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The zoobenthos structure in the Dniprovske (Zaporizke) reservoir, Ukraine

Petrovsky Olexandr, Fedonenko Olena, Marenkov Oleh*

Department of General Biology and Aquatic Bioresources, Faculty of Biology and Ecology, Oles Honchar Dnipro National University, 72 Gagarin Avenue, 49010 Dnipro, Ukraine

*E-mail address: gidrobions@gmail.com

ABSTRACT

The article presents data on monitoring the species composition of the zoobenthos of the Dnipro reservoir during 2015-2018. It has been found that a biocenosis of Dreissena (*Dreissena bugensis, D polymorpha*) was formed on the pass of the upper part of the reservoir on slightly silty sand. The bottom layers of water have been found to be slightly exposed to climatic factors due to slow flow; thus seasonal changes in zoobenthos in the profundal biotope are insignificant.

***Keywords*:** Dniprovske reservoir, zoobenthos, species diversity

1. INTRODUCTION

Benthos, as defined, are groups of organisms which use the bottom of water bodies as a substrate on which or in which organisms spend their entire life [1]. Zoobenthos is one of the most important elements of the ecosystems of continental reservoirs and watercourses [2]. However, studies on zoobenthos are insufficient. The main reason is its taxonomic composition: representatives of up to twenty classes and ten types are found in freshwater zoobenthos of temperate latitudes [2-4].

Despite the fact that the anthropogenic impact on the Dniprovske reservoir is moderate and the self-purification mechanisms of the reservoir are still in effect, the situation may worsen in the near future, so a comprehensive study on the entire natural complex in the reservoir basin is of urgent importance. Zoobenthos is one of the most important links in any hydroecosystem, since most modern methods for determining the quality of the aquatic environment are based

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on indicators of bottom invertebrates groups. Meanwhile, at the present stage, this natural component of the reservoir basin is studied insufficiently. Therefore, the studying the bottom fauna of the Dniprovske reservoir is very relevant.

According to the first report, during the construction of the reservoir, the abundance of zoobenthos has increased up to 10680 ind./m^2 during the first year of the reservoir [5]. Many rheophilous forms have disappeared; the *Dreissena polymorpha* Pallas mollusk, which had been met singly in the stepped part of the Dnieper, multiplied massively. On the back of the construction of the reservoir, the development rate of Oligochaeta and Chironomidae increased while the number of species of these groups of benthos reduced [6, 7].

In 1947–1950 20 species of rheophilous invertebrates disappeared from the benthic fauna structure of the reservoir, common for the former Dnipro stepped part, the number of other organisms has decreased. Detritophagous chironomids dominated, during the following years the number of predatory chironomids has increased. The upper reaches of the reservoir with a typical river conditions were defined by moderate development of the molluscs fauna due to litoreophils and peloreophils. Closer to the dam with increasing depth the thickness of silt deposits and the accumulation of organic substances grew, there was a gradual decrease in the quantitative indicators of mollusks development, species composition of bentofauna depleted. Littoral and sublittoral are inhabited by rich malacofauna, dominated by Quagga mussel and zebra mussel [8].

In 1955–1959, an increase in the biomass of zoobenthos at the expense of tubificidae oligochaetes in profundal of the reservoir was noted; oligochete and mollusk complex prevailed. In sublittoral huge clusters of Dreissena were discovered (up to 10 kg/m^2). Littoral and sublittoral had the richest bottom fauna in qualitative terms. As moving closer to the dam, with increasing depth, the biomass of zoobenthos decreased, with dominating oligochaetes. This period was characterized by further accumulation of silt bottom sediments in the lower part of the reservoir, accumulation of loess and fine soil in the littoral and sublittoral [9].

A crucial role in changes of zoobenthos structural and functional parameters after the construction of the dam, was played by silt accumulation in profundal of the lower part. Yu K. Gaidash noted that in 70-80th the main biotopes of the upper part of the reservoir were silts and sands of varying degrees of silting. Due to these changes the number of rheophilic forms has significantly reduced, pelophilic forms have spread and phytophagic, phytophilous forms have spread in higher water vegetation thickets. Yu. K. Gaidash considered water blooming caused by blue-green algae in all the reservoirs on Dnipro river, including the Dniprovske reservoir as the main reason for the impoverishment of the qualitative composition of the macrozoobenthos, which occurred due to the death of oxyphilic forms and some of the Caspian crustaceans.

