Species composition and qualitative distribution of the macrophytes in three Turkish lakes (Kandira, Kocaeli, Turkey)

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Abstract. The macrophytic flora of the lakes Saklıgöl, Sarıcagelin, and Sarısu was investigated in the spring and summer in the period between 2010 and 2013. Materials collected from the lakes were evaluated and 19 macrophyte species belonging to 14 genera were identified.

Key words: Lake Saklıgöl, Lake Sarıcagelin, Sarısu Lagoon, macrophytes

Introduction

Turkey has 135 wetlands of international significance covering 2.2 million ha (GDNCNP 2010). According to many researchers, it is known that: a) aquatic macrophytes play an important and vital role in healthy ecosystems, b) they serve as primary producers of oxygen through photosynthesis, provide a substrate for the algae and shelter for many invertebrates; and c) they aid nutrient cycling to and from the sediments, and help stabilize river and stream banks, d) macrophytes can maintain clear water in lakes by competing with phytoplankton for nutrients, light and environment, e) submerged plants in particular in shallow wetlands may also provide a refuge for the invertebrates, they can change the nutrient dynamics of the system and prevent resuspension of sediments. According to Kohler & Schneider (2003), hydrophytes are a specific group of plants adapted to grow in water, and thus the presence of macrophytes, their species composition, abundance and distribution could be regarded as important indicators for evaluation of the ecological conditions in water bodies. Aquatic macrophytes can serve as useful indicators of water pollution along the littoral of lakes (Melzer 1999). The macrophytes show diverse reactions to important environmental factors (such as light, epiphytes, intra- and inter specific competition, and herbivores), whereas all macrophyte species show similar reaction to nutrients (Melzer 1999). Presence, absence and abundance of macrophytes can be effectively used as biological indicators (Suominen 1968; Uotila 1971). Submerged macrophytes are crucial for the stabilization of water clarity in shallow mesotrophic and eutrophic lakes (Van Donk &Van de Bund 2002). 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 the lakes with herbivorous fish. Regional differences between topographical and climatic zones are accepted as main factors for the rich biodiversity of Turkey. Anthropogenic impact on wetlands has increased during the last centuries. For

centuries in Turkey, the role played by human settlements in terms of environmental change was minor in comparison to natural causes. However, especially in the last fifty years, the increase of human population of Turkey and the human impact on the water cycle has reversed the situation. Wetlands cover 1.3 million hectares since 1950 (Nivet & Frazier 2004) and their natural composition and structure have been either reversibly or irreversibly destroyed for the purpose of gaining agricultural land in Turkey throughout the last century as the result of various interferences, mainly in the form of drainage and agricultural irrigation projects. Also, unchecked urbanization, dam construction, draining of wetlands, poaching, and excessive irrigation are the most widespread threats to biodiversity of Turkey (Şekercioğlu & al. 2011). There are three lakes different from each other within the boundaries of Kandıra District: Sarısu is a coastal shallow brackish lagoon lake, Sarıcagelin and Saklıgöl are karstic shallow freshwater lakes. Karstic lakes originate from limestone and/or gypsum dissolution. The main lithological unit in the study area are the Upper Cretaceous-Paleocene limestone (karstic and carbonate) rocks (MTA 2003). Of the three wetlands studied altogether, none has a protected status. The floristic data presented here are based on the collections and observations during different floristic studies. The most important study so far of the aquatic flora 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 genuine aquatic macrophytes in the three lakes. A survey of aquatic macrophytes in the three lakes of Kandıra District (Kocaeli, Turkey) was conducted during the period 2010–2013. In all cases, the entire shoreline of the lakes has been investigated. Detailed data on the actual condition of macrophytes were collected and compared between the lakes. This paper presents the biodiversity and spatial distribution of macrophyte vegetation from lakes Akçagöl and Akgöl. Presently, there are several published scientific papers on macrophytic flora of the adjacent lakes in the area (Seçmen & Leblebici 1997; Altınsaçlı 2003; Altınsaçlı & al. 2013).

For the purposes of research, we have studied stonewort green algae (*Charophyta*) and vascular plants (Spermatophyta) and have divided them into three groups: hydrophytes, amphiphytes (species capable of growing on land or in water), and helophytes (emergent plants rooted under water). Macrophytic flora clearly reflects the anthropogenic impact on aquatic systems, and macrophytes are thus very useful scientific material for detecting, monitoring and assessment of the human impact. The main aim of our study is to contribute knowledge about the spatial distribution of aquatic macrophytes in Lake Saklıgöl, Lake Sarıcagelin and Sarısu Lagoon. In other words, the main objectives of this study were to characterize the spatial and seasonal distribution of macrophytes and to determine the factors involved in the dynamics of macrophytic vegetation. The major physical and chemical variables of the lakes and the lagoon were monitored in order to evaluate their role in the macrophyte dynamics. In this paper we discuss the spatial and qualitative distribution and species composition of macrophytes, and their relationship to some physical and chemical parameters. In other words, this paper presents the biodiversity of macrophytic vegetation and the distribution zones of macrophytes from Lake Sarıcagelin, Lake Saklıgöl and Lagoonal Lake Sarısu.

