Analysis and research of the state of Lake Sukorivshchyna as a result of anthropogenic influence, as well as hydroecological and geomorphological conditions of species coexistence

J. L. Poleva*, O. O. Varyshkina**, V. V. Demyanov***

*Florida Institute of Technology, Melbourne, Florida, USA
**Public formation “Ecological Patrol”, Dnipro, Ukraine
***Dniproprovodkhoz, Dnipro, Ukraine

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This article is devoted to the study of Lake Sukorivshchyna in the Pishchanska united rural community of Novomoskovsk district. When studying the characteristics of the lake, the landscape location, hydrochemical and hydrobiological characteristics, and the degree of their anthropogenic transformation were taken into account. In the conditions of the northern part of the steppe zone of Ukraine, lakes are located exclusively in valley-terrace landscapes, the constituent elements of which differ in the most significant biodiversity. Ecosystems of lakes, despite their considerable similarity, also have many differences: their size and shape, trophic level, and degree and nature of overgrowth with macrophytes. There are examples of typologies of continental bodies of water, including lakes, but for the steppe zone of Ukraine, where the lakes have an insigniﬁcant area, and number and ecological differences inherent in water bodies of the steppe zone, a separate typology for them has not been developed. The quality of water at all times has been and is one of the main indicators of the standard of living. Therefore, all developed societies make every effort to provide the population and economy with a sufﬁcient amount of water of a quality that is adequate to the requirements of the consumer. Most of the water comes from natural sources – rivers, lakes, and reservoirs, the water quality of which must not only be assessed, but also predicted. Two main components are responsible for the quality of water in nature – the catchment basin and the ecological system of the water body. Each of them is located in certain conditions of geography and climate, characteristic of the region under study, which in our research is the Steppe zone of Ukraine. This article reﬂects the studies of Lake Sukorivshchyna, and also shows the role of the location of the studied water body, and reveals the patterns of the reaction of the aquatic ecosystem to human activity, which was carried out without scientiﬁc justiﬁcation and proper recommendations for action.

Keywords: Lake Sukorivshchyna; hydrological and hydrobotanical features; ecological differences; biodiversity; anthropogenic transformation

Introduction

We are talking about a place that requires a special attitude, respect, and careful treatment - this is Lake Sukorivshchyna in the district of Pishchanska united rural community of Novomoskovsk district. The history of the location goes back a long way. Today, people usually come to the lake to recover from chronic fatigue and enjoy the scenery and silence.

In the problem of rational nature management, a special place is occupied by the preservation of water resources in the specific case of lake ecosystems. This issue is particularly relevant due to the arid climate of the steppe zone, negative water balance, poorly developed hydrographic network and insufficient area of reservoirs and adjacent territories where water quality is formed. The research of reservoirs is one of the most important priorities in Ukraine.

Materials and methods

The material was collected during stationary and route surveys during the period of 1993–2021 at Lake Sukorivshchyna in the Pishchanska united rural community of Novomoskovsk district. Hydrological indicators were analyzed based on literary, cartographic, and archival data of the
Institute of Dniprodiprovhodsp. The mineralization levels of the lake were determined by the express method using the “Milwaukee” salt meter, Conductivity Meter with ATC CD 601, and according to the materials of the Dniprodiprovhodsp Institute. Hydrochemical indicators were obtained according to literature data (Bajdak et al., 2021), data of the hydrochemical laboratory of the Institute of Dniprodiprovhodsp, and the hydrochemical laboratory of the Dnipro State Agro-Economic University.

Results and discussion

Lake Sukorivshchyna (named after the tract of the same name) is located on the left bank of the Samara River on the northwestern side of the village of Orlivshchyna of the Novomoskovsk district. The distance from the Samara River to the western shore of the lake is 120 m. The lake stretches from east to west, its length is 280 m, width 60–80 m. On the northern side, at a distance of 90 and 200 m, there are two more lakes with an area of 0.54 ha and 1.70 ha. On the southeastern side, at a distance of 280–500 m, there is an arc-shaped swamp with a length of 0.93 km.

The area of the water mirror of Lake Sukorivshchyna, according to topographical survey data as of May 29, 2020, was 2.07 hectares, and the volume of water was 14,000 m³. The average depth of the lake is 0.7 m; the largest depth is 2.4 m. The water elevation in the lake as of May 29, 2020 was 51.81 m, which is 0.4 m higher than the water elevation in Samara. Calculations of the dependence of lake water volumes on the area of horizons based on the topogeodetic survey data are given in Table 1.

The plan of the lake according to the data of the 1993 topographical survey is given in Fig. 1. At that time, the area of the lake was 3.5 hectares, the length was 420 m, and the greatest width was 95 m. The approximate volume of water in the lake was 20,000 m³. The water level mark of 51.4 m indicated on the survey is probably erroneous.

