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Hydrobiological Studies of the Kosinskie Lakes

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***Abstract* – The Kosinskie Lakes are the only natural reservoirs of glacial origin on the territory of Moscow that are part of the natural and historical Kosinski park. Moreover, they are a natural landmark. Therefore, they need to be studied thoroughly and attentively. The ecological situation of the area is quite controversial. The lake drainage area suffers a great anthropogenic load. According to the calculation results of the Mayer index in 2018, the situation has worsened compared to 2017. There is a decrease in biodiversity of hydrobionts of the Kosinskie Lakes, as well as a decrease in the number of types of indicators used in the calculation of the Mayer index. The Lakes Beloe, Svyatoe and Chernoe refer to polysaprobic water bodies. The massive development of saprotrophic organisms is most likely caused by sharply increased eutrophication of the Kosinskie Lakes as they now locate on the territory of Moscow. Besides, the area nearby the Kosinskie Lakes is extensively used for mass**

construction. As a result, the recreational use of the Beloe and Svyatoe Lakes has increased. The importance of systematic hydrobiological observations has significantly increased under such unfavorable conditions for the Lakes (strong anthropogenic pressure).

Keywords – Kosinskie Lakes; zoobenthos; hydrobiological study; Mayer method; sampling; indicator organisms; eutrophication.

I. INTRODUCTION

The territory of Kosino is unique not only for Moscow, but also for the Moscow region due to its three lakes (Beloe (White), Chernoe (Black) and Svyatoe (Holy) Lakes). The lakes are of glacial origin, formed in the ancient Pramoskva valley [5]. The Kosinskie Lakes are the only natural reservoirs of glacial origin on the territory of Moscow that are part of the natural and historical park Kosinski and are a natural landmark. Therefore, they need to be studied thoroughly and attentively.

In 1908, a stationary Kosinskaya biological station was set on the shore of the Beloe Lake, where hydrobiological studies and internship were successfully carried out. After the liquidation of the Kosinskaya biostation in 1941, regular hydrobiological (in particular, microbiological) research was stopped being conducted on these lakes. They were renewed again in 2009 by the members of the Chair of Hydrobiology, Biological Department, Moscow State University named after M.V. Lomonosov [8]. The ecological situation of the area is quite controversial. The Kosinskie Lakes are located on an area of only 64.5 hectares, but each lake differs from each other in a number of characteristics.

The Lake Beloe is the largest among other lakes. Its depth reaches 13.5 m. The shape of its bed is compared to a funnel. The type of water body is eutrophic; it contains many dissolved and suspended organic substances. The bottom is composed of silts. Hydrogen sulfide is present in the bottom layers of the water and is toxic to the inhabitants of the lake.

The Lake Chernoe is connected to the Lake Beloe whith a narrow canal. In the 1940s - 1950s, peat was mined on the shores of the Chernoe Lake. In the northern part of the lake, there are remains of a lowland swamp with a very peculiar flora and fauna, which has no analogues.

The Lake Svyatoe has exceptional historical and balneological significance. The lake is located on the eastern outskirts of the Kosino-Ukhtomsky district of Moscow with an area of 0.08 km^2, an average depth of 3 m and a maximum depth of 5.1 m. The lake is of round shape with a sphagnum bog on all sides. The chemical properties of the water of the Svyatoe Lake differ significantly from the water of other Kosinskies Lakes, i.e. it contains very little organic matter (a dystrophic type). The lake is surrounded by a swamp, which means that there are 200 -250 m of bog around the Lake. The bottom of the lake is covered with a thick layer of silt; however, it has a unique feature, i.e. it never blooms.

II. RESULTS OF RECONNAISSANCE SURVEY OF THE KOSINSKIE LAKES

The object of our study is the Moscow region complex of the lakes located in the Kosino-Ukhtomsky district, the Kosino microdistrict behind the Moscow Ring Road (MKAD) – the Kosinskie Lakes (survey route, Fig. 1). The relief of Eastern Moscow in the central and northern parts is mainly represented by the fluvioglacial accumulative type, corresponding to the fluvioglacial accumulative plain composed of sand, sandy-gravel deposits, and loam. The northwestern and southeastern parts are presented by fluvial accumulative-denudation type with terraces above the floodplain of the Moscow River, complex sand around the Lakes Beloe and Svyatoe on ancient alluvial and fluvioglacial sediments, and bottoms of beams, hollows, valleys of small rivers with permanent or temporary watercourses [6].

