PROSPECTS OF WATER SUPPLY WITH FRESH GROUNDWATER UNDER ANTHROPOGENIC IMPACT CONDITIONS

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ABSTRACT

The role of water resources at the present stage of human development becomes more and more significant every year and, actually, just the availability of water resources of required quality limits the further production force growth, city enlargement and the improvement of living standards and industry and agriculture development.

The water supply deficit reduction and the water supply level increase are some of the priority national objectives, which are also related to the international obligations of the Republic of Kazakhstan.

The prospects for fresh groundwater supply under anthropogenic impact conditions are given in the article for the water-stressed region as exemplified by Nur-Sultan city.

Currently, the centralized water supply of Nur-Sultan city is provided by supplying water from the Vyacheslav Water Reservoir on the Esil River, which under the existing population size, does not satisfy completely the city's water demand.

The problem of utility and drinking water supply in the capital becomes more acute due to the growth population and its economic activity and, increased impact on natural components and geosystems.

As a result of consolidation and analysis of the information on the anthropogenic impact as the most significant factor of change in the groundwater formation conditions, the article shows it's the negative impact on the fresh groundwater resource quantity and quality. It is noted that the main groundwater pollutants in the research area are the sewage ponds, domestic and industrial waste deposits of Nur-Sultan city, as well as the livestock breeding complexes, filtration fields and ash-disposal areas. According to the monitoring results, the areas of groundwater pollution have been identified in the zone of individual deposit influence.

Various methods of geophysical and geochemical surveys, as well as the Earth remote sensing methods are used to identify large pollution areolas and prospective areas for groundwater exploration.

The results of the integrated use of modern methods are shown, which increases the prospecting and exploration work efficiency. The specified prospects for fresh groundwater supply are especially relevant for water-stressed regions.

Keywords: *Groundwater, Hydrogeology, Water supply, Anthropogenic impact, Remote sensing data*

INTRODUCTION

Reducing the deficit of water resources and water supply level increase are among the priority objectives of the state-related inter alia to the international commitments of the Republic of Kazakhstan. In recent years, the problem of utility and drinking water supply to the capital of the Republic of Kazakhstan – Nur-Sultan city is becoming more and more critical. At present, centralized water supply to Nur-Sultan city is ensured by a supply of water from Astana water-storage reservoir on the Esilriver, which with the existing population does not fully cover present-day needs of Nur-Sultan city in water.

In 2010, to satisfy the capital's need in drinking water, the Ministry of Industry and New Technologies carried out exploration works and completed the revaluation of usable groundwater resources in Atbasarskoye, Atbasar-Priishymskoye, Nurinskoye and Rozhdestvenskoye deposits. In the long term (until 2040),to cover possible drinkable water deficit, it is necessary to envisage discovering of promising areas and sites in the territory of Akmola region, exploring groundwater on them and engaging additional groundwater resources within the explored territory with account to conditions of groundwater distribution and formation, rock water abundance, well output, water salinity within limits of aquifers and aquifer systems.

The issue of water supply to population, use of reserves and resources of good quality groundwater for supplying water to population centers is becoming exceptionally important due to growing year in year out water supply deficit with the account to human impacts and demographic factors. So, space-planes shown on Figure 1 are indicative of rapid growth of Kazakhstan capital – Nur-Sultan city, which is accompanied by the growing men-induced load upon the environment.

a) b)

Figure 1- Landsat image of city a) 2001 year, b) 2019 year

METHODS AND METHODOLOGY

Methods of geophysical and geochemical surveys. as well as the remote sensing method, are used to discover perspective areas to search for groundwater and large pollution areas [1], [2].

Extensive statistical, archived, published and library material of previously conducted geological, hydrogeological and geological-geophysical surveys in the territory of Akmola region was collected, processed and consolidated in the process of surveys, where, due to environmental and man-made factors, hydrogeological conditions significantly changed, change in aquifers and aquifer systems hydrogeological parameters occurred. As a result, corrections were made and groundwater deposits design hydrogeological parameters were adjusted with account to ecological changes in the natural environment and impact of human economic activity (anthropogenic loads) upon groundwater runoff.

To calculate operation capabilities of key aquifer systems and water-bearing horizons, extracts of their hydrogeological parameters were made (water abundance data, design and actual flow rates and decreases of groundwater bedding and piezometric level, water dynamic level fluctuations, water loss (gravitation and resilient), design distribution areas, thickness, duration of design life cycle, lithic characteristics etc.).

