Determination of the underground component of the water balance of lake Lebedyne (Sumy region) in the context of prospects for the restoration of its water constitution and the project

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SUMMARY

An analysis of the situation in the country's water bodies over the past decades due to climate change shows a further exacerbation of the problem of water supply of the population and industries. Objective identification of trends and forecasting of changes in groundwater status are usually performed on the basis of monitoring studies. But currently there is no effective system for monitoring the status of groundwater in Ukraine.

In recent years, Lake Lebedyne has become significantly shallower, which is of concern to the local community. The authors of the article studied the connection between surface and groundwater in the area adjacent to Lake Lebedyne.

According to our own field research in June 2020 and the available stock information on low floodplains, groundwater is in places very close to the day surface and forms wetlands. The level of groundwater in accordance with the obtained marks in the engineering and geological wells around the lake decreases in all directions. This indicates that Lake Lebedyne is currently a source of groundwater in the surrounding area.

The available information allowed to perform the actual calculation of water losses from Lake Lebedyne for groundwater supply (groundwater flow costs) on the current strips corresponding to the available engineering and geological sections.

Given the size of the perimeter of the lake, the amount of water losses from Lake Lebedyne to groundwater supply was determined as a component of the overall water balance.

Introduction

An analysis of the situation in the country's water bodies over the past decades due to climate change shows a further exacerbation of the problem of water supply of the population and industries. Rivers and lakes are flowing, water levels in wells and wells are significantly reduced. There is a growing concern of the country's population, mainly rural, for which groundwater is the only source of drinking water. Objective identification of trends and forecasting of changes in groundwater status are usually performed on the basis of monitoring studies. But currently there is no effective system for monitoring the status of groundwater in Ukraine.

The current situation requires the immediate development and implementation of a number of measures to be envisaged by the Water Strategy of Ukraine, which is being developed by the country's leading research institutions. The problem is complex and requires a joint effort by public authorities, local governments and scientists.

In 2020, specialists of the Taras Shevchenko National University of Kyiv (Department of Hydrogeology and Engineering Geology and Department of Hydrology and Hydroecology) systematized natural and anthropogenic factors based on available factual and stock information to determine the components of the water balance of Lake Lebedyne (Sumy region) and prospects for restoring its water content according to the available factual and stock information.

Method and Theory

In recent years, Lake Lebedyne has become significantly shallower, which is of concern to the local community. Therefore, establishing the causes of shallowing (natural and anthropogenic factors of shallowing) is an urgent task.

The catchment area of Lake Lebedyne is located in the interfluve of two small left tributaries of the Psal River - the Vilshanka River (length 34 km, basin area 186 km2) and the Budylka River (length 16 km, catchment area 103 km2). It is known that the level regime of the lake is due in particular to meteorological factors, terrain and conditions of the relationship between surface and groundwater.

The authors of the article studied the connection between surface and groundwater in the area adjacent to Lake Lebedyne. Unfortunately, the lack of actual data from local or on-site monitoring observations required a different approach to the organization and conduct of research *(Koshliakov et al., 2020)*. It should be noted that according to the available data of the regional monitoring significant changes in the groundwater level in the territory are not recorded.

According to the scheme of hydrogeological zoning of the territory of Ukraine according to the peculiarities of the formation of groundwater, the research area belongs to the zone of unstable moisture *(Forecast of groundwater levels of Ukraine)*. Groundwater is separated from the aquifers below by a thick layer of water-resistant rocks, ie they do not have a significant hydraulic connection. Therefore, the existing long-term operation of interstratal groundwater for water supply cannot be a direct cause of changes in the natural water balance of groundwater and the lake. Groundwater is used by the local population through mine wells and wells for their own drinking and drinking needs.

According to our own field research in June 2020 and the available stock information on low floodplains, groundwater is in places very close to the day surface and forms wetlands. The level of groundwater in accordance with the obtained marks in the engineering and geological wells around the lake decreases in all directions *(Khoruzhenko et al., 2013)*. This indicates that there is a close hydraulic connection between the surface waters of the lake and the groundwater, and Lake Lebedyne is currently a source of groundwater in the surrounding area (Fig. 1). Another source of groundwater supply is precipitation, the amount of which has decreased significantly in recent years. A decrease in

the water level in the lake leads to a decrease in the water level in the soil aquifer. According to local residents, the groundwater level in the area has recently decreased, wetlands have almost dried up.

