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# Monitoring of Some Aquatic Ecosystems in the Northeastern Part of Armenia

***Vardanyan Zaruhi,***
***Bayramyan Liliya,***
***Sahakyan Gayane,***
***Mkhitaryan Hasmik***

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**Abstract**

The geographical location of Armenia determines its landscape diversity. Natural ecosystems and vegetation cover are extremely rapidly changing elements. The object of research is the wetland flora of Tashir area, located in the center of the Lori plateau of the Lori floristic region, at an altitude of 1400-1600 m at sea level, between the Bazum and Virahayots ridges. In the lakes of the Tashir area of Armenia, monopopulations of the species *Nymphoides peltata* (*S. G. Gmelin) O. Kuntze* were identified, which indicates the eutrophication of these lakes. Climatic conditions and anthropogenic changes in landscapes contribute to succession processes and a reduction in the species composition of plants in aquatic ecosystems.

## Introduction

The geographical location of Armenia determines the landscape diversity. The historical development of the territory of Armenia, complex physical and geographical conditions, biogeographic position, altitude zone, hypsothermal fluctuations, climatic conditions, geological processes and anthropogenic factor contributed to the formation and development of various ecosystems and biodiversity (Ziroyan & Manasyan, 2018). Natural ecosystems and vegetation cover are extremely rapidly changing elements. Climatic and anthropogenic impacts on ecosystems lead to successional changes in vegetation, both its general character and the distribution and ratio of habitats change. Armenia is experiencing degradation not only of land resources, depletion of biodiversity and biological resources of terrestrial, but also aquatic ecosystems. This is a global environmental problem and includes a set of undesirable and harmful processes and their consequences. (Vardevanyan, 2002). In Armenia, there are wetland (hydro-hygrophilic) ecosystems that are distributed in all belts, covering an area of 1774 km$^2$. The species of wetland vegetation varies depending on environmental conditions and altitude (Barseghyan 1990, Ziroyan & Manasyan, 2018).

More than 755 species of higher plants have been registered in the wetland cenoses of Armenia, of which dicotyledons make up 387 species or 62.4 % of the flora, monocotyledons make up 225 species or 36.3 %, horsetails and ferns make up 8 species or 1.3 %. The increased role of monocots in the formation of flora is characteristic of wetland habitats. The family *Cyperaceae* is the richest in edificatory species (85 species, 13.7 % of the flowering flora). The second place in the composition of vegetation is occupied by the *Poaceae* family (69-11.1%). In third place is the family *Asteraceae* (40 species - 6.4 %), which indicates the boreal origin of the wetland flora.

The northeastern part of Armenia belongs to the Lesser Caucasus mesophilic type of

altitudinal zone (Grigoryan, 1987). The landscape diversity of the study area is due to its geographical location, the large difference in relative heights, complex topography, and the characteristics of the mesophilic Ponto-Hyrcanian floristic province. (Takhtajyan, 1941).

The territory of the Lori region is located in the northeastern part of Armenia and is part of the Caucasian floristic province of the Circumboreal region of the Boreal subkingdom of the Holarctic kingdom (Takhtajyan, 1978).

## Material and Methods

The object of research is the wetland flora of the Tashir district, located in the center of the Lori plateau of the Lori floristic region, at an altitude of 1400-1600m at sea level, between the Bazum and Viraayots ridges. (Takhtajyan, 1941, Tamanyan & Faivush, 2009, Fayvush & Aleksanyan, 2016). The geographical location and topography of the region shaped the nature, climate, soil and vegetation cover and other elements of the entire territory (Mnatsakanyan & Tadevosyan, 2007) (Table 1).

