Water supply of Azovsky Nemetsky (German) National District in the Omsk Region: present-day situation, problems and outlook

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Abstract. The article deals with the problem of drinking water supply to population. The water supply sources of Azovsky Nemetsky (German) National District of the Omsk Region are characterized in the research. The Irtysh River is the main source of drinking water supply. In general, the studied district is situated in the territory with a shortage of fresh groundwater. Currently, the water supply to Azovsky Nemetsky (German) National District settlements is provided by a complex of hydraulic constructions of the Lyubino-Isilkul and Tavrichesky group water conduits. These pipes take water from the Irtysh River as part of water intake and treatment facilities, water pipelines and a pressure distribution network. In addition to the generally accepted water supply from the group water conduit we define the aquifers of the lower Miocene deposits of the Abrosimov (N1 ab) and upper Oligocene deposits of the Zhuravsky suites (P3 zr) with water mineralization from 1.3 to 5.4 g/l. as the most potentially productive in the period of increasing anthropogenic load within Azovsky Nemetsky (German) National District. In case of their usage for drinking water supply the technology of demineralization is recommended.

Keywords: group water conduits; surface and underground water sources; ground water aquifers.

1. Introduction
The major objective of this study was to analyze the present-day situation within the water supply in the settlements of Azovsky Nemetsky (German) National District. The findings are important for working out the federal programme "Clean Water" and special programs for the Omsk region. The problem of clean water has become a central issue not only for the Russian Federation but also for the European countries. For example, in 1998 the Council of the European Union established Council Directive 98/83/EC on the quality of water intended for human consumption. According to this document and the amendments to it in 2003 the European water policy addresses these issues through a series of legislation acts that take different approaches for solving the problem.

2. Problem Statement
Providing the population of Azovsky Nemetsky (German) National District of the Omsk Region with quality drinking water is an increasingly important and priority concern, since its territory is situated in
the place with a shortage of fresh groundwater. The water from the Irtysh River does not meet the requirements of SanPiN (Sanitary Rules and Regulations in Russia) 2.1.4.1074-01 "Drinking water" in a number of indicators [1].

Azovsky Nemetsky (German) National District sits on the left bank of the Irtysh River in the south steppe zone to the south-west of the Omsk region. It consists of eight rural settlements. According to its geomorphological characteristics the territory of the district is mainly confined to the Ishim neogene-quaternary denudation-accumulative plain with a morphostructure of a low lake plain. Only the northeastern part of the territory lies in the modern alluvial plain of the Irtysh basin valley region.

There are no surface water sources within the territory Azovsky Nemetsky (German) National District. Also there is absence of explored groundwater deposits of drinking water. The hydrographic network is poorly developed. The area is characterized by a small development of lakes associated with suffosion-subsidence phenomena. The lakes are not deep with low gentle banks. They are subjected to degradation due to both natural-climatic and anthropogenic factors. Lakes nutrition is due to spring snowmelt, atmospheric precipitation and to groundwater, to a lesser extent. Lake Prishib is an example of such lakes.

The main source of water supply to the population of the district is the surface water of the Irtysh River.

Groundwater storage on the territory of Nemetsky (German) National District is calculated for aquifers of Neogene and Paleogene ages, with water mineralization of 1.5-5.0 g/l or more [2].

3. Materials and Methods

The object of the research is surface and underground water as water supply sources of Azovsky Nemetsky (German) National District in the Omsk Region.

In the study we used the data, collected by the private limited company “Rodnik”. The material is a result of synthesis and integrated assessment of water resources of the region, analysis of geological and hydrogeological, ecological, operational information, analyses of water quality of underground sources [3,4,5] and many others.

The investigation of the existing water supply system of settlements was carried out according to a specially developed programme including the method of questionnaire of water supply systems owners.

4. Results and discussion

The chemical composition and mineralization of the Irtysh River water along its entire length is of the same type. It is represented by hydrocarbonate calcium, less often sodium, very fresh waters with mineralization from 0.15 to 0.33 g/l. The Irtysh River water is soft. It has good drinking qualities, but it requires cleaning from pollution.