Material and methods

Site description and sampling

Lake Saklıgöl: Lake Saklıgöl (41°07'25, 81"N 29°55'19, 27"E) is a karstic freshwater lake situated in the Upper Cretaceous-Paleocene limestones in the northwestern part of Kandıra District (Kocaeli, Turkey), at an altitude of 77 m a.s.l. (Fig. 1). The lake basin was formed by dissolution of the carbonated rocks. It is a mesotrophic lake, with a mean depth of 1.5 m, maximum depth of 4 m and surface area of 3.9 ha. The lake was found to be alkaline (8.19–9.10), well oxygenated (6.72–8.30 mg/L) and fresh (0.0–0.1 ‰), or oligosaline (0.6 ‰), with low electrical conductivity and hard water. The lake is fed by underground water source and rain water falling into a depression with no surface inlet or outlet. The only outlet of the lake water is via discharge through a karst aquifer. The lake waters are discharged in the north to a little stream via shallow holes in the limestones. The karst aquifer of Lake Saklıgöl was clogged several times with debris or silt. Thus lake overflowed during the rainy sea-

son several times in the past, owing to the fact that the water volume entering the lake exceeded greatly the drainage capacity of the lake in that period. The lake is surrounded by a shrub cover of *Corylus avellana* L. (Common Hazel), *Laurus nobilis* L. (Bay Laurel) and *Salix* (Willow). There is a little *Juglans regia* L. (Common Walnut) plantation at the eastern coast. Therefore, the proportion of arable land is low around the lake. Three commercial fish species inhabit Lake Saklıgöl: Common Carp (*Cyprinus carpio* L.); Mirror Carp (*C. carpio* subsp. *carpio* L.) and Crucian Carp (*Carassius gibelio* (Bloch). There is also a major non-commercial fish species living in the lake: Western Mosquitofish (*Gambusia affinis* Baird & Girard)

Lake Sarıcagelin: Lake Sarıcagelin (41°07'58.17"N 30°00'51.35"; 26 m. a.s.l.) is a karstic freshwater lake situated in the Upper Cretaceous – Paleocene limestones in the northwestern part of Kandıra District (Kocaeli, Turkey), at an altitude of 26 m a.s.l. (Fig. 1). The lake basin was formed by dissolved carbonated rocks. It is a mesotrophic lake, with a mean depth of 1 m, maximum depth of 3 m and surface area of 1.6 ha. The lake was found to be alkaline (7.78–10.20), well oxygenated (6.20–7.51 mg/L) and freshwater (0.0–0.1 ‰), with low electrical conductivity and hard water. The lake is fed by an underground water source and by rain water falling into a depression with no surface inlet or outlet. The only outlet of the lake water is via discharge through a karst aquifer. The lake has overflowed in the past several times, and its waters flow into the Black Sea from the surface in the northern section of lake, similarly to Lake Saklıgöl. An underground drainage pipeline was built to prevent lake overflowing. The lake is surrounded by cultivated areas and secondary housing cooperatives. Therefore, the proportion of arable land is low around the lake. One non-commercial fish species [Eastern Mosquitofish (*Gambusia holbrooki* Girard)] inhabits the lake.

Lagoonal Lake Sarısu: It is located in the northern part of Kandıra District (Adapazarı Province) (41°08'17.77"N 30°09'01.14"E), at an altitude of 0 m (Fig. 1). Like many other lagoonal lakes, Lake Sarısu is situated on a sandy shore. This semi-enclosed water body is separated from the open sea by a sandy barrier. The lagoon is formed in a depression behind the coastal dunes. It is a mesotrophic lagoon, with a mean depth of 1 m, maximum depth of 2.8 m and surface area of 1.94 ha. The lake was found to be al-

