Species composition and qualitative distribution of macrophytes in four lakes (Karasu, Adapazarı, Turkey)

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Abstract. The macrophytic flora of the lakes Küçükboğaz, Akçagöl, Akgöl and Dalyan was investigated during the spring and summer periods between 2007 and 2011. Materials collected from the four lakes were evaluated and 22 macrophyte species belonging to 18 genera were determined.

Key words: Lakes Akçagöl, Akgöl, Dalyan, and Küçükboğaz, macrophytes

Introduction

Aquatic plants are in close contact with the environmental conditions of lakes, through their root-system and especially through the leaves which are surrounded or floating in a dense chemical solution, as compared with terrestrial plants (Heegaard & al. 2001). The term "macrophytes" is used for aquatic plants (Westlake 1975; Wetzel 1975), however in taxonomy it covers the macro-algae (e.g. *Cladophora, Chara*), mosses and liverworts, ferns, and tracheophytes (Casper & Krausch 1981; Frahm & Frey 1992; Wetzel 1975).

Macrophytes are conspicuous plants that dominate the wetlands, shallow lakes, and streams. In such wetlands, aquatic macrophytes are responsible for most primary production and also play an important role in increasing the ecosystem structures or in recycling nutrients and elements. Aquatic plants supply a wide variety of wildlife with food and suitable nesting habitats. Aquatic macrophytes play a vital role in healthy ecosystems. They serve as primary producers of oxygen through photosynthesis, provide a substrate for algae and shelter for many invertebrates; they aid nutrient cycling to and from the sediments, and help stabilize river and stream banks. In most lakes, the documented main problems are land use along the lakeshores and catchments, intensive agriculture, changes in water level, eutrophication, and illegal stocking of herbivorous fish in the lakes. There are three types of lakes within the boundaries of Karasu District: Dalyan and Küçükboğaz are shallow lagoonal brackish lakes, Akçagöl is karstic shallow freshwater lake, and Akgöl is coastal shallow freshwater lake. The new floristic data presented here are based on collections and observations during a floristic study. The most important study so far on the floristic structure of wetlands in Turkey was conducted by Seçmen & Leblebici (1997). A total of 468 macrophyte taxa were recorded from 58 lakes and wetlands during these investigations (Seçmen & Leblebici 1987, 1997). The primary aim of this taxonomic study is determined by the presence and distribution of true aquatic macrophytes in the four lakes. A survey of aquatic macrophytes in the four lakes of Karasu District (Adapazarı, Turkey) was conducted during the period 2007–2011. Detailed data on the actual condition of macrophytes were collected and compared between the four lakes. This paper presents biodiversity of the macrophyte

vegetation from lakes Akgöl, Akçagöl, Küçükboğaz, and Dalyan. In spite of the ecological hazards, none of the four lakes has any protected status. Presently, only one scientific publication is available on macrophytes in the nearby lakes (Acarlar, Poyrazlar, Büyük Akgöl, Taşkısığı, and Küçük Akgöl) (Seçmen & Leblebici 1997). The authors' effort was aimed at identification and distribution of the submerged, emerged and floating leafed macrophyte species in the lakes Küçükboğaz, Akçagöl, Akgöl, and Dalyan. Hydrophytes are a specific group of plants adapted to grow in water (Kohler & Schneider 2003). Since water is their habitat, their presence, species composition, abundance, and distribution could be regarded as important indicators of the ecological conditions occurring in the water bodies (Kohler & Schneider 2003). In this case, hydrophytes can be considered as important indicators of the status of the four lakes in Karasu District.

Material and methods

Study sites and sampling

Lake Küçükboğaz (lagoon) is located in the eastern part of the district of Karasu (Adapazarı Province) (41°05'07.0" N 30°44'41.5" E), at an altitude of 2 m a.s.l. (Fig. 1). It is mesotrophic, with a mean depth of 2 m, maximum depth of 3 m and surface area of 50 ha. The eastern and southern part of the lake are freshwater, whereas the transitional freshwater-brackish water zones are in the northern part of lake. The lagoon is fed principally by several small creeks (Beydağ Creek, Karakaş Creek, Sığırdam Creek, Yetmişbirin Creek, Koçun Creek and Arabacı Creek) and rain water. It has only one temporary outlet in the north. When water level rises, the outlet of the lake is opened with a dipper dredger by the local administration and the surplus water spills into the sea. The lake is surrounded by a cover of *Corylus avellana* L. (Common Hazel) shrub. Three major commercial value fish species inhabit the lake: Pike (*Esox lucius* L.), Common Carp (*Cyprinus carpio* L.) and Common Rudd (*Scardinius erythrophthalmus* L.).

