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5. Community of higher aquatic plants

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The most recent data (obtained in July, 2011) regarding species composition and community structure of macrophytes from Lake Drūkšiai after the shutdown of the INPP are presented. The characteristics of overgrowth and productivity of aquatic plants are given. The current flora composition is compared with the data of previous investigations. According to the data obtained on the development of macrophyte communities, the lake can be referred to as a mesotrophic water body, and after the shutdown of the NPP the macrophyte succession is at the initial stage.

Išanalizuoti naujausi duomenys apie makrofitų rūšinę sudėtį, bendrijos struktūrą, ežero užaugimą ir vandens augalų produktyvumą Drūkšių ežere po IAE uždarymo. Dabartinė vandens augalijos sudėtis palyginta su ankstesnių tyrimų duomenimis. Makrofitų bendrijų vystymasis rodo, kad Drūkšių ežeras yra mezotrofinis vandens telkinys. Sustabdžius Ignalinos AE, makrofitų sukcesija yra pradinėje stadijoje.

Keywords: aquatic ecosystem; water cooler; higher aquatic plants

5.1. Species composition and community structure

In recent decades, studies on higher aquatic plants from Lake Drūkšiai[1] were carried out repeatedly. Initial material on the lake overgrowth was obtained in 1979–1983 (State of hydrobiocenosis in basin-cooler of Ignalina Nuclear Power Plant during pre-initial period, 1987). Further observations of vegetation were carried out in 1986–1988 (State of Ignalina Nuclear Power Plant basin-cooler ecosystem during the initial period of its operation, 1992). The most recent data were obtained by the authors in 2011. The study was performed using standard methods (Katanskaya 1956; Vlasov, Gigevich, and Hryshchankava 2011).

Based on the above-mentioned publications and according to the list of vascular plants of water bodies and streams of the Republic of Belarus (Gigevich 2001) we compiled a consolidated classification list of higher aquatic plants of Lake Drūkšiai (Table 5.1). The species, the presence of which in the lake was doubtful were not included in the list. A comparison of the current composition of flora with the data of previous studies shows a significant persistence of species diversity for nearly 30 years.

Analysis of the vascular flora as a hydrophilic component of Lake Drūkšiai showed that it contained 49 species of higher (vascular) plants, 3 Charales species, 1 bryophyte species and filamentous algae (see Table 5.1), including 44 hydrophytes: 21 truly aquatic species (15 euhydrophytes and 6 nymphaeids) and 23 air-aquatic aerohydrophytes, as well as 10 species of semi-aquatic plants – hygrophytes (5 euhygrophytes and 5 hygrohelophytes) having different taxonomic status, geographical origin, distribution and history of distribution and becoming part of the modern natural aquaflora of the investigated region.

A characteristic feature of the lake flora was the presence of Charales and filamentous algae in its composition. The Charophyta division was represented by the family Characeae (*Chara* sp. – sufficient quantity) and Nitellopsidaceae (*Nitellopsis obtusa* – low abundance). The latter is a protected species in Belarus. Nitella (*Nitella* sp.), which had been previously included in the list, was not registered during our study.

Filamentous algae have been massively developing in the intertidal zone since the mid-1980s. They covered the bottom from the waterline to a depth of 0.7–1.5 m and grew on various substrata with the projective cover up to 60%, sometimes 100%. If they were sufficiently abundant, they formed a mat. At the deeper sites, filamentous alga was mixed with broad-leaved pondweed, at some sites with watermilfoil, hornwort. Still deeper they were replaced by narrow-leaved pondweed or nitellopsis. All plants were abundantly covered with periphyton.

Representatives of two ecological groups – hydrophytes and hygrophytes – were identified in flora composition.

The group of submerged hydrophytes included 15 species where Charales dominated. Aggregations of perfoliate, shining and fennel pondweeds, watermilfoil, *Fontianlis* moss and Canadian waterweed were common.

The group of hydrophytes with leaves floating on the water surface comprised six species. The floating leaf vegetation was poorly developed and was located at the second layer among reeds. The yellow water lily

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Table 5.1. Classification list of higher aquatic plants of Lake Drūkšiai.