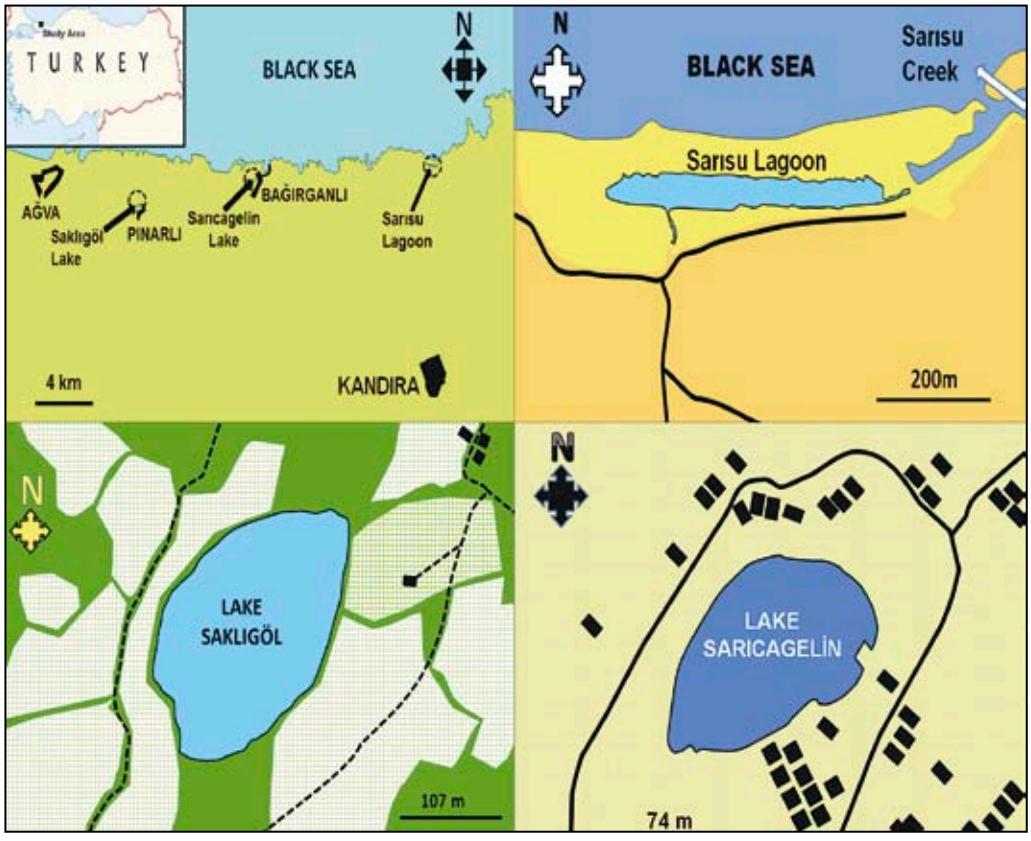

Fig. 1. Map of the lakes showing their location in Northwest Turkey.

kaline (7.71–8.49), well oxygenated (5.6–8.22 mg/L) and oligo-mesosaline (0.7–8.1 ‰), with high electrical conductivity and hard water. It is fed by the rain water, a small freshwater stream and Sarısu Creek. Its only temporary outlet is in the east. 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. Where it is partly open to the Black Sea, the mouth of Sarısu Creek has brackish water. Some creeks generate brackish water by having their river mouths in the sea. Sarısu Creek (Yellow-Water Creek) is one of the turbid creeks on the Black Sea Coast of Kocaeli Province. The sediments are deposited in the sea around the river mouth. The Sarısu Lagoon is linked to the Black Sea by a temporary short channel. A sand dune lies between Sarısu Lagoonal Lake and the Black Sea. The area is used as a public beach in summer by the Kocaeli Municipality. The hydrochemical regime of the Sarısu Lagoon water is determined by the hydrological and climatic regime of the surrounding area and by the degree of water exchange with the Black Sea. The lowest salinity value of 0.7 ‰ was recorded in spring and early summer in this lagoon. Also, the highest salinity value of 8.1 ‰ was recorded in the summer months in the lagoon, due to interventions of the Kocaeli Municipality. The proportion of arable land is low around of the lagoon. The Sarısu area is covered by forests along the coast, composed of fast-growing native pine species, Red Dogwood, Linden, Hornbeam, Natural Oak, Juniper, Beech, Chestnut, and Red Dogwood trees (Çobanoğlu & al. 2013). Several commercial fish species of the *Mugilidae* family inhabit the Lagoonal Lake Sarısu. Two major non-commercial fish species also live in the lake: Western Mosquitofish (*Gambusia affinis* Baird & Girard) and Three-Spined Stickleback (*Gasterosteus aculeatus* L).

The areas of research are characterized by strong northern winds: the northeasterly (Poyraz), northwesterly (Karayel) and northern (Yıldız). According to the Davis grid system (Davis 1965–1985), the research area is located in the A3 square and lies within the Euro-Siberian phytogeographical region.