Lake Akgöl is located in the eastern part of the Karasu District (Adapazarı Province) 41°03'57.7" N 30°49'01.1" E) at an altitude of 2 m a.s.l. (Fig. 1). It is an eutrophic lake, with a mean depth of 2 m, maximum depth of 5 m, and surface area of 4.2 ha. The lake basin is formed by the shoreline activities of the Black Sea and by river activity. The lake is fed by temporary small creeks (Taşlıdere Creek and Kuru Creek) and rain water. A short canal (outlet) connects it to the Balıklı Creek in the north and its surplus waters spill into the Balıklı Creek. The waters of this stream contain domestic sewage of the district of Kocaali. The lake is surrounded by hills covered with *Corylus avellana* shrub. Three major commercial value fish species inhabit the lake: *Esox lucius*, *Cyprinus carpio* and *Scardinius erythrophthalmus*.

Lake Akçagöl is small lake located in the southern part of the Kuzuluk district of Karasu (Adapazarı Province) (41°03'56.3" N 30°48'59.5" E), at an altitude of 58 m a.s.l. (Fig. 1). Lake Akçagöl, which is of karstic origin (located in a shallow doline depression), lies near the Kuzuluk quarter of the Karasu District (Fig. 1). It is a freshwater lake, eutrophic and with a mean depth of 2 m, maximum depth of 3 m and surface area of 1.3 ha. The lake has no outlet (it is endorheic). Water from the lake is lost by evaporation and infiltration. Drainage takes place through an aquifer under the lake. The lake is surrounded by hills covered with *Corylus avellana* and *Salix triandra* L. (Willow). Three major commercial value fish species inhabit the lake: *Esox lucius*, *Cyprinus carpio* and *Scardinius erythrophthalmus,* as well as Grayfish (*Astacus leptodactylus* Eschscholtz, 1823).

Lake Dalyan is located in the eastern part of the Karasu town (Adapazarı Province) (41°04'58.6" N 30°47'12.4" E), at an altitude of 4 m a.s.l. (Fig. 1). It is a mesotrophic lake, with a mean depth of 1 m, maximum depth of 1.5 m and surface area of 0.6 ha. It is located on the sandy shore as many lagoon lakes. The lake is fed by the rain water and spring water. It is a brackish-water lake with no surface-water outflow; a landlocked (sand dune) lake. Salinity in the lake is controlled by evaporation. It has no outlet. Water is lost from the lake by evaporation and infiltration. The shores of the lake are covered with reed, bulrush and rush vegetation. The lake is surrounded by little sand hills.

In Karasu District, summers are hot, very humid and sunny, whereas winters are cool and damp. Generally, the prevailing northeastern (Poyraz) and northwestern (Karayel) winds come to the District coasts from the Black Sea.

Fig. 1. Map of lakes, showing their location in western Turkey.

The macrophytic flora of lakes Küçükboğaz, Akçagöl, Akgöl and Dalyan was investigated every spring and summer between 2007 and 2011.

The distribution and abundance of macrophytes in the four lakes were assessed on foot along the lake shore or by boat. The macrophytes were collected by rake with hooks. The distribution and abundance of macrophytes in the four lakes are shown on the map of each lake (Fig. 2).

The methodology followed the European Standard EN 14184 recommended for the assessment of aquatic macrophyte vegetation in running waters, and the principles of Kohler 1978; Kohler & al. 1971 and Kohler & Janauer 1995. The method is based on assessment of aquatic macrophytes in contiguous survey units. In all survey units the abundance of each species was estimated on a five-level descriptor scale (1– rare, 2– occasional, 3– frequent, 4– abundant, 5– very abundant). For each species, the growth form (acro-pleustophytes, submerged pleustophytes, submerged anchored, floating leaf rooted plants, amphiphytes and helophytes) was identified in the survey unit.