RESULTS AND DISCUSSION

Based on materials collected, preliminary collation of data of groundwater chemical composition was carried out, key regularities of chemical composition of groundwater in the first from the surface aquifer were established. Hydrochemical zoning is closely linked with hydrodynamic regularity, since the development and intensity of various hydrochemical processes occurring in groundwater are regulated by water flow dynamics and water exchange activity.

Main source of utility and drinking water supply and process water supply to the city of Nur-Sultan is the surface water of rivers and lakes located close to population centers.

Fresh groundwater is confined mainly to valleys of large rivers of the region – Esil and Nura, as well as to valleys of temporary streams and sites of ancient buried valleys. Formation of salinity and chemical composition of valley alluvial deposit interstitial water is predetermined by floodwater and precipitation chemical composition conditioning their main feed.

Interpretation of remote sensing data was performed to explore groundwater resources in valleys of rivers of Esil and Nura, and also on sites for groundwater artificial replenishment for water-supply to Nur-Sultan [3]. Cloudless fragments of satellite images Landsat-8for 2013 - 2016 were processed. To increase their information value, spectral transformations of source space images were carried out. To create a uniform coverage of the territory under study (figure 2), tiled data Landsat-8 for August 30, 2016, May 19, 2016, September 30, 2015, August 25, 2016 was made.

To reach the set hydrogeological objectives based on remote sensing data, composite images 7-4-2 and 5-6-4 were also used as well as normalized differential water index NDVI which is calculated as dependency of difference and sum of waves absorption indexes in green (0.53-0.59 μm) and near infrared spectral range (0.85-0.88 μm) of OLI sensor Landsat-8 satellite.

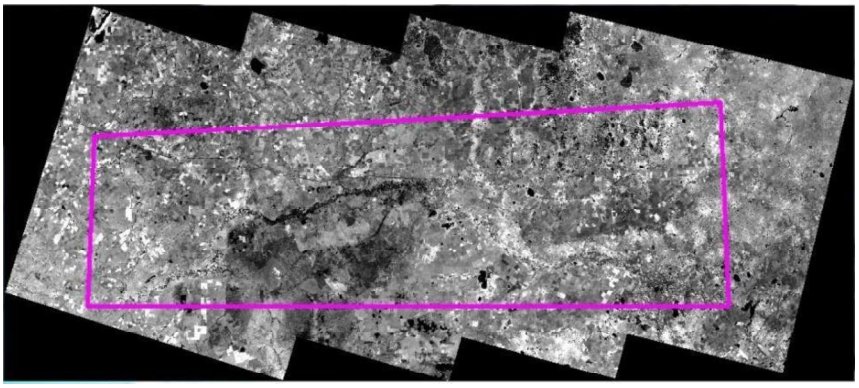


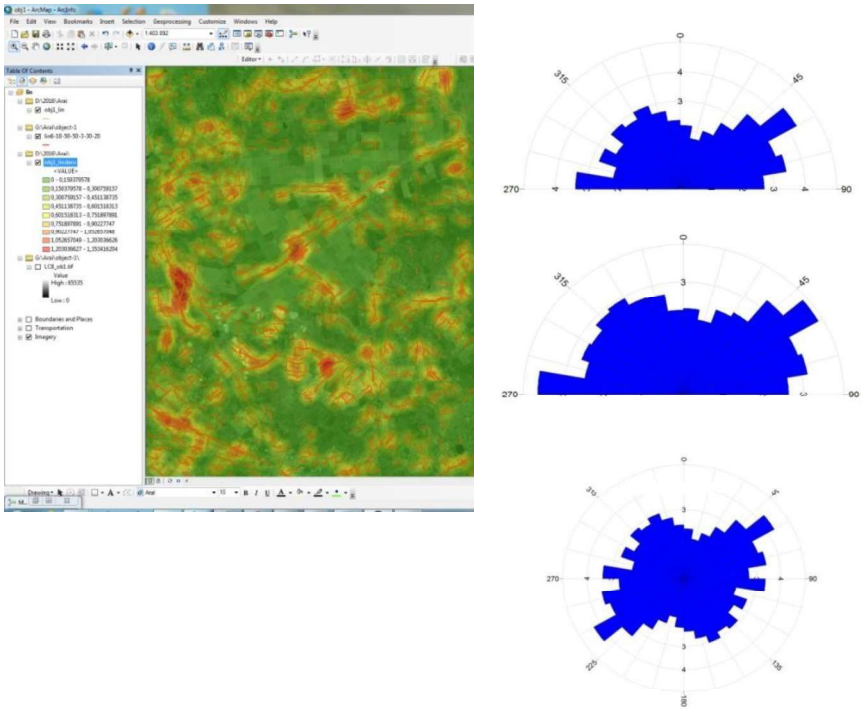
Figure 2 - Tiled data Landsat-8, Channel 6 - SWIR1 (560-1660 nm),