The Kocaeli Province is situated within the eastern boundaries of the Marmara Region, and the researched lakes are located along the Black Sea coast of Kandıra District of the Kocaeli Province. The climate of Kandıra District is influenced by the climate of the Western Black Sea and Marmara regions. Therefore, the climate in Kandıra is affected by the Mediterranean and the Black Sea climate. The climate is temperate there. Rainfalls are significant throughout the year in Kandıra. Even in the driest month there is still plenty of rain. The mean annual temperature is 14.6 °C and the annual precipitation is approximately 816.4 mm (Akman 1990).

This study was carried out in the summers of the period 2010–2013 in the lakes Saklıgöl, Sarıcagelin and Sarısu Lagoon located in Kandıra District of the Kocaeli Province, Turkey. The distribution and abundance of macrophytes in the three 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 three 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, as well as 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, and 5 – very abundant). For each species, the growth form (acropleustophytes, 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 & al. 1964–1980, 1993). Coordinates of the lakes were obtained with a Garmin Etrex 12-channel GPS. Salinity was measured *in situ* with a handheld WTW 340i multimeter.

Statistical analysis

Sorensen's Similarity Quotient (QS) (Sorensen 1948), i.e. the species similarity based on the presence or absence of species, was used to determine the degree of similarity of macrophyte species collected from the three 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 Bray-Curtis similarity analysis of the macrophyte species in the three lakes was conducted using the Multivariate Statistical Package (SPSS 1999).

Results and discussion

The present study has attempted to determine the macrophytes (submerged, emergent and free-floating species) in three lakes in the Kandıra District (Kocaeli). As a result of the samplings performed in summer between 2010 and 2013, 19 macrophyte species were identified: (*Chara vulgaris* L., *Nitellopsis obtusa* (N.A.Desvaux) J.Groves., *Najas marina* L., *Alisma lanceolatum* With., *Alisma plantago-aquatica* L., *Ceratophyllum demersum* L., *Myriophyllum spicatum* L., *Juncus acutus* Thuill., *Juncus effusus* L., *J. maritimus* Lam., *Iris pseudacorus* L., *Lemna minor* L., *Spirodela polyrhiza* (L.) Schleid., *Potamogeton crispus* L., *Potamogeton natans* L., *P. pectinatus* L., *Phragmites australis* (Cav.) Steud., *Holcus lanatus* L. and *Typha angustifolia* L.). They belong to 11 families and 14 genera in the three lakes (Table 1). In the following list, the taxonomic and systematic nomenclature largely follows Davis (1965–1985) and Seçmen & Leblebici (1997). The complete and current catalogue of the macrophytes found in lakes Saklıgöl, Sarıcagelin and Sarısu (Lagoon) and their life-forms is given in Table 1.

Nineteen taxa were registered in the lakes Saklıgöl, Sarıcagelin and Sarısu, of which 17 are *Spermatophyta* (89.47 %) and two are *Charophyta* (10.53 %).

A total of 19 macrophyte taxa were identified in the three lakes (Table 1), the largest number being found in Lake Sarısu (lagoonal) (15 taxa), and the lowest in Lake Sarıcagelin (7 taxa).

Macrophytes are aquatic plants, growing in or near water and are emergent, submerged or floating. Macrophyte classification according to Dorotovičová (2005) in the three wetlands is as follows: *Chara vulgaris*, *Nitellopsis obtusa*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Potamogeton crispus*, *P. natans*, *P. pectinatus*, *Najas marina*, *Lemna minor,* and *Spirodela polyrhiza* are hydrophytic species; *Alisma lanceolatum* and *Alisma plantago-aquatica* are amphiphytic species; and *Iris pseudacorus*, *Juncus acu-*

Table 1. List of macrophyte species and their life forms determined in the three lakes (Abbreviations: LSKG: Lake Saklıgöl, LSG: Lake Sarıcagelin, SLL: Sarısu Lagoonal Lake, SM: submerged, FF: free-floating, E: emergent).

		LAKES			MACROPYTE TYPES		
	TAXA	LSKG	LSG	SLL	FF	E	SM
CHAROPHYTA							
Characeae	*Chara vulgaris*	●		●			■
Characeae	*Nitellopsis obtusa*		●				■
SPERMATOPHYTA							
Hydrocharitaceae	*Najas marina*	●					■
Alismataceae	*Alisma lanceolatum*	●		●		■	
Alismataceae	*Alisma plantago-aquatica*	●		●		■	
Ceratophyllaceae	*Ceratophyllum demersum*	●	●	●			■
Haloragidaceae	*Myriophyllum spicatum*	●	●	●			■
Juncaceae	*Juncus acutus*			●		■	
Juncaceae	*Juncus effesus*	●		●		■	
Juncaceae	*Juncus maritimus*			●		■	
Iridaceae	*Iris pseudacorus*			●		■	
Lemnaceae	*Lemna minor*		●		■		
Lemnaceae	*Spirodela polyrhiza*			●	■		
Potamogetonaceae	*Potamogeton crispus*	●	●	●			■
Potamogetonaceae	*Potamogeton natans*		●	●			■
Potamogetonaceae	*Potamogeton pectinatus*	●		●			■
Poaceae	*Phragmites australis*	●		●		■	
Poaceae	*Holcus lanatus*	●				■	
Typhaceae	*Typha angustifolia*		●	●		■	
Total number of species		11	7	15			

