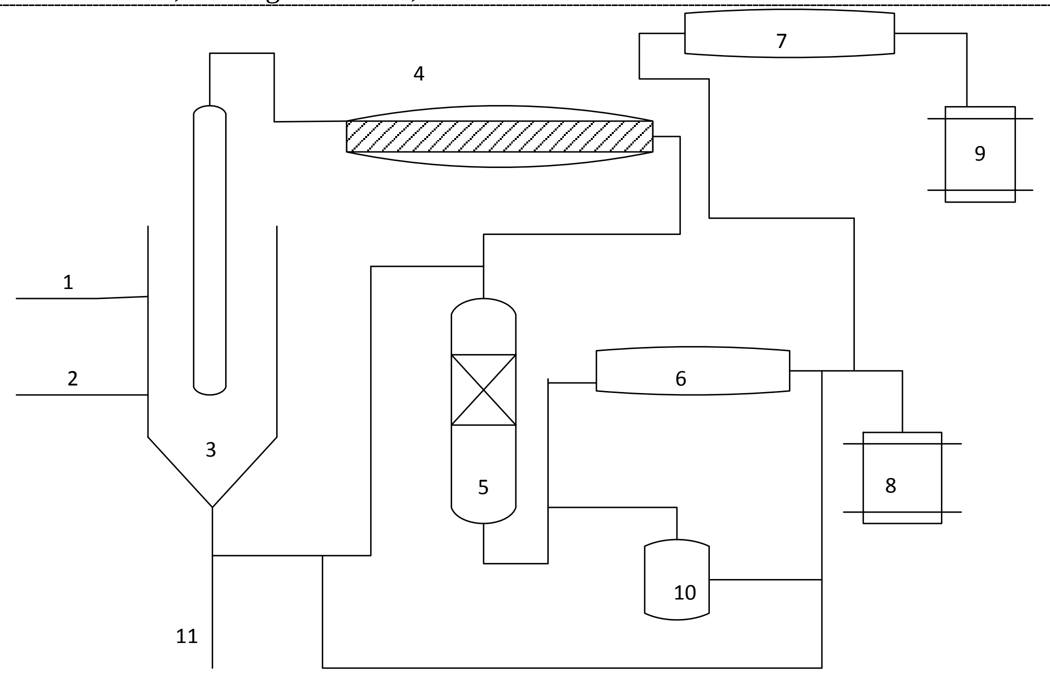

Figure 1. 1 - supply of artesian water for treatment; 2 - air supply from the blower; 3 - deironing site; 4 - installation of ultraviolet irradiation; 5 - cartridge filters for fine cleaning; 6 - installation of nanofiltration; 7 - installation of reverse osmosis; 8 - pot of drinking water; 9 - tank of water reserve for feeding the open-type heating system; 10 - unit for preparation of reagents for regeneration of membrane modules; 10 - discharge into sewerage network.

The deferrization unit is an aeration column designed for a twenty minute stay in the treated water. The air flow delivered by the blower to the bottom of the aeration column is about 2.5 - 3.5 l / m3 of treated water. The released colloidal iron precipitates in the lower conical part of the plant with a periodic discharge into the sewerage network.

Ultraviolet irradiation, provided that the supplying water supply networks are completely tight, has significant advantages over the reagent methods of water disinfection in terms of compactness and ease of operation of the plant. In addition, the use of chlorine and its derivatives for disinfection requires the observance of special conditions for the operation of chlorination plants and compliance with safety requirements. Cartridge filters for fine cleaning are designed to remove residual concentrations of colloidal compounds. Reduction of mineralization of water for domestic and drinking purposes is carried out with the help of a single-stage nanofiltration plant. Nanofiltration membranes can remove stiffness cations almost completely and reduce the concentration of monovalent ions by more than 70%. Since such a reduction in residual concentrations can be excessive, negatively affecting the taste qualities of drinking water, the bypass scheme is provided in the process flow, which allows to optimize the degree of mineralization of drinking quality by passing a part of the water flow past the nanofiltration plant.

