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ACCUMULATION OF HEAVY METALS BY AQUATIC MACROPHYTES OF KYIV CITY LAKES AND THEIR ROLE IN BIOMONITORING AND PHYTOREMEDIATION

НАКОПИЧЕННЯ ВАЖКИХ МЕТАЛІВ ВОДНИМИ МАКРОФІТАМИ ОЗЕР МІСТА КИЄВА ТА ЇХ РОЛЬ У БІОМОНІТОРИНГУ ТА ФІТОРЕМЕДІАЦІЇ

Pasichna O. O.
Candidate of Biological Sciences,
Senior Researcher at the Department
of Water Plants Ecology and Toxicology
Institute of Hydrobiology of the National
Academy of Sciences of Ukraine
Kyiv, Ukraine

Пасічна О. О.
кандидат біологічних наук,
старший науковий співробітник
відділу екології водяних рослин
та токсикології
Інститут гідробіології Національної
академії наук України
м. Київ, Україна

Platonov M. O.
Candidate of Biological Sciences,
Researcher at the Department of Water
Plants Ecology and Toxicology
Institute of Hydrobiology of the National
Academy of Sciences of Ukraine
Kyiv, Ukraine

Платонов М. О.
кандидат біологічних наук,
науковий співробітник відділу екології
водяних рослин та токсикології
Інститут гідробіології Національної
академії наук України
м. Київ, Україна

Godlevska O. O.
Candidate of Physical
and Mathematical Sciences,
Associate Professor at the Department
of Physics
National University of Life and
Environmental Sciences of Ukraine
Kyiv, Ukraine

Годлевська О. О.
кандидат фізико-математичних
наук,
доцент кафедри фізики
Національний університет
біоресурсів і природокористування
України
м. Київ, Україна

Aquatic macrophytes are not only ones of the important components of aquatic ecosystems and a source of food for fish and a habitat for many aquatic invertebrates, but also serve as “biological filters” and play an important role in migration and transformation of different substances in the aquatic environment. For many years, studies have been conducted on the accumulative properties of aquatic plants with the aim of their use for biomonitoring and phytoremediation of water bodies contaminated with heavy metals. It has been established that the amount of heavy metals

accumulated by aquatic plants correlates with their concentrations in water and/or bottom sediments [5, 6]. Since the accumulation of metals by plant organisms occurs over a long period of time, based on biomonitoring using aquatic plants, it is possible to identify chronic water pollution, while determining metal concentrations in water using chemical methods indicates the level of its pollution at a specific point of time.

Water bodies of the city of Kyiv are subject to significant anthropogenic impact, especially those located in industrial zones, nearby construction sites, transport highways and landfills. Today pollution of many water bodies in the city is a consequence of military operations. Therefore, water bodies of Kyiv require constant monitoring of their pollution level and the overall ecological state.

Heavy metals are ones of the most common and dangerous for living organisms pollutants of natural waters. In this regard, we have shown the feasibility of using some species of submerged macrophytes for biomonitoring of heavy metal pollution of water bodies, as well as for their phytoremediation.

The studies were carried out using submerged higher aquatic plants Ceratophyllum demersum L., Myriophyllum spicatum L., Potamogeton perfoliatus L. and Potamogeton crispus L. These species are typical and the most abundant in the water bodies of the city of Kyiv. Samples of plants and water were taken in the summer of 2019 and 2023 from right-bank (Minske, Lugove, Bogatyrske, Kyrylivske, Yordanske, Redchyne, Verbne, Tsentralne) and left-bank (Vygurivske, Almazne, Rayduzhne, Telbin, Soniachne, Lebedyne, Vyrlytsia, Tiagle) lakes of Kyiv.

Preparation of plant material and water samples was carried out according to generally accepted methods [1]. Determination of the content of heavy metals (Fe, Mn, Cu, Zn, Pb, Ni, Co, Cd) in plant material and the concentration of dissolved forms of metals in water was carried out by optical emission spectroscopy with inductively coupled plasma on the spectrometer iCAP 6300 Duo (Thermo-Fisher Corporation, USA) [2].