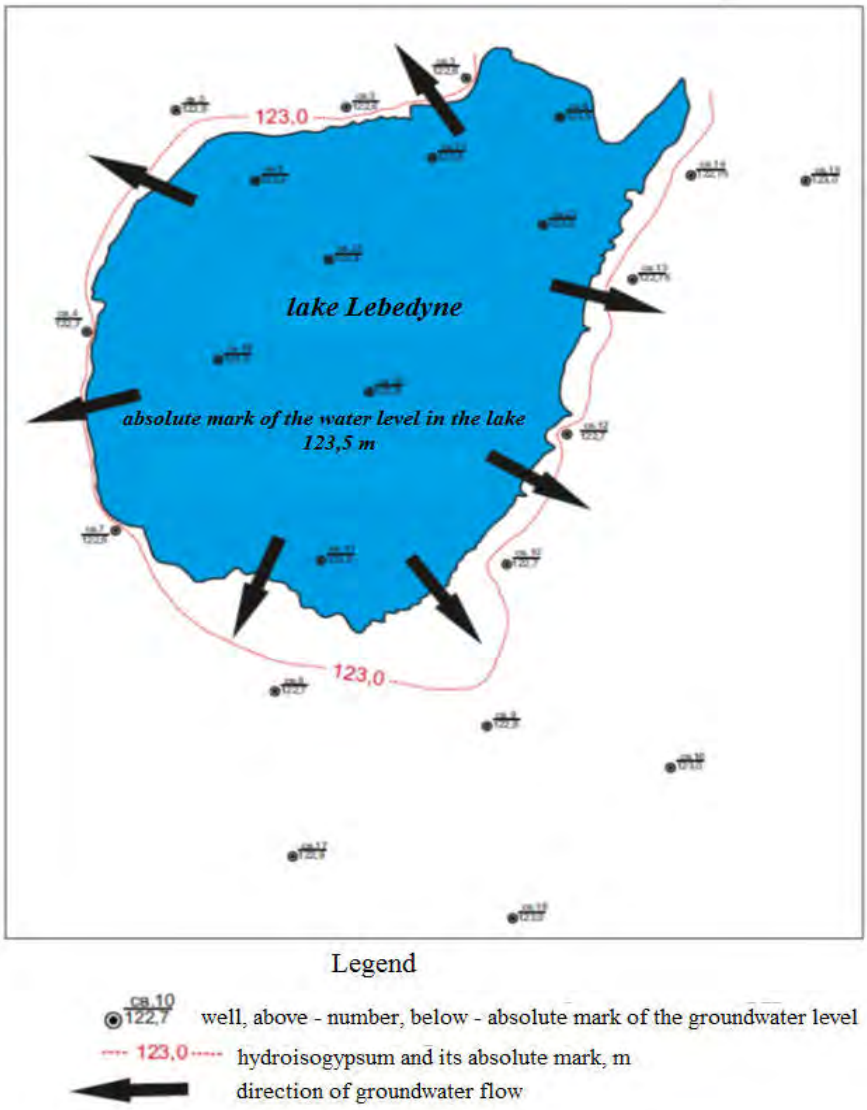

Figure 1 *The direction of unloading of water from the lake Lebedyne*

Insignificant anthropogenic load on the area adjacent to the lake (especially the presence of wells and wells that capture groundwater) cannot be considered a factor that significantly affects the state of groundwater and, consequently, the natural water balance of the lake.

The main task of the study of the relationship between surface and groundwater in the area adjacent to Lake Lebedyne was to determine the amount of water lost from Lake Lebedyne to feed groundwater during the year. This amount is part of the overall water balance of the lake.

The available information allowed to perform the actual calculation of water losses from Lake Lebedyne for groundwater supply (groundwater flow costs) on the current strips corresponding to the available engineering and geological sections *(Khoruzhenko et al., 2013)*. The model of a steady one-dimensional flow was used. When calculating such flows, it is assumed that the width of the flow is equal to 1 m. The flow rate, the width of which is equal to 1 m, is called the specific flow rate and is denoted as q. The dimension of the specific consumption is m2 / day. To obtain the total flow rate of

groundwater flow Q (in m3 / day), it is necessary to multiply the average specific flow rate by the length of the shoreline of the lake.