Currently, the lake is surrounded by private buildings on the northern and western sides; the eastern and southern shores are undeveloped, occupied by forest and swamp. In the central part of the northern shore of the lake, on the property of one of the estates adjacent to the lake, fill has been placed to form a flat extension of the estate property. The shore is reinforced in the form of a vertical embankment using plastic sheeting. On the western side, the shore of the lake has been cleared and graded. A metal fence has been installed along the eastern and southern sides of the lake. On the eastern side of the lake is a reed swamp with an area of 0.6 ha. Individual trees of sticky alder (Red Book of the Dnipropetrovsk region) and willow grow in the swamp, which indicates that until recently the water in the lake was fresh (alder grows only on the shores of freshwater lakes and in swamps, and cannot withstand salty water). Currently, the alder trees are in a depressed state, which is due to the increase in mineralization of water in the lake and in the surrounding swamps.

The bottom deposits of the bottom of the lake consist of a layering of silty and clay soils with layers of sand, the total thickness of which is approximately 4 m. By its origin, the lake is floodplain is the remnant of an ancient river channel of the Samara River, now separated from the Samara River by sand sediments that were deposited along the banks of the river during large floods. Large floods inundating floodplains also scoured and removed sediment from floodplain lakes.

In the surrounding forests, flood water flowed slowly and calmly, while in the open water areas of the lakes there were fast moving streams that cleaned sediment from them (Voloshyna, 2014). The last major flood was observed on March 25, 1985; the maximum flow of water on that day was 867 m³/s. An even greater flood was observed on March 29, 1964 – the maximum flow was 2,400 m³/s. According to a survey of local residents of the village of Orlivshchyna, the water level of the 1964 flood reached 68.0 m (the water rose above the limit water level in Samara to a height of 6.6 m above the river bank elevation).

![Fig. 1. Location plan of Lake Sukorivshchyna according to data taken in 1993](image-url)
base and protection for aquatic mammals (musket, water vole) (Zagubizhenko, 1980). But excessive overgrowth of water bodies reduces water space, negatively affects the same inhabitants of water ecosystems (birds, fish, reptiles, amphibians, etc.), and turns water bodies into swamps.

The lake is fed by precipitation, which falls directly on the water surface and flows as runoff from the surrounding area, as well as by underground feeding with groundwater. The expenditure component of the water balance is evaporation from the water surface and underground runoff in the Samara River. In winter and spring, the incoming component of the water balance predominates, and the water level in the lake rises. In summer and autumn, the outgoing component predominates and the lake dries up.

The water level in the lake strongly depends on the groundwater levels in the surrounding area (Fig. 2). Recently, there has been a significant decrease in underground water levels throughout Ukraine, which is associated with global warming, and accordingly, the soil nutrition of rivers, lakes, and ponds has decreased (Poleva, 2020). Many small rivers dry up in the summer, many lakes in the valleys of the Oryol and Samara rivers have completely dried up, and ponds and small reservoirs are drying up (Fig. 2).

In Lake Sukorivshchyna, soil nutrition is limited by the presence of a thick layer of bottom sediments, which have a weak filtering capacity.

The decrease in the size and area of the lake's water is associated with its drying up and a decrease in water levels in it, which, in turn, is associated with climatic changes - an increase in the average air temperature, and an increase in evaporation both from the water surface and from the soil surface (Kobyakov et al., 2020). Regarding Lake Sukorivshchyna, the water level cannot fall below the water level in the Samara River, which is at elevation 51.40 m during the watershed period.

The chemical composition of water in the lake is formed under the influence of water balance factors: with a predominance of incoming components, the total mineralization of water decreases, with an increase in evaporation, mineralization increases. Comparative chemical composition of water in the lake (Poleva, 2021). Sukorischyna and the Samara River are given in the Table 2.

Thus, we found out that the hydrological state of Lake Sukorivshchyna and the ecological state of its inhabitants are gradually deteriorating. The main factors of deterioration of the hydrological and ecological state of the lake are as follows:

- climatic changes, an increase in air temperature and an increase in evaporation from the water surface, which leads to a decrease in water levels in the lake;
- lowering of groundwater levels in the surrounding area, which also affects the water level in the lake;
- excessive overgrowth of the banks with higher wetland (reed) vegetation, reduction of the area of open water;
- overheating of water in the lake in the summer and rapid development of submerged aquatic vegetation (Kushiru);
- annual sedimentation of aquatic vegetation to the bottom of the lake, which leads to siltation and shallowing;
- reduction of the filtration properties of the bottom of the lake, which worsens its nutrition with groundwater;
- anthropogenic development of the shores of the lake also has a significant negative impact - construction of the shores, construction of "embankments", cleaning of the shores, enclosing the lake with a fence, use of chemical means for the destruction of coastal vegetation, unfounded clearing projects with complete destruction of coastal aquatic vegetation.