Species		1979–1983	1986–1988	2011
Hydrophytes				
Euhydrophytes				
Completely submerged euhydrophytes				
Completely submerged euhydrophytes, not rooting				
Rigid hornwort	*Ceratophyllum demersum* L.	+++	++++	++++
Water soldier	*Stratiotes aloides* L.	+	+++	+++
Completely submerged euhydrophytes, rooting				
Chara	*Chara* sp.	++++	+++	+++
Water moss	*Fontinalis* sp.	+	++	+++
Nitella	*Nitella* sp.	+	–	–
Starry stonewort	*Nitellopsis obtusa* (Desv. in Lois.) Gr.	++	++	++
Filamentous algae	*Rhizoclonium*, *Oedogonium*	–	+++	++++
Euhydrophytes with aerial reproductive organs				
Euhydrophytes with aerial reproductive organs, not rooting				
Common bladderwort	*Utricularia vulgaris* L.	++	++	++
Euhydrophytes with aerial reproductive organs, rooting				
Flatstem pondweed	*Potamogeton compressus* L.	++	++	+
Variable-leaf pondweed	*Potamogeton gramineus* L.	+	+	–
Shining pondweed	*Potamogeton lucens* L.	+++	+++	++
Fennel pondweed	*Potamogeton pectinatus* L.	+	++	+++
Perfoliate pondweed	*Potamogeton perfoliatus* L.	++	+++	++
Eurasian watermilfoil	*Myriophyllum spicatum* L.	++	+++	+++
Longbeak buttercup	*Batrachium circinatum* (Sibth.) Spach.	+	++	+++
Canadian waterweed	*Elodea canadensis* Michx.	++	++	++
European bur-reed	*Sparganium emersum* Rehm.	–	–	++
Nymphaeids				
Nymphaeids, not rooting				
Lesser duckweed	*Lemna minor* L.	–	–	+++
Star duckweed	*Lemna trisulca* L.	+	++	+++
Nymphaeids, rooting				
Amphibious bistort	*Polygonum amphibium* L.	+	++	++
Yellow water lily	*Nuphar lutea* (L.) Smith.	++	+++	+++
European white water lily	*Nymphaea alba* L.	+	+	–
Dwarf white water lily	*Nymphaea candida* J. et C. Presl.	–	–	++
Floating pondweed	*Potamogeton natans* L.	++++	+++	++
Aerohydrophytes				
Tall aerohydrophytes (average burgeon height 100–250 cm)				
Grey club-rush	*Schoenoplectus lacustris* (L.) Palla.	++	++	++
Mannagrass reed	*Glyceria maxima* (Hartm.) Holmb.	+	+	–
Lesser bulrush	*Typha angustifolia* L.	+	+	++
Common rivergrass	*Scolochloa festucacea* (Willd.) Link.	+	+	++
Common reed	*Phragmites australis* (Cav.) Trin. ex Steud.	++++	++++	++++
Average tall aerohydrophytes (average burgeon height 20–100 cm)				
Fibrous tussock-sedge	*Carex appropinquata* Schum.	+	+	–
Tufted sedge	*Carex caespitosa* L.	+	+	–
Lesser panicled sedge	*Carex diandra* Schrank.	+	+	+
Yellow sedge	*Carex flava* L.	+	+	+
Hairy sedge	*Carex hirta* L.	+	+	+
Woollyfruit sedge	*Carex lasiocarpa* Ehrh.	+	+	+
Black sedge	*Carex nigra* L.	+	+	+
Cyperus-like sedge	*Carex pseudocyperus* L.	+	+	+
Bottle sedge	*Carex rostrata* Stokes.	+	+	+
Blister sedge	*Carex vesicaria* L.	+	+	+
Marsh spike-rush	*Eleocharis palustris* (L.) Roem. et Schult.	+	+	+
Hawaii arrowhead	*Sagittaria sagittifolia* L.	+	+	+
Grass rush	*Butomus umbellatus* L.	–	–	++
Water horsetail	*Equisetum fluviatile* L.	++	++	++
Marsh horsetail	*Equisetum palustre* L.	+	+	+

