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Impact of Kaniv Hydroelectric Power Plant on the Zooperiphyton Communities in the Downstream

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Abstract- The construction and operation of hydroelectric power plants significantly affect the rivers' ecosystems on which they were built. This impact regards not only to the upstream sections, where the reservoirs are created but also to sections of rivers in the downstream of the dams. This article deals with the influence of Kaniv Hydroelectric Power Plant on the zooperiphyton communities of the shore protection constructions in the downstream. In order to estimate the impact of the hydroelectric power station, the quantitative parameters of the periphyton communities (such as density and biomass) were compared at different distances from the hydroelectric dam. The tendency to decreasing the density and the biomass of these communities at the more long distances from the dam has been detected at the more long distances from the dam. The tendency is clear in the some seasons of the year (spring, early summer, and autumn).

Keywords- *Hydroelectric, Dam, Periphyton, Downstream*

I. INTRODUCTION

Hydropower takes an important place in the production of electricity in the modern world. The hydroelectric power stations are used in 159 countries of the world and generate 16.3% of the world's total electricity (The Current State..., 2014). In the current context, great attention is paid to the development of the renewable energy. But wind and solar power plants produce non-regulated power and they need the regulatory capacity (Landau, Stashuk, 2018). Hydropower is also a renewable energy source. Besides, hydroelectric power stations provide intermittent power, that's why they are very important in regulating the daily generation of electricity (Schmutz et al., 2015; The Current State ..., 2014). Therefore, in today's conditions, the importance of hydropower is increasing (Ashraf et al., 2014). However, it should be noted the significant negative impact of this industry on the environment. The construction of dams leads to the fragmentation of rivers and causes disturbance of the functioning of water and coastal ecosystems (Revenga et al., 2000). First of all, it concerns the construction of reservoirs, which leads to a complete reorganization of the ecosystems of the rivers on which they are created. At the same time, there is a less radical transformation of the ecosystems in the downstream of the hydroelectric power stations. However, a specific hydrological regime appears in the conditions of the downstream which is not usual for the natural rivers (Vinson, 2001; Ward 1976; Ward, Stenford, 1982; Obodowsky, Grebin, 2001). There are the changes of the hydrological regime and other environmental factors which affect the biocenoses of river ecosystems in these areas (Bernez, Ferreira, 2007; Smolar-Žvanut, Mikoš, 2014; Vinson, 2001; Zębec, Szymańska, 2014). Therefore, it should be explored the influence of the operation of hydroelectric power stations on biocenoses and their components in the downstream. But this influence is more explored on the mountain rivers. Most of the mentioned researches are related to them. The situation on the Dnipro River below Kaniv Hydroelectric Power Plant can be an example of such impact on a large lowland river with a cascade of hydroelectric power stations.

The zooperiphyton communities are quite sensitive to these factors among the components of the river's biocenoses. The stone shore-protecting constructions, which are situated on the right bank of the Dnipro River below Kaniv Hydroelectric Power Plant, are a favorable substrate for these communities. Because such constructions are located at various distances from the dam of the hydroelectric power station, we can attempt to estimate the impact of its work on the communities by the way of comparing the development of periphytic communities on them.

The objective of this paper was to find out the taxonomic composition and quantitative parameters (such as density and biomass) of the zooperiphyton communities inhabiting the stones of the shore protection constructions in the downstream of Kaniv Hydroelectric Power Plant and their seasonal dynamics, and to estimate the impact of the operation of the hydroelectric power station on these communities.

II. MATHERIALS AND METHODS

The research was carried out in the upper section of the Kremenchuk reservoir on the Dnipro River below Kaniv Hydroelectric Power Plant. On this site, the water level and flow velocity depend on the work of the power plant. By using the hydropower plant to regulate daily generating of electricity, its launches occur twice a day (in the morning and the evening). At this time, the flow velocity and water level are increasing. During the periods between the launches the water level is significantly reduced (the difference may be several meters, but during the period of spawning of the fish from April till early June - no more than 0.5 m). Also, the water level varies depending on the season, although not so much as in natural rivers (Obodovsky, Grebin, 2001). As a result, some of the shore-protecting constructions are dried from the end of summer till spring.

The 7 stations were selected for sampling on the section of the Dnipro river from the town of Kaniv to the village of Pekari. These stations are located at various distances (3.46-7.72 km) from the dam of the hydroelectric power station. At every station, samples were taken from two points (upstream and downstream of the shore protection construction), except for the station 3, where the sampling was carried out only from one point. The samples were taken every season (except for the winter period, when the river was covered by ice) from November 2016 to October 2018. At the station 5, the samples were not taken in all seasons, since this shore protection construction was dried when the water level was declining (below 80.6 m. a.s.l. by the Baltic system of altitudes), which was observed at the end of summer and autumn. In total, 196 samples were taken.