Various important reviews on the subject were used for identification of the species (Allorge 1921; Davis 1965–1985; Fassett 1957; Seçmen & Leblebici 1997; Tutin & Heywood 1964–1980). Coordinates of the lakes were obtained with a Garmin Etrex 12-channel GPS. Salinity was measured *in situ* with a handheld WTW 340i multimeter. According to the Davis grid system (Davis 1965–1985), the research area is located in the A3 square.

Statistical analysis

Sorensen's Similarity Quotient (QS) was used for determining similarity of the macrophyte flora in the four lakes. Sorensen's Similarity Quotient (QS) (Sorensen 1948), i.e. species similarity based on the pres-

ence or absence of species, was used to determine the degree of similarity of macrophyte species collected from the four lakes: QS = 2C/(A+B), where A and B are the number of species from each sample, and C is the number of common species.

A percentage similarity analysis of the macrophyte species in the four lakes was conducted using the Multivariate Statistical Package (MVSP 3.0) (Kovach 1999).

Results and discussion

The present study has attempted to determine the macrophytes (submerged, emerged and floating-leaved species) in the four lakes in Karasu District (Adapazarı). As a result of the samplings performed in summer between 2007 and 2011, 22 macrophyte species were identified (*Salvinia natans* (L.) All. *Nasturtium officinale* R.Br., *Alisma plantago-aquatica* L., *Ceratophyllum demersum* L. *Carex riparia* Curtis., *Myriophyllum spicatum* L. *Juncus effusus* L., *J. littoralis* C.A.Mey., *J. maritimus* Lam., *Iris pseudacorus* L., *Mentha aquatica* L., *Lemna minor* L., *Utricularia vulgaris* L., *Nuphar lutea* (L.) Sm., *Nymphaea alba* L., *Trapa natans* L., *Potamogeton crispus* L., *P. pectinatus* L., *Phragmites australis* (Cav.) Steud., *Sparganium erectum* L., *Typha angustifolia* L., and *T. latifolia* L.). They belonged to 16 families and 18 genera in the four lakes (Table 1). In the following list, taxonomic and systematic nomenclature largely follows Davis (1965–1985) and Seçmen & Leblebici (1997). The complete and current catalogue of the macrophytes found in lakes Akçagöl, Akgöl, Küçükboğaz and Dalyan is given in Table 1.

Sixteen taxa were registered in the lakes Akçagöl, Küçükboğaz and Akgöl, of which 15 are Spermatophyta (93.75 %) and one is Pteridophyta (6.25). Five taxa were reported from Lake Dalyan, of which two are Spermatophyta (100 %). A total of 22 macrophyte taxa

Table 1. List of macrophyte species and their life form were determined in four lakes (Abbreviations: FF: Free floating, FL: Floating-leaved leaved, E: Emergent, SM: Submerged, AG: Akçagöl, AKG: Akgöl, KB: Küçükboğaz, DA: Dalyan).

		MACROPHYTE TYPES				LAKES			
	TAXA	FF	FL	E	SM	AG	AKG	KB	DA
PTERIDOPHYTA									
Salviniaceae	*Salvinia natans*	■				●	●	●	
SPERMATOPHYTA									
Brassicaceae	*Nasturtium officinale*			■		●	●	●	
Alismataceae	*Alisma plantago-aquatica*			■		●	●	●	
Ceratophyllaceae	*Ceratophyllum demersum*				■	●	●	●	
Cyperaceae	*Carex riparia*			■		●	●		
Haloragidaceae	*Myriophyllum spicatum*				■	●	●	●	
Juncaceae	*Juncus effusus*			■			●	●	
Juncaceae	*Juncus littoralis*			■		●			
Juncaceae	*Juncus maritimus*			■				●	●
Iridaceae	*Iris pseudacorus*			■		●	●	●	
Lamiaceae	*Mentha aquatica*			■		●	●	●	
Lemnaceae	*Lemna minor*	■				●	●	●	
Lentibulariaceae	*Utricularia vulgaris*				■	●			
Nymphaeaceae	*Nuphar lutea*		■				●	●	
Nymphaeaceae	*Nymphaea alba*		■			●	●		
Onagraceae	*Trapa natans*		■			●	●	●	
Potamogetonaceae	*Potamogeton crispus*				■		●	●	
Potamogetonaceae	*Potamogeton pectinatus*				■				●
Poaceae	*Phragmites australis*			■		●	●	●	●
Typhaceae	*Sparganium erectum*			■		●		●	
Typhaceae	*Typha angustifolia*			■			●	●	●
Typhaceae	*Typha latifolia*			■		●			●