testing site №6 Akmola region

Taking into account that lineaments may indicate rock fracturing, Liniament Extraction procedure was applied. Calculations of small linear elements of distribution and orientation were made based on the texture of medium infrared channel SWIR-1 spectral range 1.56-1.66 μm. Display of the above deformation on satellite images is explained by the fact that the processes occurring at different lithosphere depth levels impact the super strata and predetermine peculiarities of day surface geology. On the terrain, lineaments are displayed by regularly aligned areas formed by straight-line boundaries or rectified sites of image texture. To exclude areas with contours representing evident linear sections from the

interpretation process, postprocessing of derived lineaments was carried out by linear objects editing.

As a result, lineaments density maps were made [4]. Figure 3 present a fragment of lineaments density map in the territory under study and diagrams of their directivity as an example.



a) *b)*

Figure 3 Lineaments map

a) Lineaments density map, b) Diagram of rock fracture direction in space images interpretation

Works results were used to confirm the prospectivity of areas discovered based on data of the Earth remote sensing, as well as sites for groundwater artificial replenishment for drinking water supply in Nur-Sultan.

The issue of utility and drinking water supply to the capital of the Republic of Kazakhstan – Nur-Sultan city is becoming more and more acute due to growing population, official statistics [5], [6] is given on Diagram (figure 4).

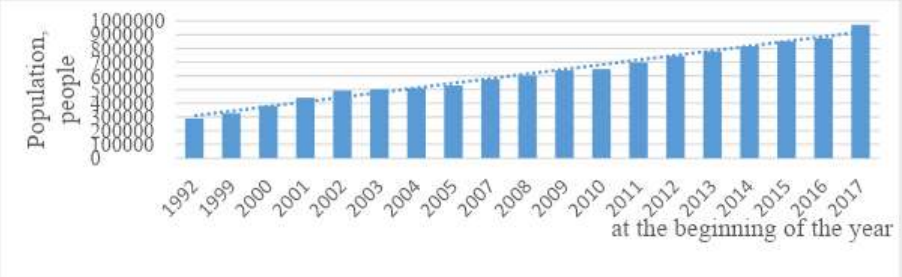


Figure 4 – Population of Nur-Sultan city (Astana)

At present, centralized water supply to Astana city is ensured by water supply from Astana (Vyacheslavskoye) water-storage reservoir on the Esilriver, it is the main source of water supply to Nur-Sultan. The volume of water in the water-storage reservoir is 291.91 mln m^3, which is 60.6% of the design volume 410.9 mln m^3. Water is supplied to Nur-Sultan in the volume of 210 thousand m^3/daily [7]. Almost all the water volume is taken to satisfy consumers' needs. The share of groundwater in the overall balance of utility and drinking water consumption of the city is less than 1 %.

The current and potential need of Nur-Sultan in quality drinking water was defined based on the materials of Kazgiprovodkhoz and data from akimat. The current need of Nur-Sultan – 210 thousand m^3/daily; the potential need of the city – 439.2 thousand m^3/daily.

Thus, taking into account growing population and anthropogenic load, Astana water-storage reservoir does not fully satisfy the present need of Nur-Sultan in water.

Despite worsening of surface water quality, akimat of Nur-Sultan developed a short-term plan of finding an acceptable solution to improve water supply to the city at account of surface water of the Nura river (Nura-Esil channel) and Irtysh – Karaganda channel (water conduit from K.Satpaev channel to the Esil river), and also Seletinskoye water-storage reservoir. The available capacity of groundwater is not taken into account.

Use of almost single source of water to supply a country capital with population of almost one million people bears the risk of occurrence of hazards of normal water supply failure of both men-made nature, as well as risks related to water intake structure contamination.