tus, *Juncus effusus*, *J. maritimus*, *Phragmites australis*, *Holcus lanatus,* and *Typha angustifolia* are helophytic species.

Macrophyte classification according to Sculthorpe (1967) in the three wetlands is as follows: *Iris pseudacorus, Alisma lanceolatum*, *Alisma plantago-aquatica, Juncus acutus, J. effesus, J. maritimus, Phragmites australis, Holcus lanatus,* and *Typha angustifolia* are emergent macrophytes; *Chara vulgaris*, *Nitellopsis obtusa*, *Ceratophyllum demersum, Myriophyllum spicatum, Najas marina, Potamogeton crispus, P. natans,* and *P. pectinatus* are submerged macrophytes; *Lemna minor* and *Spirodela polyrhiza* are free-floating macrophytes.

Submerged macrophytes (8 taxa) were dominated by the species of genus *Potamogeton* (*Potamogeton crispus, P. natans* and *P. pectinatus*). Emergent macrophytes (9 taxa) were dominated by the species of genus *Juncus* (*J. acutus, J. effesus,*and *J. maritimus*).

The hydrophytes found during this study fall into the following four categories, according to their growth forms: 1 – Surface floating plants (acropleustophytes): *Spirodela polyrhiza, Lemna minor*; 2 – Plants entirely submerged, floating at mid-depth (mesopleustophytes): *Ceratophyllum demersum*; 3 – Rooted in sediment plants which, except for their flowers or inflorescences, are submerged (hyphydates): *Myriophyllum spicatum*, *Najas marina*, *Nitellopsis obtus*a, *Chara vulgaris*, *Potamogeton crispus*, *P. pectinatus*,and *P. natans*; 4 – Plants with roots penetrating the substrate but leaves and/or stems emerging above the water surface (hyperhydates): *Phragmites australis*, *Typha latifolia*, *Alisma lanceolatum*, *Alisma plantago-aquatica*, *Juncus acutus*, *J. effesus*, *J. maritimus*, *Holcus lanatus*,and *Iris pseudacorus*.

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

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

	LAKES		
TAXA	**LAKE SAKLIGÖL**	**LAKE SARICAGELIN**	**SARISU LAGOONAL LAKE**
CHAROPHYTA			
Chara vulgaris	2■	—	2■
Nitellopsis obtusa	—	3♦	—
SPERMATOPHYTA			
Najas marina	4▲	—	—
Alisma lanceolatum	2■	—	2■
Alisma plantago-aquatica	2■	—	3♦
Ceratophyllum demersum	4▲	4▲	5▮
Holcus lanatus	3♦		—
Myriophyllum spicatum	4▲	4▲	5▮
Juncus acutus		—	3♦
Juncus effusus	2■	—	3♦
Juncus maritimus	—	—	3♦
Iris pseudacorus	—	—	2■
Lemna minor	—	2■	—
Spirodela polyrhiza	—	—	3♦
Potamogeton crispus	4▲	4▲	3♦
Potamogeton natans		5▮	3♦
Potamogeton pectinatus	4▲	—	3♦
Phragmites australis	3♦	—	4▲
Typha angustifolia		3♦	3♦
Total number of species	**11**	**7**	**15**

According to both Salinity Classification of Gasse and Venice System (1959), the waters of Lake Sarıcagelin and Saklıgöl are fresh (0.0–0.1 ‰). However, the water of Lake Saklıgöl is slightly brackish (oligosaline 0.6 ‰) in summer. Sarısu Lagoonal Lake can be classified as a brackish (oligo-mesosaline 0.7–8.2 ‰) water body.

According to the Percentage Similarity Analysis results, the three lakes must be divided into two major groups due to similarity of the macrophyte species (Fig. 2).

