Assessment of salinization of soils and groundwater of the Khojaly district (Southern Aral sea region)

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Abstract. The article considers the solution of the problem of climate mitigation, improvement of the ecological situation of the Khojaly district and protection from salt dust, which is carried out by the wind from the drained bottom of the Aral Sea and salt marshes on the example of the city of Khojaly and its environs. To assess the salinization of the studied territory, the data of engineering and geological surveys necessary for the design of buildings and structures in the studied territory and the results of the analyses of the authors of the article were used. Based on the results of research and the use of GIS technologies, maps-schemes of salinization of groundwater and groundwater of the Khojaly district have been compiled. These maps can be used for more effective landscaping of the territory and the creation of forest protection strips around the city of Khojaly. Maps can be used to select the type of trees depending on the salinity of soils and groundwater, i.e. in the most saline areas it is proposed to create forest strips of salt-resistant trees.

1 Introduction

The city of Khojaly is the center of the Khojaly district, located on the modern alluvial–delta plain of the Amu Darya River, on its left bank. In the east and northeast, the prospective border is bounded by the Amu Darya River. It is bounded by the Republic of Turkmenistan from the southwest and west, and the alluvial-delta plain of the Amu Darya River extends to the north and northwest of the city. The area is 550 km^2, there are 26 village and 10 village gatherings of citizens. As of July 1, 2019, the population of the district is 121.8 thousand people. Khojaly is connected with the capital Nukus by first class highways.

The area of work is characterized by a sharply continental climate, expressed in large differences in daily and seasonal temperatures, low precipitation, with an uneven distribution of them by seasons [2].

The air temperature has significant seasonal and diurnal amplitudes. The hottest months are July-August, the coldest are December-January.

The average annual air temperature is 11.6 °C. The maximum temperature is in July, the absolute maximum temperature is 44.6 °C. The lowest temperature is observed in January, the absolute minimum is -34.2 °C.

The maximum depth of seasonal freezing of soils is 1.38 m with a repeatability of 1 every 50 years and 1.17 m with a repeatability of 1 every 10 years (in the Republic of Karakalpakstan). Figure 1 shows the annual temperature of the district [2].
The analysis of the observations of the Karakalpakstan Meteorological Service shows that the summer temperature in Karakalpakstan is increasing.

In recent years, due to the drying of the Aral Sea, dust storms have become more frequent, which bring salt from the drained bottom of the Aral Sea and salt marshes to the territory of the region. To mitigate the climate, the territory of the city of Khojaly needs to be landscaped, and forest strips should be created for protection. For effective landscaping of the territory and creation of protective forest strips around the city, it is necessary to draw up maps of salinization of groundwater and soils not only of the city, but also of its surroundings. Maps can be used for landscaping and creating forest strips around the city, depending on the degree of salinity of groundwater and soils. Similar maps were compiled for the conditions of the city of Nukus in the Republic of Karakalpakstan [2].

Analysis of the results of existing studies has shown that the last map of soil salinity in the Southern Aral Sea region was compiled in 1979 on a scale of 1:500,000 [8], which is outdated, since the salinity of soils has changed compared to that time. Along with this, in order to create forest strips and landscaping of the city within one district, it is necessary to build maps with a larger scale. Because the map [8] was compiled for the Khojaly district basically to solve the problems of the agricultural sector. In this regard, the purpose of this work is to make maps of salinization of soils and groundwater of the Khojaly district on a larger scale using modern computer technologies.

2 Materials and methods.

To assess the nature of the distribution of salts and to determine the types of salts in groundwater that have a depressing effect on green spaces, maps of salinization of groundwater in the Khojaly district were compiled. The analysis of the results of studies on the survival and durability of woody and shrubby plants depending on the salinity of soils and groundwater of the Southern Aral region showed that the zoning of the territory on the survival, durability of woody plants from the degree of salinity of soils and groundwater was practically not carried out [2, 4]. Engineering and geological surveys were carried out on the territory of the district for the construction of facilities. As a rule, the reports of engineering and geological surveys contain the results of chemical analysis of groundwater and soils that are used in the design of underground parts of buildings and structures. These open data are obtained from local engineering and geological survey organizations. Systematization of the results of these studies allows them to be used for greening the city territory and creating forest protective strips around through the compilation of salinity maps. Along with this, open data of the State Hydro-Reclamation Service were used to assess the dynamics of changes in the groundwater level over the years.

