Analysis of water supply sources in Kormilov district of Omsk region

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Abstract. The article describes the sources of water supply in Kormilovka district of Omsk region. The main sources of water are surface waters of the Om and Taburga rivers, lakes and artificial reservoirs, groundwater. In general, the territory of Kormilovka district lacks fresh groundwater. Currently, water is supplied by hydraulic structures on the Om river as part of water intake and treatment facilities, water pipelines and a pressure distribution network. Water supply from underground sources is carried out from tubular wells with a depth of 5.0 - 9.0 m, from wells with a depth of 200 m and deep-water wells of about 1100 m. Water intakes from underground sources are available in almost all rural settlements, but they are used for technical and (or) economic purposes. An ecological assessment of the state of surface and underground sources is provided. The results of an analysis of the geological and hydrogeological situation are presented. Of greatest interest are Neogene-Quaternary, Upper Oligocene-Lower Miocene and Lower Upper Cretaceous (Pokursky) complexes. According to the generalized characteristics of quality of groundwater from three underground aquifers in Kormilovka district, the most acceptable is the Pokursky aquifer, since its groundwaters are less mineralized, softer, more protected, and, consequently, their microbiological and parasitic indicators comply with the sanitary standards. When using both surface and groundwater for household and drinking purposes, it is environmentally safe for the population only after adjusting such indicators as turbidity, color, chlorine, iron, and dry residue content and bringing the microbiological indicators to SanPiN 2.1.4.1074-01 and SanPiN 2.1.4.544-96.

1. Introduction

Providing the population of Kormilovka municipal district of Omsk region with high-quality drinking water is an urgent and priority task, since its territory lacks fresh groundwater. For the majority of rural settlements, substandard groundwater is the only source of water supply. Due to the shortage of fresh water, the decentralized exploitation of groundwater from aquifers with a salinity of 2.5 g / l and higher is performed [1,2].

The need to solve water supply problems is typical for most districts of Omsk region. The networks and structures of the water supply system of Kormilovka district do not meet the standards which is the reason for the lack of household and drinking water.

The existing water treatment system does not meet SanPiN 2.1.4.1074-01. In accordance with the calculations of water consumption and the volume of water production, only Kormilovkasky (100%) and Bogdanovka (100%) are provided with water; other rural settlements are not provided with drinking water. These are: Alekseevskoe (0.94%), Borchanskoe (0.3%), Georgievskoe (37.56%), Pobeditelnoe (1%), Chernigovskoe (0.39%), Yurievskoe (0.34%).
According to the program "Provision of the population of Omsk region with drinking water" for 2004 – 2010, in 2006 local water treatment stations were built. Syropyatskoe and Kormilovka with a capacity of 10-15 m$^3$ of water per day made it possible to partially provide people with clean water.

In this regard, it is important to select a natural source for drinking water supply, as well as to assess the state of surface and underground sources taking into account sanitary standards [3,4].

JSC "Rodnik" assessed the surface and underground water resources of the Kormilovka district of Omsk region, analyzed the geological and hydrogeological, environmental, operational information and water quality of underground sources [http://mpr.omskportal.ru].

One of the largest regional works summarizing the accumulated material on hydrogeology is the "Regional (prospective) assessment of operational reserves of groundwater in the southern part of the West Siberian artesian basin" for 1971-1984.

In 1991, based on these works, the book "Resources of fresh and low-mineralized groundwater in the southern part of the West Siberian artesian basin" was published [3].

In 1995, based on the same materials, OJSC "Novosibirskgeologiya" compiled the "Map of groundwaters of Omsk region, M 1: 500,000", according to which there are eight wells in Kormilovka district for the lower-Upper Cretaceous (Pokursky) complex.

2. Research Methods

The territory of Kormilovka district lacks fresh groundwater. The main sources of water are:

- surface waters of the Om and Taburga rivers, lakes (163 ha) and artificial reservoirs (84 ha);
- underground waters.

Since the end of the 1970s, water has been supplied to Kormilovka district through group water pipelines supplying water from surface sources of the Om and Irtysh rivers. The northern part of the district, geographically located on the right bank of the Om river, was supplied from the Syropyats water intake. Water from the river was supplied by a pumping station. After purification, the water was collected in clean water tanks. Further, it entered the villages Alekseevka, Yuryevo, and Syropyatskoe.