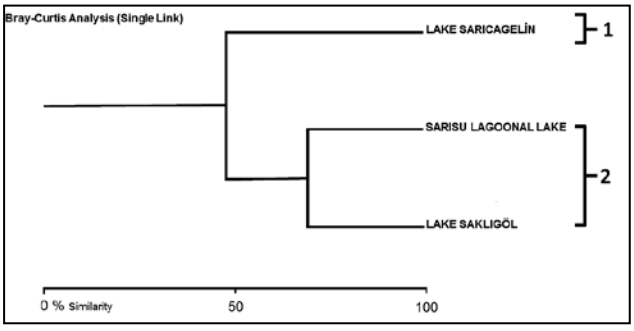

Fig. 2. Dendrogram according to the Bray-Curtis Index of Similarity for the three studied lakes. The dendrogram is showing the Bray-Curtis Index of Similarity of the macrophyte species composition in the three lakes, **Group 1**: freshwater lakes (Sarıcagelin); **Group 2**: fresh and oligo-mesosaline lakes (Lake Saklıgöl and Sarısu Lagoonal Lake).

Distribution of the submerged, emergent and free-floating macrophytes in the three lakes in Kandıra District is shown in Fig. 3.

Potamogeton pectinatus (Sago Pondgrass), *P. crispus* (Curly-Leaf Pondweed), *Najas marina* (Spiny Naiad), *Ceratophyllum demersum* (Hornwort), and *Myriophyllum spicatum* (Eurasian Watermilfoil) predominated among the submerged macrophyte species in the littoral parts of Lake Saklıgöl. These submerged species are situated along the northern, southern and western coast of the lake. *Najas marina* is a cosmopolitan species of fresh and brackish waters. *Potamogeton pectinatus* and *Najas marina* grow submerged in the brackish water of salt marshes, ditches and estuaries. *Potamogeton pectinatus* can tolerate high salinity, pH, and alkaline water (Kantrud, 1990). The shoots of *P. pectinatus* act as habitat or anti-predation refuges for juvenile fish and planktivores in Lake Saklıgöl. These species have cosmopolitan distribution and can survive very sudden and strong fluctuations in salinity. *Phragmites australis* (Common Reed) has extended to many wetland habitats. Along the shallow-sloped shores of many Turkish lakes it forms monospecific belts which often cover many hectares, or even square kilometers. Whereas, *P. australis* is an emergent macrophyte species found in two narrow strips in at the northern (karstic front wall) and southern banks of the lake. The landside border of pure *Phragmites* reeds is controlled by the substrata and rock structure of Lake Saklıgöl. The emergent species *Holcus lanatus* (Yorkshire Fog) was identified in narrow emergent macrophyte belts in the eastern section of Lake Saklıgöl. The presence of emergent macrophyte of *H. lanatus* indicates nutrient- poor soil conditions (Hutchings & al. 2000). Such emergent macrophyte species like *Juncus effesus* (Common Sea Soft Rush), *Alisma plantago-aquatica* (Common Water Plantain) and *Alisma lanceolatum* (Narrow-Leaved Water Plantain) are occasional inhabitants

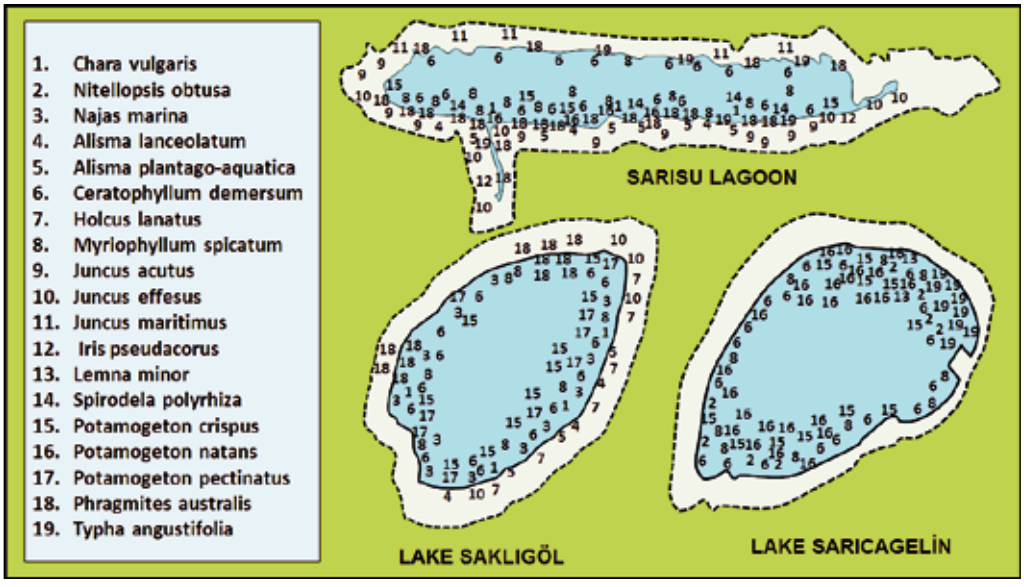

Fig. 3. Distribution map of the macrophyte species in the three lakes located in Kandıra District.