According to the Information Bulletins on the condition of surface water objects, water supply systems and constructions in the Omsk region the water balance of the Irtysh River is currently positive. These data were verified by Nizhe-obskoye Basin Water Governance and the Department of Water Resources in the Omsk region on the basis of materials from observation points. However, the annual increase in water withdrawal from the Black Irtysh in China can cause regular functioning of the Bukhtarma reservoir in the Republic of Kazakhstan. This will lead to reduction of waterways from the cascade of the Verkhne-Irtysh reservoirs, and, therefore, make problems with the water supply of the central and southern parts of the Omsk region [6].

The Annual Bulletin of the Omsk Region Government and the Ministry of Agriculture and Food of the Omsk Region reported that the Irtysh River water comes polluted (3A class) to the territory of Russia (cross section Tatarka) (Table 1).
The Irtysh River water is estimated as ‘polluted’ and ‘very polluted’ in the cross section near the borders of Omsk. From 8 to 9 of the 15 assessment indicators influence upon its pollution (an excess of TLV was observed). Reference contaminants of water are presented by hardly oxidizable organic substances (COD), easily oxidizable organic substances (BOD-5), compounds of iron, copper, zinc, aluminum, manganese, phenols. The recurrence of the number of threshold level value (TLV) exceedance for these indicators made 26-96%. For ammonium nitrogen and petrochemicals it made 5-8%. There were single cases of TLV in exceeding pesticides pp-DDE and gamma-HCCH. The critical indicator of water pollution was not defined [7,8].

In addition to the generally accepted water supply from the group water conduit we define the aquifers of the lower Miocene deposits of the Abrosimov (N1 ab) and upper Oligocene deposits of the Zhuravskiy suites (P3 zm) with water mineralization from 1.3 to 5.4 g/l. as the most potentially productive in the period of increasing anthropogenic load within Azovsky Nemetsky (German) National District.

Azovsky Nemetsky (German) National District is situated in the territory of a shortage of fresh groundwater.

In 1979, the Novosibirsk Geological and Search Expedition carried out work on a promising assessment of the operational reserves of the Omsk region groundwater. In accordance with previously developed projects for the water supply facilities in the Omsk region, Azovsky Nemetsky (German) National District is assigned to the southern hydrogeological region. According to the data of the ‘Information Bulletin on the State of the Geological Environment (Subsoil) in the Omsk Region’ it is not provided with fresh groundwater resources. Also there are no forecast groundwater resources for this district [9,10].

In the north-eastern part of the district the first aquifer from the surface is the lower-geogenic aquifer of the Pavlodar suite. Within the central and southern territories of the territory the top layer is represented by the lower-middle-upper-quaternary aquifers of the Karasuk, Smirnov and Sladkovodsky suites. In general the mineralization of these aquifers usually makes from 2 to 5 g/l.

Based on a joint decision of the Main Governance of Natural Resources and Environmental Protection of the Ministry of Natural Resources of Russia (No. 05-19/84 of 01.12.2003) and the

\[1\] TLV – threshold level value
Economic Committee of the Omsk Region (No. 14-07/4291 of 11.12.2003), the first aquifer is not a source of centralized water supply.

The territory of Azovsky Nemetsky (German) National District is located within the Irtysh artesian basin, which covers a vast territory in the south-west of the Siberian Plain.

The aquifer complex of the Nekrasov series (Oligocene, lower Miocene - P3-N1 nk) is a watered thick layer, characterized by sharp facial variability. It is composed of uneven layering of aleurites, sands, aleurite clays. The Nekrasov series includes deposition of the Abrosimov, Zhuravsky and Chertala suites. The depth of the watered thick layer top ranges from 23-135 metres depending on the topographical location.