Water supply to the middle part of the district, located on the left bank of the river was carried out from a group water supply system with a water intake from the river Om in Kormilovka.

Water supply to the southern part of the district (Pobeditel, Mikhailovka) was carried out from a group water supply system with a water intake from the Irtysh in Achair and deep-water wells.

At the end of the 90s, when the reform of the housing and agriculture system began, many pipelines were dismantled and plundered.

At present, water supply to Kormilovka District is provided by hydraulic structures consisting of groups of water intake and treatment facilities, water pipelines and a pressure distribution network.

Water supply from underground sources is carried out from tube wells with a depth of 5.0 - 9.0 m, from wells with a depth of up to 200 m and deep-water wells of about 1100 m.

Water intakes from underground sources are available in almost all rural settlements, but they are used for technical and (or) economic purposes.

3. Results and discussion

For the implementation of the regional target program aimed at providing the population of Omsk region with drinking water, the aquifers of the Neogene-Quaternary, Upper Oligocene-Lower Miocene and Lower Upper Cretaceous (Pokursky) complexes [5] are of interest.

The Neogene-Quaternary complex is the first from the surface. The underground waters are hydraulically interconnected and circulate in the zone of free water exchange. Low water availability and vulnerability from surface sources of technogenic pollution limit its use for centralized domestic drinking water supply. However, due to substandard groundwater below the underlying Upper Oligocene-Lower Miocene complex in the central and southern regions of the region, in order to solve the problem of alternative drinking water supply to the population, the study of water with a salinity of less than 2.0 g / l is an urgent task [6, 7].
The quality of groundwater extracted from wells capturing groundwater from this water-bearing complex within Kormilovka district is presented in Table 1 (according to the protocols of the Testing Laboratory Center for Hygiene and Epidemiology in Omsk Region, Kalachinsky District).

Table 1. Results of the test of water from well No. 20-0208 (Ignatievo, Yuryevsky) with a depth of 19.0 m and an interval of occurrence of the aquifer of 15.0 - 17.0 m (conducted by the laboratory of Omskoblvodoprovodon December 15, 2008)

| Indicator                     | Measurement results, mg/dm³ | Allowable values, mg/dm³ |
|-------------------------------|-----------------------------|--------------------------|
| Nitrates                      | 2.0                         | Not more than 45.0       |
| Nitrites                      | 0.2                         | Not more than 3.0        |
| Ammonia (nitrogen)            | 3.0                         | Not more than 2.0        |
| Chlorides                     | 485.0                       | Not more than 350.0      |
| Hardness                      | 25.0                        | Up to 7.0                |
|                                | Total ferrum                | Up to 0.3                |
| pH                            | 7.5                         | From 6 - 9               |
| Oxidizability                 | 9.8                         | Up to 5.0                |
| Dry remainder                 | 3883.0                      | Up to 1500.0             |
| Sulphates                     | 145.6                       | Up to 500.0              |

Groundwaters of the aquiferous Neogene-Quaternary complex on the watershed plains with salinity less than 1.5 g/l are locally distributed. They are neutral, in terms of chemical composition, hydrocarbonate or sulfate. 85% of the waters are hard (more than 7 mmol / l), 60% of waters have high oxidizability (more than 5 mmol / l) and high amount of dissolved oil products (more than 0.1 mg / l).

In general, the underground waters of the Neogene-Quaternary complex distributed within the watershed plains are characterized by an excess of the MPC for iron, manganese, oil products and nitrates.

The underground waters of the aquiferous Neogene-Quaternary complex are not protected from surface sources of pollution. But due to the unstable regime of centralized water supply or the lack of alternative sources, the water of this complex is consumed by the population. The quality characteristics for groundwater extracted from the wells of this aquifer is presented in Table 2.