were identified in the four lakes (Table 1), the largest number of them being found in lakes Küçükboğaz, Akçagöl and Akgöl (16 taxa), and the lowest in Dalyan (five taxa).

Macrophytes are aquatic plants, growing in or near water and are emergent, submerged or floating. Macrophyte classification according to Dorotovičová (2005) in the four lakes is as follows: *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Potamogeton crispus*, *P. pectinatus*, *Nymphaea alba*, *Nuphar lutea*, *Trapa natans*, *Utricularia vulgaris, Lemna minor* and *Salvinia natans* are hydrophytic species; *Mentha aquatica*, *Nasturtium officinale* and *Alisma plantago-aquatica* are amphiphytic species; and *Carex riparia*, *Iris pseudacorus*, *Juncus effusus*, *J. littoralis*, *J. maritimus, Phragmites australis*, *Sparganium erectum, Typha angustifolia,* and *T. latifolia* are helophytic species.

Macrophyte classification according to Sculthorpe (1967) in the four lakes is as follows: *Carex riparia, Iris pseudacorus, Alisma plantago-aquatica, Nasturtium officinale, Mentha aquatica, Juncus effusus, J. littoralis*, *J. maritimus, Phragmites australis, Sparganium erectum, Typha angustifolia* and *T. latifolia* are emergent macrophytes; *Ceratophyllum demersum, Myriophyllum spicatum, Utricularia vulgaris*, *Potamogeton crispus* and *P. pectinatus* are submerged macrophytes; *Nymphaea alba* and *Nuphar lutea* are floating-leaved macrophytes; *Salvinia natans, Lemna minor* and *Trapa natans* are floating macrophytes.

Aquatic plants are well adapted to lentic ecosystems (still water). Submerged macrophytes (five taxa) were dominated by the species of genus *Potamogeton* (*P. pectinatus* and *P. crispus*). Emergent macrophytes (12 taxa) were dominated by the species of genus *Potamogeton* (*Juncus effusus*, *J. littoralis* and *J. maritimus*)

Spatial distribution and abundance of the macrophytes in the four lakes are shown in Table 2.

According to the Salinity Classification of Gasse & al. (1987) and the Venice System (1959), water in Lake Küçükboğaz is slightly brackish (as freshwater 0.0–0.4 ‰) in its southern part and oligosaline (0.5 ‰) near the sea. Anyway, salinity rate for most of Lake Küçükboğaz is below 0.5 ‰. Akgöl and Akçagöl are

Table 2. The spatial distribution and abundance of the macrophytes in the four lakes (1- rare (—), 2- occasional (■), 3- frequent (♦), 4- abundant (▲) and 5- very abundant (▮). Black bars indicate the abundance of macrophytes.