***Table 1***

***Spatial distribution of average annual and extreme temperatures, duration of the frost-free period and sum of temperatures in the Tashir district***

| *Station* | *Height M* | *Average, Annual temperature* | *Transition time 10°C* | | | *Sum of temperatures* | | *Average t° January* | *Average t° July* |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Spring* | *Autumn* | *Duration* | *Higher 5°C* | *Higher 10°C* | | |
| Tashir | 1507 | 5.8 | 13.05 | 3.10 | 142 | 2376 | 1956 | –4,9 | +18-20 |

The physical and geographical conditions of the region are not conducive to the formation of aquatic ecosystems. However, they exist in the territory of Lori region. The wetland flora has a significant supply of various raw materials of medicinal, essential oil, tanning, edible and other plants. It should be noted that the lake and wetland habitats of Tashir largely correspond to those of other areas of northern Armenia. The region is rich in mesotrophic lakes (Mnatsakanyan & Tadevosyan, 2007). The surface is almost flat, slightly hilly in places. The soils are mountain-meadow, meadow-steppe. The natural resources of Tashir are swamps, alpine meadows, black soil. The vegetation of the region was formed under the influence of the characteristic features of the Caucasian mesophilic flora. Climatic factors are closely related to the height of the area and landforms (Table 2). The climate is moderate (Mnatsakanyan & Tadevosyan, 2007).

***Table 2***

***Distribution of average precipitation valuesand air humidity in the territory of Tashir***

| *Station* | *Total precipitation Mm* | | | *Average snow depth Intercession* | | | *Duration of snow cover* | *Relative humidity air (mb)* |
|---|---|---|---|---|---|---|---|---|
| *Tashir* | *In year* | *4-9* | *11-3* | *Average* | *Max.* | *Min.* | | |
| | 713 | 556 | 157 | 17 | 37 | 2 | 72 | 75 |

However, climate warming and active human economic activity in the region contribute to the degradation of aquatic ecosystems. Numerous studies have shown the impact of climate change on aquatic ecosystems (Bates et al., 2008).

During the research, we used the route method, as well as methods adopted in hydroecology (Zilov, 2009).

## Results

A special study of the plants of the lakes of the Lori plateau was first conducted by academician A. L. Takhtajyan in the period from 1931 to1932. About 50 species were recorded in the surveyed seven lakesplants (Takhtajyan, 1939). According to the research by the renowned expert on wetland flora and vegetation in Armenia, A. M. Barseghyan, the lakes in this area boast a flora that encompasses 66 species of vascular plants. (Barseghyan, 1981, Barseghyan, 1990). Many species are relics of the Tertiary and Postglacial periods. Some of them are endangered (Barseghyan, 1978).

The object of research is four unnamed lakes on the segment of the Stepanavan-Tashir highway, numbered 1, 2, 3, 4. The first, second, and third lakes are located to the left of the highway, while the fourth lake is on the right.

The lakes studied belong to level C1.2 (surface standing waters) (Permanent mesotrophic lakes, ponds and pools). C1.2 represents lakes that are not very rich in trophic substances (nitrogen and phosphorus) and dissolved bases, with pH levels often ranging between 6 and 7.

The C1.2 category is most common among the habitats with stagnant waters in Armenia. Several communities are found here: C1.23 – Rooted underwater vegetation of mesotrophic reservoirs (Rooted submerged vegetation of mesotrophic waterbodies) *Ceratophyllum demersum L.*

C1.231 – Thickets of large pondweed beds *Potamogeton lucens L.*

C1.232 – Small pondweed communities. *Potamogeton crispus L.*

C1.24 – The rooted floating vegetation of the studied mesotrophic reservoirs (Rooted floating vegetation of mesotrophic waterbodies) is very poor floristically. They are dominated by several species: *Nymphoides peltata(S. G. Gmelin) O. Kuntze, Potamogeton natans L. Potamogeton lucens L. Ceratophyllum demersum L.* Occasionally, the free–floating species *Utricularia vulgaris L.* also forms a community of floating broad-leaved carpets - C1.241.

A special place is occupied by Carpets made of marsh flower (Fringed waterlily carpets) - C1.2413. Communities of aquatic plants with floating leaves dominated by *Nymphoides peltata (S. G. Gmelin) O. Kuntze.*

C1.2414 – Broad–leaved pondweed carpets. Communities of aquatic plants with floating leaves dominated by *Potamogeton natansL.*

The geographical characteristics of mesotrophic reservoirs - Bezymyane, Tashir, Pyatachok - are most typical for lakes of the Lori upland plain, as well as for the habitats of lakes 1-4. Presumably, the depth of lakes 1-3 in different places ranges from 3 to 7 meters (Mnatsakanyan & Tadevosyan, 2007).