Materials of available engineering-geological sections and results of laboratory determinations of soil properties were used to construct the calculated scheme of groundwater flow *(Khoruzhenko et al., 2013)*. According to these data, the water-saturated stratum consists of two main layers. At the top lies a layer of medium-sized sands 0.6-1.9 m thick, below - fine sand 1.8-3.0 m thick. The porosity coefficient of the sands of the lower layer varies from 0.39 to 0.472, the average value is 0.427. The following filtration coefficients were used for calculations: for the upper layer K_1 = 1.0 m / day, for the lower K_2 = 0.4 m / day.

The specific loss of water from the lake to feed groundwater q (in m2 / day) was determined using the dependence (1) *(Koshlyakov and Mokienko, 2005)*:

$$q = T \cdot \frac{H_0 - H_L}{L}. \quad (1)$$

Here H0 corresponds to the mark of the groundwater level in the well, m; HL - water level mark in the lake, m; L is the distance from the lake to the well, m; T - total total water conductivity of the stratum, m2 / day. The corresponding calculation scheme is shown in Fig.2.

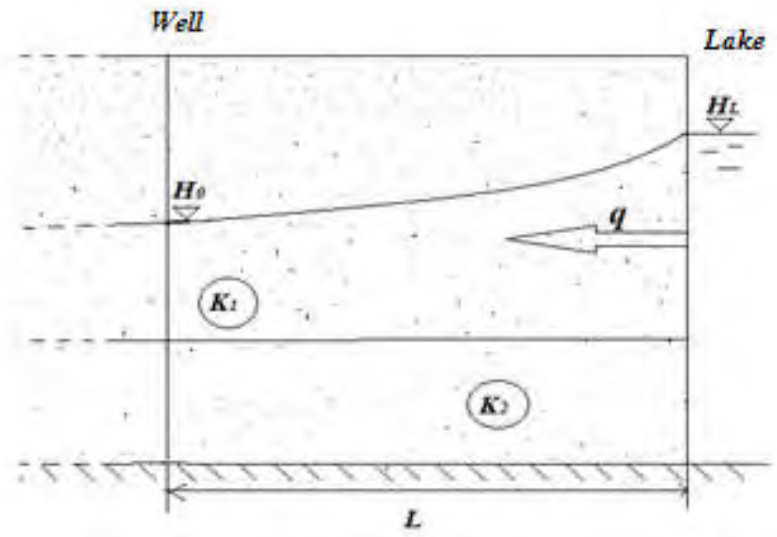

Figure 2 *The calculated scheme of one-dimensional flow of groundwater to determine the specific loss of water from the lake*

Results

The results of calculations on the dependence (1). Given the size of the perimeter of the lake the amount of water losses from Lake Lebedyne to groundwater supply was determined as a component of the overall water balance. The results of this definition are shown in table 1.

Table 1 *The results of determining the amount of water loss from the lake to feed groundwater*

The perimeter of the lake, m	2669
The total consumption is probable, m3 / day	209,99292
The total consumption is minimal, m3 / day	118,73498
The total consumption is maximum, m3 / day	651,99857

Conclusions

1. In recent years, Lake Lebedyne has become significantly shallower, which is of concern to the local community. Therefore, establishing the causes of shallowing (natural and anthropogenic factors of shallowing) is an urgent task.

2. The level regime of the lake is determined in particular by meteorological factors, terrain and conditions of the relationship between surface and groundwater. Insignificant man-caused load on the territory adjacent to the lake (especially the presence of wells and wells that capture groundwater) can not be considered a factor that significantly affects the natural water balance of the lake.

3. The authors of the article studied the relationship between surface and groundwater in the area adjacent to Lake Lebedyne. Objective identification of trends and forecasting of changes in groundwater status are usually performed on the basis of monitoring studies.

4. According to the available data of regional monitoring, significant changes in the groundwater level in the territory are not recorded. Unfortunately, the lack of actual data from local or on-site monitoring observations required a different approach to the organization and conduct of research.

5. The main task of research on the relationship of surface and groundwater in the area adjacent to Lake Lebedyne was to determine the amount of water lost from Lake Lebedyne to feed groundwater during the year. The available information allowed to perform the actual calculation of water losses from Lake Lebedyne to groundwater supply (groundwater flow costs) on current streams. The results of the calculation are shown in table 2.

6. The results obtained by the authors are the basis for the scientific substantiation of the arrangement of the system of local monitoring of the groundwater condition of the territory adjacent to Lake Lebedyne.

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