The mass development of blue-green algae has caused a decrease in the zoobenthos species richness due to the increased content of organic matter, including humic matter, substances and decay products of blue-green algae in the water, the growth of water color index, the deterioration of the gas regime at the bottom due to hyper-accumulation of organic substances and dead algae in the bottom sediments of the reservoir [5-7]. At depths of more than 20 m in the middle part of the Dniprovske reservoir only 2 groups of bottom inhabitants developed: oligochaetes and larvae of chironomids. Oligochaetes dominated, reaching up to 97–99% of the number of bentofauna. Zebra mussel has reached a mass development; some members estuary Caspian complex have become widespread [5-7].

I. P. Lubyanov noted that changes in the hydrological and hydrochemical factors caused by the existence of the Dniprovske reservoir under the conditions of the cascade has led to the disappearance of the "Corophiidae soil" in places of *Corophium curvispinum* accumulation and mass development of the *Dreissena bugensis* molluscs [8].

The scientist also pointed out that on soils consisting of a liquid non-compacted loess, the species composition of benthofauna was poor and had quantitative indicators 7-15 times less than on pure productive silts. Under the new conditions, the spring flood waters prevented silt accumulation at the top of the reservoir and became the main factor that determined the seasonal dynamics of the zoobenthos. I. P. Lubyanov distinguises following four types of biocenoses, which belonged to the macrofauna of the reservoir benthos: pelorheophilous (on silted sands and silts), psamorheophilous (sand and loess), phytophilous (on submerged vegetation) and littophilous (on the rocks and hydraulic facilities).

Thus, after the regulation of the reservoir, there were simultaneous processes of impoverishment of species composition and growth of quantitative indicators of the reservoir bentofauna. These processes reached the highest development level in profundal of the reservoir`s lower part due to silt accumulation [8, 10].

Along with hydrological and meteorological conditions, structural and functional changes in the groups of the Dniprovske reservoir zoobenthos were often caused by various anthropogenic factors such as pollution of the reservoir by man-made effluents, as well as mineral and organic substances, pesticides, oil products. The largest anthropogenic load was experienced by the upper part of the reservoir with tributaries that flow into it, which was almost constantly under the influence of industrial wastewater of Kamianske (formerly Dniprodzerzhynsk) and Dnipro (formerly Dnipropetrovsk) Cities, resulting in significant changes of the natural ecosystem. This was expressed in the simplification of the trophic structure of zoobenthos, reduced number of filtrating hydrobionts and depletion of species composition. Comparing the number of benthic fauna species in 1935 with the current one, we can see its decrease by almost 4–5 times. Thus, in the summer of 1935 on the almost same area more than 70 species of zoobenthos were revealed [5]; current indicator is up to 2 dozen species and forms [6, 7].

According to reports of A. Dyga [9], in places of drains, even such unpretentious organisms, as oligochaetes, have had little development, moreover, only in the spring [6, 8]. In the area ofpollution influence in summer and autumn there is a complete degradation of biocenoses. An increase in the development of oligochaetes and zooplankton was noted in the area of food industry effluents and in the area of moderate pollution with organic matter [10, 11].

2. MATERIALS AND METHODS

Studies on zoobenthos were conducted on the Dnieper reservoir in 2015-2018. The reservoir is located in the South-west of Ukraine, in the territory of the agro-industrial zones and been under strong anthropogenic influence. Distribution of zoobenthos along the Zaporizke Reservoir and its tributaries has been studied in the spring 2018 by zoobenthos sampling at 8 sites (**Fig. 1**): 1) Orel' river 2) near Kodaki water draw-off, 3) near Solnechny residental district, 4) near discharge of urban sewage, 5) near Monastyrsky island, 6) Samara bay, 7) near the stream of Tonelna beam, 8) near Viys'kove villiage.