Lakes 1-3 are located along the Stepanavan-Tashir highway. The free-floating vegetation (Lemna covers) in these waters, which are not very rich in trophic substances typical of mesotrophic reservoirs (Free-floating vegetation of mesotrophic waterbodies), is represented by species of the genus *Lemna L.* of the Araceae family and various algae.

Ecosystems like these are typical for eutrophic reservoirs. The dominance of species of the genus *Lemna L.* in the lake indicates processes of eutrophication and succession in the ecosystem (Fayvush & Aleksanyan, 2016). The lakes cover a significant area, and the presence of *Lemna minorL.,* in the coastal areas indicates the initiation of eutrophication processes (Fig. 1).

***Figure 1. Lemna minor L., 2023.***

The processes of eutrophication of all three lakes begin with water-fringing large sedge communities (Water-fringing large sedge communities) of large sedges *Carex acuta L, Juncus effusus L.* and 2-2.5 meter thickets (Great reedmace beds) of *Typha latifolia L* widespread along the edges of the lakes, *Typha angustifolia L.* (Fig. 2)

***Figure* 2. *Typha latifolia L., 2023.***

Free-floating communities of common bladderwort (*Utricularia vulgaris L.*) in Lakes 1-3, which are not very rich in trophic substances, form floating colonies of bladderwort (Floating bladderwort colonies). The species occurs in the central part of the lakes and forms monopopulations.

The shores of the lakes are slightly indented, swampy, bordered by tall reeds, cattails, and sedges. The lake bottom is smooth and muddy. The silt layer in the coastal zone reaches up to 30 cm. The water is clear with a marsh taste and smell.

The fluctuation of the lake level is almost not observed, contributing to the flowering of water (Fayvush & Aleksanyan, 2016).

In eutrophic Lakes 1-3, we found carpets of plants with floating leaves of marsh flower (Fringed waterlily carpets), dominated by *Nymphoides peltata (S. G. Gmelin) O. Kuntze* (Fayvush & Aleksanyan, 2016).

There are studies in the literature related to populations of *Nymphoides peltata* (S. G. Gmelin) *O. Kuntze*. In Japan, the species is native and vulnerable (Mikulyuk & Nault, 2018). According to Lansdown (R. V. 2014 1), in Spain, Belarus, the Czech Republic, Lithuania, Germany, Switzerland, the species *Nymphoides peltata* (S. G. Gmelin) *O. Kuntze* is on the verge of extinction.

This species, a perennial rooting aquatic plant with floating leaves of the Menyanthaceae family, was described by Takhtajyan in 1981 (Life of rast 5(2) p. 370). At the beginning of the 21st century, *Nymphoides peltata* (S. G. Gmelin) *O. Kuntze* was primarily found in local lakes in the coastal zone, at a depth of 1 to 1.5 m. In the 20s of the 21st century, populations of the species spread over the entire surface of the lakes, reaching greater depths, up to 4.0 meters. It blooms from May to October. At the end of the 20th century, the northernmost limit of the distribution of *N. Peltata* (S. G. Gmelin) *O. Kuntze* was considered to be the temperature of +16 °C. This temperature regime for the growth of plants of the species was also noted in the works of Van der Voo (Van der Voo & Westhoff, 1961). This is further confirmed by the research of G. Fayvush. According to his data, the population of the species *N. Peltata* (S. G. Gmelin) *O. Kuntze* at the beginning of the 21st century is found only in the coastal zone (Fayvush & Aleksanyan, 2016).

However, in the Tashir area in recent decades, the average temperature in July reaches +18-20 °C (Vardevanyan 2002; Mnatsakanyan & Tadevosyan, 2007) (Fig. 3, 4).

***Figure 3. Mono population of Nymphoides peltata (S. G. Gmelin) O. Kuntze. 2023***

***Figure 4. The plant of Nymphoides peltata (S. G. Gmelin) O. Kuntze. 2023***

Currently, the species almost covers the entire surface of lakes 1-3 and is a monodominant population.