Information on the boreholes in the territory of Azovsky Nemetsky (German) National District is presented in Table 2. It includes the data about the boreholes, drilled-in for water supply on different aquifers, on the example of Kuduk-Chilik village.

| No, borehole and year of construction | Cover thickness of base, m | Piezometric level, m | Discharge, l/s | Degradation, m | Total hardness of water, mg eq dm$^3$ | Chemical formula |
|--------------------------------------|--------------------------|---------------------|---------------|---------------|---------------------------------|-----------------|
| No8, 1976                            | 94                       | 5.0                 | 2.5           | 40.0          | 12.4                            | $M_{17} Cl_{48}$ $SO_2_{28}$ $HCO_2_{24}$ |
|                                      |                          |                     |               |               |                                 | $Na_{68}$ $Mg_{27}$ $Ca_5$ |
| No44-377, 1977                       | 123.0                    | 7.0                 | 0.56          | 50.0          | 15.6                            | $M_{42} Cl_{80}$ $SO_4_{11}$ $HCO_2_{9}$ |
|                                      |                          |                     |               |               |                                 | $Na_{78}$ $Mg_{16}$ $Ca_6$ |
| No25-368, 1968                       | 164.0                    | 7.0                 | 1.1           | 13.0          | 28.8                            | $M_{12} Cl_{63}$ $SO_4_{34}$ $HCO_3_{3}$ |
|                                      |                          |                     |               |               |                                 | $Na_{63}$ $Mg_{28}$ $Ca_9$ |

Due to the facial variability of deposits the aquifers of all layers are spread along the river flow and hydraulically interconnected. All groundwater, confined to layers, interlayers and lenses, in the deposition of the Nekrasov suite are subartesian. In most boreholes the piezometric level is set at depths from 4.0 to 18.0 metres.

Absolute reference points of the piezometric level vary within the borehole from 109.0 to 69.0 metres. Maximum points (over 100 metres) can be found to the western extreme of the Omsk Region.

The nature of the piezometric surface of the aquifer complex of the Nekrasov series within the region indicates that its saturation comes from the elevated edges of the Irtysh artesian basin. The groundwater is unloaded in the valley of the Irtysh River, where the overlapping clay thick layer of neogene is significantly eroded.

The aquifer complex is quite water-rich. Water discharge of boreholes ranges widely: with a decrease to 30 m from 0.8 l/s and to 3.3 l/s with a decrease to 40.0 m. The filtration coefficient of water-containing rock ranges from 0.045 to 2.8 m/day, but usually it does not exceed 1 m/day. The water temperature at the mouth is 5-8°C.

The mineralization of waters is marmorate, from 1.3 to 5.4 g/l. The coefficient of 2-4 g/l prevails. Mineralization increases with depth. The total water hardness varies widely - from 5.7 to 28.8 mg.eq. In terms of hardness, the waters can be moderately hard, hard and very hard. Very hard water usually prevails.

In most cases, the waters of the deposits of the Nekrasov series are not suitable for drinking due to the increased mineralization and high hardness.
According to the salt composition, the waters are mainly chloride and mixed – chloride-sulfate. The salt waters of chloride-sodium composition are typical for Azovsky Nemetsky (German) National District. A weighted average mineralization value is of about 4.0 g/l.

Continental deposits of the Pokurskaya suite in the territory of the studied district are widely spread. A distinctive feature of the underground waters of the suite is their thermal nature: the water temperature at the borehole mouth is from +27° to +32.2°C.

Water-containing rocks are light gray micaceous sands and slightly cemented greenish-gray sandstones, fine-grained sandstones. The total density of the rocks makes from 50 to 90% of the penetrated density of the suite.

The top of the water-containing rocks lies from a depth of 965 m; the base is at the depth of 1089 m; the penetrated thickness of the suite is 124 m. The underground waters are high-pressured. The piezometric levels are set above the ground surface (+ 30.0 - + 1.0 m). Water discharge of the boreholes varies from 9.4 to 22.8 l/s with level degradation of 23-35 m, respectively.

According to the chemical composition the waters have different formulae: from chloride to chloride-hydrocarbonate. Water mineralization changes from southwest (1.5-2.0 g/l) to northeast (up to 4.2 g/l). The groundwater is alkaline, soft, with total hardness from 0.6 - 4.6 mg-eq/l.

The underground waters of the deposits of the Kursk suite are important as a source of water supply (mainly economic), especially in the central and southern parts of the region.

The results of the study on the groundwater quality in the territory of Azovsky Nemetsky (German) National District show that wells and boreholes cannot provide the population with drinking water due to the quality discrepancy of a number of indicators, especially in terms of the content of total water mineralization.