Samples of zoobenthos were taken by Ekman-Birge bottom sampler (with a capture area of 0.004 m^2) and hydrobiological scrapers nets (diameter of the scraper net hoop is 20–25 cm), which are more convenient to take samples in shallow water areas of the reservoir at a depth of 1.0–1.5 m [12, 13]. At each station, two samples were selected using bottom sampler and one sample using a hydrobiological scraper net according to the standard method. The bottom inhabitants were fixed in 4% formalin solution [14]. The soil was washed through a grid of close-meshed mill gauze. Samples were weighted on torsion scales by groups [15, 16]. The species composition was determined using microscopes MB-1 and MBS-1. Occurrence was determined for each species [12-16].

Statistical analysis of the experimental material was performed using *Microsoft Excel* and *STATISTICA 6.0* software packages for personal computers.

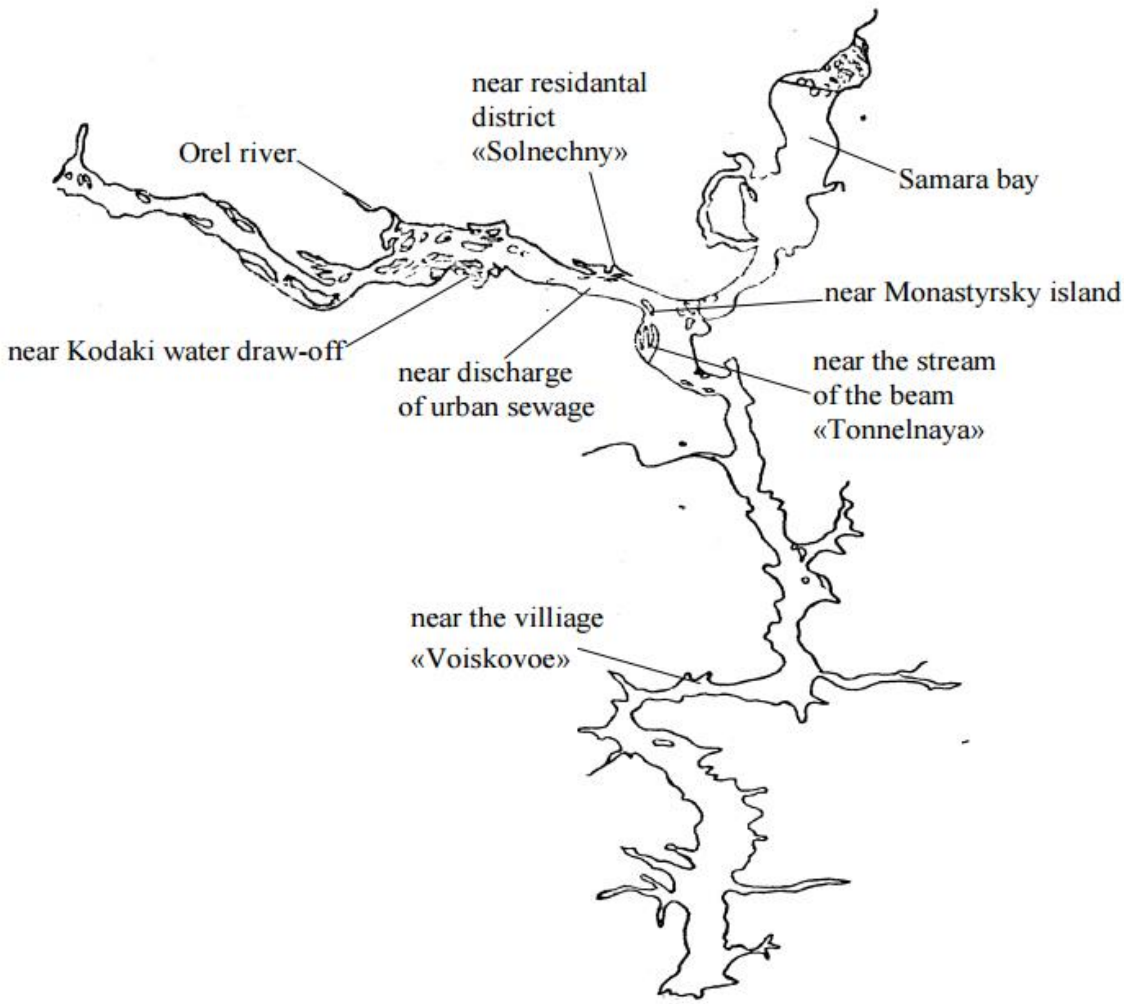

Figure 1. The sites of zoobenthos sampling along Dnieper reservoir and its tributaries

3. RESULTS AND DISCUSSION

In the zoobenthos structure of the Dniprovske reservoir and its tributaries (rivers Mokra Sura, Konoplyanka, Samara, Oril) during the study, 96 species of zoobenthos were found, which belonged to 14 groups. It was recorded: among the chironomids larvae – 36 species, oligochaetes – 24, mollusks – 14, crustaceans – 10, leeches – 4, other groups – 8 (**Table 1**).

Table 1. The species composition of the Dniprovske reservoir zoobenthos, 2015-2018.