Table 2. The chemical analysis of water of the Neogene-Quaternary aquifer in Kormilovka district, Omsk region

| Location of the well and its number | OKB, CFU in 100 ml | BMP, CFU in 1 ml | TCB in 100 ml | Odorat 20 deg. | Odorat 60 deg. | Brix, mg/dm³ | Chromaticity, chroma | Sulfates, mg/dm³ | Chlorides, mg/dm³ | Nitrates, mg/dm³ | Oxidizability, mg O₂/dm³ | Total mineralization, mg/dm³ |
|------------------------------------|--------------------|-----------------|---------------|----------------|----------------|--------------|---------------------|-------------------|-------------------|----------------|------------------------|-----------------------------|
| Yuryev (depth 6 m)                 | n/f                | 18              | n/f           | 2              | 2              | 0.74         | 2                   | 40                | 954.71            | 975             | 352                    | -                           |
| Pobeditel (5.5 m)                  | 28.0               | 37.0            | 28.0          | 2              | 2              | 4.37         | 15                  | 578.8             | 280               | 411.18                  | 9.6                         | 2150.0                    |
|                                  | 30.3               | 97.0            | 30.3          | 2              | 2              | 4.17         | 10                  | 393.8             | 250               | 372.84                  | 8                           | 2134.0                    |
|                                  | 22.0               | 33.0            | 22.0          | 2              | 2              | 3.79         | 10                  | 197.6             | 915               | 72.84                   | 6.4                         | 2729.0                    |
In Kormilovka district, groundwater is "motley" in terms of salinity (from 2.5 to 6.5 g / dm$^3$) and chemical composition. In some areas there are slightly saline waters with a mineralization of 2.5 - 3 g / dm$^3$.

The quality characteristics for groundwater extracted from the Upper Oligocene-Lower Miocene aquifer complex is presented in Table 3.

**Table. 3** The chemical analysis of water from well No. 5-375 drilled in the Lower-Upper Cretaceous (Pokursky) complex (interval 1071-1095 m and 1105-1120 m) in Spayka, Kormilovka district

| Na$^+$Kmg/dm$^3$ | Ca, mg/dm$^3$ | Mg, mg/dm$^3$ | Fe, mg/dm$^3$ | Clmg/dm$^3$ | SO$^-$mg/dm$^3$ | CO$^-$mg/dm$^3$ | HCO$^-$mg/dm$^3$ | NO$^-$mg/dm$^3$ | NO$^+$mg/dm$^3$ | NH$^+$mg/dm$^3$ | Total hardness, mmol/dm$^3$ | Dry remainder mg/dm$^3$ |
|-----------------|---------------|---------------|---------------|-------------|-----------------|-----------------|-----------------|----------------|----------------|----------------|-----------------------------|-------------------|
| 1               | 2             | 3             | 4             | 5           | 6               | 7               | 8               | 9              | 10             | 11             | 12                          | 13                |
| 1100.0          | 8.0           | 6.08          | 0.1           | 970         | 115             | 12              | 927             | 0.001          | 0.2            | 0.4            | 0.9                         | 2730              |

Physical properties: Color – 5$^0$; Transparency - 30 cm; Odor - 1 point; pH - 8.2, oxidizability - 5.12 mg $\text{O}_2$ / dm$^3$.

In the underground waters, there is an increased content of iron and manganese, and in soda waters containing sodium bicarbonate in the amount from several units to 990 mg / dm$^3$, there is an increased content of aggressive carbon dioxide.

The waters are hard, with a total hardness of 4.5 to 38.5 mmol/l. With a mineralization of more than 2.5 g / dm$^3$, without expensive preliminary water treatment, they are unsuitable for drinking, but, nevertheless, they are widely used by the population for watering cattle and industrial needs. Logging is carried out by single and (or) group wells.

In 70% of the surveyed water wells (within the Report of Omsk State Electric Power Station in 2000-2001), the content of oil products exceeds the MPC, the weighted average content is 0.16 mg / l. The total alpha and total beta activity, as well as the content of nitrates, nitrites, polyphosphates and pesticides comply with the requirements of SanPiN 2.1.4.1074-01 [8].

The underground waters have a high content of oil products.

The aquiferous Lower-Upper Cretaceous (Pokursky) complex is ubiquitous within the Kormilovka district.

The thick sandy-argillaceous stratum of the Pokurskaya suite is exposed at depths of 800 - 1000 m. The upper Cretaceous water-resistant clays of the Kuznetsov formations are found in the top, and the Lower Cretaceous water-resistant clays of the Kiyalinsky formations.