In the absence of appropriate measures to restore its hydrological regime and ecological state, the lake can simply turn into a swamp. The successive process of changing the lake ecosystem into a swamp is becoming more evident recently, primarily due to climatic changes, but also due to anthropogenic influences.

**Conclusions**

To restore and maintain the normal hydrological regime and ecological state of Lake Sukorivshchyna, it is currently being cleared with the removal of part of the bottom sediments.
Table 2
Chemical composition of lake water. Sukorivshchyna and the Samara River

<table>
<thead>
<tr>
<th>№</th>
<th>n/p</th>
<th>Chemical components</th>
<th>GDK</th>
<th>Place and date of sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td>Dry residue, mg/dm3</td>
<td>1000</td>
<td>Lake Sukorivshchyna</td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>Hydrogen index, pH</td>
<td>6.5-8.5</td>
<td>10/21/2021</td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td>Hardness, mmol/dm3</td>
<td>7.0</td>
<td>Samara</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>Alkalinity, mmol/dm3</td>
<td>4.5</td>
<td>10/21/2021</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td>Sodium+potassium Na++K+, g/dm3</td>
<td>2676</td>
<td>40</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td>Calcium Ca2+, mg/dm3</td>
<td>190-192</td>
<td>2006</td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>Magnesium Mg2+, mg/dm3</td>
<td>170</td>
<td>235-255</td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>Cl- chlorides, mg/dm3</td>
<td>350</td>
<td>140</td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td>Sulfates SO42-, mg/dm3</td>
<td>500</td>
<td>621</td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td>Hydrocarbons HCO3-, mg/dm3</td>
<td>274</td>
<td>237</td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td>Nitrates NO3-, mg/dm3</td>
<td>45.0</td>
<td>0.3</td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td>Nitrite NO2-, mg/dm3</td>
<td>3.3</td>
<td>0.009</td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td>Ammonium NH4+, mg/dm3</td>
<td>2.0</td>
<td>1.86</td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td>Total iron Fe, mg/dm3</td>
<td>0.3</td>
<td>0.09</td>
</tr>
</tbody>
</table>

The formula of water according to its chemical composition

- Chloride-sulfate-sodium-magnesium
- Chloride-hydrocarbonate-sodium-magnesium

But to reduce the negative impact of clearing on the aquatic ecosystem, the following restrictions are recommended:

1. Clearing should be carried out by means of small hydromechanization (low power dredger);
2. The recommended clearing depth is 2.5 m, with the arrangement of a separate buried area (up to 5 m) – no more than 10% of the clearing area;
3. It is necessary to leave a strip of aquatic vegetation along the shores with a width of at least 6–7 m. Aquatic vegetation performs an important function for waterfowl, aquatic reptiles, amphibians, fish fry, etc., and also performs the function of water purification. Complete destruction of coastal vegetation is allowed only on recreational areas (beaches) – no more than 10% of the total length of the coastal strip;
4. Cleaning is allowed only in the non-spawning period for fish and the non-nesting period for waterfowl – mainly in September-November, before the onset of persistent frosts;
5. When performing clearing, mark the boundary of the works in the water area with clearly visible signs-buoys;
6. It is forbidden for the dredger and its working bodies to go beyond the boundaries of the works marked on the water area (except for the shore area where the dredger is lowered and raised from vehicles to and from the water);
7. During the execution of work, mowing of dry stems of aquatic plants (reeds, rushes, etc.), which are the habitat of aquatic animals, nesting territory of birds, is prohibited until the new growth is restored;
8. Places of storage of removed bottom sediments (washout maps) must be substantiated by the relevant project;
9. To protect the lake from re-siltation from the banks of the lake and the sides of the sediment storage areas, siltation control devices such as geotubes, shafts made of dead reeds, etc. shall be installed.

The following measures are recommended to maintain the normal ecological state of the lake:
1. Lining the shores of the lake with moisture-loving trees: willow, poplar, swamp cypress, etc. Trees shade the shores and protect the lake from overheating;
2. Dismantle and remove the fence along the shore of the lake, which limits the migration of aquatic animals and is a direct violation of the norms of the Water Code of Ukraine;
3. Avoid the installation of any shore fortification, sloping or vertical;
4. It is recommended to dismantle the existing pile row (vertical embankment) and restore the soil slope of the bank;
5. It is recommended to develop a land management project to establish the boundaries of the coastal protective strip and water protection zone of the lake, with the demarcation of these boundaries of the project area with the installation of water protection signs.

References