#	Species	Occurrence
	Chironomid group	
	Tanytarsini	
1.	*Tanytarsus lauterborni* Kieff.	+
2.	*T. lobatifrons* Kieff.	+
3.	*T. mancus* Wulp.	++++
	Tendipedini	
4.	*Allochironomus* sp.	+
5.	*Corynoneura* sp.	++
6.	*Clinotanypus nervosus* Mg.	+
7.	*Tendipedini macrophtalma*	+
7.	*Syndiamesa nivosa*	Sporadic
8.	*Prodiamesa* sp.	Sporadic
9.	*Diamesa prolongata* Kieff.	+
10.	*Einfeldia carbonata* Mg.	++++
11.	*E. pagana* Mg.	++
12.	*Endochironomus dispar* Mg.	+
13.	*E. tendens* F.	+++
14.	*Glyptotendipes gripecoveni* Kieff.	++
15.	*G. polytomus* Kieff.	++
16.	*Limnochoronomus nervosus* St.	+++
17.	*L. tritomus* Kieff.	+
18.	*Micropsectra praecox* Mg.	+
19.	*Pentapedilum exsectum* K.	+++
20.	*Polypedilum convictum* Walk.	++++
21.	*P. nubeculosum* Mg.	+++

22.	*P. scalaenum* Schr.	+
23.	*Sergentia longiventris* Kieff.	++++
24.	*Tendipes plumosus* L.	++++
25.	*T. thummi* Kieff.	+++
26.	*T. plumosus-reductus*	++
27.	*Trichocladius lucidus* Staeg.	+
	Orthocladiinae	
28.	*Cricotopus algarum* Kieff.	++
29.	*C. silvestris* F.	++++
30.	*Cryptochironomus anomalus* Kieff.	++
31.	*C. conjugens* Kieff.	+
32.	*C. pararostratus* Lenz.	+
33.	*C. viridulus* F.	+++
34.	*Psectrocladius psilopterus* Kieff	+++
	Pelopiinae	
35.	*Pelopia villipennis* Kieff.	++
36.	*Procladius* Scuze.	++++
	Heleids group	
37.	*Chaoborus crystallinus*	+
38.	*Culicoides* sp.	++
	Efidrides group	
39.	*Eristalis tenax*	+
	Dragonflies group	
40.	*Coenagrion* sp.	++
	Ephemera group	
41.	*Cloen dipterum* L.	+++
	Hamarids group	
42.	*Ch. ischus*	+