The drainage area of the lakes is under great pressure. The proximity of the Moscow Ring Road (MKAD) affects the state of the Lake Chernoe. The minimum distance from the MKAD to the water's edge is 103 m, and the maximum is 240 m, residential development closely approaches the Lake Beloe. In most of the territory, the specific anthropogenically-transformed soils are widespread, among them are as following: urban-podzolic, urbanozem, industrizem, ecranozem and technozem [13]. Both non-saline and slightly saline soils are found in small spots [12]. These lakes are actively used by residents as a recreational zone. However, because of recreational exposure, the degradation of vegetation occurs, as a result of which indigenous phytocenoses are transformed into derivatives [11].

Fig. 1. The survey route of facility from 2016 to 2018.

It is allowed to swim in the Svyatoe Lake, unlike the Black Lake. Swimming in the Beloe Lake is allowed, however in the part that is fenced - the beach area (Fig. 2).

Fig. 2. The Lake Beloe beach

Fig. 3. The Lake Svyatoe beach

During the reconnaissance survey the presence of a yellow-green film with an unpleasant smell and the presence of dead fish were noted. During the summer months, the lakes are strongly eutrophic [2]. Their biological rehabilitation is possible with the involvement of Chlorella vulgaris, which is accompanied by the prevention of water "blooming" (including the suppression of the growth of blue-green algae) [9].

Fig. 4. The Lake Beloe coast is covered with yellow film.

Fig. 5. The Lake Beloe coast. Great number of dead fish

III. MATERIALS AND METHODS OF RESEARCH

Zoobenthos combines organisms that live on the ground and in the soil of the bottom of rivers, seas, and oceans. In zoobenthos, there are animals living in the soil and on the ground, who are mobile, slow-moving and stationary, partially embedded in or attached to the soil. Most of them are important organisms-indicators of the quality of the aquatic environment [1, 3, 4].

The study used a qualitative method of collecting samples.

The selection was made with a net consisting of a round metal hoop with the diameter of 20 cm. After that, the organisms were placed in a small container and sent to the laboratory for further study (Fig. 6).

Fig. 6. Laboratory of Department of General and Environmental Engineering

The analysis of species composition of hydrobionts is carried out using different indices. The most used in the research activities of students is the Mayer index, which allows us to estimate the purity of water of the investigated freshwater reservoir [7]. The determination of water quality applying this method does not require very detailed determination of organisms and is suitable for any type of water body [15]. It is enough to mention the presence of organisms presented in Table 1 in the water body [10].

To determine the quality of water, it is necessary to note which of the indicator groups given in the Table were found in the samples.

TABLE I. INDICATOR GROUPS OF WATER ORGANISMS [10]

Clean water inhabitants	**Inhabitants of water bodies with average pollution**	**Dirty waters inhabitants**
Spring grubs	Scrape	Mosquito-bellied larvae (Fig. 11)
Mayfly Larvae (Fig. 8)	Crayfish	Leeches (Fig. 11)
Caddis larvae	Dragonfly larva (Fig. 9)	Water donkey (Fig. 13)
Larvae vislokrylok	Larvae of mosquitoes	Pond fish (Fig. 16)
Bivalve mollusks	Clam coils (Fig. 10)	Midge larvae (Fig. 14)
	Viviparas	small-necked worms (Fig. 15)

The number of detected groups from the first section of the Table should be multiplied by 3, the number of groups from the second section - by 2, and from the third - by 1. The results obtained should be summarized. The value of the sum shows the degree of reservoir contamination. [10]

When the fugure is:

- over 22 - the reservoir is clean and belongs to the 1st class of quality
- from 17 to 21 - the quality of water indicates the second class of quality (as in the first case, the reservoir will be characterized as oligosaprobic)
- from 11 to 16 - the quality of water indicates the third class, meaning moderate pollution (beta-mesosaprobic zone)
- less than 11 means that the water body as dirty (alpha-mesosaprobic or polysaprobic) - 4-6 quality classes. [10]

The simplicity and versatility of the Mayer method makes it possible to quickly assess the condition of the reservoir under investigation. The accuracy of the method is not high; however, if to check water quality regularly for some period of time and compare the results obtained, one can understand in which direction the state of reservoir changes.