The surface heats up and dries up a lot on summer days. Petrophytes have adapted to group growth, with a minimum amount of fine-grained soil. The herbage of the rocky steppes is generally poorly developed and sparse. The most common species are stony steppe perennial essential oil plants from the family *Lamiaceae*, including low-growing aromatic shrubs such as *Thymus serpyllum L.*, as well as low reddish mats formed by the perennial species *Sedum hispanicum minus* from the family *Crassulaceae*, and *Saxifraga aizoides L.* from the *Saxifragaceae* family. These species demonstrate good drought tolerance. In the Poludi-herbosa zone of Lake 4, reed beds form focal populations along the lake's border, dominating the vacated shoreline of the swampy lake. Additionally, isolated *Lemna minor L.* plants float in the water gaps. The banks are bordered by *Carex vaginata Tausch, Carex appropinquata Schumach, Carex elata Bell ex All, Peplis alternifolia Bieb.*

At the end of hot August 2023, a rare phenomenon of duckweed flowering was observed on swampy lake 4. This can be explained by a decrease in water in the lake and the active process of swamping. The same phenomenon was noted by A. Takhtajyan in the 30$^{s}$ of the 20$^{th}$ century (Takhtajyan, 1939).

It should be noted that in lakes 1-4, some species for this period do not have independent phytocenological significance and are components of coastal phytocenoses.

The most common types of aquatic plants in lakes and grass on rocky shores (Table 3).

*Table 3*

*The most common types of aquatic plants and herbage of rocky shores of lakes 1-4, 2023*

| *Lakes* | | | *Herbage of stony steppes* | | |
|---|---|---|---|---|---|
| ***Species*** | ***Genus*** | ***Family*** | ***Species*** | ***Genus*** | ***Family*** |
| *Lemna minor L.* | *Lemna L.* | *Araceae* | *Carex acuta L.* | *Carex L.* | *Cyperaceae* |
| *Typha latifolia L.* | *Typha L.* | *Typhaceae* | *Carex vaginata Tausch* | | |
| *Typha angustifolia L.* | *Typha L.* | | *Carex appropinquata Schum* | | |
| *Utricularia vulgaris L.* | *Utricularia L.* | *Lentibulariaceae* | *Carexelata Bell ex ALL* | | |
| *Utricularia minor L.* | | | | | |
| *Utricularia intermedium Hayne* | | | | | |
| *Nymphoides peltata (S. G. Gmelin) O. Kuntze* | *Nymphoides* | *Menyanthaceae* | *Juncus effusus L.* | *Juncus L.* | *Juncaceae* |
| *Potamogeton natans L.* | *Potamogeton L.* | *Potamogetonaceae* | *Thymusserpyllum L.* | *Thymus L.* | *Lamiaceae* |
| *Potamogeton lucens L.* | | | | | |
| *Potamogeton crispus L.* | *Potamogeton L.* | *Potamogetonaceae* | | | |
| *Ceratophyllum demersum L.* | *Ceratophyllum L.* | *Ceratophyllaceae* | *Sedum hispanicum minus* | *Sedum L.* | *Crassulaceae* |
| *Sparganium minimum Wallr* | *Sparganium L.* | *Sparganiaceae* | *Saxifraga aizoides L.* | *Saxifraga* | *Saxifragaceae* |
| | | | *Peplisalternifolia Bieb.* | | *Lythraceae* |

Thus, table 3 shows that 10 species are most common in the coastal grassland, and 12 species are the most common in lakes 1-4. In recent decades, there has been a drop in the water level of the studied lakes, which contributes to undesirable changes, eutrophication and processes of structural and functional relationships between the ecosystem and the species composition of aquatic organisms. As a result, phytoplankton biomass has now increased, and lakes regularly "bloom" due to the massive reproduction of green algae and higher aquatic plants.

## Discussion

In the area of Tashir, on average, there are about 30 small relict lakes (from 0.5 to 10 hectares) located at an altitude of 1400-1600 m above sea level. The plateau, along with these lakes, stands out as an "Important vegetation area" (Asatryan 2008; Khanjyan & Tumanyan, 2011). The current state of flora and vegetation of 11 lakes was studied by A. A. Tumanyan, Aleksanyan A. S., Fayvush G. M. (Tumanyan et al., 2018).