43.	*Chaetogammarus tenellus* Sars.	++
44.	*Ch. Warpachowski* Sars.	+
45.	*Corophium curvispinum* Sars.	+
46.	*Dikerogammarus haemobates* Eich.	+
47.	*D. villosus* Sowin	++
48.	*Synurella* sp.	+
	Cumacea group	
49.	*Shizorhynchus eudorelloides*	+
	Isopod group	
50.	*Asellus aquaticus* L.	+++
	Mizida group	
51.	*Limnomysis benedeni* Czern.	+
	Oligochaetes group	
	Family Aelosomatidae	
52.	*Aelosoma variegatum* Vejd.	+
	Family Naididae	
53.	*Stylaria lacustris* L.	++++
54.	*Dero dorsalis* Ferr.	+++
55.	*Nais barbata* Mull.	++++
56.	*N. behningi* Mich.	+
57.	*N. communis* Pig.	+++
58.	*N. elinguis* Mull.	++
59.	*N. pardalis* Pig.	++
60.	*N. pseudobtusa* Pig.	+++
61.	*N. simplex* Pig.	+
62.	*Paranais littoralis* Mull.	+
63.	*Pristina bilobata* Bretsch.	++
64.	*P. aequiseta* Bourn.	+
65.	*Chaetogaster crystallinus* Vejd.	++

66.	*Ch. diaphanus* Gruith.	+++
67.	*Ophidonais serpentina* Mull.	++
68.	*Uncinais uncinata* Levin	+
	Family Tubificidae	
69.	*Iiyodrilus bedoti* Pig.	+
70.	*I. hammoniensis* Mich.	++
71.	*Limnodrilus claparedeanus* Ratz.	+++
72.	*L. hoffmeisteri* Clap.	++++
73.	*L. michaelseni* Last.	++
74.	*L. udekemianus* Clap.	+
75.	*Tubifex tubifex* Mull.	+++
	Mollusk group	
76.	*Amphipeplea glutinosa* Mull.	+
77.	*Bithynia leachi* Shep.	+
78.	*B. tentaculata* L.	++
79.	*Dreissena bugensis* Andr.	++++
80.	*Dr. polymorpha* Pall.	+
81.	*Limnaea auriculata* L.	++
82.	*L. stagnalis* L.	+
83.	*Lithoglyphus naticoides* C. Pf.	+
84.	*Physa acuta* Drap.	+
85.	*Planorbis corneus* L.	++
86.	*P. planorbis* L.	++
87.	*Theodoxus fluviatilus* L.	+++
88.	*Valvata piscinalis* Mull.	++
89.	*Viviparus viviparus* L.	++++
	Leeches group	
90.	*Glossiphona complanata* L.	++
91.	*Helobdella stagnalis* L.	+++
92.	*Herpobdella octoculata* L.	+

93.	*Protoclepsis tessulata*	Sporadic
	Bryozoans group	
94.	*Plumatella fungosa* Pall.	+
	Hydras group	
95.	*Hydra vulgaris* Pall.	+
96.	*Pelmohydra oligactis* Pall.	Sporadic

Note: (Sporadic) – occasional finds, (+) – low occurence, (++) – medium occurence, (+++) – high abundance, (++++) – dominant species.

Near Kamenka village in the upper part of the reservoir a rare representative of Cumacean, *Shizorhynchus eudorelloides* was found, and in Konoplyanka river the freshwater hopper *Synurella ambulans* was found.

Structural and functional characteristics of zoobenthos were studied for evaluation of the food potential for benthic fish and the ecological state of the Dniprovske reservoir sites [18-21]. In 2018, the seasonal dynamics of zoobenthos was studied in the upper part of the reservoir near Monastyrsky island. In the spring of 2018, zoobenthos samples were collected in different sites of the Dniprovske reservoir, including areas influenced by effluents. It has been found that, despite the pollution, the species diversity of zoobenthos in the Dniprovske reservoir was high in most of the studied sites. The development of zoobenthos reached maximum in winter and spring in the clusters of the molluscs of the Dreissena genus. Indices and indicators of zoobenthos development revealed the best ecological condition of silted sand in the upper part of the reservoir. The zones influenced by effluents and the profundal of the lower part of the reservoir were assessed as the most polluted.