The sampling was carried out by washing of the periphyton from stones taken from water from a depth of 0.5 m. The 4% formalin was used for the fixation of organisms. Preliminary analysis was carried out using the Bogorov counting camera and stereomicroscopes MBS-9 and MBS-10. The linear size of organisms was measured using an eyepiece reticle. The torsion weighing scale VT-500 or the calculation method according to the linear size was used to determine the biomass (Methods of Hydroecological Research, 2006; Balushkina, 1982). The density and biomass of periphytic organisms were calculated per unit area of the stone surface.

Besides, measurements of some abiotic factors at various distances from the dam (water temperature, flow velocity, pH, total dissolved solids) were carried out.

The Pearson correlation coefficient (for linear relationships) and Spearman's rank correlation coefficient (for nonlinear relationships) were used to estimating the relationship between the density and biomass of the zooperiphyton communities and the distance from the dam.

III. Results and Discussion

Representatives of 8 phyla of invertebrates (Porifera, Cnidaria, Platyhelminthes, Annelida, Bryozoa, Tardigrada, Arthropoda, and Mollusca) were detected in the zooperiphyton communities of shore protection constructions in the downstream of Kaniv Hydroelectric Power Plant. The main taxa were Cnidaria (family Hydridae), Oligochaeta, Bryozoa, Gastropoda and Bivalvia (*Dreissena*), and Insecta (the larvae of Chironomidae and Trichoptera).

The total density of periphyton fluctuated within the limits of 35-26868 ind./m2 during the research period. The dominant taxa were: Chironomidae - in 40.3% of samples, Oligochaeta - 28.6%, *Dreissena* - 20.9%, Gastropoda - 5.6%, Hydridae - 0.5%, Trichoptera – 0.5%. Besides, there were cases when two dominant taxa were detected: Oligochaeta + Chironomidae - 1.5% of samples, Gastropoda + *Dreissena* - 1.5%, Chironomidae + *Dreissen*a - 0.5%. It should be noted that the dominance of the oligochetes and chironomids is more typical for the spring and early summer, and the dominance of *Dreissena* - for the end of summer and autumn.

The total biomass varied from 0.004 to 699.7 g/m2 and biomass excluding mollusks was 0.004-197.4 g/m2. The taxa that dominated in the biomass were Gastropoda - 55.6% of samples, Chironomidae - 18.4%, *Dreissena* - 18.4%, Bryozoa - 5.1%, Oligochaeta - 1.5%, Isopoda - 0.5%, Oligochaeta+Chironomidae - in 0.5% of samples. The dominance of the Chironomidae larvae was most often observed in the spring, and *Dreissena* was at the end of summer and autumn, while the gastropods could dominate in all seasons during the research period.

As a result of fluctuations in water levels, which resulted in the drainage and of some shore protection constructions and icing, the zooperiphyton communities disappeared during the winter. After that, they recovered during the next growing season. Thus, the density of the communities was lowest at the beginning of the spring season. Then the density quickly grew and reached the maximum in the summer (in most cases in June, although sometimes in July or in August). The total biomass could be quite significant already at the beginning of the season, with maximum values achieved in different months throughout the research season. This situation is related to the presence in the communities of the gastropods, which are mobile organisms and can have large individual biomass. The biomass excluding mollusks is characterized by more distinct seasonal dynamics. Its values were small from March till April. Then the values were growing rapidly. The maximum values were observed in June most often (in some cases in May or July). Then the values declined, although the autumn values were usually higher than in spring.

To estimate the impact of the operation of the hydroelectric power station on the development of the zooperiphyton communities, we tried to find out the relationship between the quantitative parameters of these communities and the distance from the dam of the hydroelectric. In the autumn period of 2016, a negative correlation of the density and the biomass excluding mollusks with the distance from the hydroelectric was detected (Borysenko, Lukashov, 2017). Also, statistically significant relations were detected in October (also autumn period) in 2018 for total biomass ($r=-0.81$, $p<0.05$). And also in the second half of June, in 2017 - for the total biomass ($r=-0.85$, $p<0.05$), and in 2018 - for soft biomass ($r_s=-0.94$, $p<0.05$) - this relation is shown in Fig. 1. The similar correlations could be observed in other periods of the year, but they were weaker and statistically insignificant.

Similar correlations were also found for certain taxa of periphytic organisms. Thus, in the autumn period of 2016, the density and biomass of Oligochaeta and Chironomidae also decreased with the distance from the dam of the hydroelectric power station (Borysenko, Lukashov, 2017).

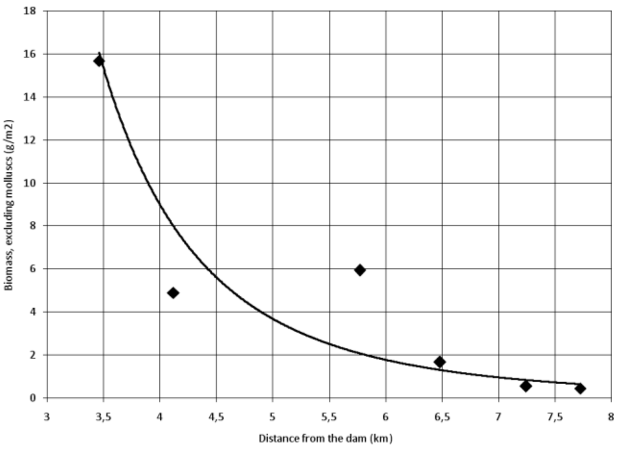

Figure 1. Relation between the biomass of the periphyton excluding mollusks and the distance from the dam of Kaniv Hydroelectric Power Plant in the second half of June 2018