	LAKES			
TAXA	**Akçagöl**	**Akgöl**	**Küçükboğaz**	**Dalyan**
PTERIDOPHYTA				
Salvinia natans	3 ♦	3 ♦	2 ■	–
SPERMATOPHYTA				
Nasturtium officinale	2 ■	2 ■	2 ■	–
Alisma plantago–aquatica	2 ■	2 ■	2 ■	–
Ceratophyllum demersum	4 ▲	4 ▲	4 ▲	–
Carex riparia Curtis	2 ■	2 ■	–	–
Myriophyllum spicatum	3 ♦	3 ♦	5 ▮	–
Juncus effusus	–	3 ♦	3 ♦	–
Juncus littoralis	3 ♦	–	–	
Juncus maritimus	–	–	3 ♦	3 ♦
Iris pseudacorus	3 ♦	3 ♦	3 ♦	–
Mentha aquatica	3 ♦	3 ♦	3 ♦	–
Lemna minor	4 ▲	4 ▲	4 ▲	–
Utricularia vulgaris	3 ♦	–	–	–
Nuphar lutea	–	3 ▲	4 ▲	–
Nymphaea alba	4 ▲	4 ▲	–	–
Trapa natans	3 ♦	3 ♦	3 ♦	–
Potamogeton crispus	–	3 ♦	3 ♦	–
Potamogeton pectinatus	–	–	–	5 ▮
Phragmites australis	4 ▲	4 ▲	4 ▲	5 ▮
Sparganium erectum	2 ■	–	2 ■	–
Typha angustifolia	–	5 ▮	5 ▮	5 ▮
Typha latifolia	4 ▲	–	–	4 ▲

freshwater lakes, whereas Lake Dalyan is a brackish (mesosaline 5–20 ‰) water lagoon. According to the Percentage Similarity Analysis results, the four lakes must be divided into two major groups due to similarity of the macrophyte species (Fig. 2).

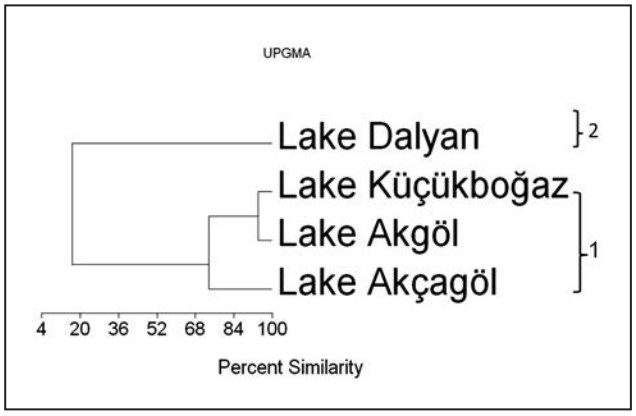

Fig. 2. Dendrogram according to percent similarity index for the four lakes studied.. Dendogram is showing percent similarity index rate of macrophyte species composition of the four lakes, **Group 1:** Freshwater lakes (Akçagöl, Akgöl and Küçükboğaz); **Group 2:** Brackish water lake (Lake Dalyan).

Distribution of the submerged, emerged and floating-leaved macrophytes in the four lakes in Karasu District is shown in Fig. 3.

The littoral zone, as compared to the large pelagic area of Lake Akçagöl from a phyto-sociological viewpoint, has maybe some shore vegetation referable to the association *Phragmiteium communis* (Allorge 1921), widely distributed over the whole lake area and characterized by the species of *Phragmites australis*, *Typha latifolia*, *Alisma plantago-aquatica*, *Iris pseudacorus*, *Juncus littoralis,* and *Carex riparia*. The indicated status of the four lakes is reflected in the presence and composition of macrophytic vegetation. In accordance to the eutrophic status of the reservoir, eutrophic species dominated. Such macrophytes as *Potamogeton crispus*, *Phragmites australis* and *Ceratophyllum demersum* belong to a set of species indicating highly eutrophic waters (Kohler & Schneider 2003). The transitional zone between terrestrial and freshwater habitats was quite distinct along the shallow margins of Lake Akçagöl. *Phrag-*