The wetland complexes of the region are formed mainly by ecologically close boreal species, although there are suggestions that some species are introduced by migratory birds. As a result of the plant inventory, it was found that the wetland flora of the Lori lakes is represented by 174 species of vascular plants belonging to 74 genera from 34 families. In terms of species richness, the leading families are *Cyperaceae* (30) and *Poaceae* (22) (Barseghyan, 1981). The purpose of the study is to monitor and identify plant species of the inland fresh surface waters of the Tashir district.

The EUNIS classification, as chosen for the classification of aquatic habitats (Fayvush & Aleksanyan, 2016), categorizes these habitats into the following categories:

- C. (inland surface waters)(Category C. Inland surface waters)
- D. (swamps and waterlogged habitats) (Category D. Mires, bogs and fens). Ecosystems of category D are located either on the margins of lakes, or in areas of overgrowth or drying of lakes.

C1.26 Sphagnum–vesicular communities of oligotrophic reservoirs (Peatmoss and bladderwort communities of mesotrophic waterbodies). Floating, partly above water, communities of moss species (*Sphagnum spp.*), pemphigus (*Utricularia minor L, U. Intermedium Hayne*), Sparganium (Sparganium minimumWallr.), formed in swamp lakes. In Armenia, these habitats are formed only in some mesotrophic lakes of the Lori upland plain with swampy shores (Fayvush & Aleksanyan, 2016).

Previously studied by scientists (Takhtajyan, 1939, Barseghyan, 1981, Barseghyan, 1990; Khanjyan & Tumanyan, 2011).

According to Takhtajyan, the vegetation of lakes and their surroundings is divided into the following formations:

1. Wet meadow Prata
2. Wetland or coastal Poludi -herbosa
3. Aquatic Aquiherbosa. There is no sharp boundary between them (Takhtajyan, 1939).

We assume that the species is most actively distributed in eutrophic lakes, swamps and wetlands. (Nault & Mikulyuk, 2009). As a result, lake biodiversity is declining. In India, the distribution of populations of the species *N. Peltata* (S. G. Gmelin) *O. Kuntze*. investigated by Sivarajan (Sivarajan & Joseph, 1993).

Dense populations of *N. peltata* destroy entire food chains. As a result, monopopulations are created that interfere with fishing, swimming, and shipping (Kelly & Maguire, 2009).

There are no known effective biological means of controlling *N. peltata*. Although the amur white species can feed on parts of *N. peltata*, the fish usually eats submerged macrophytes first, and it has not been proven that it feeds on *N. peltata*. (Di Tomaso et al., 2013). Researchers find that a mechanical method of control is most effective against the invasive species *N. peltata*. The species is also invasive in Canada (Darbyshire & Francis, 2008).

It can be assumed that successional processes occur in these aquatic ecosystems. According to Van der Velden, the distribution of the species *N. peltata* indicates the eutrophication of aquatic ecosystems (Van der Velder et al., 1979).

The surrounding slopes to the border with the water of the fourth lake are rocky, dry, and covered with various types of scale lichens and petrophyte mosses. The slopes are prone to denudation. Upland xerophytic vegetation is widespread, with subtypes of tragacanths and tomillaries (Grechushkina, 2011).

## Conclusion

- Lakes 1-4 located on the Stepanavan-Tashir highway are characterized by low species diversity, unlike the lakes studied by A.L.Takhtajyan and A.M. Barseghyan.
- in lakes 1-3, monopopulations of the species Nymphoides peltata (S. G. Gmelin*) O. Kuntze*. have been identified, which indicates eutrophication of these lakes.
- an in-depth study of the lakes of the Lori plateau is necessary, since climatic conditions and anthropogenic changes in landscapes contribute to successional processes and a reduction in the species composition of plants in aquatic ecosystems.