of the eastern and western coasts of the lake, without strong mass density. Charophytes in particular often play an important role, because they are typically rapid colonizers and because the charophyte meadows are believed to have a particularly strong positive effect on water transparency, as compared to other macrophytes (Van Donk &Van de Bund 2002). Most charophytes prefer hard waters of relatively high alkalinity (Kufel & Kufel 2002). According to Stroede (1937), the minimum calcium concentration in *Chara vulgaris L.* (Common Stonewort) is 55 mg/L. In hard- water lakes, calcium cations are usually accompanied by bicarbonate anions, which are often the main inorganic carbon source for macrophytes. Of the other submerged macrophytes, *C. vulgaris* inhabits some littoral parts of the lake, but is not as common as the other submerged macrophytes there. Karstic Saklıgöl is a suitable habitat for *C. vulgaris* due to the fact that it is surrounded by calcium carbonate-rich rocks. There were no species belonging to the genus *Typha* in Lake Saklıgöl. No *Phragmites* and *Typha* belt occurred along the shores of Lake Saklıgöl, because the lake was surrounded by limestone rocks and lacked sediments.

Potamogeton natans, *P. crispus*, *Najas marina*, *Ceratophyllum demersum*, and *Myriophyllum spicatum* predominated among the submerged macrophyte species in the littoral zone of Lake Saklıgöl. Submerged macrophytic vegetation occurs in the northern and southern littoral zone of the lake. The littoral is widely occupied by macrophytic vegetation, dominated by the *Potamogeton natans*. *P. natans* is the most dominant and common species in the lake. The plant community is dominated by *Potamogeton natans* and *Ceratophyllum demersum*. Among the other submerged macrophytes, *Nitellopsis obtusa* also inhabits some littoral parts of Lake Sarıcagelin. The permanent growth range of *N. obtusa* is restricted to oligohaline waters, with salinity not exceeding 5‰ (Winter & al. 1999). Clear-water habitats such as highly translucent lakes are preferred by *N. obtusa* (Spence 1982, Coops & al. 1999). According to the results of the study, the water of Lake Sarıcagelin is not translucent in the summer months. As the Secchi disc depth measurements recorded 1.2–1.8 meters in summer, *N. obtusa* was not as common as other submerged macrophytes in the lake. The karstic Sarıcagelin Lake is a suitable habitat for *Nitellopsis obtusa* due to the surrounding calcium carbonate-rich rocks. *Lemna minor* (Duckweed) is an invasive free-floating macrophyte species. There is a little hill, about 37 m high, in the north of this lake, which stops the strong northern winds of region. Thus *Lemna minor* was identified in the less windy northern parts of the lake. *Typha latifolia* has created a small rush zone in the north of the lake. According to the residents of the nearby Bağırganlı village, the lake was formed about 35 years ago. Formation conditions and size of the lake explain the low number of identified macrophyte species there.

In the littoral region of Sarısu Lagoon, are distributed different populations of macrophyte vegetation. In the Sarısu Lagoon, macrophyte vegetation shows a relatively great species diversity in different parts of the littoral. There is a great number of macrophyte species in the south littoral zone and coastline of the lagoon. *Potamogeton pectinatus*, *P. crispus*, *Ceratophyllum demersum,* and *Myriophyllum spicatum* are dense submerged macrophyte species along the shores of the lagoon, which is shallow. In the course of this study, *Ceratophyllum demersum* and *Myriophyllum spicatum* were determined as dominant species among the other submerged macrophyte species found in the open-water areas of the lagoon. According to Schneider & Melzer (2003), *Myriophyllum spicatum* can grow in eutrophic and nutrient-poor habitats. The northern shore of the lagoon has only sand substrate, whereas the southern shore has a muddy-sand substrate. For this reason, macrophytes create a narrow belt along the southern coast of the lagoon. The free-floating macrophyte *Spirodela polyrhiza* (Greater Duckweed) was identified at the southern shore of the lagoon, together with other submerged macrophyte species. *Spirodela polyrhiza* is a floating aquatic macrophyte belonging to the family *Lemnaceae* and can be found worldwide on the surface of fresh and brackish waters (Zimmo 2003). Significantly higher biomass of emergent and submerged macrophytes was seen in the southern part of the lagoon. *Iris pseudacorus, Alisma lanceolatum*, *A. plantago-aquatica, Juncus acutus, J. effesus, J. maritimus, Phragmites australis,* and *Typha angustifolia* are identified as emergent and helophytic macrophytes at the southern shore of the lagoon. A habitat of reed beds spreads south of the lagoon besides the embankment, where colonies of the tall helophyte *Phragmites australis* occur. To grow, this species requires still water, fresh or of low-salt content. The southern coastal sections showed a helophytic macrophyte belt dominated by *J. effesus, J. maritimus* and *J. acutus,* and *P. australis. Phragmites*

