Commissioning of Water Treatment Facilities in Rural Areas

A M Sargsyan, N A Ilyin, M S Drondin

1Samara State Technical University Architecture and Civil Engineering Academy, 194, Molodorogvardeyskaya st., Samara, 443001, Russia

E-mail: ashotu@mail.ru

Abstract. This article raises the problem of providing rural residents with drinking quality water and routing the water supply network. It is advisable to install a centralized water supply system. In view of the existing structure of the territories of rural settlements, cramped conditions and numerous structures, the network will be laid in trays. There will be two pipelines in the trays. One pipeline will be used for household and drinking needs, the other for irrigation of green spaces. The article discusses the technological scheme of the existing treatment facilities, and the technological scheme of the projected treatment facilities, and also presents the layout of the treatment facilities.

1. Introduction
The problem of providing rural residents with drinking quality water using a centralized system remains urgent. In most cases, residents of rural settlements use their own wells, bringing the water quality up to the required indicators. Often, the quality of the source water is so unsatisfactory that its purification becomes unreasonable and economically unjustified.

2. Problem specification
So, in some rural settlements of the Samara region, groundwater, in addition to chemical components, contains microbiological contamination. This is mainly due to the widespread use of unequipped and not isolated cesspools. Such water, even after passing through proper purification, is not suitable for drinking purposes. In view of the current problems, it becomes expedient to set up centralized water supply and sewerage systems in rural settlements.

In cases of presence of microbiological indicators in groundwater, such water is also not suitable for irrigation of personal plots, vegetable gardens and flower beds.

At the design stage of water treatment facilities and a water supply network, the following difficulties can be encountered:
- the operation of treatment facilities must be flexible in terms of their productivity, mainly in the range from 20 to 100% of the design capacity, because it is impossible to perform a one-time connection of all water consumers, and the design and construction of several stages of water treatment facilities is not expedient and economically unprofitable;
- due to the cramped conditions, the layout of the water treatment facilities with all auxiliary buildings and structures requires detailed study;
- routing of the water supply network is also extremely problematic, due to the existing structure of the territories of rural settlements, cramped conditions, numerous communications and structures with an unidentified property right (illegal seizure). Thus, the unauthorized expansion by residents of their...
sites and buildings on them of various structures leads to difficulties arising at the design stage, namely, in the course of engineering surveys, tk. prospectors sometimes cannot examine a closed area even for the presence of various communications and cesspools. In the course of construction, the Administrations of rural settlements for the purposes of possible laying of various communications or building / increasing the road surface, are carrying out procedures for the withdrawal of illegally fenced and used territories. [1, 2, 3, 4, 5]

3. Discussion
Consider the option of water supply to a certain rural settlement located in the Samara region (figure. 1). For the purpose of obtaining water of drinking quality, as well as water for irrigation purposes, it was decided to use the water of a surface water body (the right bank of the Volga river).

![Figure 1. Map-scheme of the location of the designed object.](image)

Currently, the rural settlement has a treatment plant with a centralized water supply. According to the documents, the water supply network performs the functions of a combined drinking and firefighting water supply (Figure 2).

![Figure 2. Technological scheme of existing treatment facilities.](image)

The work of treatment facilities is carried out as follows: source water from underground sources is taken using underground water intakes. Further, the water is directed into two successive reservoirs that serve as a settling tank. There is no mechanized drainage of sediment from the tanks. Water from the reservoirs is directed to the pumping station, from where it is pumped to the water tower and then distributed through the water supply network of the village.

In order to bring the quality of the source water to the required requirements, water treatment facilities with a capacity of 8000 m³ were designed with the prospect of development. The layout of the treatment plant is shown in figure. 3 and 4. [6,7,8]
Figure 3. Projected water treatment facilities (fragment 1 (top view)).

1 - pumping station with frequency converters (4 slaves, 2 cut); 2 - two-section receiving chamber (2 pcs); 3 - Two-section clarifiers with a layer of suspended sediment (3 pcs); 4 - fast filters (4 pcs); 6 - pumping station for pumping water from clean water tank to water tower; 8 - mechanical dehydration workshop; 9 - hydrocyclones (2 pcs); 10 - blowers (1 slave, 1 cut); 12 - reagent facilities (coagulant); 13 - reagent facilities (sodium hypochlorite); 14 - reagent farm (floculant)

Figure 4. Projected water treatment facilities (fragment 2 (top / side view)).