To assess the patterns of salt distribution, the coordinates of the points where the salinity of soils and groundwater were determined were plotted on a digitized map at a scale of 1:25000. The maps are compiled using the ArcGIS computer program. When drawing up maps, the results of determining the salinity of groundwater of 59 workings were processed. The research covered 110 km^2 of the territory of the Khojaly district.

3 Results and discussion.

Figure 1 shows the dynamics of changes in the maximum and minimum values of the groundwater level of the Khojaly district for the period 1990-2018. The analysis of the

graph shown in Fig. 1 shows that there is a high level of groundwater in the Khojaly district. This is primarily due to the irrigation of this territory and the filtration of water from the irrigation system, the main channels flowing through the area, as well as the insufficiency of the drainage system. The ground water level is especially high during the growing season. Studies show that the groundwater of Karakalpakstan is salted with sulfate and chloride salts [3, 5, 6].

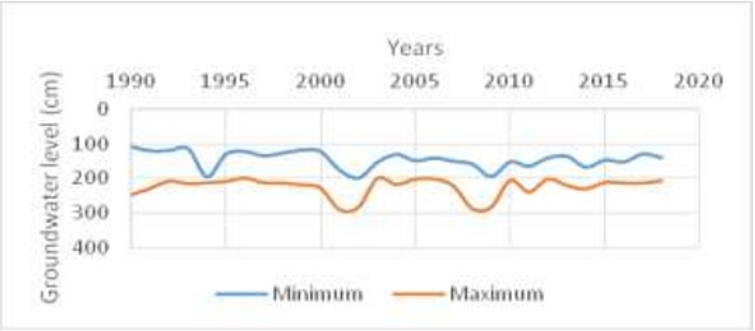
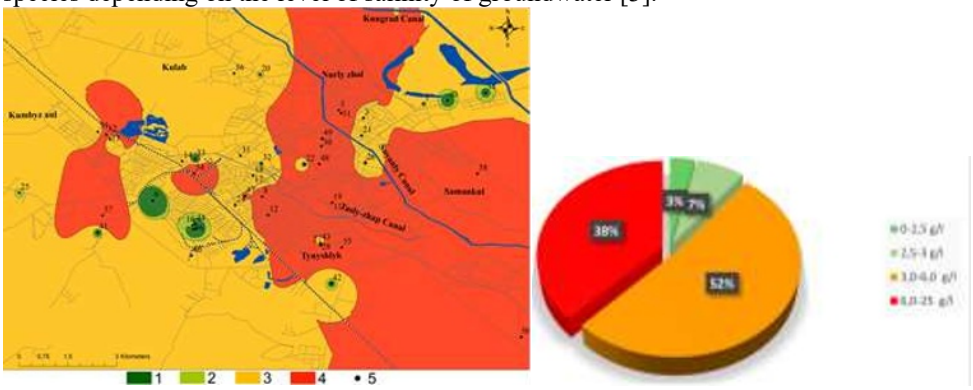


Fig. 1. Dynamics of changes in the depth of underground waters of the Khojaly district by year.

The graph shown in Fig. 1 was constructed according to the data of the State Hydro-Reclamation Service. It should be noted that the results of the research of the Hydro-Reclamation Service are mainly used to solve the problems of the agricultural industry.

Figure 2 shows a map-scheme of salinization of groundwater in the Khojaly district with water-soluble salts by district. As shown in Fig. 2, the content of water-soluble salts varies from 0.5 g/l to 25 g/l. At the same time, the greatest salinity is observed between the Suyanly and Tasly-Zhap channels, as well as on the left bank of the Tasly-Zhap channel. The largest part of the underground waters of the district contains 3-6 g/l and 6-25 g/l of salts, 52% and 38%, respectively. On an area of about 7%, groundwater contains salts of 2.5-3 g/l. Small individual areas have a minimum salinity of 0.5-2.5 g/l. The different salinity of groundwater can be explained by various filtration properties, the presence of a drainage system and natural drainage [6, 7]. This map should be used when selecting tree species depending on the level of salinity of groundwater [3].