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## Հայաստանի հյուսիսարևելյան հատվածի որոշ ջրային էկոհամակարգերի մոնիթորինգ

***Վարդանյան Ջարուհի,***
***Բայրամյան Լիլիա,***
***Մահակյան Գայանե,***
***Մխիթարյան Հասմիկ***

### Ամփոփում

***Հանգուցային բառեր***. *ջրային բույսեր, էկոհամակարգ, լանդշաֆտային բազմազանություն, մոնիթորինգ, սուկցեսիա, տեսակային բազմազանություն*

Հայաստանի աշխարհագրական դիրքը որոշում է նրա լանդշաֆտային բազմազանությունը, սակայն բնական էկոհամակարգերն ու բուսական ծածկույթը կլիմայական և մարդածին գործոնների ազդեցությամբ շատ արագ են փոփոխվում: Հետազոտության օբյեկտն է Տաշիրի տարածաշրջանի խոնավ տարածքների ֆլորան, որը գտնվում է Լոռու սարահարթի կենտրոնում՝ Լոռու ֆլորիստիկ շրջանում, ծովի մակարդակից 1400–1600 մ բարձրության վրա, Բազումի և Վիրահայոց լեռնաշղթաների միջև: Հոդվածում ներկայացվում է Տաշիրի տարածաշրջանի ջրային էկոհամակարգերի (լճերի) մոնիթորինգը: Հետազոտության օբյեկտ են ընտրվել Ստեփանավան–Տաշիր ճանապարհի վրա գտնվող չորս լճերը (№ 1-4), որոնք դասակարգվում են C1.2 (մշտական մեզոտրոֆիկ լճեր, ավազաններ և ջրամբարներ) կատեգորիայի մեջ: Հետազոտության ընթացքում կիրառվել են երթուղային մեթոդը և հիդրոէկոլոգիայում ընդունված մեթոդները: Արդյունքները ցույց են տվել, որ 1–3-ում լճերում գերակշռում են *Nymphoides peltata (S. G. Gmelin) O. Kuntze* տեսակի մոնոպոպուլյացիաները, ինչը վկայում է էվտրոֆիկացման և սուկցեսիայի գործընթացների մասին: Ափային հատվածներում նկատվում են լայն տերևավոր լողացող բույսերի և *Lemna* տաքսոնի ազատ լողացող տեսակների տարածված զանգվածներ, ինչը նույնպես ցույց է տալիս ջրամբարների վիճակի փոփոխությունը: Կլիմայական պայմանները և լանդշաֆտների մարդածին փոփոխությունները նպաստում են ջրային էկոհամակարգերում բուսականության տեսակային կազմի նվազմանը, ինչը պահանջում է այդ էկոհամակարգերի շարունակական մոնիթորինգ և պահպանություն:

## Мониторинг некоторых водных экосистем северо-восточной части Армении

***Варданян Заруи,***
***Байрамян Лилия,***
***Саакян Гаяне,***
***Мхитарян Асмик***

***Резюме***

***Ключевые слова**: водные растения, экосистема, ландшафтное разнообразие, мониторинг, сукцессия, видовое разнообразие*

Географическое положение Армении определяет её ландшафтное разнообразие, однако природные экосистемы и растительный покров под воздействием климатических и антропогенных факторов отличаются высокой динамичностью. Объектом исследования является флора влажных местообитаний Таширского региона, расположенного в центральной части Лорийского плато Лорийского флористического района, на высоте 1400–1600 м над уровнем моря, между хребтами Базум и Вирахаёц.

В статье представлен мониторинг водных экосистем (озёр) Таширского региона. В качестве объектов исследования выбраны четыре озера (№1–4), расположенные вдоль автодороги Степанаван–Ташир, которые относятся к категории C1.2 (постоянные мезотрофные озёра, пруды и водоёмы). В ходе исследования применялись маршрутный метод и методы, принятые в гидроэкологии.

Результаты показали, что в озёрах 1–3 доминируют монопопуляции вида *Nymphoides peltata (S. G. Gmelin) O. Kuntze*, что свидетельствует о процессах эвтрофикации и сукцессии. В прибрежных зонах отмечены обширные скопления широколистных плавающих растений и свободноплавающих видов таксона *Lemna*, что также указывает на изменение состояния водоёмов. Климатические условия и антропогенные изменения ландшафтов способствуют сокращению видового состава растительности водных экосистем, что обуславливает необходимость их постоянного мониторинга и охраны.

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