1 - pumping station with frequency converters (4 slaves, 2 cut); 2 - two-section receiving chamber (2 pcs); 3 - Two-section clarifiers with a layer of suspended sediment (3 pcs); 4 - fast filters (4 pcs); 6 - pumping station for pumping water from clean water tank to water tower; 8 - mechanical dehydration workshop; 9 - hydrocyclones (2 pcs); 10 - blowers (1 slave, 1 cut).
Figure 5. Technological scheme of the projected water treatment facilities.

1 - pumping station with frequency converters (4 work., 2 res.); 2 - two-section receiving chamber (2 pcs); 3 - two-section clarifiers with a layer of suspended sediment (3 pcs); 4 - fast filters (4 pcs); 5 - clean water tank (2 pcs); 6 - pumping station for pumping water from clean water tank to water tower; 7 - water tower V = 300m³; 8 - mechanical dehydration workshop; 9 - hydrocyclones (2 pcs); 10 - blowers (1 work, 1 cut); 11 - reservoir - averaging; 12 - reagent facilities (coagulant); 13 - reagent facilities (sodium hypochlorite); 14 - reagent farm (flocculant); 15 - storage well.

So, the source water through the supply pipelines with the help of the pumping station 1 is supplied to the receiving chamber 2, which serves as a contact reservoir and an air separator. The number of sections of the receiving chamber is 2. Into the receiving chamber 2, a uniform return of circulating water (pre-purified wash water) is provided, as well as the introduction of a chlorine-containing reagent (primary chlorination with sodium hypochlorite) and a coagulant (aluminum oxychloride). Further, the water enters the clarifiers with a layer of suspended sediment 3. In view of the low turbidity and color of the source water, a corridor-type clarifier with a suspended layer of recirculated sediment was adopted for the calculation. The supply of sludge from clarifiers 3 is provided in an intermediate tank, from where it is taken to the line of the mechanical dewatering shop 8. An automatic screw dewatering device is provided as the main equipment. To ensure the process of sludge dewatering, a flocculant is introduced into the treated sludge. For the preparation and supply of the flocculant solution, a complete automatic station for the preparation of the reagent solution is provided.[9,10]

As the second stage of purification, single-layer high-speed filters 4 were adopted, loaded with crushed expanded clay with the following parameters: grain diameter 0.5-1.2 mm, equivalent grain diameter 0.7-0.8 mm, load heterogeneity coefficient 1.8-2.0, the height of the loading layer is 0.8 m, the filtration rate in the normal mode is 6.0-7.0 m / h, the forced mode is 7.0-9.0 m / h. The supporting layer h = 0.5 m is planned to be made with 20-40 mm gravel.

Then the water enters the clean water tank 5, from where it is fed by gravity to the pumping station 6, which pump water into the water tower 7. The water supply network in the rural settlement is looped (figure. 6).
Figure 6. Tracing the water supply network of a rural settlement.

The water supply network is represented by a loop-back united utility-drinking and fire-fighting water conduit, as well as a separate loop-through water conduit with technical water for irrigation needs of personal plots, vegetable gardens and flower beds.

The supply of the village with irrigation water is ensured by re-equipping the existing treatment facilities for a maximum water consumption of 5000 m³ (Figure 8):

Figure 7. Technological scheme of the designed technical water supply system for irrigation needs. 1 - pumping station of the 1st rise; 2 - 1st stage settling tank; 3 - stage 2 settling tank; 4 - pumping station of the 2nd rise; 5 - water tower V = 50 m³

On the territory of the water treatment facilities (Fig. 7) there are two water towers: one for supplying combined household drinking and fire-fighting water (V tank 300 m³) - existing, the other supplies water for irrigation needs of the population (V tank 50 m³) - designed. Water used for irrigation needs is taken using a pumping station of the 1st lift 1 before entering the treatment plant into the existing sedimentation tanks 2 and 3, from which it is taken by the pumping station of the 2nd lift 4, pumping water into the water tower 5. As a result cramped conditions, when laying the water supply network, it was decided to install it in reinforced concrete trays. Since the water supply of the village is assigned to the 1st category, the water supply network is looped to increase the reliability of the water supply. Water supply chambers are installed around the entire ring. Cameras with fire hydrants are installed at the intersection of streets, and intermediate cameras are installed between the streets to connect nearby consumers. Shut-off butterfly valves and check valves are installed in each chamber. Drainage wells were installed across one street next to the cameras to empty the network.[11,12,13,14].