australis, an important southern weed, has been observed in the Sarısu Lagoon, where it created a narrow macrophyte belt along the southern shore of the lagoon. The Sarısu beach is an important summer resort of the Kocaeli Province. Therefore, a large part of the rushes (*Typha angustifolia* and three *Juncus* species) and reeds (*Phragmites australis*) are cut every summer by the recreational facility workers of Kocaeli Municipality. *Iris pseudacorus* has become widely distributed in North America and can form dense colonies in low-elevation freshwater or brackish wetlands, along lake and pond shorelines, and in floodplain riparian areas (Raven & Thomas 1970). Among the other submerged macrophytes, *C. vulgaris* inhabits the southern littoral parts of the lake.

According to the Bray-Curtis Index of Similarity (SPSS 1999), Lake Saklıgöl is at 69.2 % similar to Sarısu Lagoonal Lake, and at 35.2 % similar to Lake Sarıcagelin. Lake Sarıcagelin is at 47.6 % similar to Sarısu Lagoonal Lake. According to the Sorensen's Similarity Coefficient (Sorensen 1948), Lake Saklıgöl is at 64 % similar to Sarısu Lagoonal Lake and at 23.5 % similar to Lake Sarıcagelin. Lake Sarıcagelin is at 36.3 % similar to Sarısu Lagoonal Lake.

Lake Sarıcagelin is a younger lake than the other two in terms of formation. The similarity rates of macrophytic flora between the karstic lakes Sarıcagelin and Saklıgöl were compared, and it has been found out that Lake Sarıcıagelin contains less macrophyte species than Lake Saklıgöl. In the 1970s, water flew from a karstic sinkhole (found in the Sarıcagelin region) obstructed by debris and soil particles. Residents of the adjacent Bağırganlı village maintain that Lake Sarıcagelin has formed as a natural consequence of this event and this could be the main reason for low diversity of macrophytes in Lake Sarıcagelin.

Similarity rates of the macrophytic flora between the karstic lakes Sarısu Lagoon and Saklıgöl were compared and it has been found that Lake Saklıgöl is more similar to Sarısu Lagoon than to Lake Sarıcagelin. Considering the number of species in the three lakes, the emergent macrophytes were strongest in numbers, followed by the submerged and the free-floating macrophytes. In our opinion, not only salinity was a determinant factor for the distribution of macrophyte species in the Lagoonal Lake Sarısu. Fifteen macrophyte species were found in that lake. The macrophytic flora of the karstic Lake Sarıcagelin, when compared with the other karstic Lake Saklıgöl in terms of similarity, has shown low similarity rate of the two lakes. Lake Saklıgöl is a small lake located at higher altitude (77 m a.s.l) than the other lakes. Consequently, altitude does not prove a noticeable factor for the distribution of macrophytes. Salinity is not a major limiting factor for the distribution of macrophyte species in the Lagoonal Lake Sarısu, and does not have any noticeable effect on the distribution of macrophyte species in the lake. Thus fifteen 15 macrophyte species were found in the Sarısu Lagoonal Lake. On the other hand, all reported macrophytes in this study were identified in high-altitude wetlands of Turkey in the past. In all these wetlands, water level did not indicate a serious decline due to evaporation, because rainfalls (although not frequent) occur in this region even in the summer months.

The research area of the district of Kandıra has as vegetation types forests, shrubs, a hazelnut grove, and fallow fields. In the study area, agricultural work is in progress, especially hazelnut farming. That is why the number of natural aquatic plant species is comparatively small, except for along the lake and creek banks.

All three lakes are affected by the agricultural and tourist activities of local people. These activities would lead to major changes in the habitats and ecosystems. The geomorphological structure of lake basins, physico-chemical variables, thickness of sediment substrata, and substrata structure of the lakes, as well as the steepness of lake margins are important determining factors for spatial distribution of macrophytes in these lakes. Macrophyte vegetation in the littoral zone of the three lakes plays a significant role for the aquatic life. Therefore, the situation calls for measures of permanent monitoring and protection of the lakes from the negative anthropogenic impact. The lakes should be declared a protected area. As compared to the other lakes in the region, the still lakes Saklıgöl and Sarıcagelin are still intact and unexplored, so no environmental pressure nor ecological imbalance have been caused in this area. No government projects are under way in forestry, nor in the sphere of environment.

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