In 2017, a similar situation was typical for the biomass of bryozoans in the second half of June ($rs=-0.89$, $p<0.05$), for the density of *Dreissena* in August ($r=-0.79$, $p>0.05$) (Borisenko, Lukashov, 2018) and for the density and biomass of larvae of caddisflies in October ($rs=-0.65$ and -0.67, respectively, $p<0.05$). In 2018, for the biomass of Chironomidae in May ($r= -0.76$, $p<0.05$), the density and biomass of *Dreissena* in the first half of June (in both cases, $rs=-0.89$, $p<0.05$) , for the biomass of bryozoans in the second half of June ($rs=-0.89$, $p<0.05$).

It should be noted that for the oligochetes in two cases the inverse relationship was detected: the biomass of the oligochaetes increased with the distance from the hydroelectric in 2017 in April ($r=0.83$, $p<0.05$), and in August ($r=0.96$, $p<0.05$).

Thus, the general tendency to decrease the density and biomass of the periphyton is noticeable with a distance from the dam of the hydroelectric power plant. This situation is typical both for communities in general and for the certain taxa of their representatives. Characteristically, that the increase in the density and biomass of the groups of aquatic macroinvertebrates and periphytic algae as a result of the operation of hydroelectric power stations was observed by the other authors (Brittain, Saltveit, 1989; Kokavec et al., 2017; Mannes et al., 2008; Smolar-Žvanut, Mikoš, 2014; Vinson, 2001). In the conditions of the downstream of Kaniv Hydroelectric Power Plant, this may be due to changes in the environmental conditions caused by the operation of the hydroelectric, which, respectively, are more pronounced at nearer distances. It is known that the work of the hydroelectric power stations leads to changes in several environmental factors in the downstream. In particular, this refers to the discharge and water level: the seasonal fluctuations of these parameters decrease, but there are the daily fluctuations that are not characteristic of natural watercourses (Ashraf et al., 2018; Brittain, Saltveit, 1989; Obodowsky, Grebin, 2001). Also, the thermal regime changes (Céréghino et al., 1997, Saltveit et al., 1994; Vinson, 2001). Hydrochemical parameters of water, such as oxygen concentration, organic matter, dissolved salts, etc. may be changed too (Kokavec et al., 2017; Bunea et al., 2010, Huliaieva, 2003).

These changes may affect the communities of aquatic organisms in these sites. In particular, higher values of the flow velocity may lead to an increase in the quantitative parameters of the communities of macroinvertebrates, including periphytic (Brittain, Saltveit, 1989, Sharapova, 2007). And according to our data, the flow velocity is higher on the areas which are closer to the dam. However, it should be noted that in the conditions of rapidly flowing mountain rivers, the growth of density and biomass of periphytic and benthic organisms may be due to decreasing the flow rate caused by dams (Smolar-Žvanut, Mikoš, 2014; Mannes et al., 2008).

Another important factor is the stabilization of the temperature regime (Brittain, Saltveit, 1989). It is known that the hydroelectric power stations with hypolimnetic release increase the water temperature in the downstream in the autumn-winter period and reduce it in spring (Cerregino et al., 1997; Saltveit et al., 1994; Vinson, 2001). As a result, the link between the water temperature and the distance below the dam is established. We also discovered such connections for particular periods of the year. Characteristically, that the clearest correlations between the distance from the hydroelectric and the density and biomass of periphyton communities were detected during the autumn or early summer. It is at this time that the temperature change with the distance from the hydroelectric is the most pronounced. In May and in June, cold water from the hypolimnion of the reservoir reduces the water temperature in the downstream of hydroelectric. But during the summer, the water warms up, and in autumn its release makes the water below the dam warmer. Thus, during the summer, there is a change in the character of the impact of water releases by hydroelectric on these parameters and we do not detect clear correlations for the distance from the dam and temperature. At the same time, correlations of the density and biomass of the zooperiphyton communities on the shore protection constructions with the distance from the dam become less pronounced.

IV. CONCLUSIONS

The representatives of 8 phyla of invertebrates were identified in the periphyton communities of shore protection constructions in the downstream of Kaniv Hydroelectric Power Plant. The dominant taxa were Chironomidae, Oligochaeta, Bivalvia (*Dreissena*), Gastropoda, Bryozoa.

These communities are characterized by the seasonal dynamics with the minimum value of quantitative parameters at the beginning of spring, rapid development with the achievement of maximum values in the summer and the gradual decrease in autumn and disappearance in the winter period.

There is the general tendency to decrease the quantitative parameters with the distance from the dam of the hydroelectric power station is revealed, but it is not equally clear in different seasons of the year. Such relations were more often detected in early summer or the fall.

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