TABLE II. SAMPLING RESULTS OF 15 JUNE 2017

Type	**Class**	**Genus/Family**	**Presence of organisms in sample**							
			Lake Beloe			**Lake Chernoe**			**Lake Svyatoe**	
			m 1	***m 2***	***m 3***	***m 1***	***m 2***	***m 3***	***m 1***	***m 2***
Arthropods	Crustacea	*Asellus aquaticus*		-	-	-	-	-	-	-
		Daphnia curvirostris	-	-	-	-	-		-	
		Cyclopidae	-	-	-			-	-	
	Insects	*Caenis sp.*	-	-	-		-		-	-
		Simuliidae		-		-	-	-	-	-
		Ephemeroptera		-	-	-	-	-	-	-
		Dytiscinae colymbetes		-	-	-	-	-	-	-
		Brachytron sp.	-		-	-	-	-	-	-
		Hydrophilidae	-		-	-	-	-	-	-
		Plea minutissima	-		-	-	-	-	-	-
		Culex pipiens	-	-		-	-		-	
		Ceratopogonidae	-	-	-	-	-		-	-
		Apterygota	-	-	-	-		-	-	-
		Chironomidae			-	-			-	-
	Rachnoid	*Hydrachnidae*		-	-	-	-		-	-
	Entognatha	*Isotomurus sp.*		-	-	-	-	-	-	-
Annelides	Oligochaetes	*Oligochaeta*			-	-		-	-	-
	Leeches	*Piscicola geometra*	-	-	-	-	-	-	-	
	Rotifers	*Eurotatoria*	-	-	-	-		-	-	-
Mollusca	Gastropoda	*Anisus vortex*	-	-	-		-	-	-	
		Lymnaea stagnalis	-		-	-				-
		Lymnaea peregra	-	-	-	-		-	-	-