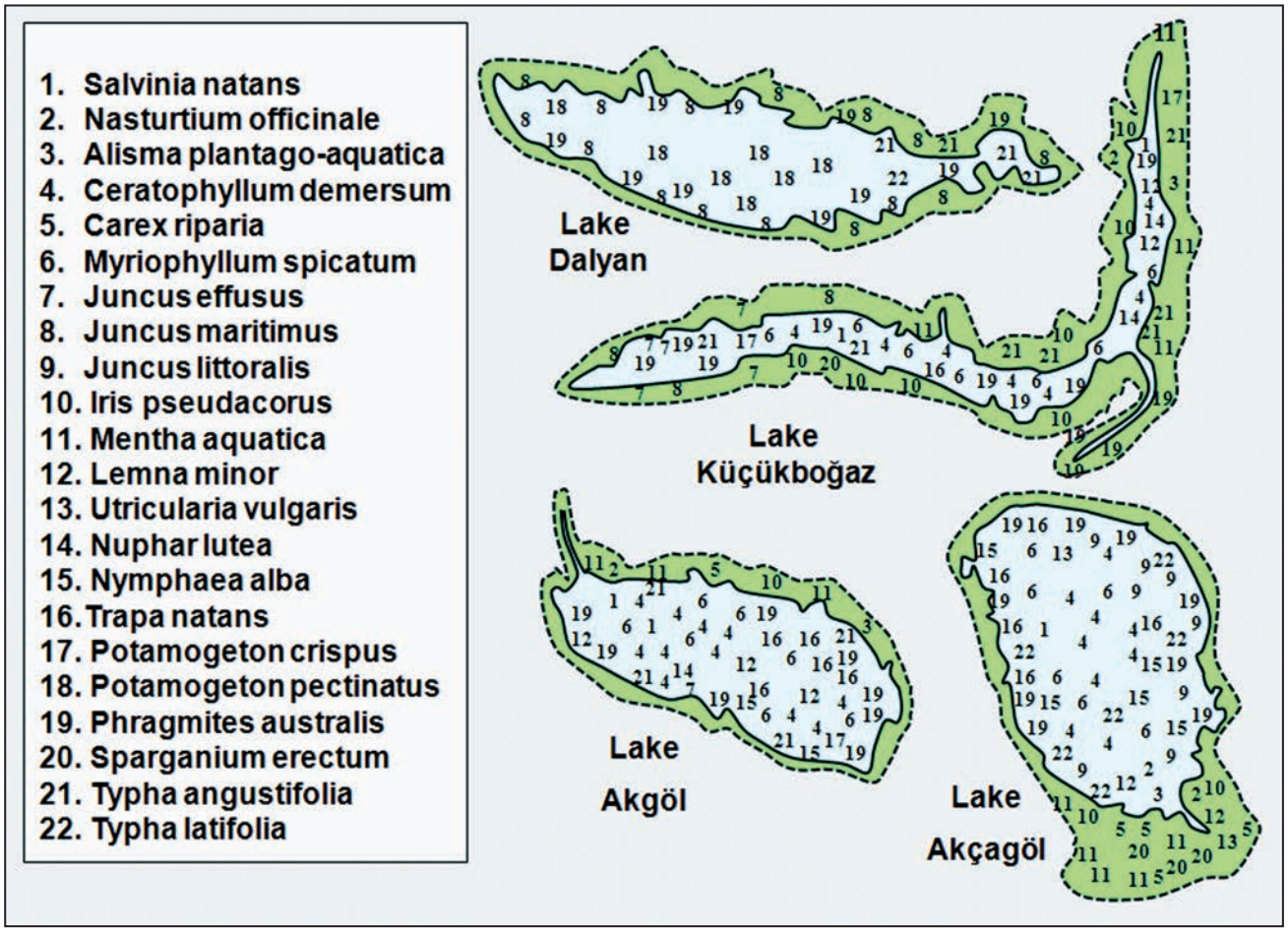

Fig. 3. Distribution map of aquatic plants of four lakes located in Karasu District.