Therefore, centralized water supply to the population of Azovsky Nemetsky (German) National District is carried out from the Irtysh River through the group water conduits (table 3): Lyubino-Isilkul group water conduit (LIGWC) and Tavrichesky group water conduit (TGWC).  

| №  | Name of settlement          | Group water conduit          |
|----|-----------------------------|-----------------------------|
| 1  | Azovsky settlement          | Northern branch of Tavrichesky GWC |
| 2  | Alexandrovskoye settlement  | Southern branch of Tavrichesky GWC |
| 3  | Berezovskoye settlement     | Northern branch of Tavrichesky GWC |
| 4  | Gaufskoye settlement        | Northern branch of Tavrichesky GWC |
| 5  | Zvonarevkutskoye settlement | Northern branch of Tavrichesky GWC |
| 6  | Prishibskoye settlement     | Southern branch of Tavrichesky GWC |
| 7  | Sosnovskoye settlement      | Lyubino-Isilkul GWC          |
| 8  | Tsvetnopolskoye settlement  | Southern branch of Tavrichesky GWC |

Water intake and treatment facilities of group water conduits are located on the Irtysh River: Lyubino-Isilkul group water conduit is in the village of Troitskoye, the Omsk region; Tavrichesky group water conduit is in the village of Kopeikino, the Tavrichesky District, the Omsk region.

Lyubino-Isilkul group water conduit (LIGWC) was built in 1973-1994. It is an onshore type water intake with a pump station of the first level rise. Water purification is carried out in horizontal desilt basin and in fast filters. The water is purified by chlorine. Main water conduits are made from steel pipes. Pressure increasing pump stations are located on water pipelines.

Tavrichesky group water conduit (TGWC) was built in 1971-1992. It includes water intake of onshore type with a pump station of the first level rise. The river water is treated with flocculant (polyelectrolyte VPK-402) on this stage. Then the water is taken to a pump station of the second level rise, where it is clarified in horizontal desilt basin and in fast filters. Simultaneously the water is purified.
by sodium hypochlorite. After that the water is taken to clean water reservoirs. Finally through the ultrasonic water meters “Irvikon SV-200” it is supplied by pumps via pressure water line D = 600 mm through two branches: northern and southern.

Water intake mouth of water intake facilities is usually filled with sand and silt. The last reconstruction of the water intake was carried out in 1991. The gravity lines were replaced by siphon lines. However, the pumping and power equipment is deteriorated without regular cleaning of the onshore well and mixer from sand and sludge. For stable operation of the water intake it is necessary to take measures for preventing further silting in the water intake area.

Existing water conduits, water supply networks and constructions of public water supply systems in the settlements of the studied district were built in the period of 1972 - 90.

The laboratory of Joint Stock Company “Omskoblvodoprovod” carries out the analysis of water quality before its entering the distribution network and the points of water intake. Water quality in the distribution network is controlled insufficiently.

Water supply networks, hydraulic and auxiliary constructions of water supply systems in the settlements of Azovsky Nemetsky (German) National District do not meet the requirements. This leads to the lack of quality drinking water in accordance with regulatory requirements for centralized and non-centralized drinking water supply systems.

One of the problems of water supply in the district is the condition of its networks. In the late 90s the reform of agricultural system and the housing and communal services began. The creation of new municipal structures and organizational disorder led to the situation when water supply networks were partly or completely dismantled. Currently, the state of the water supply and distribution network is characterized as unsatisfactory.

In the overwhelming number of settlements of Azovsky Nemetsky (German) National District there are no water storage reservoirs in case of emergencies or fire. Lack of water storage is unacceptable.

Water supply networks and constructions do not have sanitary protection zones.

5. Conclusion

The authors come to the conclusion that in order to guarantee water supply to the population and to improve the reliability of water supply facilities of Azovsky Nemetsky (German) National District of the Omsk Region, to achieve compliance with the parameters of drinking water quality with the established standards [1], it is necessary to carry out construction and reconstruction of:

1) new and functioning water conduct, distribution water pipe lines within the settlements;
2) water storage reservoirs according to the relevant legislation regulations in 16 settlements;
3) functioning pump stations with variable-frequency drive.

Sanitary protection zones (SPZ) should be arranged on all water pipelines for household and drinking purposes in order to ensure sanitary and epidemiological reliability.

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