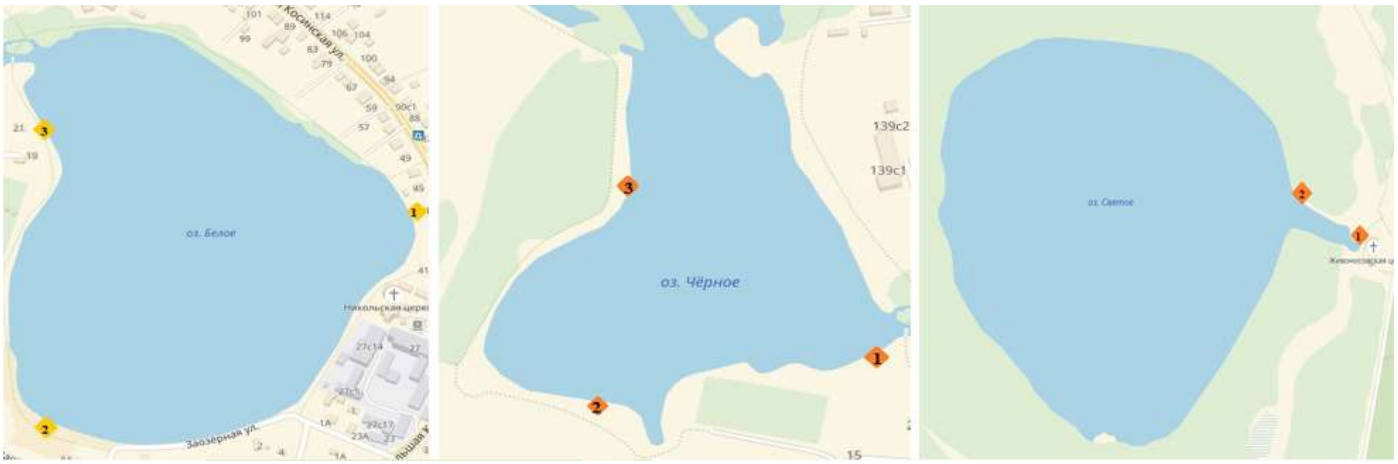

Fig. 7. Sampling points on the Kosinskie lakes

TABLE III. SAMPLING RESULTS OF 15 MAY 2018

Type	Class	Genus/Family	Presence of organisms in sample							
			Lake Beloe			Lake Chernoe			Lake Svyatoe	
			m 1	*m 2*	*m 3*	*m 1*	*m 2*	*m 3*	*m 1*	*m 2*
Arthropods	Crustacea	*Daphnia curvirostris*	-	-	-	-		-	-	-
		Harpacticoida	-	-		-	-	-	-	-
		Cyclops strenuus	-		-			-		
	Entognatha	*Isotomurus sp.*	-	-	-	-	-	-	-	-
	Insects	*Caenis sp.*	-	-		-	-	-	-	-
		Culex pipiens		-		-	-		-	
		Chironomidae				-				-
	Rachnoid	*Hydrachnidae*		-	-	-	-	-	-	-
Annelides	Leeches	*Erpobdella octoculata*	-		-	-	-	-	-	
	Rotifera	*Eurotatoria*			-			-		-
Mollusca	Gastropoda	*Lymnaea stagnalis*	-	-	-	-		-	-	

IV. RESEARCH RESULTS

The sampling was arranged in summer (15 June 2017) and in spring (15 May 2018) on three lakes - Beloe, Chernoe and Svyatoe. 3 points were selected for sampling on the Lakes Beloe and Chernoe, and 2 were selected on the Lake Svyatoe because the Lake is surrounded by a swamp and can only be approached from one side.

TABLE IV. CALCULATION RESULTS OF MAYER INDEX

Lake Beloe		Lake Chernoe		Lake Svyatoe	
June 17	*May 18*	*June 17*	*May 18*	*June 17*	*May 18*
10	5	9	2	4	3

Fig. 8. Mayfly larvae (*Ephemeroptera*).

Fig. 9. Dragonfly larva (Brachytron sp.).

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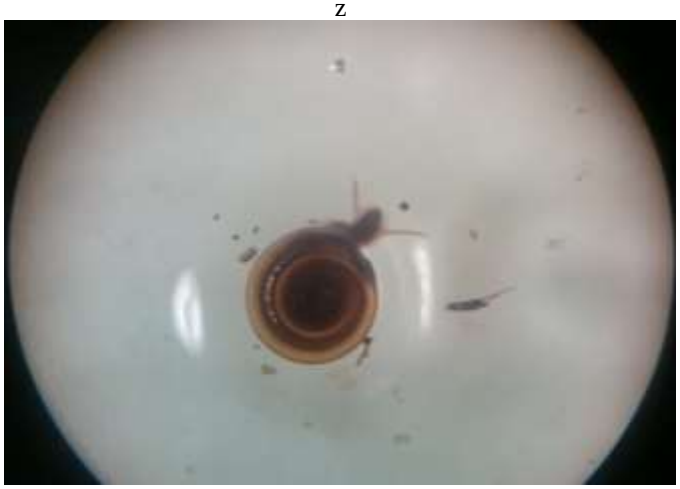

Fig. 10. Aquatic gastropod mollusk (*Anisus vortex).*

Fig. 11. Larva of the bell ringing mosquito (*Chironomus sp.).*

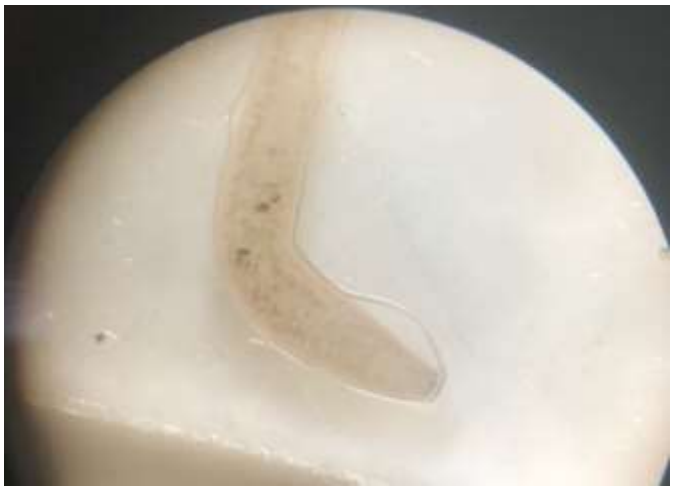

Fig. 12. Leech (Erpobdella octoculata).