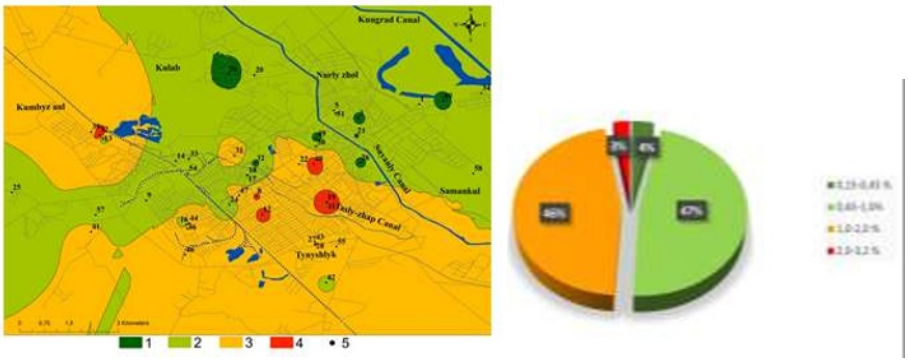


(a) (b)

Fig.2. Schematic map (a) and percentage distribution (b) of salinization of groundwater in the Khojaly district with water-soluble salts (by dense residue), g/l: 1- 0,5-2,5 g/l; 2- 2,5-3 g/l; 3- 3-6 g/l; 4- 6-25 g/l; 5- well.

Figure 3 shows a schematic map of soil salinization up to the groundwater level of the Khojaly district. Analysis of the map shows that the content of water-soluble salts varies

from 0.15% to 3.2%. At the same time, the highest salinity is observed in the central part of the studied territory (2.0-3.2%). The north-eastern, central and south-western parts of the district contain 0.45-1% salts in most groundwater, which is about 47% of the total area. In the southern and northwestern part of the territory, 46% of the area contains 1-2% of salts in groundwater. The minimum salinity of small isolated areas is 0.15-0.45%. About 77% of the area of the district is mainly of the chloride-sulfate type.



(a) (b)

Fig.3. Schematic map (a) and percentage distribution (b) of soil salinization to the groundwater level of the Khojaly district, %: 1- 0,15-0,45 %; 0,45- 1 %; 3- 1-2 %; 4- 2-% g/l; 5- well.

The analysis of the map presented in Fig. 3 shows that in the northern and north-eastern part of the vicinity of the city of Khojaly, the least salinity of soils is observed, therefore it is advisable to create forest strips on this territory. At the same time, it is necessary to use recommendations on the selection of types of trees and shrubs in the conditions of Karakalpakstan [1]. According to the studies given in [1], the most durable woody plants include narrow-leaved loch, common quince, common ash, silver poplar. When landscaping the territory of the city, it is also possible to use data on the durability of some woody and shrubby plants, given in [1].

4 Conclusion

1. The analysis of long-term observations of hydrogeological conditions of the Khojaly district showed that there is an increase in the groundwater level in the district, which has a negative impact on the ecological situation of the district, since the increase in the level of mineralized groundwater leads to additional salinization of the earth's surface. This has a depressing effect on green spaces.
2. The results of the research have shown that the soils of the Khojaly district are salted with sulfate and chloride salts. There is an uneven spread of salinity throughout the city. The least clogging is observed in the northern and north-western parts. For greening the city and creating protective forest strips in the vicinity of the city, it is necessary to use data from existing studies on the durability of woody and shrubby plants in the conditions of the Republic of Karakalpakstan [1]. To create forest strips, it is recommended to plant narrow-leaved loch, common quince, common ash, silver poplar, which are the most durable on saline soils of Karakalpakstan. This will protect the city from salt dust, which is carried out from the drained bottom of the Aral Sea.
3. In order to improve the ecological and hydrogeological situation in the city of Khojaly, it is necessary to design a new innovative drainage system that will allow brining groundwater for landscaping the city. Along with this, it is necessary to monitor changes in the level and salinity of groundwater.

4. Studies of the salinity of groundwater and soils should be carried out in other cities of the Republic of Karakalpakstan. These studies will make it possible to effectively create forest zones around cities to delay salt dust that is carried out from the drained bottom of the Aral Sea. To effectively create maps, it is necessary to develop a computer database of salinity of soils and groundwater. This will allow you to effectively create electronic maps, track the dynamics of changes in the salinity of soils and groundwater.

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