The species composition of the Dniprovske reservoir benthofauna was typical for the reservoirs of this cascade, with a predominance of freshwater species of Northern and temperate latitudes. Representatives of the Ponto-Caspian complex dominated the overgrowth of the Dreissena and biotopes of the upper part of the reservoir. The number of species in stations fluctuated from 6 to 26, the lowest one was on the silts of profundal, the highest one was in thickets of the littoral zone. Mainly detritophagous and sestonophagous forms prevailed.

Most of the fauna that were part of the benthic communities were met in the reservoir during the growing season rarely and in small quantities. Only about 1/3 of the species composition was found relatively often and in large quantities. This part was characterized by a large biomass, making out the core of macrozoobenthic groups, determining their structure and specificity, and playing a prominent role in the transformation of organic matter and energy in biocenoses. Predators took a secondary place in the composition of biocenoses in comparison with peaceful filtrating forms, sedimentators, collectors and swallowers, which indicates the high trophicity of the reservoir.

Benthic invertebrates inhabite five substrates in the Zaporizke Reservoir such as sand, muddy sand, slime, aggregations of *Dreissena* mussel, macrophyte beds. Abundance of zoobenthos is determined mainly by the substrate of intertebrates dwelling. The substrates listed above were associated with four bottom types: muddy sand of profundal, slime of profundal, muddy sand of littoral and slime of littoral. Intensive hydrodynamics and sediment erosion in littiral and partly in profundal of the Zaporizke Reservoir upper part caused that the trophic structure of zoobenthos was diverse including such trophic types of invertebrates as collectors as well as euryphagous phytophagous and detritophagous invertebrates. Concortium of *Dreissena* mussel (*Dr. bugensis, Dr. polymorpha*) has been formed in muddy sand of profundal of reservoir upper part. Bottom layer of the Zaporizke Reservoir water column is slightly affected by climatic factors due to slow stream that's why seasonal changes of zoobenthos are insignificant in these layers. Abundance of zoobenthos in winter often was maximal compared to other seasons. Thus in December and in early spring in profindal of reservoir upper part near Monastyrsky island abundance of "soft" zoobenthos averaged 4.2±0.21 thous. ind./m^2 varying from 3 to 6.5 thous. ind/m^2 and biomass of "soft" zoobenthos averaged 27.7±1.72 g/m^2 varying from 9.6 to 39 g/m^2. Biomass of *Dreissena* mussels averaged 3.1±0.12 kg/m^2 and biomass of zoobenthos in favorable conditions of *Dreissena* aggregations was high: abundance of gammarids averaged 19.8 ±1.18 g/m^2, polychaetes – 3.5±0.41 g/m^2, oligochaetes – 2.3±0.12 g/m^2.

4. CONCLUSIONS

Quantitative development of zoobenthos largely determines the substrate for organisms development. In the reservoir during the study period the representatives of zoobenthos formed biocenoses on following types of substrate: sand, silted sand, silt, Dreissena clusters and macrophyte thickets. These types of substrates have been associated with four types of biotopes, namely silty sand of profundal, silt of profundal, silted sand of littoral and silt of littoral.

The main regulating factor of sediment distribution in the reservoir is hydrodynamics. With increasing distance from the shore and the depth, the deposition of smaller particles occurs, the dispersion of silt decreases. In littoral and partly on the meadstream of the opper part in a tense hydrodynamics and erosion of fine sediment trophic structure of aquatic organisms were diverse, including representatives of gatherers, euryphagous, phytophagous, and detritophagous forms. At the depths of the reservoir more than 20 m, under the conditions of slow hydrodynamics, cumulative processes prevail over the hydrogenic ones; there is an accumulation of fine sediment and domination of groups of animals that selectively swallow the soil (tubificidae and oligochaetes). Such spatial structure of the bottom inhabitants is common for lakes. Thus average "soft" zoobenthos biomass indicates good fishing potential of the reservoir. The reservoir according to the fishery classification is evaluated as water body of middle or high nutrient status (I – II fish-farming class). In the future the reservoir can be effectively used for growing fishes consuming macrozoobenthos, but it is necessary to carry out stocking with bentivorous fishes such as common carp or wels catfish to use effectively rich resourses of 'soft' zoobenthos.

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