Fig. 13. Water donkey (Asellus aquaticus).

Fig. 14. Larva midges (*Simuliidae).*

Fig. 15. Malachish worm (*Oligochaeta).*

Fig. 16. Pond snail (Lymneae stagnalis).

V. CONCLUSIONS

According to the results of calculation of the Mayer index in 2018, the situation has worsened compared to 2017. It is necessary to note the fact of a decrease in the biodiversity of the hydrobionts of the Kosinskie Lakes, as well as a decrease in the number of types of indicators used in the calculation of the Mayer index. The Lakes Beloe, Chernoe and Svyatoe belong to polysaprobic water bodies. The massive development of saprotrophic organisms is most likely caused by sharply increased eutrophication of the Kosinskie Lakes as they now locate on the territory of Moscow. Besides, the area nearby the Kosinskie Lakes is extensively used for mass construction. As a result, the recreational use of the Beloe and Svyatoe Lakes has increased. The importance of systematic hydrobiological observations has significantly increased under such unfavorable conditions for the Lakes (strong anthropogenic pressure).

References

[1] J. Heino, "Are indicator groups and cross-taxon congruence useful for predicting biodiversity in aquatic ecosystems?", Ecological Indicators, vol. 10, iss. 2, pp. 112–117, 2010.

[2] B. Vinçon-Leite, C. Casenave, "Modelling eutrophication in lake ecosystems: A review", Science of the Total Environment, vol. 651, part 2, 2019, pp. 2985–3001.

[3] Y. Wu, "Chapter 3 – Indicators for Monitoring Aquatic Ecosystem", Periphyton, Elsevier, 2017, pp. 71–106.

[4] Y. Xu, Y. Cai, T. Sun, X. Yin, Q. Tan, "An indicator to quantify the effects of hydrodynamic disturbances caused by coastal reclamation on aquatic organisms", Ecological Indicators, vol. 93, 2018, pp. 152–163.

[5] V.Yu. Berezkin et al. "Ecological-geochemical assessment of the territory of Kosino-Ukhtomsky district (Moscow)", Bulletin of the Peoples' Friendship University of Russia. Series: Ecology and life safety, no. 2, 2015.

[6] D.V. Vlasov, N.S. Kasimov, N.E. Kosheleva, "Mapping of the landscape-geochemical structure of an urbanized territory (using the example of Moscow)", InterCarto/InterGIS, vol. 23, no. 1, pp. 242–255, 2017.

[7] A.G. Goretskaya, I.L. Margolina, "Use of bioindicative assessment of the state of ecosystems in the practice of environmental education", Life of Earth, no. 3, pp. 350–354, 2018.

[8] V.V. Ilinsky, I.V. Mosharova, A.Yu. Akulova, S.A. Mosharov, "Current state of heterotrophic bacterioplankton of Kosinsky Three Territories", Water Resources, vol. 40, no. 5, pp. 477–487, 2013.

[9] T.S. King et al., "Study of the possibility of using Chlorella vulgaris microalgae in technological processes of disinfection and purification of wastewater", Water Purification. Water treatment. Water supply, no. 8, pp. 34–40, 2017.

[10] "River observation: manual for public environmental monitoring", Appendix 3. St. Peterburg: Ecocentrum/Clean Baltic Coalition, 2018 p. 32.

[11] A.V. Novikov, O.V. Sumarukova, "The problem of formation of road-path networks in specially protected natural territories", Bulletin of the Scientific and Methodological Council on environmental management and water use, no. 11, pp. 116–119, 2018.

[12] E.M. Nikiforova, N.S. Kasimov, N.E. Kosheleva, "Long-term dynamics of anthropogenic salinization of the soils of Moscow (on the example of the Eastern District)", Soil Science, no. 3, pp. 351–363, 2014.

[13] T.V. Prokofieva, I.A. Martynenko, F.A. Ivannikov, "Systematics of soils and soil-forming rocks of Moscow and the possibility of their inclusion in the general classification", Soil Science, no. 5, pp. 611–623, 2011.

[14] V.P. Seven, General hydrobiology: Text of lectures. Yaroslavl: YarSU, 2012, p. 184.

[15] Environmental monitoring: a manual for teachers, students. Moscow: Academic Project, 2008, 416 p.