To feed heating system, an additional water treatment installation for a single-stage reverse osmosis, to successfully remove monovalent ions of the water, which has a positive effect on reducing corrosivity aqueous medium and scale formation processes [3-8]. This additional processing unit is necessary to ensure the requirements for the quality of water supplied to make up water heating boilers and circulating in the heat network (Tables 2).

Table 2. Requirements for make-up water quality of hot-water boilers.

Water Quality Indicators	The value of the normative indicator
Concentration of suspended solids, mg / l	<5
Transparency in the "ring", cm	40
The value of the total hardness, mg-eq / l	not standardized
The value of carbonate hardness, mg-eq / l	0,5-1,5
Concentration of iron, mg / l	0,3
The concentration of dissolved oxygen, mg O_2 / l	0,03
Concentration of free carbon dioxide, mg / l	<3
The pH value, units. pH	7,0-8,5
Value of relative alkalinity,%	not standardized
The value of the dry residue, mg / l	<2000

In the technical and economic parameters of operation considered flowsheet influence temperature water to be treated, the initial concentration of salt, the concentration of iron ions and high molecular natural organic compounds present in water in a colloidal state [9-20].
The temperature of artesian waters can vary within wide limits. However, for the conditions under consideration, the temperature, as a rule, ranges from 5 to 12 ° C, which is due to local climatic and hydrogeological conditions. This temperature is far from optimal values for conducting reagent deposition of colloidal compounds, but since we abandoned this variant of colloid removal, the temperature factor is not a limiting factor. For water treatment on nanofiltration and reverse osmosis membranes, this temperature range is acceptable.
The performance of the nanofiltration plant depends on the salt content and the concentration of colloidal impurities (3-6). The conducted studies have shown that the concentration of the main ions and microimpurities present in a truly dissolved state in a water source varies within a fairly wide range within a year. Accordingly, the efficiency of desalination of water will change not only during the filter cycle, showing a decrease in the efficiency of purification to its end, but also depending on the value of the initial salt content. In Fig. 2 shows the performance of the nanofiltration and reverse osmosis units according to the main indicators of the treated water. The technical and economic performance of the water treatment plant, depending on the characteristics of the source water, is given in the table 3.

Table 3. Experimental data of the water desalination process on a single-stage and two- cascade pilot reverse osmosis unit.

Indicators	Type of membrane	
	ECO-440	BW 30-400
The average value of the pH of the permeate	6,95	6,91
Average value of permeate salt content	180	120

This technological scheme is different in that it allows to minimize capital and operating costs due to the fact that only a part of the estimated water discharge is subjected to desalting. The used membranes allow not exceeding the maximum permissible concentration limits after mixing of the initial and desalted water. In addition, the secondary processing of the concentrate, which is about 15% of the flow of water entering the reverse osmosis unit, makes it possible to reduce the total discharge of waste waters by almost half. As reverse-osmotic membranes of the pilot plant, Dow Filmtec membranes manufactured by Film Tec Corporation (Dow Chemical, USA) ECO-440 and BW30-400 were used, characterized by a perfect structure that minimizes the supply of total organic carbon to the purified water, which is especially important in the preparation water of drinking quality.In addition, membranes of this type, capable of operating even at low operating pressure, are characterized by resistance to chemical contamination and durability.

3. Conclusions

The developed and approved technology of processing artesian waters has the following advantages:
1. In the operation of the unit, no precipitation forms, requiring dehydration and disposal.
2. All wastewater generated during the operation of the unit is to be taken to the municipal sewerage network - they have a neutral pH and do not require the creation of additional technological units for their neutralization and decontamination.
3. Purified water before the installation of reverse osmosis is multi-stage cleaning, which avoids the complications typical for operation of baromembrane plants with insufficient pre-cleaning.
4. The node for the preparation of drinking water and additional water for the heat supply system are autonomous, which significantly increases the reliability of the installation as a whole.

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