Water-bearing rocks are represented by an uneven alternation of sands, poorly cemented sandstones, silts, clays and silts. Both a rough alternation of these rocks and their thin interbedding with facial replacement along the vertical and horizontal are observed. Fine-fine-grained sands, sandstones and siltstones prevail. The upper part of the aquifer is most studied and exploited (Table 4); there are brief single data on the lower part.
Of three underground aquifers in, the most acceptable is the Pokurskyone, since these groundwaters are less mineralized, softer, more protected, and, therefore, their microbiological and parasitic indicators meet the sanitary standards.

Table 4. The chemical analysis of water of the Upper Oligocene-Lower Miocene aquifer in Kormilovka district, Omsk region

| Location of the well and its number | Yuryevo No. 68-376 (interval 90-100 m) | Pobeditel, No. 113-377 (interval 111-121 m) | Pobeditel, No. 30-382 (interval 93-103 m) | Chernigovka, No. 69-377 (interval 112-124 m) | Alekseevka, No. 27-377 (interval 97-109 m) |
|------------------------------------|----------------------------------------|------------------------------------------|----------------------------------------|------------------------------------------|----------------------------------------|
| pH / oxidizability, mg / l         | 7.4/8.64                               | 7.2/15.0                                 | 6.8/12.8                               | 7.8/4.64                                 | 7.0/7.84                               |
| Na+Kmg/dm³                         | 1622                                   | 857.5                                    | 1275                                   | 560                                      | 675                                    |
| Ca, mg/dm³                         | 306                                    | 96                                       | 86                                     | 106                                      | 82                                     |
| Mg, mg/dm³                         | 400                                    | 134                                      | 142                                    | 141                                      | 175                                    |
| Fmg/dm³                            | 0.13                                   | 2                                        | 4.2                                    | 0.1                                      | 0.1                                    |
| Clmg/dm³                           | 3440                                   | 1140                                     | 1720                                   | 680                                      | 990                                    |
| SO4 mg/dm³                         | 384                                    | 552                                      | 518                                    | 379                                      | 417                                    |
| CO3 mg/dm³                         | 0                                      | 0                                        | 0                                      | 0                                        | 0                                      |
| HCO3 mg/dm³                        | 495                                    | 393                                      | 470                                    | 748                                      | 545                                    |
| NO2 mg/dm³                         | 0.4                                    | 0.001                                    | 0.001                                  | 0.004                                    | 0.004                                  |
| NO3 mg/dm³                         | 2                                      | 0.2                                      | 0.6                                    | 1                                        | 0.1                                    |
| NH4 mg/dm³                         | 2                                      | 0.2                                      | 4.2                                    | 0.4                                      | 4                                      |
| Totalhardness, mmol/dm³            | 48.2                                   | 15.8                                     | 16                                     | 17                                       | 18.5                                   |
| Dryremainder, mg/dm³               | 6520                                   | 3040                                     | 4040                                   | 2310                                     | 2670                                   |

The weighted average content of the elements is presented in Table 5. In sanitary and bacterial terms, the underground waters are clean and healthy.

Table 5. The summary table of the microcomponent composition of groundwater of the main aquifers in Omsk region

| Aquifers                              | V   | Bi  | Al  | Cd  | Cu  | Cr  | Ni  | Pb  | Mn  | Fe  | Zn  | Co  | F   | Mo  | As  |
|---------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Neogene-Quaternary                    | 0.01| 0.01| 0.06| 0.001| 0.005| 0.002| 0.004| 0.004| 0.002| 0.004| 0.001| 0.002| 0.005| 0.005|
| Oligocene-LowerMiocene                |     |     | 0.05| 0.001| 0.003| 0.002| 0.004| 0.004| 0.002| 0.004| 0.001| 0.002| 0.005| 0.005|
| Lower-UpperCretaceous (Pokursky)      | 0.010| 0.010| 0.062| 0.001| 0.005| 0.003| 0.005| 0.004| 0.004| 0.002| 0.004| 0.001| 0.002| 0.005| 0.005|

The total microbial number (TMN) is not more than 50, and thermotolerant bacteria (TTB) are absent, which meets SanPiN 2.1.4.1074-01 [8].
High-pressure groundwater. Piezometric water levels, according to the measurements taken in the 1960-70s, were set at an altitude of +5 to +15 m, less often at +28 m. Due to intensive exploitation and depletion of the level, the spontaneous flow area has greatly decreased.