To mitigate risks, it is necessary to engage alternative sources of water-supply, in particular groundwater poorly used in this region. From the point of view of security, groundwater has a number of advantages over surface sources of water supply. They are much better protected from contamination ingression into water, has as a rule much better sanitary condition and organoleptic indicators, allow performing distributed intake throughout the area of aquifer distribution.

For utility and drinking water supply to Nur-Sultan, four groundwater deposits were explored previously: Tselinogradskoye, Akmolinskoye, Rozhdestvenskoye and Nurinskoye. These deposits are confined to river valleys alluvial formations,

their reserves are replenished by surface water. Worsening of environmental situation in river valleys in the course of intensifying economic activity results in pollution of surface water of rivers Nura, Esil, Koluton, to the valleys of which the explored groundwater deposits are confined. Surface water pollutants ingress aquifers. Mode of river valley groundwater feeding has a seasonal periodicity. Within spring snow melting and high water, water level in rivers increases and surface water actively feed the groundwater, at that moment, salinity of surface water decreases as well as pollutants concentration due to dilution with relatively low-polluted melt water. In low-water season, reverse process occurs: river valley groundwater is discharged into river bed ensuring land runoff.

The most perspective proven deposits with approved groundwater reserves were selected to be engaged as sources of water supply to Nur-Sultan (Table1).

Table 1 – List of deposits recommended for drinking water supply to Nur-Sultan

Deposit name	Useful resources, thousand m^3/daily	Water salinity, g/l	Distance from Astana, km
I-stage			
Zhabaiskoye	16.6	0.5	243
Atbasarskoye	21.2	0.2-1.0	220
Arbasar-Priishymskoye	65.0	0.5-1.2	230
Nurinskoye	48.0	0.3-0.8	68
Rozhdestvenskoye (Nizhneromanovskiy site)	19.5	1.0	36
Rozhdestvenskoye (Verhneromanovskiy site)	22.0	1.0	36
Tamsorskoye	24.1	0.1-2.9	196
Chaglinskoye-2	17.3	0.1	276
Total	*233.7*		
II-stage			
Nizhne-Kievskoye	37.0	1.0	94
Kievskoye	18.9	1.0	113
Molodetskoye	116.8	up to 3.0	158
Kotyrskoye	105.0	0.4-0.8	187
Zhartasskoye	103.3	0.4-0.6;0.3-1.2	200
Headwater	228.9	0.9-1.5	186
Tailwater	26.9	0.5-1.2	159
Total	*636.8*		
III-stage			
Pavlodarskoye-Priirtyshye	2669	0.2-0.4;1.5-2.0	430
Priirtyshskoye	498.2	1.0-1.3	485
Total	*3167.2*		

At the first stage, it is suggested to use deposits located within Akmola region only, at the second stage – engagement of deposits located in the territory of neighboring Karaganda region and at the third stage –engagement of deposits located in the territory of Pavlodar region where reserves of high-quality fresh confined groundwater allow ensuring water supply to the capital for period of up to 2050 and further.

The above deposits comply with the existing sanitary regulations and norms: water is fresh, salinity – below 1 g/l, quality is satisfactory. Their approved useful resources vary from 16.6 to 2969.0 thousand m^3/daily.

Based on the results of monitoring, groundwater pollution sites were found in the area of influence of individual deposits. Moreover, multiple unowned wells that are not closed even with covers are the hazardous sources of groundwater contamination. Analysis of contamination showed that large sources of contamination in Nur-Sultan are treatment facilities of large, waste water storage facilities, domestic and industrial waste disposal sites, as well as animal production units, absorption fields and ash dumps [8]. Due to the above-stated, it is necessary to construct intake structures on the explored deposits.

Based on the results of works performed, it is possible to make a conclusion about the possibility of staged transition of Nur-Sultan city water supply to the use of groundwater.

CONCLUSION

It is necessary to use surface and groundwater for utility and drinking water supply to population of Nur-Sultan. Poor use of groundwater reserves explored for this purpose observed.

Current and potential need of Nur-Sultan in quality drinking water identified.

It is recommended to introduce staged use of groundwater deposits to ensure drinking water supply to Nur-Sultan with account to preliminary analysis of hydrogeological conditions, water quality, volume of groundwater explored and approved commercial reserves.

Use data of the Earth remote sensing in finding promising areas for forecasting of new perspective zones for initiation of exploration.

Increase of groundwater exploration effectiveness will allow improvement of quality drinking water reserves supply to population in Nur-Sultan and reduce the growing deficit of water resources.

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