(*Continued*)

Table 5.1. *(Continued).*

Species		1979–1983	1986–1988	2011
Wood horsetail	*Equisetum silvaticum* L.	+	+	+
Meadow horsetail	*Equisetum pratense* Ehrh.	+	+	+
Common water plantain	*Alisma plantago-aquatica* L.	+	+	+
Hygrophytes				
Euhygrophytes				
Tall euhygrophytes (average burgeon height 100–250 cm)				
Canarygrass reed	*Phalaroides arundinacea* (L.) Rausch.	+	+	+
Western dock	*Rumex aquaticus* L.	+	+	+
Average tall euhygrophytes (average burgeon height 20–100 cm)				
European bugleweed	*Lycopus europaeus* L.	+	+	+
Meadow foxtail	*Alopecurus pratensis* L.	+	+	+
Jointleaf rush	*Juncus articulatus* L.	+	+	+
Hygroheliophytes				
Tall hygroheliophytes (average burgeon height 100–250 cm)				
Bittersweet nightshade	*Solanum dulcamara* L.	+	+	+
Average tall hygroheliophytes (average burgeon height 20–100 cm)				
Sweet flag	*Acorus calamus* L.	+	+	+
Purple loosestrife	*Lythrum salicaria* L.	+	+	+
Bog marsh cress	*Rorippa palustris* (L.) Bess.	+	+	+
Low hygroheliophytes (average burgeon height less than 20 cm)				
Needle spike-rush	*Eleocharis acicularis* (L.) Roem. et Schult.	+	+	+

dominated and formed mono-species aggregations, and it was registered in aggregations with watermilfoil and hornwort, sometimes with knotweed and floating pondweed, pure-white water lilies, sometimes with patches of reeds and cane stalks, skirting the belt of surface macrophytes with discontinuous sections of a width from a few to 100 m in the bays.

The group of aerohydrophytes included 23 species. Common reed aggregations were spread almost everywhere, and club-rush and bulrush were less common. Same as in previous years, common reed dominated forming pure and mixed aggregations.

Hygrophytes were poorly developed within the lake water area and were represented by 10 species.

Analysis of the registered genetic structure of flora of Lake Drūkšiai and its comparison with that of Belarusian aquaflora showed their correspondence. The group of boreal species was the most numerous. Herbaceous plants predominated in the life form spectrum; perennial grasses comprised the main part of it.

In general, the macrophyte flora of Lake Drūkšiai was quite diverse. Its taxonomic groups, ratio of environmental and geographical elements, as well as biomorphological structure were typical of similar local floras of most temperate zone shallow eutrophic lakes. In recent years, there have been changes in the dominant complex species composition of submerged hydrophytes. Rigid hornwort began to develop in mass. α-mesosaprobic narrow-leaved pondweed species (fennel pondweed) started to replace β-mesosaprobic broad-leaved (shining) pondweed, which indicates the change of the ecosystem into eutrophic state.

5.2. Characteristic of overgrowth and productivity of aquatic plants

Overgrowth features

Lake Drūkšiai has an extensive open water area, a meandering coastline and a wide and shallow littoral zone with predominantly sandy and rocky-sandy sediments. The lake's natural conditions contribute to extensive development of macrophytes. Macrophytes cover about 15% of the lake water surface. Surface plants cover the largest area, the area occupied by underwater plants is smaller and plants with floating leaves occupy a still smaller part of the water area.

Significant fluctuations in overgrowth were registered during the investigated period. Thus, in 1979–1983, macrophytes occupied about 20% of the lake mirror area; 50% of that area was covered by surface plants and 34% by underwater plants. By 1986–1988, the overgrowth degree increased slightly. In 2011, the area occupied by macrophytes decreased. Currently, the water body is considered to be moderately overgrown according to the degree of overgrowth. The overgrowth analysis according to formations shows increase in the area occupied by surface macrophytes and decrease in the area covered by underwater macrophytes.