The water abundance is higher in comparison with the aquiferous Oligocene-Lower Miocene complex. Well flow rates are 5.9-30.5 l/s with a decrease of 11-44 m, specific flow rates are 0.2-1.5 l/s. The water permeability, which depends on the total thickness of sands (Plotnikov, 1983) varies from 230 to 1,450 m²/day with the sand filtration coefficient of 3 to 6 m/day.

The aquiferous Lower-Upper Cretaceous (Pokursky) complex is fed in the foothills of Altai, and the entire territory of Omsk region is a transit zone.

The underground waters of the aquiferous Lower-Upper Cretaceous (Pokursky) complex are chloride-hydrocarbonate sodium or sulfate-hydrocarbonate sodium, their salinity level varies from very slight to slight.

The waters are most often soft, with a hardness of 0.2 - 4.8 mmol/dm³, slightly alkaline and alkaline (8 - 8.4 pH), with a temperature of 18-32°C.

Hardness over 7 mmol/dm³ is typical of highly mineralized waters. Hydrogeologists explain the low mineralization and soda composition of the underground waters by

- the proximity of the feeding area (Altai foothills), where feldspar rocks are widespread (a source of alkalization of groundwater);
- the presence of glauconite, a natural water softener.

To the north of the 55th parallel, the content of manganese exceeds the MPC and reaches 0.28 mg/dm³. To the north of the Om River, a high fluorine content is observed everywhere, with a weighted average content of 3.5 mg/dm³, its maximum is - 20.8 mg/dm³.

Among chemical compounds, an increased concentration of ammonium (up to 26.8 mg/dm³ or 13 MPC) and oil products (up to 3.89 mg/dm³ or 38.9 MPC) was recorded. In general, with a normal weighted average iron content in neutral waters with a mineralization of more than 3 g/dm³, its concentration is more than 0.3 mg/dm³ (up to 3.1 mg/dm³).

According to the long-term observations of groundwater (Table 5), it was found that the content of copper, manganese, iron, arsenic slightly increased. These changes, except for the content of fluorine and petroleum products, did not affect water quality. During the operation of the field, a regular increase in the concentration of copper, manganese, iron, zinc, fluorine and arsenic was observed.

The waters of this aquifer are safe.

Based on the results (Tables 1, 2, 3, 4) of studies, wells cannot provide the population with drinking water due to the substandard nature of a number of indicators, especially the content of total water salinity. Water treatment associated with desalination is unlikely to be in demand by the population due to the high energy consumption and water costs.

Water supply to the territory of Kormilovka district should be divided into three zones, depending on the possibilities of providing the population with water according to the optimal ratio of water quality and water consumption.

The northern part of the district, located on the right bank of the river can be provided with water from the Syropyat water intake. To meet the needs of the population for water, it is necessary to modernize the existing water intake from the river and restore the pressure distribution network of water pipelines.

To supply water to the middle part of the district, located on the left bank of the river to Novorossiyka, it is necessary to take water from group water pipelines with a water intake from the river Om in Kormilovka. The design capacity of the existing water intake system is 3.2 thousand m³/day. The water intake capacity is about 1.0 thousand m³/day, which is about 30% of the design capacity. The existing water intake in Kormilovkakan meets water demand of the population of the middle part of the district. For the long-term operation of the existing water intake, it is necessary to improve the water purification technology, to reconstruct the distribution unit, to partially replace sections of the water conduit and restore the pressure distribution network.

To supply water to the southern part of Kormilovka district, where small dispersed water consumers predominate, it is advisable to use the underground waters of the Lower Upper Cretaceous
(Pokursky) complex as an alternative, if it is impossible to provide settlements with a water supply network from a surface source.

4. Conclusion
In order to conserve the resources of underground aquifers, it is necessary to ensure protect groundwater from pollution, equip sanitary protection zones near wells and liquidate inactive (abandoned) wells [9,10]. Since the use of any water supply source requires additional water purification, it is necessary to find a technology for its purification, bringing it to SanPiN 2.1.4.1074-01 [8].

5. Acknowledgments
The research was carried out using the equipment of the Center for Collective Use of Omsk State Agrarian University "Agricultural and technological research".

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