mites australis (Common Reed) was the dominant emergent macrophyte species in the littoral of Lake Akçagöl. *Typha latifolia* and *Juncus littoralis* were common species in the littoral of Lake Akçagöl, while *Phragmites australis*, *Typha latifolia* and *Juncus littoralis* were accompanied by *Phragmites* on the bank of the lake. *Ceratophyllum demersum* (Hornwort) and *Myriophyllum spicatum* (Eurasian Watermilfoil) were the dominant submerged species in the deeper part of the lake. *Myriophyllum spicatum* is able to grow in eutrophic and nutrient-poor habitats (Schneider & Melzer 2003). *Nymphaea alba* (European White Water Lily) was a common floating-leaved macrophyte in the deeper parts of the lake. In mid-to-late- summer, some parts of Lake Akçagöl were covered by the floating-leaved macrophyte *Trapa natans* (water chestnut). Vegetation in the centre mainly comprised *Myriophyllum spicatum* and *Ceratophyllum demersum*. *Nymphaea alba* was common across the lake. The shallower regions towards the banks supported the growth of *Alisma plantago-aquatica* (Common Water Plantain), *Nasturtium officinale* (Watercress), *Sparganium erectum*, *Mentha aquatica*, *Iris pseudacorus* (Yellow Iris), and *Carex riparia* (Greater Pond Sedge). The free-floating macrophyte *Salvinia natans* formed a continuous edge mat of vegetation in the lake and was a rare species. Duckweed (*Lemna minor*) is an invasive free-floating plant that can cover quickly the surface of a pond or a small lake, also, this species is often identified in the less windy parts of many great lakes. *Lemna minor* was identified in the less windy parts of the lake. *Salvinia natans* (Floating Fern) had similar distribution to *Lemma minor* in the lake. A wet meadow was located along the eastern part of Lake Akçagöl. *Mentha aquatica* (Water Mint) was found in the shallow margins of the lake. *Utricularia vulgaris* (Common Bladderwort) is free-floating and did not put down any roots. These species and their yellow flowers were observed in the wet meadow located in the eastern part of Lake Akçagöl.

Phragmites australis was a dominant emergent macrophyte species in the littoral of Lake Akgöl, as well as at the bottom of the Lake Akçagöl. *Phragmites* is a plant with extreme tolerance for wave exposition and steep lake-floor conditions. *Typha angustifolia* (Lesser Cattail) and *Juncus effesus* (Common Sea Soft Rush) were common species in the littoral of Lake Akgöl, while *Phragmites australis*, *Typha angustifolia* and *Juncus effesus* were accompanied by *Phragmites australis* on the banks of Lake Akgöl. Lake Akgöl has a deeper littoral zone than the other lakes. Therefore, a narrow macrophyte belt was formed along the lake shore from such emergent macrophytes as *Typha angustifolia*, *Phragmites australis* and *Juncus effusus*. The invasive plant species *Myriophyllum spicatum* and *Ceratophyllum demersum* mainly caused the aquatic plant nuisance conditions in lakes Akgöl, Akçagöl and Küçükboğaz. No milfoil species (*Myriophyllum spicatum*) were reported for Lake Dalyan. *Ceratophyllum demersum* and *Myriophyllum spicatum* were the dominant submerged species in the deeper part of Lake Akgöl. *Nymphaea alba* and *Nuphar lutea* (Yellow Water Lily) were common floating-leaved macrophytes in the littoral parts of the lake. During mid-to-late-summer, some parts of Lake Akgöl were covered by the floating-leafed macrophyte *Trapa natans*. Vegetation in the centre mainly comprised *Myriophyllum spicatum* and *Ceratophyllum demersum*. *Potamogeton crispus* was identified on the southeastern banks of the lake. *Nymphaea alba* was common across the lake. The shallower regions towards the banks supported the growth of *Alisma plantago-aquatica*, *Nasturtium officinale*, *Mentha aquatica*, *Iris pseudacorus,* and *Carex riparia*. The free-floating macrophyte *Salvinia natans* (Floating Fern) formed a continuous edge mat of vegetation in that lake and was a rare species. *Lemna minor* (duckweed) was identified on the less windy side of the lake. A narrow wet meadow was located around Lake Akgöl. *Mentha aquatica* was found in the shallow and narrow littoral margins of the lake.

The water was occasionally brackish from (oligosaline 2.4‰) and occasionally freshwater (less than 0.5‰) in the northern part of Lake Küçükboğaz. The transitional zone between terrestrial and freshwater habitats was well developed along the shallow margins of the lake. *Juncus maritimus* was identified in that part of Lake Küçükboğaz. *Phragmites australis* was the dominant emergent macrophyte species in the littoral of that lake, similarly to the other studied lakes. *Typha angustifolia* and *Juncus effesus* were common species in the littoral of Lake Küçükboğaz, similarly to *Phragmites australis*. *Typha angustifolia* and *Juncus effesus* were accompanied by *Phragmites australis* across the banks of Lake Akgöl. *Ceratophyllum demersum* and *Myriophyllum spicatum* were the dominant submerged species in the deeper part of the lake. *Nuphar lutea* was a common floating-leaved macrophyte identified in the