4. Conclusions

1. In the construction of water treatment plants and water mains in rural areas with established infrastructure and cramped conditions, one has to resort to a reduction in the minimum distance between the newly constructed facilities and communications.
2. It becomes expedient to amend the regulatory documents in terms of the requirements of the laying of the linear part of the object.

3. Commissioning of water treatment plants is only possible after connection of the minimum amount of water users in accordance with the production capacity of treatment facilities themselves.

5. References
[1] Sargsyan A M, Ilyin N A, Averyanov D A 2019 IOP Conference Series: Materials Science and Engineering, Surface wastewater purification from emulsified and dissolved organic pollutants with the city of samara as an example (Samara) Samara: IOP Publishing Ltd p 012097
[2] Strelkov A K, Stepanov S V, Teplykh S Yu, Sargsyan A M 2016 Procedia Environmental Sciences, Monitoring Pollution Level in Railroad Right-of-Way (Samara) Vol 32 pp 147-154
[3] Palagin E D, Strelkov A K, Pavluhin A A 2019 IOP Conference Series: Materials Science and Engineering, Rainfall parameters for the design of surface water treatment facilities (Samara) Samara: IOP Publishing Ltd p 012094
[4] Palagin E D, Gridneva M A, Bykova P G 2019 IOP Conference Series: Materials Science and Engineering, Determination of design layer of rainfall for design of treatment facilities of surface runoff (Chelyabinsk) p 044022
[5] Strelkov A K, Teplykh S Yu, Bukhman N S 2017 Vide. Tehnologija, Resursi - Environment, Technology, Resources : Environment. Technology. Resources - Proceedings of the 11th International Scientific and Practical Conference, Railway natural industrial complexes and their impact on waterbodies (Rezekne: Rezekne Academy of Technologies) pp 284-289
[6] Omarova A, Kalishev M, Dosmagambetova R 2019 International Journal of Environmental Research and Public Health. Water supply challenges in rural areas: A case study from central Kazakhstan Vol 16 5 688
[7] Ahsan M S, Akber M A, Islam M A 2017 Monitoring bacterial contamination of piped water supply in rural coastal Environmental Monitoring and Assessment Vol 189 11 p 597
[8] Shygonskyy V 2017 Advances in Intelligent Systems and Computing Determining prospects of european countries’ positive experience implementation into the water consumption process in (Ukraine) Vol 543 pp 723-733
[9] Pchelnikov I V, Fedotov R V, Breus S A 2020 IOP Conference Series: Materials Science and Engineering : International Conference on Construction, Architecture and Technosphere Safety, ICCATS 2020 On the choice of the water treatment technology for rural areas (Sochi) p 042083
[10] Alekseev S 2018 MATEC Web of Conferences : electronic edition (Irkutsk) The introduction of resource-saving technology in water treatment plants (Irkutsk: EDP Sciences) p 01002
[11] Volkova O I, Zolotukhina N A, Zolotukhin V M, Yazevich M Y 2020 IOP Conference Series: Earth and Environmental Science : Current Problems and Solutions, Yurga Influence of Water Treatment Plants on the Ecological Situation in Industrialized Regions (Yurga) p 012012
[12] Nikolaev N V, Avramenko O N, Sakalo L A 1992 Chemistry and technology of water Increase in specific capacity of small water-treatment plants Vol 14 11 838-846
[13] Khafizov F Sh, Afanasenko V G, Khafizov I F, Khairakhanov A Sh 2008 Main treatment ways of manufacturing water on the local plants Russian Journal of Applied Chemistry Vol 81 9 pp 1697-1698
[14] Panteleyev A A, Ryabchikov B E, Zhadan A V, Khoruzhii O V 2012 Design solutions for water treatment plants constructed on the basis of membrane technologies Thermal Engineering Vol 59 7 pp 517-523