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MULTI-MARKER APPROACH WITH THE UTILIZING OF BIVALVE MOLLUSKS FOR THE EVALUATION OF HYDROPOWER PLANTS IMPACT IN LATVIA AND UKRAINE*

Hydropower is the most important and most economical of renewable energy sources for electricity generation; and its importance in the future is expected to increase (Kaunda et al., 2012). Hydropower could prove especially valuable power source in the context of climate change due to its low carbon footprint and high power generation efficiency. Additionally, large reservoirs could be utilized for other purposes (recreation, source of drinking water). On the other hand, these artificial reservoirs could accumulate toxic effluents, alter temperature regime and cause degradation of aquatic ecosystems (Rambo et al., 2017). Therefore, the environmental impact of HPP reservoirs needs to be evaluated. The majority of ecotoxic studies of the impact of HPPs is focused on the biodiversity and accumulation of toxic metals and persistent organic substances in the reservoirs (Lebedynets et al., 2004, Quadroni et al., 2017) and genotoxicity caused by the sediment (Rambo *et al.*, 2017). Biochemical markers of the

effect and exposition in the aquatic animals from the HPPs related areas are studied scantly (Tarnowska et al., 2013). The selection of relevant bioindicative organisms is a crucial point for an ecotoxicological studies. Bivalve mollusks are excellent indicator organisms to assess the effects of environmental stressors on aquatic ecosystems and human exposure since they have sedentary nature, filter-feeding behaviour, ability to accumulate pollutants and sensitivity to environmental temperature (Dailianis, 2010).

The aim of this study was the evaluation of the environmental relevance of artificially transformed river sites related to hydropower plants (HPPs) activities basing on the detecting of biochemical markers of stress and toxicity of bivalve mollusks. We selected the indices of oxidative stress, metabolic depression, metallothionein levels (as the marker of contamination by toxic metals), and cholinesterase levels (as the marker of organophosphate and thiocarbamate toxicity). Vitellogenin-like proteins, determined as alkali-labile proteins (ALP), were included as components that supply gametogenesis with phosphates and zinc. The enzyme of apoptosis, caspase-3, was also evaluated.

Bivalve mollusks *Dreissena polymorpha* (Pallas, 1771), in Latvia and Ukraine, and *Unio tumidus* (Retzius, 1788) in Ukraine were studied. *D. polymorpha* was sampled in autumn, and *U. tumidus* - in summer and autumn. In Latvia, the mussels were sampled at the reservoir of Riga HPP (River Daugava) and natural Lake Kanieris (shallow lagoon clearwater macrophyte lake, part of Kemeri National Park). In Ukraine, the specimens of *U. tumidus* were collected at the tributaries of the Dniester River basin within its middle streams (before and after dam of small HPP in Kasperivtsi (r. Seret) and micro HPPs in Krasnostavtsi (r. Zvanchyk), and the specimens of *D. polymorpha* - in Ternopil Lake (r. Seret)). The applied methods are described thoroughly in (Falfushynska et al., 2012).

Water chemical composition has shown the similarity of the characteristics depending on the geographic location. The analysis of antioxidant enzymes has also indicated that superoxide dismutase, catalase and glutathione S-transferase activities were similar within the same species in the mussels from both Latvian sites and in the mussels from small HPP and micro HPP (before and after the dam) with some exceptions. Surprisingly, the level of lipid peroxidation detected as thiobarbituric acid-reactive substances, was higher in the specimens from expectedly less contaminated sites (the natural lake in Latvia and micro HPP in Ukraine). In contrast, protein carbonyl (PC) level was higher in mollusks from big reservoirs (Kasperivtsi and Riga). Besides, higher level of PC was accompanied with the low activity of the main apoptotic executive enzyme caspase-3. This regularity can reflect the delayed apoptosis and, therefore, the accumulation of the oxidized proteins in the digestive gland of mollusks in these reservoirs.

The level of low weight thermostable protein metallothionein, known by its unique ability to keep the reserve of zinc, copper and cadmium ions in the low-toxic metal-thiolate clusters within the cells, was detected from their sulfhydryl groups (MT-SH). This level was similar in the groups of comparison in most cases, and only was lowest in the mollusks from Kasperivtsi in autumn. The levels of glutathione (GSH, GSSG) and/or the GSH/GSSG ratio in the digestive gland were substantially different between the groups of comparison, with higher values for all of them in the mussels from the natural lake and micro HPP. Hence, the mollusks from the big artificial reservoirs had the manifestations of the elevated oxidation of thiols and proteins, whereas the mollusks from the comparatively less disturbed sites demonstrated the reductive stress (high levels of thiols MT-SH, GSH and GSH ratio) accompanied by the intensified lipid peroxidation.

The analyses of the markers of toxicity detected high level of metals (Zn and Cu) in the tissues of mussels from the Kasperivtsi reservoir in two seasons and in Ternopil lake in autumn. In the mussels from the Riga reservoir, it was rather low. The level of vitellogenin-like proteins (ALP) was higher in the mussels from the big reservoirs (Kasperivtsi in summer, Riga) than in the groups of comparison. Despite the skepticism concerning the validity of this marker of endocrine disruption in mollusk, the elevated activity of gonads function in the

mussels from the big reservoirs can be attested as a sign of particular environment. The evaluation of cholinesterase (ChE) activity also detected differences between the mussels from sites of comparison, with lower values in the Kasperivtsi reservoir in two seasons. The depletion of the ChE activity indicated the effect of neurotoxic xenobiotics (Dailianis, 2010). This response indicated the typical impact of the agricultural and municipal effluents in the reservoir of HPP in Ukraine.

It is worth mentioning, that even two closely located sites separated only by dam at both studied HPPs in Ukraine demonstrated very different responses of mollusks. The correlation analysis shows the highest number of associations for cellular thiols. The standardization of the biomarker parameters for the Index of Integrated Biological Response (IBR) indicates the metallothionein, caspase-3 and protein carbonyl levels as the most different responses between the sites before and after the dam.

Overall, the current study represents the first evaluation of the biochemical responses of bivalve mollusks from HPP-related areas. The biomarker response in zebra mussels of the Riga HPP reservoir supports the evidence of comparatively low environmental impact of such reservoirs (Álvarez-Vázquez et al., 2017), whereas the high impact of pollution of the reservoir of small HPP in Kasperivtsi and also the Ternopil Lake is evident. These results confirm the evidence of the amplification of the typical environmental impact in the area due to the change in water runoff. The indexes of the redox capacity and ChE activity in the bivalve mollusks can serve as appropriate markers of the environmental impact depending on the artificial disturbing of water flow in the rivers. The monitoring of the environmental impact with the utilization of multi-biomarker approach in bivalve mollusks can promote the constructive hydrodynamic policy in the exploitation of HPPs and control of the local sources of pollution.

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