southern parts of the lake. Free-floating (*Salvinia natans* and *Lemna minor*) and floating-leaved (*Nuphar lutea* and *Trapa natans*) macrophytes were common in the southern parts of Lake Küçükboğaz. *Potamogeton crispus* was identified on the southeastern banks of the lake. The southern part of Lake Küçükboğaz was less affected by the northern winds than the northern part. However, the southern part of the lake had completely the features of a freshwater lake. Therefore, emergent macrophytes were dense in the southern part of the lake, namely submerged, free-floating and floating-leaved macrophytes.

The brackish and shallow Lake Dalyan is occasionally oligosaline (below 5 ‰) in winter and spring and generally mesosaline (9 ‰) in summer and autumn. Salinity is a limiting factor which determines the distribution of aquatic plants in Lake Dalyan. *Phragmites australis* was a dominant emergent macrophyte species in the littoral of Lake Dalyan. *Typha latifolia* and *Juncus maritimus* were the other common species together with *Phragmites australis. Typha angustifolia*, *T. latifolia* and *Juncus maritimus* were accompanied by *Phragmites* on the bank of Lake Dalyan. *Potamogeton pectinatus* was a dominant submerged species in the middle of the lake. Sago Pondgrass (*Potamogeton pectinatus*) was identified in some brackish lagoon lakes in the Black Sea region by Seçmen & Leblebici (1987, 1997). This species is rather tolerant to hyposaline and mesosaline waters.

According to the Percentage Similarity Matrix (Kovach 1999) and Sorensen's Similarity Coefficient (Sorensen 1948), Lake Akgöl is at 90 % similar to Lake Küçükboğaz, at 75 % similar to Lake Akçagöl, and at 19 % similar to Lake Dalyan. Lake Akçagöl is similar at 72 % to Lake Küçükboğaz and at 19 % to Lake Dalyan. Lake Küçükboğaz is similar at 27 % to Lake Dalyan. The decision to use Lake Akgöl as a point of comparison for the nearby Lake Küçükboğaz was taken because of the similarities in morphology, climate and local geology of the two lakes. Both watersheds have similar soil types and are both formed by the shoreline activities of the Black Sea. Lake Akçagöl is a small lake located at higher altitude (58 m a.s.l) from the other lakes. Generally, distribution of macrophyte species within Lake Dalyan is mostly limited by salinity. Therefore, only five macrophyte species were found in Lake Dalyan.

Evaporation does seem to play an important role for the water level of these lakes. The lakes are fed by rains and underground water sources, thus the amount of water does not decrease during the less rainy summer season. The lakes are surrounded by *Corylus avellana* shrub plantations. In April and May, the fertilizer Nitrogen 26 and Diammonium Phosphate (DAP) are frequently spread among the *Corylus avellana* shrubs. Agricultural pesticides, herbicides, fungicides and agricultural fertilizers applied to the soil are eventually transported to the lakes by rain water and consequently the lakes are negatively influenced by these chemical influxes. In the course of this study, a large number of empty agricultural drug boxes were observed around the lakes during the authors' field visits.

Uncontrolled hunting activities are very high in the region because of lack of any strict control on the protection of wildlife in the lakes. The number of waterfowl visiting the lakes, especially in the winter months, is decreasing. All four lakes provide an important habitat for *Mauremys caspica* (Gmelin 1774) (Caspian Turtle).

There is no earlier information, nor records before this study about the negative impact of human activities on the lakes. We assume that continuous alteration of the lake coasts, urbanization or industrialization, as well as the proximity of the lakes to some major main roads have contributed to the negative evolution of these natural wetlands. Consequently, biological diversity of the lakes, their productivity and density of the aquatic plant species in them should be carefully and frequently monitored so as to understand the evolution of these lakes. It is certain that eutrophication will possibly increase in the next years in the four studied lakes. Local administrations need to develop strategies for monitoring the macrophyte vegetation. Thus, if negative ecological trends will be confirmed in these lakes, the administrations should come out with rapid restoration projects for the protection of lake ecosystems.

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