As a result of the conducted studies on the accumulation of heavy metals by submerged macrophytes (Ceratophyllum demersum, Myriophyllum spicatum, Potamogeton perfoliatus, Potamogeton crispus) of Kyiv lakes, it was found the highest content of heavy metals in plants from the Opechen lakes system (Minske, Lugove, Bogatyrske, Kyrylivske, Yordanske). The maximum content of Cu was found in Ceratophyllum demersum from Minske, Lugove and Bogatyrske lakes (respectively 18.1; 29.2 and 17.2 μg/g of dry weight) and in Potamogeton crispus from Lugove lake (19.8 μg/g of dry weight). The highest accumulation of Fe was found in Ceratophyllum demersum from Lugove and Yordanske lakes (respectively 3115 and 3705 μg/g of dry weight). Ceratophyllum demersum from the Opechen lakes

system accumulated the largest amount of Zn – 119–262 μg/g of dry weight. The maximum content of Co was noted in Ceratophyllum demersum from lakes Lugove and Yordanske (respectively 2.81 and 2.10 μg/g of dry weight). The maximum accumulation of Mn was found in Ceratophyllum demersum from lakes Lugove and Bogatyrske (respectively 3225 and 4509 μg/g of dry weight). Ceratophyllum demersum from the Opechen lakes system also accumulated the largest amount of Pb and Ni – respectively 7.9–11.8 and 12.4–28.6 μg/g of dry weight.

It has been established that Cd accumulates in insignificant amounts (0.08–0.96 μg/g of dry weight) in submerged higher aquatic plants from the studied lakes. Most likely, this is due to both significant toxicity of the metal for plant organisms and its relatively low concentrations in the water of the studied water bodies [4, 7].

It should be noted that submerged macrophytes from some other lakes of the city of Kyiv with less anthropogenic impact (Redchyne, Tiagle, Telbin) in most cases accumulated several times less quantity of metals than aquatic plants from the Opechen lakes system. Among the left-bank lakes of Kyiv, macrophytes of Vyrlytsia and Almazne lakes were characterized by a higher content of metals.

Higher concentrations of dissolved metals were also found in the water of the Opechen lakes system compared to other lakes in Kyiv. The established concentrations of dissolved metals in the water of the Opechen lakes system (during the vegetation period of plants) were within the following limits: Fe – 59–175; Mn – 112–270; Pb –7,3–18,4; Ni – 8,5–19,6; Zn – 22,5–56,1; Cu – 6,8–31,2; Co – 1,1–2,7; Cd – 0–0,61 μg/dm^3.

Thus, determination of the concentration of heavy metals (Cu, Fe, Zn, Co, Mn, Pb, Ni, Cd) in the water of lakes of Kyiv and the levels of their accumulation in submerged macrophytes Ceratophyllum demersum, Myriophyllum spicatum and Potamogeton perfoliatus has showen that these species are capable of significantly accumulating and concentrating metals from the aquatic environment, contributing to its purification. It was found a relationship between the concentration of the studied metals in water and their content in representatives of submerged macrophytes: aquatic macrophytes from the lakes more polluted with heavy metals accumulate greater amount of metals. Based on this, it is possible to recommend the use of Ceratophyllum demersum, Myriophyllum spicatum and Potamogeton perfoliatus in the biomonitoring system of pollution of natural waters with heavy metals, as well as for phytoremediation and restoration of the ecological state of water bodies.

As a result of studies of the pollution levels of right-banks and left-banks lakes of Kyiv with heavy metals, using submerged macrophytes as bio-

monitors, it was found that the most polluted by heavy metals are lakes Minske, Lugove, Bogatyrske, Kyrylivske and Yordanske (Opechen lakes system). These lakes are subject to significant anthropogenic impact due to their location near industrial enterprises and also pollutants enter the water with surface runoff through the system of drain collectors [3]. The lowest concentrations of the studied heavy metals were found in the water of Redchyne, Verbne, Tiagle and Telbin lakes.

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