Hence, moderate development of higher aquatic plants is characteristic of the lake in general. On the one hand, a strongly pronounced littoral zone and chemical composition of the water mass contribute to distribution of macrophytes. Whereas on the other hand, active dynamics and low transparency of the water mass due to phytoplankton development limit the distribution depth of higher plants.

Vegetation distribution

Investigations into vegetation of the lake were carried out using a profile method. Analysis of the material indicates non-uniformity in macrophyte distribution throughout the lake's water area. Vegetation developed along the coastline up to the depth of 3–4 m, sometimes 5–6 m, but the central area was free from overgrowth.

Near the shore, where water surface plants were distributed, mono-dominant aggregations of common reed (lines of 80–150 m, sometimes of 300 m), club-rush or bulrush were usually growing from the water edge up to the depth of 1.5–2 m. At deeper sites they were replaced by yellow water lily and further by submerged plants (pondweeds, watermilfoil, rigid hornwort, Canadian waterweed). The maximum depth of their distribution rarely reached 4 m and mostly did not exceed 2.5–3 m. Charophytes and water moss were characterised by the maximum transfer depth (5 and 6 m, respectively).

Vegetation productivity

Biomass is the main index of plant community production intensity. To evaluate the biomass, quantitative samples were taken at the profiles with a frame; at big depths they were taken while diving with an aqualung.

The water surface plant communities are characterised by the highest indices of the air dry mass and, above all, this refers to common reed. The mass of particular cuts fluctuated from 1.4 to 5.752 kg/m^2 with the average reed biomass of 3.264 kg/m^2.

The biomass of plants with floating leaves was rather small.

The underwater macrophyte communities occupied a significant part in the total overgrowth area; however, their biomass was rather small (2.327 kg/m^2 of the green weight). Charophytes were the most widespread among submerged hydrophytes. They formed both rare and close, almost pure tangles and groups mixed with other water plants. The phytomass of fennel pondweed in rare groups was 0.584 kg/m^2. The average biomass of long-beak buttercup in pure groups was 1.128 kg/m^2, of pondweed 0.224, of rigid hornwort 2.312 kg/m^2 and of Nitella in joint tangles with *Chara* 6.936 kg/m^2 of green weight.

The highest macrophyte biomass was registered in 2011 due to development of water surface plants. The production of plants with floating leaves and underwater plants decreased. The total macrophyte biomass increased due to the widening of the area of water surface plants.

Conclusion

A comparison of the current flora composition with the data of previous investigations showed a significant persistency of diversity of macrophyte species for almost 30 years. In recent years, changes in the dominant complex species composition have occurred. Hornwort started to grow massively. α-mesosaprobic narrow-leaved pondweed species (fennel pondweed) replaced β-mesosaprobic broad-leaved (shining) pondweed, which indicates eutrophication. Before starting the INPP, the macrophyte overgrowth comprised 20% of the lake mirror area and by 1986–1988 the overgrowth somewhat increased. By 2011, the overgrowth decreased again. The overgrowth analysis according to formations indicates increase in the area occupied by water surface macrophytes and decrease in the area occupied by underwater macrophytes. The maximum biomass was recorded in 2011 due to the widening of the area overgrown with water surface plants. After starting the Ignalina Nuclear Power Plant, filamentous algae developed massively in the littoral zone. Now they cover the bottom from the water edge to the depth of 0.7–1.5 m and overgrow different substrata with the projective cover up to 60, sometimes 100%. In great abundance they look like a mat. Broad-leaved pondweed mix with *Nitella* at a greater depth, sometimes watermilfoil and hornwort are present there. Still deeper they are replaced by narrow-leaved pondweeds or *Nitellopsis*. All plants are abundantly covered with periphyton. Low transparency due to intensive phytoplankton development limits the distribution depth of higher plants. In general, according to the data obtained on investigated development of macrophyte communities the lake may be referred to as a mesotrophic water body; and macrophyte succession after the INPP shutdown at the initial stage.

Note

1. Lake on the border between countries, in Belarus its name is Lake Drysviaty.

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